ACA*GIScience

Austria-Central Asia Centre for GIScience

Graz University of Technology
Institute of Geoinformation

Kyrgyz State University
for Construction, Transportation
and Agriculture

Austrian Academy of Sciences
Institute for GIScience

openSolarCA'09

open access for success - ☼ - solar energy potentials in Central Asia
evaluated by GIS methods

W O R K B O O K

August 24 - 26, 2009
Bishkek, Kyrgyzstan

Editors:
Scientific Workshop Organization: Gilbert Ahamer, Rainer Prüller, Johannes Scholz, Clemens Strauß
Workshop Committee: Josef Strobl, Erkin Boronbaev, Brigitte Winklehner
Kyrgyz Workshop Partners: Akylbek Chymyrov, Akjol Djenaliev

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Link of the entire openSolarCA'09 Seminar: http://www.aca-giscience.org/opensolar
(contains also the link to this workbook)

Direct link for this publication: http://129.27.89.66/opensolar/download/presentations/opensolar_workbook.pdf

Contents

Topics of the workshop

Geo-referenced open-access tools are presented in practical demonstrations including these topics:

- Energy data and their spatial analysis
- Evaluation of solar potentials in Central Asia
- Analysis of concrete circumstances for the implementation of solar energy in CA
- Evaluation of potentials for small hydro power.

Workshop Committee

Prof. J. Strobl, ÖAW/GIScience, Austria
Prof. E.K. Boronbaev, KSUCTA, Bishkek
Prof. B. Winklehner, Eurasia-Pacific Uninet

Workshop targets

1. Understand the motivation for renewable energy (climate change and supply security)
2. Ability to evaluate concrete solar energy potentials for one's own region by freely available GIS software
3. Use GIS tools for sustainable planning in accordance with one's own local needs in Central Asia.

Guidelines for participation

Interested persons from Central Asia who seek to participate must meet the following requirements:

(1) sufficient knowledge of English
(2) basic knowledge in GIS tools
(3) interest in advanced training in energy & GIS.

UNIGIS students receive 1 ECTS credit for electives.

Submission of applications

See the application form attached or at http://www.aca-giscience.org/opensolar until July, 25.
Travel and accommodation are free for selected members of UNINET universities.
The workshop as such is free. Capacity: 20 participants.

Views of Bishkek

Tienshan mountains

EURASIA-PACIFIC UNINET

ACA*GIScience

Austria-Central Asia Centre for GIScience

Graz University of Technology - Institute of Geoinformation

Kyrgyz State University for Construction, Transportation and Agriculture

Austrian Academy of Sciences - Institute for GIScience

Workshop Announcement & Invitation for participants from Central Asia

openSolarCA'09

open access for success - ☼ - Solar energy potentials in Central Asia

August 24 - 26, 2009
Bishkek, Kyrgyzstan

Dear interested colleagues in Central Asia,

The organisers welcome applications from Central Asia to participate in the **openSolar'09 workshop** held jointly with GISCA'09 from August 24 to 26, 2009 at the Austria-Central Asia Centre for GIScience at KSUCTA in Bishkek. Please submit your application including a precise description of your qualifications using the application form to rainer.prueller@tugraz.at by July 25.

Workshop language: **English**.

Preliminary workshop program

	Mornings (9-12h)	Afternoons (13:30-17:30)
24.8.	*Theoretical lecture*	*Practical workshop*
25.8.	*Theoretical lecture*	*Practical workshop*
26.8.	*Completion of the practical assignments*	

24 August 2009:

09:00-09:45: Ahamer, G.: "Climate change as global motivation for renewable energy and forecasts of future energy demand"

09:45-10:30: Salmhofer, C.: "Effects of climate change and climate protection: global facts and practical examples for solar energy in Kyrgyzstan"

11:00-11:45: Staller, H. & Kaltenegger, E.: "From the solar potentials to concrete solar buildings: which technologies and architectures do we need?"

12:00-13:30: Lunch

13:30-14:15: Paulus, G.: "Spatial Analysis with regard to solar and hydro energy potentials"

14:15-15:00: Strauss, C.: "Freely accessible data sources for calculation of solar and hydro potentials"

15:30-16:15: Prüller, R.: "Introduction to SAGAGIS as an example for free and open source software."

16:15-17:00: Scholz, J.: "Data bases for the assessment of concrete solar potentials: analysis of a digital elevation model".

25 August 2009:

09:00-09:45: Holzmann, H., Fürst, J.: "Methodology for modelling hydro energy potentials: Austrian & Central Asian examples".

09:45-10:30: Mittlböck, M.: "Multi-resolution Modelling of Regional Solar Energy Potentials: Austrian & Central Asian examples".

11:00-11:45: Holter, C. & Weiss, W.: "Solar Thermal Technology- bright opportunities" & "Solar Heating and Cooling - Markets and Applications".

12:00-13:30: Lunch

13:30-14:15: Prüller, R.: "Computation of solar energy potentials in the participants' countries of origin by means of SAGAGIS"

14:15-15:00: Gartner, G.: "International projects and institutions on solar energy potentials, the institutional landscape and dissemination by multimedia cartography"

15:30-16:15: Strauss, C. & Scholz., J.: "Dissemination of solar and hydro potentials with Geobrowsers. Computation, evaluation and presentation of concrete solar potentials in Kyrgyzstan (*mandatory assignment*)"

16:15-17:00: Smith, A. et al.: "Connection to ongoing activities at the ACA*GIS and in Kyrgyzstan".

26 August 2009: *Completion of practical assignments*

Contacts

Kyrgyz workshop partners:

- Mr Akylbek Chymyrov, KSUCTA, Tel: +996 (312) 545602, gisca09@aca-giscience.org.

Scientific workshop organisation:

- Mr Rainer Prüller, Institute for Geoinformatics, TU Graz, rainer.prueller@tugraz.at (application)
- Mr Gilbert Ahamer, Austrian Academy of Sciences, Salzburg, gilbert.ahamer@oeaw.ac.at.

Photo at right in the Ala Archa National Park: Central Asian members of the GISCA'08 conference and some of the lecturers of this workshop.

Workshop lecturers and their expertise

- Dr. **Gilbert Ahamer** (ÖAW/GIScience & Uni Graz): global change, climate change, energy strategies.
- DI Mag. **Rainer Prüller** (TU Graz): Geoinformation mobile GIS, practical solar implementation.
- DI(FH) **Johannes Scholz** (TU Graz): urban emergency systems, spatial decision support systems.
- DI **Clemens Strauß** (TU Graz): GI-based Route Computation, GIS technologies.
- Dr. **Christian Salmhofer** (European Climate Alliance): Land use change, organic farming and climate protection
- Dr. **Gernot Paulus** (FH Kärnten): Geoinformation, Spatial Decision Support Systems, GIS in Education.
- Prof. Dr. **Hubert Holzmann** (Univ. of Nat. Res.): water management, hydrology, environmental technology.
- Prof. Dr. **Georg Gartner** (TU Wien): cartography, multimedia cartography, location-based services.
- Ing. Dipl.-Päd. **Werner Weiss** (TU Wien): practice of solarthermal technology, Austrian solar pioneer.
- Dr. **Christian Holter** (Uni Graz): large-scale solar thermal applications (China), own panel production.
- Prof. **Andrew Smith** (IS NAS, Bishkek): Geodesy and Geoinformatics (ICGG 2007).
- Arch. DI. **Heimo Staller** (FH Joanneum Graz): pioneering architect of the first passive houses.
- Arch. DI. **Erwin Kaltenegger** (TU Graz): architect of first plus energy houses, European Solar Prize.
- Mag. **Manfred Mittlböck** (Uni Salzburg): Multiresolution Modelling of Regional Solar Energy Potentials.

Participants

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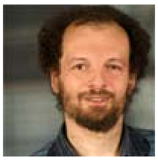

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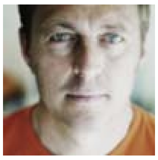

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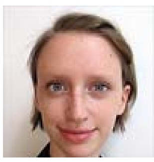

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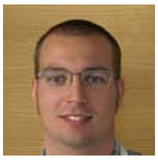

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The rationale for this program

1. In the morning of the first workshop day, the motivation for the workshop theme is presented: how does the greenhouse effect work and what is its effect, what causes CO2 emissions and how can they be reduced? We distinguish the following types of potentials: theoretical, technical, economic and practical. The train of thought goes from abstract to concrete, from global to local, from theory to practice, from theoretical potential to its concrete application.

2. In the afternoon of the first workshop day, an answer to the above challenges is developed: GIS tools are described as suitable tools to evaluate concrete space related potentials. Freely available GIS tools and freely available geo-data are suitable for the situation in Central Asia. Participants learn how to operate with the SAGAGIS software on the computers provided in the workshop room, a region around Bishkek will be the test area.

3. In the morning of the second workshop day, the theoretical approach is deepened: Hydro energy is the other suitable energy form in Kyrgyzstan, the assessment of solar energy potentials is made more concrete, and said forms of alternative energy are applied to actual buildings in Asia.

4. In the afternoon of the second workshop day, the practical workshop training continues with an emphasis on the presentation of results, both in SAGAGIS and by multimedia cartography. The mandatory assignment for all Central Asian participants consists in applying that which has been learned at the workshop in their own home countries or home regions using SAGAGIS. Lecturers from TU Graz provide on-site support to participants. Furthermore, participants receive information concerning the institutional network in Central Asia and the activities of the Austria-Central Asia Centre for GIScience ACA*GIS.

Abstract

Climate change as global motivation for renewable energy and forecasts of future energy demand

Gilbert Ahamer

ÖAW/GIScience & University of Graz

The motivation for this workshop is twofold:

1. global climate change and
2. energy supply security.

Both reasons are explained on a global scale using long-term projections and using a logical chain of cause and effect.

The mechanisms of the greenhouse effect are explained and lead to the conclusion that only abatement of global CO_2 concentration will lead to lowering CO_2 concentrations – deforestation is of comparatively lesser importance.

Only considerable decrease of energy consumption as such can lead to lower CO_2 emissions – fuel switch to biomass or other has lower potential.

However, the remaining energy demand must be covered by other fuels than fossil fuels because their remaining reserves of ~6000 Gt C would boost the global CO_2 concentration to several times the pre-industrial value.

Within a countries options to reduce (a) energy demand and (b) to switch towards renewable and carbon neutral energy sources, the following result of analyses is stated:

(a) the highest technical potential lies in the sector of household, namely heating

(b) a high potential is biomass energy which, however, cannot be implemented in Kyrgyzstan for geographic reasons. Hence solar, hydro and wind potentials take the lead of practice-oriented climate protection.

Strategies of solar energy for heating appear as best adapted to the Kyrgyz and Central Asian situations because of their practicality, relative low capital input and openness to personal craftwork of local citizens.

Welcome to openSolar'09!

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August 24 - 26, 2009
Bishkek, Kyrgyzstan

ÖAW GIScience

Welcome!

- To our series of openSolar'09 presentations
- Covering the entire range

workshop program

	Mornings (9-12h)	Afternoons (13:30-17:30)
24.8.	*Theoretical lecture*	*Practical workshop*
25.8.	*Theoretical lecture*	*Practical workshop*
26.8.	*Discussion preparing the practical implementation of solar energy*	

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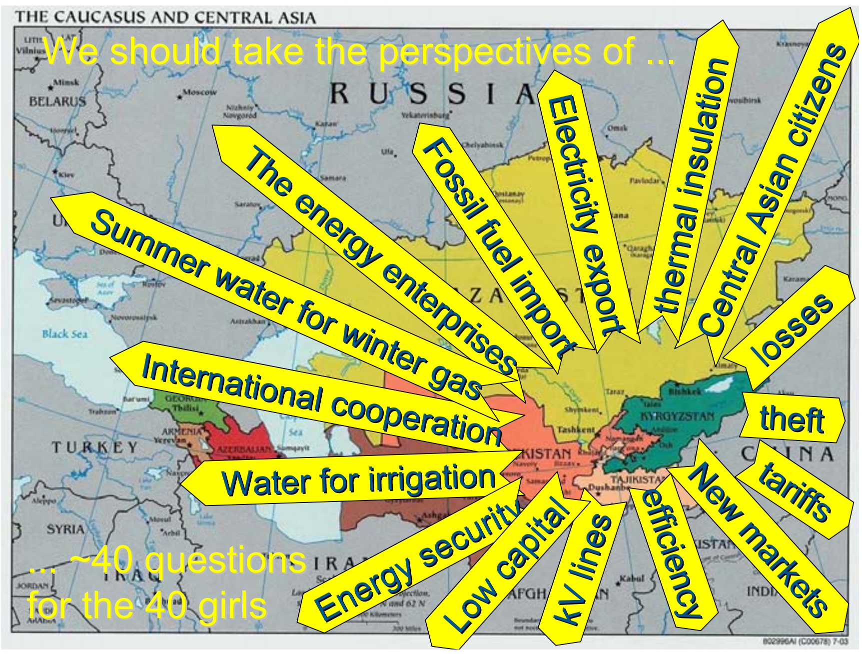
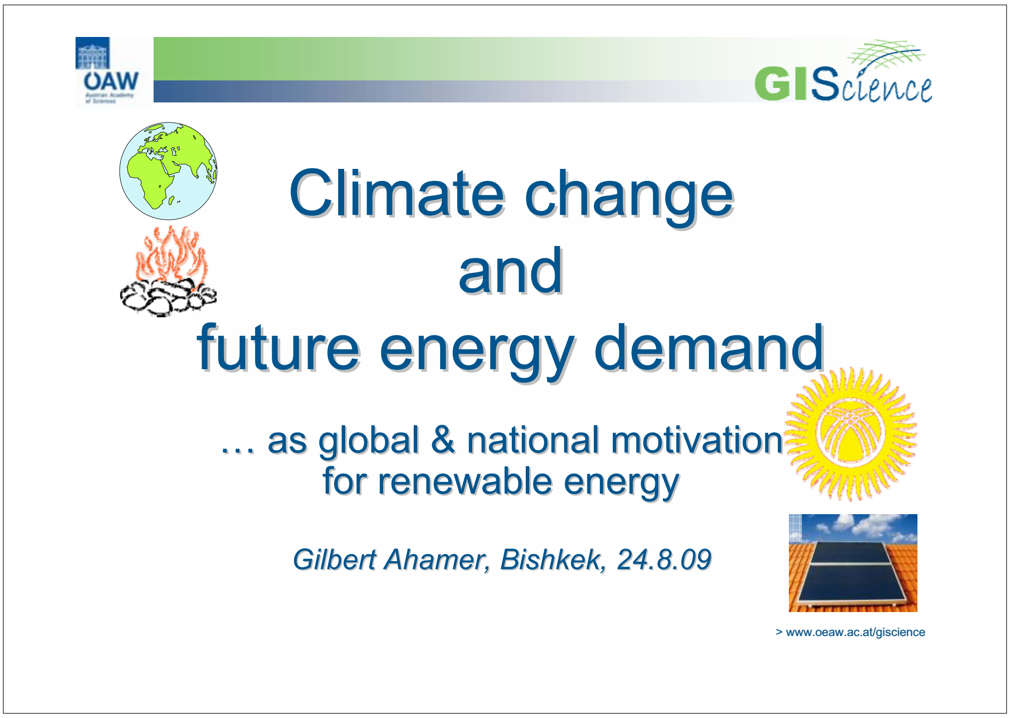
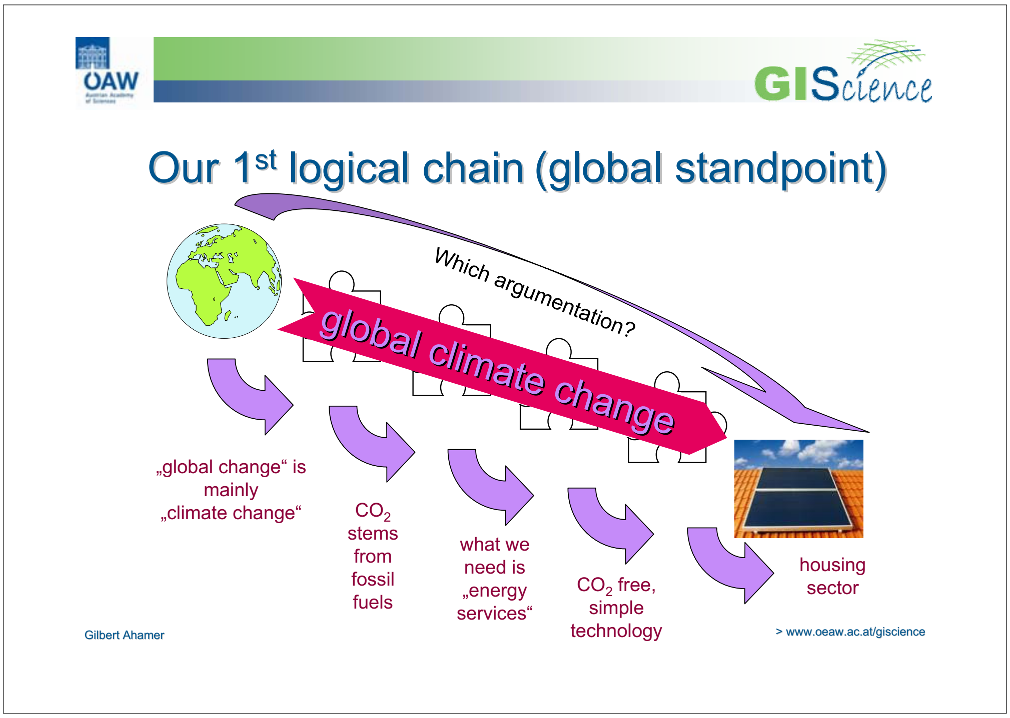



ÖAW
GIScience
Climate change
and
future energy demand
… as global & national motivation
for renewable energy
Gilbert Ahamer, Bishkek, 24.8.09
> www.oeaw.ac.at/giscience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Our 1st logical chain (global standpoint)
Which argumentation?
global climate change
„global change“ is mainly „climate change“
CO2 stems from fossil fuels
what we need is „energy services“
CO2 free, simple technology
housing sector
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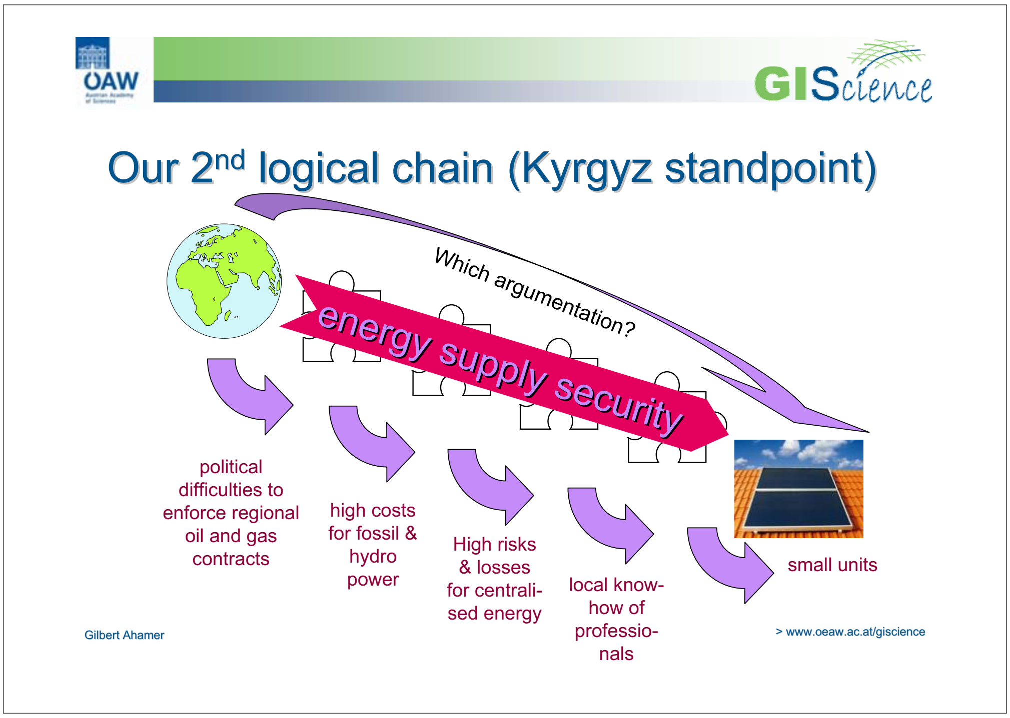
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Our 2nd logical chain (Kyrgyz standpoint)
Which argumentation?
energy supply security
political difficulties to enforce regional oil and gas contracts
high costs for fossil & hydro power
High risks & losses for centrali-sed energy
local know-how of professio-nals
small units
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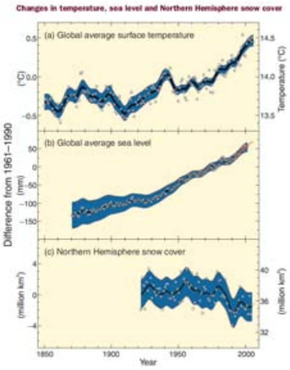
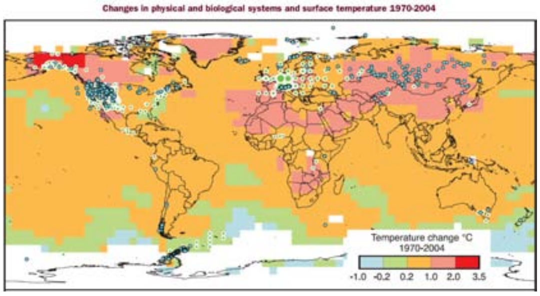
1st argument: global climate change – 1

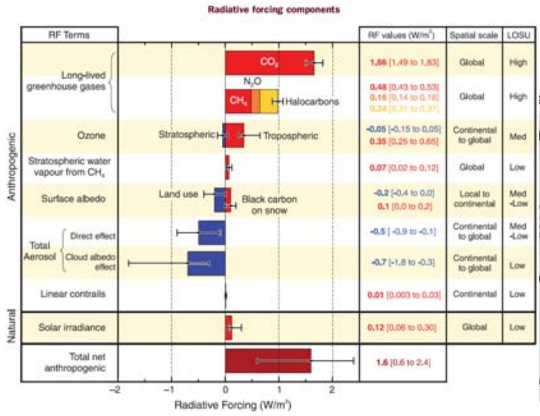
climate change

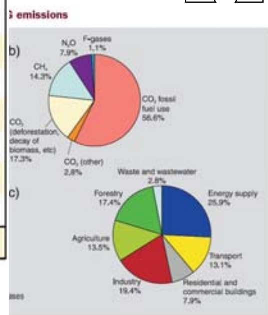




1st argument: global climate change – 2

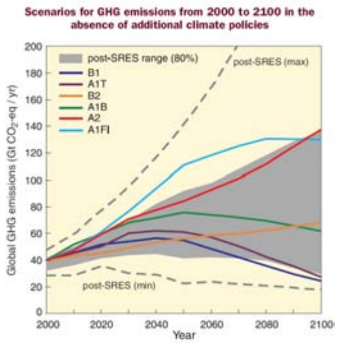
climate change

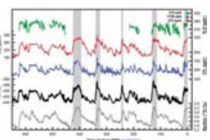




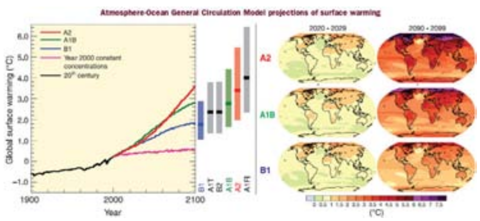
1st argument: global climate change – 4

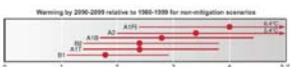
climate change



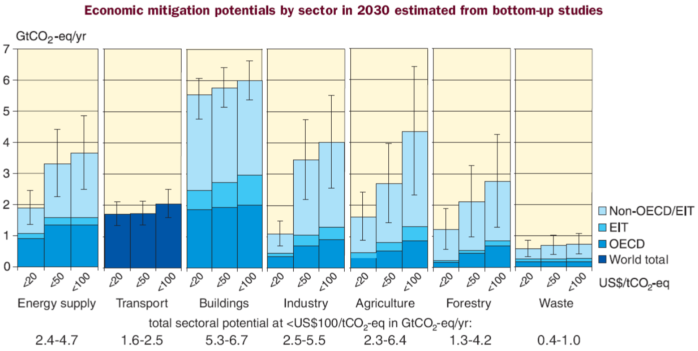


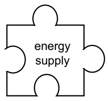
2100: +5°C in Kyrgyzstan!





1st argument: global climate change – 8





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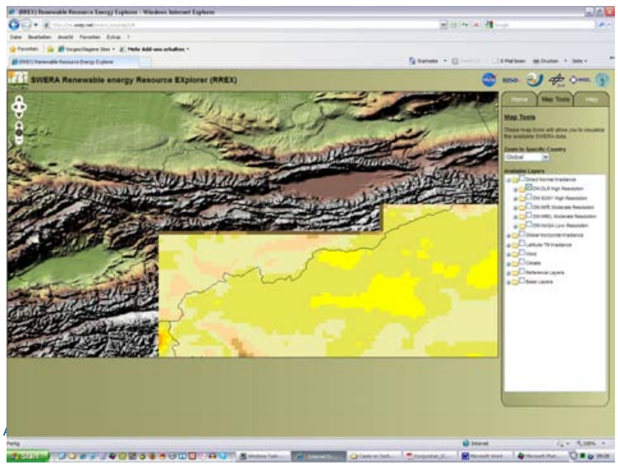
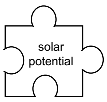
1st argument: global climate change – 12





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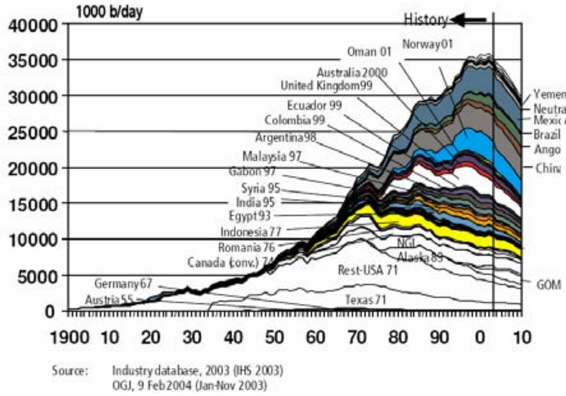
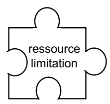
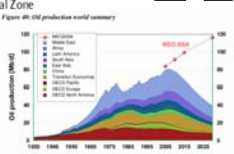
2nd argument: energy supply security – 1







Hubbert believed:
"Our principal constraints are cultural. During the last two centuries we have known nothing but exponential growth and in parallel we have evolved what amounts to an exponential-growth culture, a culture so heavily dependent upon the continuance of exponential growth for its stability that it is incapable of reckoning with problems of nongrowth

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Fossil resources in Central Asia

Figure 6. Kazakstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan: Fuel and Energy Centers, 1996

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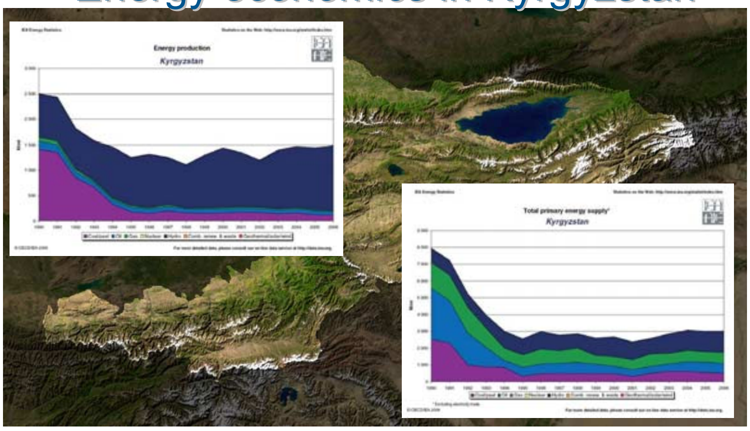
Energy economics in Kyrgyzstan



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2nd argument: energy supply security – 1

- In Soviet times, the plants operated mostly during the summer,
- since the primary purpose of the Toktogul reservoir was to provide water for irrigation in Uzbekistan and Kazakhstan.
- At the time, Kyrgyzstan was supplied with fossil fuel by other republics in the FSU.
- Source: Energy Charter Secretarariat, Report on Kyrgyzstan, 2007

2nd argument: energy supply security – 2

- With independence, priority was given to Kyrgyzstan's own needs for electricity and the plants began operating mostly in winter, when electricity demand is high and water has to be stored for summer.
- There is potential for development of more hydropower generation further upstream from the Toktogul dam.
- Some construction has taken place since independence, but high investment costs have caused the projects to be put on hold.

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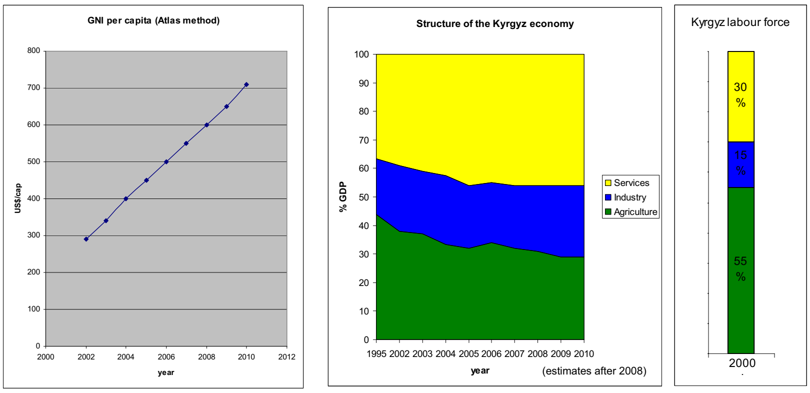
Structure of the Kyrgyz economy



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The „real“ economic constitution

- WB report, §24: "It is estimated that about 53 percent of [economic] output is produced in the shadow economy."
- §25: "Institutional weaknesses and widespread corruption in the public sector also diminished the ability of the public administration to act in the public interest."
- Remittances may amount to at least 19% of GDP
- "Gastarbeiter": 700,000 in Russia, 70,000 in KZ

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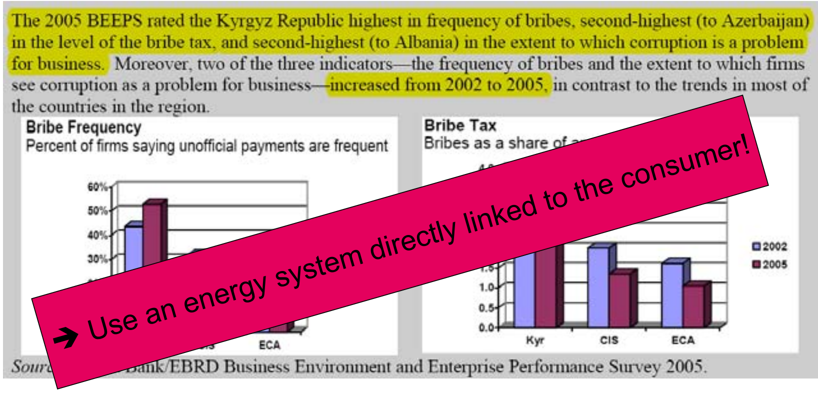
Deplorable practice in the Kyrgyz economy


The 2005 BEEPS rated the Kyrgyz Republic highest in frequency of bribes, second-highest (to Azerbaijan) in the level of the bribe tax, and second-highest (to Albania) in the extent to which corruption is a problem for business. Moreover, two of the three indicators—the frequency of bribes and the extent to which firms see corruption as a problem for business—increased from 2002 to 2005, in contrast to the trends in most of the countries in the region.

Sour... Bank/EBRD Business Environment and Enterprise Performance Survey 2005.

Kyrgyz energy demand pattern

- Significant structural adjustment took place during the 90s, when industrial activity declined and the services sector of the economy expanded.
- The share of industry in final energy consumption fell from more than 41% to less than 30%.
- The residential and commercial sector emerged as the largest consumer of energy (>50% in ~2006).

Joint Country Support Strategy (2007-10), Goal 1.1: Energy sector

- Tariffs increased to full cost recovery ???
- Improved tariff collections to 93% by 2010
- Analysis of the feasibility of expanded hydropower production and export completed
- Improvements in loss reduction
- Progress made in concession management and privatization of distribution companies

Joint Country Support Strategy (2007-10), Goal 1.1: Energy sector

Country Development Goals	Issues and Obstacles	CAS Outcomes
Improve financial viability of the energy sector *Percentage of population with access to clean fuel for heating* Baseline: 40% (2006) Target: 50% (2010) *Energy sector growth at 2.5% per year* *Reduce energy sector losses* Baseline: 8.1% of quasi-fiscal deficit (2006) Target: 1.9 % (2010)	Large financing gap of 2.5 billion with deteriorated assets Tariffs below cost of production Significant losses and theft Low energy efficiency Problems with regional cooperation	**Increased efficiency of the energy sector** *Reduce electricity losses and increase cash collection* Baseline: 40% and 58.3% (2006) Target: 14% and 94.3% (2010)

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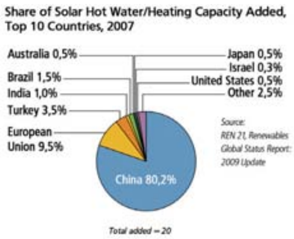
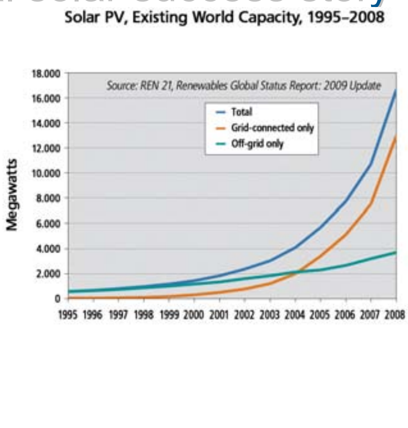
The idea = use global solar success story

- Global PV
- solarthermal





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Correct priotities in energy use!

1. First **reduce energy demand**
2. Then take care of energy **efficiency**
3. Then care for **sustainable** energy & fuel

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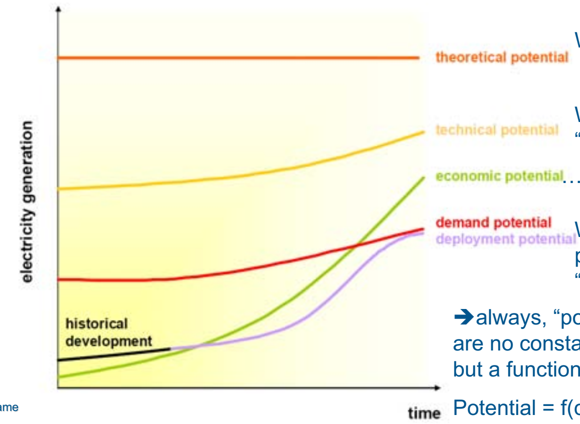
Energy efficiency in KG?

- Kyrgyzstan's economy has a substantial potential for energy savings.
- 37% of electric power,
- up to 33% of thermal power, and
- up to 47% of boiler fuel
- could be saved if required measures were taken and appropriate investments made
- KG's energy intensity equals 1080 toe/US$, which is 3.6 higher than the world average.

What means „potential"?



What nature offers

What can be built with "reasonable effort"

...with "reasonable cost"

What is "practically, politically feasible" & "demanded"

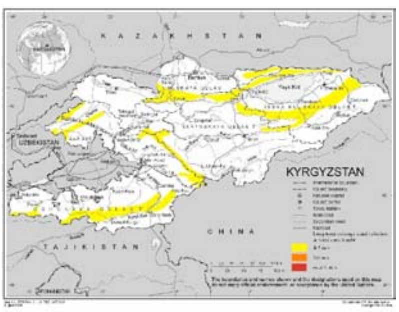
→always, "potentials" are no constant figure but a function of costs:

Potential = f(cost)

Concepts of renewable energy potentials

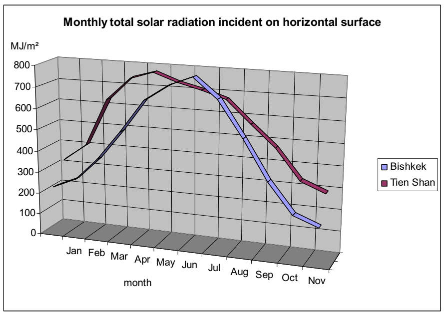
Wind energy in Kyrgyzstan

- Although there has been minimal wind development activity, Kyrgyzstan has a fair potential for wind energy development.



Solar energy in Kyrgyzstan

- Currently the use of solar energy in Kyrgyzstan is mainly limited to solar water heating plants on flat solar collectors that are produced domestically.
- The general area of solar collectors being in operation constitutes 60,000 m².



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Solar situation in Kyrgyzstan

- “Kyrgyzstan has adequate solar energy resources, but there are economic and institutional barriers for developing solar energy:
- There is no feed-in tariff for electricity from renewable energy sources
- and no particular legal framework for support of solar energy projects.”

- Source: Energy Charter Report, 2007

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Example: Solar cell production in Kyrgyzstan

- Kyrgystan Polysilicon Plant Opens:
- Silicon production in Tash-Kumyr is based on the Crystal JSC which was established in Soviet times.
- The plant was reopened in 2009 as Tashkumyr Silicon Productions (TSP).
- To produce polycrystalline silicon for advanced technologies, the plant needs $180-$200 million investment. Support can be obtained from Russia.
- In future, TSP plans to produce also solar panels.

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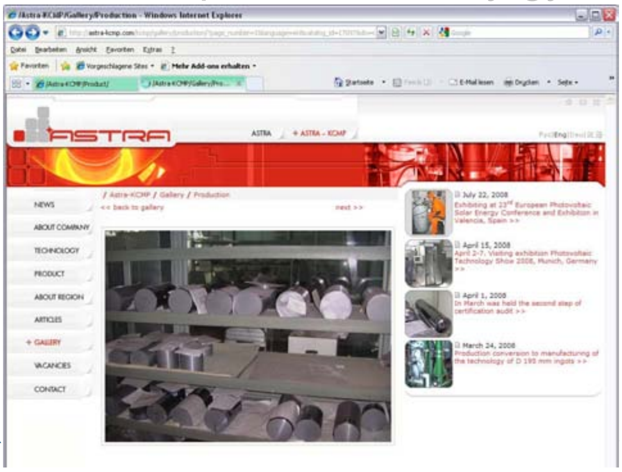
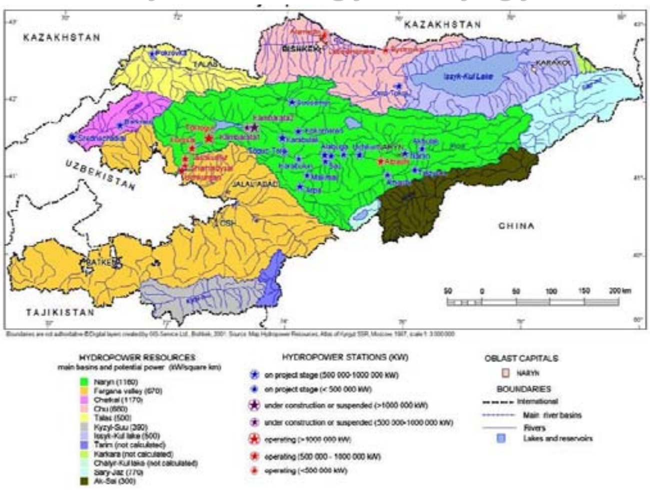
Solar cell production in Kyrgyzstan



Hydro energy in Kyrgyzstan



Characteristics of KG hydro electricity generation

- Since Toktogul reservoir provides multi year storage facility for irrigation and agriculture in the downstream countries, water releases from it are subject to annual consensus.
- This leads to substantial release of water and export of electricity in summer and limited release of water and import of fuels in winter.
- Thus to a large extent, trade in electricity is a byproduct of water release agreements.

Strategic situation of KG for electricity

- In a 1997 study, the World Bank points out that Kyrgyzstan
  - has large hydro potential, an estimated total of 163 TWh/yr,
  - but only 73 TWh/yr is technically feasible
  - and 48 TWh/yr economically exploitable,
  - of which roughly 12 TWh is in use now.
- Hence, in the FSU, Kyrgyzstan was assigned the role of providing hydro generation to the regional interconnected system. The total usable potential of Kyrgyzstan's hydropower is up to approximately 26,000 MW, most of it in the basins of the rivers Naryn, Sary-Dzhaz, Chatkal & Chu.
- Overall, it is possible to construct hydropower plants at more than 100 locations.

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Alternative energy for KG: institutions

- Government of Kyrgyzstan established a Centre on the problems of using renewable energy resources (CPURER).
- Together with the Kyrgyz Association of renewable energy resources, CPURER has developed a program of the use of RES.
- The state business project “KUN” (sun) was founded in 1993 by presidential decree

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Hydro projects map

- In the Kyrgyz Republic there are
- 16 power-generating stations with a total installed capacity of 3678 MW.
- This generation scheme comprises 16 hydroelectric and 2 thermal energy (CHP) plants
- In the nearest future, 2009-2011, priority purpose is completion of construction and commissioning Kambarata Hydroelectric-Station – 2, construction with intermissions has being held since 1986.
- (Source: INOGATE Report)

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Hydro projects map

Main existing and proposed HPP and 500 kV lines in Kyrgyzstan

Hydro electricity: need for export lines

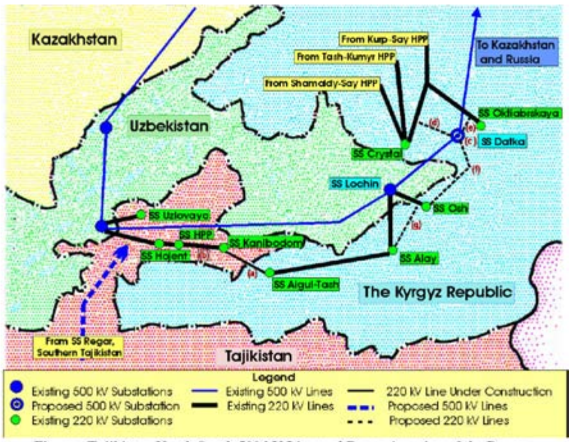
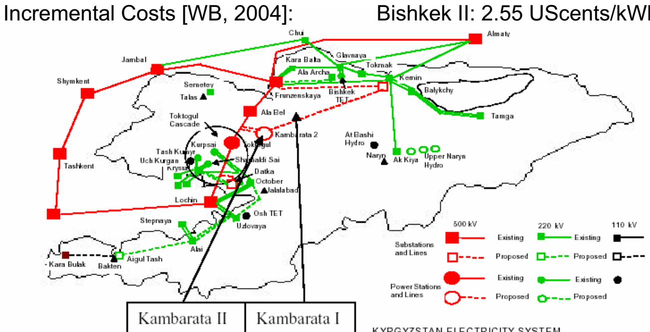


Figure : Tajikistan North South 500 kV Line and De-conjunction of the Power Transmission in the Southern CAPS

Kyrgyz electricity system

Average Incremental Costs [WB, 2004]: Bishkek II: 2.55 UScents/kWh



Source: Kyrgyz Republic-UK DfID Tariff Policy Project, 2003

Karambata 1: 7.17 UScents/kWh!

Karambata 2: 3.72 UScents/kWh

Kyrgyz electricity system: Kambarata 1

- The incremental cost of power generation by Kambarata-1 at US¢7.17/kWh is the highest among those from all the generation options available or contemplated in CA.
- However, Kambarata 1 is a large storage hydro plant which enables electricity generation in winter, since the water released would be stored in downstream Toktogul reservoir.
- Thus it will enable Toktogul hydro units and the Naryn cascade hydro units operate following the irrigation regime as per international agreements.

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Country Development Strategy: Energy

- §148: Systemic losses in the power distribution network exceeded 40%, about 25% due to commercial losses and theft.
- As a result, the power sector's quasi-fiscal deficit at the end of 2006 amounted to 5.4% of GDP and negatively affected macroeconomic stability and the budget's sustainability.

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Kyrgyz National Energy Strategy Paper

- Planning for 2008-2010 with outlook to 2025
- Governmental decree of 13 February 2008
- Chapter 1: Substitution of imported energy by alternative (renewable) energy sources & prevention of waste of energy (efficiency)
- cutting down energy losses from 40%
- Finishing the Kambaratinsko-2 hydro station until end of 2009 costing 3,5 Mrd. Som

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Conclusion: why solar energy is useful

- **Small units are possible, personal ownership**
- **No distribution across long distance**
- **No tariff changes are necessary** (social problems)
- **Demand-side orientation**
- **Insulation is in the interest of the local actor**
- **No high investment cost into structures(?)**
- **Independence of international questions** (water, fossils

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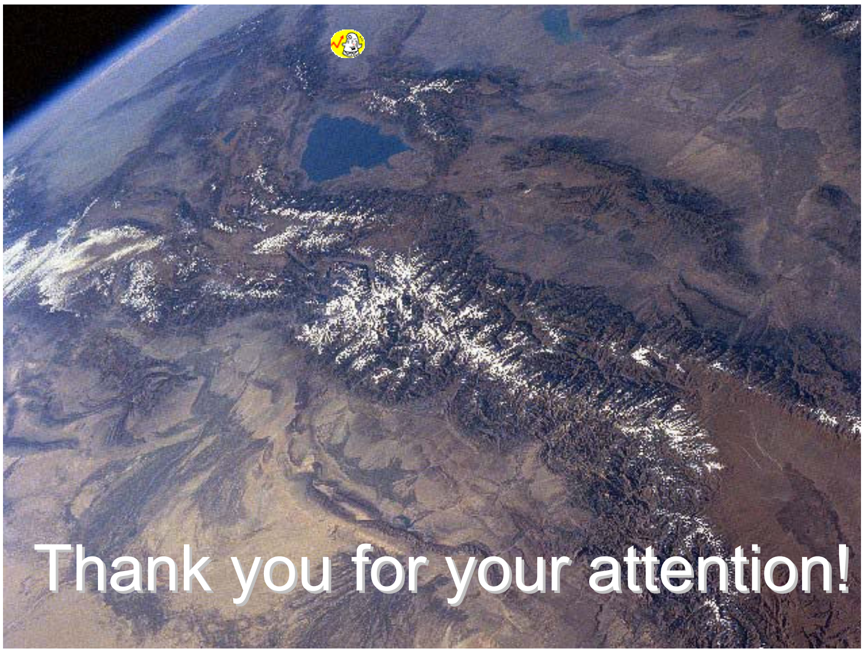


Abstract

Effects of climate change and climate protection: global facts and practical examples for solar energy in Kyrgyzstan

Christian Salmhofer

Universität Klagenfurt

In relation to the facts of climate change we have to see our world from a new point of view – like the end of globalisation. All our greenhouse gas emissions are associated with the final consumption of goods and services. National average per capita carbon footprints vary from 1 t CO_2e/y in Kyrgyzstan to 13.8 t/y in Austria. Food and services are more important in developing countries, while mobility and manufactured goods rise fast with income and dominate in rich countries.
Based on the scenarios for climate change we have to act now. Austria as a rich country has not reached any target of its own climate policy. Just the opposite happens. Austria imports 52% of CO_2 emissions which are hidden in the products the Austrian people are consuming. The life style of the people in Kyrgyzstan suffers from another dimension. It is one of the poorest countries of the world and there is no biomass and only the use of water can support the way of sustainability in the sense of climate change. Because of the strength summer heat waves and the cold winters the planting of trees must be in the centre of their activities. Electricity is no way to heat the water; especially the sun is shining most of the time. Also their houses should be built in a simple way to get the heat of the winter sun inside the rooms.
For the future we have to build up a sensitive partnership between Austria and Kyrgyzstan. That means to open the borders. If Europe works like a fortress for the poor people it has no sense to discuss the problems auf climate change. Only together we can find a path for our common future. Because the people in Kyrgyzstan need not only good windows for their houses they also need a good window of opportunity to check their democratic way. And in the end we only can find the way only if we are going together, because the greenhouse gas emissions don't care of our borders and economic areas.

Climate Alliance will point to our behavior in a global context

klimabündnis Kärnten

Climate Alliance

an alliance between local communities, European countries and the peoples of the Amazon

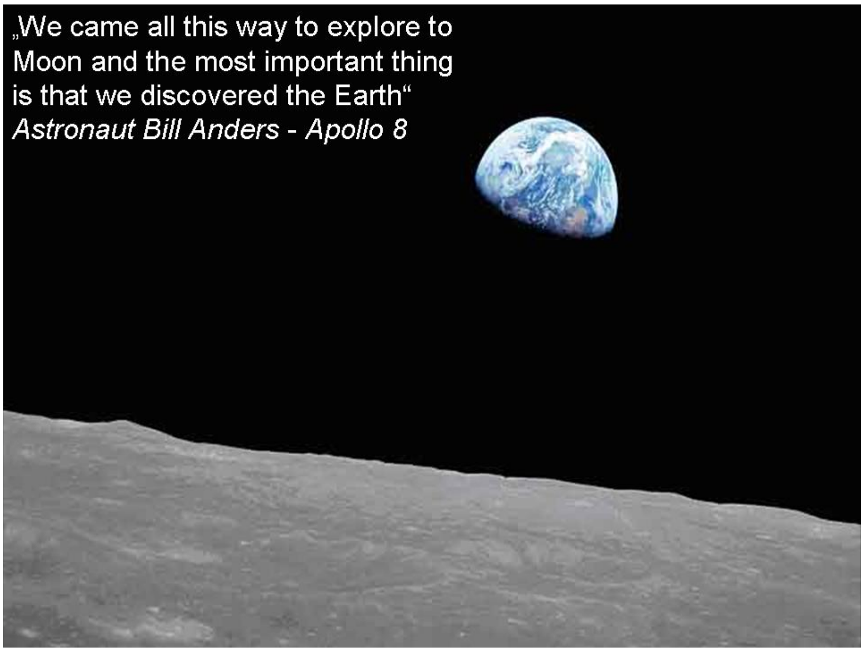
in Austrian

- 800 communities
- 500 businesses
- 200 schools

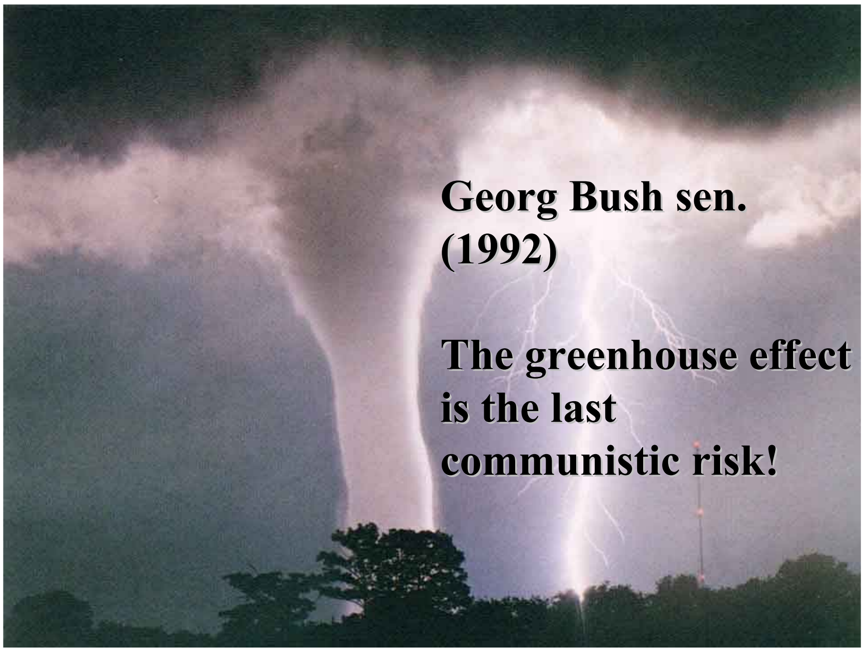
founded 1990

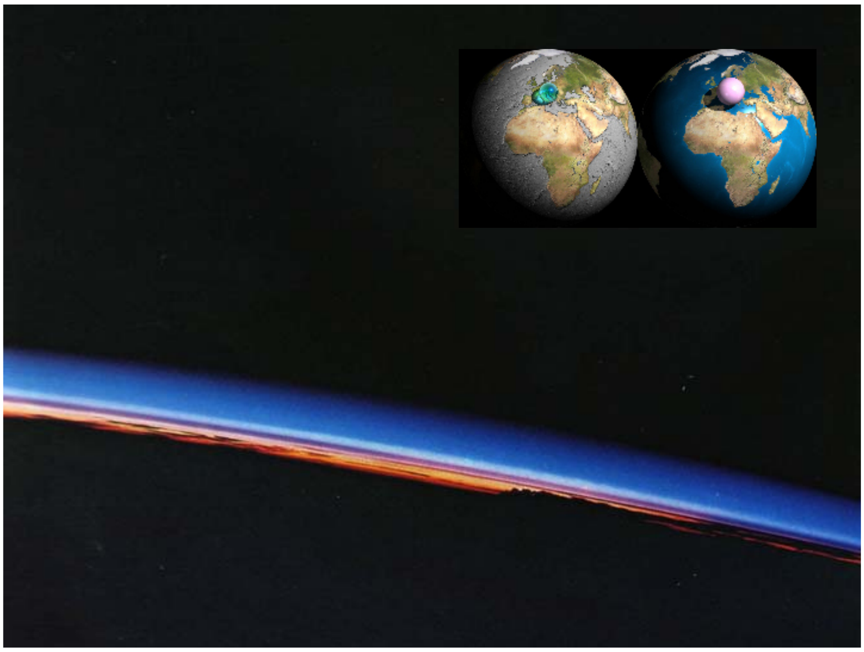
our goals

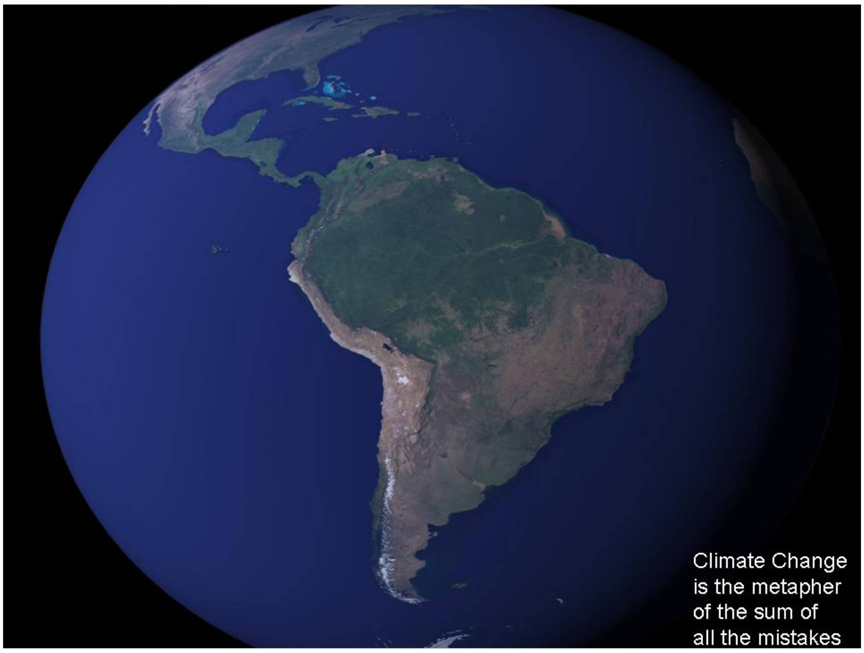
- reduction of greenhouse gas emissions
- energy efficiency and use of renewable energy
- environmentally acceptable means of transportation
- use of regional and ecologically products
- support for our partners in the Amazon rainforest in the preservation of their local environment

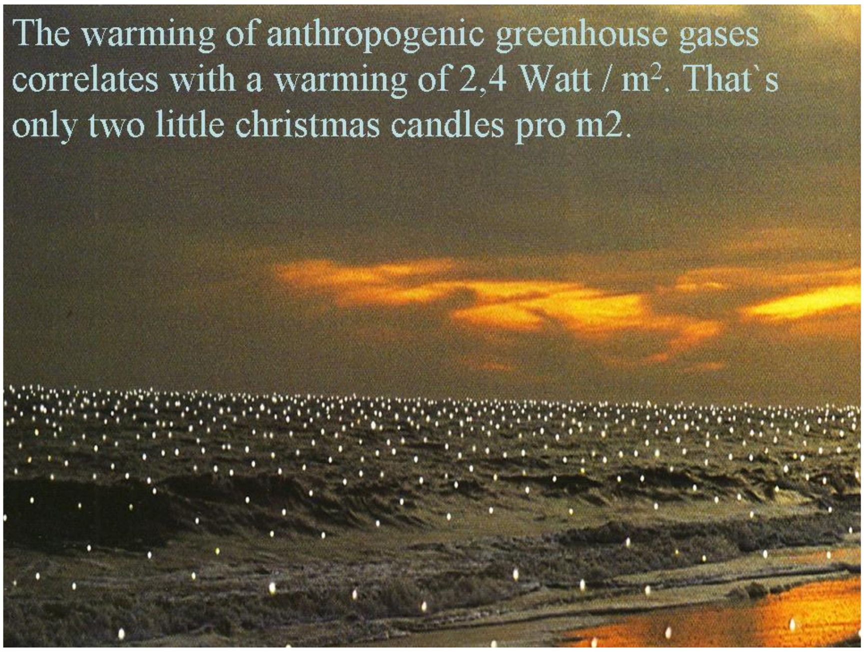


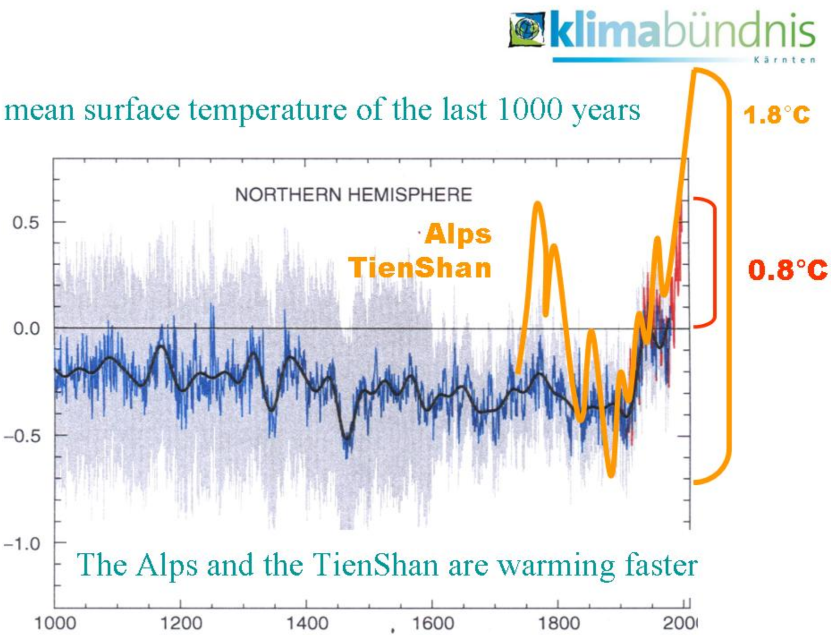

the end of globalisation

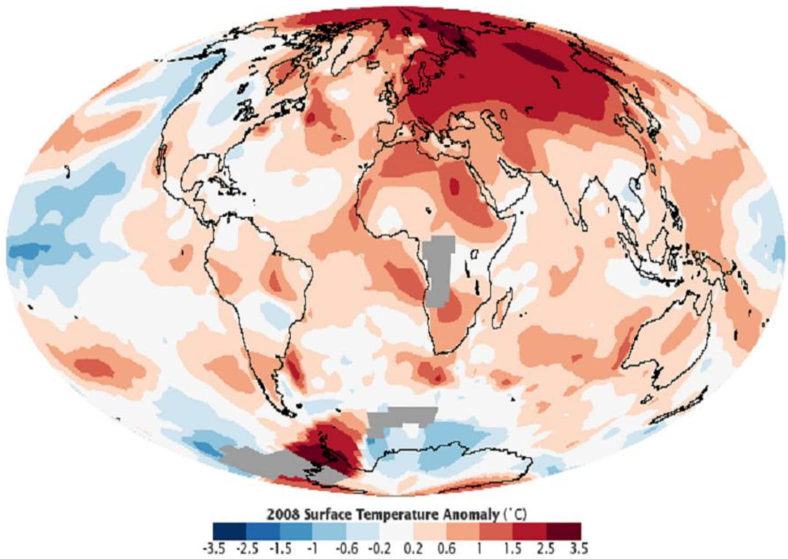

Georg Bush sen.
(1992)
The greenhouse effect
is the last
communistic risk!

