Forests and Cooling

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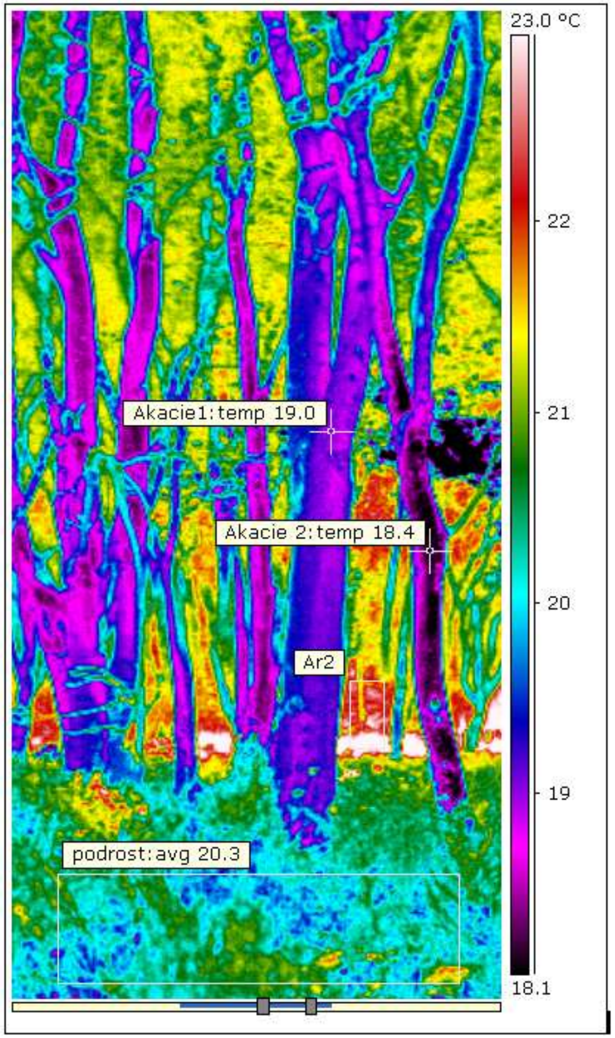
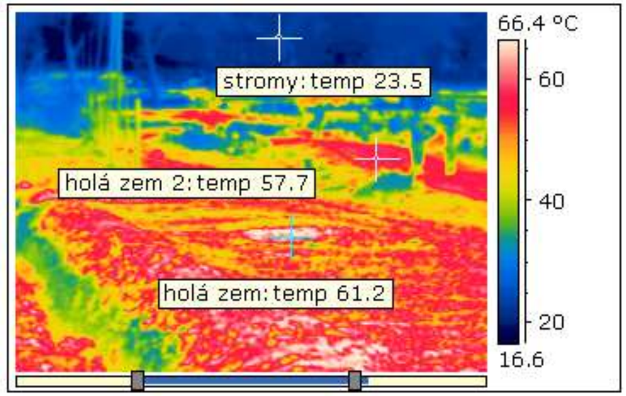
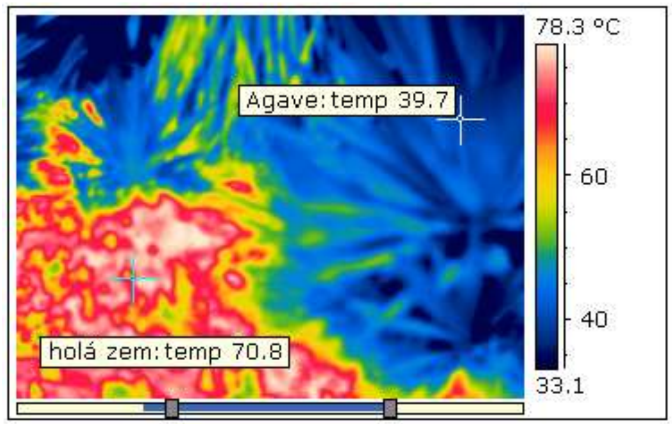
Czech Republic

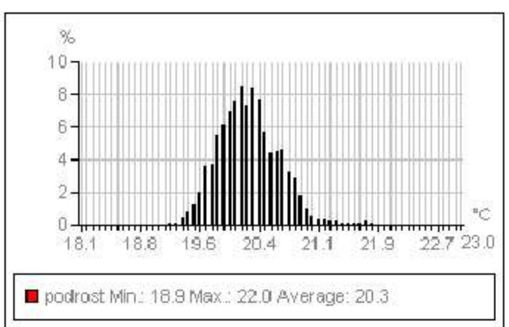
Why do Forests Matter for Climate Change?
Strategies for Sustainability
Leuven 8.-10. June 2015

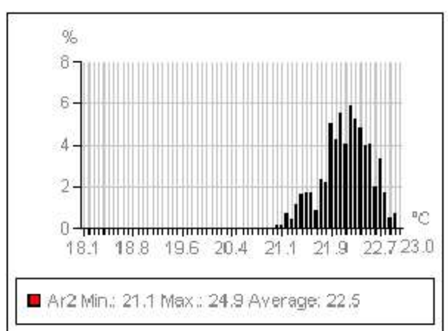




Sand has lowest albedo but highest temperature







Accacia forest about 20 C
bare land up to 70 C

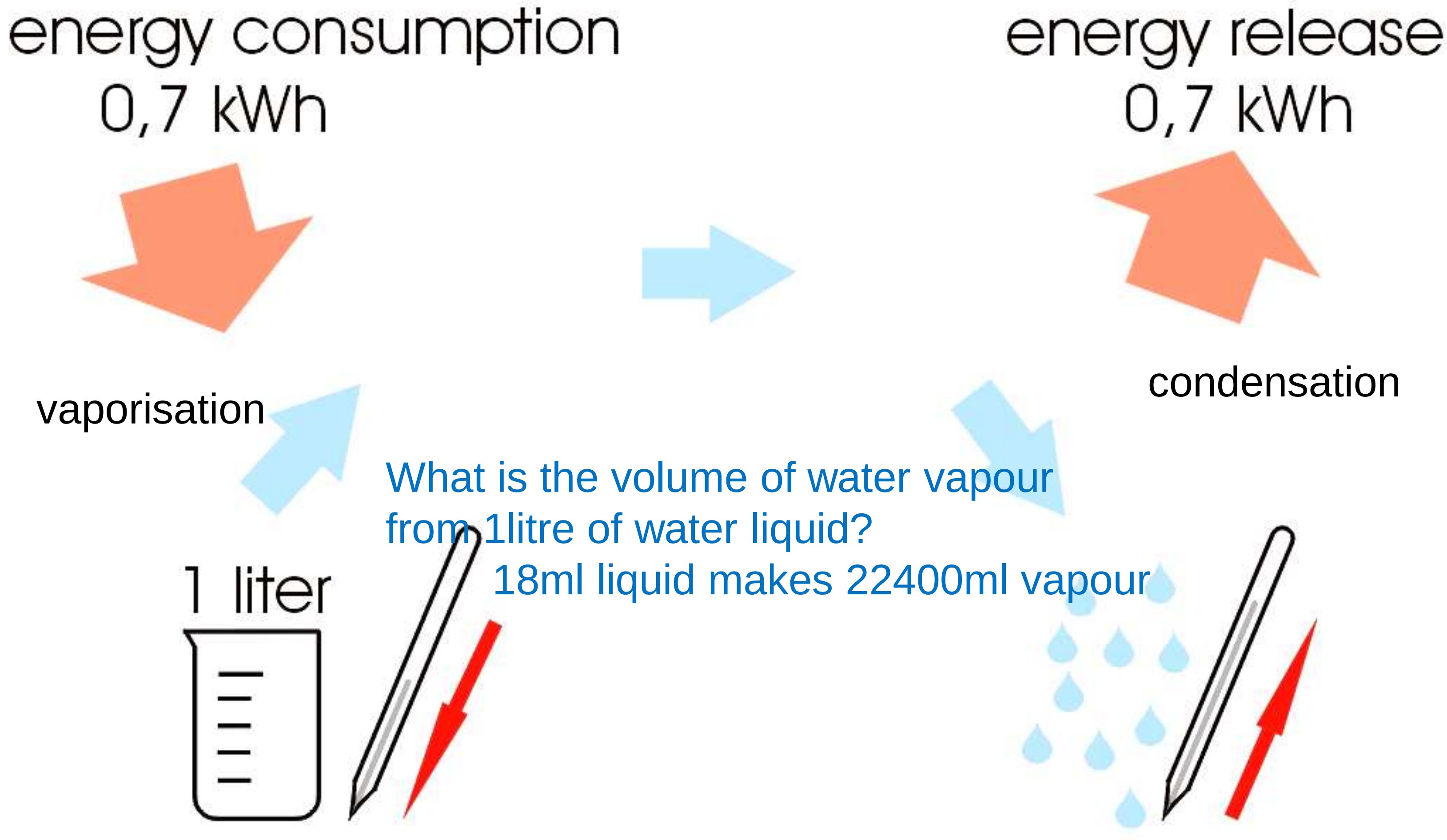
Concept

Sunshine and water are twins

Plants/Trees distribute solar energy via water cycle

An attempt for quantification

LATENT HEAT of water vaporization – princip of perfect airconditioning: cooling (vaporisation) and warming (condensation)



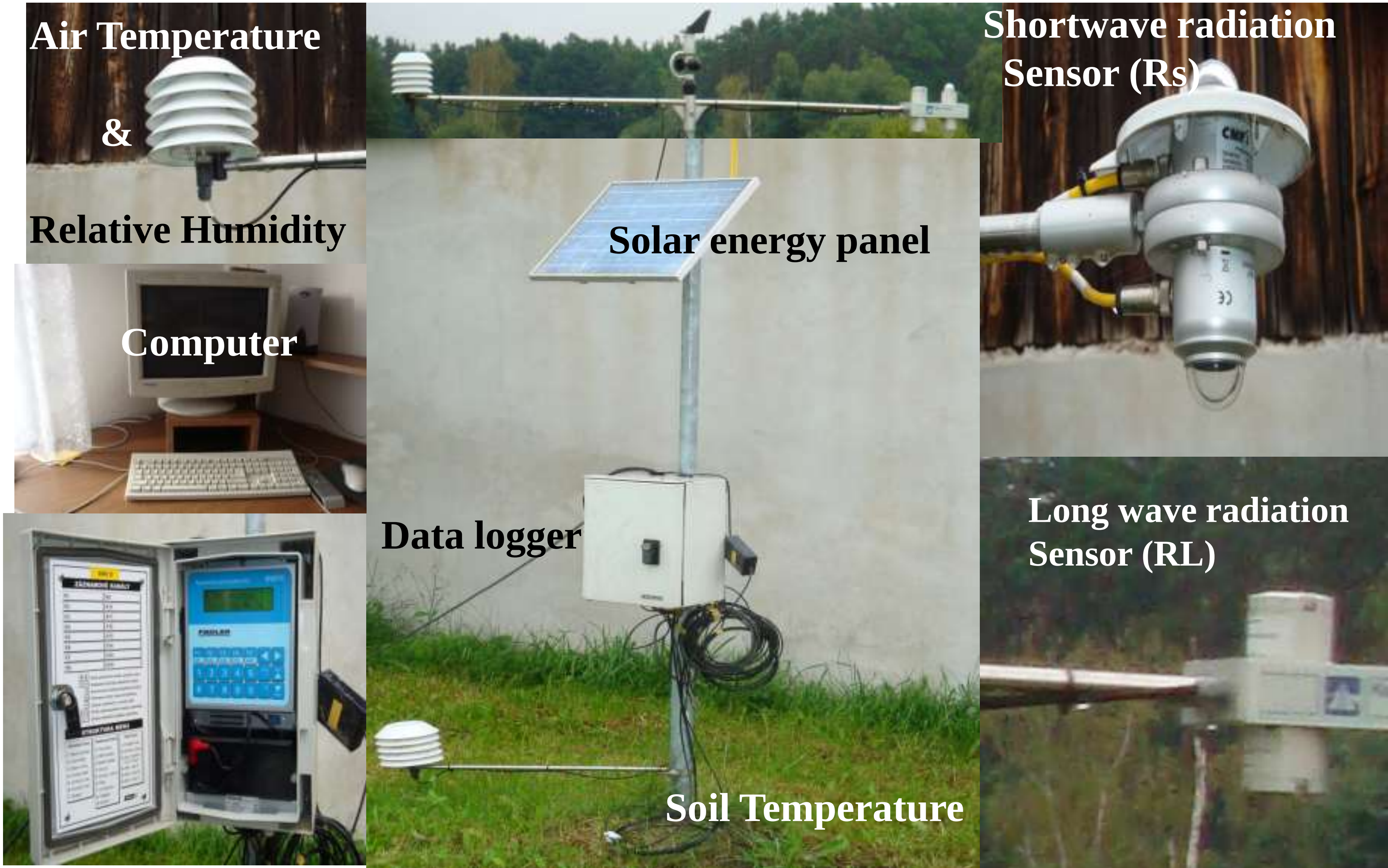
What is the volume of water vapour from 1litre of water liquid?

18ml liquid makes 22400ml vapour

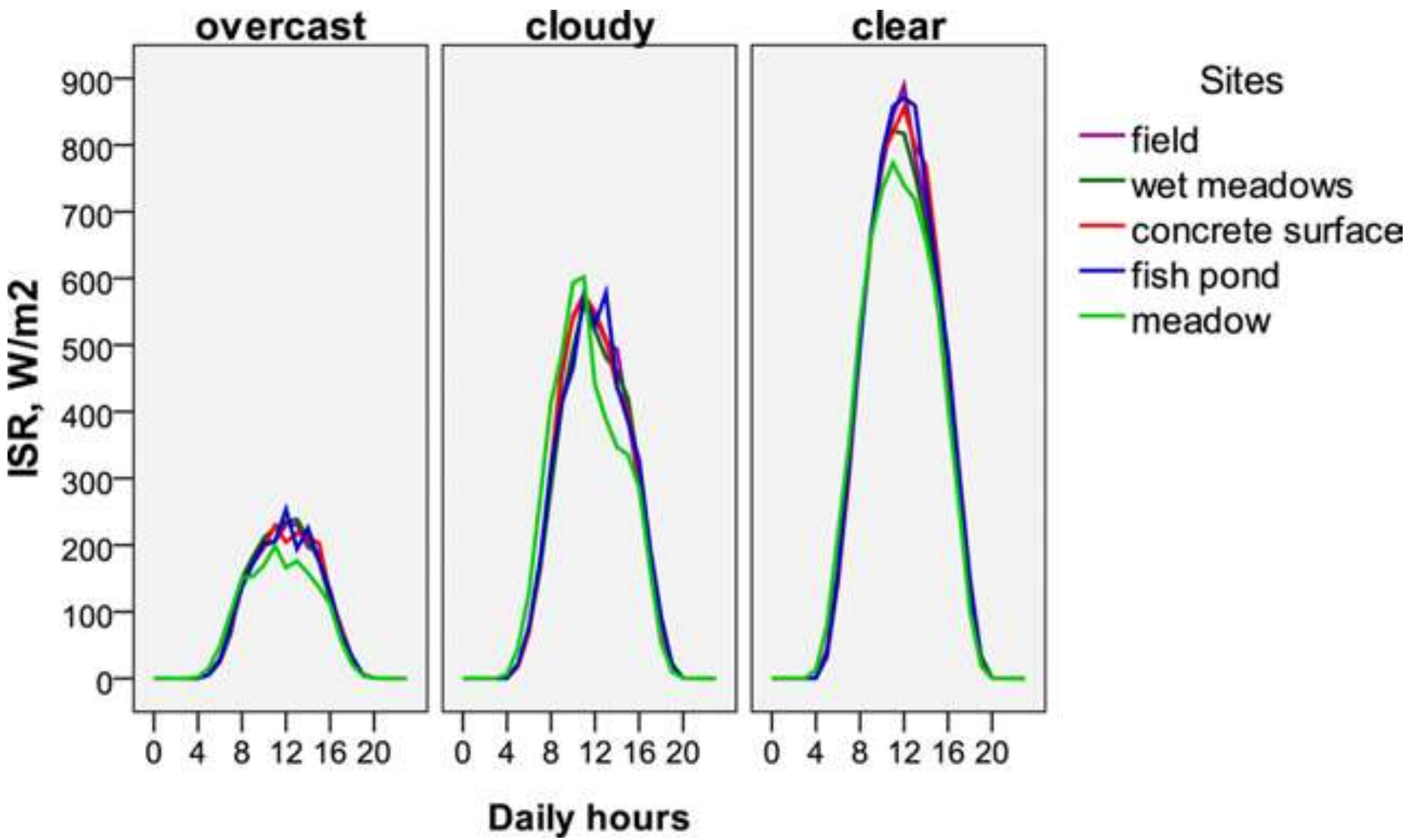
The actual direct solar irradiance at the top of the Earth’s atmosphere

fluctuates
from 1412 W m^{-2} to 1321 W m^{-2}
due to eliptic trajectory of Earth around Sun.
The amount of solar energy changes over the year by about ±3.2% (45 W m^{-2})

