Ministerstvo životního prostředí

Wetlands and climate

Indirect and direct thermodynamic effects of wetland ecosystems on climate

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Project sub-task

- to assess the interaction of wetlands and climate

- to summarize and enhance the direct role of wetlands in local climate

- the activity was based on previous scientific activities (literature reviews, PhD. thesis) and data (meteorological, remote sensing, thermography, calculation of radiation and energy balance of wetlands), as well as new studies and data processing

Project outputs

1. To assess the interaction of wetlands and climate change; provide information about the role of wetlands and water in landscape functioning

- book chapters

Pokorný, J., Hesslerová, P., Hurynna, H., Harper, D. (2016): Indirect and direct thermodynamics effects of wetland ecosystems on climate. In: Vymazal, J. (ed.): Natural and Constructed Wetlands. Nutrients, heavy metals and energy cycling, and flow. Springer. 91 - 108.

Pokorný, J. and Huryna, H. , Weather, Climate and Wetlands: Understanding the Terms and Definitions. Finlayson, C.M. et al. (eds) The Wetland Book., Springer Netherlands, Dordrecht

Pokorný, J., Huryna, H. and Harper, D. Greenhouse Gas Regulation by Wetlands. Kapitola pro knihu: Finlayson, C.M. et al. (eds) The Wetland Book. Springer Netherlands, Dordrecht.

- journals (with impact factor, per-reviewed)

Hesslerová, P., Pokorný, J., Semerádová, S. (2016): The retention ability of the agricultural landscape in the emergency planning zone of the Temelín nuclear power plant and its changes since the 19th century. Land Use Policy 55, 13 – 23.

Pokorný, J., Hesslerová, P., Huryna, H., Harper, D. Nepřímý a přímý vliv mokřadů na klima – část 1. Vodní hospodářství; accepted, under review

Pokorný, J., Hesslerová, P., Huryna, H., Harper, D. Nepřímý a přímý vliv mokřadů na klima – část 2. Vodní hospodářství; accepted, under review

- scientific reports

a) Agriculture landscape assessment and the importance of wetlands in local climate

Use of various thermal data (satellite images; aerial and airship thermography, ground measurements) for the wetlands – climate relationship assessment ; surface temperature as indicator of wetlands functioning

The assessment of land cover – surface temperature relationship from remote sensing data – enhancing the importance of wetlands and forest in local climate

Collection of 8 studies

b) the assessment of land cover change (deforestation) and surface temperature as a potential threat to wetland functioning – study from the Šumava National Park

2. Book chapter: Wetlands and climate (ed. D. Pithart)
3. Book chapter: Summary of wetlands – climate subtask in the book Wetlands in the Czech Republic
4. The recommendations for the wetlands management and conservation in terms of climate change and current agriculture practice
5. The assessment of the littoral zones of fishponds from orthophotos – study
6. Lead of chapter on a)Fishponds, b) Hydrology and climate
7. Positive examples of landscape restoration based on rain water retention (India, Kenya, Australia) presented in Paris 2015 etc.

Role of wetlands in landscape

- Wetlands are well-known as important units for their role in regulating the hydrological cycle - retain flood water and moderate floods

- Other functions: biodiversity, accumulation of organic matter, recycle nutrients, trap sediments, recreation function, food, biomass production .

- A largely unrecognised service, but potentially the most important of all those known, is their role in regulating and air temperature – hence climate change - through **evapotranspiration – DIRECT ROLE**.