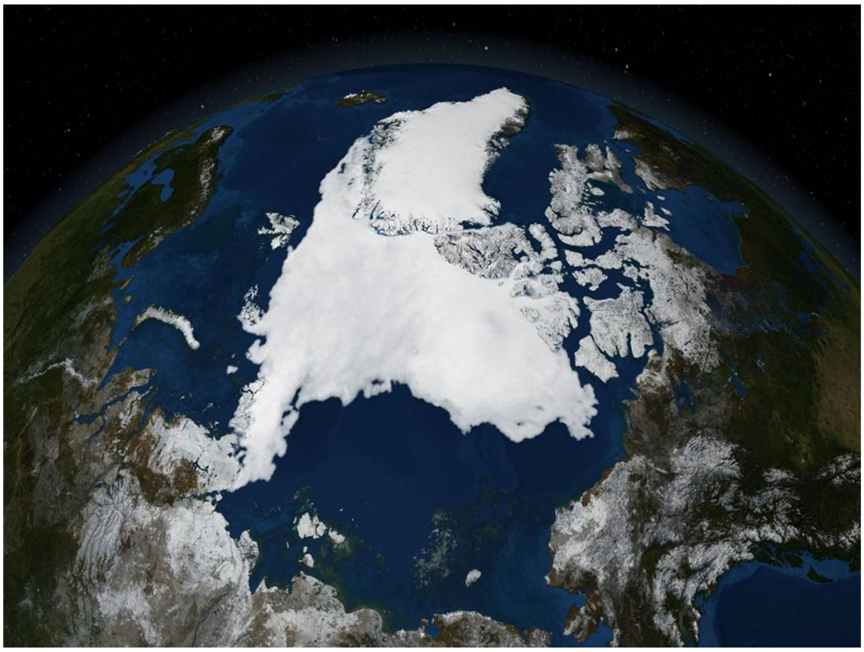


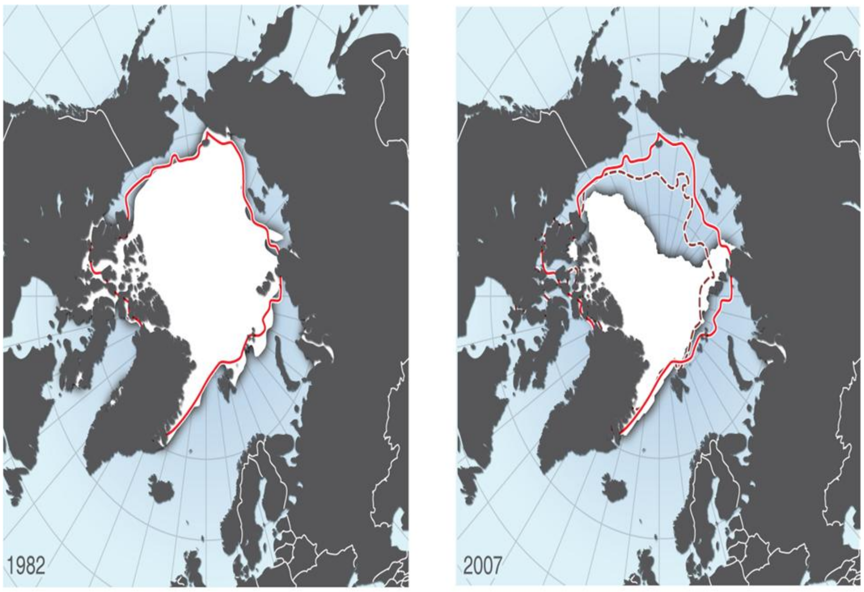

Climate Change
is the metapher
of the sum of
all the mistakes


The warming of anthropogenic greenhouse gases correlates with a warming of 2,4 Watt / m². That`s only two little christmas candles pro m2.


klimabündnis
Kärnten
mean surface temperature of the last 1000 years
1.8°C
NORTHERN HEMISPHERE
Alps
TienShan
0.8°C
0.5
0.0
−0.5
−1.0
The Alps and the TienShan are warming faster
1000
1200
1400
1600
1800
2000


2008 Surface Temperature Anomaly (°C)
-3.5 -2.5 -1.5 -1 -0.6 -0.2 0.2 0.6 1 1.5 2.5 3.5

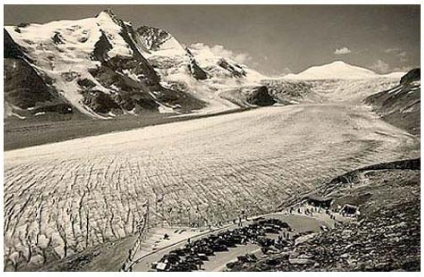



1982
2007
Minimum extent of ice cover 2005
Median minimum extent of ice cover (1979-2000)

melting glaciers

klimabündnis Kärnten

energie:bewusst Kärnten
Die unabhängige Energieberatung

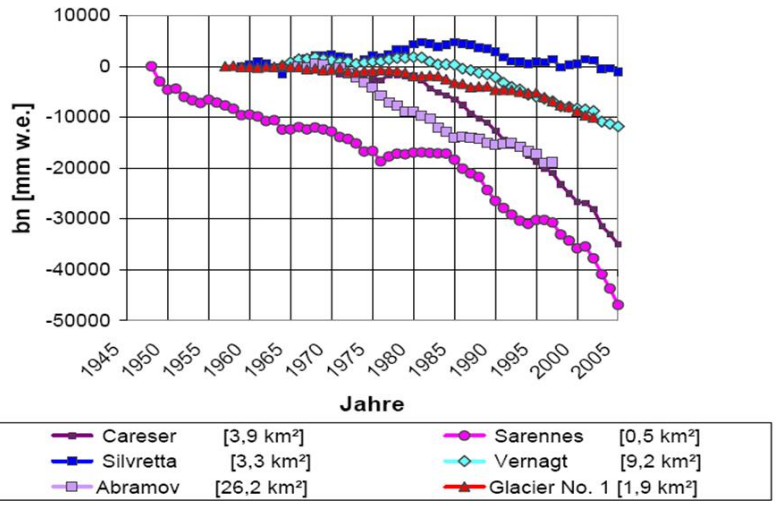


1940 **2003**

glacier snout of the Pasterze Glacier in the Austrian Alps

Großglockner (3798 m)

http://www.gletscherarchiv.de



Mass loses of four glaciers in the Alps
and two in Central Asia 1947 - 2005

climate change and security

klimabündnis Kärnten

document of the EU commission (S412 / 18.Dez. 2008)

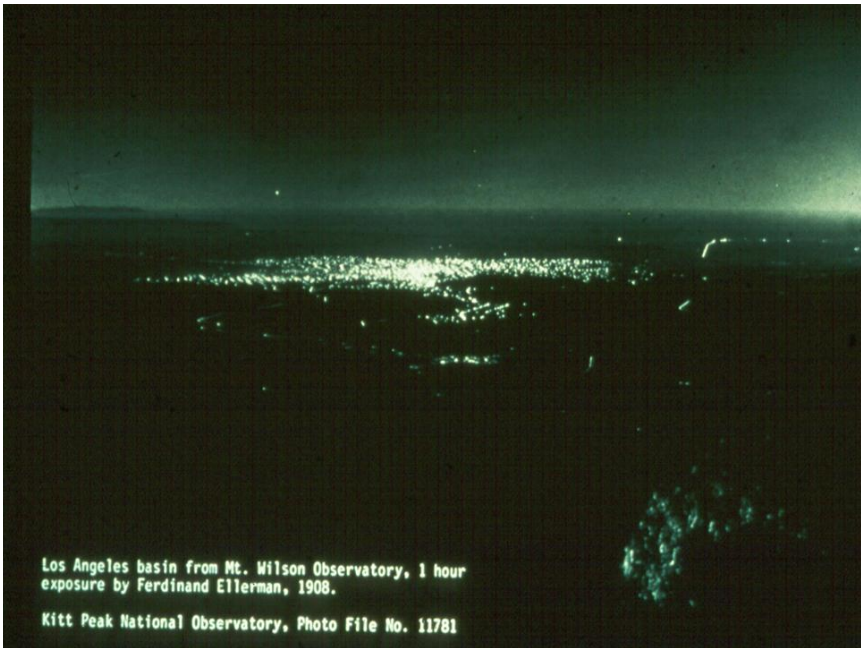
the consequences for central asia

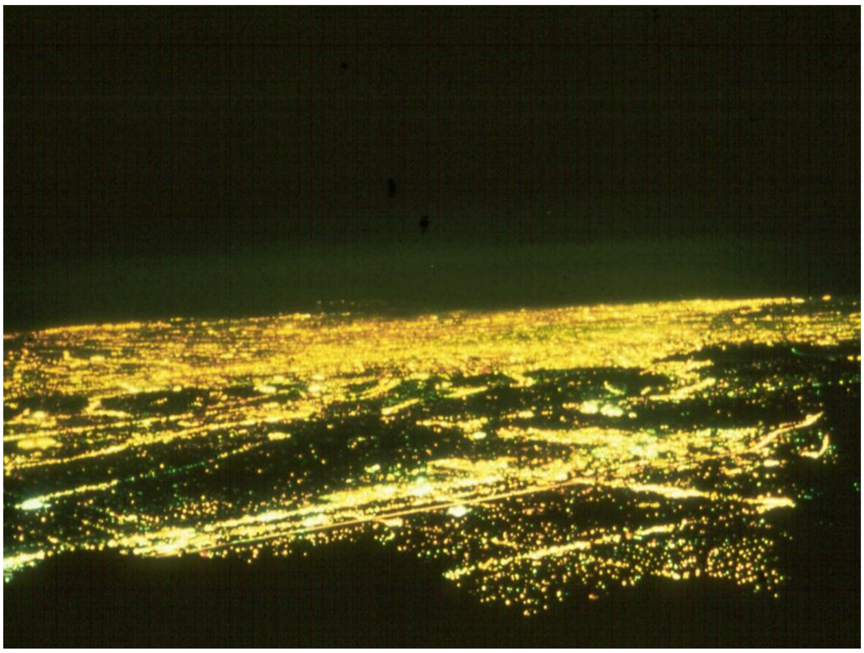
• Until 2050 20% of the kirgisistan glaciers can be disappear. As a result of this, conflicts about the water are possible.

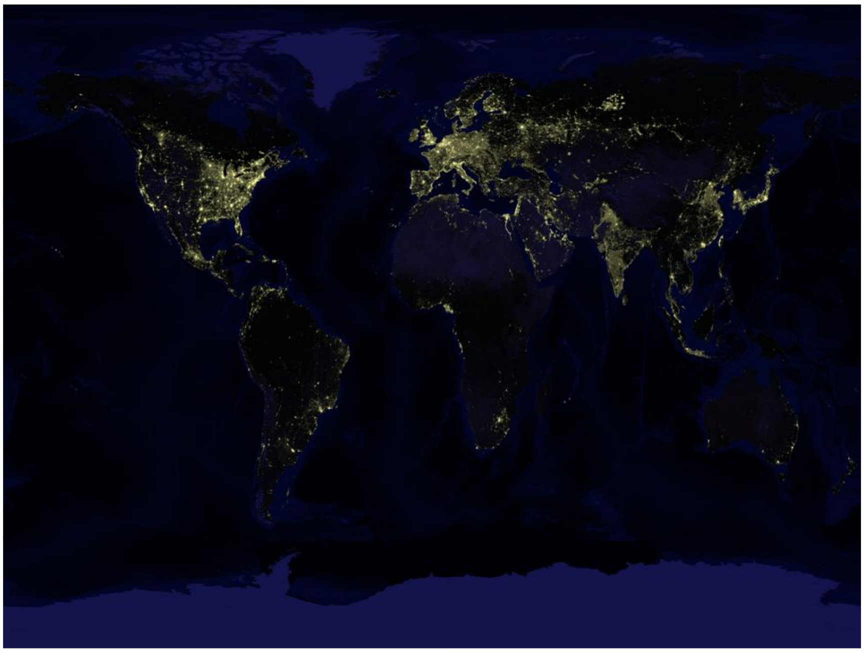
• If the water level of the rivers Amu Darya and Syr Darya will be sinking the consequences for the hydropower in Kirgisistan / Tadschikistan and for the cotton harvest in Usbekistan will be very stressful.

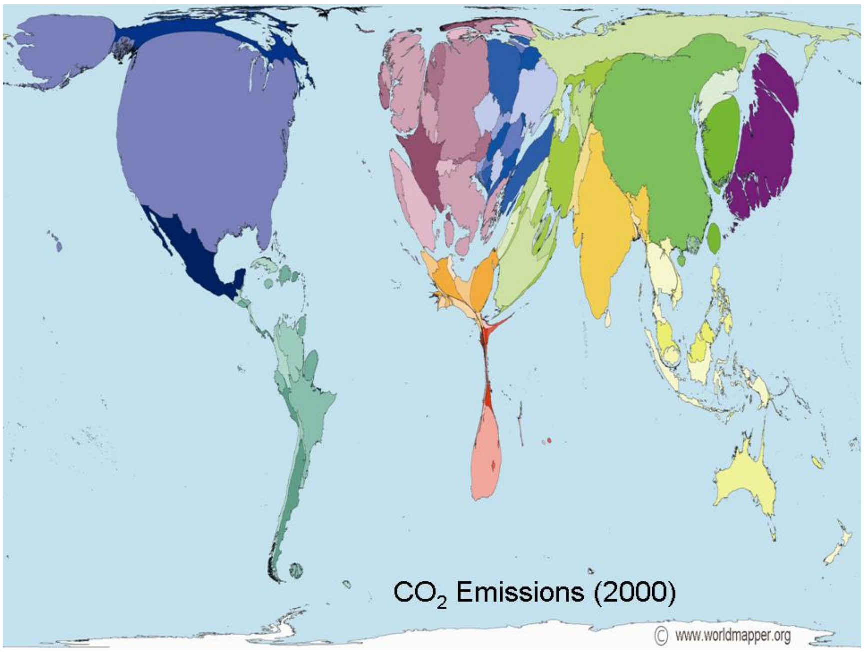
• Center of conflicts are the fergana valley and aral sea. task force for helping to create a better watermanagement, renewable energies, little hydro electric power plants and a kind of sustainable agriculture…


an ice bear on a melting ice floe
takes more attention than the human beings
which are suffering because of bad soils
»Peak Soil«

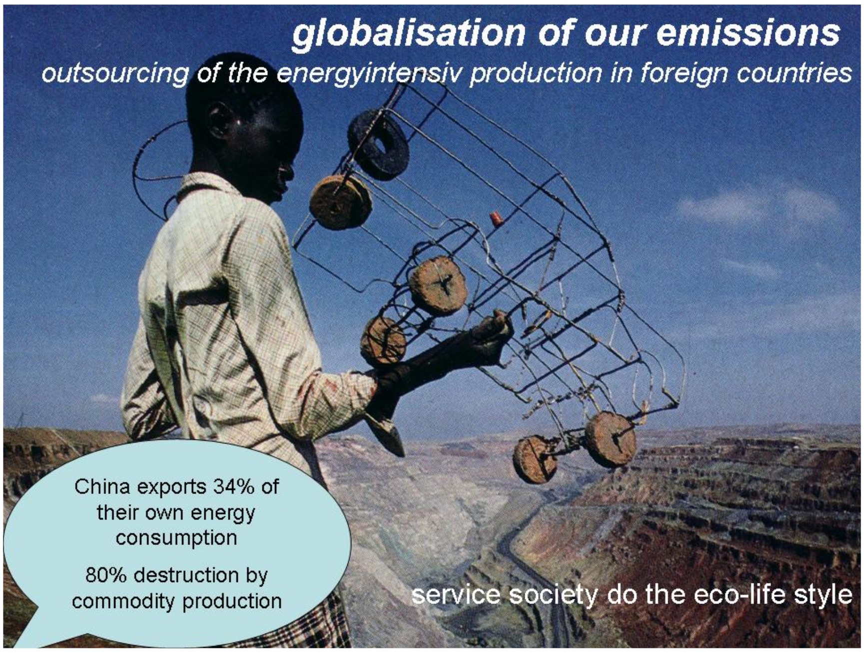

Los Angeles basin from Mt. Wilson Observatory, 1 hour
exposure by Ferdinand Ellerman, 1908.
Kitt Peak National Observatory, Photo File No. 11781



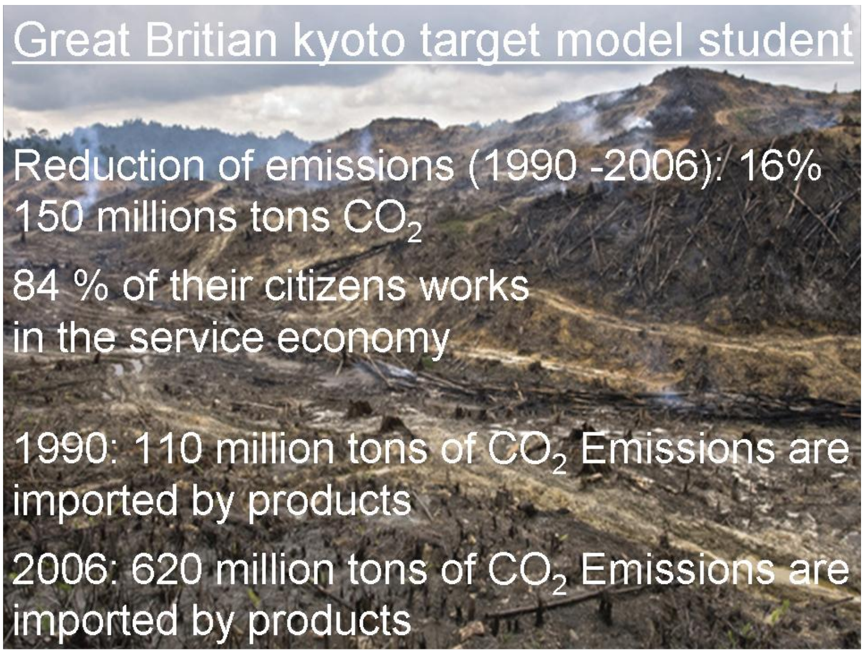


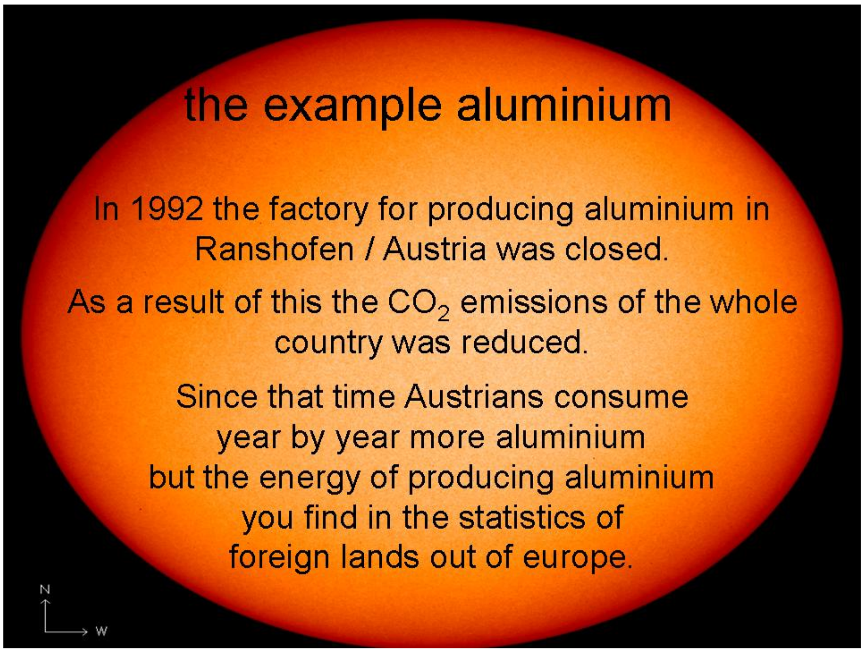

CO_2 Emissions (2000)
© www.worldmapper.org


10 Tons of CO2 can be saved from a forest by the size of an football field
Austria: 10 Tons CO_2 per capita
Kirgisien: 1 Tons CO_2 per capita

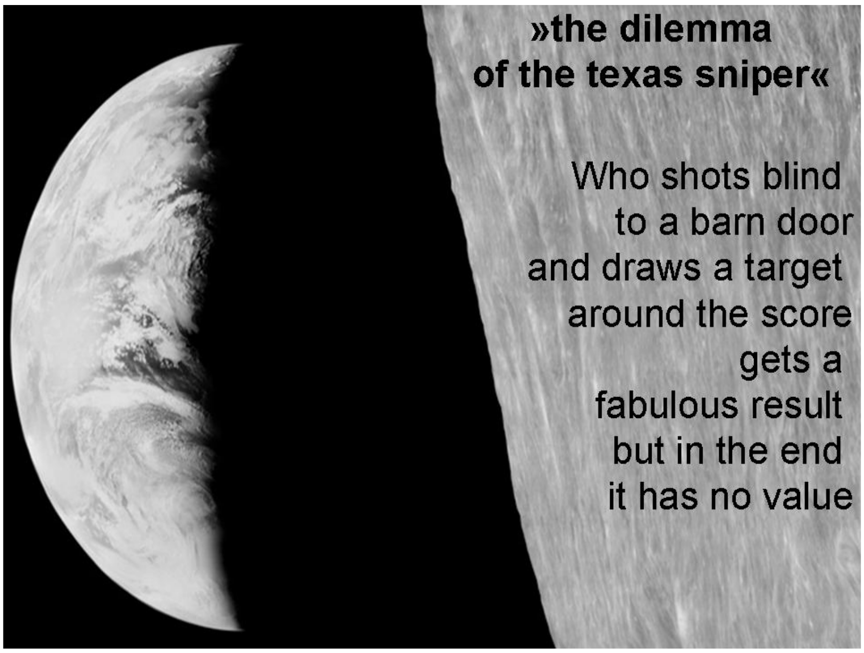

globalisation of our emissions
outsourcing of the energyintensiv production in foreign countries
China exports 34% of their own energy consumption
80% destruction by commodity production
service society do the eco-life style

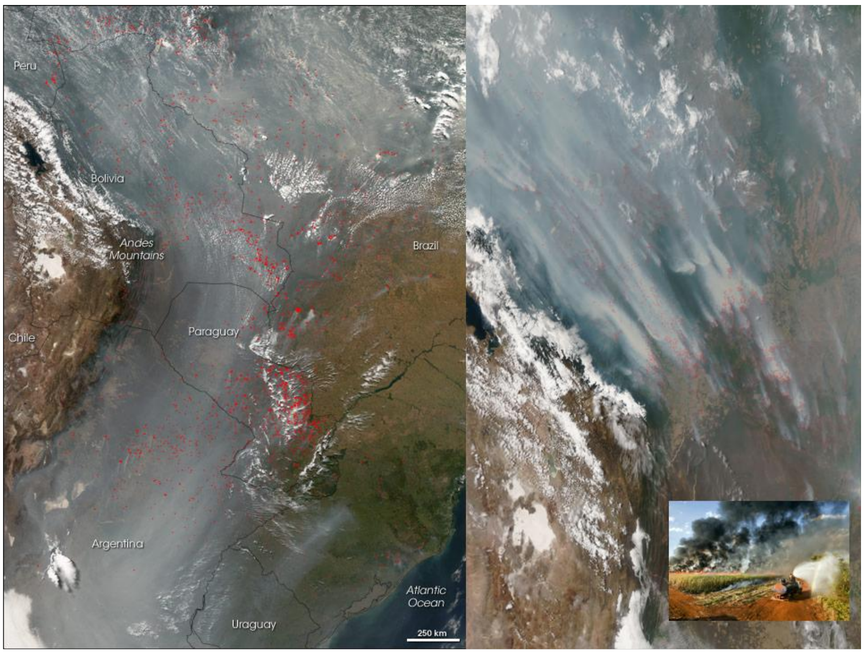

Austria
48 % of the CO_2 Emissions are produced within the borders of Austria
52 % imported „grey" energy
Juni 2009


Great Britian kyoto target model student
Reduction of emissions (1990 -2006): 16%
150 millions tons CO_2
84 % of their citizens works
in the service economy
1990: 110 million tons of CO_2 Emissions are imported by products
2006: 620 million tons of CO_2 Emissions are imported by products


the example aluminium
In 1992 the factory for producing aluminium in Ranshofen / Austria was closed.
As a result of this the CO_2 emissions of the whole country was reduced.
Since that time Austrians consume year by year more aluminium but the energy of producing aluminium you find in the statistics of foreign lands out of europe.
N
W

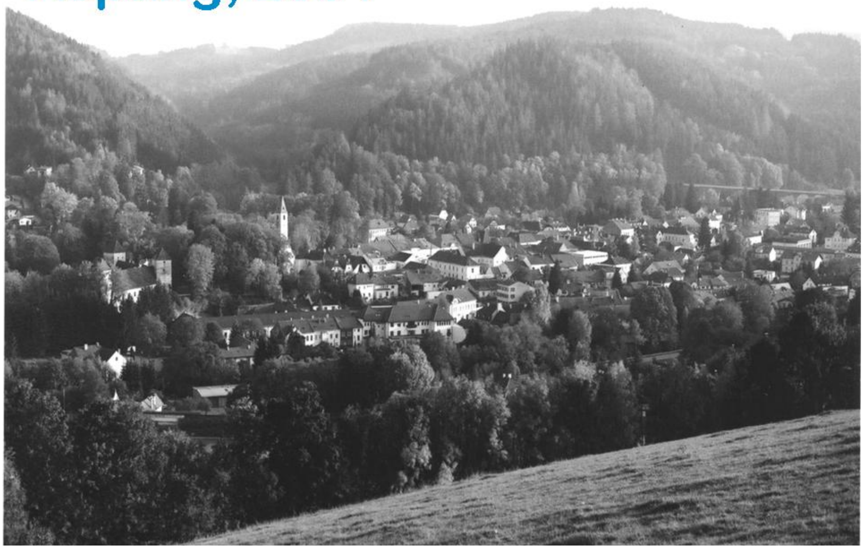

All the states which have signed the Kyoto-target for reducing their CO_2-Emissions do emit 25% of their emissions outside the own country
the problem: the nations have commit only to reduce the emissions on their own territory
No responsibility for the transfer of emissions in foreign countries
„You know nothing about a river If you are looking one after another water buckets!"

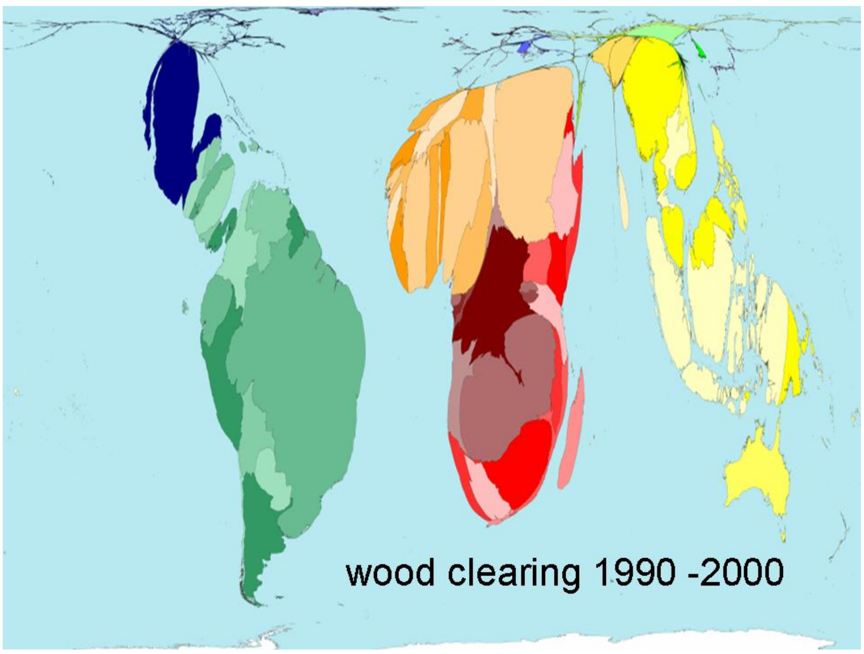

»the dilemma of the texas sniper«
Who shots blind to a barn door and draws a target around the score gets a fabulous result but in the end it has no value


Peru
Bolivia
Andes Mountains
Brazil
Chile
Paraguay
Argentina
Atlantic Ocean
Uruguay
250 km

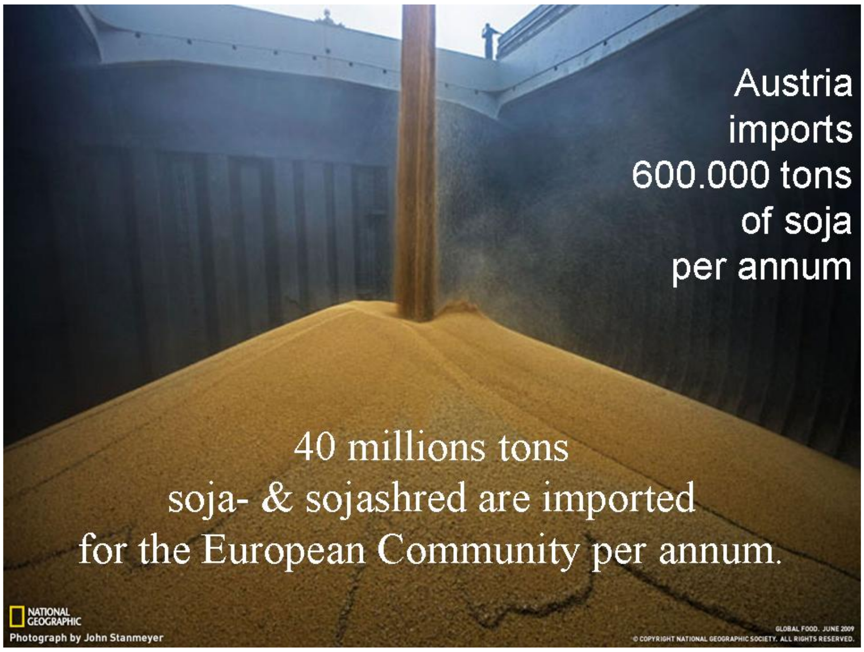
Aspang, 1900

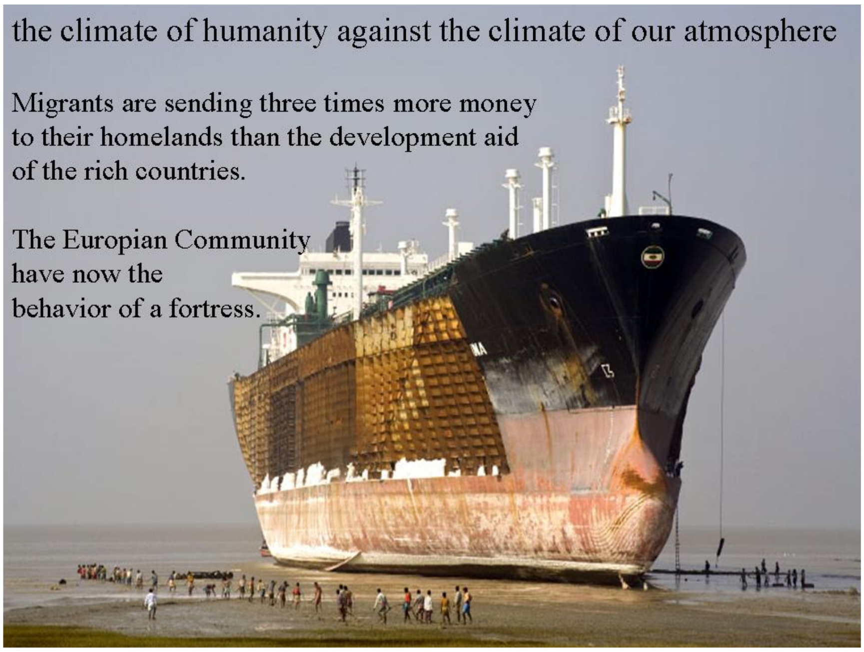
Aspang, 2001





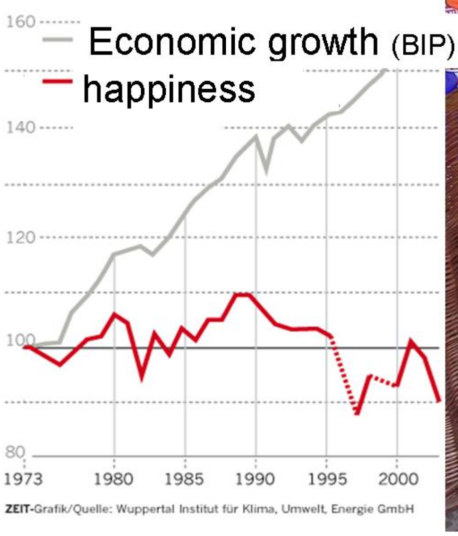

especially in
Brasilia, Argentinia
and in the USA
soja has a global land use of 1.000.000 km2

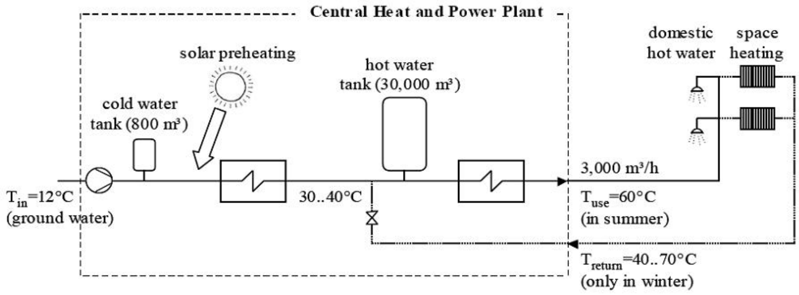

Austria
imports
600.000 tons
of soja
per annum
40 millions tons
soja- & sojashred are imported
for the European Community per annum.
NATIONAL GEOGRAPHIC
Photograph by John Stanmeyer
GLOBAL FOOD. JUNE 2009
© COPYRIGHT NATIONAL GEOGRAPHIC SOCIETY. ALL RIGHTS RESERVED.


the climate of humanity against the climate of our atmosphere
Migrants are sending three times more money
to their homelands than the development aid
of the rich countries.
The Europian Community
have now the
behavior of a fortress.

Money and happiness

Index: 1973 = 100

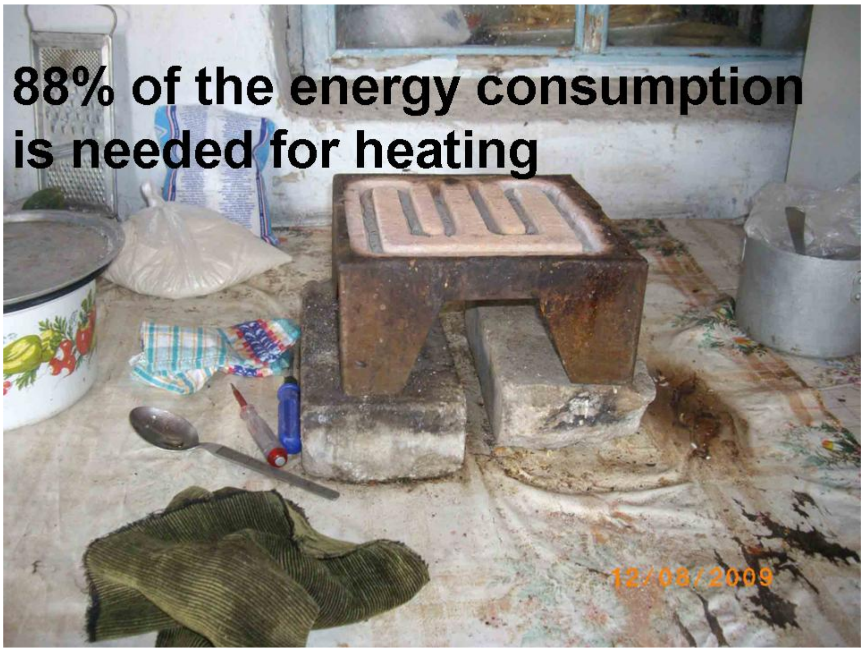



Central Heat and Power Plant
solar preheating
hot water
tank (30,000 m³)
domestic
hot water
space
heating
cold water
tank (800 m³)
3,000 m³/h
T_in=12°C
(ground water)
30..40°C
T_use=60°C
(in summer)
T_return=40..70°C
(only in winter)


the need for heating is
three to five times above
the average of the EU states


Disneyland & Legoland
Houses with bricks heated by electricity


In rural Kyrgyzstan nearby 70%
of the people live in
houses made of clay
12/08/2009


88% of the energy consumption
is needed for heating
12/08/2009


clay is a
very good and cheap
regional resource


05/08/2009


cow dung is good stuff for composting
and shouldn´t burn for heating


organic farming

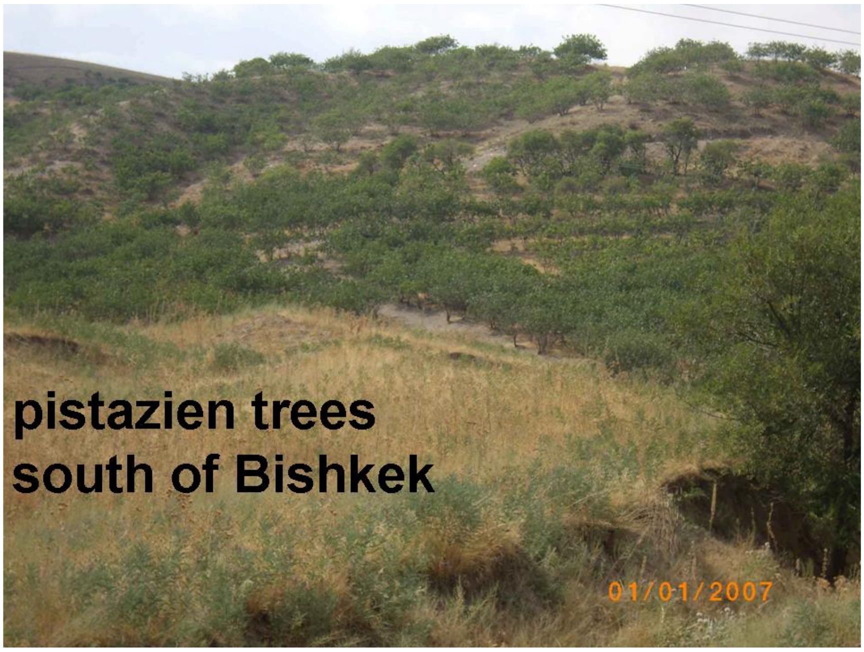

plant trees for building houses


Reforesting trees
for climate and soil protection
The skin of the planet store
more carbon than the atmosphere
& vegetation together
01/01/2007


klimabündnis Kärnten

roots

half an hectar
has the weight
of a bus



Cooking with solarenergy

Abstract

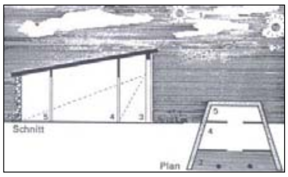
From the solar potentials to concrete solar buildings: Which technologies and architectures do we need?

Erwin Kaltenegger*, Heimo Staller**

* architectural firms: Erwin Kaltenegger, Passail
** Inter-University Research Centre for Technology, Work and Culture, Graz, A+ ZT GmbH, Weiz

Vernacular architecture always was based on climatic aspects like solar radiation, wind, temperature, humidity etc. Knowledge of geographical conditions, physical principles and their integration in the design of the buildings was handed from generation to generation, creating buildings perfectly adapted to their local context. Probably these buildings were the first “zero-energy and passive houses”. Today most of the modern architecture is neglecting these local climatic conditions, by forcing an international style, generating buildings looking the same from Alaska to Central Africa. Until the last decades energy consumption for building has not been a very important aspect, as it was considered to have enough fossil fuels to run our buildings. But now scarcity of fossils and climate change forces us to rethink our concepts for building design.
Undoubtedly solar energy (passive and active) provides largest potentials for the building sector. But what are the strategies and technologies for their integration in buildings?
First target should be minimising the energy demand for heating, cooling, humidification and electricity. Here main potentials can be found in the building design, which – and here we can learn a lot from vernacular architecture - has to be based on local climatic conditions. Especially the use of passive solar energy provides large potentials for energy efficiency, linked with low investment costs. New building concepts like low energy- and passive houses are based on these aspects.
Second target should be the use of renewable energy sources for the remaining energy demand. Active solar energy use (thermal, electrical) offers large options for the building related energy consumption, as most of the energy used in buildings (heating, cooling) is on low temperature level, which easily can be provided by solar energy systems.
Only a combination of passive and active solar energy concepts and the integration of bioclimatic aspects in our building design will lead to sustainable, energy efficient buildings, which is a big challenge for architects and engineers.

From the solar potentials to concrete solar buildings: which technologies and architecture do we need?











Introduction

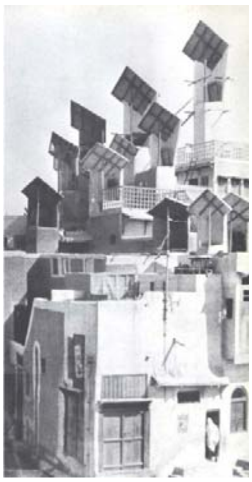
IFZ – Inter-University Research Centre for Technology, Work and Culture, Graz

- Interdisciplinary research, consulting and training focusing on the complex relationship between technology and society
- IFZ
  - works on an interdisciplinary basis
  - initiates social and institutional learning processes
  - involves all stakeholders in the research process
- Clients: national and international public institutions, companies

Architect Heimo Staller

- Study of architecture at the Technical University of Graz
- CEO of A + ZT GmbH, Weiz, A, architecture office specialised in planning low-energy-and passive house buildings
- Scientific employee in the field of "energy and climate" at the IFZ, main working areas: Green buildings, sustainable environments
- Lecturer at FH JOANNEUM - University of Applied Sciences

Solar architecture - Historical background



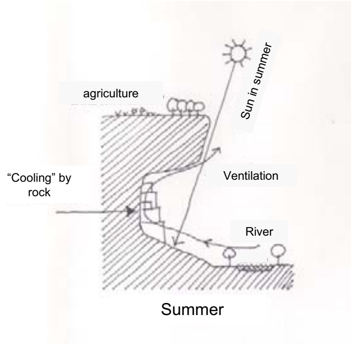
Vernacular architecture

- Buildings are perfectly adapted to their local context
- Knowledge of geographical and climatic conditions
- Use of physical principles (Solar radiation, wind, thermal mass, …) for conditioning of houses
- Low tec – In general no building services for heating and cooling
- Form follows energy
- Use of sustainable building materials
- "Zero-energy and passive houses"

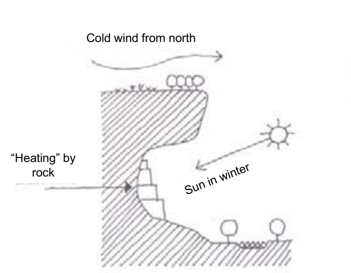
"Wind catchers", Haiderabad, Pakistan

Solar architecture - Historical background

Adaption to the local context



Summer



Winter

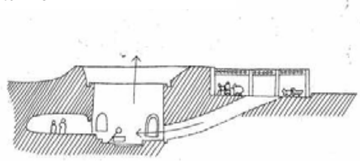
Cliff Palace, Mesa Verde, Colorado, Anasazi people 12th century A. D.

Solar architecture - Historical background

Similar geographical and climatic conditions => similar architectural solutions

Cooling principle:

Warm air rises in the courtyard and sucks cold air through the entrance tunnel

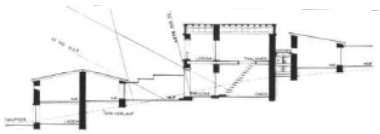


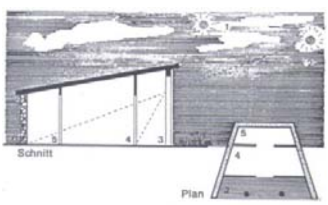
Megaron Houses, Gharian, Libya

Megaron Houses, Hennan, China

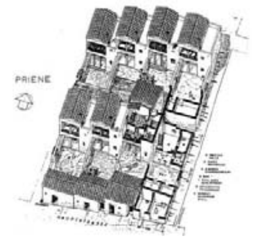
Solar architecture - Historical background

Solar architecture in the ancient world





Concept for a solar house by Socrates, 469 - 399 B.C.



Solar town planning, Priene, 300 B.C.

Solar architecture - Historical background

International Style, 1920`s

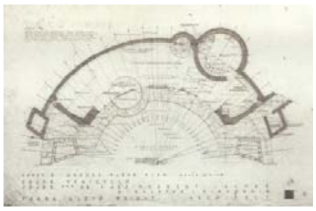
- Decoupling of building design from energy related design aspects
- International design independent from local geographical and climatic conditions
- Emergence of glass architecture
- Increase of energy consumption
- New building services for heating and cooling, mainly based on crude oil

Lever Building, New York, 1952, SOM

Solar architecture - Historical background

Solar architecture – F.L. Wright

- Solar gap - South orientation of the building
- Large glazing areas in the south, small windows in the north
- Thermal mass in the north (stone bricks, earth)
- Windbreak by integration of the building into the landscape
- Building perfectly fits to local conditions

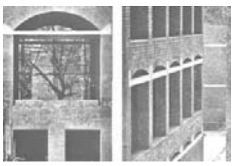


Solar Hemicycle, Wisconsin, 1944, F.L. Wright

Solar architecture - Historical background

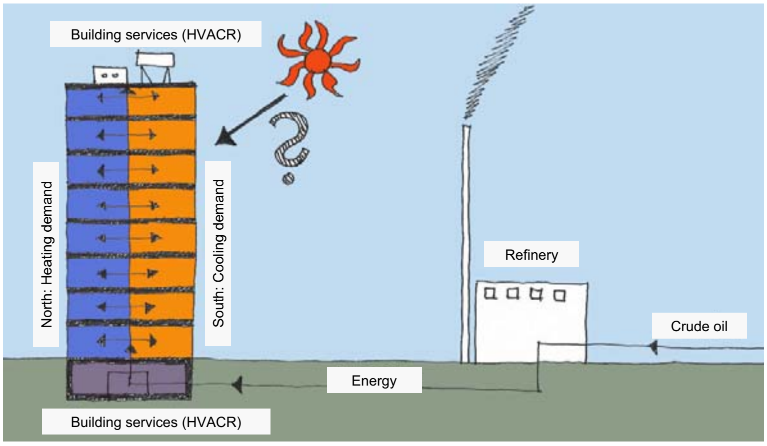
Solar master plan and architecture – Louis I. Kahn
Institute of Management, Ahmedabad, India

- Adaption of the buildings to local climate (sun, wind, thermal mass)
- Use of local building materials material



…………………and today?

Insufficient building design is compensated by building service measures

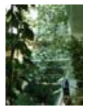


Energy and buildings – what are the main aspects?