Materials and Methods



Incoming solar radiation



Clouds/water control amount of incoming solar energy

Clear sky *versus* overcast

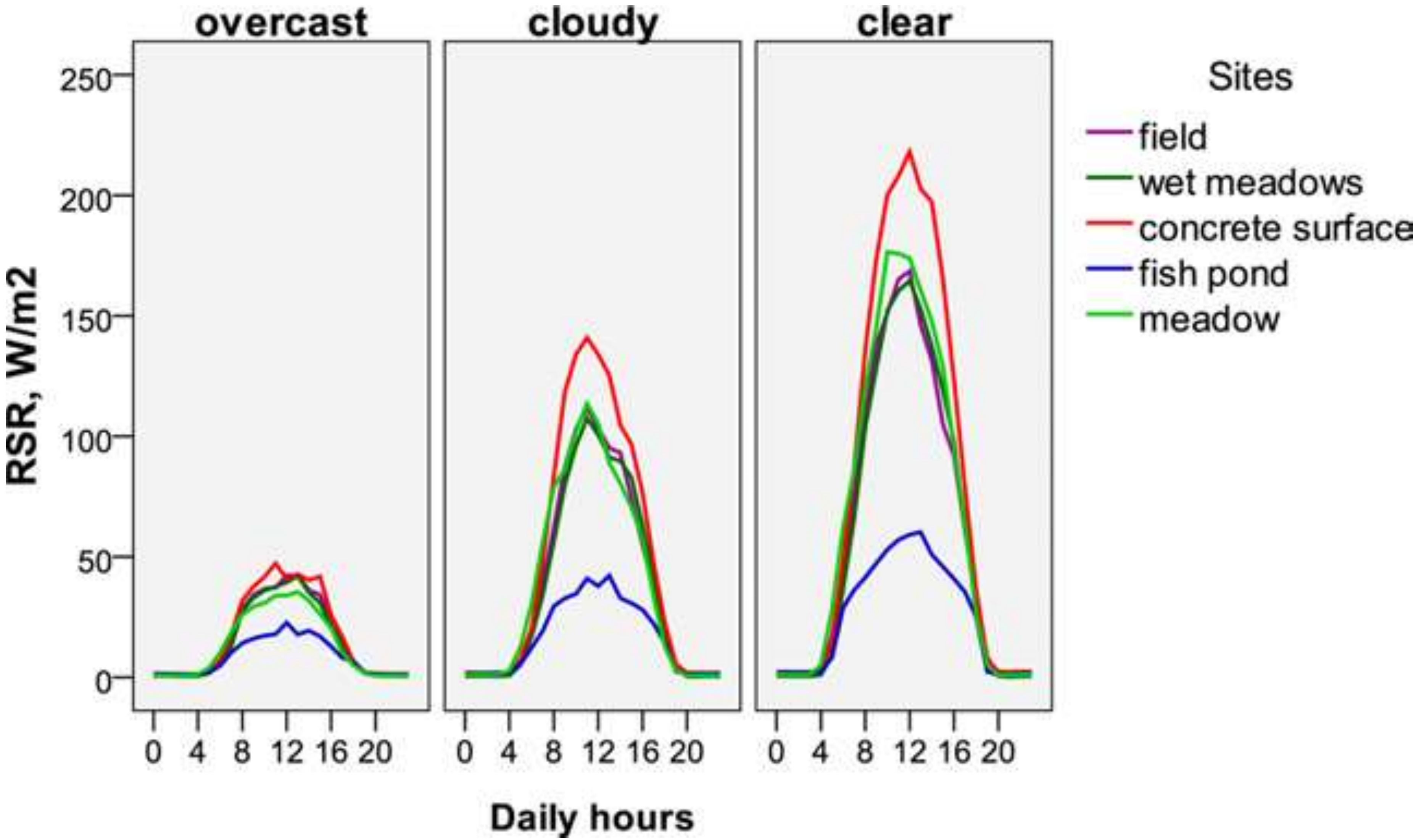
- Incoming radiation on a **clear day**

(**8 kWh m^{-2}, max. flux 1000 W m^{-2}**) can be an order of magnitude higher than the incoming radiation on an **overcast day**

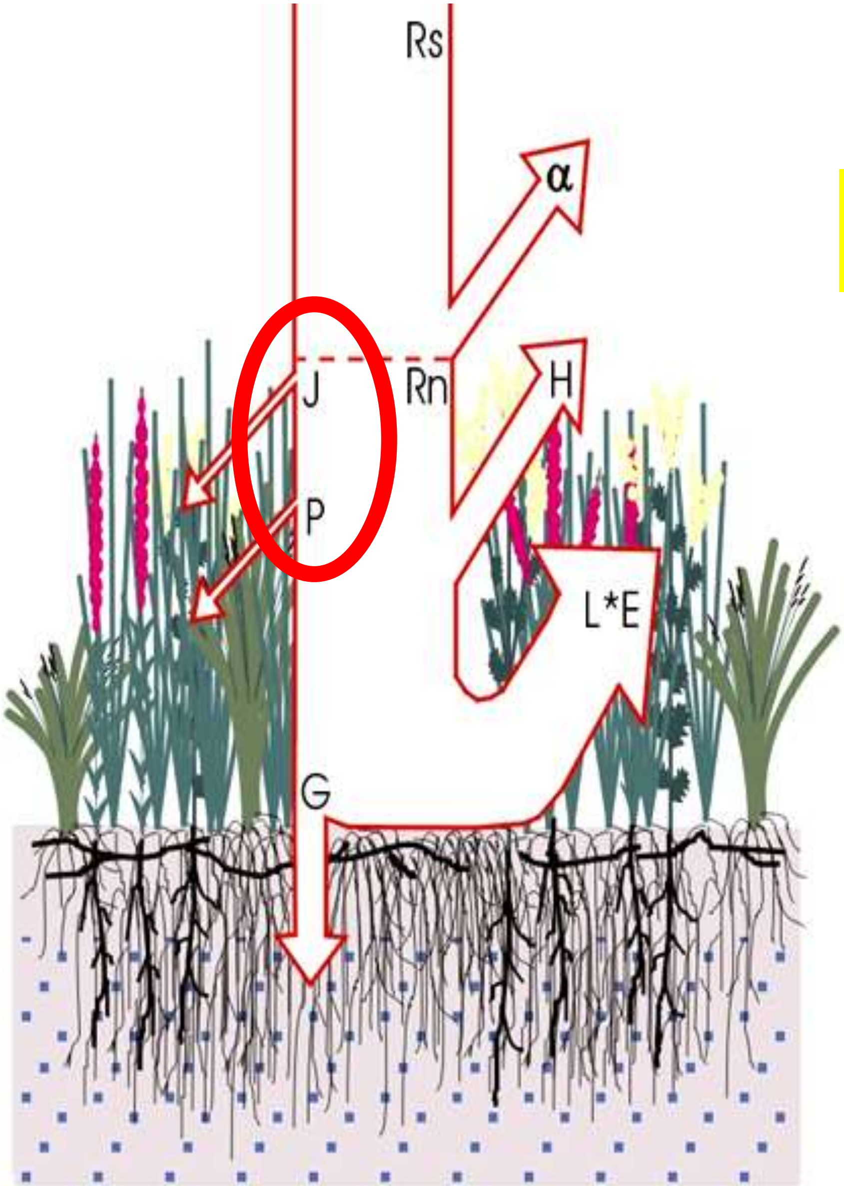
(**0.78 kWh m^{-2}, max. flux 100 W m^{-2}**).

Reflected solar radiation

Concrete has highest albedo



Energy fluxes in ecosystem

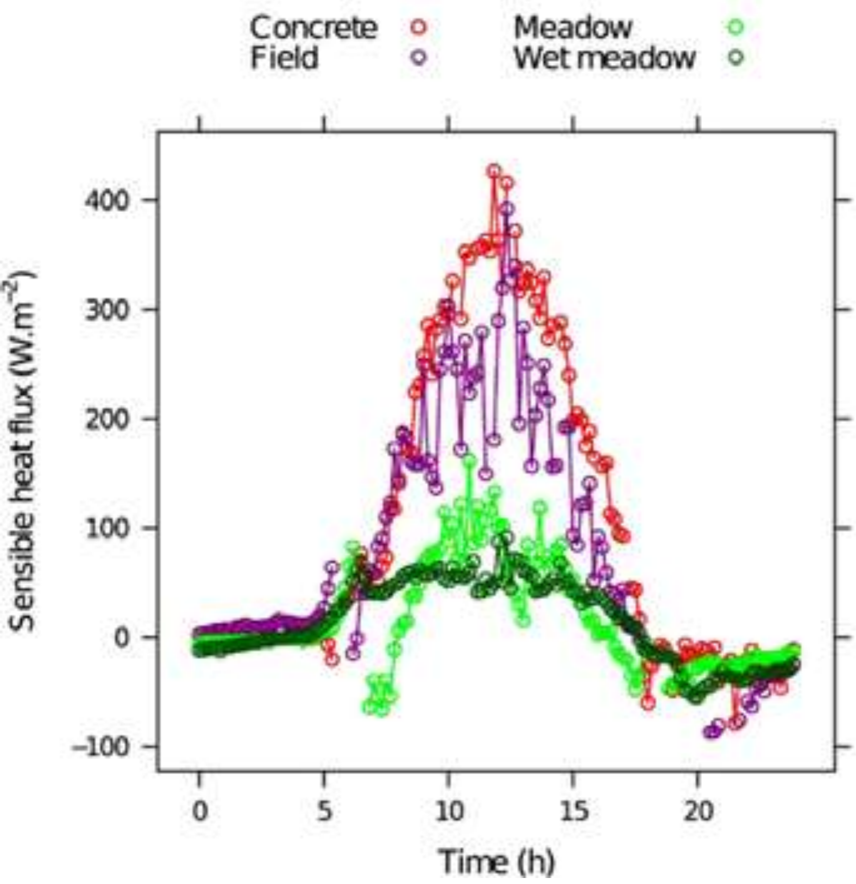


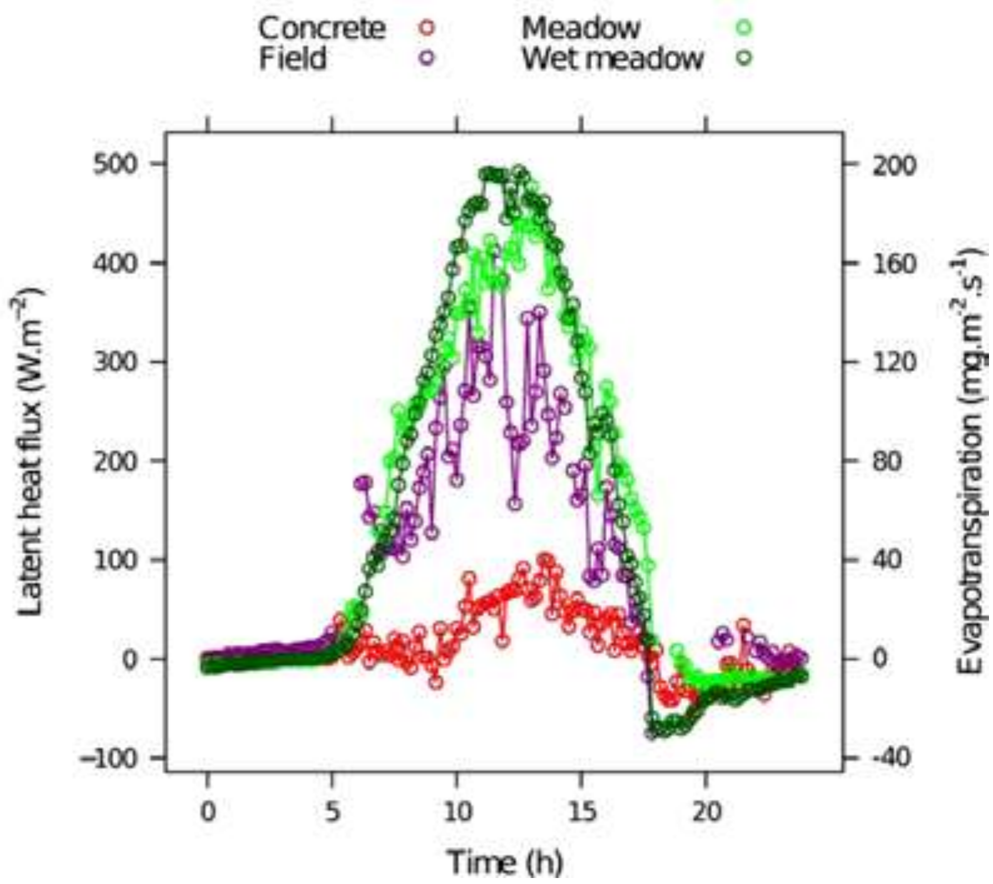
$R_n = J + P + G + H + L^*E$

Rs - global radiation
Rn - net radiation
α - albedo (reflection)
H - sensible heat flux
L*E - latent heat * evapotranspiration
G - ground heat flux
J - accumulation of heat in biomass
P - photosynthesis

Sensible and latent heat fluxes

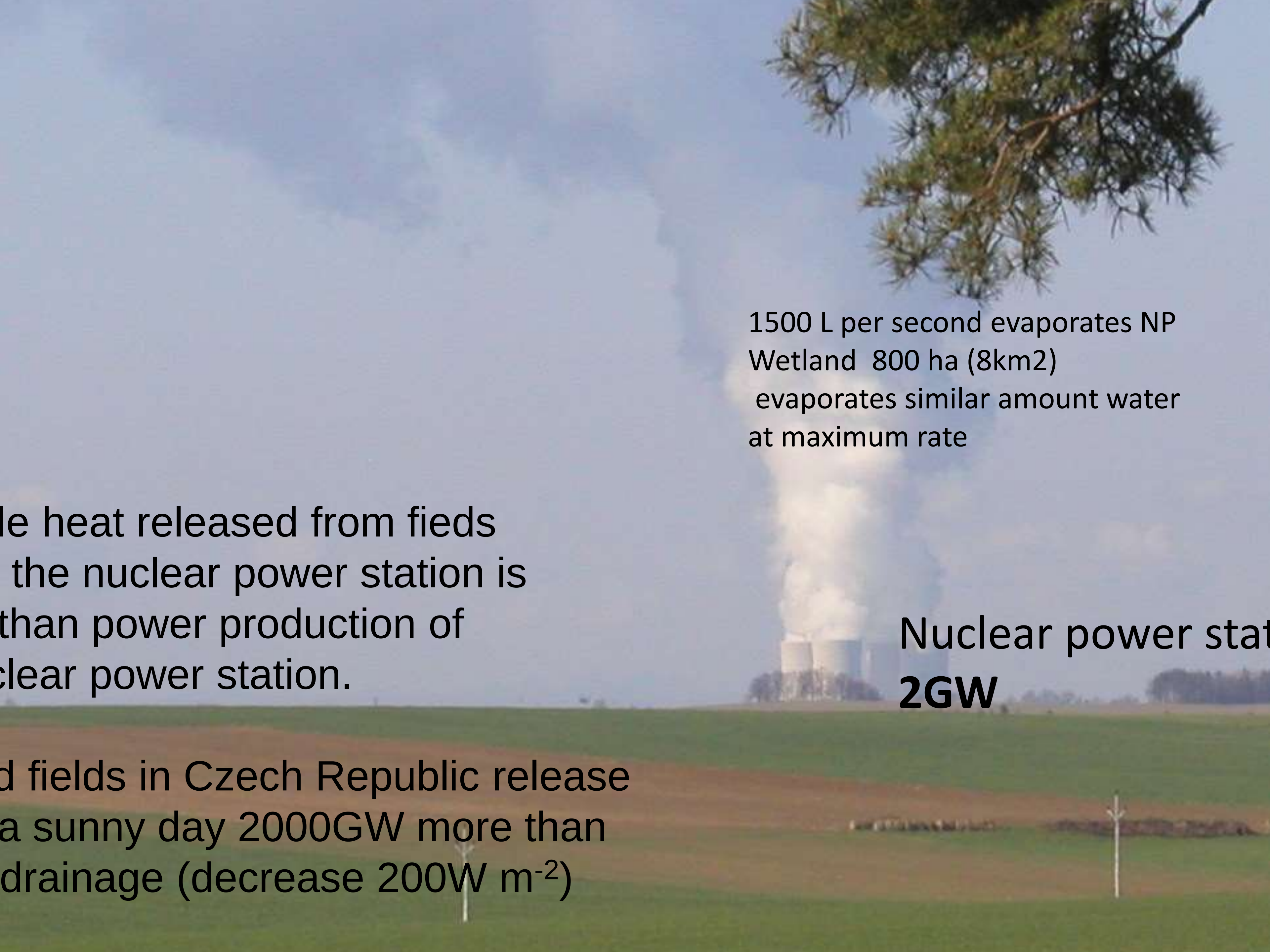
Land cover controls several hundreds W m^{-2}