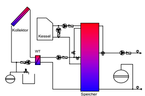
Energy during operation stage
- Heating
- Cooling
- Humidification
- Hot water
- Electricity

Solar strategies





Energy for construction and disposal
- Building material and construction
- Building services

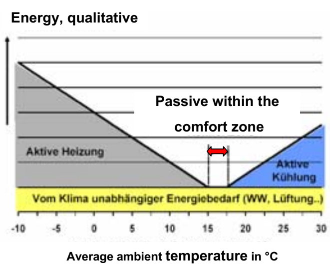



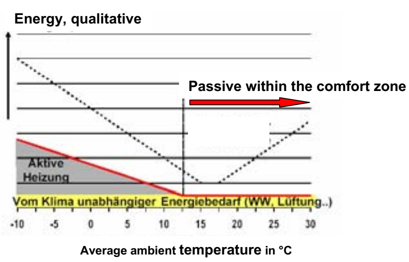
External aspects
- Mobility (traffic)
- Technical infrastructure (sewage, water, electricity…)


General strategies for energy efficient buildings

Energy demand of buildings - today

Energy demand of buildings - future





Active heating

Active cooling

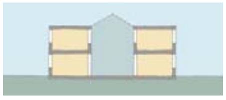
Energy demand independent from climate (hot water, ventilation,…)

General strategies for energy efficient building design

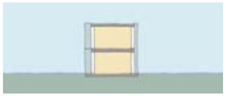
Thermal quality of the building shell
e.g. Passive house standard

Climate shell

Climate shell – winter garden



Climate shell - atrium

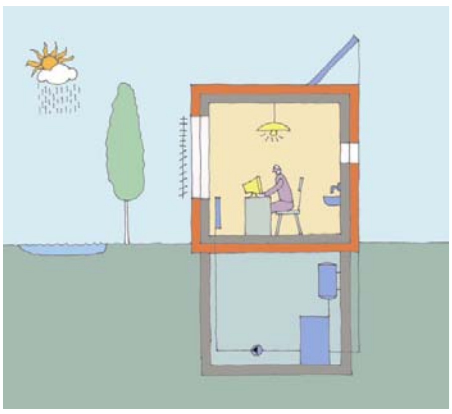


Skin/facade elements
- TWD-Transparent insulations
- PCM – Phase Change Materials
- Double-Skins-Facades

Solar architecture – Strategies

- Step 1: Minimising the energy demand for heating, cooling, humidification and electricity
- Step 2: Covering residual energy with active solar energy systems (thermal, electrical)
- Integration of solar energy aspects in town planning
- Solar design - Integration of solar aspects in the early design phase
- Integration of solar collectors in the buildings shell (skin and roof) provides synergy effects (energy production + architectural functions in one element)
- Cost assessment: From construction costs to Life Cycle Costs (LCC)

Solar architecture – Strategies



Hierarchy of measures

Climate and site
- Temperature
- Solar radiation
- Humidity
- Wind

Building design
- Compactness
- Orientation
- Windows (area, orientation)

Thermal quality of the building shell
- U-values
- Air tightness
- Cold bridges
- Summerly overheating

Building services (HVACR)
- Energy source
- HVACR - System

User

Solar architecture – Passive strategies



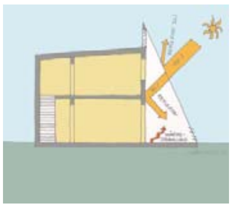
Cooling
- Orientation
- Size of windows
- Thermal mass
- Shading devices

Heating
- Compactness
- Orientation
- Size of windows
- Thermal mass
- U-values

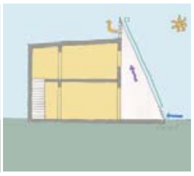
Illumination
- Natural daylight systems

Solar architecture – Passive strategies

Winter gardens




Functional principle

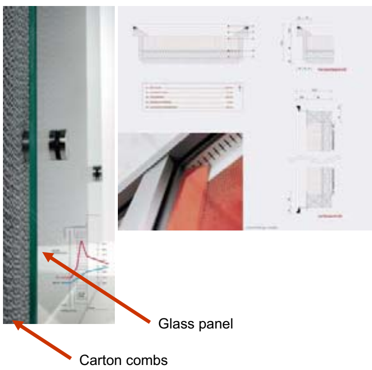



Heating Cooling

- Heat trap principle:
  Short-wave sunlight is transferred into long wave radiation
- Winter gardens enable to heat neighbouring rooms
- Restricted use of Winter gardens during cold periods
- No heated winter gardens! Waste of energy!
- Winter gardens are thermal instable (Warm – Cold) =>
- Thermal mass is very important
- Measures against summery overheating => Shadow devices, effective ventilation and exhaust
- High construction costs – low benefits
- => Passive house?

Solar architecture – Passive strategies

“Intelligent” façade panels



Glass panel

Carton combs

Gap solar panel

Winter
- Solar radiation enters carton combs
- Heating of the gap up to 80°C (depending on orientation)
- Energy losses in night are low, as element has good insulating properties
- U-values under 0,1 W/m2K are possible
- Average temperature in the panel around 18° C => minimal transmission losses for rooms behind

Summer
- Shading of the panel because of high solar altitude
- No shading devices required

Solar architecture – Active strategies


Heating


Cooling


Electricity

Solar architecture – Active strategies

- Depending on the solar fraction requested, active solar elements have large impacts on town planning and building design =>
- Integration in preliminary design phase is extremely important
- Solar panels are cost-intensive elements => best coefficient should be aspired (orientation, inclination are very important)
- Multifunctional elements (building shell + energy production)



Facade


PV-sunblind


PV- art

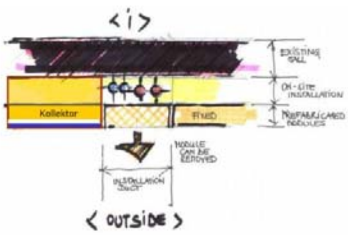
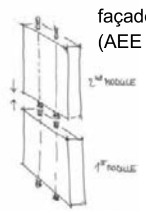




Roof elements

Solar architecture – Active strategies

Multifunctional elements

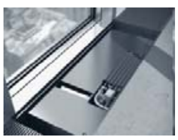


Scheme multifunctional façade element for renovation (AEE INTEC)

One façade element – multiple functions => Schüco E^2


Energy - PV

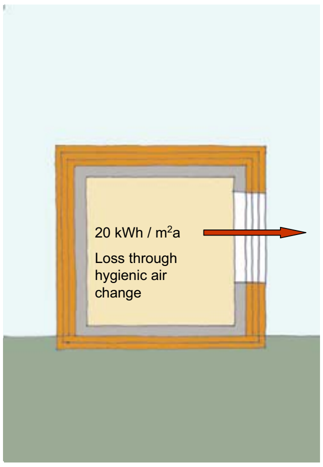

Ventilation


Sunblind


HVACR

Solar architecture – Passive + active strategies

From „Energy waste house“ to passive house



EI = 90 kWh / m^{2}a

EI = 60 kWh / m^{2}a

EI = 40 kWh / m^{2}a

EI = 35 kWh / m^{2}a

EI = 15 kWh / m^{2}a

=> Passive house:
Mechanical ventilation system with heat recovery, reduction of ventilation losses

EI (Energy Index) = Net energy consumption for heating per m^2 heated net area and year

Solar architecture – Passive + active strategies

Passive house

Solar architecture – Passive + active strategies

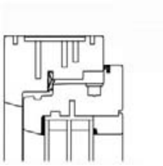
Passive house – Building standard of the future?

Passive house 2154 m above sea level

Alpine refuge Schiestlhaus, Hochschwab, A
Architects: GP-ARGE pos architekten and Treberspurg & Partner Architekten ZT GmbH, Vienna

Solar architecture – Passive + active strategies

Passive house



Definition by Passive House Institute Darmstadt:

- Heating energy consumption max.15 kWh/m^2a
- Combined Primary energy consumption (heating, hot water, electricity-household) max. 120 kWh/m^2a

Requirements on the thermal building shell

- Air leakage n_{50} less than 0,6 h^{-1}
- U-values of opaque thermal components less than 0,15 W / m^2K
- U-values of windows and translucent thermal components less than 0,8 W / m^2K
- No cold bridges
- www.passiv.de/

Solar architecture – Passive + active strategies

Passive house

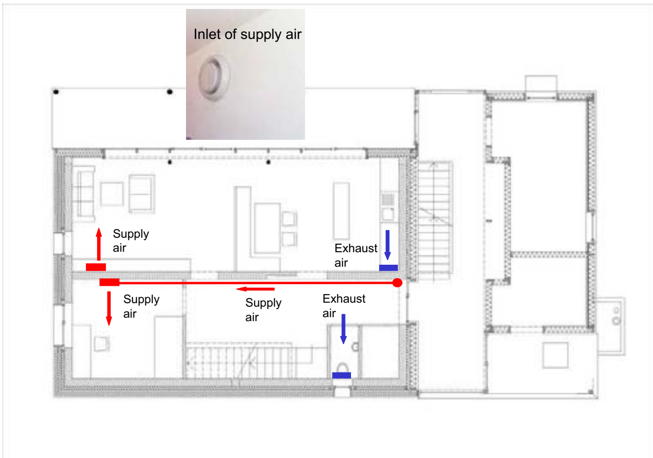
Passive house Haas, Gleisdorf, A
Architects: A + ZT GmbH, Weiz, A

Requirements on translucent areas (according to Passive House Institute Darmstadt):

- Translucent areas west or east orientated deviation from south max. ± 50°
- Translucent areas with inclination under 75° to the horizontal should not exceed 15% of the floor space behind
- Or temporary sunscreens with reduction factor of min. 75%
- Area of south orientated windows should not exceed 25% of the floor space behind

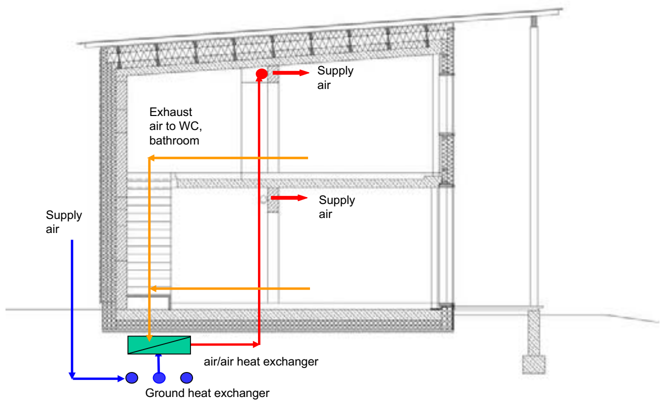
Solar architecture – Passive + active strategies

Passive house Haas in Gleisdorf, A + ZT GmbH, A



Solar architecture – Passive + active strategies

Passive house Haas in Gleisdorf, A + ZT GmbH, A



openSolarCA`09_Bishkek, Kyrgyzstan, August 2009_Architect DI Heimo Staller IFZ – Inter-University Research Centre Graz
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Solar architecture – Passive + active strategies

Passive house Haas in Gleisdorf, A + ZT GmbH, A

openSolarCA`09_Bishkek, Kyrgyzstan, August 2009_Architect DI Heimo Staller IFZ – Inter-University Research Centre Graz
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Examples – Dieselweg, Graz, A

- Passive house renovation with gap solar panels
- Heat storage tank 1200m^3 (1.2 Mio litres of water)
- Rental and operation costs for a 60m^2 flat after renovation:

  60 Euro **less** than before

openSolarCA`09_Bishkek, Kyrgyzstan, August 2009_Architect DI Heimo Staller IFZ – Inter-University Research Centre Graz
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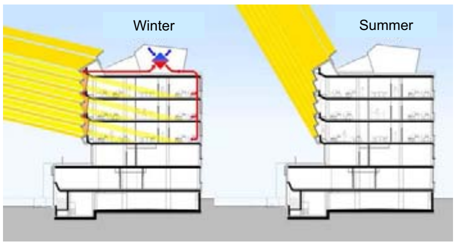
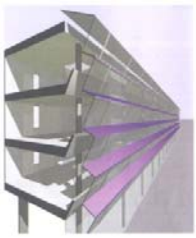
Examples – Dieselweg, Graz, A

Renovation process, source: gapsolution

Examples – ENERGY Base, Vienna, A

Office building – Passive house, Pos architecture, Vienna, A





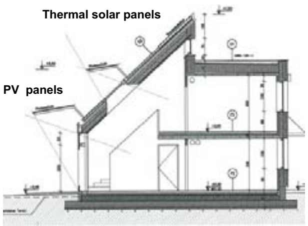
- Climate design
- Multifunctional façade
- Bent skin for active solar elements and sunblind
- 280 m2 thermal panels
- 400 m2 PV panels

Examples – PlusEnergieWohnen, Weiz, A

- 22 residential row houses in passive house standard
- 2000 m2 of useful area
- Construction: Prefabricated wood elements
- Passive house standard (PHPP: 14,6 Kwh/m2a
- Plus energy housing estate
- Output PV: 110 kWp
- Overrun of energy per house ca. 1200 kWh/a
- Architect: Erwin Kaltenegger, Passail, A

Examples – Solar-Active-House, A

- Prototype for a pre fabricated single family house
- 3 types, best type: Zero-energy house
- Thermal solar panels
- PV panels
- Ventilation system with heat recovery
- Architect: Georg W. Reinberg, Vienna



Examples – Research Centre Ökopark Hartberg, A

- Solar cooling
- First solar desiccant air-conditioning system in Austria
- Output: 30 kWc
- Thermal solar panels
- Conception: JOANNEUM RESEARCH

Examples – Alpine refuge Schiestlhaus, Hochschwab, A

- First passive house refuge in the world
- Hochschwab, 2154 m above sea level
- Thermal solar panels for hot water
- PV panels, 8 kWp
- Ventilation system with heat recovery
- CHP with plant oil
- Ecological sewage system, utilisation of rainwater
- Architects: GP-ARGE pos architekten and Treberspurg & Partner Architekten ZT GmbH, Vienna

Examples – Solar City Linz, A

- Master plan for a settlement of ca. 6.000 people, following solar principles
- Energy related measures following the European Charter for Solar Energy in Architecture and Urban Planning of 1996
- Low energy and passive houses, average energy demand throughout the urban district 36 kWh/m²a
- Solar energy systems cover about 50 % of hot water needs
- Utilisation of rainwater
- Architects: Foster, Herzog, Piano, Treberspurg, Kaufmann, Laudon….

Thank you for your attention!

Abstract

GIS and Spatial Decision Support Systems with regard to solar energy potentials

Gernot Paulus

Carinthia University of Applied Sciences

Solar energy is one of the environmentally sustainable resources for solar heating and producing electricity using photovoltaic (PV) systems. The main input data used in the planning process are solar radiation and digital elevation and digital surface models. Geographic Information Systems (GIS) and geospatial technologies provide an important framework for estimating the solar energy potential at various scales ranging from continent-wide to single building estimates. Furthermore, GIS helps to determine the current status of non-renewable and renewable energy sources used in a region and compare it to the site-specific solar energy potential. Based on such comparisons different scenarios for the utilization of solar energy can be developed and communicated effectively to stakeholders like planning authorities, policy makers and the public using GIS. Spatial Decision Support Systems offer an additional approach to select suitable sites for utilizing renewable energy resources based on user-defined criteria.

This workshop module will provide a comprehensive overview about different geospatial data sets used as input data and spatial analysis techniques for calculating the solar potential at different scales. Strategies for using Spatial Decision Support Systems for selecting suitable sites will be presented. Different ways will be discussed to visualize and communicate solar energy potential ranging from static map representations and dynamic Web-GIS applications.

Carinthia University of Applied Sciences
Austria

Spatial Analysis with regard to Solar and Hydro Energy Potentials

openSolarCA'09
Bishkek, Kyrgyzstan
2009

Gernot Paulus
Department of Geoinformation
Carinthia University of Applied Sciences
Villach, Austria

www.cuas.at

Content

- **Introduction & Motivation**
- **Spatial and temporal aspects of solar energy potentials**
  - Basics
  - Data
  - GIS Tools & Methods
- **Best practise example**
  - Energy efficient communities - Survey, Assessment, Spatial Analysis and Visualisation of Energy Index Data in Austria

Introduction

- Utilization of renewable energy is world wide a major strategic goal
  - USA – Obama administration
  - EU
- (Geospatial) Technologies offer reliable analytical procedures & solutions
  - Geographic Information Systems (GIS)
- Comprehensive digital spatial and temporal data sets are available at different scales
  - DEM, Meteorological data, Land Cover/ Land Use, Infrastructure, ...
- Interdisciplinary approach – „One Stop Shop"
  - Assessement of topographic, technological & financial suitability

Motivation

Solar Potential & Utilization is scale depended

- Ressource assessment
  - Region to single building

- System Siting
  - Site selection for solar power plant
  - Single building
- Grid Management (Photo voltaic)
  - Distance

(Betke 2009)

Motivation

Any stakeholder has two basic questions:

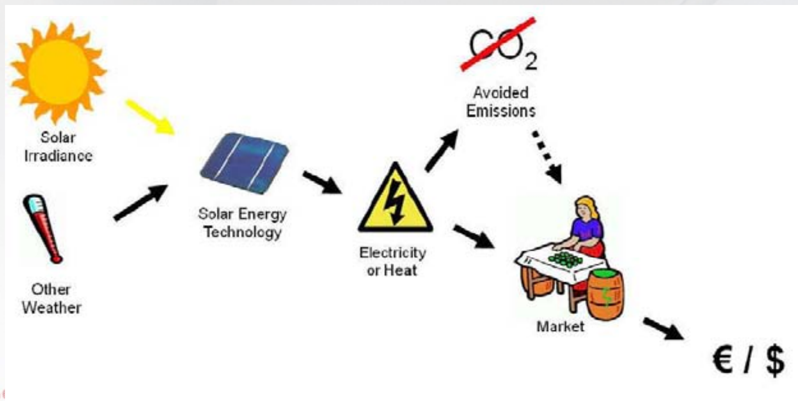
- How many kWh or J can/will be produced?
  - worldwide / in a specific region
  - at a specific location
  - with a specific design
  - at a specific moment in the past, present or future
- What will it cost per kWh or J?

- Both questions need solar resource data and geospatial technology to be answered!

WWW.FH-KAERNTEN.AT

Motivation

- Interdisciplinary approach – „*One stop shop*"



Spatial & temporal aspects

FACHHOCHSCHULE KÄRNTEN

- The interaction of solar radiation with the earth's atmosphere and surface is determined by 3 groups of factors:
  - ***Earth's geometry, revolution and rotation*** (declination, latitude, solar hour angle)
  - ***Terrain*** (elevation, surface inclination and orientation, shadows)
  - ***Atmospheric attenuation*** (scattering, absorption) by:
    - Gases (air molecules, ozone, CO_2 and O_2),
    - Solid and liquid particles (aerosols, including non-condensed water),
    - Clouds (condensed water).

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Spatial & temporal aspects

FACHHOCHSCHULE KÄRNTEN

- Intensity of the extraterrestrial solar radiation traversing through the earth's atmosphere is attenuated by (1) ***gases***, (2) ***liquid and solid particles*** and (3) ***clouds***.
  - The path length through atmosphere is also critical.
  - Because of its dynamic nature and complex interactions the atmospheric attenuation can be modeled only at a certain level of accuracy.
  - Clouds are the strongest attenuates depending on instantaneous thickness, position and number of layers of clouds, as well as their optical properties. Therefore a *simple empirical techniques* are used to estimate the attenuation of cloud cover.

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Spatial & temporal aspects

FACHHOCHSCHULE KÄRNTEN

- **Components of global radiation** [$Wh.m^{-2}$]
  - The radiation, selectively attenuated by the atmosphere, which is not reflected or scattered and reaches the surface directly is ***beam (direct) radiation***.
  - The scattered radiation that reaches the ground is ***diffuse radiation***.
  - The small part of radiation that is reflected from the ground onto the inclined receiver is ***reflected radiation***.
  - Omitting the clouds attenuation factor leads to **clear-sky radiation** values.

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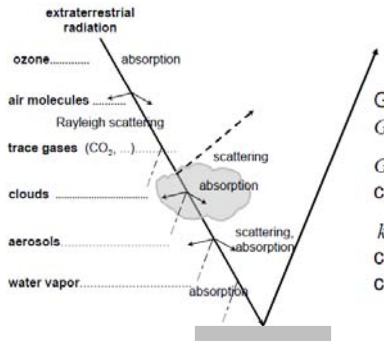
Spatial & temporal aspects

FACHHOCHSCHULE KÄRNTEN

➢ **Components of global radiation**

Atmospheric extinction processes



Global irradiance
$GHI = k^* \; GHI_{clear}$

GHI_{clear}:
clear sky global irradiance

k^*:
clear sky index, describes cloud transmissivity

(Lorenz 2009)

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Spatial & temporal aspects

FACHHOCHSCHULE KÄRNTEN

➢ **Components of global radiation**

Clear sky

Definition: cloudless sky

maximum possible insolation at a given site, time and atmospheric conditions

used as normalization function for most of radiation models

I_{clear} = f(geometry, air molecules, ozone,aerosols, water vapour)

(Lorenz 2009)

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Spatial & temporal aspects

FACHHOCHSCHULE KÄRNTEN

➢ **Geometry of global radiation**

- Global Radiation on ***Horizontal Plane*** (GHI)
- Diffuse and Direct Radiation on Horizontal Plane (DHI)
- Diffuse and Direct Radiation on ***Inclined Plane*** and Plane Normal to Sun Rays (DNI)
  - Once the direct and diffuse components known for a horizontal plane, one may derive the direct and diffuse components on any inclined plane. The algorithms used are those of the European Solar Radiation Atlas (2000).
- **Shadowing effects**

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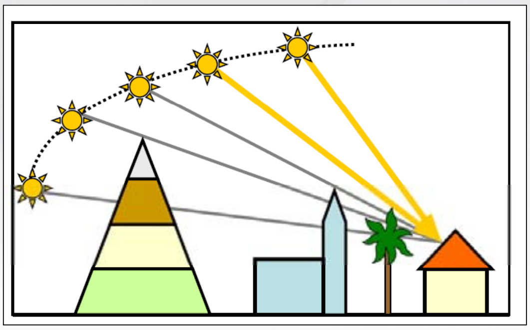
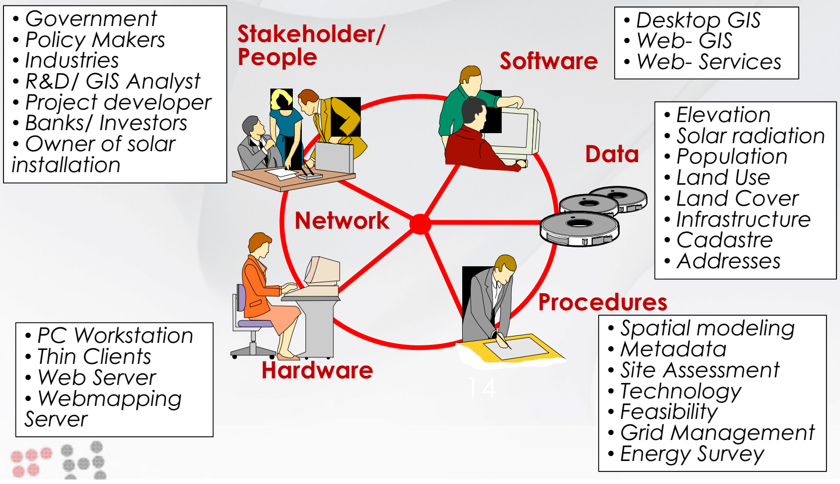
Spatial & temporal aspects

- **Shadowing effects (temporal variation)**
  - Topographic/ Regional
    - Mountains
  - Local
    - Buildings, Vegetation



(LASERDATA 2008)

Geographic Information System (GIS) & Solar Potential



Data Overview

- **Solar radiation**
  - Ground measurement
  - Satellite data
- **Elevation**
- **Other useful planning relevant data**
  - Infrastructure (Street, transmission grids)
  - Population – „Customer distribution“
  - Georeferenced Adresses
  - Buildings
    - Footprints
    - 3D models (Laserscan)

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Data – Solar radiation

➢ Ground measurement

- Solar radiation instruments
- National Meteorological offices
- World radiometric Network (by World Meteorological Organisation)

World radiometric network

- global irradiance & sunshine duration
- ca. 1200 stations

World Radiometric network 1966- 1993
(source: WRDC/WMO, Cros et al. , 2004)

(Lorenz 2009)

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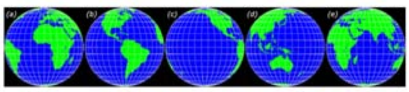
Data – Solar radiation

➢ Satellite Data

Coverage by Meteosat satellites

world map with the areas covered by Meteosat satellites
(source: DLR)

Coverage by geostationary satellites



coverage area map of geostationary satellites in operation
(source: http//swera.unep.net)

(Lorenz 2009)

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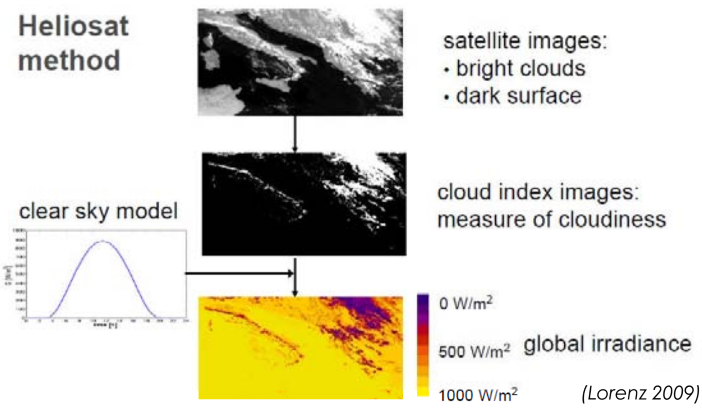
Data – Solar radiation

➢ Satellite Data - Methodology



(Lorenz 2009)

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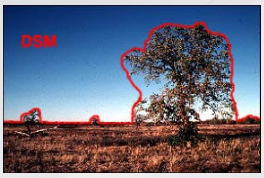
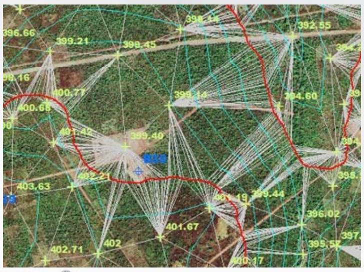
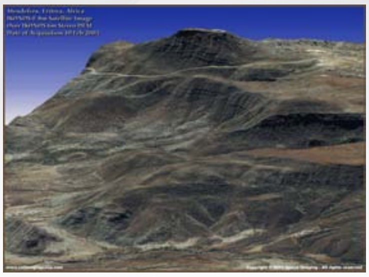
Data – Elevation

➢ **Digital Elevation/Terrain Models - Basics**
- Processes and Scales
- GIS Data Structures
- Data Capture

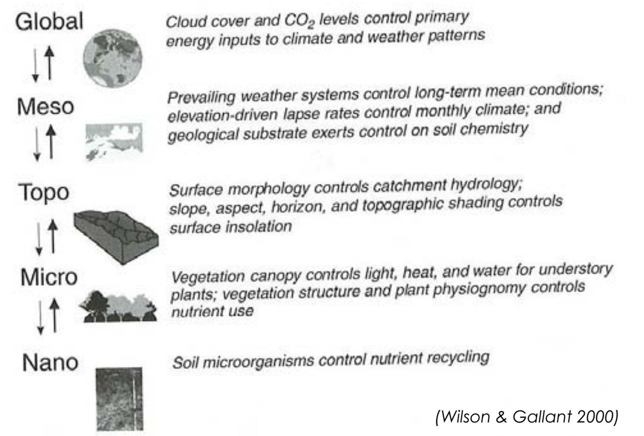






Data – Elevation

➢ **Processes & Scales**

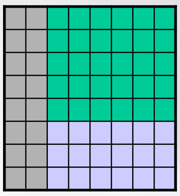


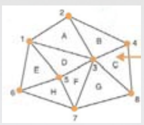
(Wilson & Gallant 2000)

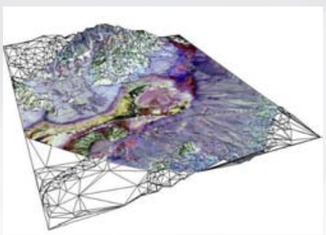
Data – Elevation

➢ **Digital Elevation/Terrain Models – Basics**
- Data Structures

Raster/GRID

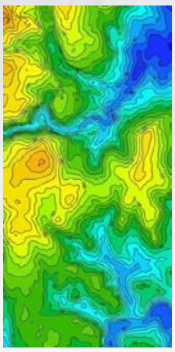






Triangular Irregular Network (TIN)

Contours



Data – Elevation

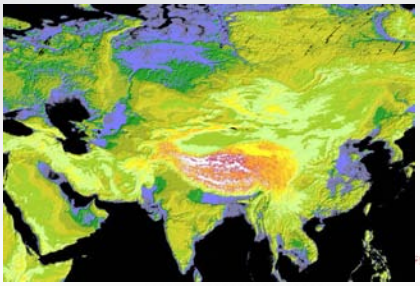
FACHHOCHSCHULE KÄRNTEN

- **Digital Elevation/Terrain Models – Basics**
  - **Data Capture**
    - **Photogrammetry:** Stereoscopic capture of aerial images/ satellite images
    - **Remote sensing – RADAR**: Shuttle Radar Topographic Mission (**SRTM**) *(http://www2.jpl.nasa.gov/srtm/)*
      - SRTM consisted of a specially modified radar system that flew onboard the Space Shuttle Endeavour during an 11-day mission in February of 2000.
      - There are three resolution outputs available, including 1 kilometer and 90 meter resolutions for the world and a 30 meter resolution for the US

Data – Elevation

FACHHOCHSCHULE KÄRNTEN

- **Digital Elevation/Terrain Models – Basics**
  - **Data Capture**
    - **Remote sensing - ASTER** (**A**dvanced **S**paceborne **T**hermal **E**mission and **R**eflection Radiometer) Global Digital Elevation Model (2009) *(http://asterweb.jpl.nasa.gov/gdem.asp)*
      - The GDEM is produced with 30 meter postings, and is formatted in 1 x 1 degree tiles as GeoTIFF files. Each GDEM file is accompanied by a Quality Assessment file.



Data – Elevation

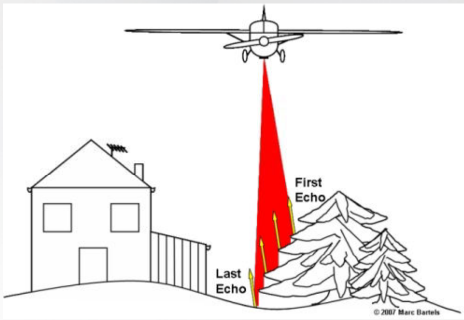
FACHHOCHSCHULE KÄRNTEN

- **Digital Elevation/Terrain Models – Basics**
  - **Data Capture**
    - **Remote sensing – LIDAR: Light Detection and Ranging**
      - High resolution elevation models based on laser scanning
    - **Digital Elevation Model (DEM)/Digital Surface Model (DSM)**
      - A digital elevation model (DEM) represents the elevation of Earth's surface, including features (vegetation, buildings, canopees, rooftops etc.).
    - **Digital Terrain Model (DTM)**
      - A digital terrain model (DTM) provides a bare earth representation of terrain or surface topography.

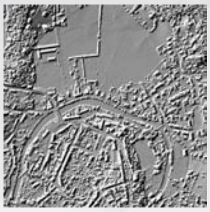
Data – Elevation

FACHHOCHSCHULE KÄRNTEN

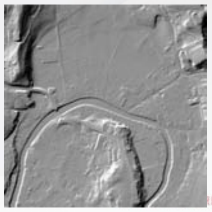
- **Digital Elevation/Terrain Models**
  - **LIDAR – Light Detection and Ranging**



(Bartels & Wei 2008)



DSM

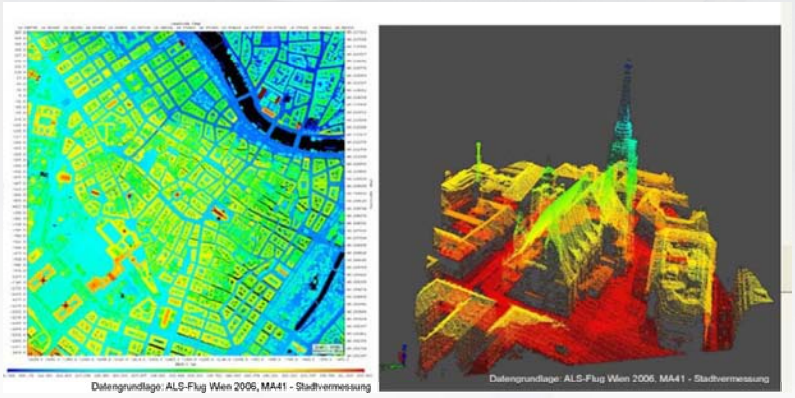


DTM

Data – Elevation

FACHHOCHSCHULE KÄRNTEN

- **LIDAR – City Models**



(Riegl 2009)

GIS Tools & Methods

FACHHOCHSCHULE KÄRNTEN

- **SAGA - GIS**
  - Open Source - Desktop
  - Module „*Incoming Solar Radiation*"
- **GRASS GIS**
  - Open Source - Desktop
  - Photovoltaic Geographical Information System (PVGIS)
  - Solar radiation model *r.sun*
- **LASERDATA-LIS**
  - Solar potential of roof tops based on laser scanning data
  - Based on SAGA GIS
- **Web- GIS Applications**
  - Example: San Francisco Solar Map
- **Web Service Application**
  - MESoR broker portal to solar information & services

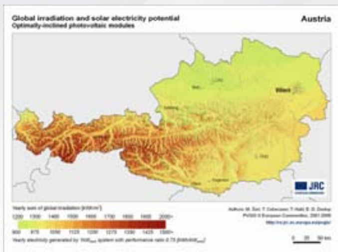
GIS Tools & Methods

FACHHOCHSCHULE KÄRNTEN

- **SAGA - GIS**
  - Open Source – Desktop; www.saga-gis.org
  - Module „*Incoming Solar Radiation*"
- **GRASS GIS** *(Geographic Resources Analysis Support System)*
  - Open Source – Desktop; http://grass.itc.it/
  - Photovoltaic Geographical Information System (PVGIS)
  - Solar radiation model *r.sun*
    - *http://re.jrc.ec.europa.eu/pvgis/solres/solmod3.htm*

Parameter name	Description	Mode	Units
incidout	solar incidence angle	1	decimal degrees
beam_rad	beam irradiance	1	$W.m^{-2}$
diff_rad	diffuse irradiance	1	$W.m^{-2}$
refl_rad	ground reflected irradiance	1	$W.m^{-2}$
insol_time	duration of the beam irradiation	2	min.
beam_rad	beam irradiation	2	$Wh.m^{-2}.day^{-}$
diff_rad	diffuse irradiation	2	$Wh.m^{-2}.day^{-1}$
refl_rad	ground reflected irradiation	2	$Wh.m^{-2}.day^{-1}$

Table 2: *r.sun* output raster maps

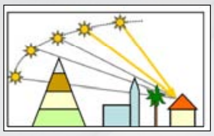


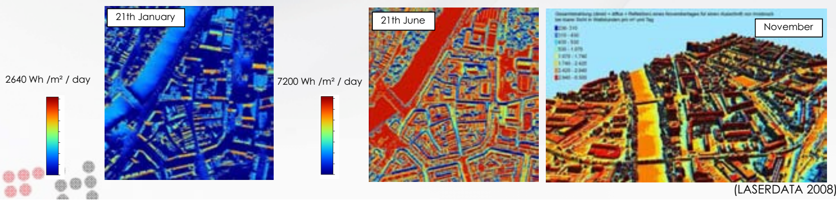
TEN.AT

LASERDATA-LIS

FACHHOCHSCHULE KÄRNTEN

- Solar potential of roof tops based on laser scanning data
- Based on SAGA GIS; www.laserdata.at
- Input Data
  - Laserscanning Data
  - Surface Model
  - Building footprints
- Output
  - High resolution solar potential per roof top based on radiation geometry (direcet, diffuse, shadows)
  - Raster maps & 3D Vector Objects (Aggregation)



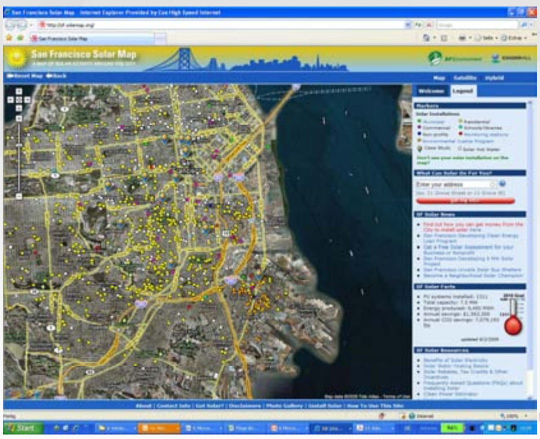


(LASERDATA 2008)

Web- GIS Applications

FACHHOCHSCHULE KÄRNTEN

- Example: San Francisco Solar Map (*http://sf.solarmap.org*/)
- Adress- based calculation of savings (electricity costs) & PV solar installation costs



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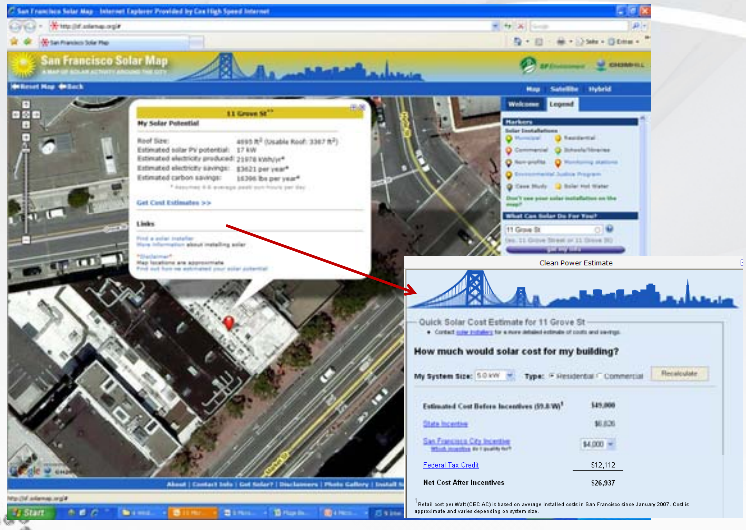
Web- GIS Applications

FACHHOCHSCHULE KÄRNTEN

- Example: San Francisco Solar Map (*http://sf.solarmap.org/*)



GIS Tools & Methods

FACHHOCHSCHULE KÄRNTEN

➢ **MESoR Web Service Application**

- <u>**M**anagement and **E**xploitation of **So**lar **R**essource Knowledge</u>
  - EU 6th Framework program
- Internet broker portal to solar information & services
- Unified access to several solar resource data bases & services
- It does *not contain and maintain data* for itself.
- It just links data bases and services with a single point of entry and a common user interface.
- Databases and services have to be hosted by the providers. They keep control over their data and applications.
- Spatial service coverage ranges from world wide to EU regions
- *http://project.mesor.net/web/guest/home*

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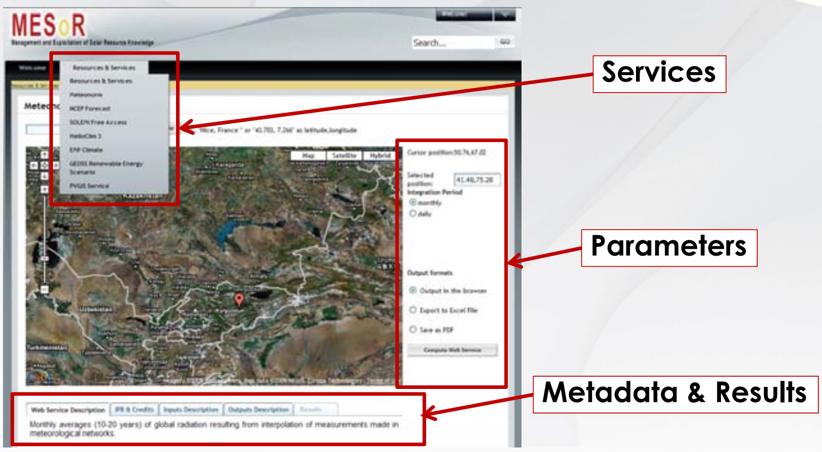
GIS Tools & Methods

FACHHOCHSCHULE KÄRNTEN

➢ **MESoR Web Service Application Overview**



http://project.mesor.net/web/guest/home

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MESoR Web Service Applications

- **Meteonorm:**
  - Monthly averages (10-20 years) of global radiation resulting from interpolation of measurements made in meteorological networks.
- **NCEP Forecast :**
  - National Centers for Environmental Prediction, NOAA (USA). provides forecasts of several meteorological parameters at surface:
  - wind, air pressure, temperature, relative humidity, precipitation, irradiances for 3 days every 3-hours
- **SOLEMI Free Access**
  - **Solar Energy Mining** (SOLEMI) is a service providing irradiance data. The data are derived from Meteosat satellite images.
- **HelioClim 3**
  - HelioClim-3 is a service providing irradiance data from 15 minutes to month, for Europe and Africa. Irradiance values from the database HelioClim-3, are computed from images of the Meteosat satellites since February 2004. Provider: MINES ParisTech / Armines (France).

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MESoR Web Service Applications

- **EMP Climate**
  - EMP Climate is a service providing climatological data aggregated over the period 1990-2004.
  - Center for Energy and Processes of Mines ParisTech / Armines
- **GEOSS Renewable Energy Scenario**
  - This service of the *Global Earth Observation System of Systems (GEOSS)* provides an unique access to a set of "core" map layers of meteorological data from the HelioClim database of Mines ParisTech such as:
  - *Global Horizontal Irradiance map* (kWh/m²) - HelioClim 3 database
  - *Direct Normal Incidence Irradiance map* (kWh/m²) - HelioClim 3 database
  - *Shadows map (%)* - computed from GTOPO 30 database
  - *Terrain elevation map* (m.) - SRTM/GTOPO 30 database
  - *Local maximum slope map (in degree)* - HYDRO 1K database
  - It also allows to retrieve "optional" geographical and environement map layers from GEOSS partners such as the World map layers from DEMIS and population density from CEISIN as listed in the optional layers section.
- **PVGIS Service**
  - Photovoltaic Estimation

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Carinthia University of Applied Sciences
Austria

Energy-efficient Communities

Survey, Assessment, Spatial Analysis and Visualisation of Energy Index Data in Austria

Gernot Paulus
Department of Geoinformation
Carinthia University of Applied Sciences
Villach, Austria

landesprogramm für energieeffiziente gemeinden

www.cuas.at

energie:bewusst KÄRNTEN
Die unabhängige Energieberatung

Content

- Motivation
- "e5" – Award Program for Energy-efficient Communities
- Survey of Energy Index Data
  - Design of Questionnaire
  - Conceptual Model
- Spatial Analysis & Visualization
  - Pilot project Trebesing
- Experience & Future Work

Acknowledgements

- **Project partner**
  - Jan Lüke, Energy consulting agency energie:bewusst Kärnten
  - Community of Trebesing
- **Student teams**
  - B. Kosar, H. Unglert, M. Regenfelder, B. Neunegger (2nd semester)
  - B. Petautschnig, C. Wang, F. Pivk (5th semester)

Motivation

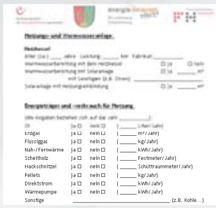
- **Climate Change, Global warming & reduction of greenhouse gas emissions**
- ***"Think globally – act locally"***
  - Provide support to communities for developing sustainable strategies for energy use at a local level
- **Bottom- up approach – Community involvement**

"e5" –Program Overview

- Certification and award program for energy efficient communities
- Support and consulting for assessment of status-quo and development of sustainable strategies for effiecient use of energy (Energy & Mobility)
- Goal is to increase the use of renewable energy at the local level
- Reduction of energy costs & climate protection
- Regional – National – EU - level

Survey of Energy Index data

- **Design of Questionnaire**
  - **Focus on private households & buildings, public buildings, commerce/industry**
  - **4 Categories**
    - Mobility
    - Energy consumption
      - Heating
      - Electricity
    - Thermal insulation Building
    - Potential for renewable Energy
      - Solar collectors

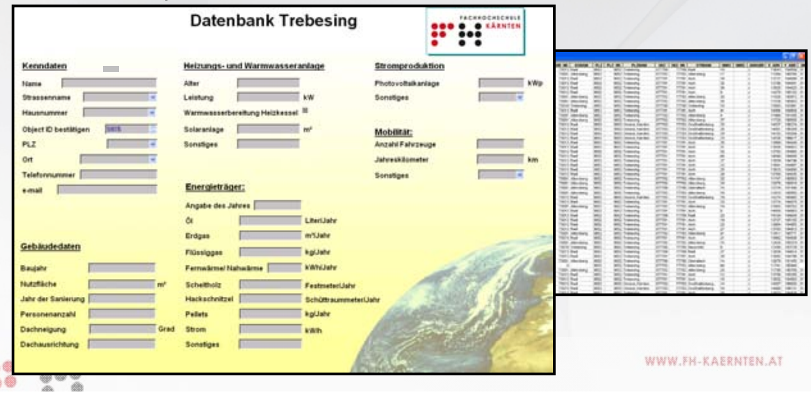


Survey of Energy Index Data

- **Buildings**
  - E.g. year of construction, type, thermal insulation status
- **Household**
  - E.g. electricity consumption, heating system, heating material (oil, gas, wood,…)
- **Potential renewable energy**
  - E.g. roof angle, roof aspect
- **Mobility**
  - E.g. Number of cars, total km/year, Use of public transport, car sharing, car pooling
- **Address join as georeferencing method**

Database Implementation

- MS Access
- Open Source Geodatabase PostgreSQL with spatial PostGIS extension



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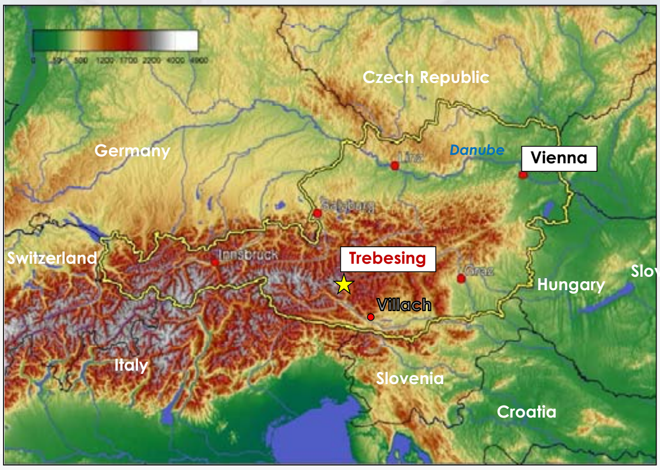
Project area

Pilot project Trebesing



Assessment & Spatial Analysis

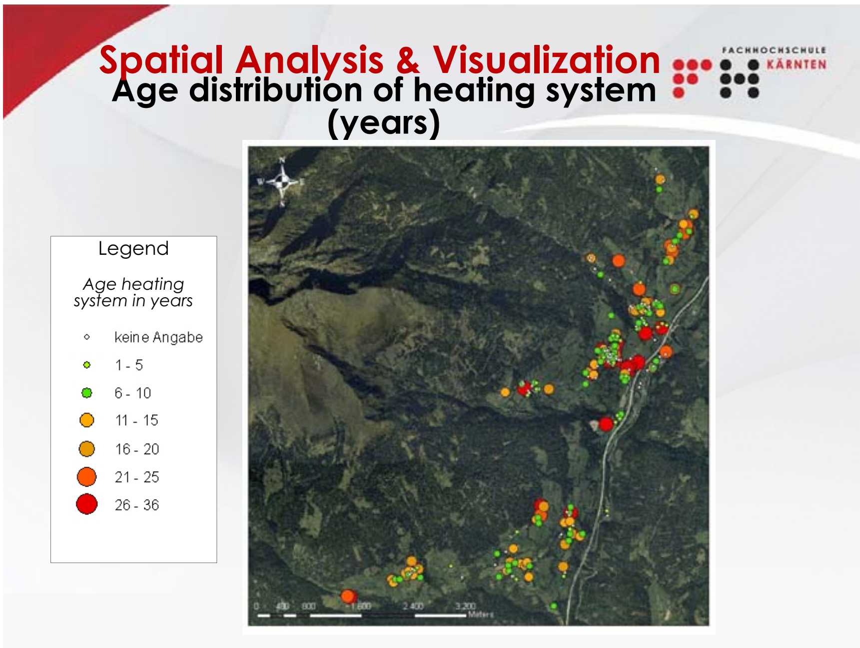
Pilot project Trebesing

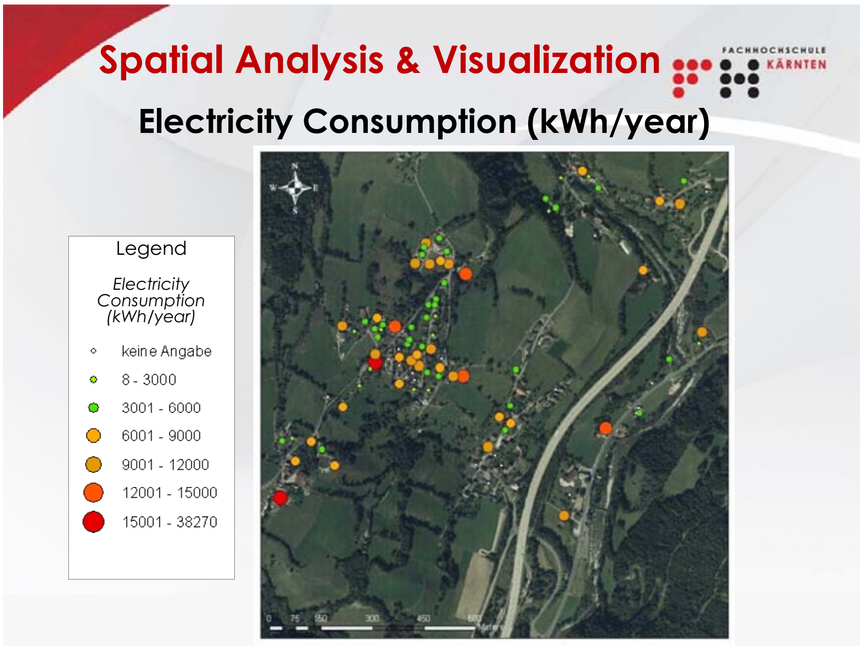
Small community in Carinthia, Austria
1300 inhabitants
Total number of addresses: 379
Total number of returned questionnaires: 256

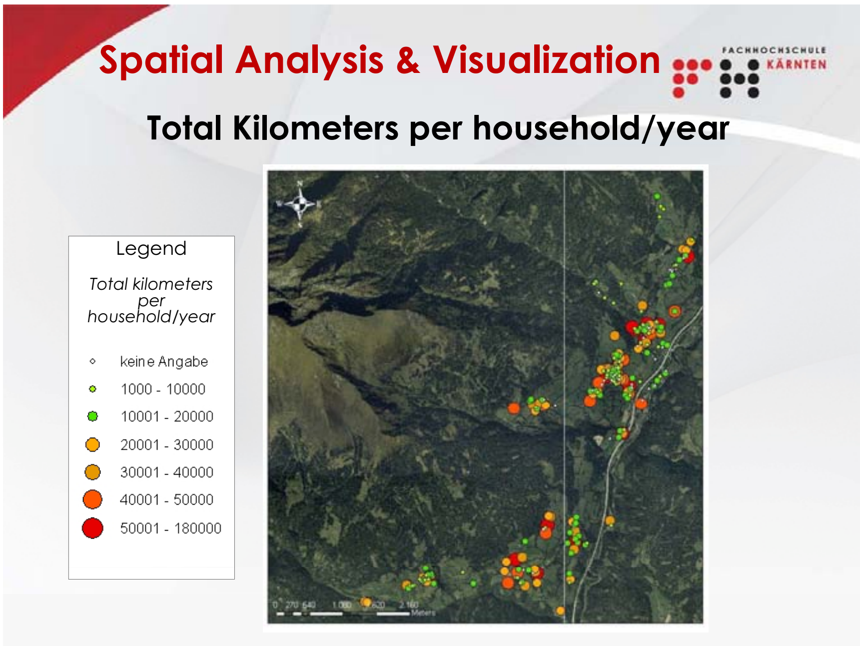
Geodata *(Carinthian Geographical Information System KAGIS)*
- Digital aerial orthoimages (2007)
- Georeferenced addresses

Data quality issues

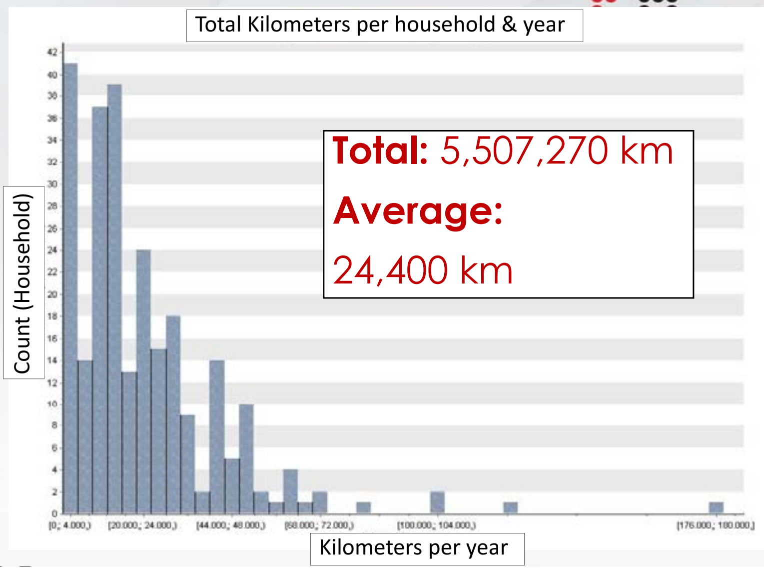
- High quality due to extensive support of project by the community
- Some questionnaire entries hard to read/interpret
- Incomplete data
- Missing addresses in spatial data set


Spatial Analysis & Visualization
FACHHOCHSCHULE KÄRNTEN
Age distribution of heating system (years)
Legend
Age heating system in years
keine Angabe
1 - 5
6 - 10
11 - 15
16 - 20
21 - 25
26 - 36


Spatial Analysis & Visualization
FACHHOCHSCHULE KÄRNTEN
Electricity Consumption (kWh/year)
Legend
Electricity Consumption (kWh/year)
keine Angabe
8 - 3000
3001 - 6000
6001 - 9000
9001 - 12000
12001 - 15000
15001 - 38270


Spatial Analysis & Visualization
FACHHOCHSCHULE KÄRNTEN
Total Kilometers per household/year
Legend
Total kilometers per household/year
keine Angabe
1000 - 10000
10001 - 20000
20001 - 30000
30001 - 40000
40001 - 50000
50001 - 180000

Spatial Analysis & Visualization



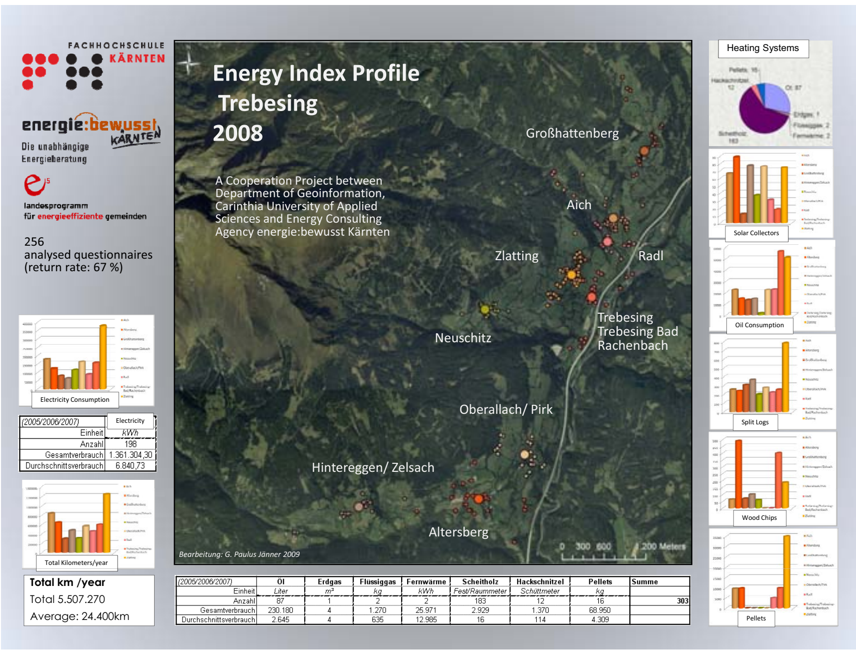
Sample Calculation
Fuel expense Trebesing

226 households, 419 cars,
Standard-car: 7 l/ 100km fuel consumption
Fuel price: 1,20 € / l (1.60 $/l)

Total kilometers per year: 5,507,270km

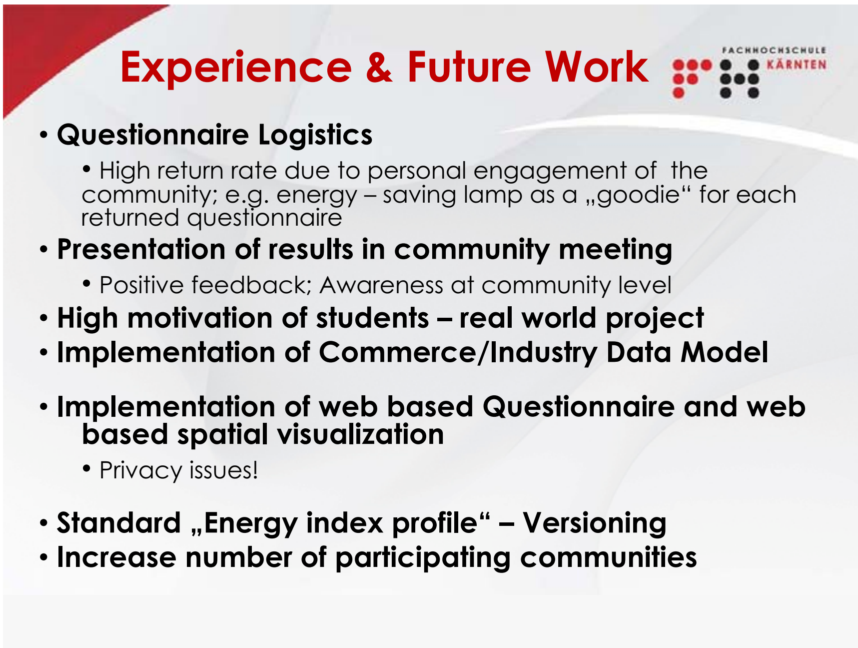
Total expense on fuel: **462.610 €**
614,855 $

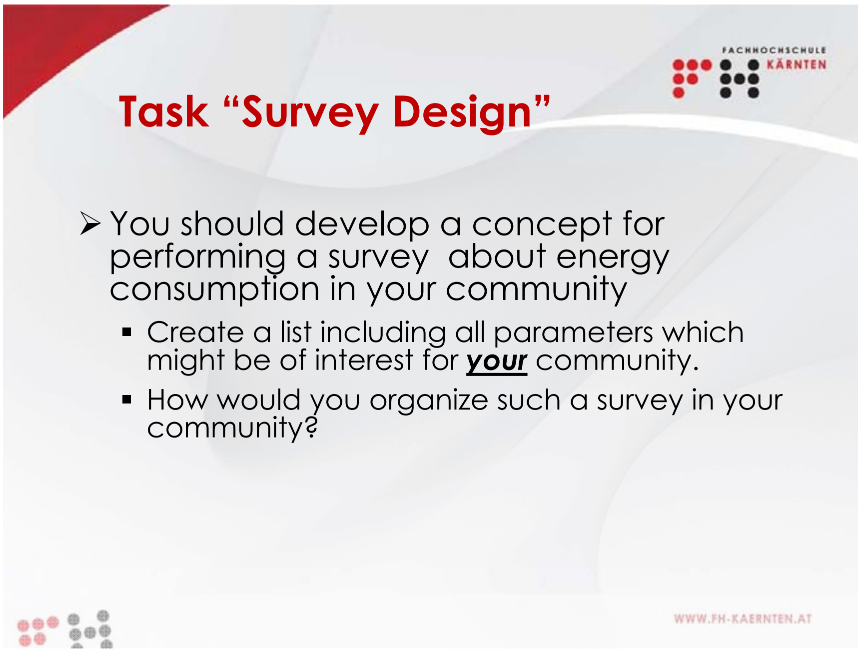
Per household: **2047 € / year**
2720 $/year



(2005/2006/2007)	Electricity
Einheit	kWh
Anzahl	198
Gesamtverbrauch	1.361.304,30
Durchschnittsverbrauch	6.840,73

(2005/2006/2007)	Öl	Erdgas	Flüssiggas	Fernwärme	Scheitholz	Hackschnitzel	Pellets	Summe
Einheit	Liter	m³	kg	kWh	Fest/Raummeter	Schüttmeter	kg	
Anzahl	87	1	2	2	183	12	16	303
Gesamtverbrauch	230.180	4	1.270	25.971	2.929	1.370	68.950	
Durchschnittsverbrauch	2.645	4	635	12.985	16	114	4.309	


Experience & Future Work
FACHHOCHSCHULE KÄRNTEN
• Questionnaire Logistics
• High return rate due to personal engagement of the community; e.g. energy – saving lamp as a „goodie“ for each returned questionnaire
• Presentation of results in community meeting
• Positive feedback; Awareness at community level
• High motivation of students – real world project
• Implementation of Commerce/Industry Data Model
• Implementation of web based Questionnaire and web based spatial visualization
• Privacy issues!
• Standard „Energy index profile“ – Versioning
• Increase number of participating communities


Task “Survey Design”
FACHHOCHSCHULE KÄRNTEN
➢ You should develop a concept for performing a survey about energy consumption in your community
▪ Create a list including all parameters which might be of interest for ***your*** community.
▪ How would you organize such a survey in your community?
WWW.FH-KAERNTEN.AT


References & Ressources
FACHHOCHSCHULE KÄRNTEN
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➢ LASERDATA (2008). Mehrwert aus Laserscanning-Daten: Werkzeuge-Anwendungen. KAGIS Fachtag 2008 “ LASERSCANNING“, 4.6.2008. http://www.laserdata.at/data/KAGIS_Laserdata_v3.pdf
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➢ Riegl (2007): The Vienna Laser Scanning Survey 2007 http://www.riegl.com/uploads/tx_pxpriegldownloads/Vienna-Laser-Scan-Survey_2007.pdf
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http://www.fh-kaernten.at/geo_msc/

FACHHOCHSCHULE KÄRNTEN

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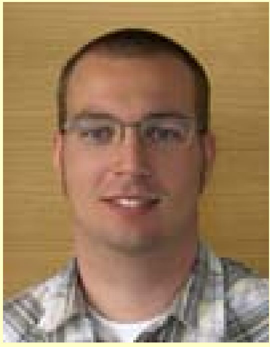

Abstract

Freely accessible data sources for calculation of solar and hydro potentials

Clemens Strauß

Graz University of Technology

In the world of geo-information sciences the knowledge of work flows and analysis methods in the context of space is a basic capability for scientists. However spatial work can be based on established data only. For many geo-problems a matching data acquisition method can be found and executed by the survey specialists. Hence, data acquisition is not the core task of geo-information scientist! But geo-information scientists have to know how to handle these spatial data.

There are many providers which offer spatial information – companies (Tele Atlas, Navteq), governmental authorities (NASA, ESA), non governmental organisations (UN), private communities (Open Street Map) and many more. The costs of spatial information have a wide range – from free data sets by communities up to high price products by companies.

The spatial data itself has different properties:

- Geometrical characteristic: Raster data set, vector information (point, line and polygon).
- Data storage: file-based, spatial data base, online source.
- Quality parameters: geometric resolution, radiometric resolution (mainly for raster data), attribute value definition, spatial reference system of coordination values.

In principle the whole information can be divided into data (geometry and attribute values) and meta data (quality parameters). If there is no meta information about the primary data you will not be able to use this primary data. Guessing attribute values can accidentally succeed, but this approach is wantonly negligent!

However there are sufficient data sources existing to have a broad data base for a project. For example projects concerning the calculation of solar and hydro potentials are mainly based on digital elevation models (DEM). For this demand of information NASA provides a global coverage of elevation data derived from a Shuttle Radar Topography Mission (SRTM). An example for online access to these SRTM data sets is given by the University of Maryland (http://glcf.umiacs.umd.edu). Figure 1 shows the SRTM DEM in the area of Kyrgyzstan overlaid by a calculated hill shade.

Figure 1: Digital Elevation Model from SRTM Data

Freely accessible data sources for calculation of solar and hydro potentials

openSolarCA'09
Bishkek, Kyrgyzstan
2009

Clemens Strauß
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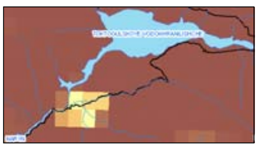
clemens.strauss@tugraz.at

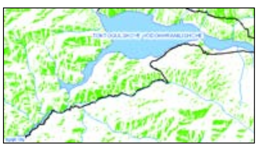
agenda

1. introduction
2. spatial data
3. data sources
4. data examples

introduction

- data base for calculation of solar and hydro potentials
  - primary data (potentials)
    - elevation model
    - water bodies
  - secondary data (further spatial analyses)
    - natural environment
    - infrastructure
      - traffic (installation, maintenance)
      - transportation (power lines)
    - population (settlements)



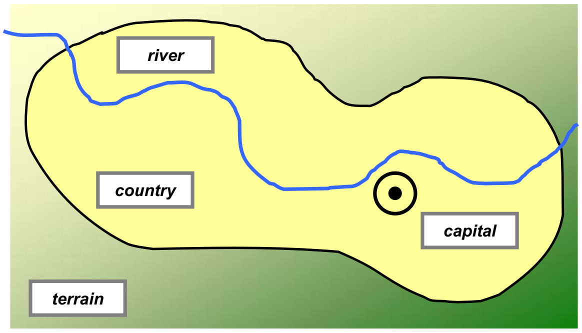


spatial data

- data types
  - geometrical characteristic of information
    - raster
    - vector
      - ➢ point, line, polygon, multi geometries
  - value of information linked to the geometry
    - raster
      - ➢ pixel value of a raster element
        - intensity value of sensor element (airborne / satellite imagery)
        - value derived from a data analysis process (demography, elevation)
    - vector
      - ➢ attribute values (other way round: one attribute value can have different geometrical shapes)

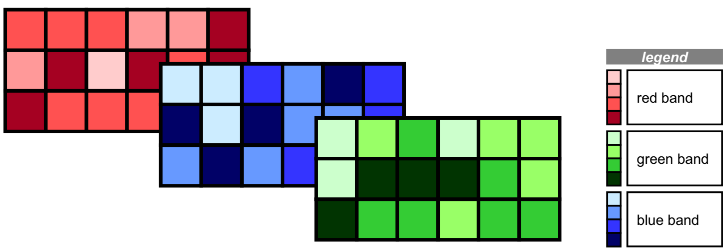
spatial data | example

- real world situation
  - country (administrative boarder line)
  - river
  - capital (settlement)
  - terrain (digital elevation model)



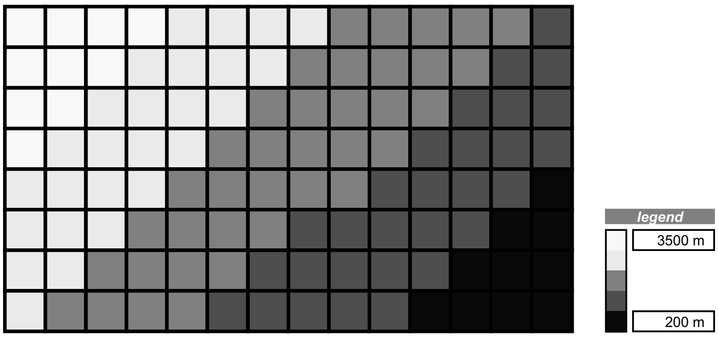
spatial data | image data

- remote sensing platform
  - intensity values for each band
  - electromagnetic spectrum
- meta data
  - spectral information of each band
  - date (season) & time of data acquisition
  - spatial information (e.g. bounding box coordinates)



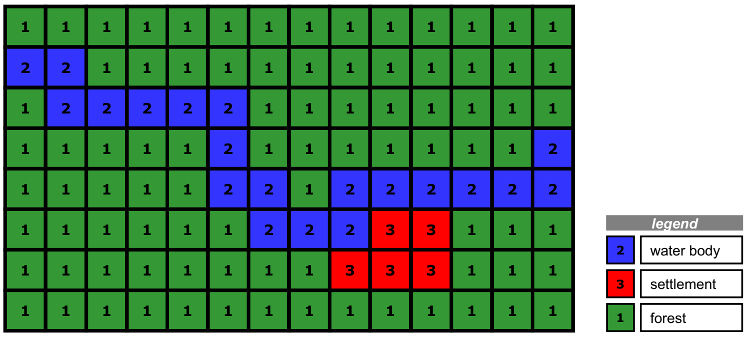
spatial data | thematic raster data set

- data pre-processing
  - digital elevation model
  - geo-statistic values
- meta data
  - pixel value definition



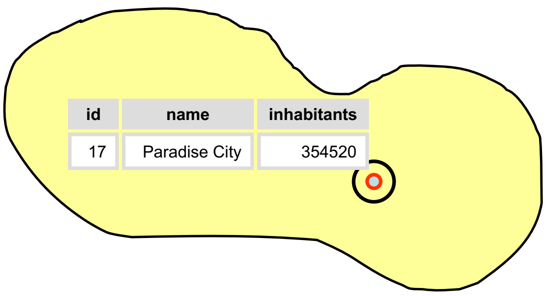
spatial data | classified raster data set

- image / data analysis
  - segmentation, definition of classes, classification of image
- meta data
  - class value definition



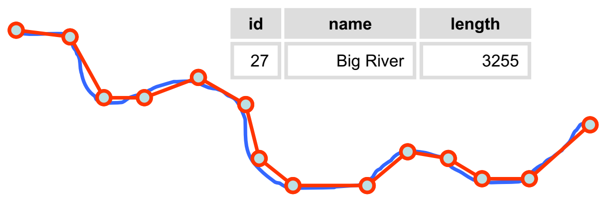
spatial data | point feature

- feature
  - point geometry
  - several attribute values linked to this geometry



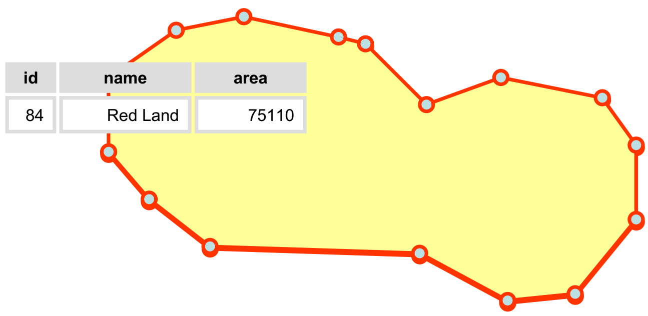
spatial data | line feature

- feature
  - line geometry (chaining of points)
  - several attribute values linked to this geometry



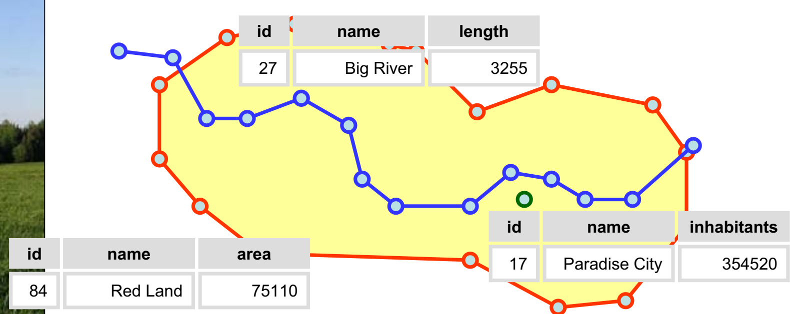
spatial data | polygon feature

- feature
  - polygon geometry (closing line)
  - several attribute values linked to this geometry



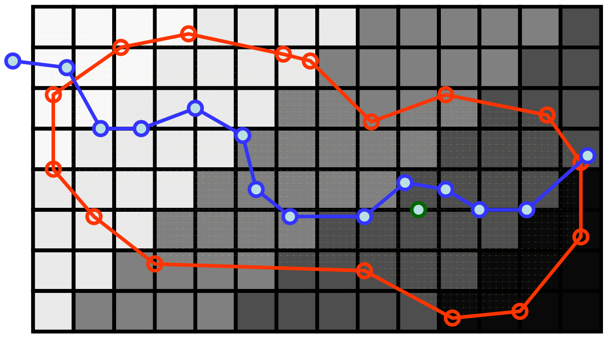
spatial data | feature

- point features (city)
- line features (river)
- polygon features (country)



spatial data | polygon feature

- raster data (terrain, land cover classes)
- features (settlement, water line, administrative area)



spatial data | spatial reference

projection coordinates WGS 84 / UTM 43 N		
x-value	**y-value**	**height**
387532 m	4737690 m	2347 m

ellipsoid coordinates WGS 84		
latitude	**longitude**	**height**
42.7835° N	73.6250° E	2347 m
42°47.01' N	73° 37.50' E	2347 m
42°47'00" N	73° 37'30" E	2347 m

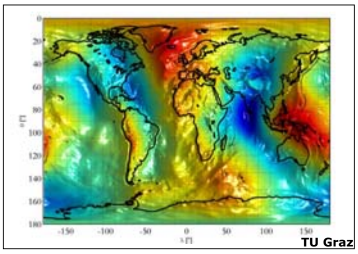
projection coordinates WGS 84 / World Mercator		
x-value	**y-value**	**height**
8195897 m	5250044 m	2347 m

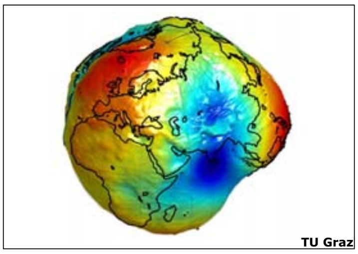
ECEF coordinates WGS 84		
x-value	**y-value**	**z-value**
13222310 m	4499803 m	4311475 m

spatial data | spatial reference

What is the shape of our Earth?

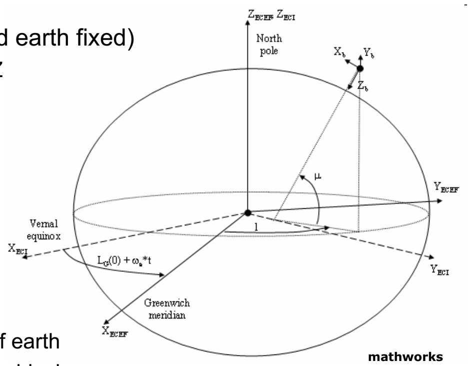
It's a **geoid**!





spatial data | datum

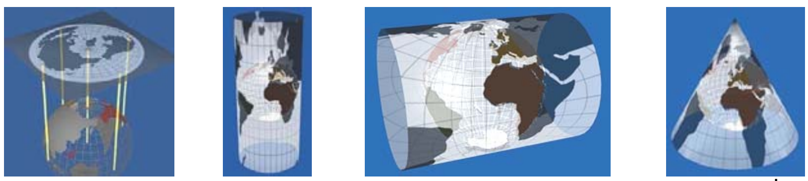
- ECEF (earth centered earth fixed)
  - coordinates: X, Y, Z



- ellipsoid
  - reference surface of earth
  - coordinates: geographical
    - longitude
    - latitude
    - height above reverence surface

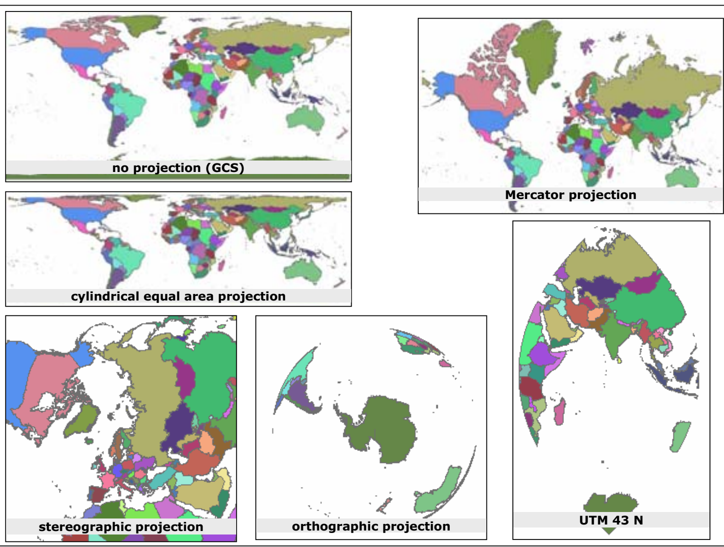
spatial data | projection

- motivation: project surface of ellipsoid into plane
- projection methods
  - stereo- / orthographic
  - cylinder
    - Mercator
    - Transverse Mercator (e.g. UTM Universal Transverse Mercator)
  - cone
- problem based choice of projection method
  - area of interest



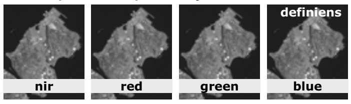
komowa

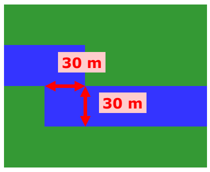
spatial data | projection



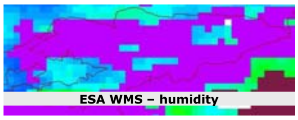
spatial data | meta data

- meta data
  - description of primary data





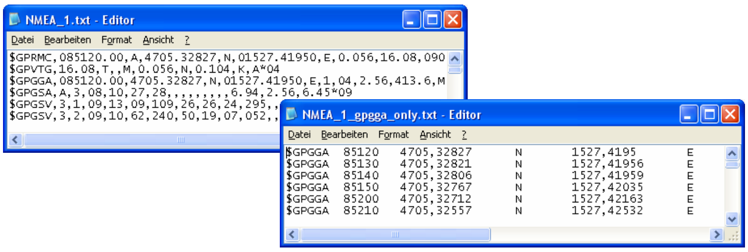
  - quality parameters
    - resolution
    - accuracy
  - meaning of attribute / pixel values



  - data origin (trustable source)
  - certificates for data quality (legal claims)

data storage | file-based

- flat file
  - list of information in e.g. ascii format
  - structure
    - comma separated values
    - tabulator separated values
  - spatial information
    - numeric values for lat/long or x, y
  - sources: e.g. GPS receiver (NMEA, RINEX)


NMEA_1.txt - Editor
Datei Bearbeiten Format Ansicht ?

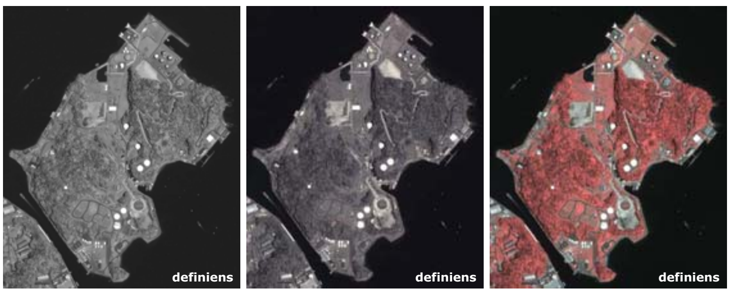
```
$GPRMC,085120.00,A,4705.32827,N,01527.41950,E,0.056,16.08,090
$GPVTG,16.08,T,,M,0.056,N,0.104,K,A*04
$GPGGA,085120.00,4705.32827,N,01527.41950,E,1,04,2.56,413.6,M
$GPGSA,A,3,08,10,27,28,,,,,,,,,6.94,2.56,6.45*09
$GPGSV,3,1,09,13,09,109,26,26,24,295,,
$GPGSV,3,2,09,10,62,240,50,19,07,052,,
```

NMEA_1_gpgga_only.txt - Editor
Datei Bearbeiten Format Ansicht ?

```
$GPGGA  85120   4705,32827    N    1527,4195    E
$GPGGA  85130   4705,32821    N    1527,41956   E
$GPGGA  85140   4705,32806    N    1527,41959   E
$GPGGA  85150   4705,32767    N    1527,42035   E
$GPGGA  85200   4705,32712    N    1527,42163   E
$GPGGA  85210   4705,32557    N    1527,42532   E
```


data storage | file-based

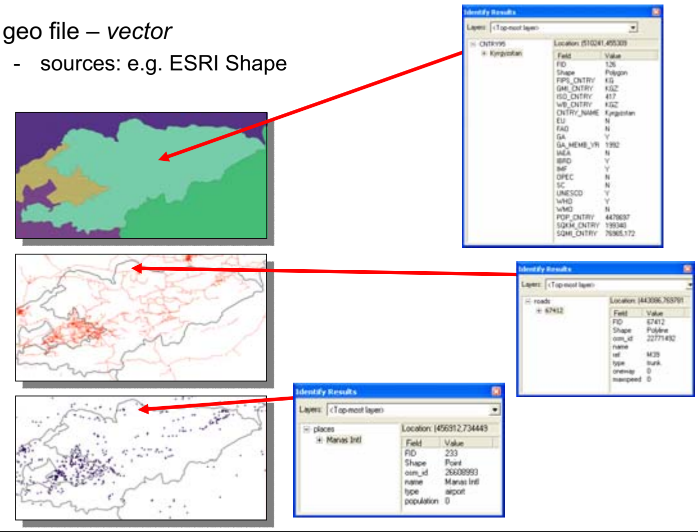
- geo file – *raster*
  - different spectral bands (depends on sensor)
  - spatial reference information
  - sources: e.g. geoTIFF, IMG, …



gray values | RGB (red green blue) | pseudo-color infrared

data storage | file-based

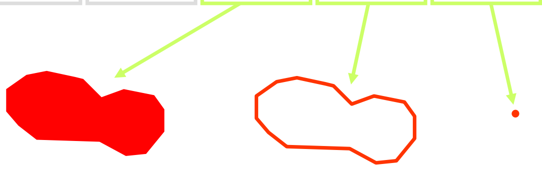
- geo file – *vector*
  - sources: e.g. ESRI Shape



data storage | data base

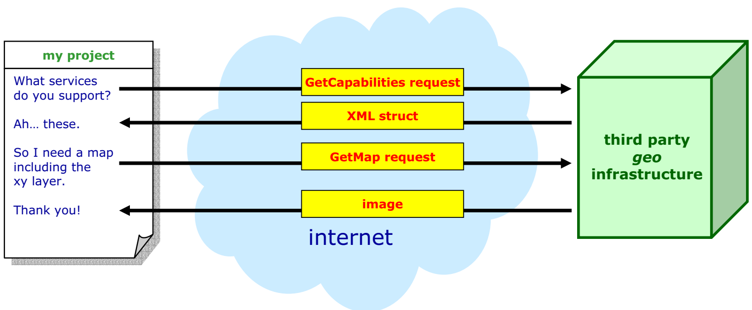
- spatial data base
  - source: postgreSQL / PostGIS (object relational DBMS)
  - additional attribute for geometries (vector)
    - geometry type (point, line, polygon, multi geometries)
    - dimensions
    - spatial reference system
    - geometry (OGC specifications)
    - user-defined numbers of geometries for one feature

id	name	area	geometry area	geometry border line	geometry centroid
84	Red Land	75110	polygon	line	point



data storage | online services

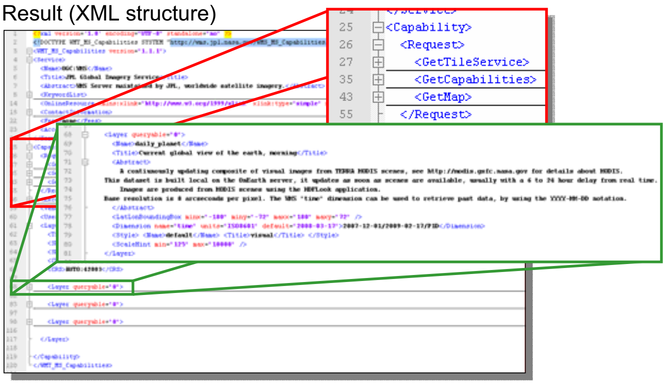
- third party infrastructure
  - accept standardized requests (e.g. WMS – Web Map Service)
  - provides
    - images (raster data)
    - textual information



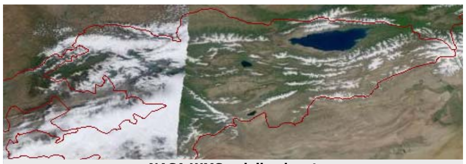
- NASA WMS
  - GetCapabilities request

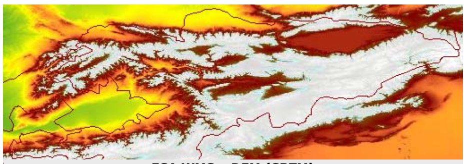
http://wms.jpl.nasa.gov/wms.cgi?REQUEST=GetCapabilities&VERION=1.1.1

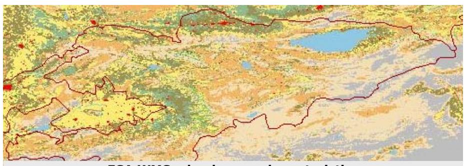
  - Result (XML structure)

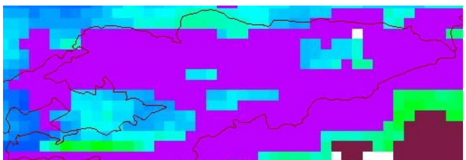


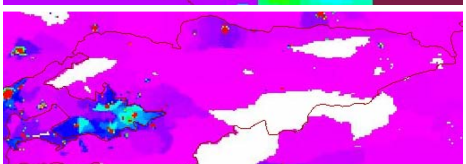

NASA WMS – Landsat


NASA WMS – daily planet


ESA WMS – DEM (SRTM)


ESA WMS – land cover characteristics


ESA WMS – humidity


ESA WMS – population density

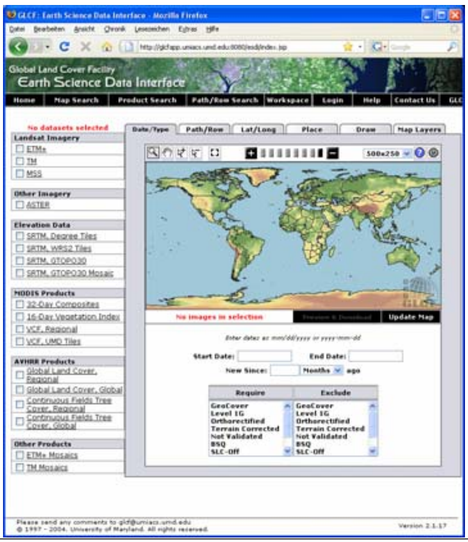
data sources

- data provider
  - companies
    - e.g.: Navteq, Tele Atlas
  - governmental authorities
    - e.g.: ESA, NASA
  - non governmental organizations
    - e.g.: UN
  - universities and other institutions of education
  - private communities (Web 2.0)
    - e.g.: Open Street Map

data sources

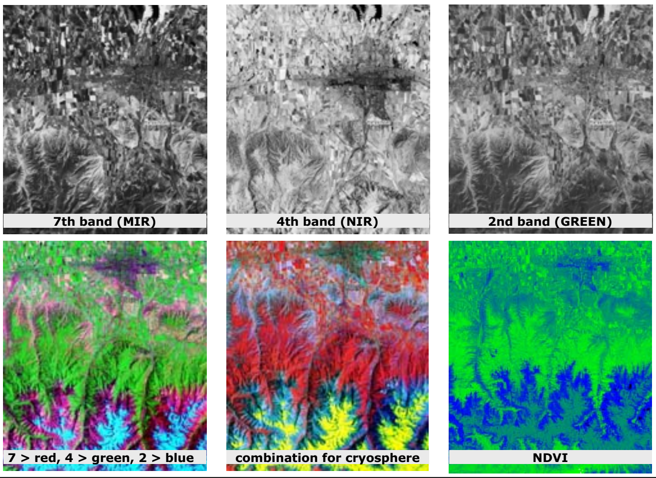
- download sides
  - http://glcf.umiacs.umd.edu/
  - http://onearth.jpl.nasa.gov/
  - https://zulu.ssc.nasa.gov/
  - http://srtm.csi.cgiar.org/
  - http://biogeo.berkeley.edu/bgm/gdata.php
  - http://geodata.grid.unep.ch/
  - http://giscenter-sl.isu.edu/other/
  - http://www.openstreetmap.org/

data sources



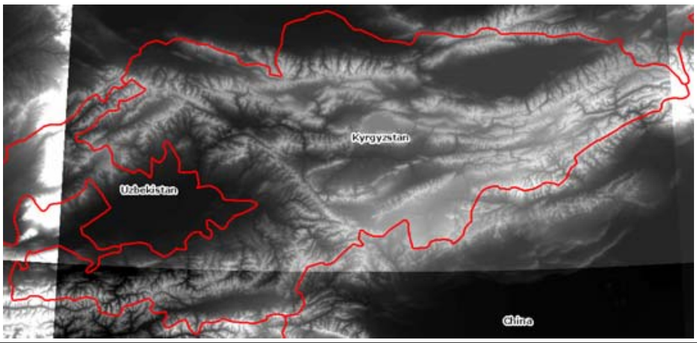
data example – raster

- satellite image *Landsat Geocover*



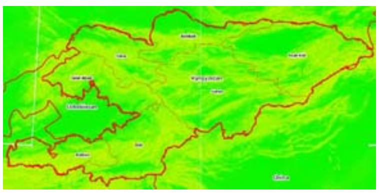
data example – raster

- elevation information

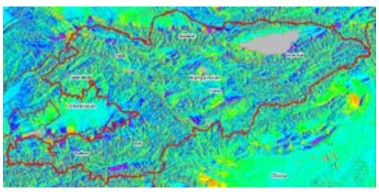


data example – raster

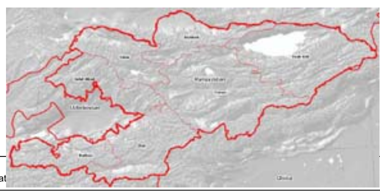
- slope model



- aspect model

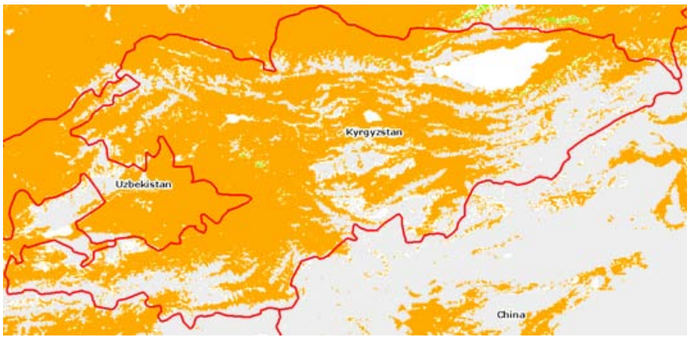


- hill shade



data example – raster

- land cover
  - bare land
  - herbaceous regions
  - trees

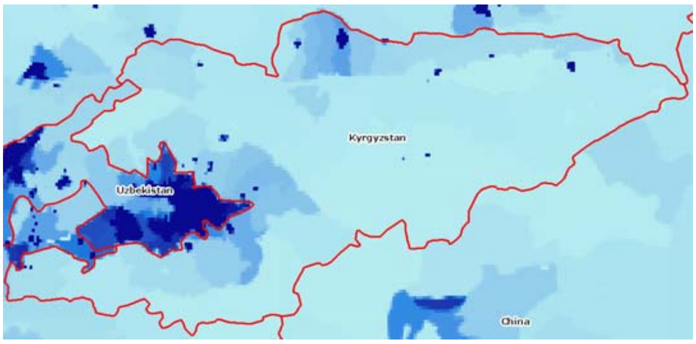


data example – raster

- population density

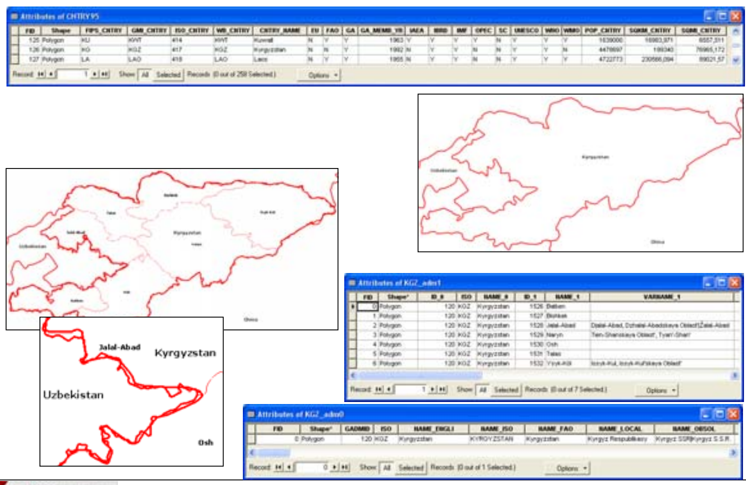
90440 p/skm

0 p/skm



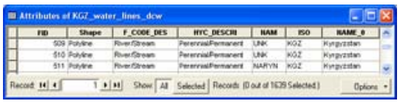
data example – vector

- administration areas



data example – vector

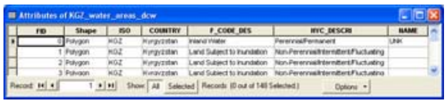
- water lines & bodies



Attributes of KGZ_water_lines_dcw

FID	Shape	F_CODE_DES	HYC_DESCRI	NAM	ISO	NAME_0
509	Polyline	River/Stream	Perennial/Permanent	UNK	KGZ	Kyrgyzstan
510	Polyline	River/Stream	Perennial/Permanent	UNK	KGZ	Kyrgyzstan
511	Polyline	River/Stream	Perennial/Permanent	NARYN	KGZ	Kyrgyzstan

Record: 1 Show: All Selected Records (0 out of 1639 Selected) Options



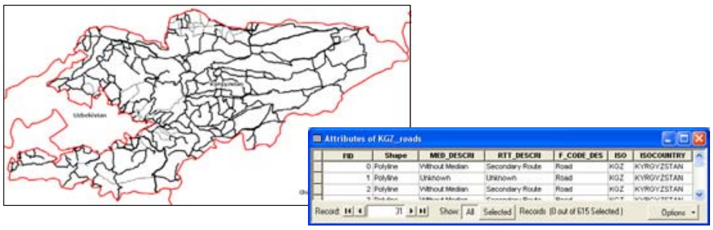
Attributes of KGZ_water_areas_dcw

FID	Shape	ISO	COUNTRY	F_CODE_DES	HYC_DESCRI	NAME
0	Polygon	KGZ	Kyrgyzstan	Inland Water	Perennial/Permanent	UNK
1	Polygon	KGZ	Kyrgyzstan	Land Subject to Inundation	Non-Perennial/Intermittent/Fluctuating	
2	Polygon	KGZ	Kyrgyzstan	Land Subject to Inundation	Non-Perennial/Intermittent/Fluctuating	
3	Polygon	KGZ	Kyrgyzstan	Land Subject to Inundation	Non-Perennial/Intermittent/Fluctuating	

Record: 1 Show: All Selected Records (0 out of 148 Selected) Options

data example – vector

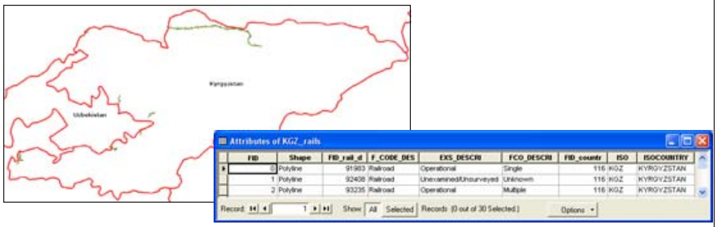
- transportation (roads, railway)



Attributes of KGZ_roads

FID	Shape	MED_DESCRI	RTT_DESCRI	F_CODE_DES	ISO	ISOCOUNTRY
0	Polyline	Without Median	Secondary Route	Road	KGZ	KYRGYZSTAN
1	Polyline	Unknown	Unknown	Road	KGZ	KYRGYZSTAN
2	Polyline	Without Median	Secondary Route	Road	KGZ	KYRGYZSTAN

Record: 31 Show: All Selected Records (0 out of 615 Selected) Options



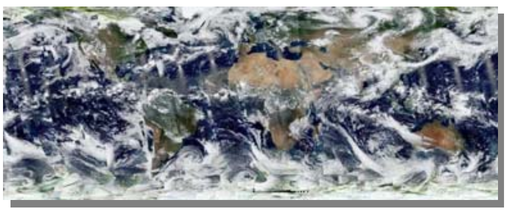
Attributes of KGZ_rails

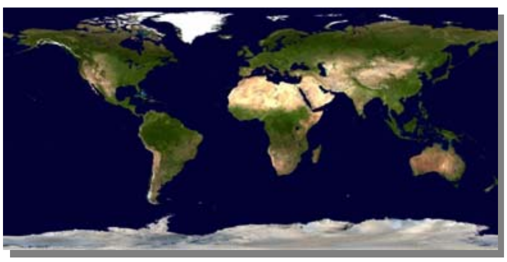
FID	Shape	FID_rail_d	F_CODE_DES	EXS_DESCRI	FCO_DESCRI	FID_countr	ISO	ISOCOUNTRY
0	Polyline	91983	Railroad	Operational	Single	116	KGZ	KYRGYZSTAN
1	Polyline	92408	Railroad	Unexamined/Unsurveyed	Unknown	116	KGZ	KYRGYZSTAN
2	Polyline	93235	Railroad	Operational	Multiple	116	KGZ	KYRGYZSTAN

Record: 1 Show: All Selected Records (0 out of 30 Selected) Options

data example

- online source





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Abstract

Introduction to SAGA GIS

Rainer Prüller

Graz University of Technology

SAGA stands for „System for Automated Geoscientific Analyses“ and is a Geographic Information System (GIS) software published as Free and Open Source Software (FOSS). It can be obtained from the website http://www.saga-gis.org/, running under Windows and Linux operating systems. The SAGA development started in the year 2001 at the University of Göttingen in Germany and is still under development with new releases. For further advancement the SAGA User Group Association has been established which primary goal is to guarantee a sustainable long-term development of SAGA. The system SAGA has been designed for an easy and effective implementation of spatial algorithms, it comes with a comprehensive set of free modules (300 modules in the actual version 2.0.3), but not all of these modules are highly sophisticated analysis or modelling tools. Many modules perform rather simple data operations but several of these modules represent the state of the art in geoscientific analysis, like integrated modules in terrain analysis covering the topics of solar energy (e.g. duration of insulation) and hydrology (e.g. watershed basin extraction). For the implementation of geoscientific methods SAGA has an Application Programming Interface (API) on the one hand and an easily approachable Graphical User Interface (GUI) on the other hand which is shown in Figure 1.

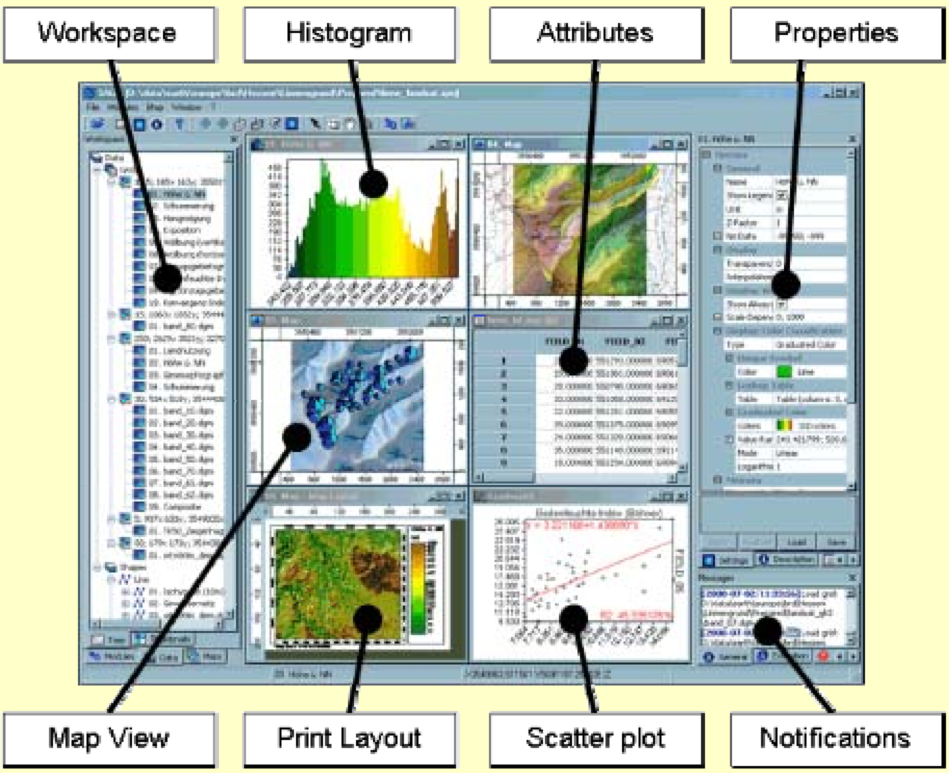


Figure 1: Graphical User Interface (http://www.saga-gis.org/)

This allows the user to manage and visualise data as well as to perform data analyses and manipulations by executing integrated modules. A module can be executed either by a button in its related settings window or via a menu entry listed in the modules entry of the menu bar. The variety of modules covers a suite of import and export options, access to free cartographic projection libraries for projecting data to appropriate coordinate systems, manipulation of vector and raster data or statistical analyses of raster data and the processing of Digital Elevation Models.

Introduction to SAGAGIS

An example for free and open source software.

Rainer Prüller

Graz University of Technology

Introduction

- http://www.saga-gis.org
- **SAGA** - short hand for "**S**ystem for **A**utomated **G**eoscientific **A**nalyses„
- Free, hybrid, cross-platform GIS software
- Computational methods for raster, vector and tabular data

Introduction

- Easy and effective implementation of spatial algorithms
- Steady growing availability of geoscientific methods
- Methods are implemented in various SAGA modules
- Runs under Windows and Linux operating systems

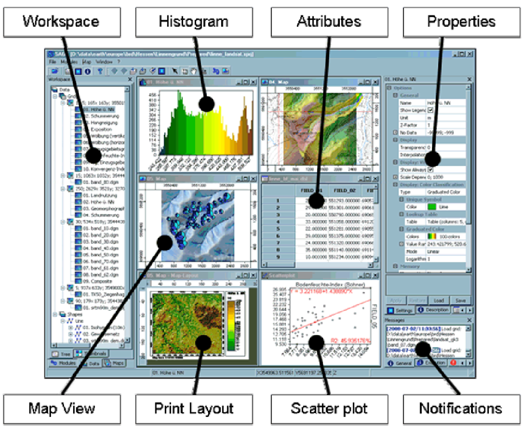
Introduction

- Development started with the beginning of the 3rd millenium
- Dept. Of Physical Geography, Göttingen, Germany
- Since 2007 Hamburg, Germany

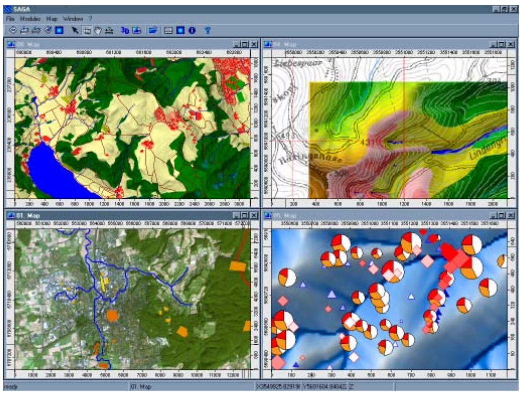
License issues

- Free Open Source Software (FOSS)
- Means the freedom
  - to run the program, for any purpose,
  - to study how the program works and to modify it,
  - to redistribute copies,
  - to improve the program, and release the improvements to the public

Graphical User Interface (GUI)

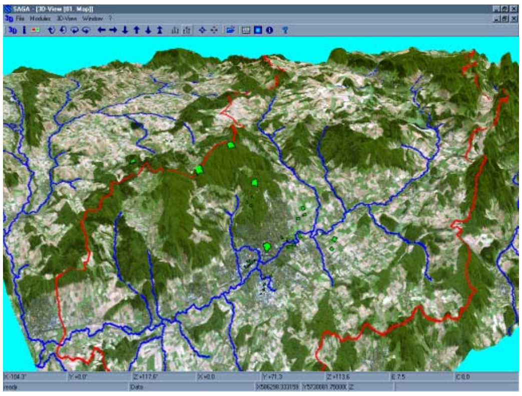


Graphical User Interface (GUI)



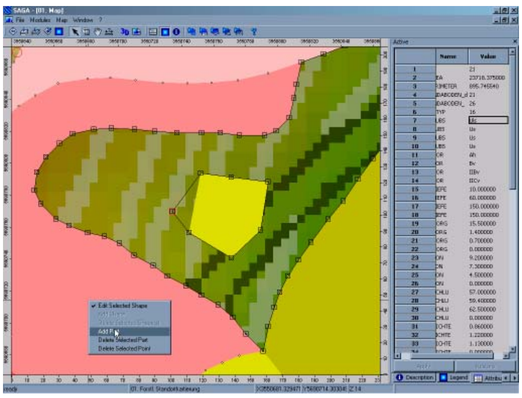
Maps

Graphical User Interface (GUI)



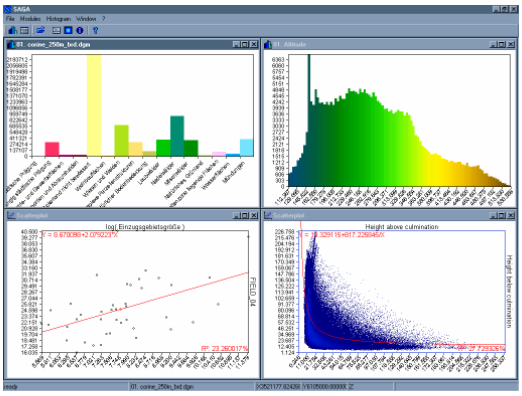
3D view

Graphical User Interface (GUI)



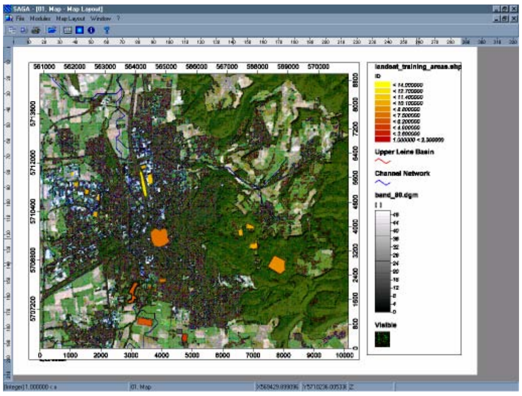
Digitizing

Graphical User Interface (GUI)



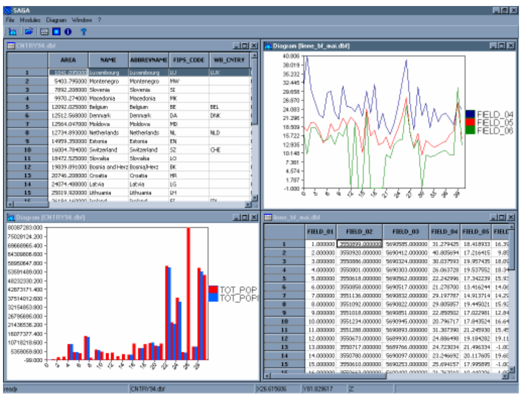
Histogram

Graphical User Interface (GUI)



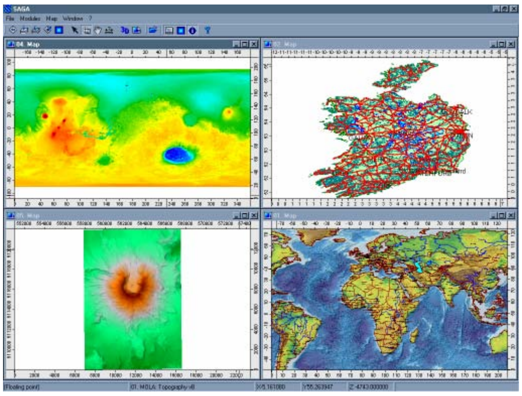
Layout

Graphical User Interface (GUI)



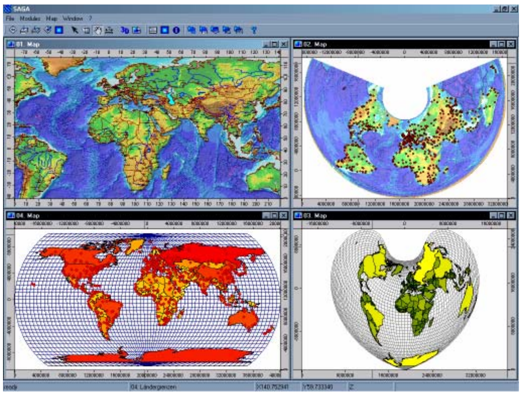
Tables

Modules



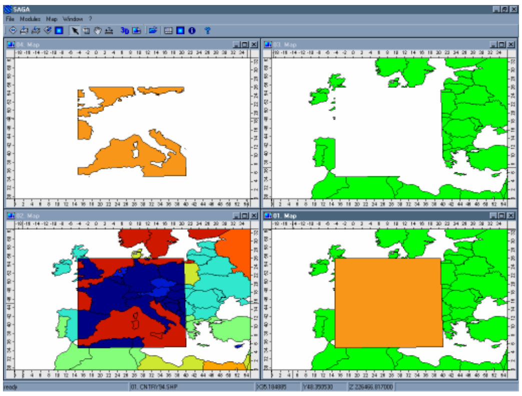
Different file formats

Modules



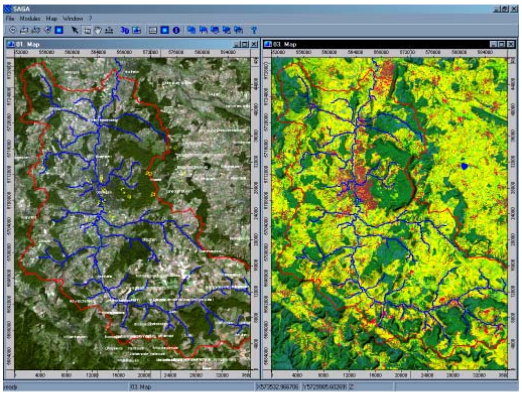
Projections

Modules



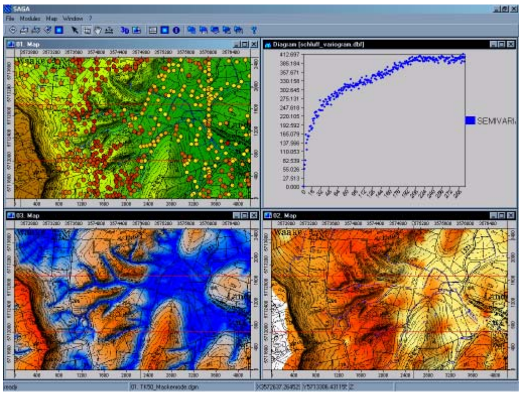
Vector data

Modules



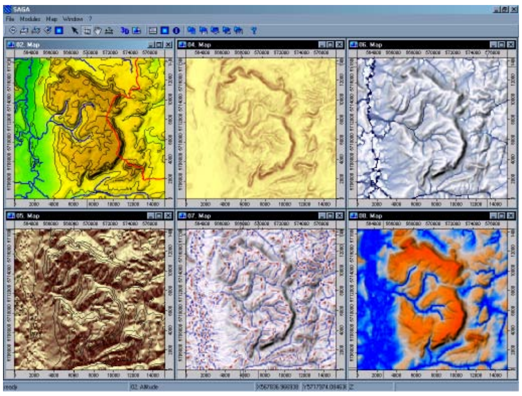
Raster data

Modules



Statistics

Modules



Various models for Terrain Analysis

Installation - Windows

- Portable software
- Download from http://www.saga-gis.org
- Unzip the file (16.3 Mbyte)
- Run 'saga_gui.exe'
- Similar process under Linux
- Wiki: http://saga-gis.wiki.sourceforge.net/

Examples

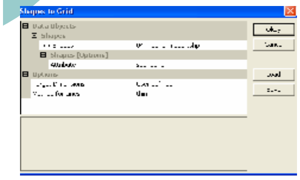
1. Data import
2. DEM calculations
3. Applying models

1. Data import

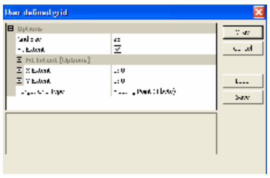
- Image files
- Shapes
- Digital elevation models: TIN, GRID
- GPS data
- DXF
- Tables using ODBC

2. DEM calculations

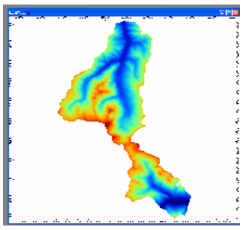
- Import of a GRID from Shapefile
  - Module Libraries: Grid – Gridding
  - Module „Shape to Grid"



Source data
Height information
Dimension



Grid Size

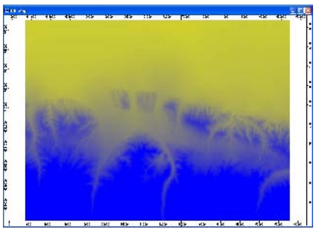


Imported Grid

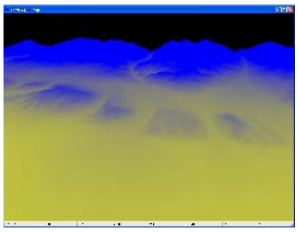
2. DEM calculations

Import of a GRID from raster image

- Modules – File – Grid – GDAL – „Import Raster via GDAL"
- Choose file raster image „Bischkek_Sued.tif"
- Raster image is converted to *.sgrid
- Analyses can be done



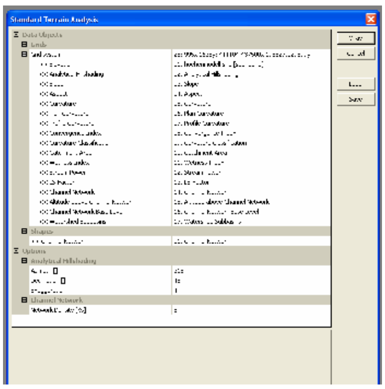
SRTM Bishkek



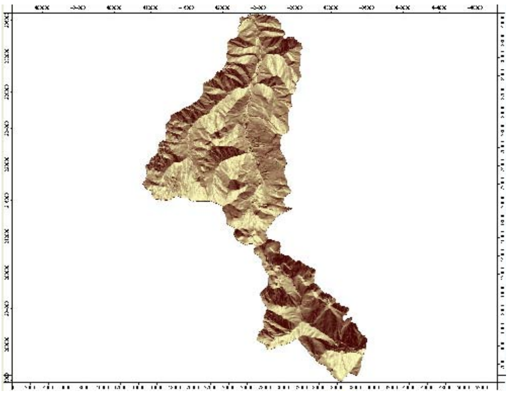
SRTM 3D view Bishkek, direction south

3. Applying models

- DEM calculations
- Modules – Terrain Analysis – Standard Terrain Analysis
  - Slope
  - Aspect
  - Curvature
  - …



3. Applying models



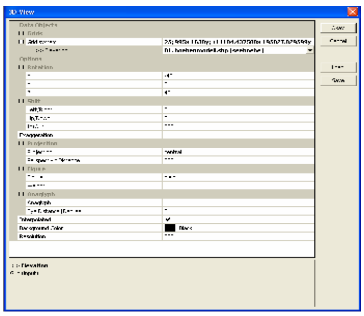
e.g. Aspect

3. Applying models

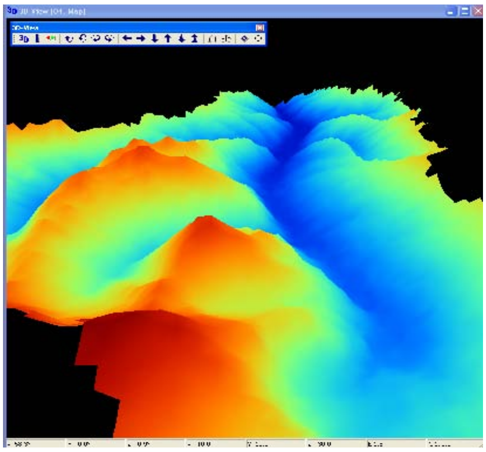
- Test of further models
  - Terrain Analysis – Hydrology
  - Simulation - Hydrology
  - Terrain Analysis – Lightning, Visibility
- Solar radiation in session tomorrow

DEM – 3D view

- Open DEM
- Choose „3D“ from the menue



DEM – 3D view



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Outlook

Dissemination of solar and hydropotentials Computation

Evaluation and presentation of concrete solar potentials in Kyrgyzstan by means of SAGAGIS

Tomorrow, 25th of August, 1330

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Abstract

Data bases for the assessment of concrete solar potentials: analysis of a digital elevation model.