Release of heat **airconditioning**


Nuclear power station 2000 MW
Solar energy coming on 2 km^{-2} on sunny day
Sensible heat (warm air) released
from several km^{-2} of dry land


1500 L per second evaporates NP
Wetland 800 ha (8km2)
evaporates similar amount water
at maximum rate
le heat released from fieds
the nuclear power station is
than power production of
clear power station.
Nuclear power stat
2GW
d fields in Czech Republic release
a sunny day 2000GW more than
drainage (decrease 200W m-2)

Meaning of average temperature in thermodynamics

- In terms of thermodynamics, **average temperature does not produce power.**
- The difference across distance – the gradient – is what makes the conditions for the flow to take place. Similarly, in atmosphere and landscape it is **gradients** of temperature, heat, air pressure, which **drive wind** and transport water vapour.
- ***Schneider****, E.D. and* ***Sagan*** *Dorior. 2005. Into the Cool, Energy Flow Thermodynamics and Life,The University of Chicago, Chicago, London*

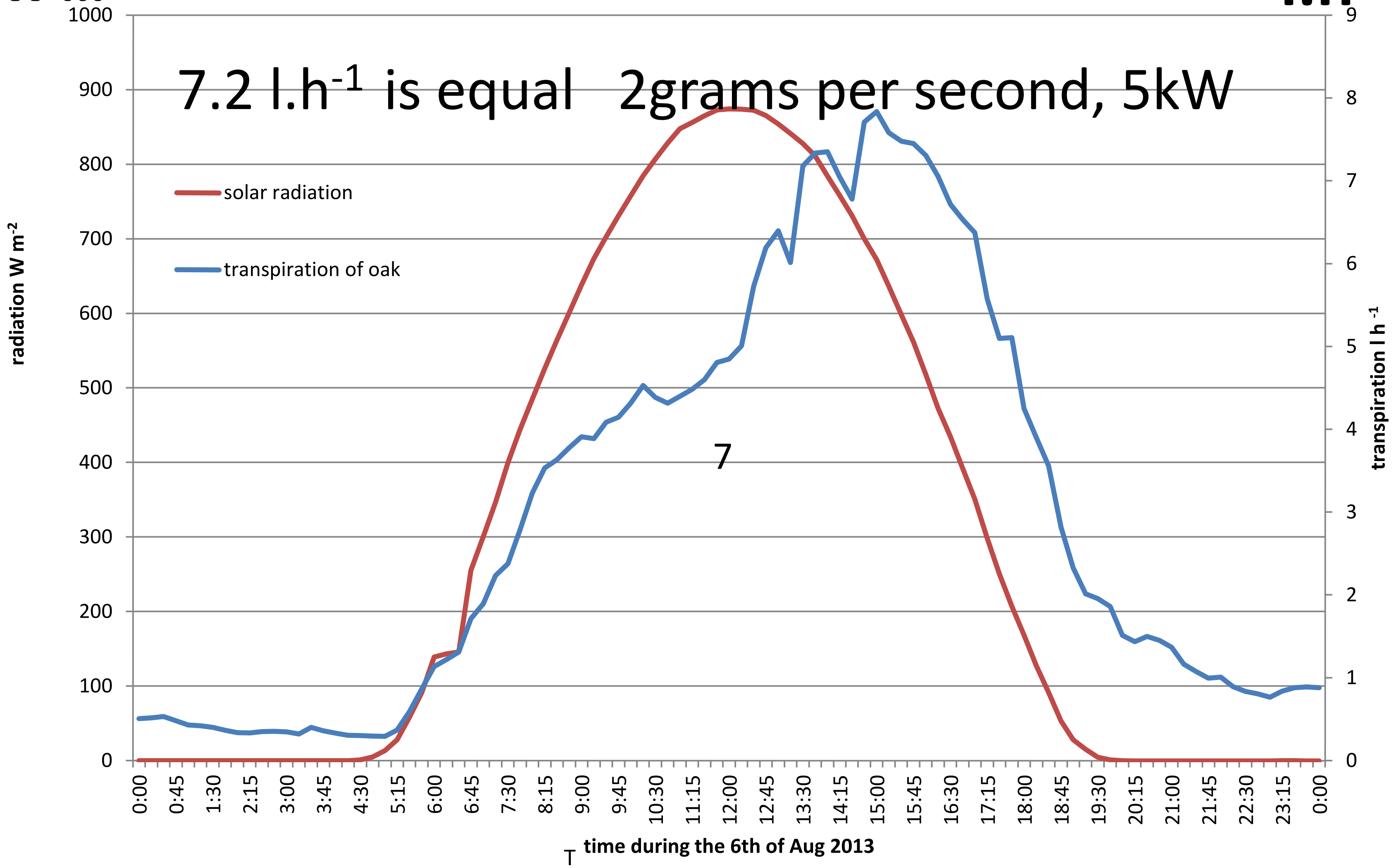
Life lives from gradients

- In 1886 Boltzmann suggested that the energy gradient imposed on the Earth by the sun drives the living processes “Life struggles for entropy which becomes available through transition of energy from the hot sun to the cold Earth”. In order to exploit this transition, plants spread their immense surface of leaves and utilise the sun’s energy before it falls to the earth’s temperature.
- ***Prigogine**, Ilya and Isabelle **Stengers** (1984) Order out of Chaos, Bantam, New York*
- ***Capra** Fritjof (1996) The Web of Life, New Synthesis of Mind and Matter. HarperCollinsPubl. Tkáň života, 2005*

Sap flow and leaves transpiration

Solar radiation and transpiration

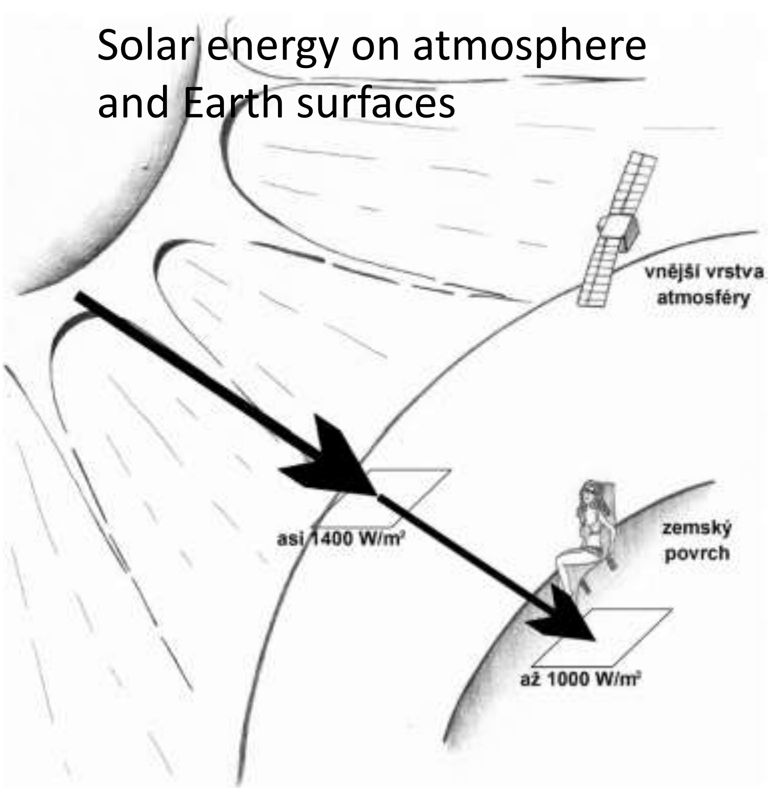
W m^{-2} l.h^{-1}



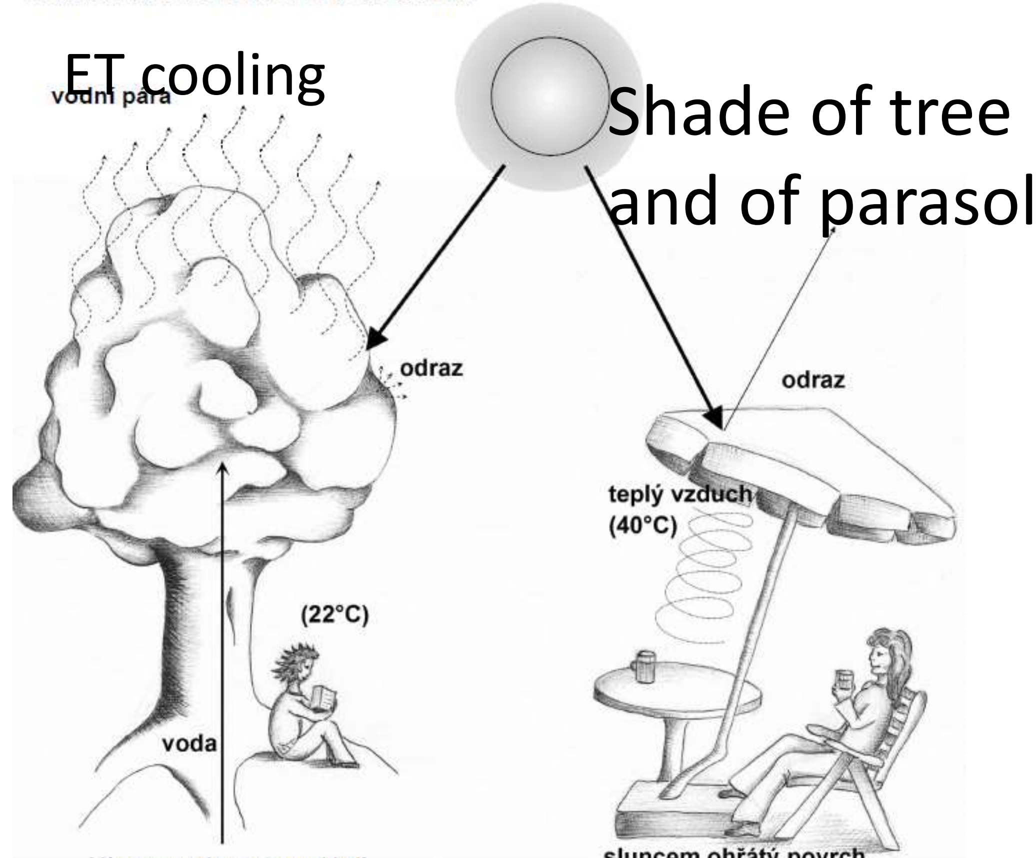
Day time 6. August 2013

latent heat of evaporation 1gram water 2,5kJ. ET of 1gram water per second 2,5kW

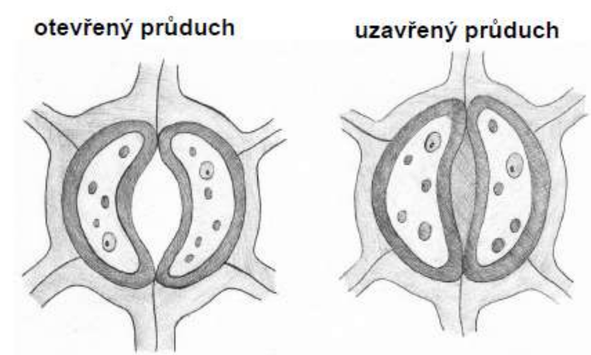
Množství sluneční energie na hranici atmosféry a na povrchu země za jasného dne



Rozdíl mezi stínem stromu a slunečníku



Výparem vody se strom chladí.



Takových průduchů je přibližně 100 na mm² plochy listu. Každý průduch se skládá ze dvou buněk ve tvaru fazole, které uzavírají a otevírají průduch a tím regulují výdej vody rostlinou v závislosti na monžství vody v listu a na okolní teplotě a vlhkosti vzduchu.

Ecosystem service of a tree

- Tree transpirates 300 litres a day
- 0.7 kWh/l latent heat of vaporization
- 300 x 0.7 = 210 kWh
- 210 kWh was not released as sensible heat. The tree cooled 210kWh.
- How much would you pay for 210kWh consumed by aircon? (c.21Euro)
- Tree has a double aircond effect

Remote sensing –
thermal scanning of radiation surface temperature

I. large-scale (several hundreds kms**) satellite images** (commonly in 7 – 14 µm)

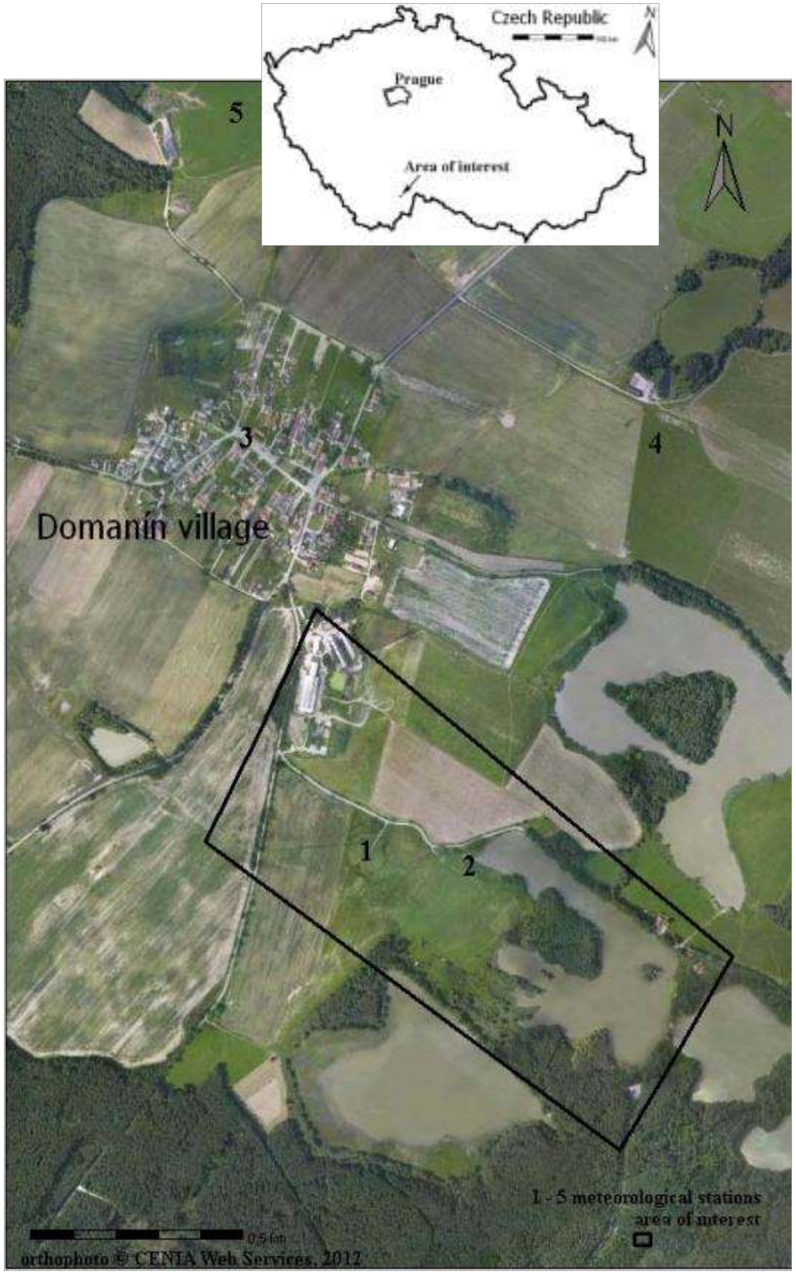
II. broad-scale monitoring (300 - 5000 m) by **aircraft** with photogrammetric equipment. Both aerial devices are equipped with FLIR thermographic cameras operating within a spectral range of 7.5 – 15 µm.