Johannes Scholz

Graz University of Technology

Based on freely accessible data sources, the functionalities of SAGAGIS and overall goal of the workshop – the calculation of solar and hydro energy potential – the analysis of the terrain is of high importance. Terrain analysis is the basis for the development of a number of applications that are related to e.g. geo-hazards or forestry and agriculture.

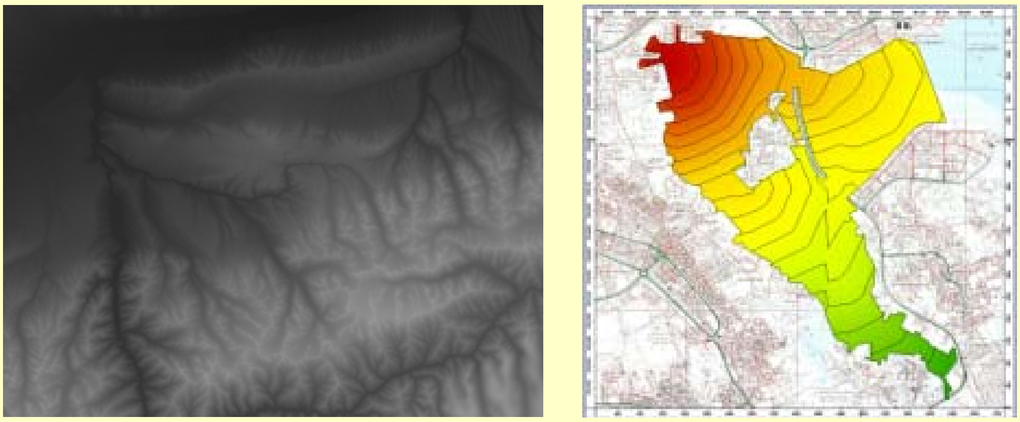


Figure 1: Original SRTM dataset in the left picture (monchrome *.tif) and colorized surface model with contour lines.

The fundamental part for the assessment of solar energy potential is the existence of a digital elevation model (DEM) – here we are using the SRTM 90 dataset. This dataset was generated by a NASA Space Shuttle mission in 2001 utilizing radar technology. With the help of several theoretical concepts that will we briefly described, we are able to create the following topographical parameters:

- Aspect
- Slope
- Gradient
- Curvature

In addition the some cartographic features can be calculated from a DEM:

- Contour lines
- Shaded relief maps

In order to calculate these parameters of the SRTM 90 dataset we are using SAGAGIS. There we have to follow a simple workflow to create accurate results.

- Create a smooth surface using interpolation algorithms
- Reduce errors in the surface – e.g. fill up small holes
- Calculate topographical parameters and additional cartographic features

The produced datasets including the topographical parameters will serve as basis for the following practical workshop lectures.

Analysis of digital elevation models (DEM's)

openSolarCA'09

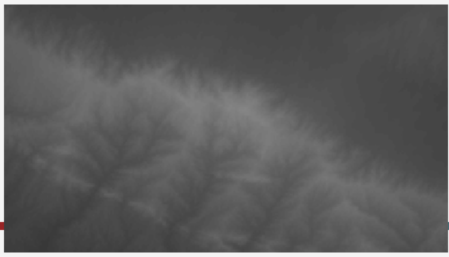
Johannes Scholz

Agenda

- Introduction
  - Base data: Nasa's SRTM 90
- Theory of DEM analysis
  - Preparation of topographic surfaces
  - "local" Parameters of topographical surfaces
    - Slope
    - Aspect
    - Curvature
    - Gradient
    - Hillshade
  - "global" Analysis of topographic surface
    - Viewshed Analysis
    - Solar potential – not covered here
    - Water run off models – not covered here
- A "how –to" perform an analysis of a DEM with SAGA GIS
- Conclusion

Introduction

- Continuous topographic surfaces – here a Digital Elevation Model (DEM) hold more information than solely the heigt above sea level at a specific point (x/y)
- If DEM's are continuous we can create 1st and 2nd order derivates of the surface
  - 1st order: slope, aspect
  - 2nd order: curvature

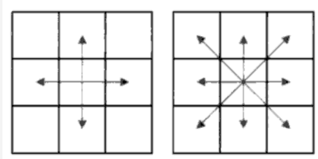


SRTM data visualized as monochrome image

GEOinformation TU GRAZ

Introduction

- Distinction of raster operators (Tomlin 1990)
  - **Local**: considers the raster cells of one or more layers at the same postition
  - **Focal**: considers the raster cells of one or more layers at the same postition and their (well defined) neighbours (e.g. Queens case vs. Rooks case)
    - **„Local“ surface parameters** are equal to **Tomlin's focal operators**!
  - **Zonal**: considers all raster cells of one or more layers with the same position and all cells of the same value (e.g. color value)
  - **Global**: considers the whole raster layer. (e.g. for interpolation)



Neighbourhood definition: Queens case (left) and Rooks case right, from Longley (1990).

GEOinformation TU GRAZ

Introduction

- Due to the fact that we are not dealing with real continuous surfaces
  - we cannot create mathematically correct 1st and 2nd order derivates
  - we have to **approximate** the 1st and 2nd order derivates
  - NASA SRTM 90 dataset is a discretized raster data model with 90 m resolution

1536.00	1538.00	1547.00	1543.00	1533.00	1541.00	1564.00	1573.00	1571.00
1561.00	1563.00	1569.00	1556.00	1543.00	1559.00	1573.00	1586.00	1591.00
1602.00	1602.00	1600.00	1589.00	1560.00	1564.00	1578.00	1584.00	1586.00
1633.00	1643.00	1648.00	1630.00	1595.00	1591.00	1599.00	1584.00	1586.00

NASA SRTM 90 dataset, pixels are visible with their according value.

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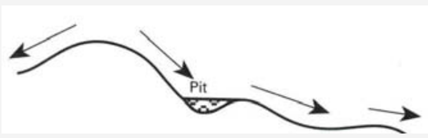
Theory of DEM analysis – prepration of surfaces

- Assumption: we have a continuous (or discretized) surface with no holes and artifacts!
  - created e.g. with interpolation algorithms ;-)
- Problems may arise through pits/sinks in the surface (accuracy errors)

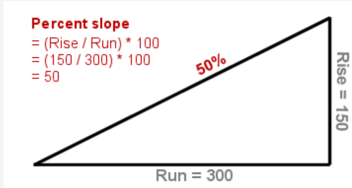


A pit in a surface – has in influence on e.g. water run off models!

  - Solution through a number of algorithms, that mostly gradually fill the sink – are very time consuming!
  - A new approach by Planchon and Darboux (2001) that inundates the surface with a thick water layer and then remeoves the excess water – fast and versatile algorithm!

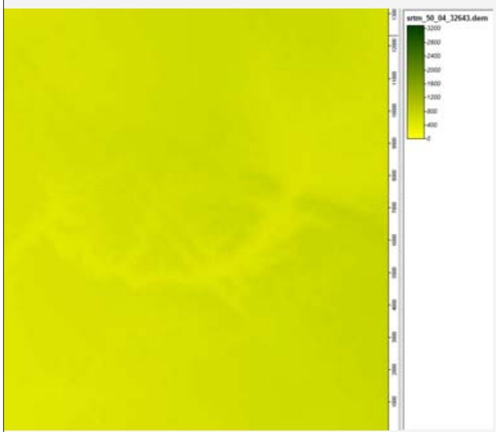
Local surface parameter

- Slope
  - is the incline (steepness) of a surface or part of a surface
  - Slope is calculated as the maximum rate of change in values between each cell and its neighbours
  - Slope may be expressed either as degrees (e.g. 45 degrees) or percentages (e.g. 50%)

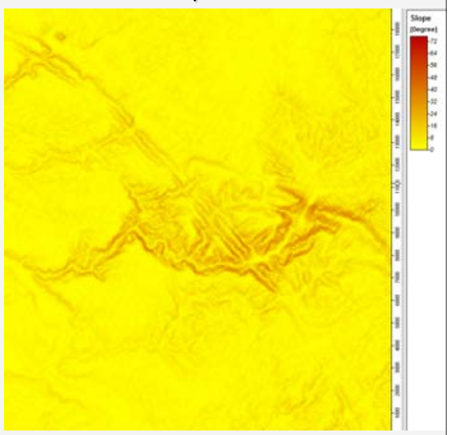


Local surface parameter

Elevation

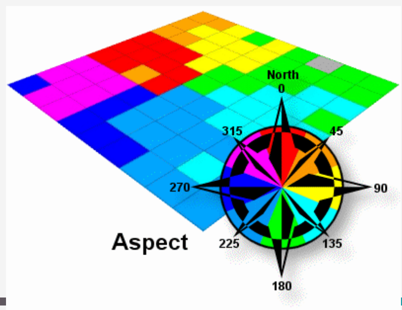


Slope



Local surface parameter

- Aspect
  - is the orientation or compass direction of slope
  - An aspect value identifies the down-slope direction of a raster cell to its neighbours
  - Aspect values are measured clockwise in degrees from 0 to 360
    - North is 0; 90 is east; 180 is south; 270 is west
    - Flat areas (those with slope values of 0) are assigned an aspect value of *nil* (e.g. -1)



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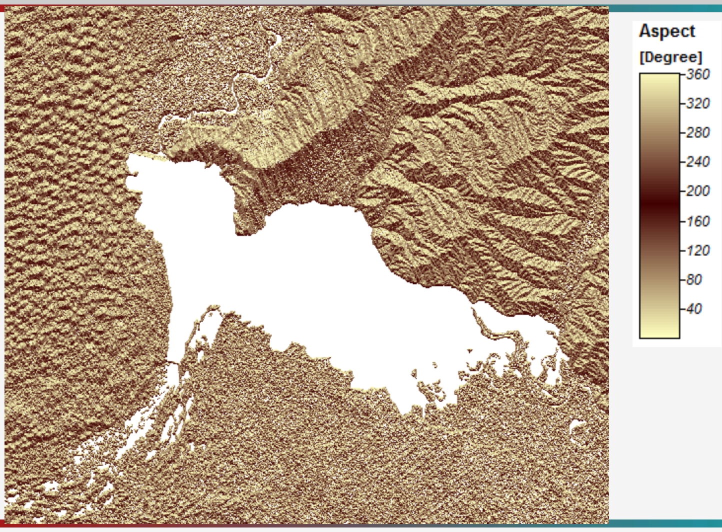
Local surface parameter



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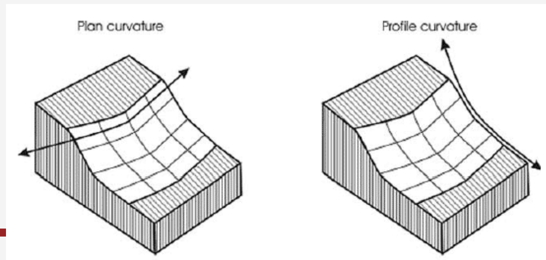
Local surface parameter

- Curvature
  - Denotes the curvature of the surface and could be calculated (theoretically) in every direction.
    In literature we restrict ourselves to:
    - Profile curvature: curvature in the direction of the maximum slope (= the **gradient**)
    - Plan curvature: curvature in horizontal direction



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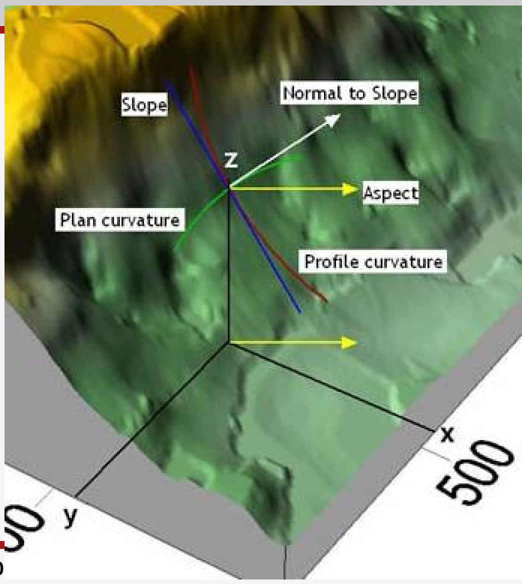
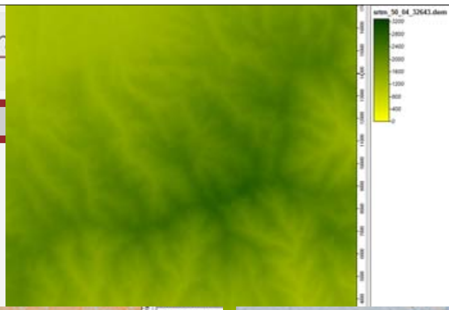
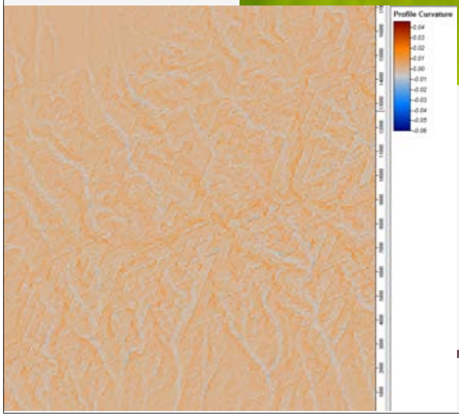
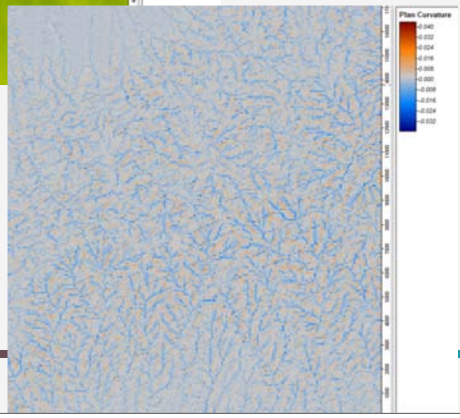
Local surface parameter



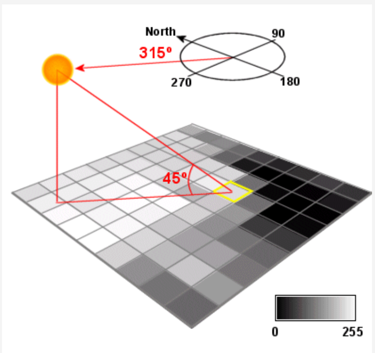






Local surface parameter

- Analytical Hillshading
  - is a technique used to create a realistic view of terrain by creating a three-dimensional surface from a two-dimensional display of it.
  - Hillshading creates a hypothetical illumination of a surface by setting a position for a light source and calculating an illumination value for each cell based on the cell's relative orientation to the light, or based on the *slope* and *aspect* of the cell.



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Local surface parameter

- Hillshades are often used to produce maps that are visually appealing.
  - Used as a background, hillshades provide a relief over which you can draw raster data or vector data.
- When creating a cartographic hillshade, you should place the light source in the north-west (upper-left) quadrant of the map to cast a shadow at the bottom of the object (e.g. mountain).
  - The eye tends to see objects better when the shadow is cast at the bottom of them; placing the light source elsewhere creates a visual effect that makes hills look like holes
  - Thus "classical" values of the sun positions are:
    - Azimuth: 315°
    - Declination: 45°

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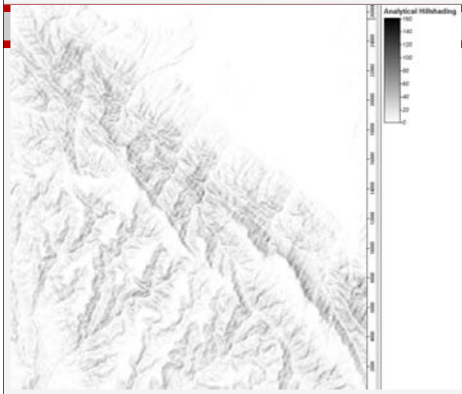
Local surface parameter



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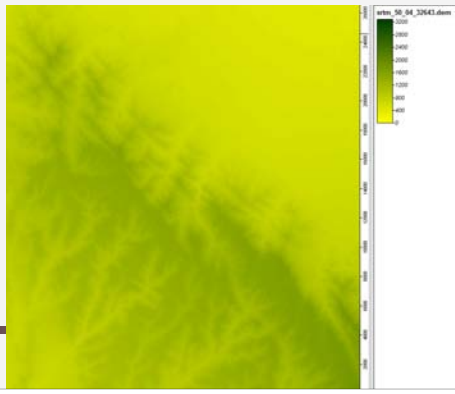

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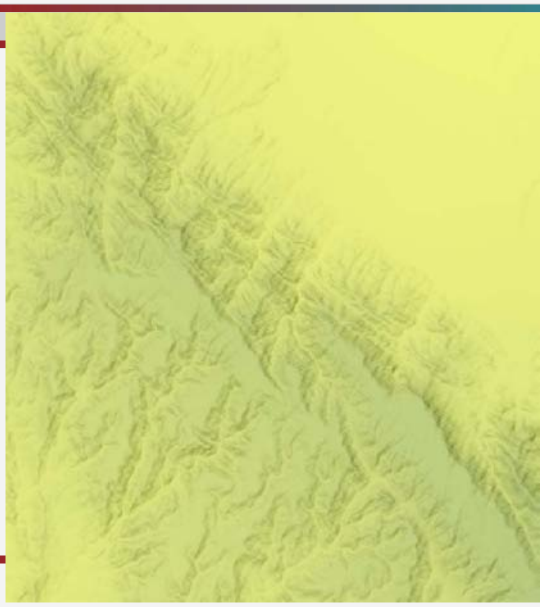
Local surface parameter



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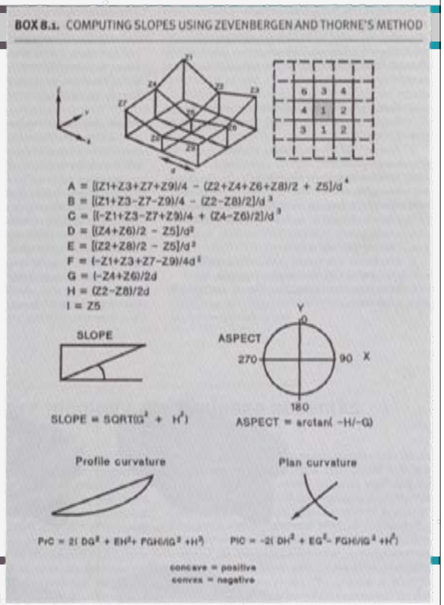
Local surface parameter

- Zevenbergen and Thorne (1987)
  - Created a number of formulas for calculating local surface parameter of discretized surfaces.
  - This method is implemented in a number of commercial GIS and has proven robust and fast.

A detailed description can be found in Burrough and McDonnell (1998)



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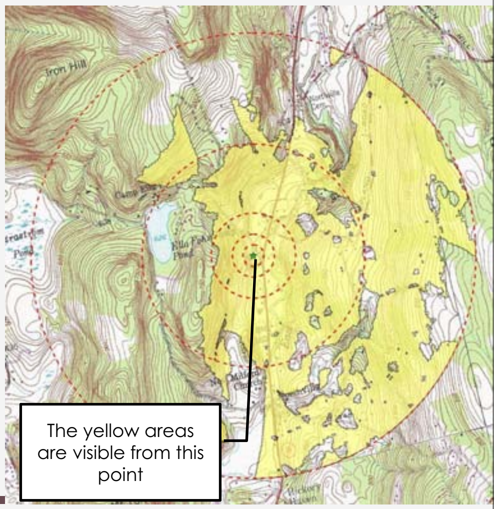
Global surface parameter

- Viewshed Analysis
  - Based on a point of view the visible cells of the surface are calculated
  - Application in:
    - Visual impact analysis
    - Planning and optimization of observer points and stations
    - Optimization of transmission towers



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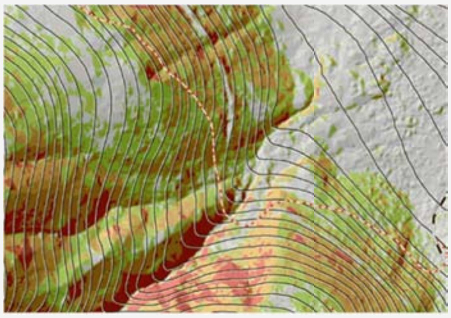
Global surface parameter

- Contour Line:
  - is a line connecting points of equal surface value. Contour lines reveal the rate of change in values across an area for spatially continuous phenomena. Where the lines are closer together, the change in values is more rapid. Elevation and barometric pressure are commonly mapped using contours
  - Contour lines are drawn at an *interval* that you specify. The interval is simply the change in z-value between the contour lines.
  - Lines connecting surface or sample points of equal value are known as *isolines*.
    The following are all examples of different types of isolines:
    - Isobar: Equal barometric pressure
    - Isochron: Connecting lines of equal time
    - Isohel: Equal duration of sunshine
    - Isohyet: Equal rainfall
    - Isoseismal: Earthquake shock intensity
    - Isotherm: Equal temperature
    - Isogonic: Equal magnetism



SAGA GIS „How-to" for surface analysis

- This is a sample walkthrough the steps to perform a surface analysis based on NASA SRTM 90 data (with **no holes and artifacts**).
- This „how-to" might also be valid for other data sources like NASA Global Digital Elevation Model (GDEM) – but several alterations might be neccesary!
- We distinguish several parts:
  - Data preparation:
    - data format change (done with GDAL – www.gdal.org)
    - warp data into a new coordinate reference system (CRS) (done with GDAL)
    - Import data into SAGA GIS
  - Data analysis: calculate the surface parameter ;-)

Open Source

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Data preparation – overview

- SRTM Data can be downloaded from http://srtm.csi.cgiar.org/ in two formats:
  - *.tif with *.tfw file that inludes the georeferencing info
  - *.asc – ESRI ASCII file
- CRS of the SRTM data: WGS 84 lat/lon (EPSG:4326)!
- We need:
  - Data as USGS DEM (*.dem) files – due to better readability of SAGA
  - Data in another CRS, in order run the surface analysis. We need data in UTM 43N (EPSG:32643) (www.epsg-registry.org)
  - Import the *.dem files in SAGA and convert to internal SAGA format (*.sgrd, *.sdat, *.hgrd)

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Data preparation – data format transformation

- Data format transformation done with GDAL
  - ESRI ASCII → USGS DEM

- GDAL is a „only"command line tool, but extremely useful!
- Command for data transfer:

```
gdal_translate -of USGSDEM [sourcepath\filename
e.g. C:\temp\srtm_51_04.asc] [targetpath\filename
e.g. C:\temp\srtm_51_04.dem]
```

→ Gdal_translate is a program of the GDAL library ;)

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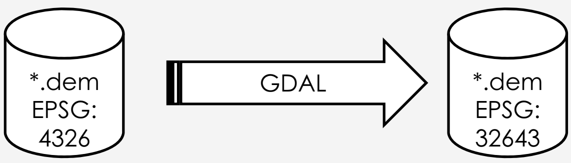
Data preparation – data CRS transformation

- Data CRS transformation of the *.dem files with GDAL
  - therefore the images have to be warped



  - Done with gdal_warp:

```
gdalwarp -s_srs "epsg:4326" -t_srs "epsg:32643"
[sourcepath\filename e.g. C:\temp\srtm_51_04.dem]
[targetpath\filename e.g. C:\temp\srtm_51_04_32643.dem]
```

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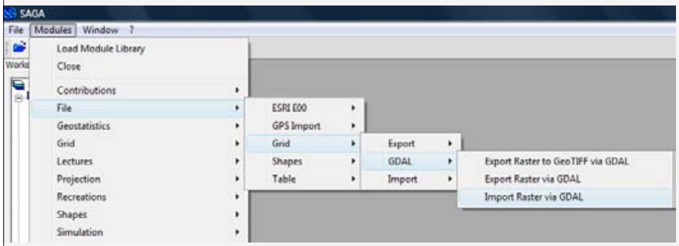
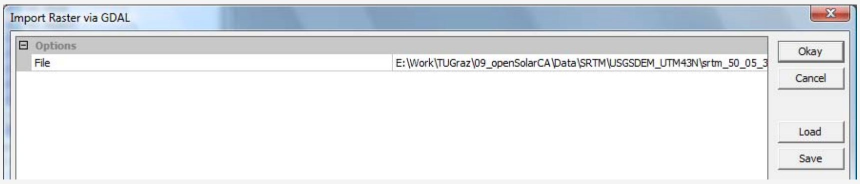
Data preparation – import into SAGA GIS





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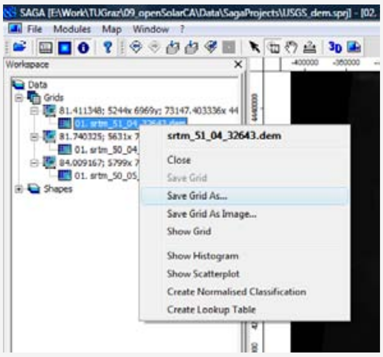
Data preparation – import into SAGA GIS

- after the *.dem has been imported
- Save it as *.sgrd – the SAGA internal format



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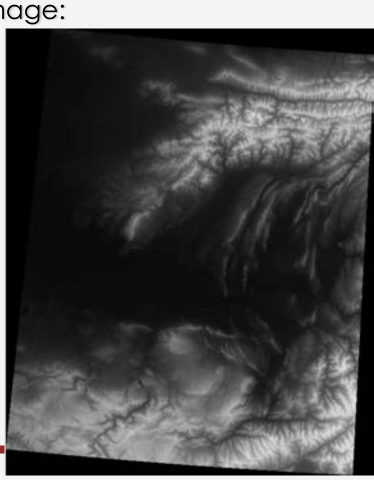
Data preparation – import into SAGA GIS

- Visualization of the DEM in a Map View results in the following image:



Black colored space indicates „no data“ This has to be „removed“

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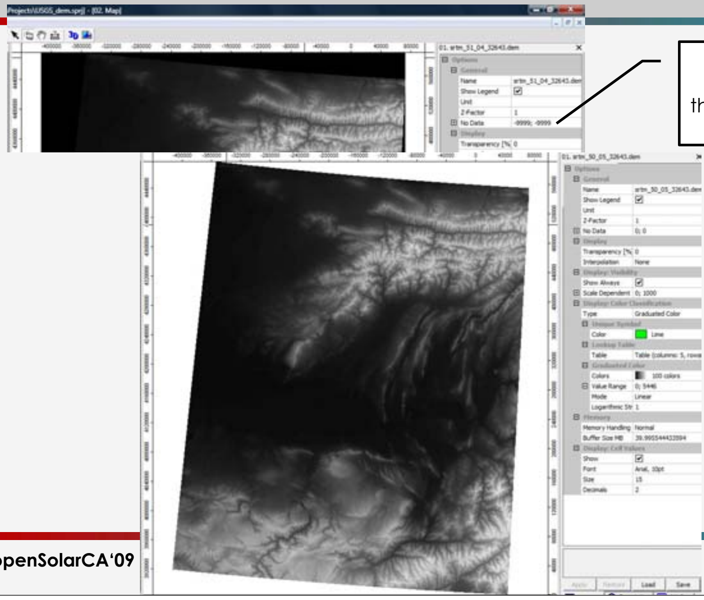
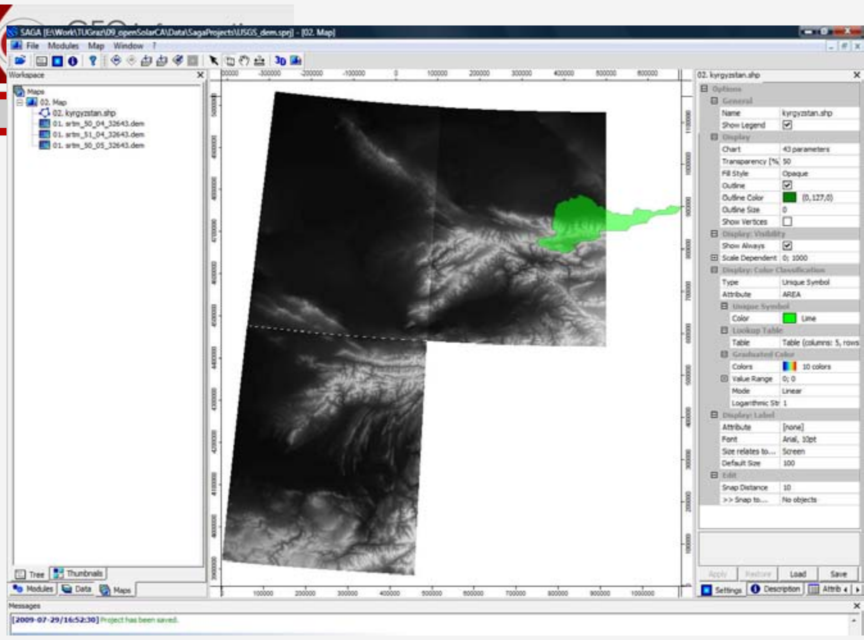
Data preparation – import into SAGA GIS



Set **No data** to **0;0 and click „Apply“** then no data are **not visualized!**



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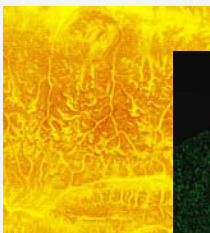
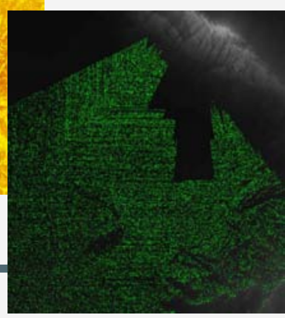
Data analysis

- Creation and calculation of
  - Slope
  - Aspect
  - Plan and Profile Curvature
  - Analytical Hillshade

  - Viewshed analysis
  - Contour lines

SAGA
System for Automated Geoscientific Analyses





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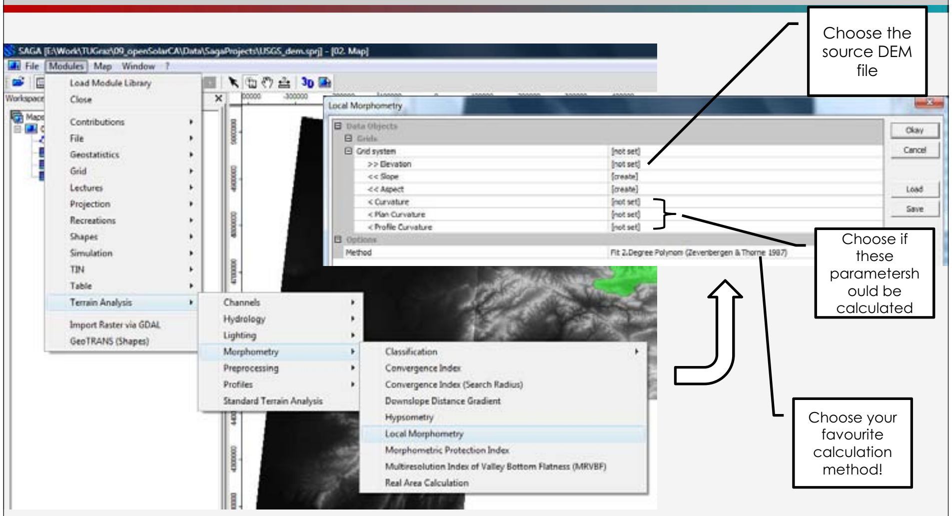
Data analysis



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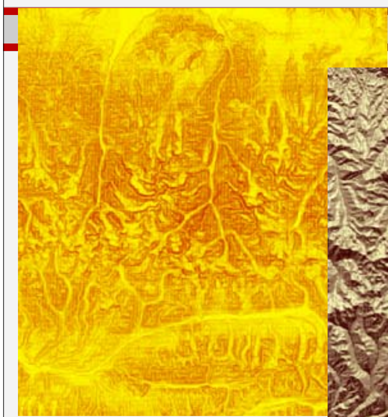
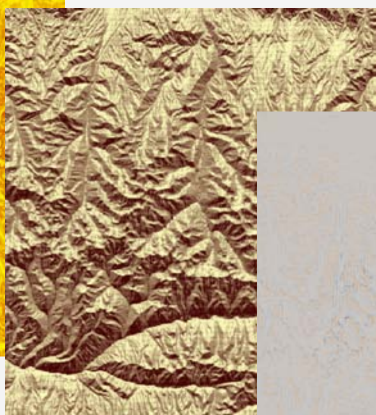
Data analysis


Slope


Aspect


Profile Curvature

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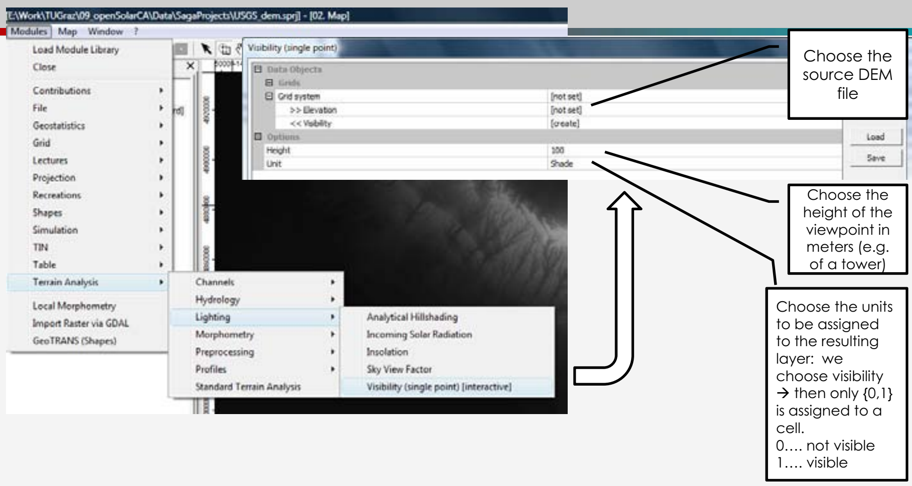
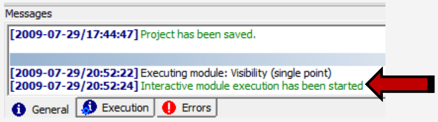
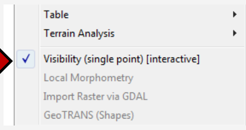
Data Analysis – Viewshed Analysis



Data Analysis – Viewshed Analysis

- After clicking of „Okay" the module starts
  - Nb! This is an **interactive module!**
  - Thus you have to click with the action tool somewhere in the desired DEM in order to select your viewpoint.
  - Calculation of the visibility starts – takes some time
- Nb! After the calculation is finished the interactive module is still **active**!
  - The activity of the module can be tracked in the Message pane and the modules menu.





  - An active moduel can be shut down by clicking on the arrow indicating the activity in the modules menu

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Data Analysis – Viewshed Analysis

Settings for a „good looking" result

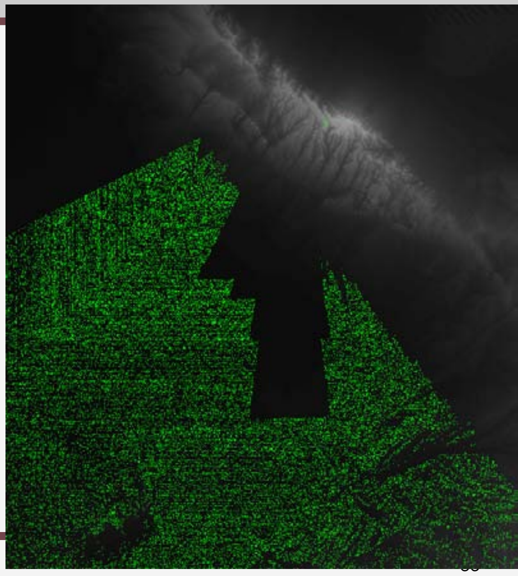
- No data: -99999;0

„real" no data cells have value -99999

to „hide" not visible cells – they have value 0

- Value range: 1;1

To visualize only visible cells ;)



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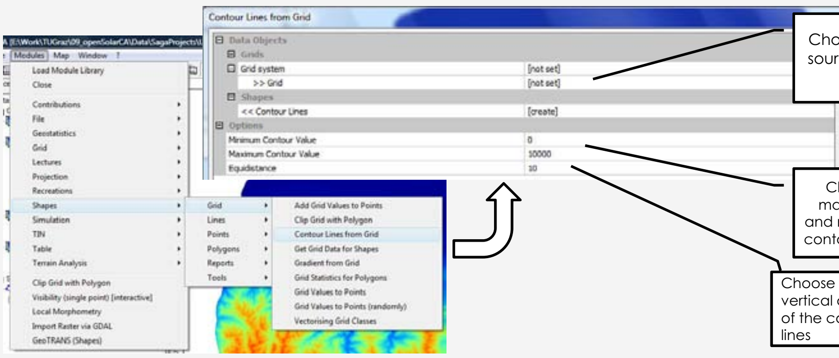
Data Analysis – Contour Lines



Choose the source DEM file

Choose maximum and minimum contour value

Choose the vertical distance of the contour lines

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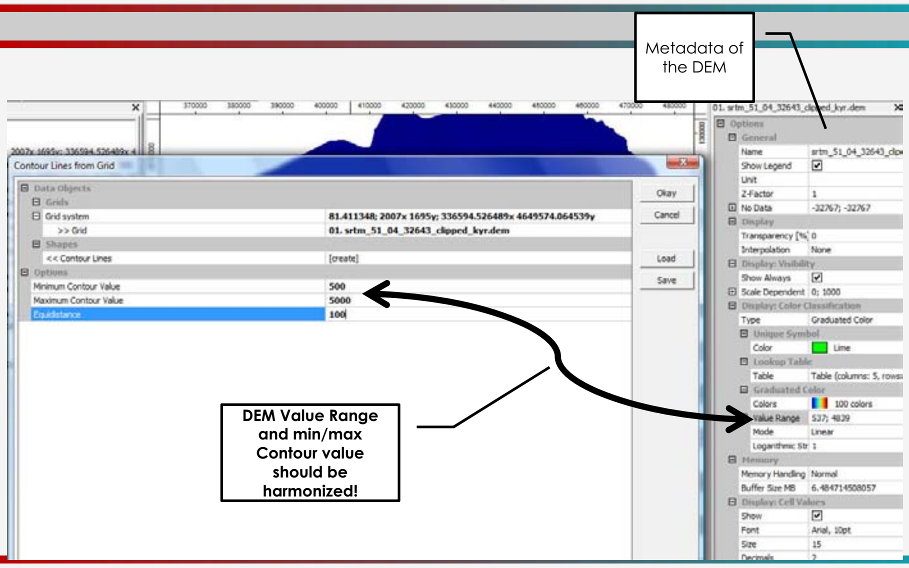
Data Analysis – Contour Lines



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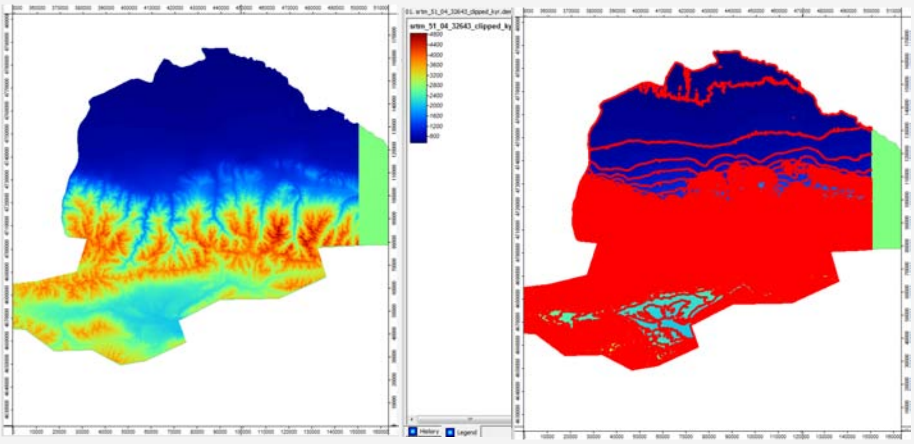
Data Analysis – Contour Lines



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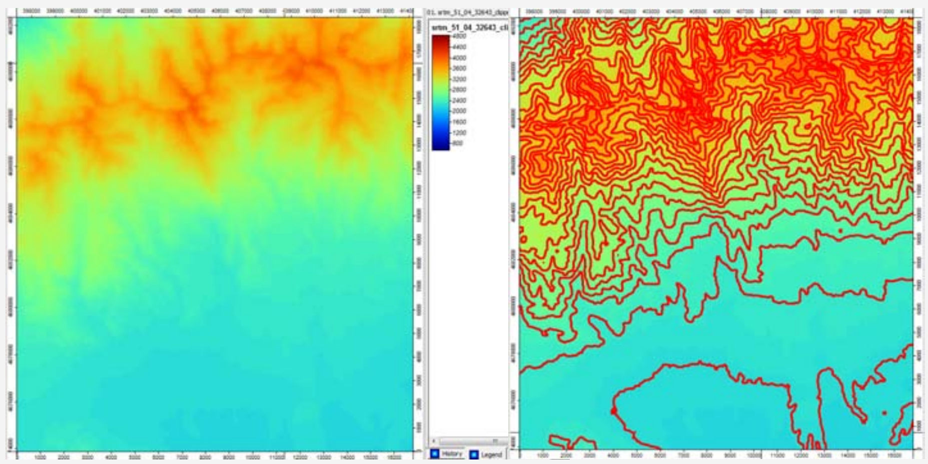

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Conclusion

- Results of analysis of DEM's is important for a number of GIS processes, e.g.
  - Hydrological modeling
  - Solar potential
  - Infrastructure planning issues
  - etc.
- Theoretical concepts:
  - Preparation of surface data
  - „local" vs. global analysis
- SAGA proves an effective and efficient tool for DEM analysis!

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Ressources

- Longley, P. A. and Goodchild, M. F. and Maguire, D. J. (2005): GEOGRAPHIC INFORMATION SYSTEMS AND SCIENCE. Second Edition. John Wiley, Chichester.
- Tomlin, C. D. (1990): Geographic Information Systems and Cartographic Modeling. Prentice Hall, Englewood Cliffs, NJ.
- BURROUGH, P. A. and MCDONNELL, R. A. (1998): Principles of Geographical Information Systems. Oxford University Press, New York.
- Zevenbergen, L.W. and Thorne, C.R. (1987): Quantitative Analysis of land surface topography. Earth Surface Processes and Landforms, 12:47-56

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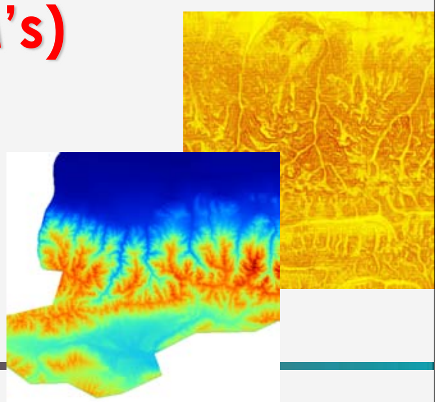
Analysis of digital elevation models (DEM's)



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Abstract

Methodology for modelling hydro energy potentials: Austrian & Central Asian examples

H. Holzmann, J. Fürst

University of Natural Resources and Applied Life Sciences Vienna (BOKU)

Content:
Definition of hydro energy potential (gross theoretical linear potential). Data demand (DEM, precipitation, runoff). Small hydro power plants (design, technical feasibility). GIS tools for potential assessment. Examples and restrictions (Austria / Central Asia)

Objectives:
The participants will learn about the benefit of small hydropower plant, the prerequisites and data demand for planning and design and the integration of GIS for optimization procedures.

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BOKU Univ. of Natural Resources and Applied Life Sciences Vienna

Methodology for modelling hydro energy potentials

Austrian & Central Asian examples

Hubert Holzmann & Josef Fuerst
Email: hubert.holzmann@boku.ac.at)

Content

Hydro Energy Production

Electricity production from hydropower has been, and still is today, the first renewable source used to generate electricity. Nowadays hydropower electricity in the European Union - both large and small scale – represents 13% of the total electricity generated, so reducing the CO2 emissions by more than 67 million tons a year. In 2001, approximately 365 TWh of hydro energy was produced in the European Union from an overall capacity of 118 GW.

Small hydro plants accounted for 8.4% of installed capacity (9.9 GW) and produced 39 TWh (about 11% of Hydropower generation). Given a more favorable regulatory environment, the European Commission objective of 14000 MW by 2010 should be achievable and that small hydro would be the second largest contributor behind windpower.

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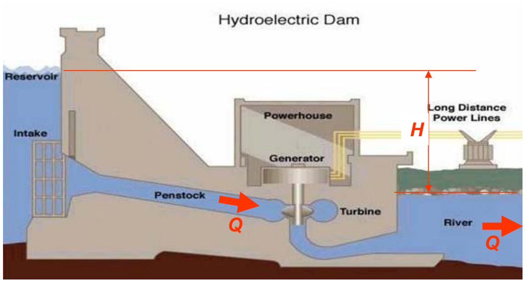
HPP Scheme



The "fuel" of hydropower is running water, which means rivers of any site can be used, whilst keeping the water available for any other purpose. The energy to be utilised is based on two input facts: **Discharge *Q*** in m3/s and **head *H*** in m. Both facts are necessary - the product indicates the power output of the hydropower station.

Head *H* is defined as the difference in elevation between two particular cross sections of the river. Making a head useful for hydropower -use needs a concentration by means of hydropower impoundment, diversion or tail water lowering. At the point of concentration the powerhouse is situated.