III. near-ground (up to 1 000 m) - an **airship** equipped with GPS was developed and successfully tested

IV. ground scanning

Enki, o.p.s. Třeboň, Airship Club.com - občanské sdružení, Praha. Soustava prostředků pro zjišťování energetických toků v přízemní vrstvě atmosféry. Původci: Jirka V., Pokorný J., Kobrzek F., Mareček P., Zicha J., Bíla J. Česká republika. Užitný vzor CZ 22671 U1. 12.9.2011

Enki, o.p.s. Třeboň. Zařízení pro měření energetických toků na rozhraní zemského povrchu a atmosféry. Původci: Jirka V., Zicha J. Česká republika. Užitný vzor CZ 22673 U1. 12.9.2011

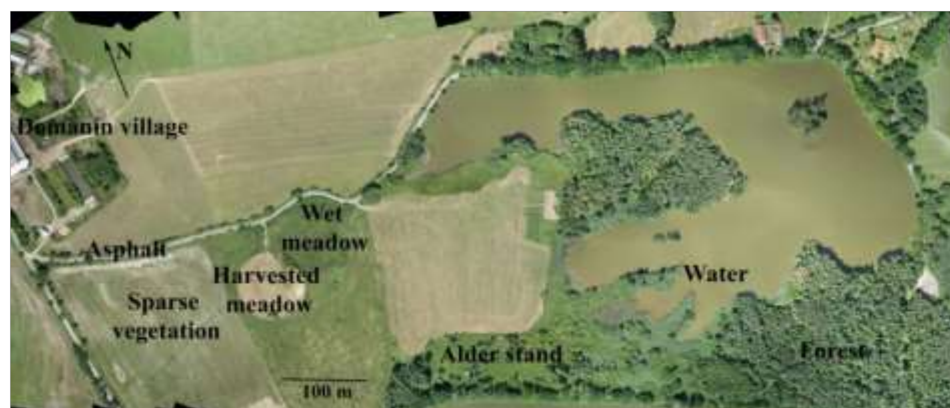


Airship Club, s.r.o.

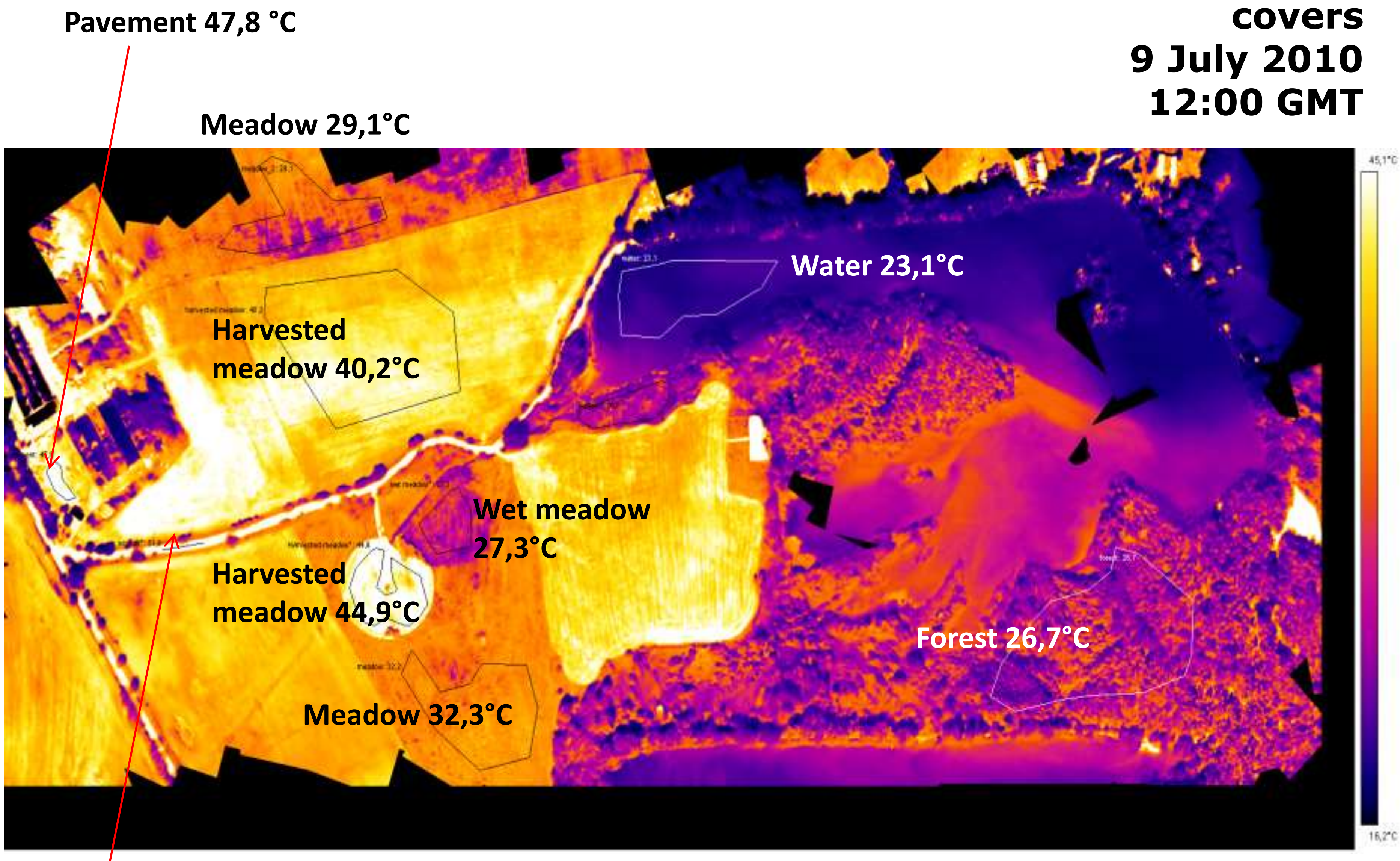
- 9 July 2009 vicinity of Třeboň

- 16 scanning times / day in 2-3 hour interval (4:30 – 19:20 GMT + 1)
- 5 screens

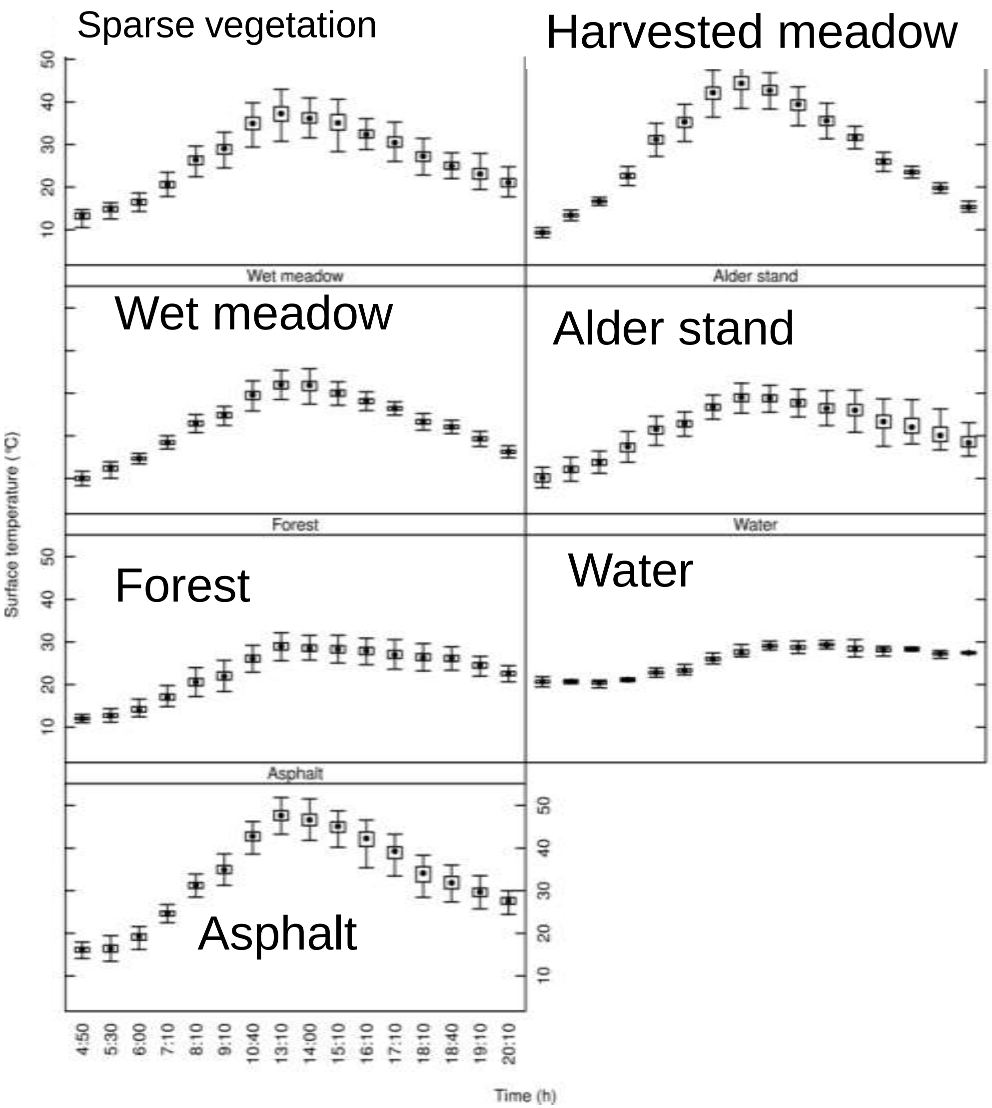
- Hight of flight 250 m
- Spatial resolution 30 cm
- Sampling area 1000 (pixelů)– wet meadow, harvested meadow, alder stand, forest, sparse vegetation, fishpond, asphalt

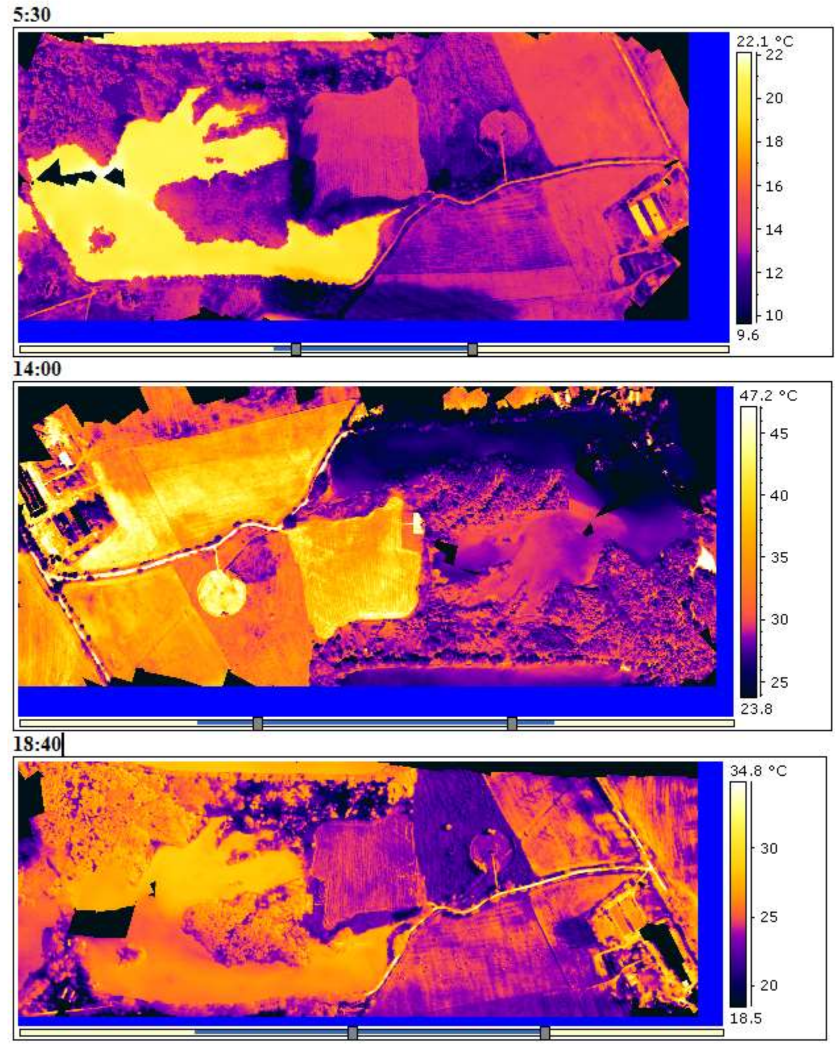


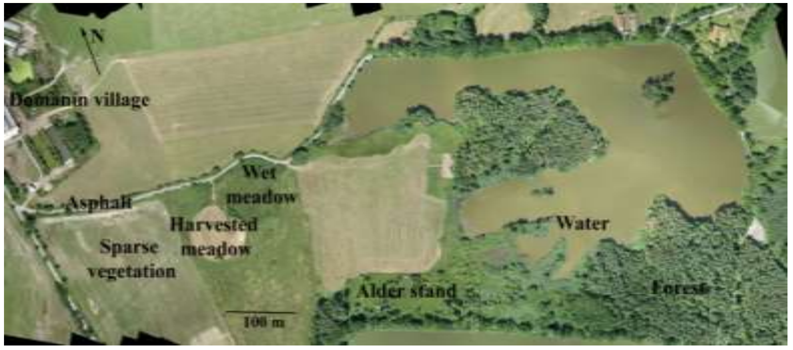
Thermal images of different land covers
9 July 2010
12:00 GMT



Air temperature 32 °C

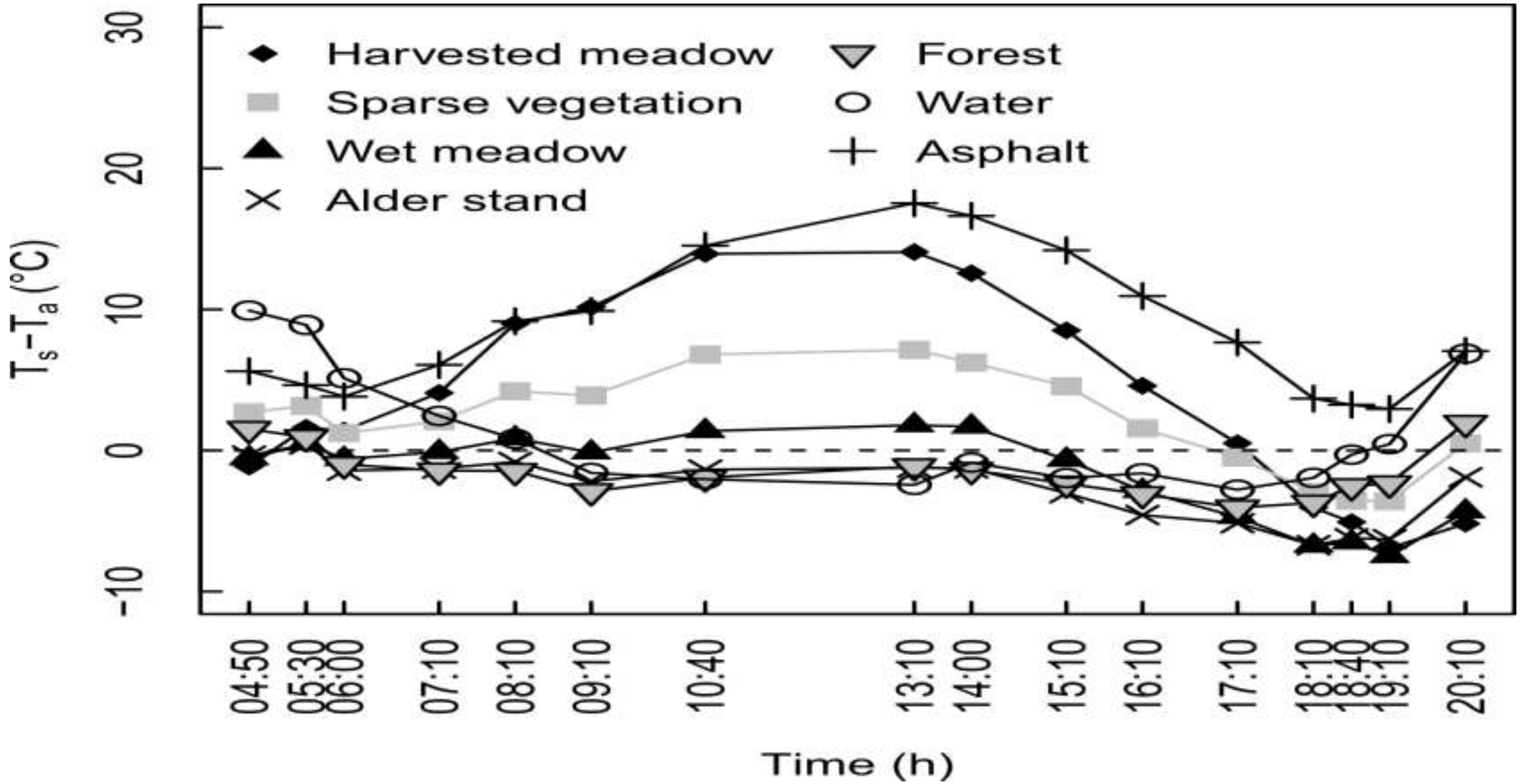






Daily courses of T_s of the studied localities

. Each point is calculated from 1000 randomly selected pixel values. Points describe the median of the data, boxes are lower and upper quartiles and whiskers show 1.5 times of inter-quartile range of the data or maximum and minimum values if extremes did not occur. Extreme values are not shown in the graph.