The conversion of the energy potential of the river into electricity requires ***a turbine*** (potential and kinetic energy into mechanical energy) [rotation] and ***a generator*** [rotation into electrical energy]. The output of a hydropower plant is given in terms of ***power*** [kW] and ***electricity production*** [kWh]. The result can be calculated as follows:

Power P:

P (kW) = Q (m³/s) x H (m) x η_{tot} x 9,81
and approximately **Q x H x 7,8**

η_{tot} = total efficiency ($\eta_{turbine}$ x $\eta_{generator}$ x η_{trafo})
P = electrical power output
Q = rated discharge
H = net head

Electricity production E:

E is power during a certain time period. The annual electricity production of a hydropower (HP) station is approximately calculated as

E (kWh) = P (kW) x 4500 (h)

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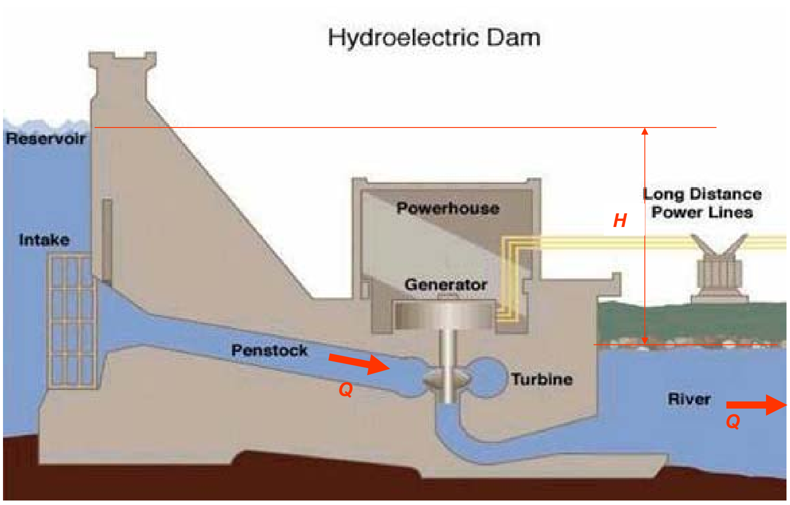
HPP Scheme



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HPP Scheme

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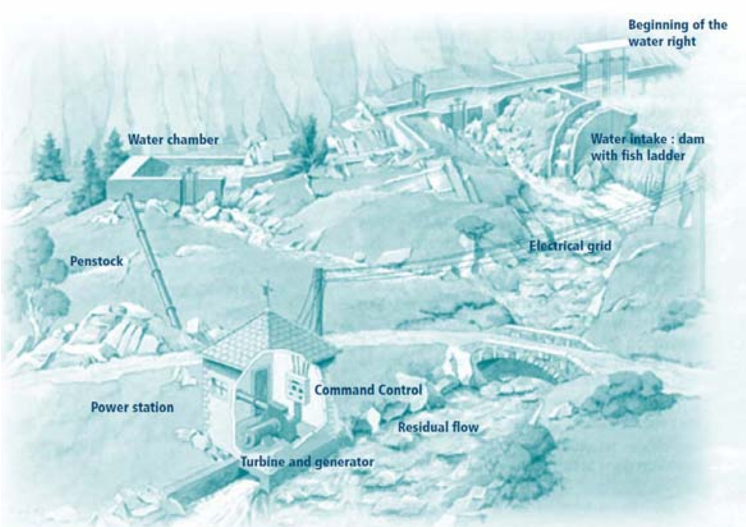

From ESHA (2006)

Workshop ***openSolar'09*** Bishkek, 24. -26. Aug. 2009

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HPP Scheme

Current Technology

There are three main types of hydroelectric schemes, these are:

- **Run of the River**
- **Diversion**
- **Pumped Storage**

In the **Run of the River** type of scheme, the turbine and generator are located either in the dam or found along side it. The dam uses the flow of the river to create the hydrostatic head.

A **Diversion** scheme is where the supply of water is taken from a dammed river or lake to a remote powerhouse containing the turbine and generator. A Canal or low-pressure tunnel transports the water to this end point and then back to the river to continue its course.

Pumped storage is a scheme that incorporates two reservoirs. At times of low demand, generally when electricity is cheap like at night, electricity is bought to pump water from the lower to the upper basin. This extra water can then be released to create power at a time when demand is high and prices high. This means that the company make money on their investment of electricity for pumping. This enables the scheme to perform with greater efficiency when matching supply and demand.

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Streamflow Estimation

In order to determine the hydro potential of a site, ***information regarding amount and variation of streamflow is essential***. You should find out if streamflow records have been kept for the stream at any time.

If historic flow records are not available, you should immediately begin monitoring the streamflow at the site: the feasibility of constructing a small power plant is dependent on exactly how much power your stream will put out. The two most important factors to consider are flow and head.

Flow is the quantity of water flowing past a point at any given time. This amount varies both seasonally and annually, so it is important to collect accurate data for each season of a full year. These data should then be compared to other information from your area to decide if it was a dry year or a wet year.

Minimum flow rates are necessary to accurately assess the minimum continuous power output you can expect from your hydro unit. Also, maximum flow estimate is needed to ensure that your structure will withstand peak flooding.

Head is the vertical distance in feet from the surface of the supply water to where the water leaves the turbine. The head exerts pressure that can be turned into usable power, so the greater distance the water falls, the more energy is available.

Once you have determined the net head and the average flow rate for your site, you can calculate the power output from your stream.

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Hydro Potential

For the theoretical hydropower potentials different definitions exist. The so called surface potential of precipitation is determined from the amount of precipitation falling on a catchment area and is the gravitational potential energy given by the amount of rainfall at a surface point and the drop of height to the basin outlet. Deduction of evaporation and infiltration results in the surface potential of the discharge, which represents the upper limit of the hydroelectric potential.

The mean hydropower potential of a river reach is defined as the energy that is produced by the flow in a stream section per unit time. For a given stream segment, it is calculated by

$$P = g \cdot \rho \cdot Q \cdot \Delta h$$

where
- P … power in (W)
- g … acceleration of gravity (9,81 m/s²)
- ρ … density of Water (1000 kg/m³)
- Q … discharge in (m³/s)
- Δh … drop of height in (m)

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Hydro Potential

In order to determine the hydro potential of a site, ***information regarding amount and variation of streamflow is essential***. You should find out if streamflow records have been kept for the stream at any time.

If historic flow records are not available, you should immediately begin monitoring the streamflow at the site: the feasibility of constructing a small power plant is dependent on exactly how much power your stream will put out. The two most important factors to consider are flow and head.

Flow is the quantity of water flowing past a point at any given time. This amount varies both seasonally and annually, so it is important to collect accurate data for each season of a full year. These data should then be compared to other information from your area to decide if it was a dry year or a wet year.

Minimum flow rates are necessary to accurately assess the minimum continuous power output you can expect from your hydro unit. Also, maximum flow estimate is needed to ensure that your structure will withstand peak flooding.

Head is the vertical distance in feet from the surface of the supply water to where the water leaves the turbine. The head exerts pressure that can be turned into usable power, so the greater distance the water falls, the more energy is available.

Once you have determined the net head and the average flow rate for your site, you can calculate the power output from your stream.

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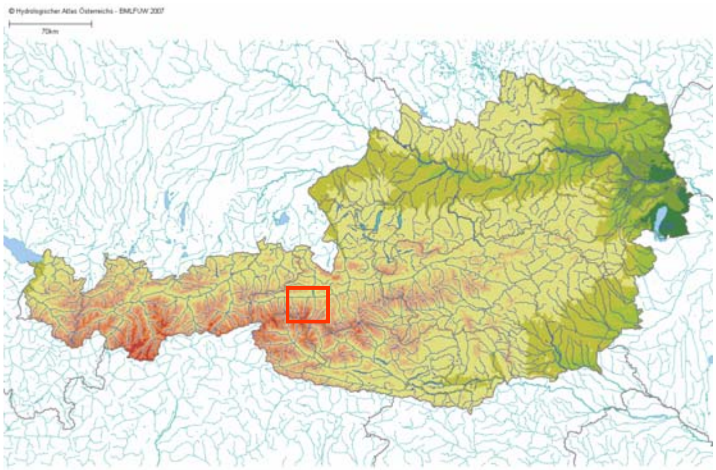
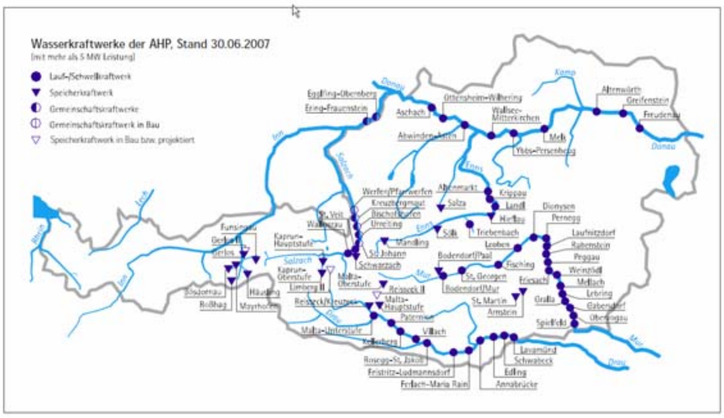
Data Demand

River Network and Elevation



HPP in Austria

- In River HPP ●
- Storage HPP ▼

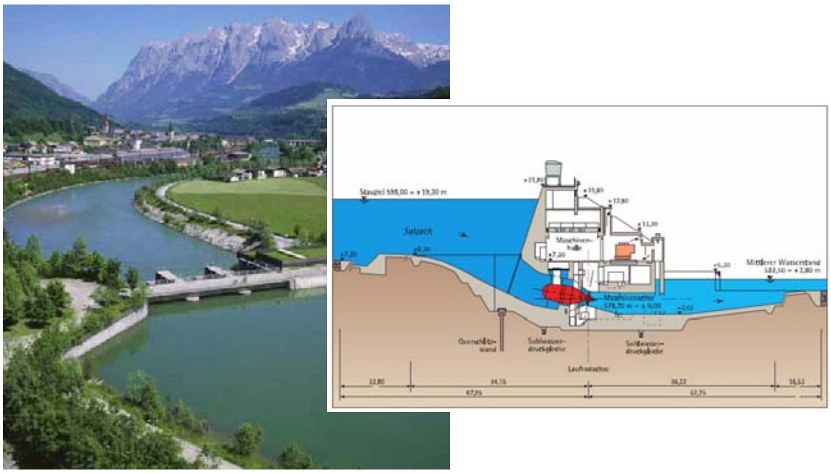


HP Schemes

Storage HP Plants

HP Schemes

In River Systems



Data Demand

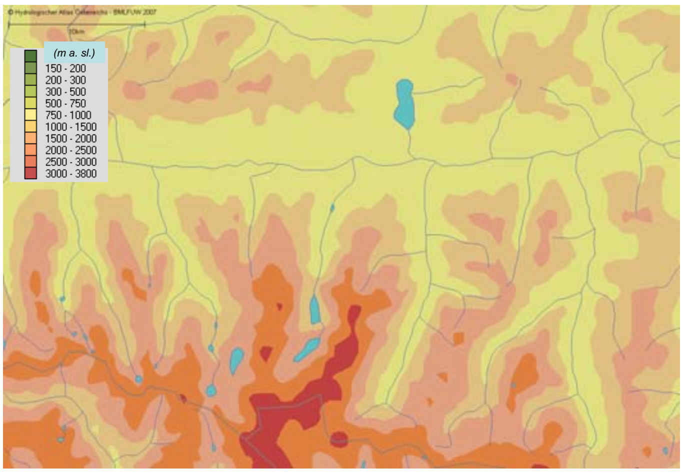
Areal potential:

Surface Potential of Precipitation:

- Mean annual (areal) precipitation
- Mean areal elevation
- Subbasin Boundaries and Elevation of basin outlet

Data Demand

River Network and Elevation



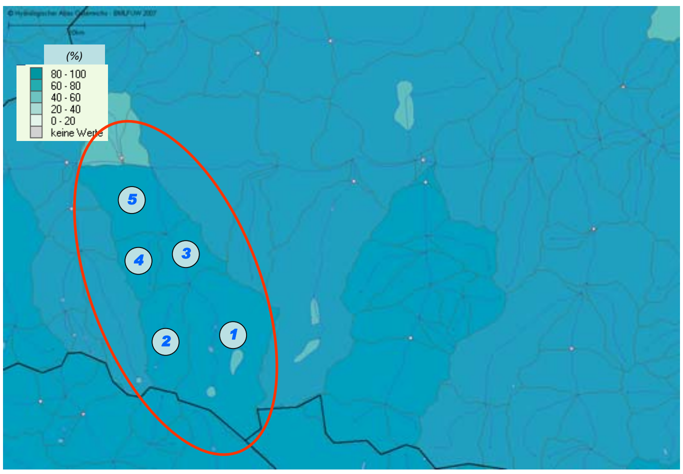
Mean Annual Precipitation / Subbasin boundaries

Areal potential:

Surface Potential of Discharge:

- Mean annual (areal) precipitation
- Mean areal elevation
- Subbasin Boundaries and Elevation of basin outlet
- Runoff coefficient

Runoff Coefficient / Subbasin boundaries



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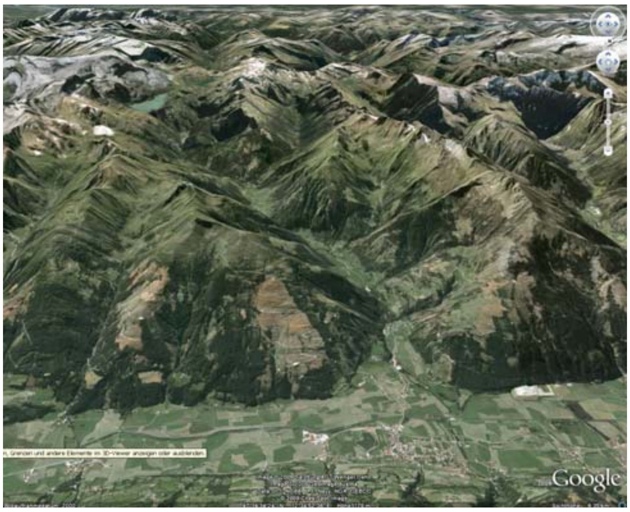
Land Information

Test Basin Stubach Valley



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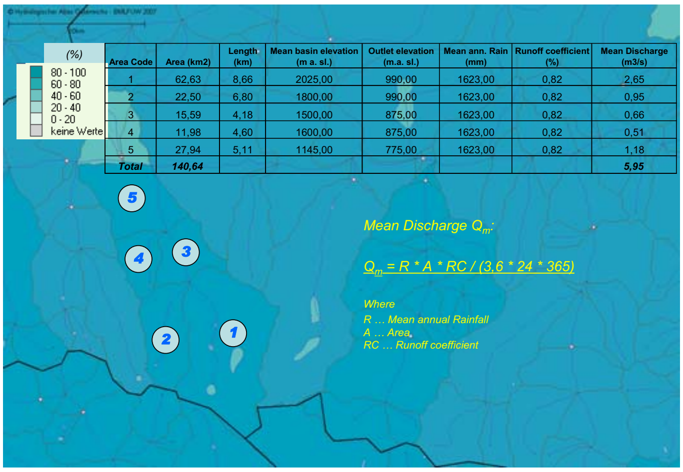
Data Demand

Computation of Surface Potential of Discharge



Area Code	Area (km2)	Length (km)	Mean basin elevation (m a. sl.)	Outlet elevation (m.a. sl.)	Mean ann. Rain (mm)	Runoff coefficient (%)	Mean Discharge (m3/s)
1	62,63	8,66	2025,00	990,00	1623,00	0,82	2,65
2	22,50	6,80	1800,00	990,00	1623,00	0,82	0,95
3	15,59	4,18	1500,00	875,00	1623,00	0,82	0,66
4	11,98	4,60	1600,00	875,00	1623,00	0,82	0,51
5	27,94	5,11	1145,00	775,00	1623,00	0,82	1,18
Total	***140,64***						***5,95***

Mean Discharge Q_m:

$$Q_m = R * A * RC / (3,6 * 24 * 365)$$

Where
R … Mean annual Rainfall
A … Area
RC … Runoff coefficient

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Data Demand

Linear Potential:

Theoretical Linear Potential of Discharge:

- Mean annual discharge (or precipitation and runoff coefficient)
- Elevation of River Course
- Definition of Nodes (river reaches; junctions)

The introduced method does not consider the total losses in energy production (sufficiency of turbine, generator, trafo; hydraulic friction and turbulence losses).

For in river HPP the selection of the design capacity is of high importance. As the natural discharge shows high annual variability (melt processes, floods, droughts, snow accumulation) the turbines have to be optimized in that way, that the product of discharge, efficiencies and net height forms a maximum. In addition environmental impacts an demands have to be considered.

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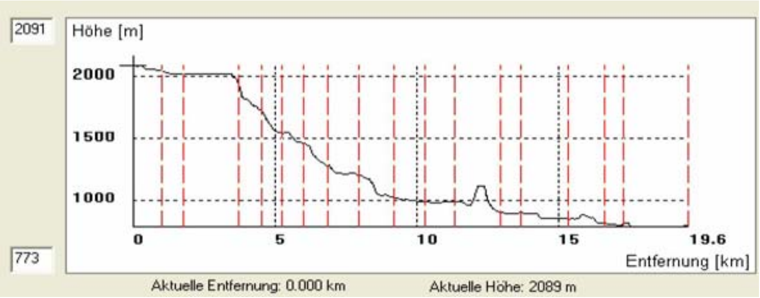
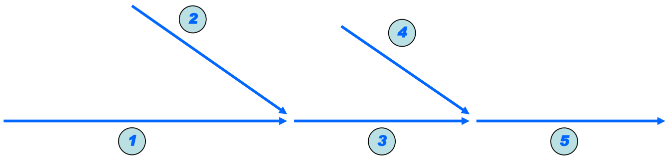
Data Demand

Linear Potential





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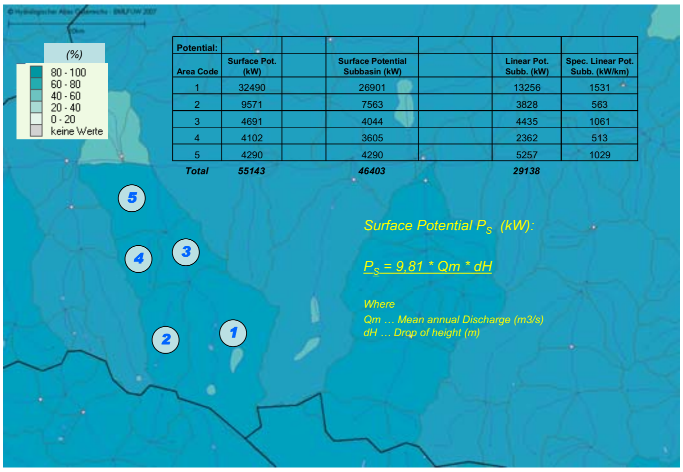
Data Demand

Surface Potential of Discharge and Linear Potential



Potential:						
Area Code	Surface Pot. (kW)		Surface Potential Subbasin (kW)		Linear Pot. Subb. (kW)	Spec. Linear Pot. Subb. (kW/km)
1	32490		26901		13256	1531
2	9571		7563		3828	563
3	4691		4044		4435	1061
4	4102		3605		2362	513
5	4290		4290		5257	1029
Total	*55143*		*46403*		*29138*	

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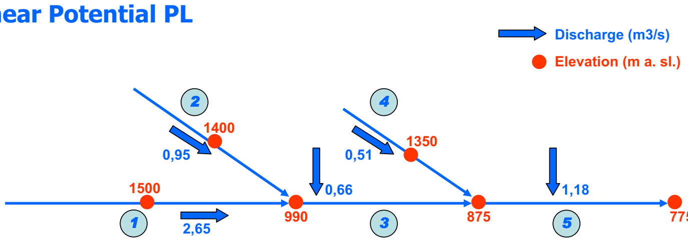
Computation Example

Linear Potential PL



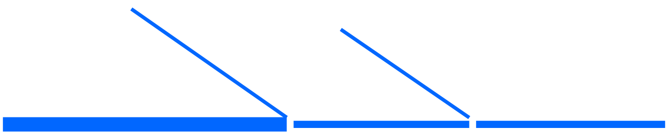
Reach 1: PL1 = 9,81 * 2,65 * (1500 – 990) = 13 256 kW = 1 531 kW/km

Reach 2: PL2 = 9,81 * 0,95 * (1400 – 990) = 3 828 kW = 563 kW/km

Reach 3: PL3 = 9,81 * ((2,65 + 0,95) * (990 – 875) + 0,66 * (990 – 875)/2) = 4 435 kW = 1 061 kW/km

Reach 4: PL4 = 9,81 * 0,51 * (1350 – 875) = 2 362 kW = 513 kW/km

Reach 5: PL5 = 9,81 * ((2,65 + 0,95 + 0,66 +0,51) * (875 - 775) + 1,18 * (875 – 775)/2) = 5 257 kW = 1 029 kW/km



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Linear Potential Map

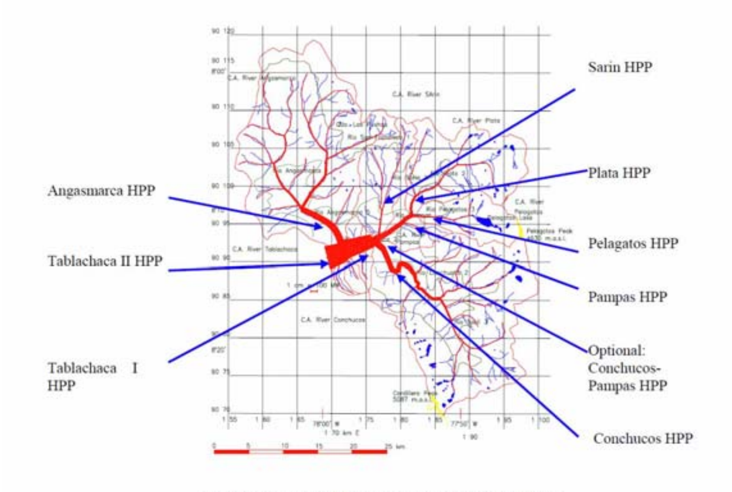

Fig.14 Linear Potential Diagram Upper Watershed Tablachaca
(From Maduenjo Ludan (2003))

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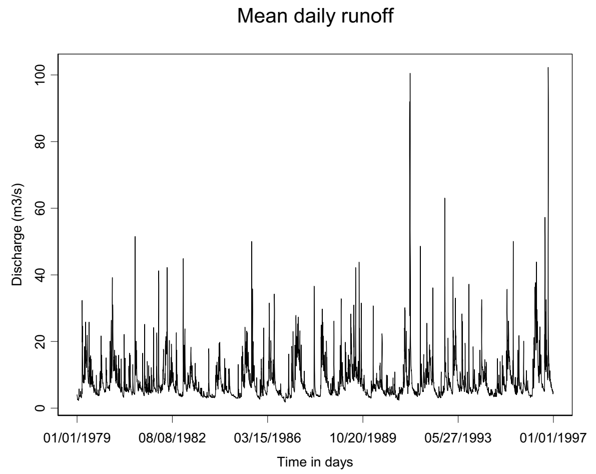
Streamflow Variability



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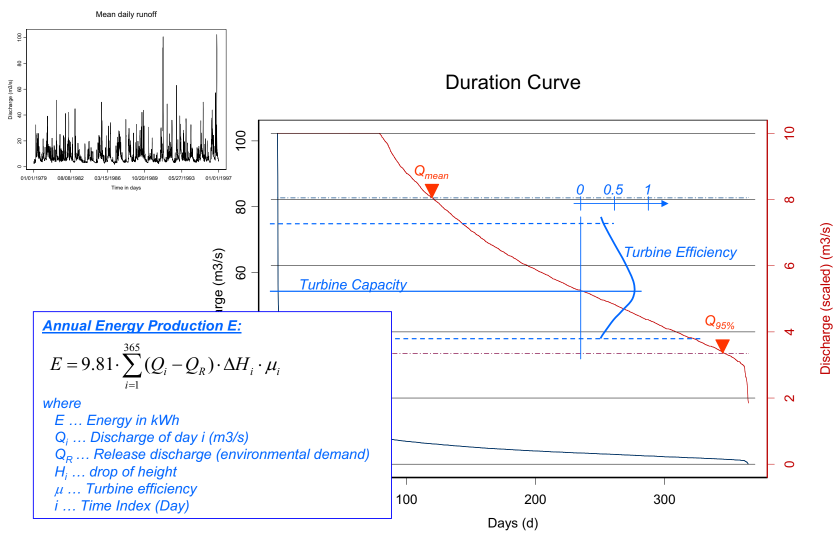
Streamflow Variability



Annual Energy Production E:

$$E = 9.81 \cdot \sum_{i=1}^{365} (Q_i - Q_R) \cdot \Delta H_i \cdot \mu_i$$

where

- *E … Energy in kWh*
- *Q_i … Discharge of day i (m3/s)*
- *Q_R … Release discharge (environmental demand)*
- *H_i … drop of height*
- *μ … Turbine efficiency*
- *i … Time Index (Day)*

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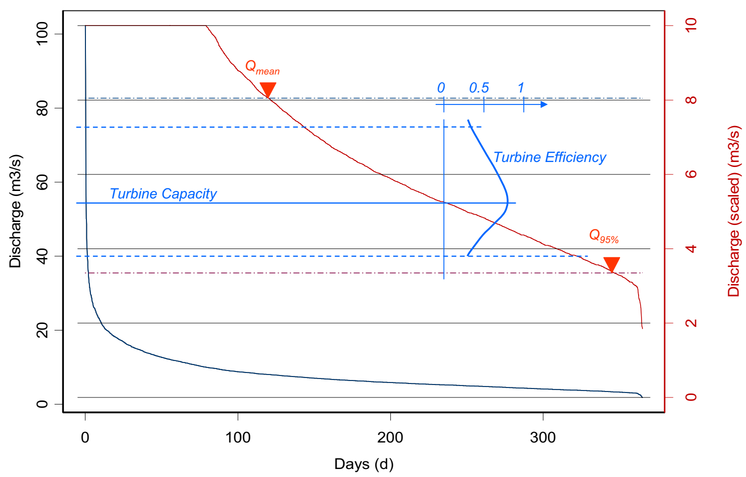
Streamflow Variability

Duration Curve



Energy Production

Annual Energy Production E:

$$E = 9.81 \cdot \sum_{i=1}^{365} (Q_i - Q_R) \cdot \Delta H_i \cdot \mu_i$$

where

E … Energy in kWh
Q_i … Discharge of day i (m3/s)
Q_R … Release discharge (environmental demand)
H_i … drop of height
μ … Turbine efficiency
i … Time Index (Day)

Environmental Impact

Affected processes

- Minimum Release Water (Reserved Flow concept)
- Artificial flash floods
- Fish Migration
- Continuity of sediment load

From: http://en.wikipedia.org/wiki/Fish_ladder

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Environmental Impact

Water turbines alone have a negligible effect on the environment. Most hydro systems, however, require **a dam** to ensure a continuous source of water. Damming a river or stream can have a long-term effect on the environment surrounding the site. Streamflow is changed, and the water table is usually raised behind the dam and lowered downstream from the structure.

You are creating a **pond or lake** where a stream ecosystem used to exist, so silt may accumulate and you may have constructed an ideal breeding ground for mosquitoes. Fish movement may be blocked if a fish ladder isn't used. Access roads may contribute to erosion and disrupt the landscape.

In general, the larger the dam, the greater the impact on the environment. If you foresee the ecological impact of installing a hydroplant, you can keep stream disruption to an absolute minimum. Keep in mind that you may have to radically change your design to work with your local ecosystem or, in some cases, abandon the hydropower project completely.

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Hydro Potential of Austria

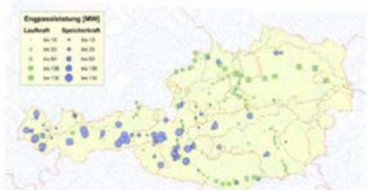
Ausgebautes Wasserkraftpotential

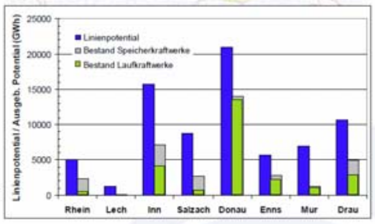
- Ausgebautes Wasserkraftpotential
  Anlagen ≥ 10 MW (147 Anlagen)

  Gesamt 35.300 GWh
  Laufkraft 25.100 GWh
  Speicher 10.200 GWh

- Kleinwasserkraft < 10 MW

  Gesamt ca. 5.000 GWh
  (Genaue Erhebung schwierig)





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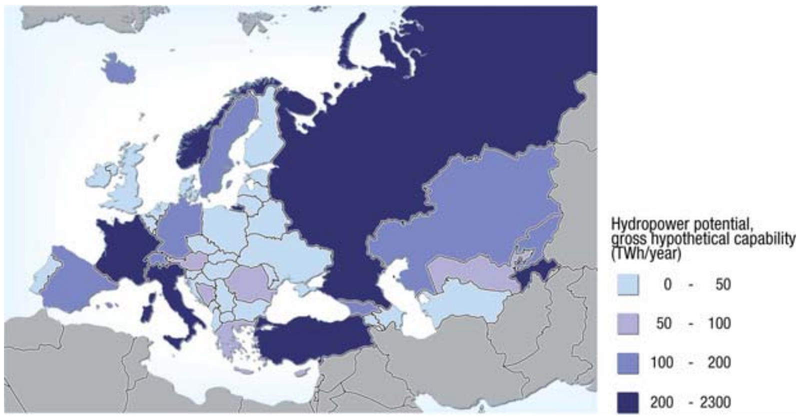
Hydropower Potential



From: UNEP / GRID (2009)

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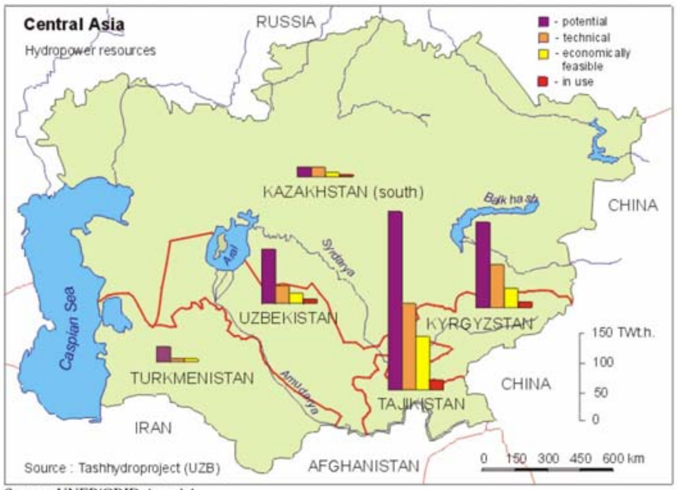
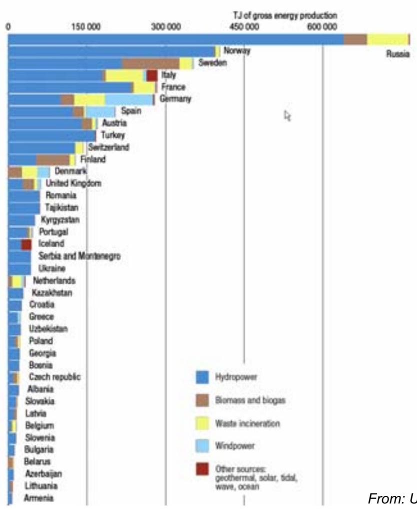
Hydropower Potential



Source: UNEP/GRID Arendal

Topography

Renewable Energy Production



From: UNEP / GRID (2009)

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Abstract

Multiresolution Modelling of Regional Solar Energy Potentials: Austrian & Central Asian examples

Manfred Mittlböck

University of Salzburg

Solar energy is quite simply the energy produced directly by the sun and collected on the Earth. Therefore the electromagnetic radiation from the sun is the indirect source of nearly every type of energy used today. The Earth's atmosphere significantly impacts the amount of solar energy reaching the surface of the Earth. Those waves - not reflected or blocked - directly hitting the surface are called direct radiation, those deflected diffuse radiation. Both together define the global radiation which will be investigated in this course for modeling the solar energy potentials using GIS tools.

Important factors for solar energy are the angle at which solar waves hit the surface (dependent on Earth rotation and different times of the year) and the weather conditions. When dealing with small landscape scales, topography are a major factor that determine the spatial variability of insolation. Variation in elevation, orientation (slope and aspect), and shadows cast by topographic features all affect the amount of sun radiation received at different locations. The course introduces the main parameters of solar radiation, solar heating and photovoltaics. In a practical approach the course will guide through calculating the solar radiation potential including digital terrain models, vegetation and climate/atmosphere parameters and introduces the most important concepts in modeling solar radiation using COTS GIS and Open Source GIS tools (SAGA GIS).

The Lab Sessions starts with a short introduction including some background information about global solar radiation. Afterwards the presentation wants to show how to calculate the total solar radiation over a given geographic area (here: extent - city of Salzburg) for a specific time period. This practical course deals with modeling solar radiation step by step.

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Solar energy potentials

openSolarCA'09

Workshop August, 2009 in Bishkek, Kyrgyzstan

Manfred Mittlboeck

Research Studios Austria Forschungsgesellschaft mbH

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Solar Energy Potentials Agenda

- Modelling solar insolation for deriving solar energy potentials in small scale environments
  - Terrestrial solar illuminance
  - Usage of solar energy potentials
  - Large Scale / scale insolation modelling
  - GIS Modelling using
    - DEM, Lidar, LaserScan and
    - Climate data

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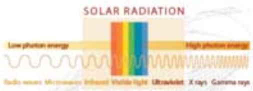
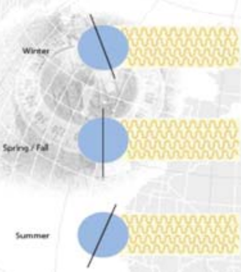
Solar Energy Potentials Terrestrial solar illuminance

- Extra terrestrial solar illuminance (E_{ext})
  - Using the solar constant (E_{sc}) = 128×10³ lx = *1,366 W/m²* for earth:

$$E_{ext} = E_{sc}\left[1 + 0.034 \cdot \cos\left(2\pi \frac{dn-3}{365}\right)\right],$$

  - Affected by
    - Angle of solar radiation reaching the earth
    - Atmospheric extinction





http://www.masstech.org

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Solar Energy Potentials
Solar energy usage

- Passive Solar (working with the power of sun)
  - Building using the power of the sun
    - Specific structure
      - Northern hemisphere focusing on **south orientation** (to take advantage of the winter sun)
      - **Natural light** optimizing window size and orientation (=daylighting techniques)
      - **Blocking heat** using overhangs and sunshades
      - Black Color (converting solar energy into heat)

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Solar Energy Potentials
Solar energy usage

- Solar heating
  - Small Scale water/space heating
    - **flat plate** collector
      - bumping fluid through a series of pipes
      - heated water will be stored in a tank
    - **batch collector**
  - Large scale/industrial heating
    - **concentration collector & parabolic trough collector**
      - Collector and storage in one device
        - Mirror reflecting the sunlight into a tube for producing large amount of heat (solar steam)

Abengoa Solar - Trough collector

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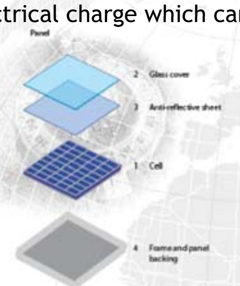
Solar Energy Potentials
Solar energy usage

- Photovoltaiks - PV
  - Relying on physical properties of some materials known as semiconductors
    - Hit with sunlight the materials produce electrical charge which can be leveraged as electricity
    - Silicon cells organized in panels
      - **Monocrystalline Silicon** Panels
        - 15-20 % efficiency
      - **Polycrystalline Silicon** Panels
        - 12-15% efficiency
      - **Amorphous Silicon** or Thin Film Panels
        - 5-6% efficiency



http://masstech.org

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Solar Energy Potentials
Solar energy usage

- Photovoltaiks - PV
  - Area consumption for 1kWp (5kWp ~ 4 persons household)
    - **Monocrystalline Silicon** Panels
      - 7 – 9 sqm
    - **Polycrystalline Silicon** Panels
      - 9 – 11 sqm
    - **Amorphous Silicon** or Thin Film Panels
      - 16 -20 sqm

Watt peak: (technical definition): The Watt Power output of a Solar module is the number of Watts Output when it is illuminated under standard conditions of 1000 Watts/meter² intensity, 25°C ambient temperature and a spectrum that relates to sunlight that has passed through the atmosphere (AM or Air Mass 1.5).

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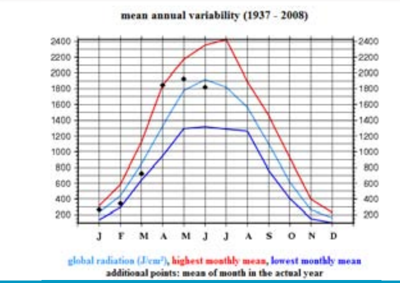
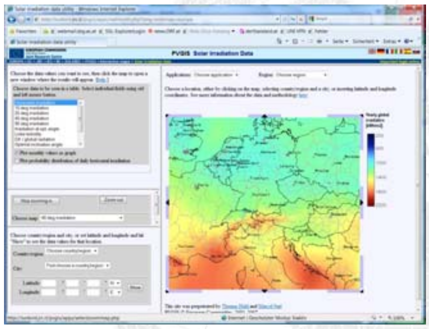
Solar Energy Potentials
Solar insolation

- Electromagnetic radiation from the sun on the surface of the earth
  - global radiation (kWh/m²)

Central Australia = 5.89 kWh/m2/day - Very High
Helsinki, Finland = 2.41 kWh/m2/day - Very Low





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Solar Energy Potentials
Solar insolation

- Electromagnetic radiation from the sun
  - global radiation
    - direct radiation
    - diffuse radiation

Global solar radiation is the total short-wave radiation from the sky falling onto a horizontal surface on the ground. It includes both the **direct solar radiation** and the **diffuse solar radiation** resulting from reflected or scattered sunlight.

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Solar Energy Potentials
Solar insolation

- Global Radiation
  - direct radiation

    It is the solar radiation that is *transmitted directly* through the atmosphere to the earth's surface without interacting with atmospheric components
  - diffuse radiation

    is the solar radiation that is *scattered or reflected* by atmospheric components (clouds, for example) to the earth's surface

National science Digital Library

NASA - Surface meteorology and Solar Energy Data Set:Average Insolation (10 year average) kWh/m²/day

Country	State/City	Latitude	Longitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year Avg
AT	Vienna	48° 13' N	16° 22' E	1.10	1.81	2.80	3.76	4.76	5.12	5.72	4.98	3.68	2.15	1.28	0.93	3.52
BE	Bruxelles	50° 45' N	4° 30' E	0.74	1.31	2.29	3.68	4.67	4.48	4.82	4.20	2.86	1.73	0.92	0.56	3.02

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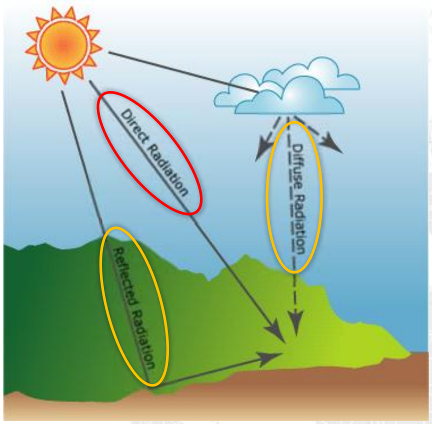
Solar Energy Potentials
Solar insolation

- $Global_{tot}$ = Global Radiation
- Dir_{tot} = Direct radiation largest part
- Dif_{tot} = Diffuse radiation Smaller part
- Reflected Radiation hard to measure

$Global_{tot} = Dir_{tot} + Dif_{tot}$



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Solar Energy Potentials
Solar insolation - GIS calculation

- Small scale global Radiation calculation
  - Calculating the upward-looking hemispherical viewshed
  - Overlay of the viewshed on a direct sunmap to estimate direct radiation.
  - Overlay of the viewshed on a diffuse skymap to estimate diffuse radiation.
  - Repeating the process for every location of interest to produce an insolation map.

  → **For both Area and point solar radiation calculation**

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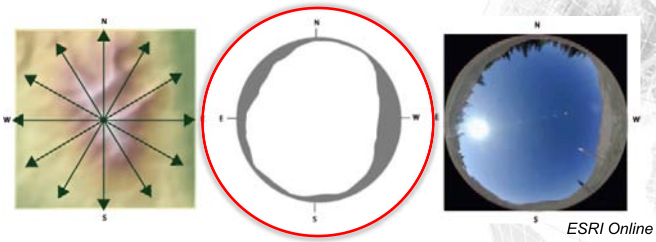
Studio iSPACE

Solar Energy Potentials
Solar insolation - GIS calculation

- Viewshed Calculation (1 raster cell)
  - Calculate the horizon angles in a number of directions (interpolation will be used between the angles) do calculate a represenation of the sky to characterize whether sky directions are visible (shown in white) or obstructed (shown in gray).

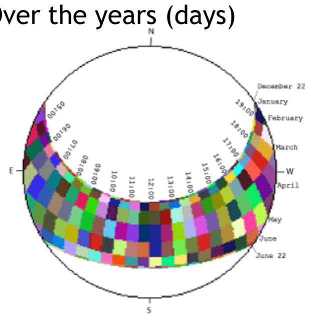


ESRI Online Help, 2009

Studio iSPACE

Solar Energy Potentials
Solar insolation - GIS calculation

- Sunmap Calculation
  - Raster represention of the sun tracks based on the altitude of the observed point
    - During the day (hours)
    - Over the years (days)

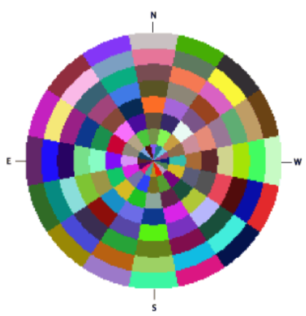


Sunmap 45° North, ESRI Online Help, 2009

Studio iSPACE

Solar Energy Potentials
Solar insolation - GIS calculation

- Skymap Calculation
  - Diffuse radiation originates from all sky directions

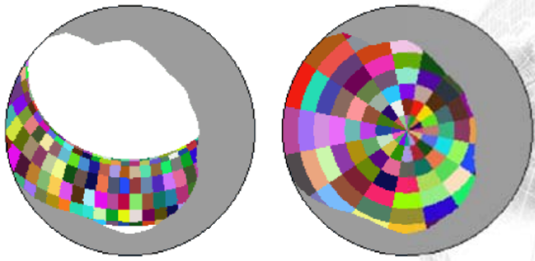


Skymap, ESRI Online Help, 2009

Studio iSPACE

Solar Energy Potentials
Solar insolation - GIS calculation

- Overlay Sunmap & Skymap with Viewshed to calculate the global radiation



Overlay Example, ESRI Online Help, 2009

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Studio iSPACE

Solar Energy Potentials
Solar insolation - Calculation

- Accuracy dependent on DEM/DTM scale
  - Medium scale DTM preferred
    - DEM 50 m²
    - DEM 25 m
  - Small scale (analyzing roof top)
    - Light detection and Ranging (LIDAR)
      - First/last Scan
    - Stereo Pair Imagery
      - (i.e. Virtual Earth 3D)
    - Multipatch (buildings) burn into DTM using manual roof top defintion

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Studio iSPACE

Solar Energy Potentials
Solar insolation - Calculation

- point and area based calculations
  - Reference days (Klein, 1977)
  - Atmosphere parameters (Schaumberger, 2007) - important factor!! use for definition
    - temperature
    - humidity
    - sky cover
  - long term globel radiation data

Monat	Tag des Jahres	Datum
Jänner	17	17. Jänner
Februar	47	16. Februar
März	75	16. März
April	105	15. April
Mai	135	15. Mai
Juni	162	11. Juni
Juli	198	17. Juli
August	228	16. August
September	258	15. September
Oktober	288	15. Oktober
November	318	14. November
Dezember	344	10. Dezember

Klein, 1977

	Jan	Feb	Mar	Apr	Mai	Jun	Jul	Aug	Sep	Okt	Nov	Dez
Diffuse Proportion	0.35	0.35	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.35	0.35
Transmittivity	0.70	0.70	0.70	0.65	0.65	0.65	0.65	0.65	0.70	0.70	0.70	0.70

Atmosphere Parameters, Schaumberger, 2006

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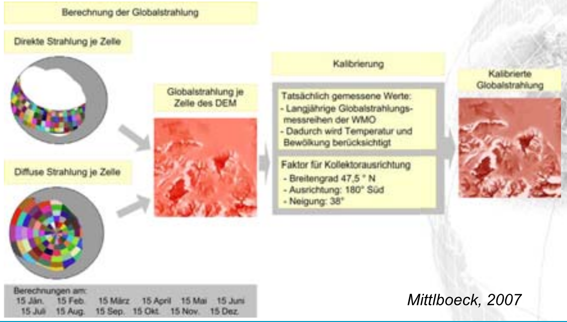
Solar Energy Potentials
Calculating solar energy potential

- Small scale solar potential calibration
  - long term climate data
    (global radiation, temperature & sky cover)
  - panel orientation 180 south and 38° inclination



Mittlboeck, 2007

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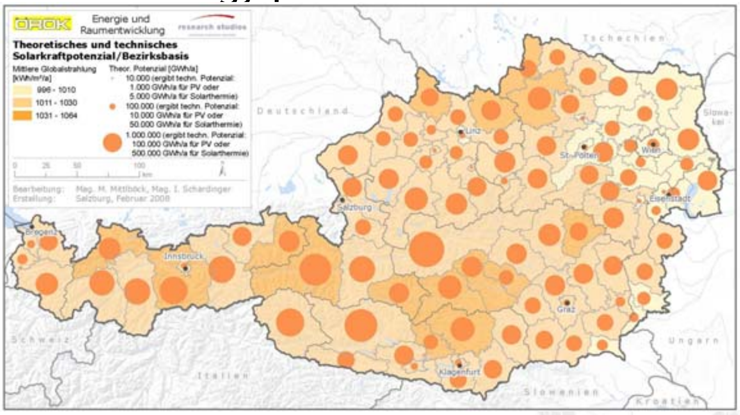
Solar Energy Potentials
Calculating solar energypotential

- Solar energy potential



Mittlboeck, 2007

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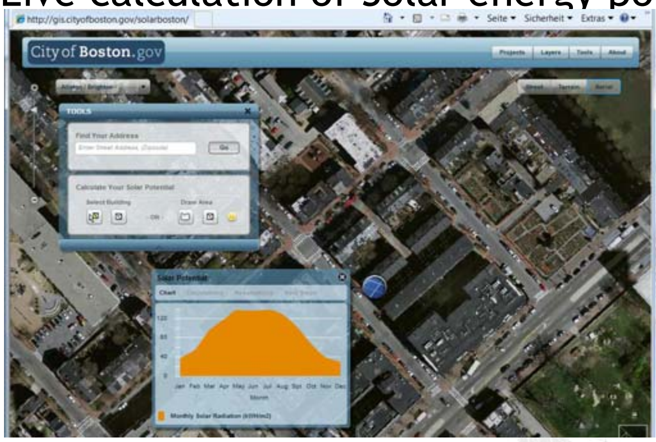
Solar Energy Potentials
Calculating solar energypotential

- Live calculation of Solar energy potential



gis.cityofboston.gov

Abstract

Solar Thermal Technology- bright opportunities

Christian Holter

University of Graz

Solar Thermal technology is well known for hot water preparation. Today 147 GW solar thermal panels are under operation world wide, 99% used for hot water preparation. But in addition, solar can contribute to process heat, cooling both for air conditioning and process energy and district heating. This market potential is significant higher than the one of DHW applications. The presentation will include an overview on today's world market and present best practice plants of Asia, Europe and America. Further, guidelines of project development will be explained.

Finally, solar plants cause high upfront costs and bring savings over decades. So detailed analyses of life cycle costs are needed to release investment budgets, and quite frequently financing packages have to be developed for a successful project implementation

Large Solar Thermal Systems

c.holter@solid.at www.solid.at

SOLID Group - What we do

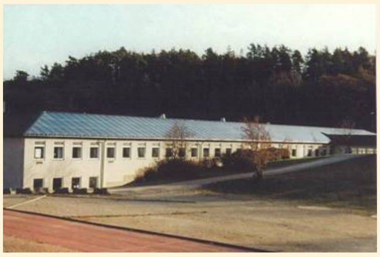
Large scale solar plants:
- district heating nets
- hospitals, dorms, prisons,...
- Resorts and hotels
- Swimming pools & sporting facilities
- Solar cooling

Existing References:
- > 250 large plants
- > 15 commercial solar cooling systems

SOLID's scope of supply:
- Project Development
- Engineering
- Construction
- Supervision
- Operating & Maintenance

R&D activities for Solar Thermal

Financing:
- Third Party Financing models
- Guarantee contracts
- ESCo arrangements



Orust Sweden, 768 m² , 540 kW , 1997

Awards

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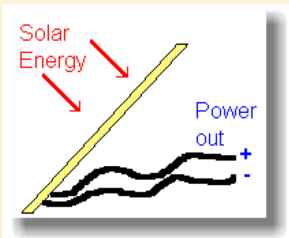
SOLAR THERMAL WORLDWIDE

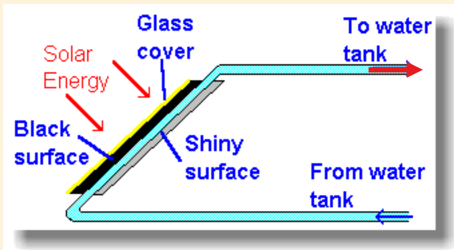
We work on Solar Thermal !

SOLID
solarinstallation+design

- Solar PV (Electricity)

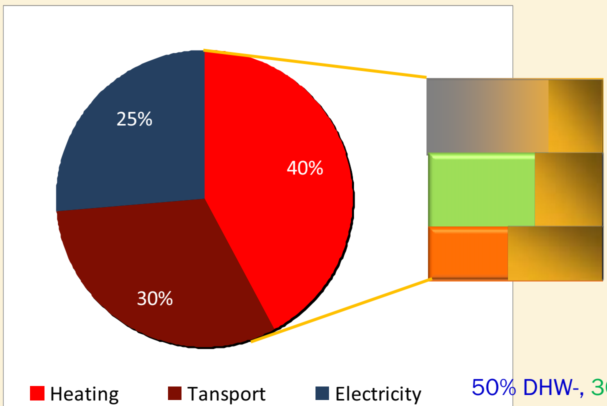


- Solar Heating (Heat)



Energy Consumption World Wide

SOLID
solarinstallation+design



50% DHW-, 30% Heating, 25% Industrial Heat demand can be covered by existing Solar Thermal Technologies !

Source: ESTTP 2006

Position of Solar Thermal

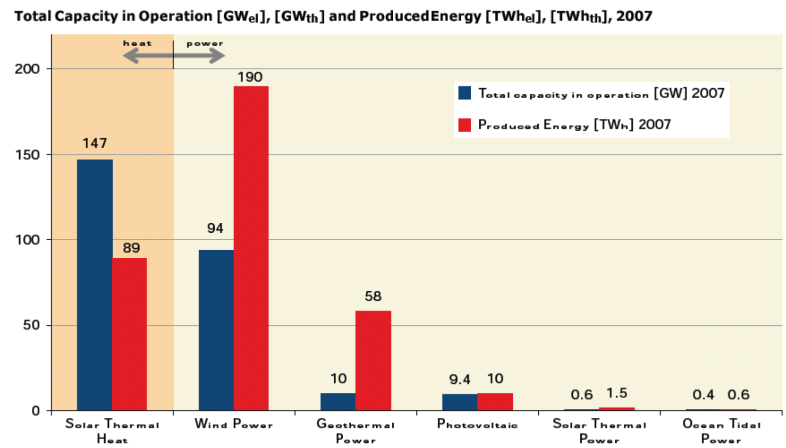
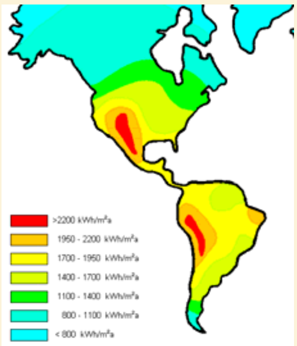
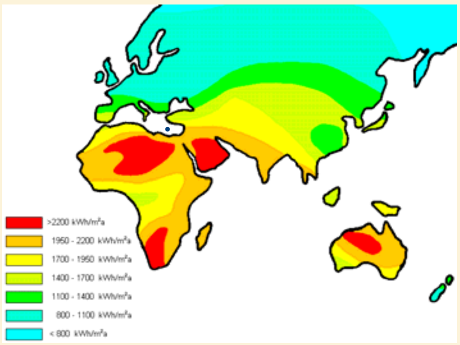


Figure 2: Total capacity in operation [GW$_{el}$], [GW$_{th}$] 2006 and annually energy generated [TWh$_{el}$], [TWh$_{th}$]. Sources: EPIA, GEWC, EWEA, EGEC, REN21 and IEA SHC 2008

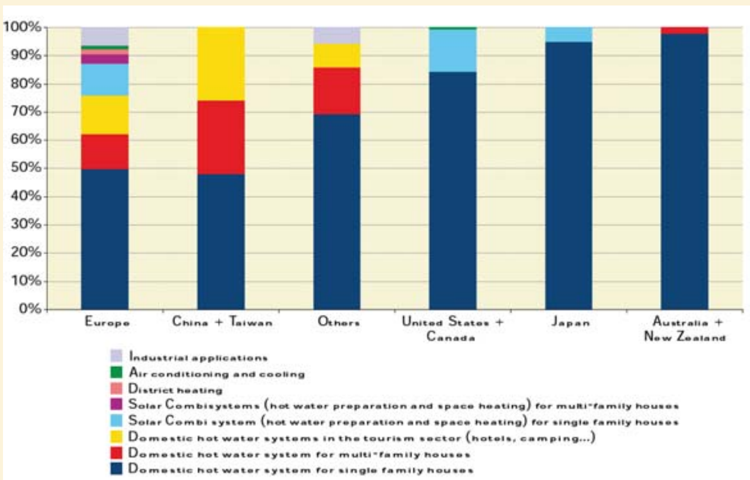
Source: Solar Heating World Wide 2009, Weiß et al.

Solar resources





Use of Solar Thermal Energy



Source: Solar Heating World Wide 2009, Weiß et al.

Future Potential

SOLID solarinstallation+design

- Solar Thermal is well known for:
  - Solar Heating like: Domestic hot water, heating, ...
- Solar Thermal is barely known for:
  - Heating of process fluids, washing detergents, heating processes, drying processes, ...
    Installed capacity worldwide Process Heat: 25MW/35.000 m²
    (Source : IEA SHC Task 33 Task 33 report)
  - Solar Cooling like air conditioning, cold storage, cooling of technical processes, ...
    Installed capacity worldwide Solar Cooling: 5-6 MW
  - Solar assisted District Heating

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BACKGROUND SOLAR COOLING

Solar Cooling- The advantage

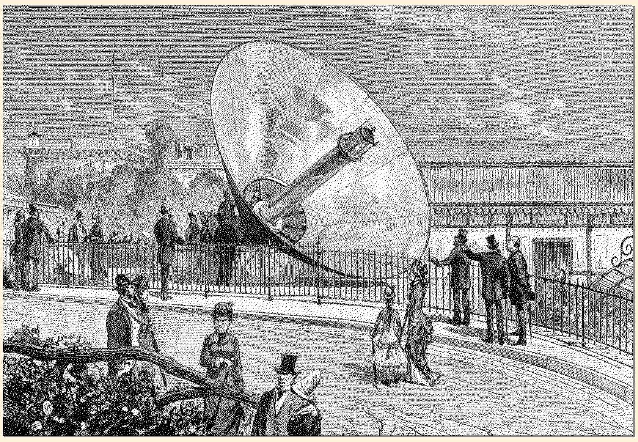
SOLID solarinstallation+design

The peak of solar radiation and the peak demand of cooling match perfectly

We can use the same radiation that creates the demand to cover the cooling demand,
cut off electricity peaks and
avoid extrem operations on the distribution grid.