Differences of air temperature T_a at 2m above ground (mean values from 5 meteorological stations) and surface temperature T_s of the studied localities.

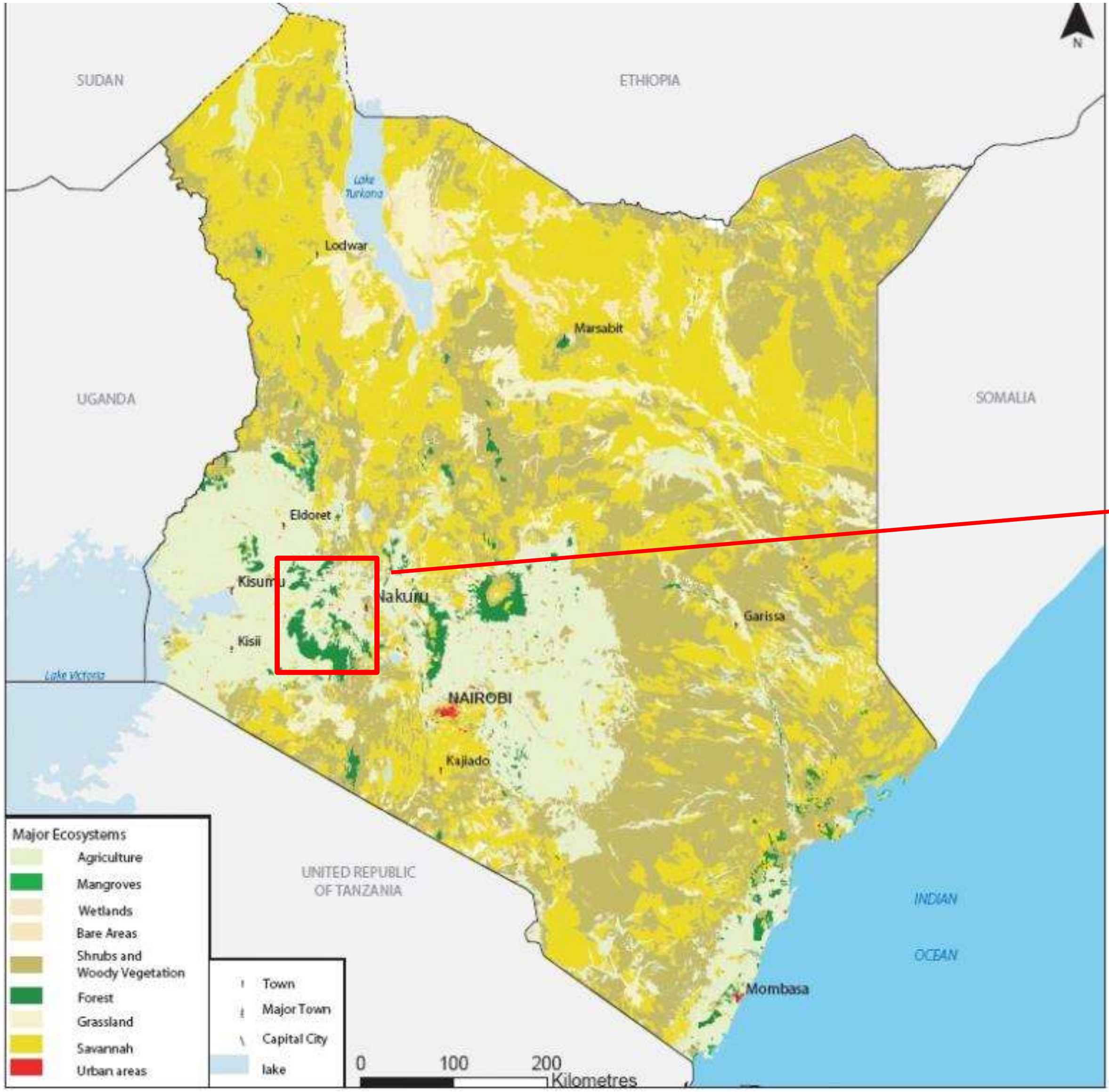
Hesslerová et al. 2013, Daily dynamics .. Ecol Eng

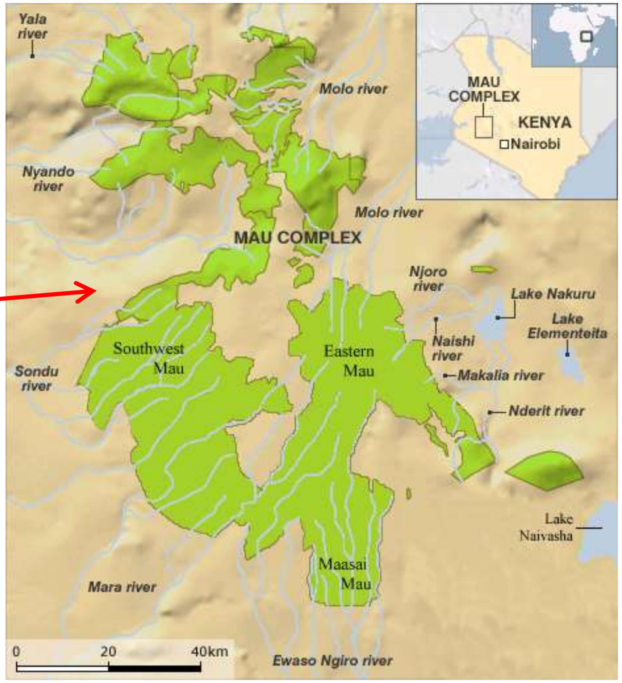
harvested meadow 15 C, wet meadow , forest 2 C

Effect of land cover change on landscape temperature distribution. A case study of Mau forest in Kenya

- Hesslerová, P., Pokorný, J. 2010, Forest clearing, water loss and land surface heating as development costs. Int. J. Water, Vol 5, No 4, 401 –418

Mau Forest

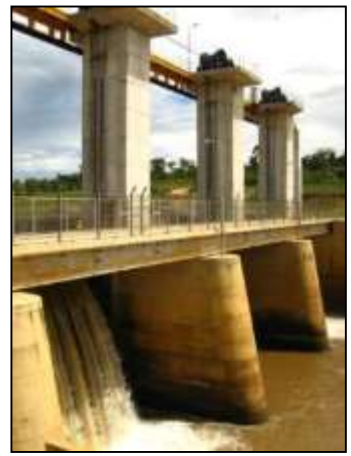

SUDAN
ETHIOPIA
UGANDA
SOMALIA
Lake Turkana
Lodwar
Marsabit
Eldoret
Kisumu
Nakuru
Kisii
Garissa
Lake Victoria
NAIROBI
Kajiado
Mombasa
UNITED REPUBLIC OF TANZANIA
INDIAN
OCEAN
N
Major Ecosystems
Agriculture
Mangroves
Wetlands
Bare Areas
Shrubs and Woody Vegetation
Forest
Grassland
Savannah
Urban areas
Town
Major Town
Capital City
lake
0
100
200
Kilometres


Yala river
Molo river
Nyando river
Molo river
MAU COMPLEX
Njoro river
Lake Nakuru
Lake Elementeita
Naishi river
Southwest Mau
Eastern Mau
Sondu river
Makalia river
Nderit river
Lake Naivasha
Maasai Mau
Mara river
Ewaso Ngiro river
0
20
40km
MAU COMPLEX
KENYA
Nairobi

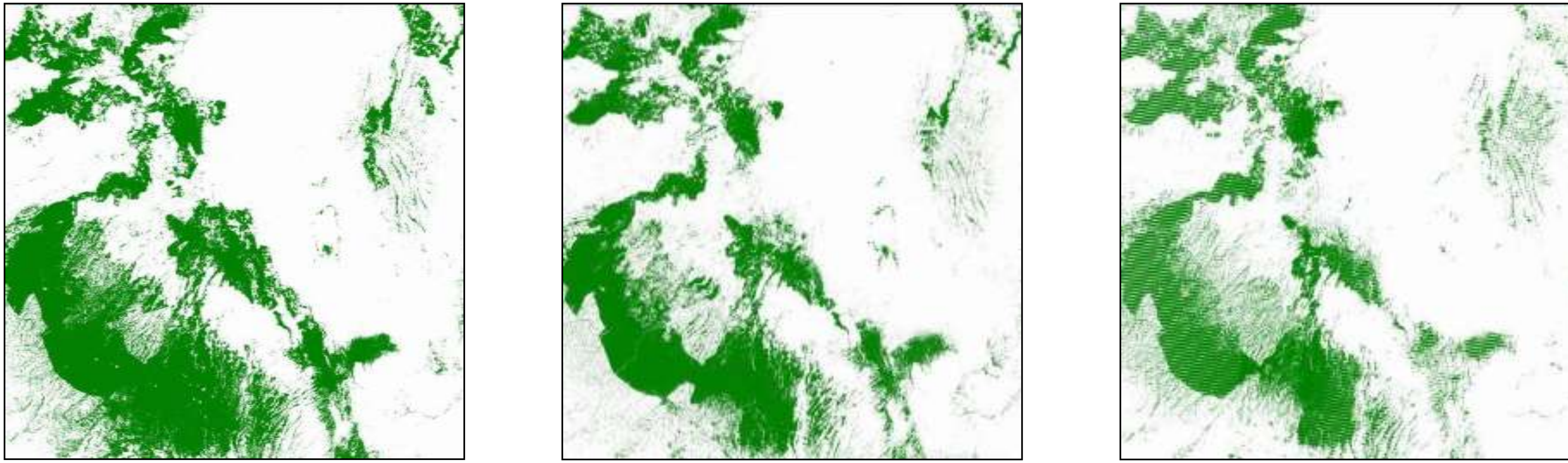


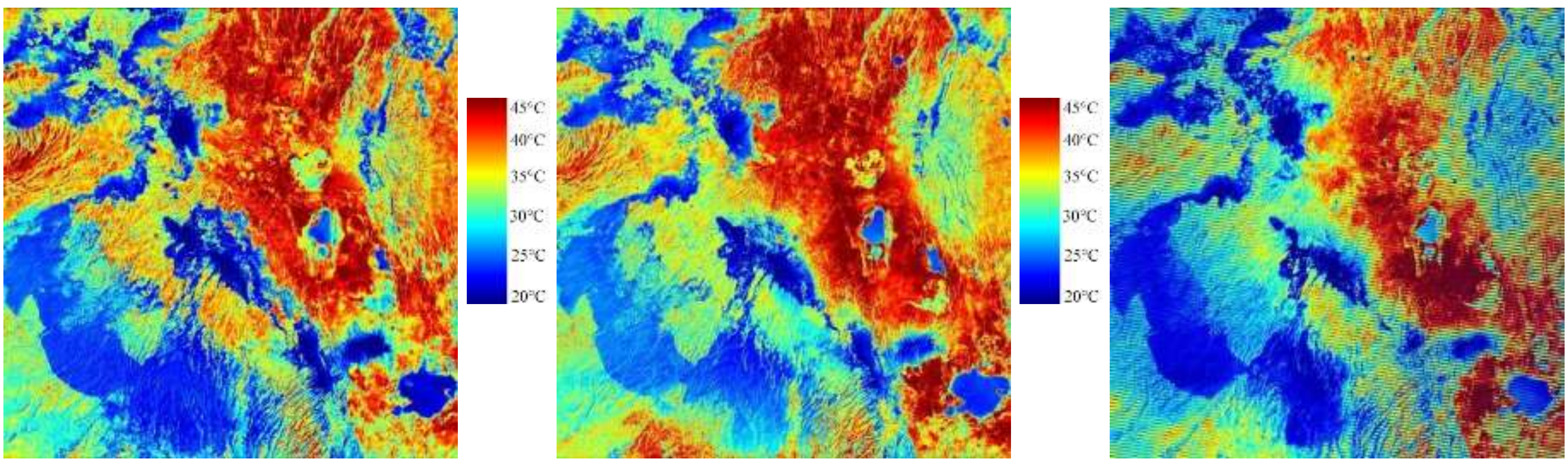

- imigration of many ethnic groups was a main course that large parts of the forest area have been cleared for settlement, arable land and teagardens
- The pressure on ecosystem was supported by politics, mainly in pre-elect periods during 80’s and 90’s
- large deforestation has dramatically affected surrounding ecosystems, local climate and hydrology of the catchments
- between 2004 and 2006 more than hundred thousand persons were forcibly evicted from Mau Forest Complex, no alternative place to live was offered

- A new hydropower plant Sondu-Miriu constructed on the river of the same name is not able to produce planned 60MW due to water shortage
- July 2008, Kenyan Prime Minister Odinga declared that during last 10 years Mau Forest lost 100 000 ha of area due to agriculture and illegal cutting, the losses were estimated to 300 million USD
- Kenyan Government decided to evict 250 000 people from the Mau Forest, to fence the Forest in order to prevent illegal logging and restore hydrology of the catchment.

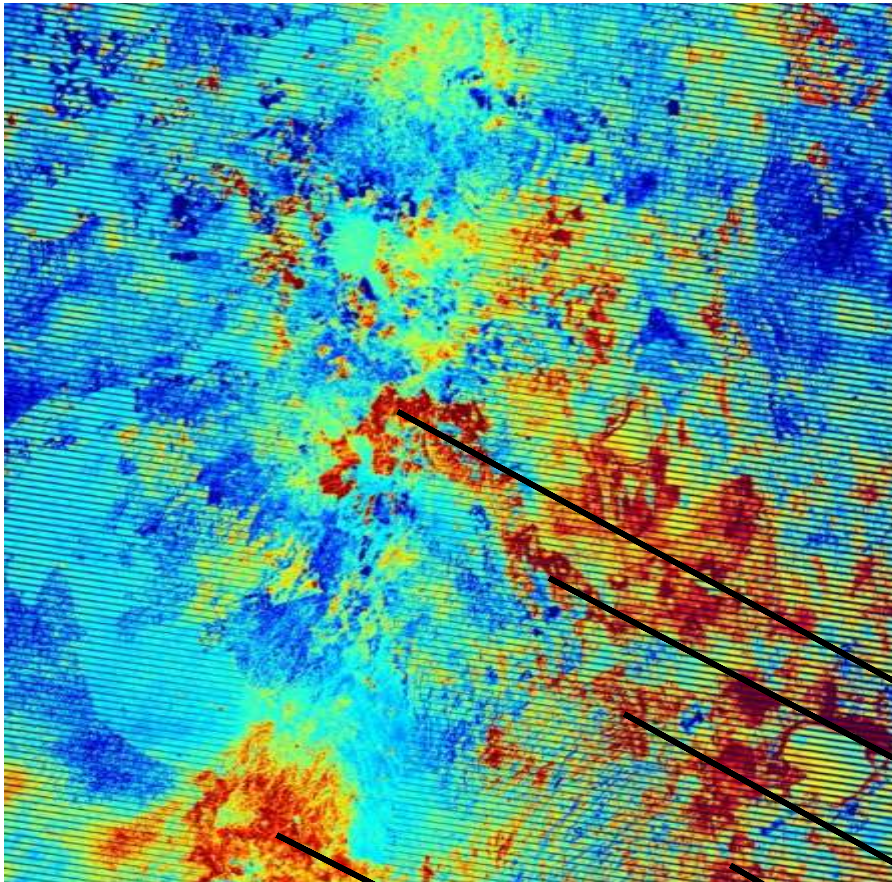


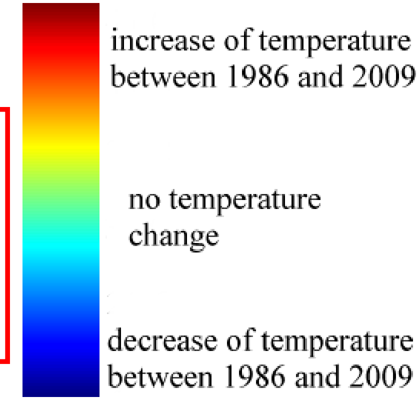
Figures show the extent of the Mau forest in the years 1986 (a), 2000 (b) and 2009 (c). The central part (Eastern Mau) and the eastern part of Maasai Mau are the areas, most affected by deforestation.