Replacement of electricity supports not only the power plants but also the distribution grid.

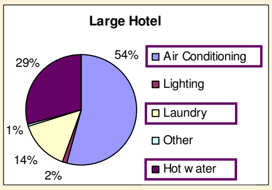
A brand new technology ?

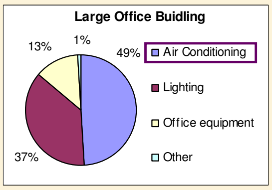


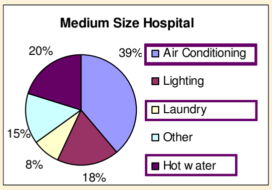
Expo 1878 in Paris, A. Mouchot produces ice with solar energy

Why solar air conditioning ?

- The buildings sector accounts for 42% of global electricity consumption (IEA 2007)
- Steadily increasing electricity price
- Air-Conditioning (AC) represents the biggest single energy/power consumer in public and commercial sectors
- AC key driver of electric peak power demand growth → negative impact on grid load factor, electricity price and environment







EXAMPELS

International projects

EAR Tower Pristina (2002/2003), 6th operating season

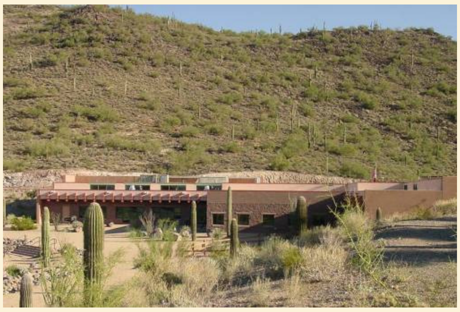
2 thermal driven absorption cooling machines with a total load of 70 kW

226 m² solar collectors

4 m³ storage tank

back up for peak load: electric chiller 30 kW.

International projects



Desert Outdoor Center Phoenix, AZ, (2006)

Solar Panels: 124 m²

Cooling Power: 70 kW

Project Partner :

Arizona Public Service

International projects

Lanta Self Storage, Phoenix , AZ, (2008)

Solar Panels: 500 m²   Cooling Power: 105 kW

International projects

Olympic Sailing Village China (2008)

Solar Hot Water for Sports Center and Olympic Village

Solar Air Conditioning for Logistic Building

Solar Panels:
1296 m²/910 kW

Backup Energy Source:
District heat

In operation

Asian Power award:
Best renewable plant of Asia 2006

CGD Bank Headquarter, Lisbon

100,000 m² Offices

5,000 people working in the building

11 floors above ground, 6 floors under ground

Bank building including employees hospital, theater, restaurants

CGD Bank Headquarter, Lisbon

Solar system for:

545 kW /155 tons Cooling

1100 kW Reheating, Heating, DHW

Solar Panels:
1.580 m² / 17,000 ft²

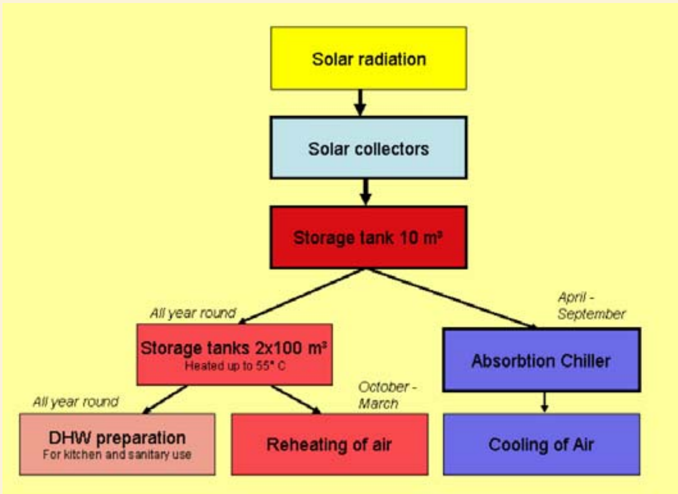
In operation since February 2008

CGD Bank Headquarter, Lisbon

Variable speed control pumps added to:

- save electricity
- create a delta T for the chiller

Sample energy flow



PROCESS HEAT & DISTRICT HEATING

Market potential Process Heat

industrial heat demand can be partly covered by solar process heat
(Source : IEA SHC Task 33 Task 33 report)

Higher potential than the whole domestic hot water market !

Gatorade Pepsico

Gatorade (Pepsi Cola) Phoenix , AZ, (2008)

Solar Hot Water for process heat in the soft drink industry.

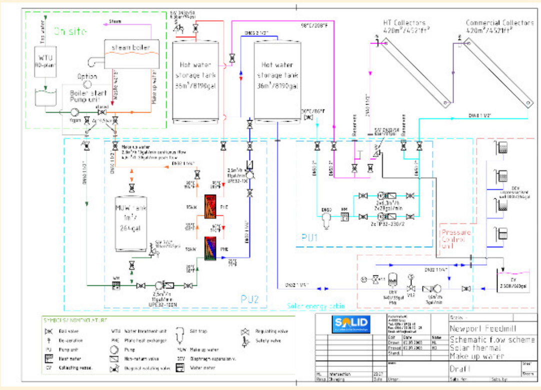
Biggest process heat installation on the American continent.

Solar Panels:
893 m² / 9,600 ft²

625 kW

Gatorade Pepsico

Feed Mill, Kingston Jam.



Feed pellets prodcution for chicken

Steam needed to glue the pellets

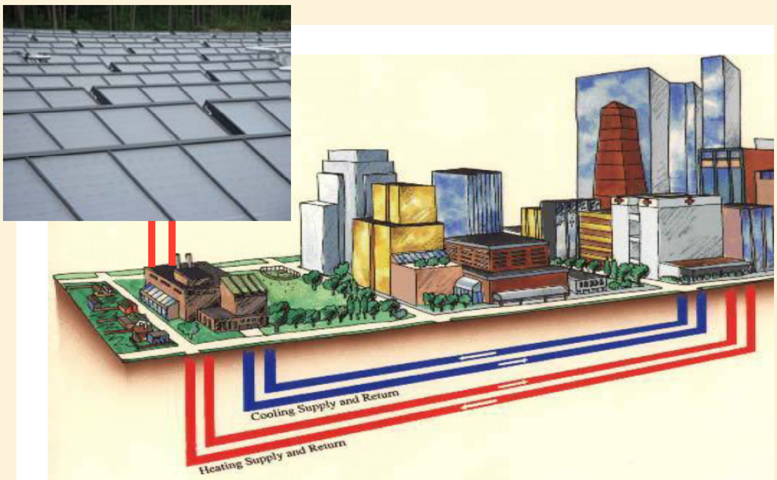
Open process

Two stage solar system:

- Preheating Process water
- Steam production

Washing

District Heating & Cooling



District Heating

SOLID solarinstallation+design

AEVG Graz District Heating

Solar Panels erected:
5.000 m²/ 3.5 MW

Solar Panels additionally planned:
2.000 m² / 1.4 MW

District Heating in Bishkek

SOLID solarinstallation+design

Solarunterstützte Fernwärr
Solarenergie billig

K. Vajen, C. Budig, J. Oroz
V. Borodin[2], R. Botpaev
Universität Kassel, Institut fü
D-3410
Tel. +49 561 804-3890,
solar@uni
www.solar.u
[2]Kyrgyz Technical University, Center for R
[3]Wagner & Co Solartechnik,

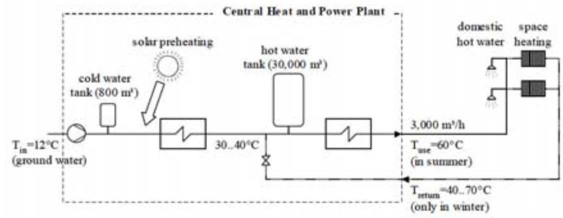


Abb. 1: Vereinfachtes hydraulisches Schema eines typischen offenen Fernwärmenetzes in der GuS (normalerweise ohne solare Vorerwärmung) (Quelle [2]).

Abb. 2: Versuchsanlage auf dem 12 MW Heizwerk „Rotor" in Bischkek (Kirgisistan) (Quelle [2]).

Latest Projects

SOLID solarinstallation+design

Harvard University, Boston

Startet up May 09

DHW only

United World College (UWC), Singapore

Contract signed

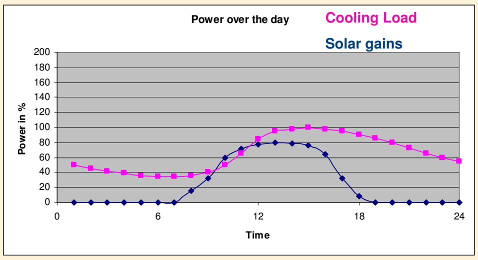
500 ton cooling
+DHW

Concepts on Sizing

SOLID solarinstallation+design

The easy and secure way-“Solar Instant“

- Solar System provides never more than 90% of actual load
- Solar energy is used immediately
- Daily electricty peak is reduced
- Energy savings
- Relatively small tanks are needed
- Back up needed either thermal or electric
- Easy to design
- Lowest investment

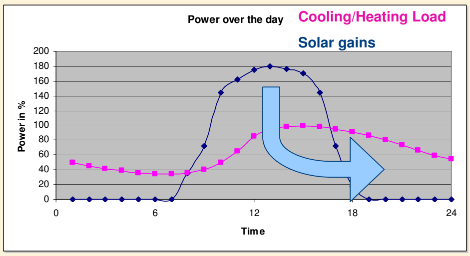


Concepts on Sizing

SOLID solarinstallation+design

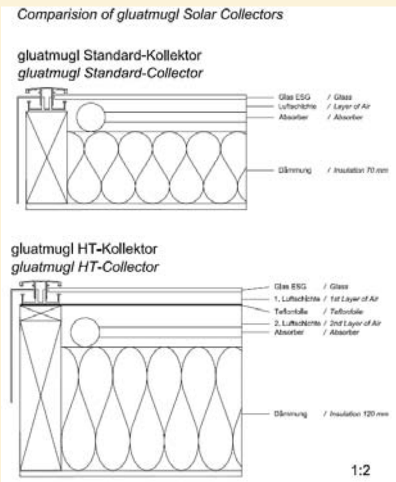
Challenge one “Surplus during Daytime“

- Solar System provides 100% on sunny days during daytime AND surplus stored for the evening& night
- Bigger Tanks needed for storing heat
- During daytime/peak electric chiller is off
- Back up needed either thermal or electric
- Energy Savings more
- Good information needed on daily/ yearly con-sumption profile (measured ton hours chilled water)
- Best Payback



Solar Panels

SOLID solarinstallation+design



ECONOMICS

General Statements

Payback depends mainly on
- Electricity rates and Peak Charges
- Solar radiation/Meteorology
- The bigger the better
- Incentives/ Funding

Determining impacts can result out of
- Integrated systems
  - DHW, Solar Cooling, (Re-) Heating, upgrading of existing system (Frequently point of sales!)
  - Peak reducing concept
  - Multifunctional use of panels (Shadowing building etc.)

Large scale Solar Thermal

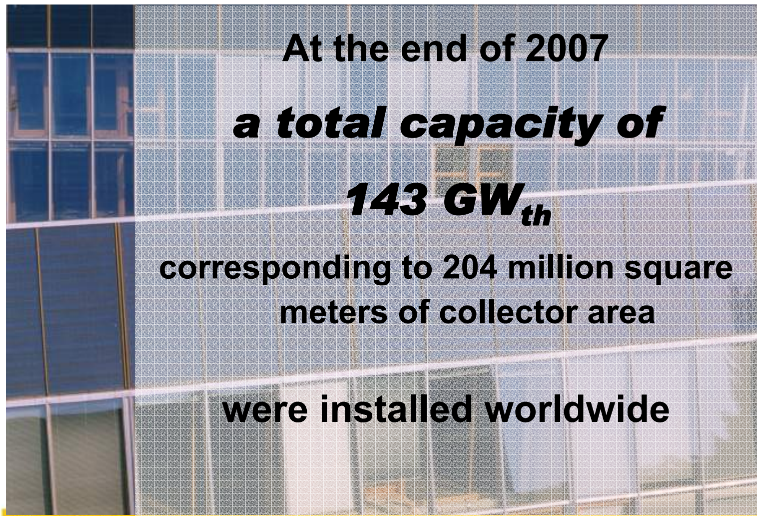
Solar Heating and Cooling

Markets and Applications

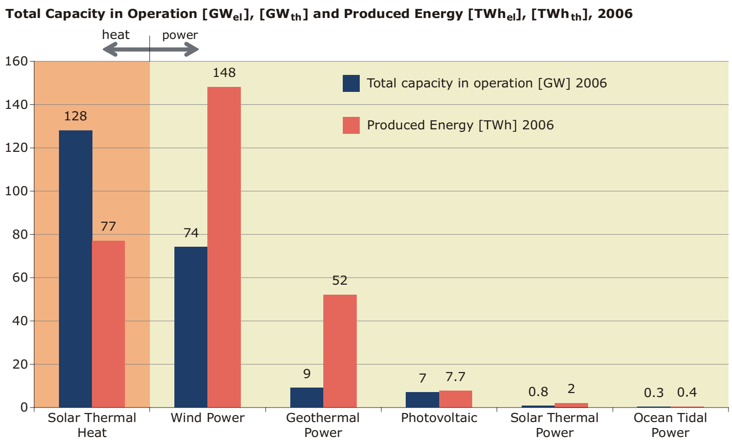
Werner Weiss

AEE - Institute for Sustainable Technologies
A-8200 Gleisdorf, Feldgasse 2
AUSTRIA

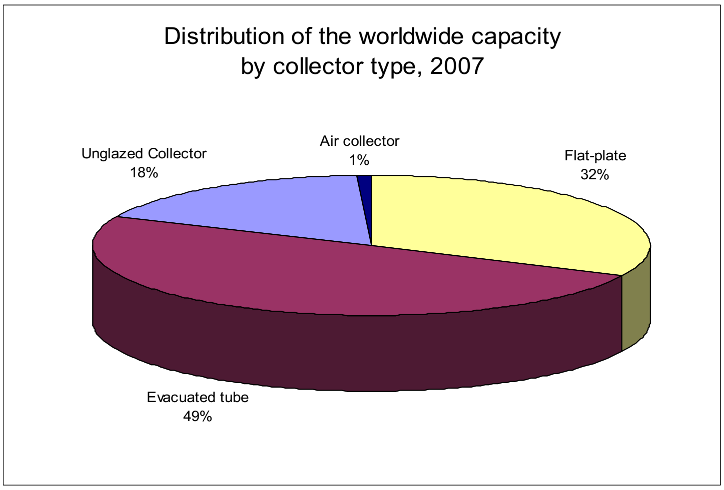
Solar Heat Worldwide



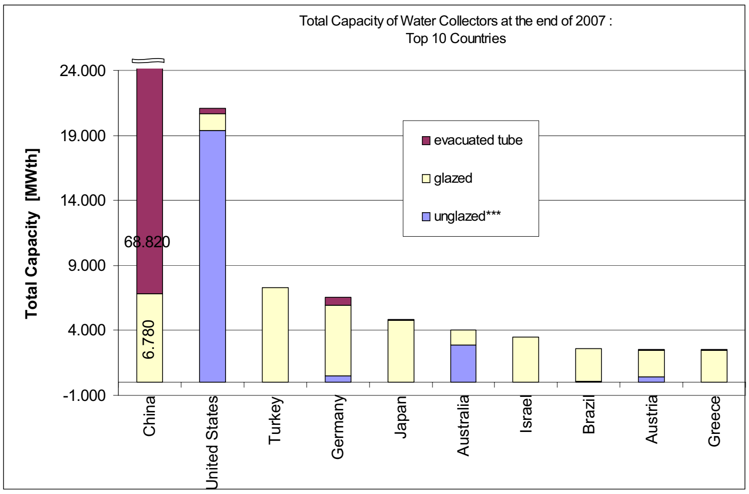
Achievements - 2006



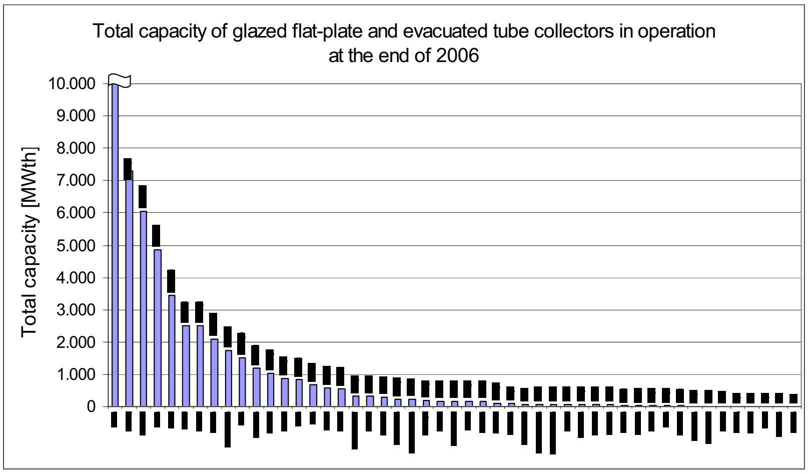
Solar Heat Worldwide



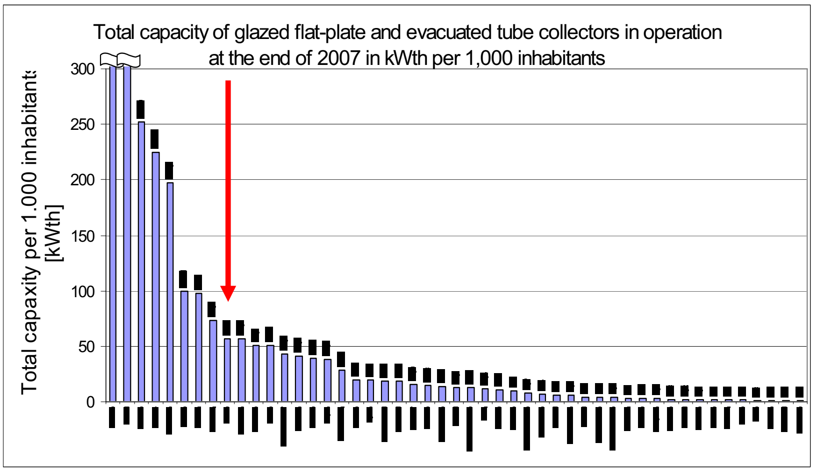
Solar Heat Worldwide - 2007



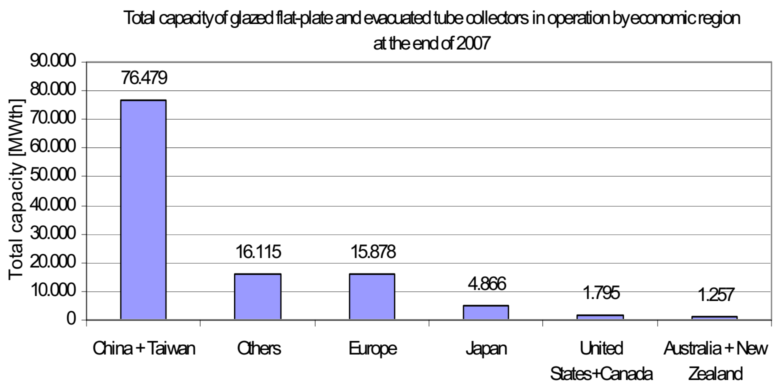
Solar Heat Worldwide



Solar Heat Worldwide



Solar Heat Worldwide



Solar Heat Worldwide

AEE INTEC

Established Applications

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AEE INTEC

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AEE INTEC

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Three different types of evacuated tube collectors:

all-glass
U-tube
heat-pipe

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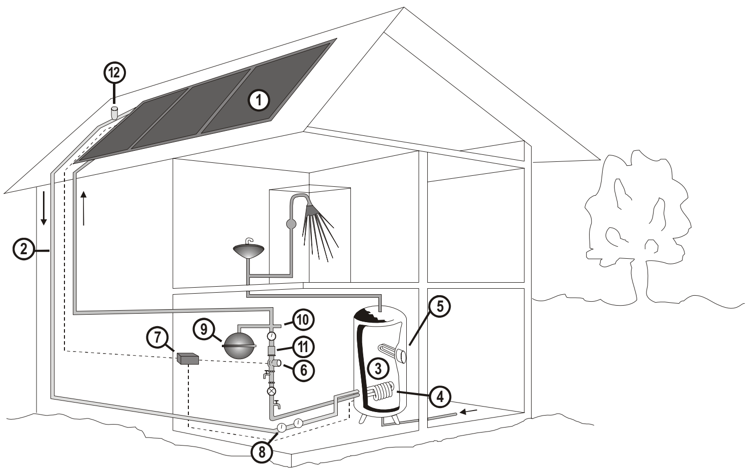

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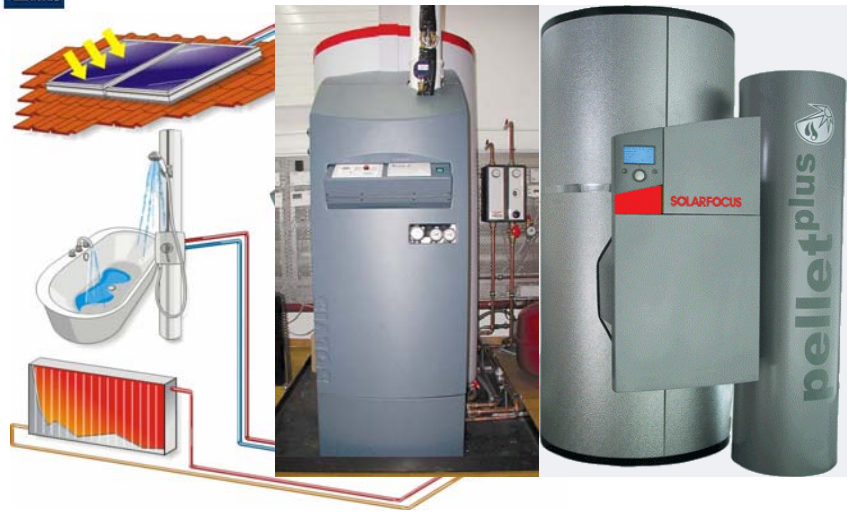

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Multi-Family Houses and Housing Estates

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Large-scale solar heating systems

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System with short-term storage – Müllheim, D

Project	Heat Storage	Project -Size			
		Collector area (m²)	Storage Volume (m³)	fsol (%)	Nb. of Flats
Müllheim	short term	446 m²	20 m³	12%	70+10

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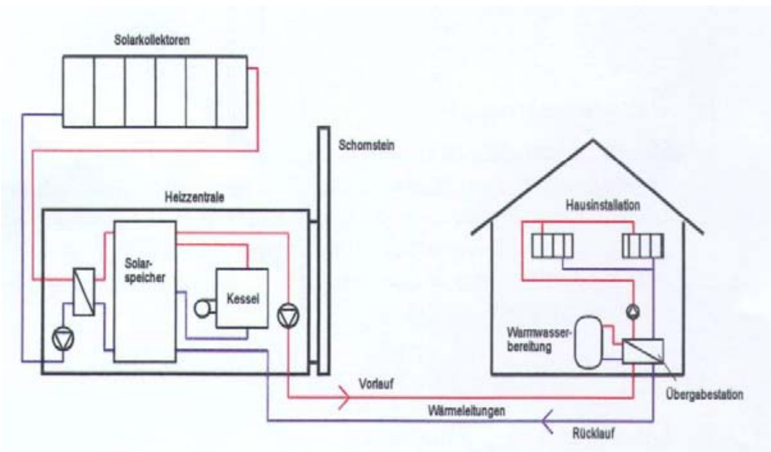
System with short-term storage – Müllheim, D



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System with seasonal storage – Anneberg, S

Project	Heat Storage	Project -Size			
		Collector area (m²)	Storage Volume (m³)	fsol (%)	Nb. of Flats
Anneberg-Danderyd	seasonal	2.400 m²	60.000 m³	70%	50

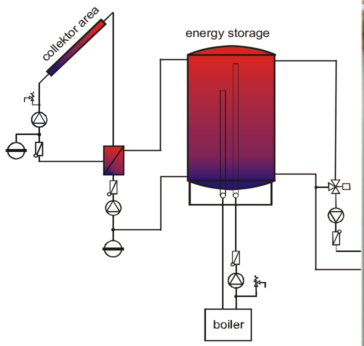
System with medium-term storage Gneis-Moos, A

Project	Heat Storage	Project -Size			
		Collector area (m²)	Storage Volume (m³)	fsol (%)	Nb. of Flats
Gneis Moos	weekly	410 m²	100 m³	34%	61

System with medium-term storage Gneis-Moos, A

AEE INTEC

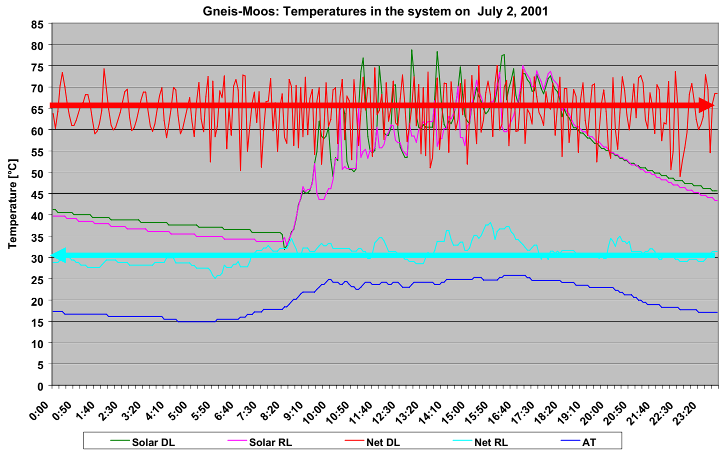
System with medium-term storage
Gneis-Moos, A



www.aee-intec.at AEE - Institute for Sustainable Technologies

AEE INTEC

System with medium-term storage
Gneis-Moos, A



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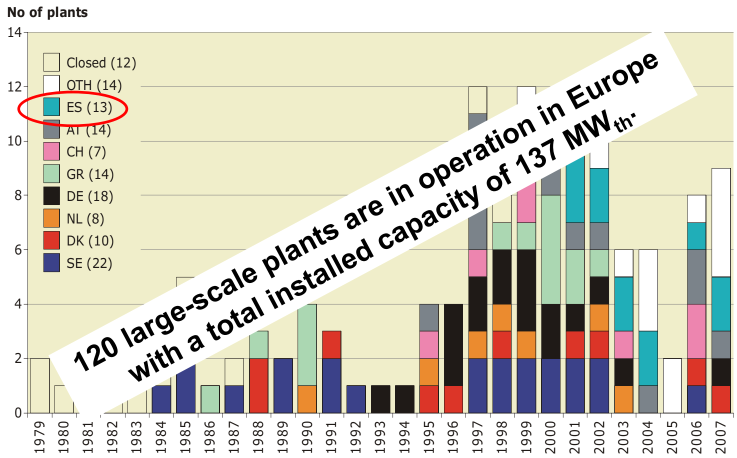
Large-scale Plants in Europe



Source: Jan-Olof Dalenbäck, 2008

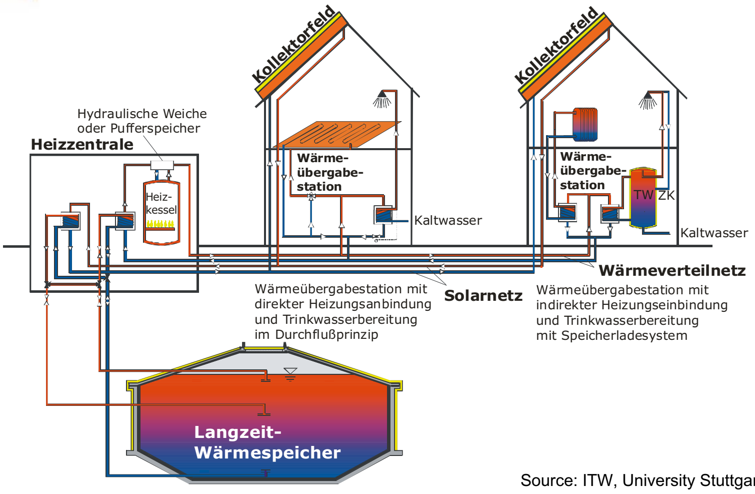
Small Local District Heating for Housing Estates

Local District Heating – Hamburg, Germany

Source: ITW, University Stuttgart

Local District Heating - Steinfurt-Borghorst, Germany

Local District Heating with Seasonal Storage



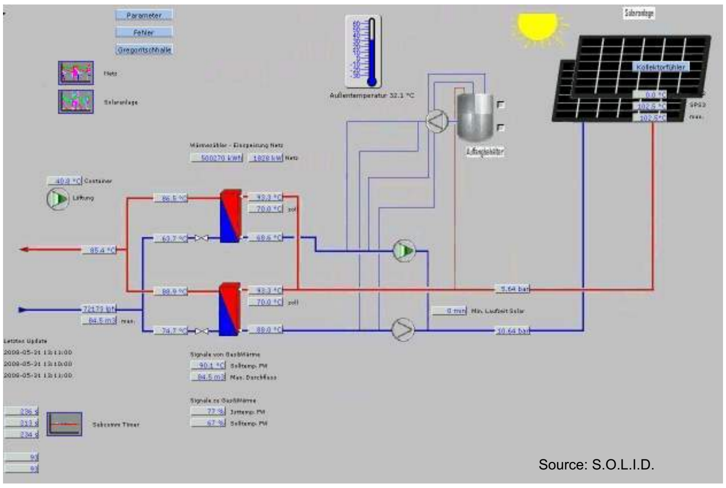
Source: ITW, University Stuttgart

Solar Assisted - Biomass District Heating, Austria

District Heating – 1 MW_{th}, Graz, Austria

Source: S.O.L.I.D.

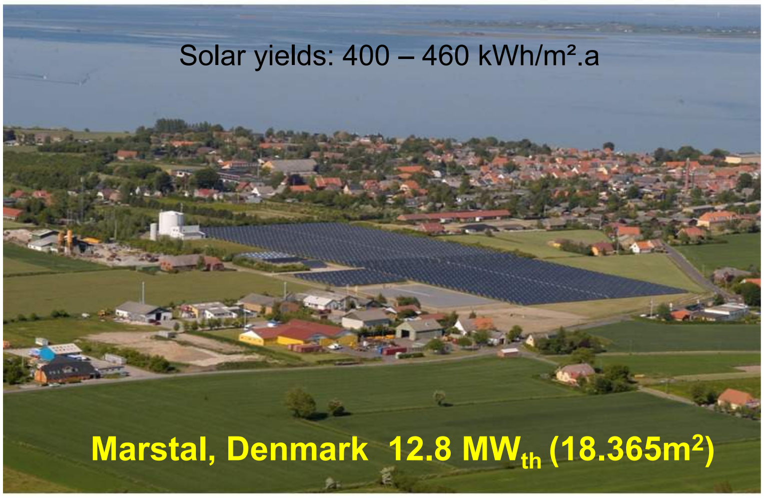
District Heating – 1 MW_{th}, Graz



Source: S.O.L.I.D.

District Heating – 7 MWth, Kungälv, Sweden

Solar District Heating



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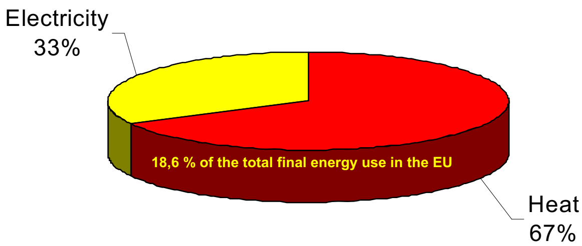
INDUSTRIAL APPLICATIONS

Final Energy Use of the EU - Industry

share of heat and electricity



Source: GREEN PAPER – TOWARDS A EUROPEAN STRATEGY FOR THE SECURITY OF ENERGY SUPPLY, Brussels, 2001

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SHORT TERM POTENTIAL FOR PROCESS HEAT

	Low Temperature Heat	Solar thermal	Mill.	5% Market Penetration	
	[PJ]	[PJ]	[m²]	[m²]	[MW_{th}]
Spain	110	17	13,6	680.000	476
Portugal	25	4	3,2	160.000	112
Austria	85	5	4,3	215.000	151
Total	**220**	**26**	**21,1**	**1.055.000**	**739**

Space Heating of Factory Buildings

Source: Solution

LARGE-SCALE INDUSTRIAL APPLICATIONS

Seawater Desalination – Gran Canaria, Spain

LARGE-SCALE DISTRICT HEATING AND COOLING

Thank you for your attention

Abstract

Calculation of solar potentials with SAGA GIS

Rainer Prüller

Graz University of Technology

Geographic Information Systems (GIS) like SAGA GIS offer the opportunity of calculation of the direct insulation of solar energy based on the analysis of various spatial and thematic data. SAGA calculates in the module "Incoming Solar Radiation" the potential solar energy of an area over a time span, the scale unit is kWh/m² resp. J/m². The insulation is fundamentally a function of the geographic latitude, the daytime and the season. In detail further parameters have to be taken into account, like aspect, slope and the sea level. GIS provide an excellent opportunity to perform such calculations. The effective solar energy depends on metrological conditions, mainly clouding and atmospheric conditions like pressure, water content and dust (Figure 1). Of 100 incoming solar radiation units, which are about 342 W/m² in average on earth, only 51 units (~ 174 W/m²) reach the surface, the other 49 units are reflected and scattered (30 units) or absorbed by atmosphere and clouds (19 units).

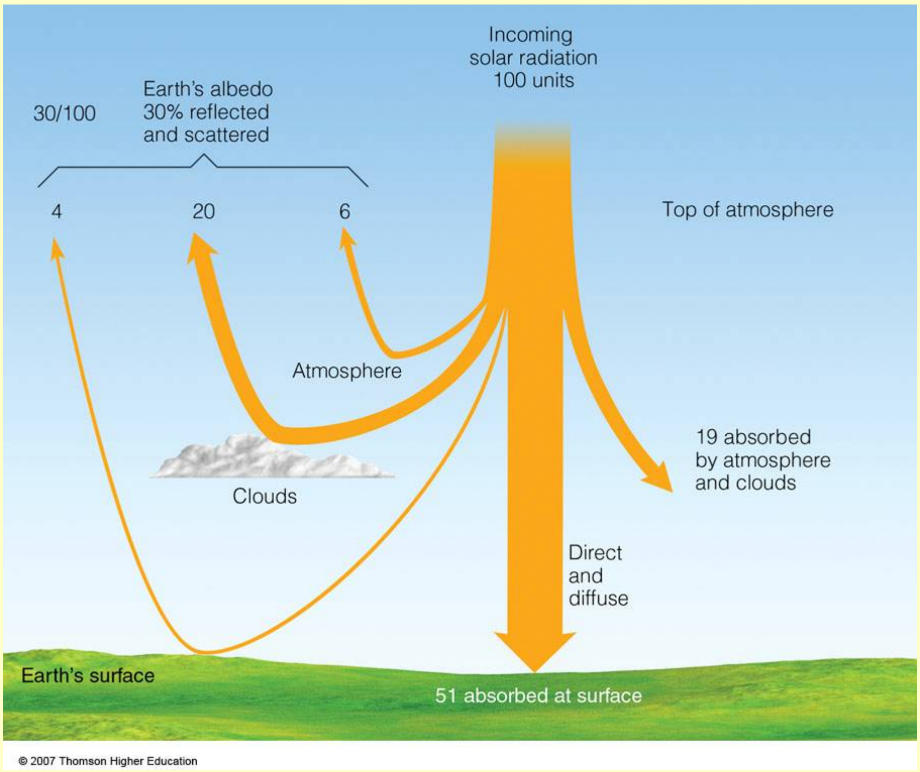


Figure 1: Interaction of incoming solar radiation with the atmosphere (Source: Thomas Higher Education)

As these parameters are very difficult to measure, SAGA offers simulation models which can be calibrated by the user in the GUI shown in Figure 2. Although the most important factor in calculation of the solar potential are the Digital Elevation Model (DEM) and the latitude of the area. A DEM is a digital representation of ground surface topography or the terrain, within the calculations in Kyrgyzstan the DEM obtained from the Shuttle Radar Topography Mission (SRTM) with a resolution of about 100 m will be used. It is free available and it covers nearly the whole earth, only 0.2 % of the total earth surface are uncoverd. The international project is led by the U.S. National Geospatial-Intelligence Agency (NGA) and the U.S. National Aeronautics and Space Administration (NASA).

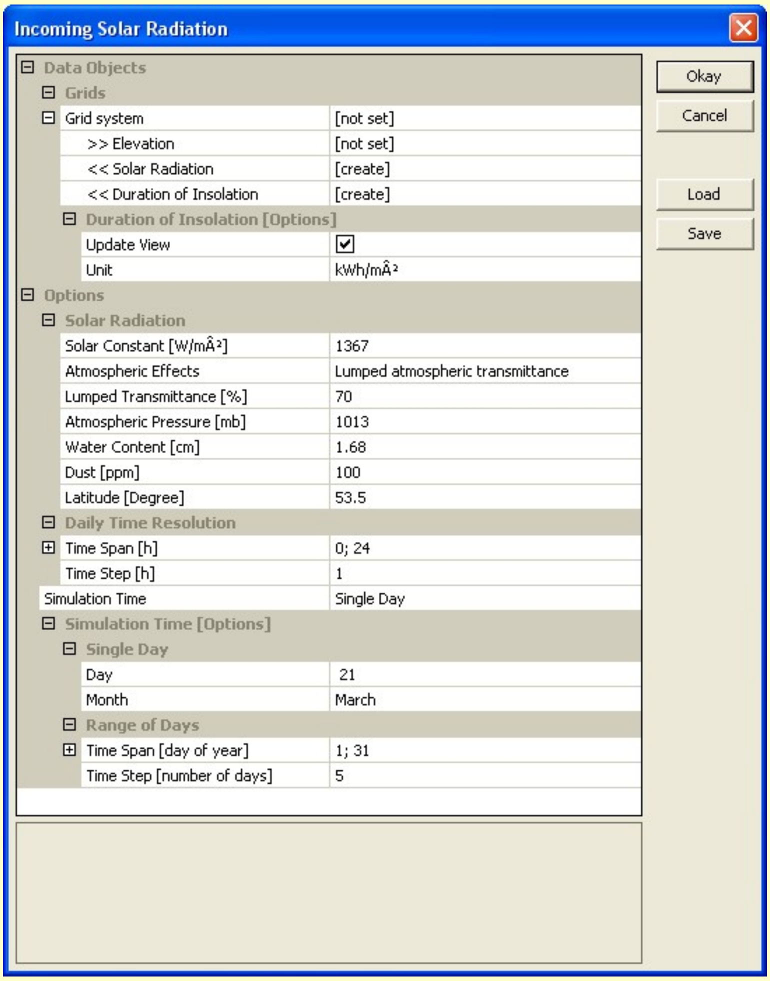


Figure 2: SAGA module „Incoming Solar Radiation“

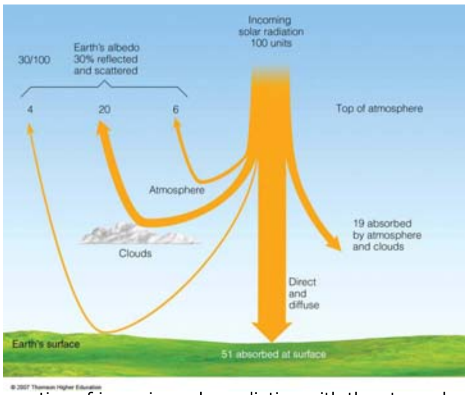
Dissemination of solar and hydro potentials Computation

Evaluation and presentation of concrete solar potentials in Kyrgyzstan by means of SAGAGIS

Rainer Prüller

Graz University of Technology

Solar radiation



Interaction of incoming solar radiation with the atmosphere (Source: Thomas Higher Education)

- ~174 of 342 W/m² reach the surface
- Absorbation
- Reflection
- Parameters are very difficult to measure
- Modeling possible

GIS and solar potential

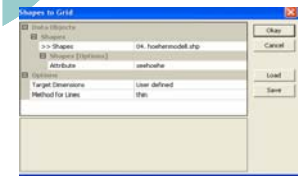
- Solar potential depends on
  - Geograhic latitude
  - Daytime and season
  - Athmospheric conditions
  - Topography
    - Altitude
    - Slope
    - Aspect
- Topography → DEM → GIS analysis

SAGA and solar potential

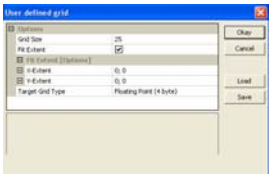
- SAGA module „Incoming solar radiation"
- Potential solar energy of an area over a time span
- Scale unit kWh/m² resp. J/m²
- Various parameters adjustable

Retrospect: DEM import

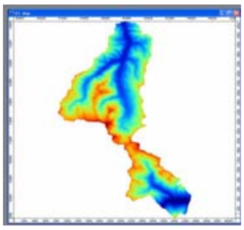
- Import of a GRID from Shapefile
  - Module Libraries: Grid – Gridding
  - Module „Shape to Grid"



Source data
Height information
Dimension

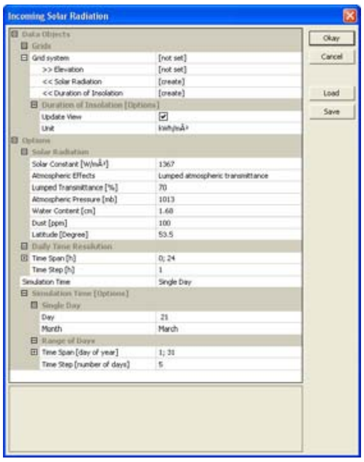


Grid Size



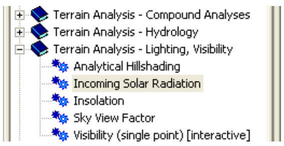
Imported Grid

SagaGIS – Incoming Solar Radiation



Found under:

Modules →
Terrain Analysis –
Ligthning, Visibility →
Incoming Solar Radiation



Input parameters - Grids

- Grid system
  - Imported Grid („Shape to Grid")
- Elevation
  - Elevation information from DEM
- Solar Radiation
  - Automatical created by the module
- Duration of Insulation
  - Automatical created by the module

Input parameters – Duration of insulation

- Update View
  - Updates the map during calculations
- Unit
  - Energy per area
    - kWh/m²
    - J/m²
  - 1 Joule = 1 Ws
  - 1 kWh = 3600000 Joule

Input parameters – Solar radiation

- Solar Constant [W/m²]
  - Long-term middle of extraterrestric solar insulation
  - Estimated by Stefan-Boltzmann-Low
  - Value defined by „World Meteorological Organization"
  - 1367 W/m²

Input parameters – Atmospheric Effects

- Atmospheric effects
  - Summary of influence by water and dust
  - Lumped athmospherice transmittance
  - Calculating the components
- Lumped Transmittance [%]
  - Transmittance of the athmosphere
  - Usually between 60% and 80%

Input parameters – Atmospheric Effects

- Atmosperic Pressure [mb]
  - Approximated by hydrostatic pressure
  - Decreases with higher altitude
  - Low pressure areas have less atmospheric mass above their location
  - Standard atmosphere: 1013.25 milibars
  - 1 mb = 1 hPa = 760 torr

Input parameters – Atmospheric Effects

- Water Content [cm]
  - Water vapor in the atmosphere
  - Continuously generated by evaporation
  - Removed by condensation
  - Atmospheric water content of a vertical slice
  - Usually between 1.5 and 1.7 cm
  - Average = 1.68 cm

Input parameters – Atmospheric Effects

- Dust [ppm]
  - Dust proportion in atmosphere
  - ppm … Parts per million
  - Denotes realitve proportions
  - Standard Dust factor = 100 ppm = 0.04 %
- Latitude [Degree]
  - Geographic latitude
  - Bishkek: 42.87°

Input parameters – Daily Time Resolution

- Time Span [h]
  - To calclulate a time span of a day
  - Minimum … Starttime
  - Maximum … Endtime
- Time Step [h]
  - Time step between calculations

Input parameters – Simulation time

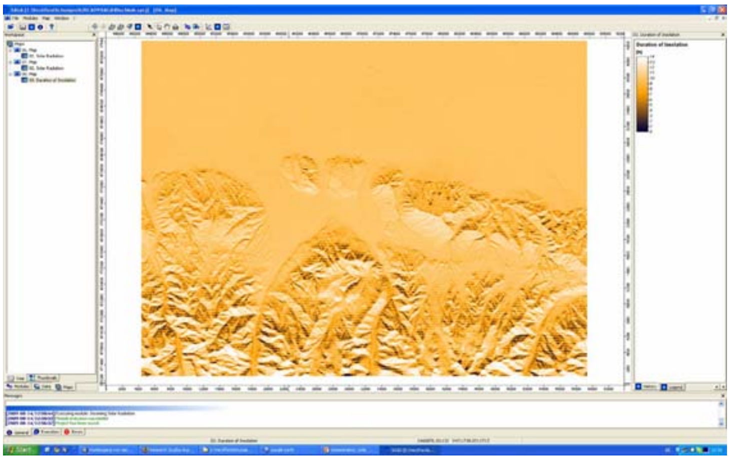
- Single Day
  - Date of day under investigation
  - Day
  - Month
- Range of Days
  - Time Span [day of year]
    - Minimum
    - Maximum
  - Time Step [number of days]

Practical part

- Single Day
  - 25th of August
  - Bishkek region
- Input paramters
  - Standard values
  - Varying those parameters

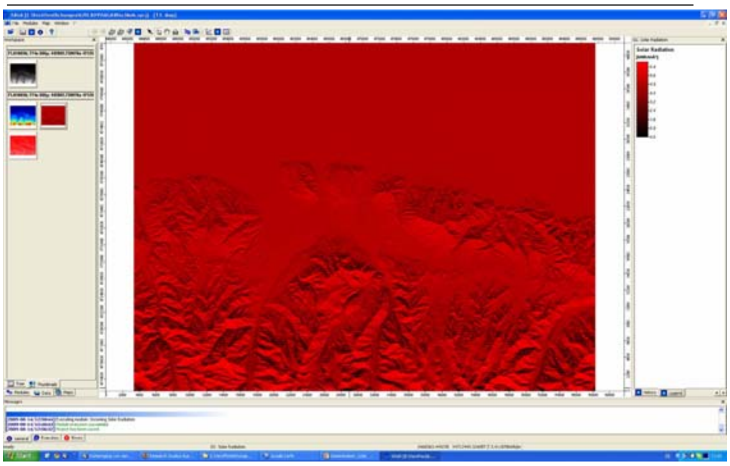
Calculation of Solar potential Rainer Prüller – Graz University of Technology 16

Results – Duration of Insulation



Calculation of Solar potential Rainer Prüller – Graz University of Technology 17

Results – Incoming Solar Radiation



Calculation of Solar potential Rainer Prüller – Graz University of Technology 18

Exercise

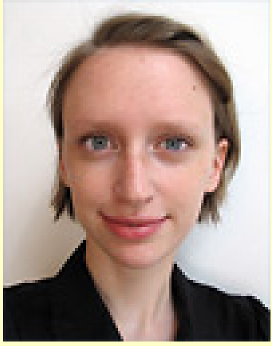
- Run with different parameter settings
- Calculation of four seasons
- Calculation morining – midday – evening
- Calculation of annual Solar radiation

Dissemination of solar and hydro potentials Computation

Evaluation and presentation of concrete solar potentials in Kyrgyzstan by means of SAGAGIS

Rainer Prüller

Graz University of Technology



Abstract

User interface design and cartographic quality in contemporary web mapping

Manuela Schmidt

Vienna University of Technology

The development of web mapping in the last years made the dissemination of maps on the internet as easy as it has never been before. The workflow from computation and evaluation to the presentation of geo data was simplified by many easy-to-use tools and services; web mapping APIs allow for a quick data visualisation on top of pre-rendered base maps. Unfortunately these visualisations do not always result in a good user experience. While the technical aspects of the workflow are well covered by different tools, the cartographic and aesthetic aspects are often neglected. As a result e.g. the user interface (UI) might be too complicated to use for the target audience or the map graphic might be cluttered and therefore not legible. As the success of a web map and the confidence, people have in the knowledge they acquire from it is directly connected to the graphical user interface, it is vital to gain some basic skills on user interface design and cartography.

The workshop focuses on the following topics:

- How to plan and design a user-centred web map.
- What to consider when developing a user interface.
- How to ensure a legible and harmonized map graphic.

The workshop will show some common pitfalls and give hints on how to improve the results of the practical assignment.

User interface design and cartographic quality in contemporary web mapping

Manuela Schmidt
manuela.schmidt@tuwien.ac.at

1. What is **contemporary web mapping?**
2. Why does **user interface design** matter?
3. How to ensure **cartographic quality** in a web map?
4. **HANDS-ON**
   - Getting to know online map production tools
   - Evaluating existing solar potential web maps
   - Planning a user-centered solar potential map

Web Mapping is…

… the process of designing, implementing, generating and delivering maps on the World Wide Web.

Neumann A. (2008) in *Encyclopedia of GIS*

Web mapping service applications

Mapping APIs

Neogeography

MashUps

Contemporary web mapping?

Geotagging

Volunteered Geographic Information

Collaborative Mapping

1 Contemporary Web Mapping / 2 / 3 / 4 # 4

Web mapping service applications

2005: Google Maps

- Using AJAX for a more responsive map browsing experience
- Simple, attractive, intuitive interface
- APIs allow for mashups

1 Contemporary Web Mapping / 2 / 3 / 4 # 5

MashUps are…

… web applications that combine data or functionality from more than one source into a single integrated tool by using public interfaces or APIs (application programming interfaces)

e.g. using the Google Maps API to show solar potential data

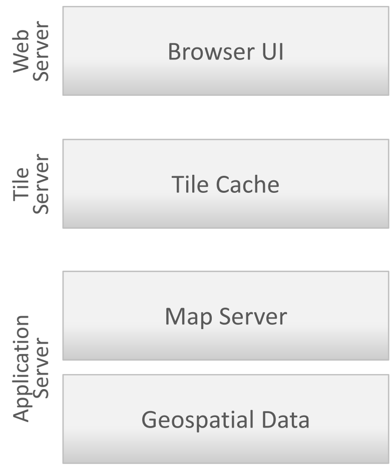
1 Contemporary Web Mapping / 2 / 3 / 4 # 6

Players in the mapping field

- (GIS/cartography) professionals
- programmer mapmaker
- **NEW:** consumer mapmaker
  Google MyMaps-Slogan: “map making so easy a caveman could do it”

  → Neogeography: Geographical techniques and tools used for personal activities or for utilization by a non-expert group of users; not formal or analytical. (Turner A., 2006. Introduction to Neogeography)

The ‚map stack‘

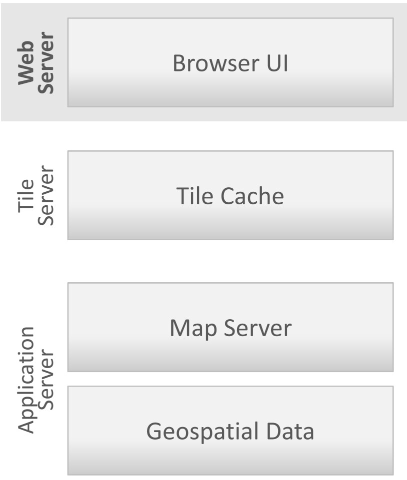


How do contemporary web mapping applications work? The concept will be explained in a so-called solution (map) stack.

Every web map consists of 3 main components:

1. Geo data
2. User interface
3. Platform

The ‚map stack‘

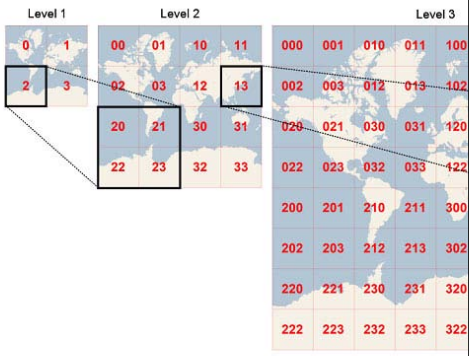


The ‚map stack'

Web Server
- Browser UI

Tile Server
- Tile Cache

Application Server
- Map Server
- Geospatial Data



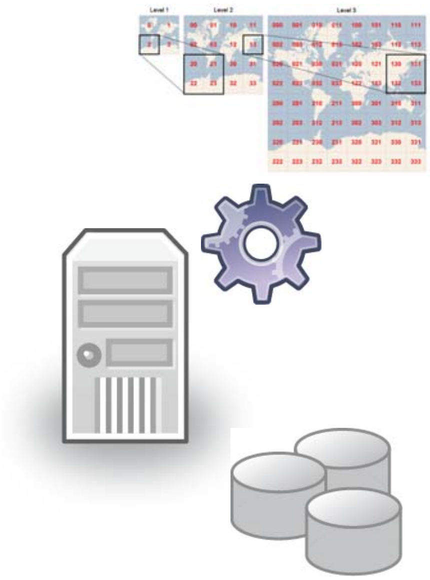
Source: Microsoft Virtual Earth SDK

The ‚map stack'

Web Server
- Browser UI

Tile Server
- Tile Cache

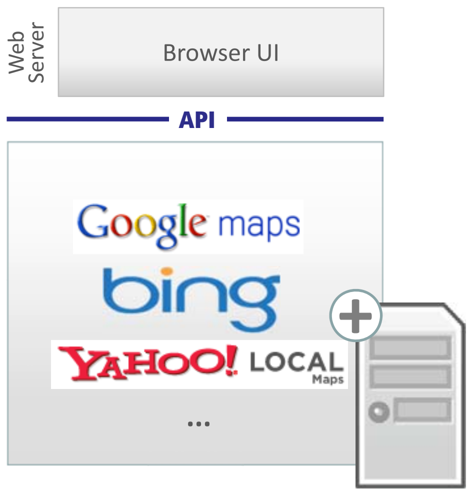
Application Server
- Map Server
- Geospatial Data



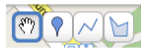
Licensing types

- Commercial solutions
- „Free as in beer" vs. „Free as in speech"
  - Free to use, but proprietary services
    Mapping services, e.g. by Google, Microsoft, Yahoo
    Free to use, but with restrictions of the terms of service
  - Open source
    Open Source Tools, e.g. UMN-MapServer
    Free, but often more challenging to install and maintain

Proprietary web mapping services



How to add data

- ✓ Gadgets 
- ✓ KML, GeoRSS, …
- ✓ Image overlays
  Own tiles

Proprietary web mapping services (cont.)

Why using them?

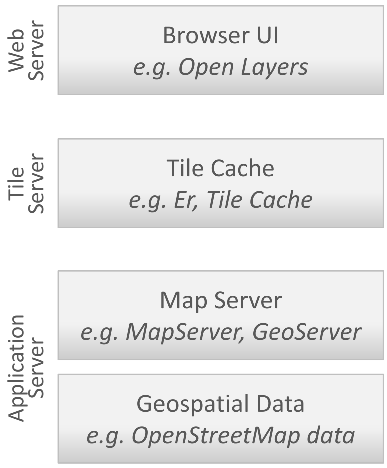
- ✓ Quick and easy setup
- ✓ Availability of huge amounts of data (maps and imagery)
- ✓ Base map data is stored on huge server farms, so maps load fast and can handle many users at the same time
- ✓ Intuitive interface

Proprietary web mapping services (cont.)

Limitations

- ✓ Pre-rendered map tiles and no possibility to change style or content of base maps
- ✓ Heterogenous data coverage in base maps
- ✓ Mercator projection not suitable for every purpose
- ✓ No access on vector data or 3rd dimension, which is a problem for thematic mapping or GIS analysis
- ✓ Limitations accordings to API options (e.g. no intranet or routing usage)
- ✓ Licensing issues (e.g. advertisment possible)

Open source web mapping



This type of configuration is also called „Open Geo Architecture“. There is a broad range of tools available that can be combined.

More Information:
http://opengeo.org/publications/opengeo-architecture

1 Contemporary Web Mapping / 2 / 3 / 4 # 16

Open source web mapping (cont.)

Why using the Open Geo Architecture?

- ✓ Possibility to create own base maps with custom content and styling; and/or the possibility to use pre-rendered (proprietary) data layers
- ✓ Possibility to programm own functionalities
- ✓ Data can be stored on own servers
- ✓ Vector functionality for use in thematic maps and GIS analysis
- ✓ Offline and intranet usage possible

1 Contemporary Web Mapping / 2 / 3 / 4 # 17

Open source web mapping (cont.)

Limitations

- ✓ Installing, using and updating can be complicated and time-consuming
- ✓ Programming skills needed for adapting the map to own needs
- ✓ Simple-to-use procedures and GUI are not primary focus for open source developers, so usability might be lacking
- ✓ Data must be stored on own servers, so it might be slow with many users
  - → Solution: Using cloud hosting services

1 Contemporary Web Mapping / 2 / 3 / 4 # 18

Open geo data sources

Free data, offered by public administrations or others, e.g.

- data.gov
- www.cia.gov/library/publications/the-world-factbook
- finder.geocommons.com

Volunteered geographic information (VGI)
VGI is a special case of user-generated content, where individuals collect and assemble geographic data, e.g.

- www.openstreetmap.org: a collaborative project to create a free editable map of the world; data can be used as pre-rendered map tiles or downloaded as vector data
  → Shape files from http://www.geofabrik.de/en/data/download.html

2 Why does user interface design matter?

User interface design is …

… the design of applications with the focus on the user's experience and interaction

Goal: design, that enables users to concentrate on their work, exploration, or pleasure → user-centered design

Shneiderman & Plaisant (2005), Designing the User Interface

Usability is…

… the quality of a user's experience when using a system

… effective, efficient, and satisfying completion of tasks by users

http://usability.gov/
http://www.gnocdc.org/usability/

Status quo

- many GIS applications today:
  = sophisticated analytical functions
  ≠ good user experience
- GIS doesn't have a usability culture, like e.g. Apple:
  UI is developed after the "important" stuff works
  UI is "nice to have"
- Developers of web maps (esp. consumer- and programmer-mapmakers) have little or no background in cartography or user interface design

http://povesham.wordpress.com/2009/05/07/neo-and-paleo-gis-%E2%80%93-is-the-difference-in-the-usability-culture/

1 / 2 **User Interface Design** / 3 / 4 # 22

Do we really need this?

- Studies from e-commerce: business metrics improve after a usability redesign by 83%
- users don't want to wait
- users don't want to learn how to use a system
- users need help to find what they want to find
- users decide about usability in seconds

http://usability.gov, http://www.gnocdc.org/usability/

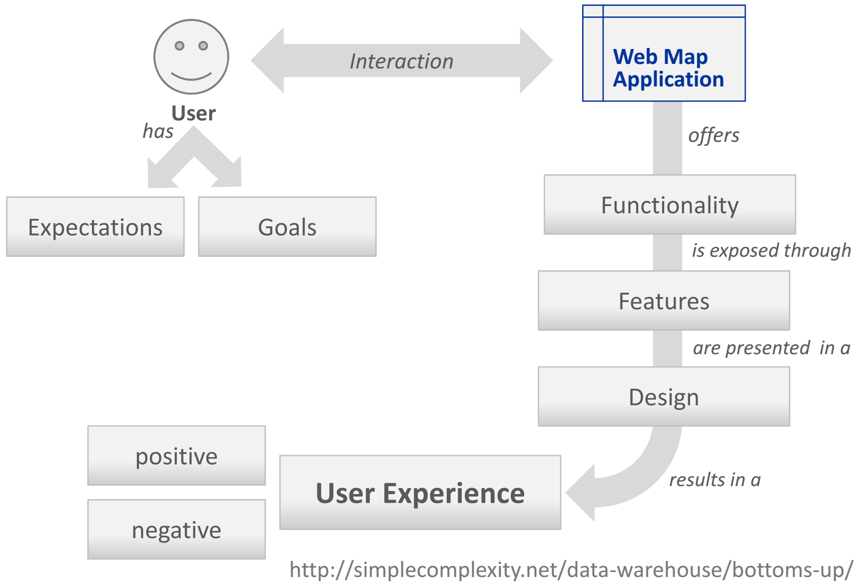
1 / 2 **User Interface Design** / 3 / 4 # 23

Do we really need this? (cont.)

- Studies in web mapping: Well designed UIs improve…
  - the user's ease about using a web map
  - the user's pleasure
  - the user's overall information retrieval
- The "Google Maps Effect": Google Maps revolutionized the way people expect to interact with an online map
  → Users expect a similar interaction experience in other web maps

Grund E. (2005) User Interface Design in Online Mapping Systems
Peterson M. (2008) Maps on the Internet: What a mess it is and how to fix it

1 / 2 **User Interface Design** / 3 / 4 # 24



http://simplecomplexity.net/data-warehouse/bottoms-up/

5 stages of a user-centered design approach

1. **Strategy plane**
   - Map Service Objective: What do we want to get out of the site?
   - User Need: What do our users want?
2. **Scope plane:** transforming strategy into requirements
   - Functional specifications for the web map UI
   - Map content requirements

Tsou M.-H. & Curran J. M. (2008) User-Centered Design Approaches for Web Mapping Applications

5 stages of a user-centered design approach (cont.)

3. **Structure plane:** How will the pieces of the site fit together and integrate?
   - Formalized function list
   - Itemized data objects
4. **Skeleton plane:** Which components will enable people to use the site?
   - Grouping functions
   - Arranging map layers

Tsou M.-H. & Curran J. M. (2008) User-Centered Design Approaches for Web Mapping Applications

5 stages of a user-centered design approach (cont.)

5. **Surface plane:** What will the finished product look like?
   - Arranging the UI with the actual use of graphic icons, buttons, windows, …
   - Selecting symbols and color schemes for the map layers

   Developing **UI mockups** (graphical models for a design) help to apply usability principles in web maps and collect feedback from users and customers without having to modify/rewrite programming code

Tsou M.-H. & Curran J. M. (2008) User-Centered Design Approaches for Web Mapping Applications, http://www.spatialknowledge.eu/2009/05/user-interface-mockup-for-gis

Usability testing: Factors measured

1. **Effectiveness:** Is the user successful in finding information and accomplishing his tasks?
2. **Efficiency:** Is the user able to accomplish his tasks quickly and easily, without getting frustrated?
3. **Satisfaction:** Does the user enjoy using the web map?
4. **Error frequency and severity:** How often do users make errors while using the map, how serious are these errors?
5. **Memorability:** If a user has used the map before, can he/she still remember how to use it effectively the next time?

http://usability.gov/

Usability testing: Test execution

Representative users try to find information on a web map while observers, including development staff, watch, listen, take notes.

→ Identify areas where users struggle with the site

→ Make recommendations for improvement

Phases of testing:

Closed beta phase (invited test users)

Public beta phase (public test users): easy-to-use feedback functionality should be implemented

http://usability.gov/

3 How to ensure cartographic quality?

A good map…

… is accurate and up-to-date
… shows only relevant information
… uses appropriate symbolization
… is clear and legible
… communicates its message
… is designed for the purpose required

A poor map …

… can confuse or mislead and thus cause serious errors in decision making

Spence M. (2008) GISProfessional, Issue No 24 October 2008

Basic cartographic principles

1. **Legibility:** the information the mapmaker is portraying must be clearly recognisable
2. **Figure-ground:** important features (figure) must sit in front of the supporting information (ground)
3. **Visual hierarchy:** information should be structured, so they can be interpreted piece by piece
4. **Contrast:** emphasis should be added to primary features in order to make them stand out

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How to improve mash-ups

- ✓ Comparing base map tiles of different vendors (e.g. Google, Yahoo, Microsoft, Cloudmade/OSM) in order to choose the one which suits best in terms of color, content and data coverage of the area needed
- ✓ Optimizing the overlay quality according to cartographic principles, e.g. using region functionality for scale dependent results
- ✓ Using icon clustering in order to avoid visual clutter
- ✓ Optimizing data and user interface for user needs

How to improve mash-ups (cont.)

✓ Be aware: a map will be a poor map if the data quality is poor! Innaccurate, incomplete and out-of-date data cannot be comouflaged with good design and fancy technology.

Always label your data sources! Apart from copyright issues, this will increase the confidence, people will have in your map.

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Some helpful tools for mapping

4 HANDS-ON!

www.geocommons.com geocommons

– Finder: platform for storing and sharing geo data in open data formats (CSV, KML, GeoRSS, Shape, txt)
– Maker: easy-to-use tool to produce thematic maps that can be visualized on different base maps
– Maps can be integrated in own websites
– Beware: In order to produce a readable and useful map it is still required to use common sense and some basic cartographic understanding; legends often not clear.

Some helpful tools for mapping

www.colorbrewer2.org

– Free tool, that helps to pick suitable colors for a map depending on your needs (screen, colorblind safe, photocopy-able, print friendly)
– Colors can be exported in several schemes

Developed by Cynthia Brewer and Mark Harrower at Pennsylvania State University

Some helpful tools for mapping

Other useful sources:

– Type Brewer: www.typebrewer.org platform that gives non-specialist mapmakers basic knowledge on selecting typography for maps

– Map Symbol Brewer: http://www.carto.net/schnabel/mapsymbolbrewer/ tool by Olaf Schnabel to generate complex map symbols

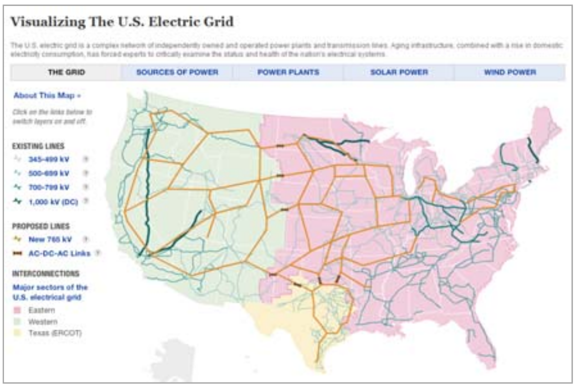
– Balsamiq Mockups: http://www.balsamiq.com/ software to create mockups (see #28)

Evaluating solar potential web maps

4 HANDS ON!

Visualizing the US Electric Grid
http://www.npr.org/templates/story/story.php?storyId=110478435

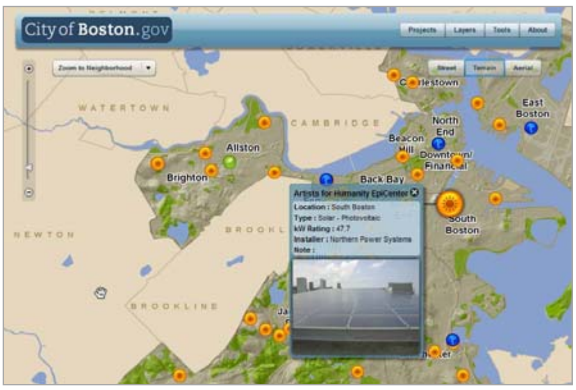
- Clear content
- Easy to use
- Restricted interaction
- Requires Flash plug-in



Evaluating existing solar potential web maps

Solar Boston
http://gis.cityofboston.gov/SolarBoston/

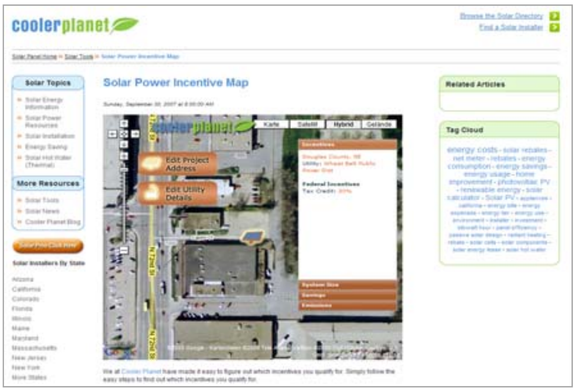
- ESRI ArcGIS based with customized base map content
- Full-screen map
- Legend is hard to find



Evaluating existing solar potential web maps

Solar Power Incentive Map
http://solar.coolerplanet.com/Articles/solar-power-incentive-map.aspx

- Google Maps mashup
- No interaction with the map; map just as a reference
- Small, crowded map window

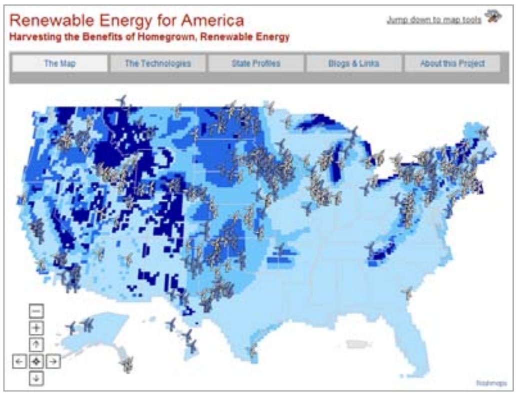


1 / 2 / 3 / 4 **Hands-on**! # 40

Evaluating existing solar potential web maps

Renewable Energy for America
http://www.nrdc.org/energy/renewables/default.asp

- cluttered map graphic; hard to distinguish map elements
- map key lacks meaning (e.g. „high / low“ potential)

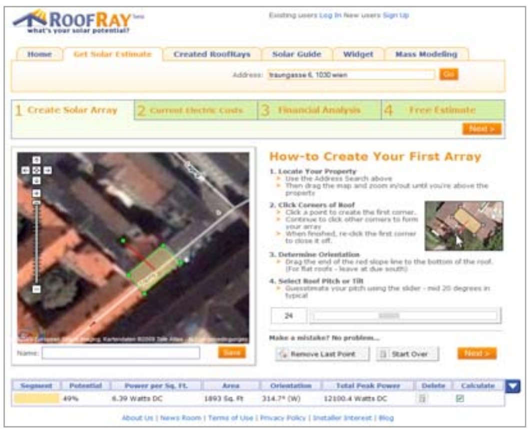


1 / 2 / 3 / 4 **Hands-on**! # 41

Evaluating existing solar potential web maps

RoofRay http://www.roofray.com/calculator

- Possibility to draw polygons on top of the Google Maps API, determine the orientation and calculate the solar energy potential

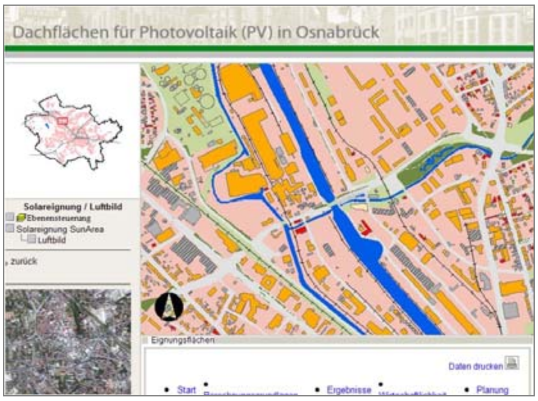


1 / 2 / 3 / 4 **Hands-on**! # 42

Evaluating existing solar potential web maps

SunArea Osnabrück http://geodaten.osnabrueck.de/website/SunArea/viewer.htm (german)

- slow
- not intuitive interface
- user can cause lots of error messages
- map key hard to find
- detailled data available



4 HANDS ON!

Plan your web map to be user-centered

Please answer the following questions concerning your assignment to build a solar potential map:

- What is your primary objective to publish this map?
- Who will be the user and what are their tasks and goals when visiting your map?
- Which information and functions do your users need and in which form?
- What hardware/software and internet connection will the majority of your users use to access your web map?

Thank you!

Manuela Schmidt
manuela.schmidt@tuwien.ac.at

Abstract

Dissemination of solar and hydro potentials with Geobrowsers

Johannes Scholz, Clemens Strauß

Graz University of Technology

Information provided by web-based technologies can reach a wide spread of prospectors by a minimum amount of complexity. This applies for geo-information as well, but it is connected to a little more complex realisation of the web portal. The visualisation of geo-information and the navigation within the website is much more user-friendly than high tech geo-software tools and even an untrained user will successfully interact with the portal.

In general there are two approaches for creating a geo-web portal. Firstly, add the project-specific spatial data to a “ready to use” geobrowser like Google maps (http://maps.google.com). In this case Google provides a fully working geobrowser with different base maps – map, satellite images and terrain (Figure 1). The project specific data has to be modified to a Google-known data format (kml or kmz) which can be imported into this browser.

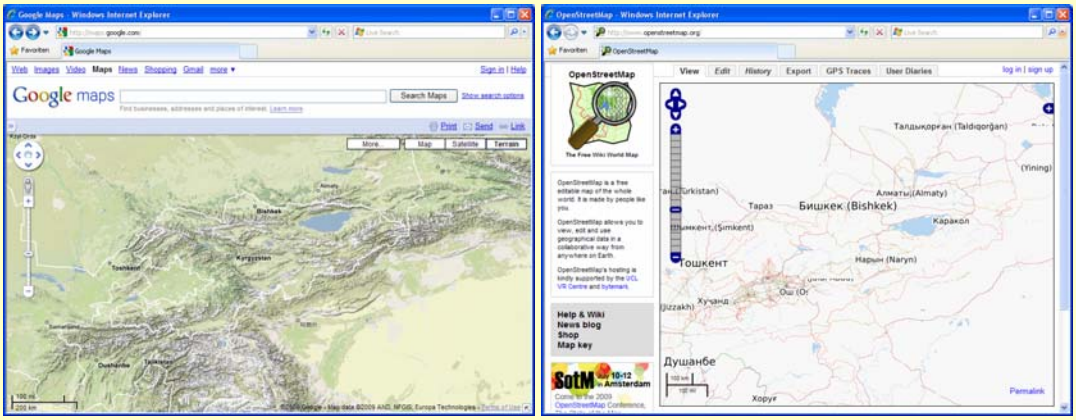


Figure 1: Google Maps Terrain (left),
OpenLayers-based visualisation of Open Street Map data (right)

Secondly, create an appropriate geobrowser with the aid of existing programming libraries – e.g. OpenLayers (http://openlayers.org) Figure 1. Here, the whole website including the spatial data viewer and navigation tools have to be setup by the software developer. The spatial information, which is displayed in this geobrowser, can have different sources. The use of standardized formats, like web map services (WMS) and web feature services (WFS) have become common practice. This implies an additional service for providing the spatial data in a WMS / WFS conform way. For this purpose an environment like Mapserver (http://mapserver.org) or Geoserver (http://geoserver.org) is necessary to provide these services.

The level of user activity can reach from viewing data only over querying attribute information about selected features to a fully operating data manipulation capability (create, delete and update). In the case of dissemination of spatial analyses results – solar and hydro potentials – the geobrowser functionality should focus on the data presentation (one way communication). Manipulation tasks (two way communication) should be restricted to experts.

Dissemination of solar and hydro potentials with Geobrowsers

openSolarCA'09

Johannes Scholz & Clemens Strauß

agenda

- concept of "geo web"
- types of geo-browsers
  - ready-to-use
  - self-designed
- technology in the background (WMS)
- google maps
- OpenLayers

concept of "geo web"

- How to disseminate spatial information for a broad auditory?
- What about the internet!?
- characteristics of spatial information
  - numbers
  - text
  - pictures (maps, diagrams)

concept for "geo web"

- capability for dissemination of spatial information covering alphanumeric data and pictures
  - numbers and text (e.g. HTML)
  - pictures (tiff, jpg, png, gif)
    - maps (e.g. WMS)
    - diagrams (e.g. google chart)

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types of geo-browsers

- ready-to-use
  - web portal
    - background data (satellite image, map, physical chart)
    - navigation tools (zoom pan, layer switching)
  - capability to overlay your own spatial information
- self-designed
  - free web space required
  - web site design
  - use of spatial tool libraries (OpenLayers, Mapbender)
  - many different data sources for map content

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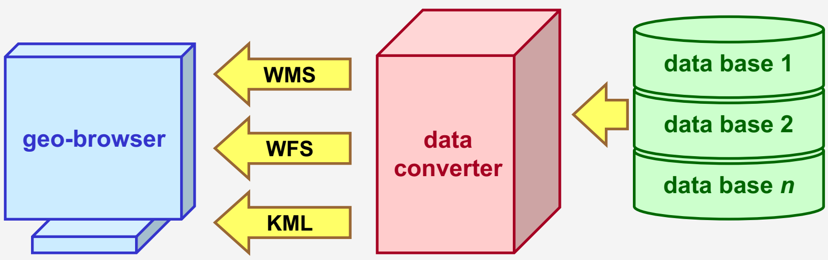
technologies in the background

- providing of spatial data
  - standardized service (e.g. WMS or WFS)
  - special format for overlays (e.g. KML)



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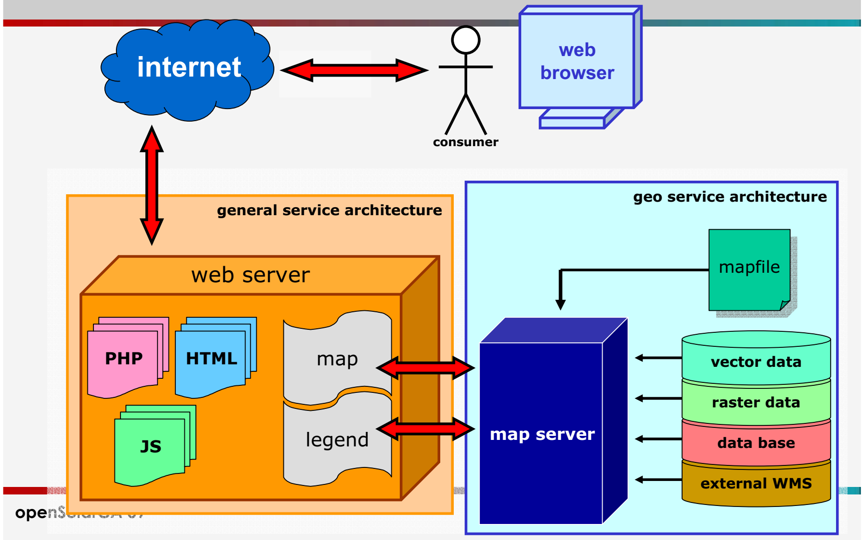
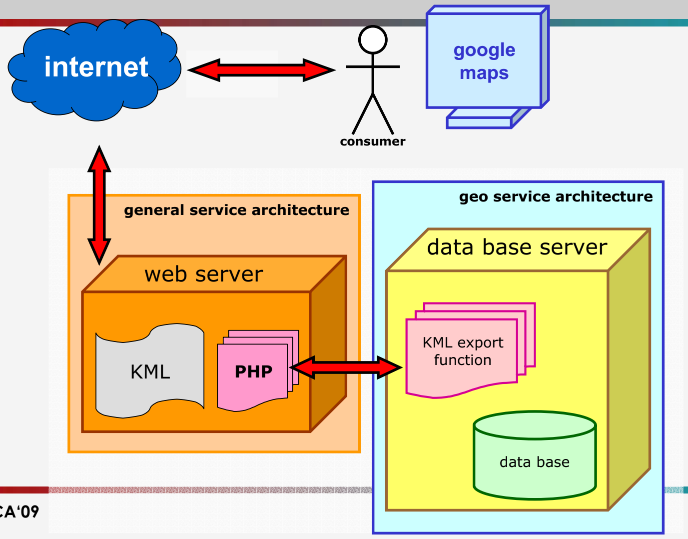
technologies in the background



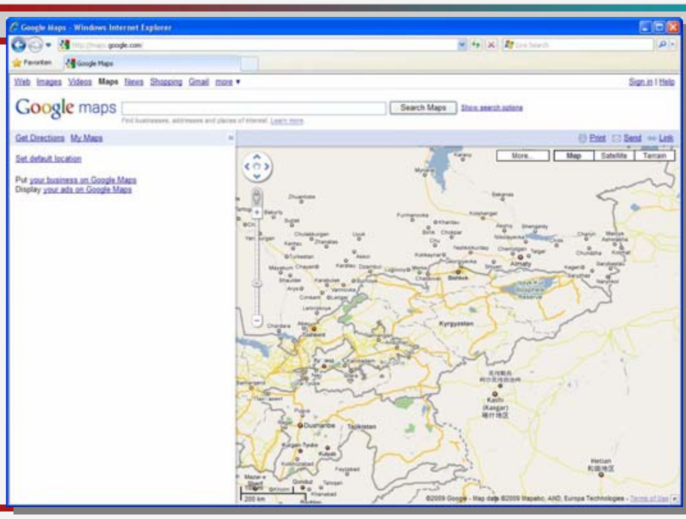
GEOinformation TU GRAZ

technologies in the background



GEOinformation TU GRAZ

google maps



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google maps

data base table (PostGIS)

	gid [PK] integer	GADMID integer	ISO character var	NAME_ENGLI character varying(	NAME_ISO character var	NAME_FAO character var	NAME_LOCAL character var	NAME_OBSOL character var	NAME_V characte
1	0	120	KGZ	Kyrgyzstan	KYRGYZSTAN	Kyrgyzstan	Kyrgyz Respubli	Kyrgyz SSR|Kyrr	
*									

conversion script

data base connection parameters

data base query

design of KML structure

export KML structure as KML file

```
<?php

// data base parameters
$host = "255.255.255";
$port = "1234";
$user = "username";
$password = "password";
$dbname = "data base name";

// data base query
$conn = pg_connect("host=$host port=$port dbname=$dbname user=$user password=$password");
$strSQL = "select \"NAME_ENGLI\", askml(the_geom) from kgz_adm0";
$result = pg_query($conn, $strSQL);
pg_close($conn);
$row = pg_fetch_row($result);
$strName = $row[0];
$strGeometry = $row[1];

// design of KML structure
$strKML = "<?xml version=\"1.0\" encoding=\"UTF-8\"?>\n";
$strKML .= "<kml xmlns=\"http://www.opengis.net/kml/2.2\">\n";
$strKML .= "<Placemark>\n";
$strKML .= "<name>$strName</name>\n";
$strKML .= "<description>$strName</description>\n";
$strKML .= "$strGeometry\n";
$strKML .= "</Placemark>\n";
$strKML .= "</kml>";

// export as kml file
$strFilename = "kgz.kml";
$hFile = fopen($strFilename, 'w');
fwrite($hFile, $strKML);
fclose($hFile);

echo "done"
?>
```

conversion result

```
<?xml version="1.0" encoding="UTF-8" ?>
<kml xmlns="http://www.opengis.net/kml/2.2">
<Placemark>
<name>Kyrgyzstan</name>
<description>Kyrgyzstan</description>
<Polygon><outerBoundaryIs><LinearRing><coordinates>69.2800380000001,39.804253 69.296776,3
</Placemark>
</kml>
```

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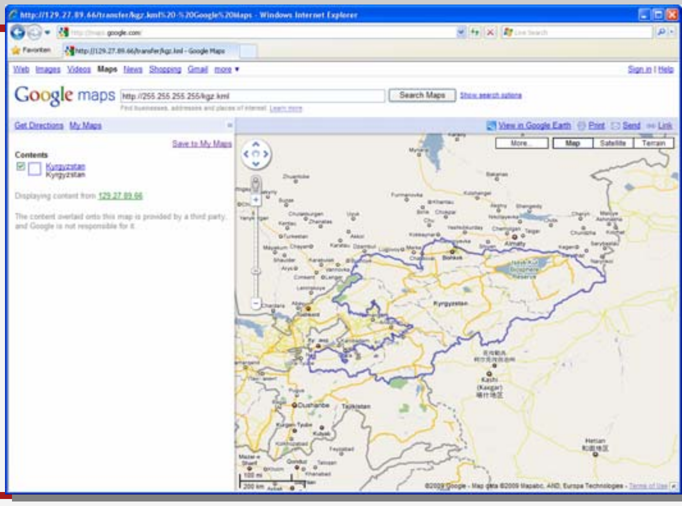
google maps



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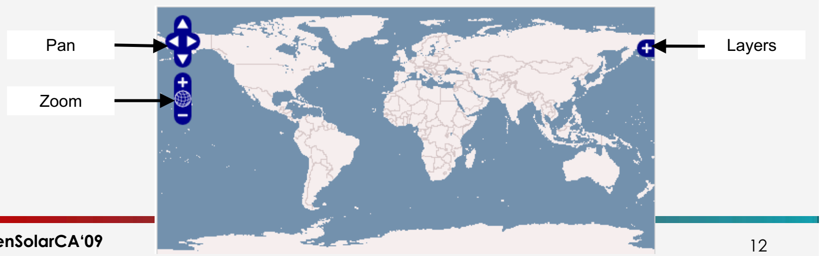
openLayers – What is it?
www.openlayers.org

- Client Side Application Programming Interface (API) for publishing spatial data independent of the server infrastructure.
- It allows a very simple "fusion" of various spatial datasets, and provides a very user friendly user interface.
- Development language: JavaScript
- Open Source Software!!



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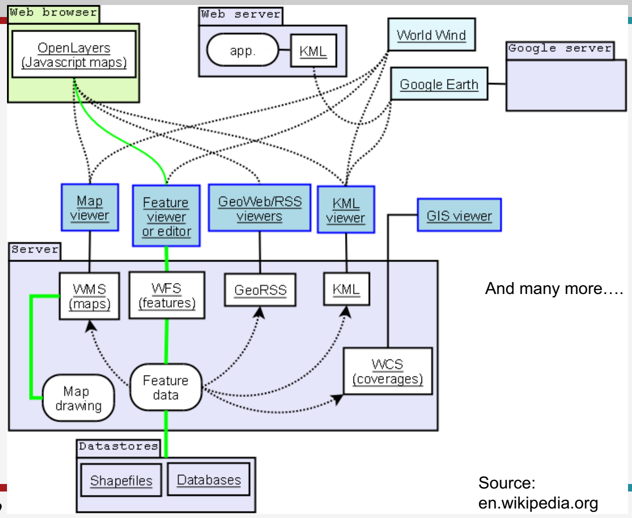
openLayers – supported interfaces



And many more….

Source: en.wikipedia.org

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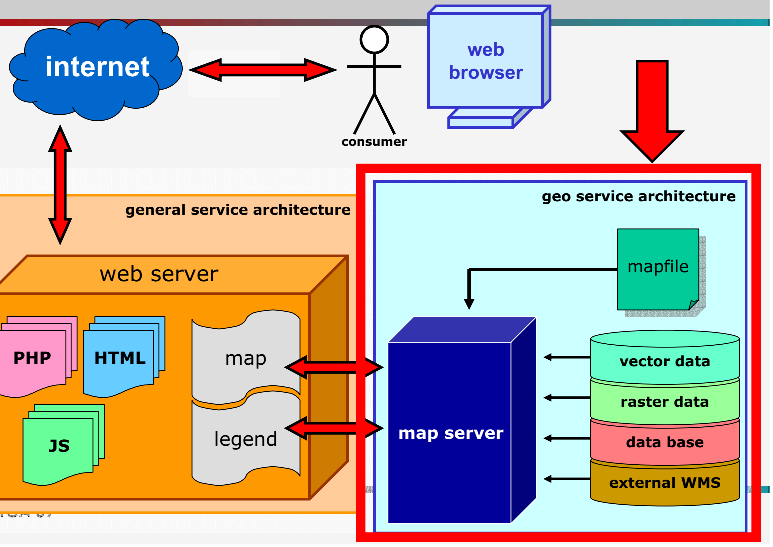
How to visualize your data with openLayers?

- Prerequisites:
  - Data in a spatial Database or in any spatial data format (e.g. Shape File *.shp)
  - Create a spatial data infrastructure (SDI)
    - e.g. Web Mapping Service (WMS), UMN Mapserver
    - Nb! the UMN Mapserver can be configured to serve as WMS
- Include SDI in openLayers
- Create a website including the openLayers Map Widget
- Publish the website on an webserver!

GEOinformation TU GRAZ

openLayers visualization: create SDI



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openLayers visualization: create SDI

- Prerequisite:
  - Any Mapserver up and running!
    - e.g. Geoserver (geoserver.org) or UMN Mapserver (mapserver.org)
  - Here we use: **UMN Mapserver**
- UMN Mapserver Configuration by a Mapfile
  - Simple text file that defines the relationships between objects, defines where data are located and defines how maps are drawn.
  - Full documentation: http://mapserver.org/mapfile/

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openLayers visualization: create SDI

- Example Mapfile with functionality
  - Display a map with Kyrgyzstan
  - Configuration as WMS Server

```
MAP
    NAME            'Example_Map_Kyrgyzstan'
    IMAGETYPE       PNG
    #EXTENT          9820 4339570 937148 4787550      # epsg:32643
    EXTENT           69 39 81 44                      #extent for epsg:4326
    UNITS           METERS
    DEBUG            ON
    SIZE             500 500
    SHAPEPATH        'C:/ms4w/Apache/htdocs/data'
    SYMBOLSET       "C:/ms4w/Apache/htdocs/umn_lernen/symbols/symbols35.sym"     # Path to symbol definition
    FONTSET         "C:/ms4w/Apache/htdocs/umn_lernen/fonts/fonts.list"          # Path to font definition


# basic settings------------------------------------------

OUTPUTFORMAT
        NAME png
        DRIVER "GD/PNG"
        MIMETYPE "image/png"
        IMAGEMODE RGB
        EXTENSION "png"
    END
```

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openLayers visualization: create SDI

Web Metadata mandatory for WMS Server!

```
WEB
    TEMPLATE  "C:/ms4w/Apache/htdocs/opensolar/template.html" # path to template
    IMAGEPATH "C:/ms4w/tmp/"
    IMAGEURL  "/tmp/"
    METADATA
            'WMS_TITLE' 'Kyrgyzstan WMS'
            'WMS_ABSTRACT' 'Kygyzstan Test WMS'
            'WMS_FEATURE_INFO_MIME_TYPE' 'text/html'
            'WMS_ONLINERESOURCE' 'http://fphotpc45.tugraz.at/cgi-bin/mapserv?map=C:/ms4w/Apache/htdocs/opensolar/map
            'WMS_SRS'       'epsg:4326'
            #"WFS_TITLE"    ""
            #"WFS_SRS"      ""
            #"WFS_ONLINERESOURCE" ""
    END
END

PROJECTION
    "init=epsg:4326"
END
```

Imagepath: Path where Mapserver should store the Map (grpahics file)
Imageurl: Web path where to retrieve the map(graphics file)

Define the projection of the Map as an EPSG Code (http://www.epsg-registry.org/)! nb! Mapserver can do an on the fly reprojection!

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openLayers visualization: create SDI

```
LAYER
    NAME        Kyrgyzstan
    TYPE        POLYGON
    STATUS      ON
    CONNECTIONTYPE postgis      #
    CONNECTION "user=*** password=*** dbname=opensolar host=129.27.89.45 port=5432"
    DATA "the_geom from kyrgyzstan"
    DUMP TRUE

    PROJECTION
        "init=epsg:4326"
    END

    METADATA
        'WMS_TITLE' 'Kyrgyzstan'
        'WMS_SRS' 'epsg:4326'
        'WMS_INCLUDE_ITEMS' 'all'
        'WMS_EXTENT' '69 39 81 44'
        'gml_featureid' 'gid'
        'GML_INCLUDE_ITEMS' 'all'
    END

    CLASS
```

Layer: defines a Layer element – geodata from one data source (e.g. postgis, Shape , …)
Multiple Layers are possible!

Define the data source of the Layer – possible are vector data sources (*.shp, postgis, oracle spatial, …) and raster data source (tiff/geotiff, jpg, png, Erdas, ArcInfo GRID, …)
Full list of supported data sources:
http://mapserver.org/input/index.html#input (vector)
http://www.gdal.org/formats_list.html (raster)

Metadata are mandatory for WMS Server support!

openLayers visualization: create SDI

```
    METADATA
        'WMS_TITLE' 'Kyrgyzstan'
        'WMS_SRS' 'epsg:4326'
        'WMS_INCLUDE_ITEMS' 'all'
        'WMS_EXTENT' '69 39 81 44'
        'gml_featureid' 'gid'
        'GML_INCLUDE_ITEMS' 'all'
    END

    CLASS
        STYLE
            OUTLINECOLOR 255 0 0
            COLOR 255 0 0
            WIDTH 7
        END

        NAME        "Kyrgyzstan"
        TEMPLATE    'ausgabetemplatefuerpostgis.html'
    END
END
END
```

Class: defines a homogeneous thematic content of a Layer! Each layer must have at least one class! E.g. Layer „City" may have several classes: major city, minor city, village.

For distinction the EXPRESSION statement is appropriate: e.g. EXPRESSION ([POPULATION] > 50000 AND '[LANGUAGE]' eq 'FRENCH')

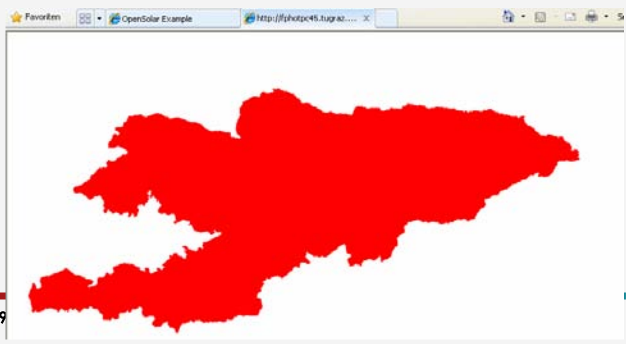
Style definition of the Class – here outline color red, polygons filled with red, outline width is 7 pt
If COLOR -1 -1 -1 is set then polygon is translucent (= transparent)

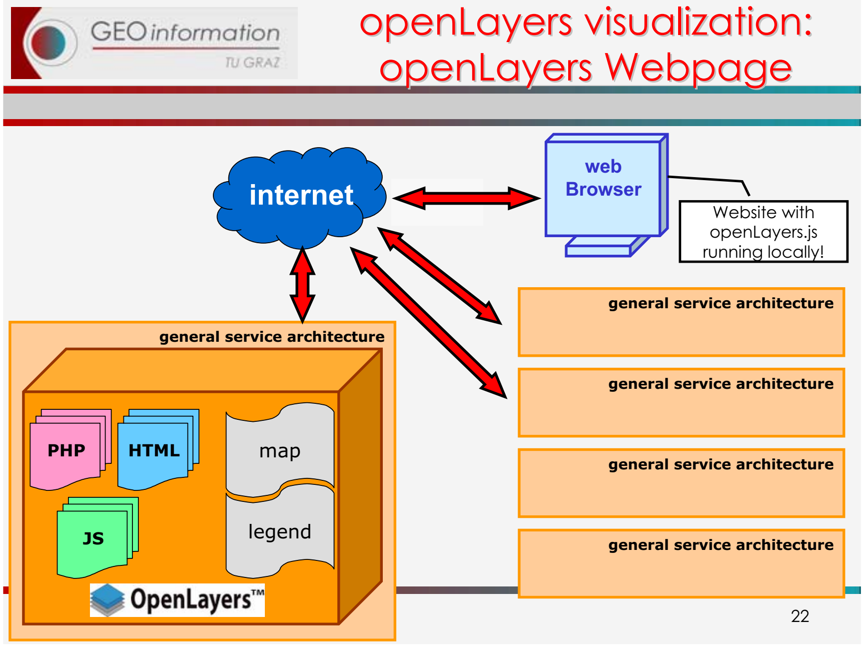
Template for the WMS GetFeatureInfo Request!

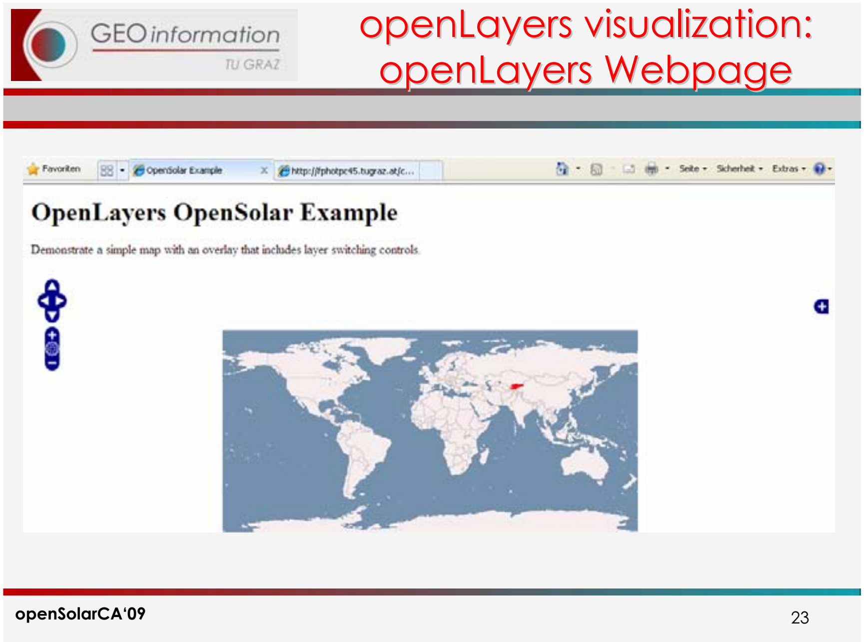
End of Mapfile

openLayers visualization: create SDI

- What have we achieved so far?
  - OGC conform Web Mapping Service (WMS)
    - WMS GetMap Request:
      - http://fphotpc45.tugraz.at/cgi-bin/mapserv?map=C:\ms4w\Apache\htdocs\opensolar\mapfile.map&REQUEST=GetMap&SRS=EPSG:4326&VERSION=1.1.0&FORMAT=image/png&Layers=Kyrgyzstan&BBOX=69,39,81,44&WIDTH=1000&HEIGHT=500




GEOinformation
TU GRAZ
openLayers visualization:
openLayers Webpage
internet
web
Browser
Website with
openLayers.js
running locally!
general service architecture
PHP
HTML
map
JS
legend
OpenLayers™
general service architecture
general service architecture
general service architecture
general service architecture
22


GEOinformation
TU GRAZ
openLayers visualization:
openLayers Webpage
OpenLayers OpenSolar Example
Demonstrate a simple map with an overlay that includes layer switching controls.
openSolarCA'09
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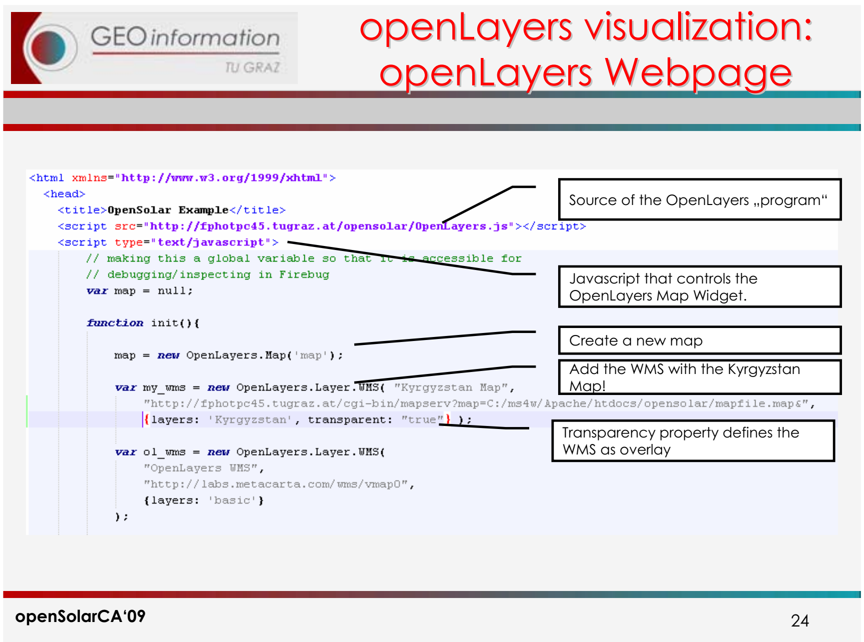
GEOinformation
TU GRAZ
openLayers visualization:
openLayers Webpage
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<title>OpenSolar Example</title>
<script src="http://fphotpc45.tugraz.at/opensolar/OpenLayers.js"></script>
<script type="text/javascript">
// making this a global variable so that it is accessible for
// debugging/inspecting in Firebug
var map = null;
function init(){
map = new OpenLayers.Map('map');
var my_wms = new OpenLayers.Layer.WMS("Kyrgyzstan Map",
"http://fphotpc45.tugraz.at/cgi-bin/mapserv?map=C:/ms4w/Apache/htdocs/opensolar/mapfile.map&",
{layers: 'Kyrgyzstan', transparent: "true"});
var ol_wms = new OpenLayers.Layer.WMS(
"OpenLayers WMS",
"http://labs.metacarta.com/wms/vmap0",
{layers: 'basic'}
);
Source of the OpenLayers „program“
Javascript that controls the OpenLayers Map Widget.
Create a new map
Add the WMS with the Kyrgyzstan Map!
Transparency property defines the WMS as overlay
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openLayers visualization: openLayers Webpage

```
map.addLayers([my_wms, ol_wms, jpl_wms, dm_wms]);
map.addControl(new OpenLayers.Control.LayerSwitcher());
map.zoomToMaxExtent();
}
</script>
</head>
<body onload="init()">
<h1>OpenLayers OpenSolar Example</h1>
<div></div>
<p>
Demonstrate a simple map with an overlay that includes layer
</p>
<div id="map"></div>
<div></div>
</body>
</html>
```

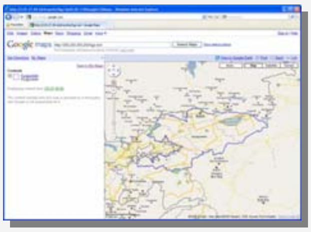
- Add the layers to the map
- Add the Layerswitch control to the Map Widget.
- Zoom to full map extent.
- Call the JavaScript function init()…
- Add the map widget to the website

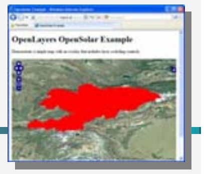
- http://fphotpc45.tugraz.at/opensolar/opensolar.html

GEOinformation TU GRAZ

summary

- project data
  - standardized interface (data converter)
    - WMS
    - WFS
    - KML
- "ready-to-use" geo-browser
  - e.g. google maps
  - project data export format (KML)
- "self-designed geo-browser
  - create website
  - function library for geo-tools (OpenLayers)





GEOinformation TU GRAZ

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Graz University of Technology
Institute of Geoinformation
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Abstract

Solar Energy in Kyrgyzstan – Connecting to the Future

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Introduction

This session will take the form of a discussion reviewing the previous two days and looking ahead into what participants will take away from "openSolarCA 09". There will be a short presentation on the state of GIS in Central Asia and its application to renewable energy in general and solar energy in particular.

Discussion Questions

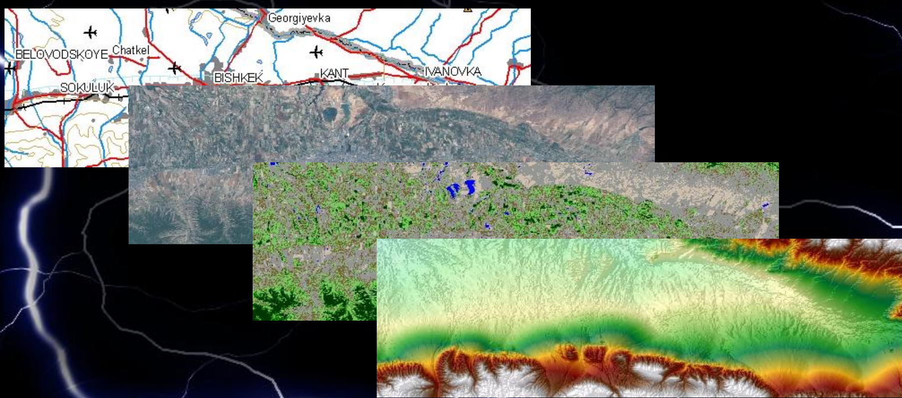
1. **Cost -** The initial cost of implementing solar energy is high – how would this cost be met in Kyrgyzstan?
   (N.B. relying on a grant from an external organisation or country is not an acceptable answer for this question)
2. **Barriers -** Other than the cost – what barriers are there to implementing solar energy in Kyrgyzstan?
3. **Demand -** Last winter 2008/09 there were severe power outages in Kyrgyzstan as demand considerably out stripped supply – is solar energy really a viable alternative to fill this gap? And if it is what is the scale (size) of implementation needed.
4. **Alternatives -** Even in Kyrgyzstan the sun doesn't always shine – what alternative alternatives could be coupled with solar power to meet future demand.
5. **Building design -** Simple alterations in design can greatly enhance a building's ability to make better use of the sun. How can Kyrgyzstan ensure that buildings in the future make the best possible use of the sun?
   (N.B. It will not be sufficient to simply state that we just need to pass a law forcing people to build in a particular way)
6. **Communication -** There are many myths surrounding solar and other alternative energies, these myths tend to cause people not to take seriously alternative energies. How can we better communicate to the stakeholders (i.e. the government, private companies, and the general public) the real potential of solar energy in Kyrgyzstan.
7. 7. **Data -** During this workshop one of the datasets we used was NASA's SRTM digital terrain data to perform our analysis.
   - What are the shortcomings of this dataset?
   - And what effect could these shortcomings have on our results?
   - One way to improve our results, especially for large scale detailed mapping, would be a finer resolution DTM. Where would a finer resolution DTM come from?
8. **Future networking -** This workshop has probably introduced participants to a considerable volume of new ideas and and techniques. Is there value in participants and organisers keeping in touch for the further promotion and advancement of solar energy in Central Asia.

Solar Energy in Kyrgyzstan...
...Connecting to the Future

Kyrgyz State University of Construction, Transport and Architecture

The state of GIS in Kyrgyzstan and Central Asia

...and its application to renewable energy in general and solar energy in particular.



Energy supply & demand in Kyrgyzstan

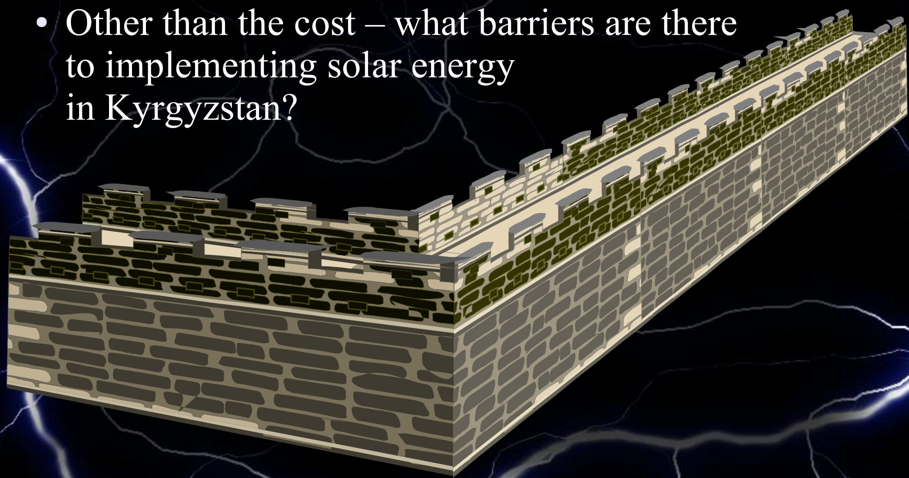
Discussion question 1: **Cost**

- The initial cost of implementing solar energy is high – how would this cost be met in Kyrgyzstan?

N.B. relying on a grant from an external organisation or country is not an acceptable answer for this question

Discussion question 2: **Barriers**

- Other than the cost – what barriers are there to implementing solar energy in Kyrgyzstan?



Discussion question 3: **Demand**

- Last winter 2008/09 there were severe power outages in Kyrgyzstan as demand considerably out stripped supply, is solar energy really a viable alternative to fill this gap?
- And if it is viable what is the scale (size) of implementation needed.

Discussion question 4: **Alternatives**

- Even in Kyrgyzstan the sun doesn't always shine – what alternative alternatives could be coupled with solar power to meet future demand

Discussion question 5: **Building design**

- Simple alterations in design can greatly enhance a building's ability to make better use of the sun. How can Kyrgyzstan ensure that buildings in the future make the best possible use of the sun?
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Discussion question 6: **Communication**

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Discussion question 7: **Data**

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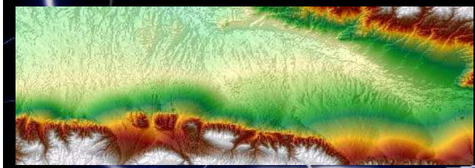
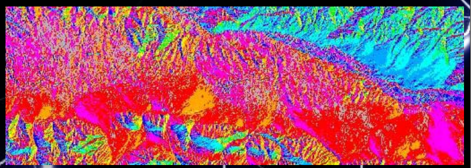
    - One way to improve our results, especially for large scale detailed mapping, would be a finer resolution DTM. Where would a finer resolution DTM come from?





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Discussion question 8: **Future networking**

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