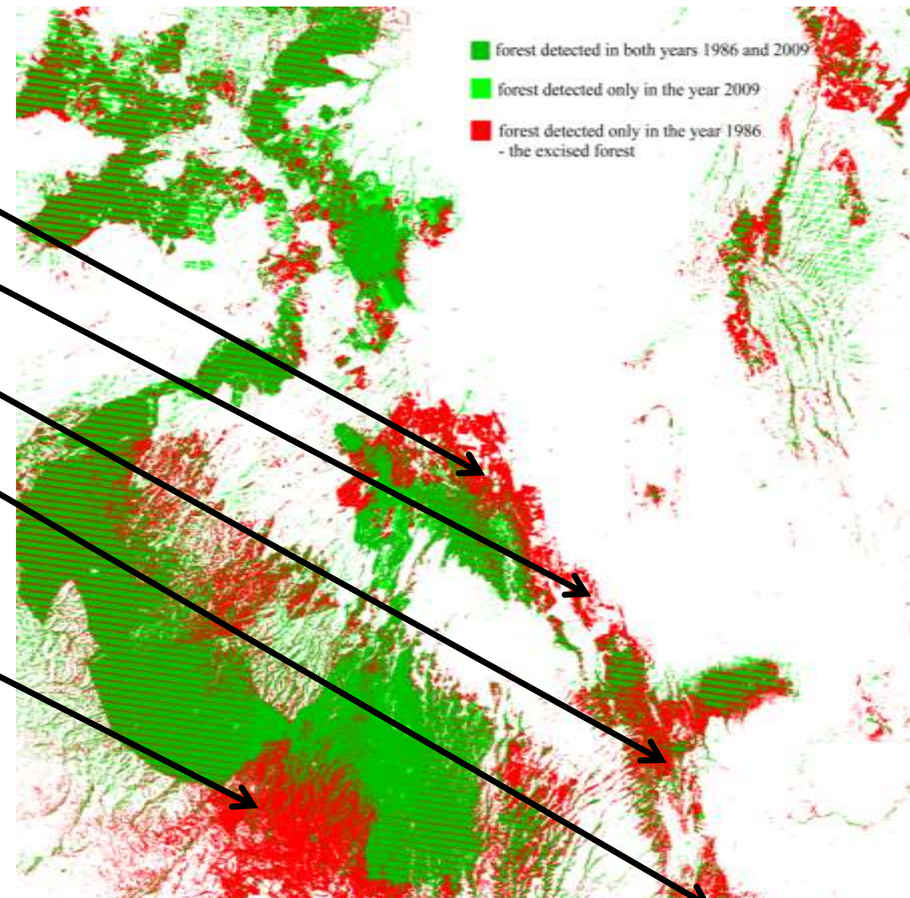


Land surface temperature distribution in the years 1986 (a), 2000 (b) and 2009 (c). The comparison with the figures above, confirms the forest belong to the coldest areas within the landscape. The temperature differences may reach even 30°C at very short distances.





Forest area covered in
1986 400 000 ha
2000 345 000 ha
2009 270 000 ha



Red – clear cuts between 1986 - 2009
Green –increase of forest area (plantation forests)
Green– no forest area change between 1986 and 2009

There are different greens in the landscape…

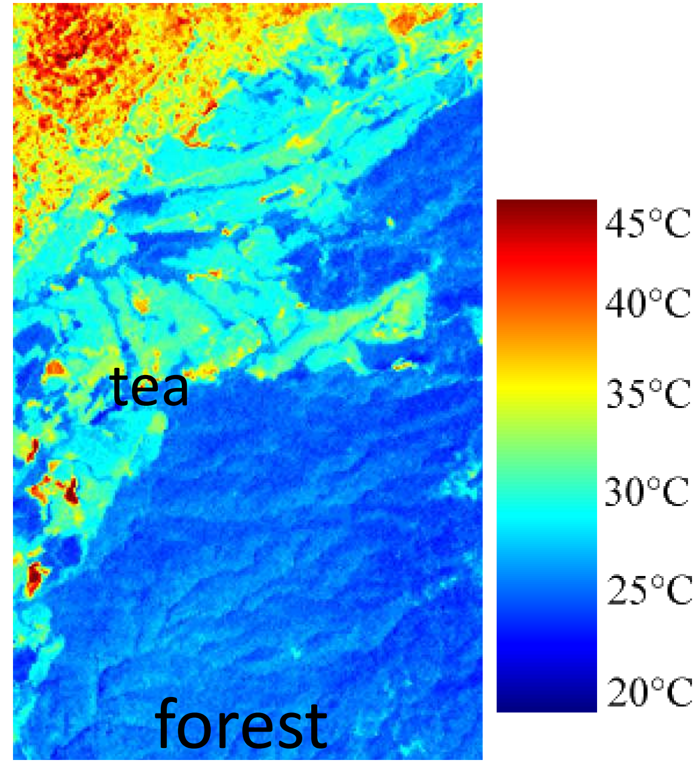


Figure (on left) is the RGB colour synthesis of Landsat ETM + channels 4-5-3 displaying different land cover types in the Kericho region (west edge of the image) in the year 2000. The scene size is 19 x 12 km. Bright and homogeneous red colour, caused by very high chlorophyll content is typical of the tea plantations; dark and light brown indicates rain forest; the patch of green display a farmland.

Figure (on right) shows temperature differences between the three different vegetation types in the same region. Despite having the highest amount of chlorophyll (being the greenest), the temperature of tea plantations ranges between 30 – 35 °C, that is more than in case of forest. The highest temperature is characteristic for the crops (35 – 45°C), depending on the crop cover, type, wetness, and other factors. This fact shows that the surface temperature depends on the type of land cover and confirms forests as the coldest landscape segments.

- t

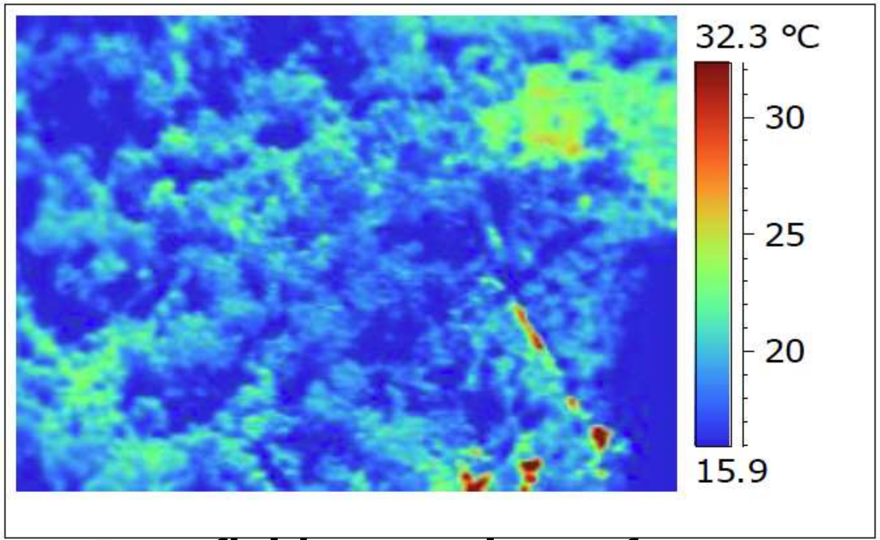
Thermopictures of MauForest

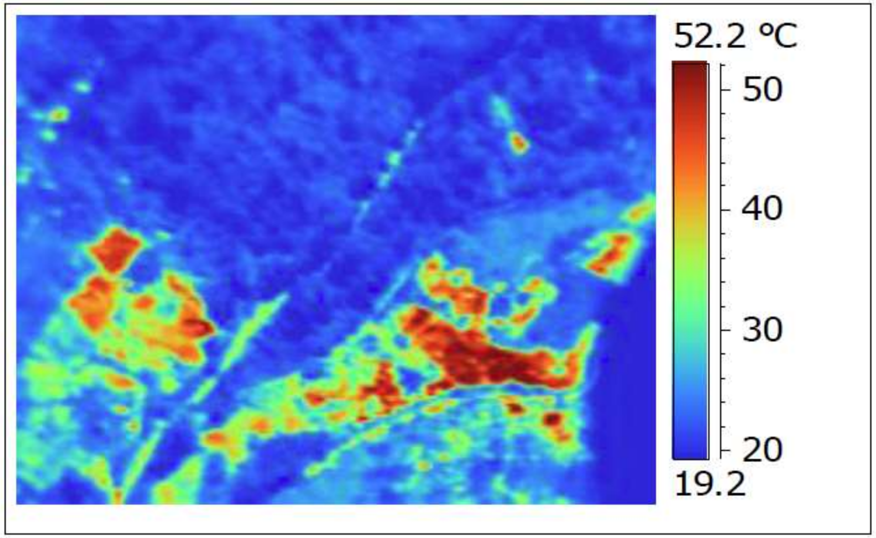
Taken from an aircraft and from land
Altitude c. 3000m

Mountain forest atracts water
it is called „water tower“

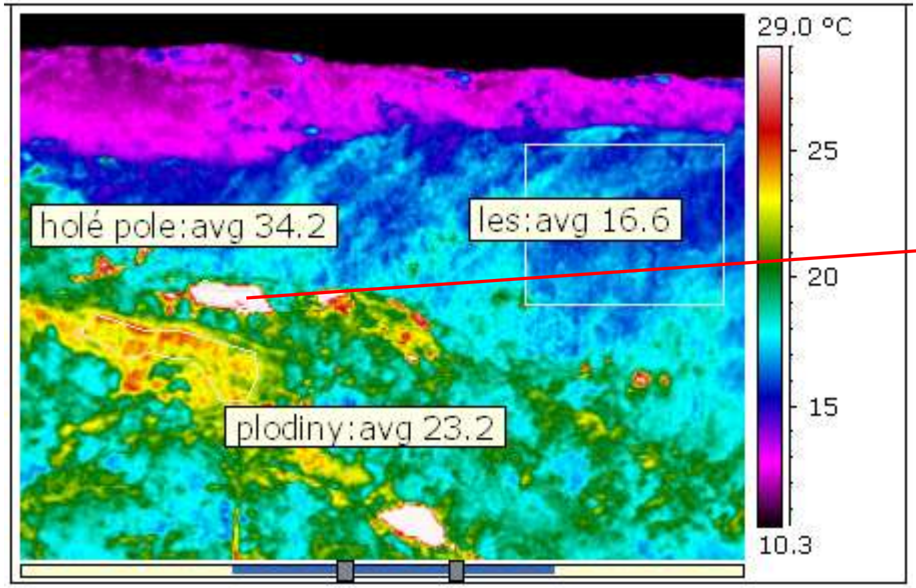
- Village Son Koi Kiminta located at cca 3000 m altitude has not allowed clearing of 600 ha forest. Local people know from experience that forest attracts due and creates mild rain.
- Forest clearing in vicinity of other villages resulted in rain shortage and early morning frost linked with crop decline.

Mau Forest (alt. c. 3000m)



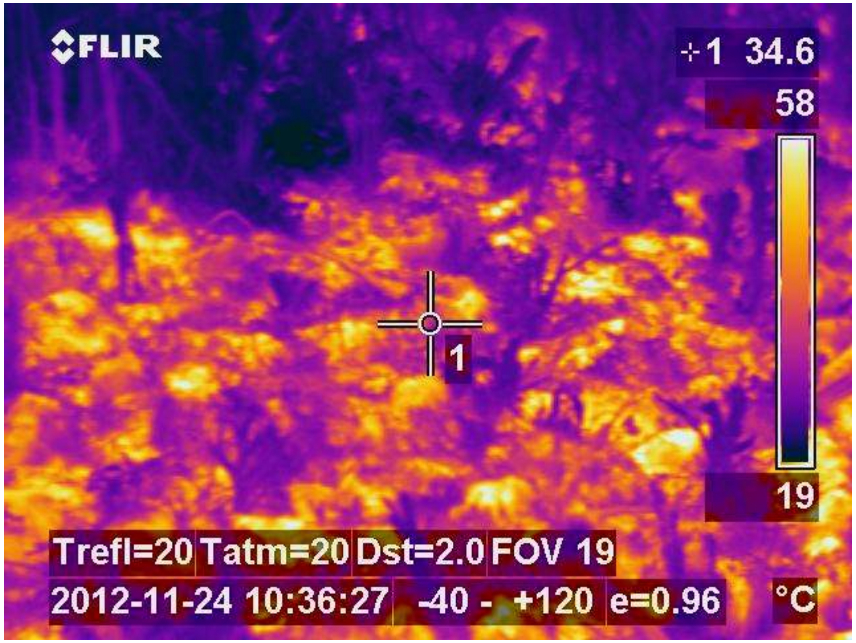


Bare field, crop plants, forest

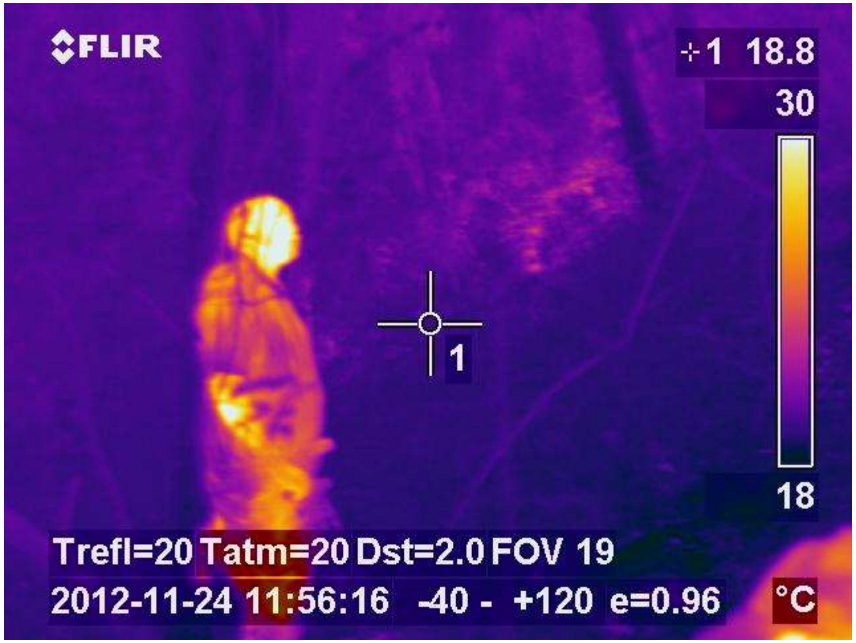


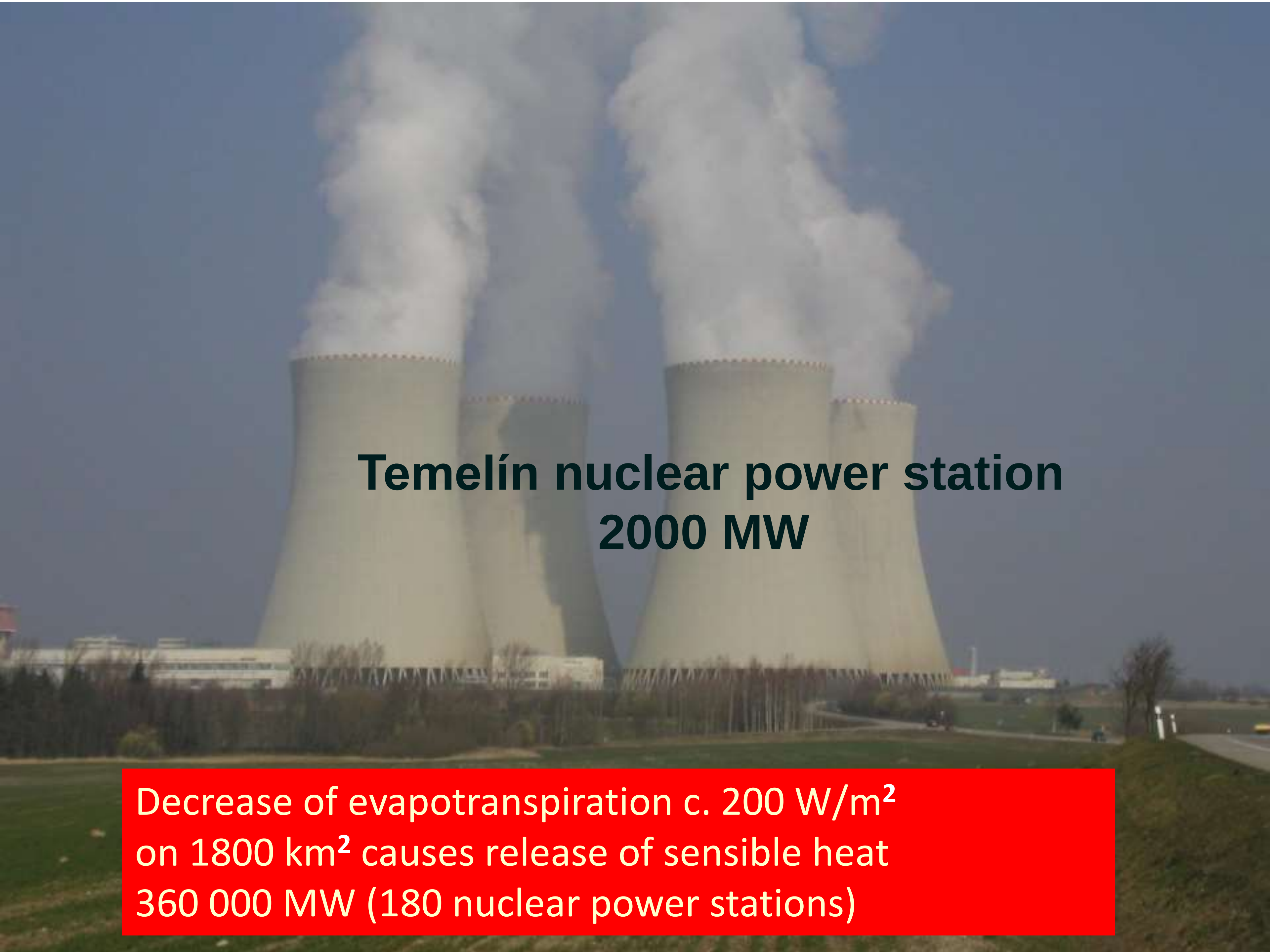
Deforested part

Surface temperature up to 58 centigrades



Temperature inside of a mountain forest
(50meters from the previous place)





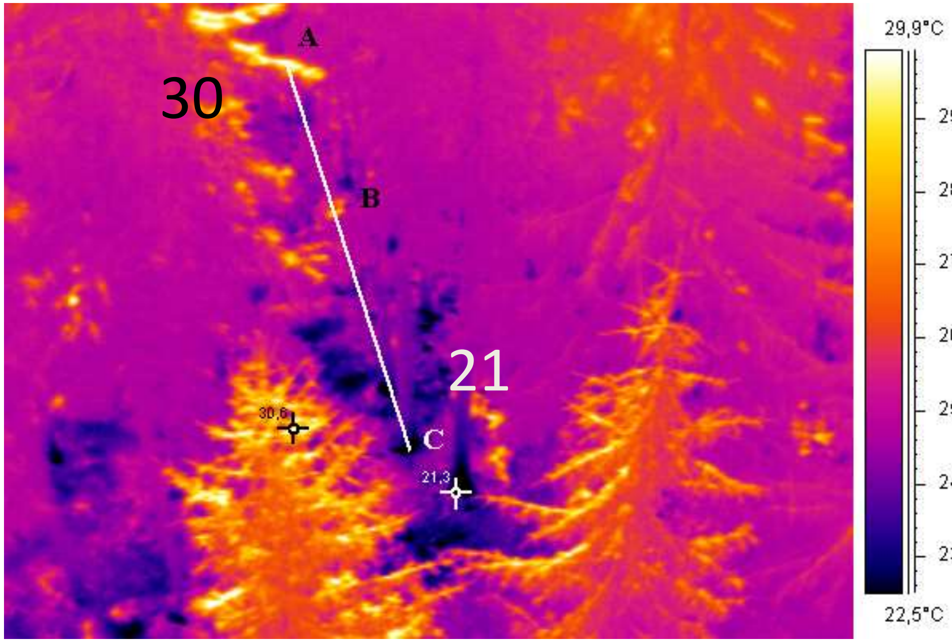
Temelín nuclear power station
2000 MW

Decrease of evapotranspiration c. 200 W/m^2
on 1800 km^2 causes release of sensible heat
360 000 MW (180 nuclear power stations)

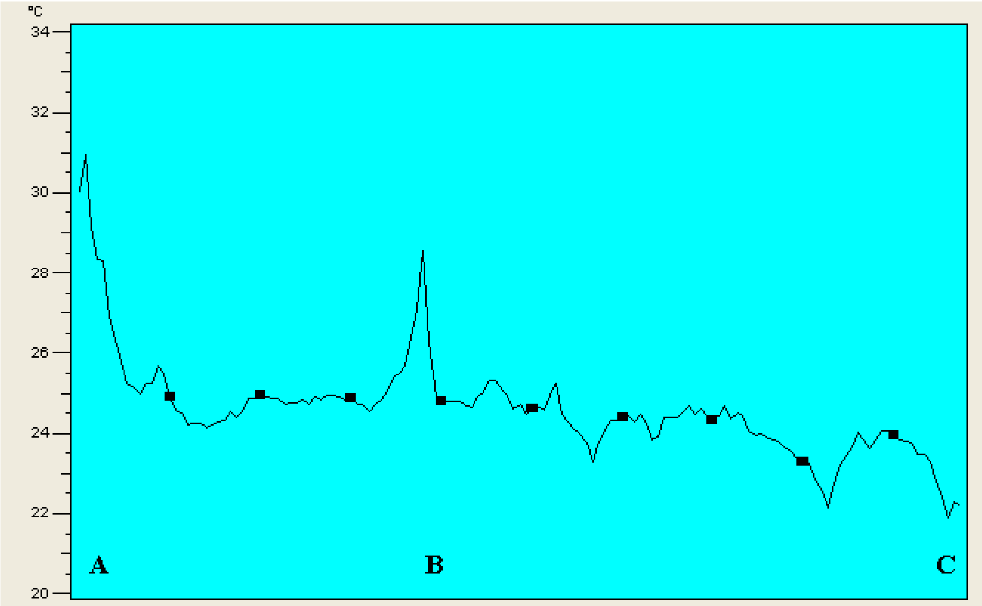
… few numbers

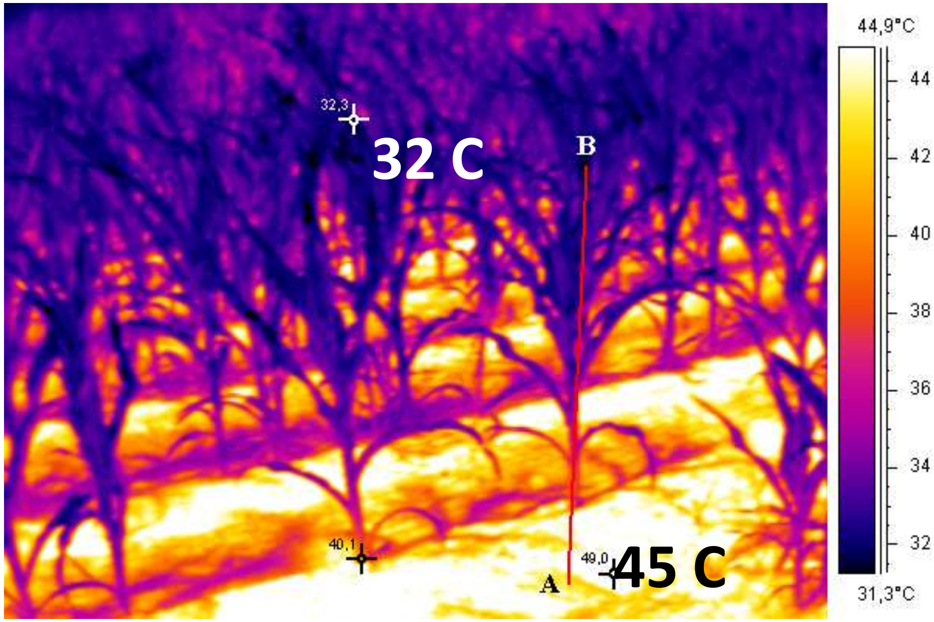
- consider air at temperature 25 ° C contains approx. 22 grams/ m^3; at 40 ° C has a doubled capacity (50 g / m^3)
- Deforestation and the consequent rise of temperature lead to a transport of warm and relatively dry air into the upper atmosphere
- Hot air = higher capacity to suck up water = the transport of water vapour by the overheated air out of short water cycle
- Decrease in evapotranspiration of about 2 mm/ km2/day = decrease in evaporation of 2 000 000 litres
- To evaporate 1 liter we need 0,7 kWh (2 500kJ)
- Latent heat of vaporisation of 2 000 000 litres of water = 1.4 million kWh
- If there is no water = no latent heat - release of 1.4 million kWh of sensible heat/ day
- The Mau Forest complex has lost 1800 km^2 in 23 years
- This means 2,6 billion kWh of sensible heat released from this area a day
- For comparison, a quarterly production of the well-known Czech nuclear power plant Temelin (2000 MW) in 2012 was 4,4 billion kWh

Vertical distribution of temperature in forest and crop

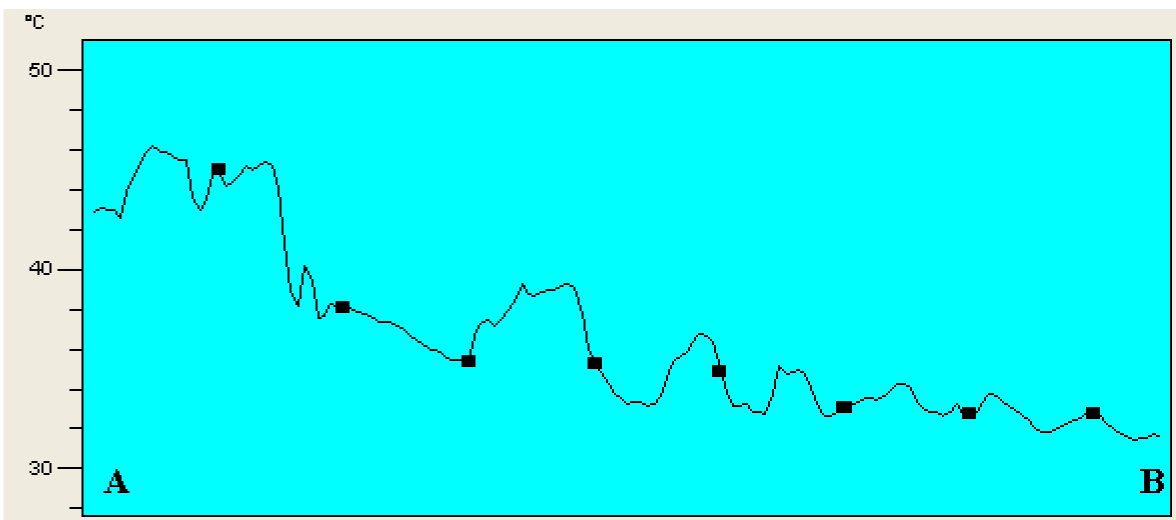


Temperature inversion
In forest:
Higher temperature in crowns
air is cooler (heavier) at ground
Water vapour is kept
In canopy





CORN loosing water due to high temperature of bare soil



Higher temperature at soil surface than at top of the stand

Fluxes of energy in ecosystems

- Primary production (photosynthesis): **W m^{-2}**
- **Evapotranspiration**: **hunderds W m^{-2}**
- Decomposition of organic matter in soil: **tens W m^{-2}**
- Heating of plant stands: **several to tens W m^{-2}**
- Radiative forcing: **0.2 W m^{-2}** for 10 years
- Solar radiation on atmosphere during one year: **1351 W m^{-2} - 1431 W m^{-2}**
- **Life processes can easily compensate for radiative forcing**

Green house gas	**CO_2**	**CH_4**	**H_2O**
conentration (ppm) for example ml/m3	**380**	**1,5**	**1000 – 40 000 (mean: 20 000)**
phase	gas	gas	**solid – liquid - gaseous exo/endo thermic phase changes 18 ml liquid water makes 22 400 ml water vapour**
Turnover rate in atmosphere	years	years	Days, hours
	emission trading	Emission trading	Is ignored

Life processes **directly** affect distribution of solar energy on Earth

- **Indirect effect of vegetation**: production or sequestration of green house gases
- **Direct effect:**

damping of heat potentials by evapotranspiration

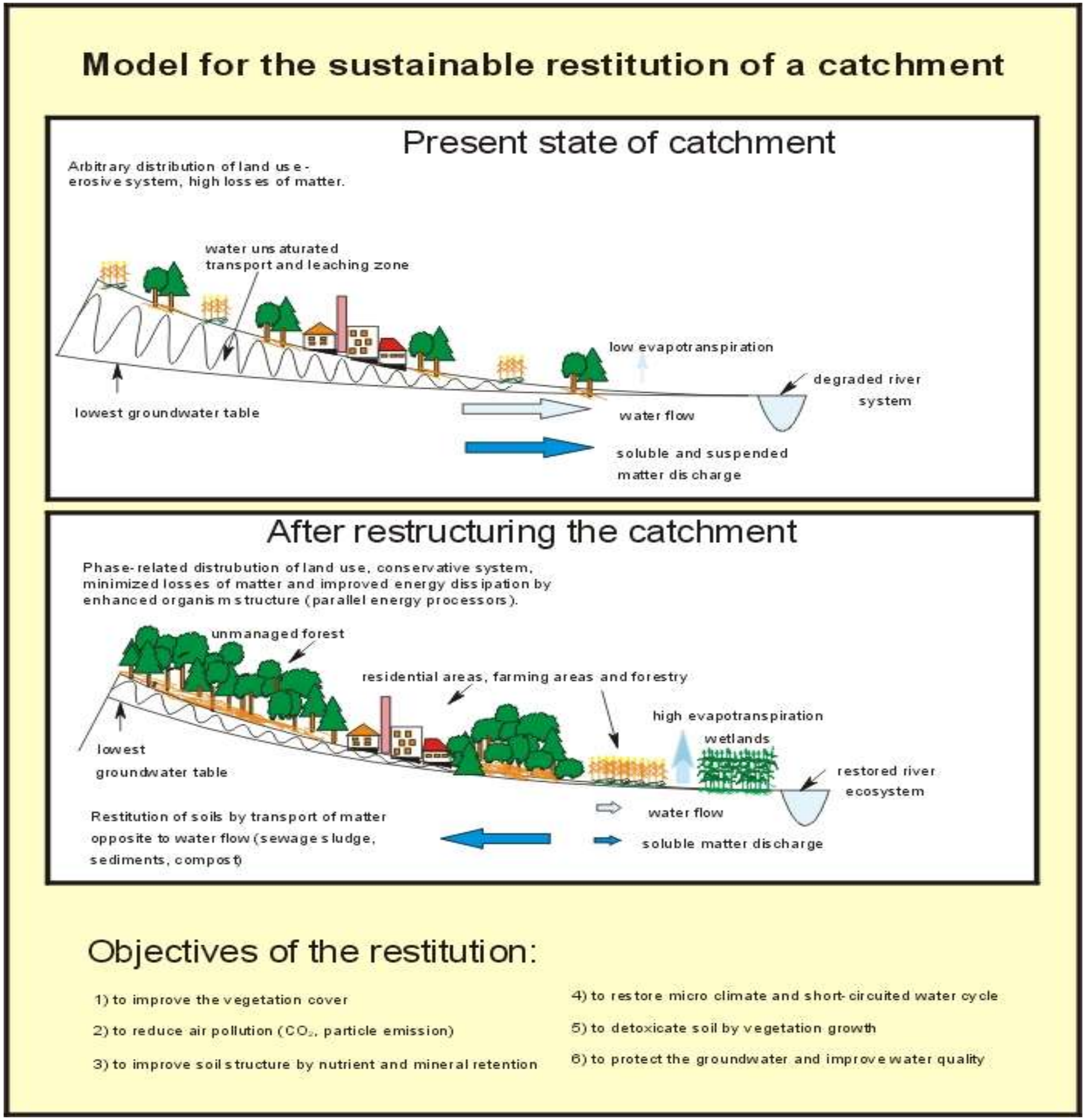
(humans create potentials by drainage – overheating)

Biosphere dissipate solar energy in terms of non-equilibrium thermodynamic. There is no simple radiation balance of Earth –Universe driven only by albedo and dry greenhouse gases.

Life abhors gradients

E.D. Schneider, D. Sagan, 2005 , Schrödinger 1944 (What is Life)

WHAT TO DO ? (*Ripl, ETR model, 1993, 2003 etc.*)



Criteria of landscape functioning and sustainability

- By the principle of self-organisation, the least ageing and most sustainable system has the best cycling capabilities and least irreversible material flow.

  It is relatively free of landscape entropy.
- Low matter losses (regular water discharge, low electrical conductivity of water)
- High gross production
- Low temperature differences (dissipation)
- (Ripl W. 1995 ETR, 2003, 2010 IJW)

Falsification Of
The Atmospheric CO_2 Greenhouse Effects
Within The Frame Of Physics

Version 3.0 (September 9, 2007)

replaces Version 1.0 (July 7, 2007) and later

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Water for the Recovery of the Climate - A New Water Paradigm

M. Kravčík, J. Pokorný, J. Kohutiar,
M. Kováč, E. Tóth

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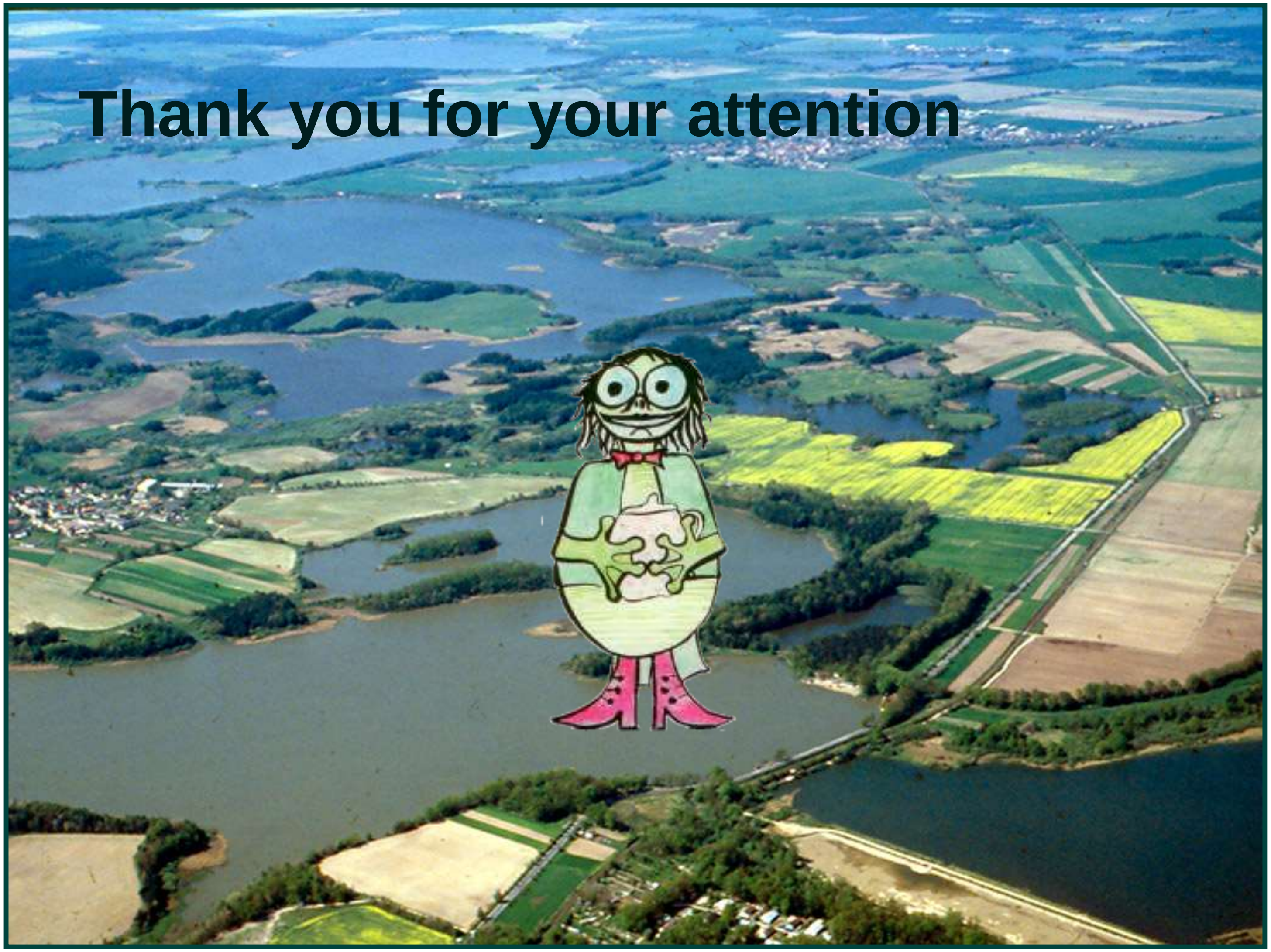
www.waterparadigm.org

South Bohema, Třeboň region, Czech Republic



Fishponds – artificial lakes were constructed in 16th century

Stop desertification and bring back water and vegetation:

- Air-conditioning via short water cycle
- More water,more biomass, more food
- Biodiversity increase
- Carbon sequestration
- Recycling of nurients and water
- Employment
- **Any negative effect??**

Kravčík, M., Pokorný, J., Kohutiar, J. et al: 2009, Water for Recovery of Climate
www.waterparadigm.org
Eiseltová, M., Pokorný, J., Hesslerová, P., Ripl, W. 2011 Evapotranspiration – A Driving Force in Landscape Sustainability In: Ayse Irmak (ed.)Evapotranspiration – Remote Sensing and Modeling, InTechopen, pp 305 – 328, Rijeka, Croatia

BIG GLOBAL CORPORATION CALLS FOR:

- Air-con system,
- Fully automatic, sun driven, outdoor use, quiet,
- Fully recyclable material only,
- Continuous self regulation,
- Minimum maintenance,
- Output power in tens of kW,
- Highly durable (decades).

Send your offer to: bigglobalcorporation@big.com

New natural air-con on market!

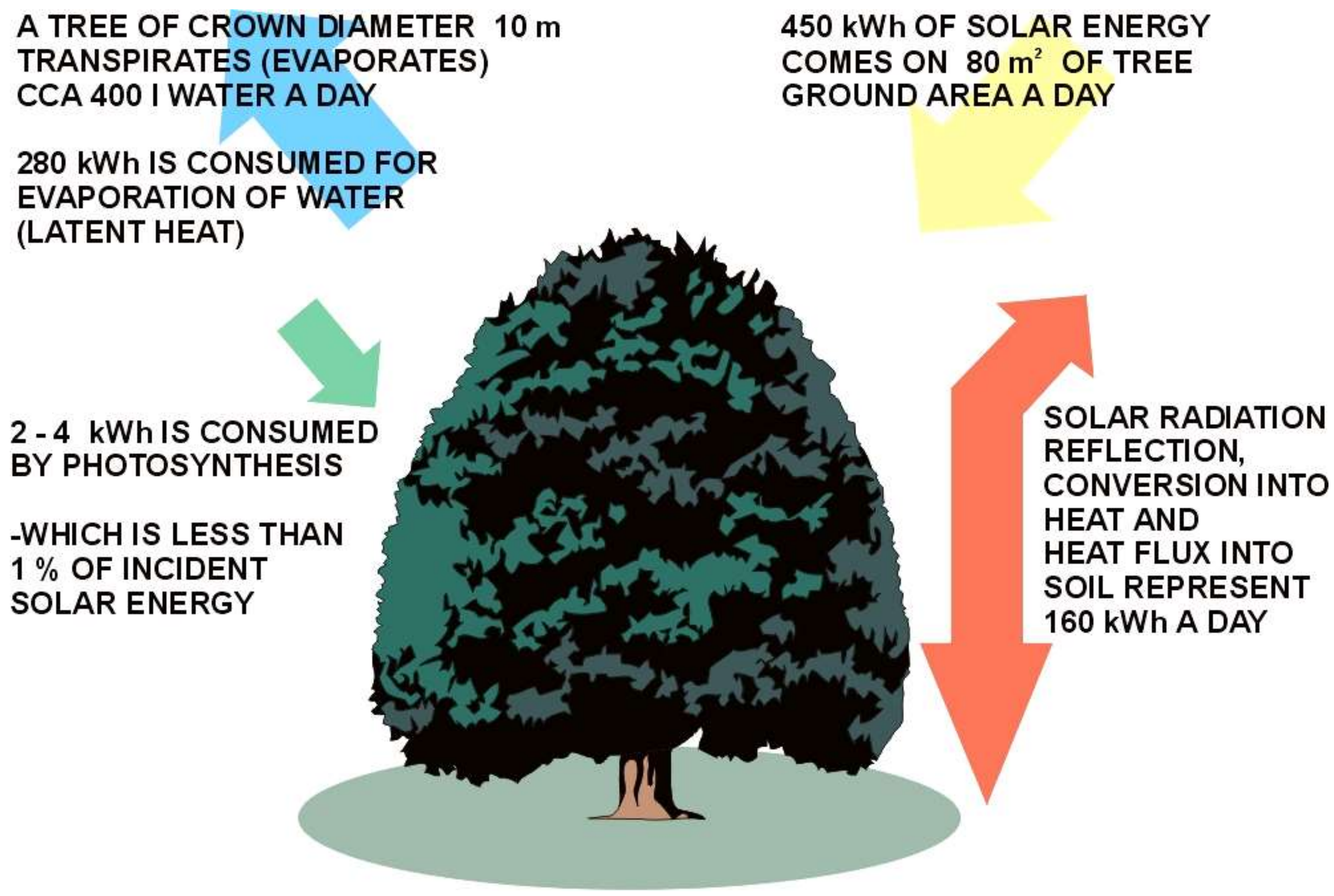
NATURE Ltd. presents highly efficient **TREE** air-com system. Standard model is able to **transpire 400 l** per day.

The latent heat would be 278 kWh, with cooling efficiency **23 kW** over 24 hours.

Regulation system consists from several billions of stomata **recycled** every year.

Warm places are cooled fully **automatically** according their demand.

EVAPOTRANSPIRATION



Open systems

- Earth is exposed to energy of Sun
- Life/biosphere developed thanks to solar energy
- Life is far from equilibrium and self-organizes – life resists the universal tendency for things to fall into dissarray, into thermodynamic randomness
- Schroedinger (1944): *„What is Life"*

Positive examples

Succes stories

Sarah Higgins mitigated effect of deforestation of Mau Forest in 1970s, 1980s (rain decline and irregularities of rain in fields)

Support of shrubs (Leleshwa) and planting trees (*Eucalyptus*) on their land (4000 acres) which resulted in more rain, and clouds forming..

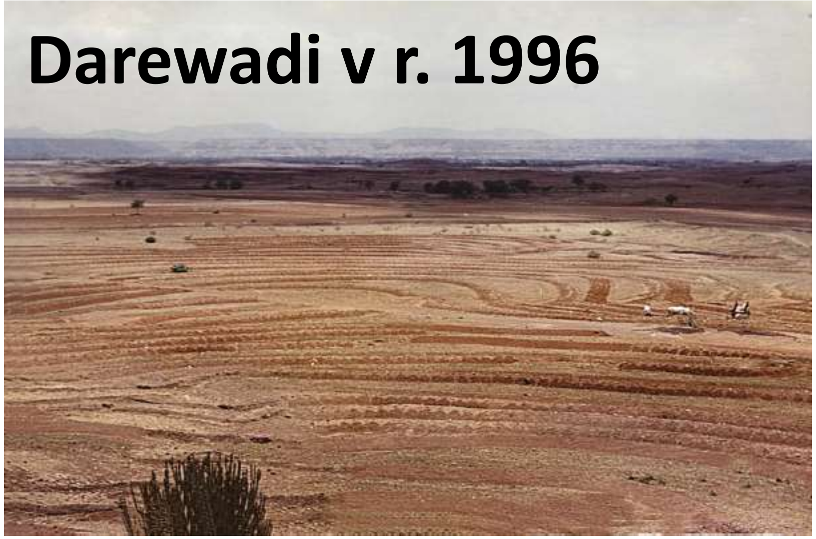
http://www.scientificamerican.com/article.cfm?id=clearing-forests-may-transform-local-and-global-climate

Kenya Naivasha region

- Jospat Macharia (Oserian Farm) – 2,2 ha, tanks for cca 100 m3 of water, retention and inteligent distribution of water respecting demands and adaptation of individual plant species. (unique in the world context). In long dry period the farm had green vegetation which atracted wild animals. Jospat showed that his farm is able to produce food for 80 persons.

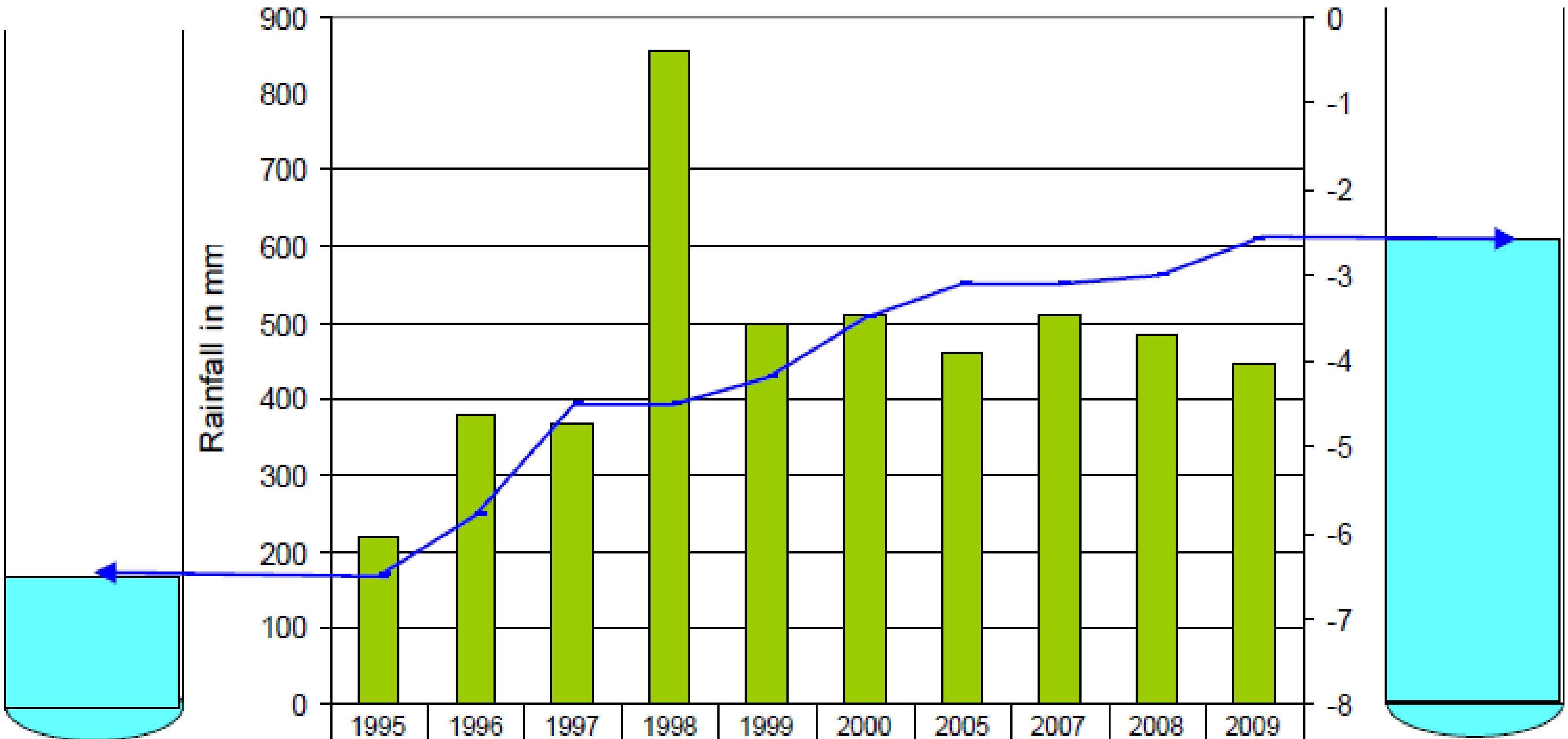
Natural Sequence Farming is based on recovery of vegetation through rain water retention

O. Hermann Bacher : „Ak to pôjde v Darewadi, tak to pôjde kdekoľvek...“



- - náklady v Darewadi (1500 ha) boli len 12 miliónov rupií (cca 270.000 € v kurzoch v r. 1996)
- Výnosy z poľnohospodárstva stúpli približne 6x a dosiahli 56 miliónov rupií (cca 850.000 €)
- Počet studní stúpol 20x, plocha poľnohospodársky obrábanej pôdy 2x, vlastníci televízorov 40x, motorky z 0 na 83. Objavili sa i prvé štyri traktory.
- obyvateľstvo sa začalo vracať späť z miest

Zvyšovanie hladiny podzemnej vody (Darewadi) increase of underground water level



	1995	1996	1997	1998	1999	2000	2005	2007	2008	2009
Rainfall (mm)	219	378	368.8	855.5	498	510	460	509	485	448
WL Below GL	-6.5	-5.8	-4.5	-4.5	-4.2	-3.5	-3.1	-3.1	-3	-2.6