- The **INDIRECT** effect of wetlands on climate as either a source, or a sink of GHGs such as CO_2 and CH_4

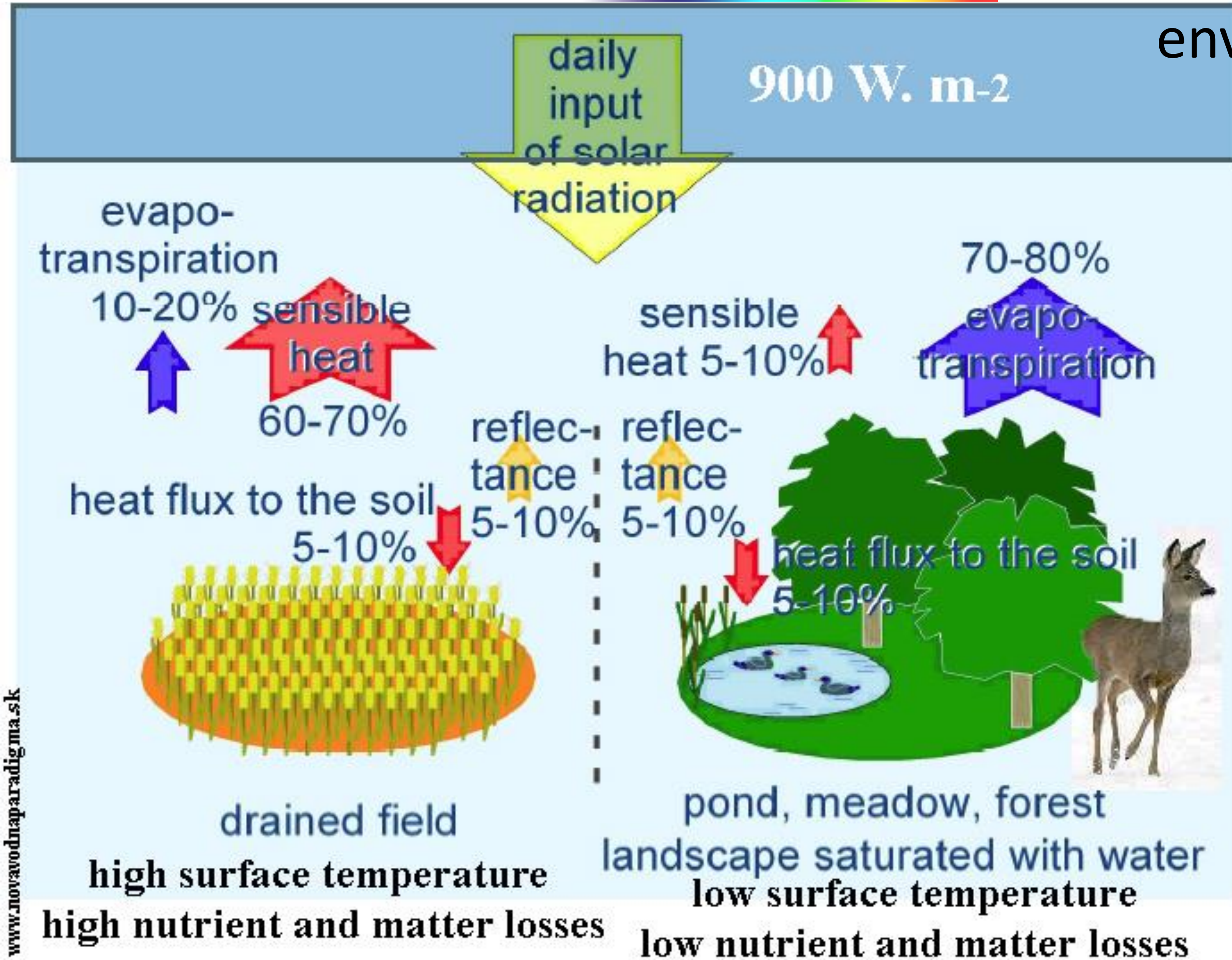
Distribution of solar radiation

- The Sun's energy drives our water cycle, plant production and all other living processes in the biosphere
- There is a large difference between the distribution of solar radiation in functioning natural ecosystems of high plant biomass well supplied with water compared to dry, biomass-poor ecosystems with far more non-living physical surfaces - because of the impacts of solar energy upon water molecules.
- The incoming solar radiation is dissipated at the surface (besides other) by **evapotranspiration-condensation**

- evapotranspiration or latent heat flux are huge energy flows within landscape in several hundreds $W.m^{-2}$.

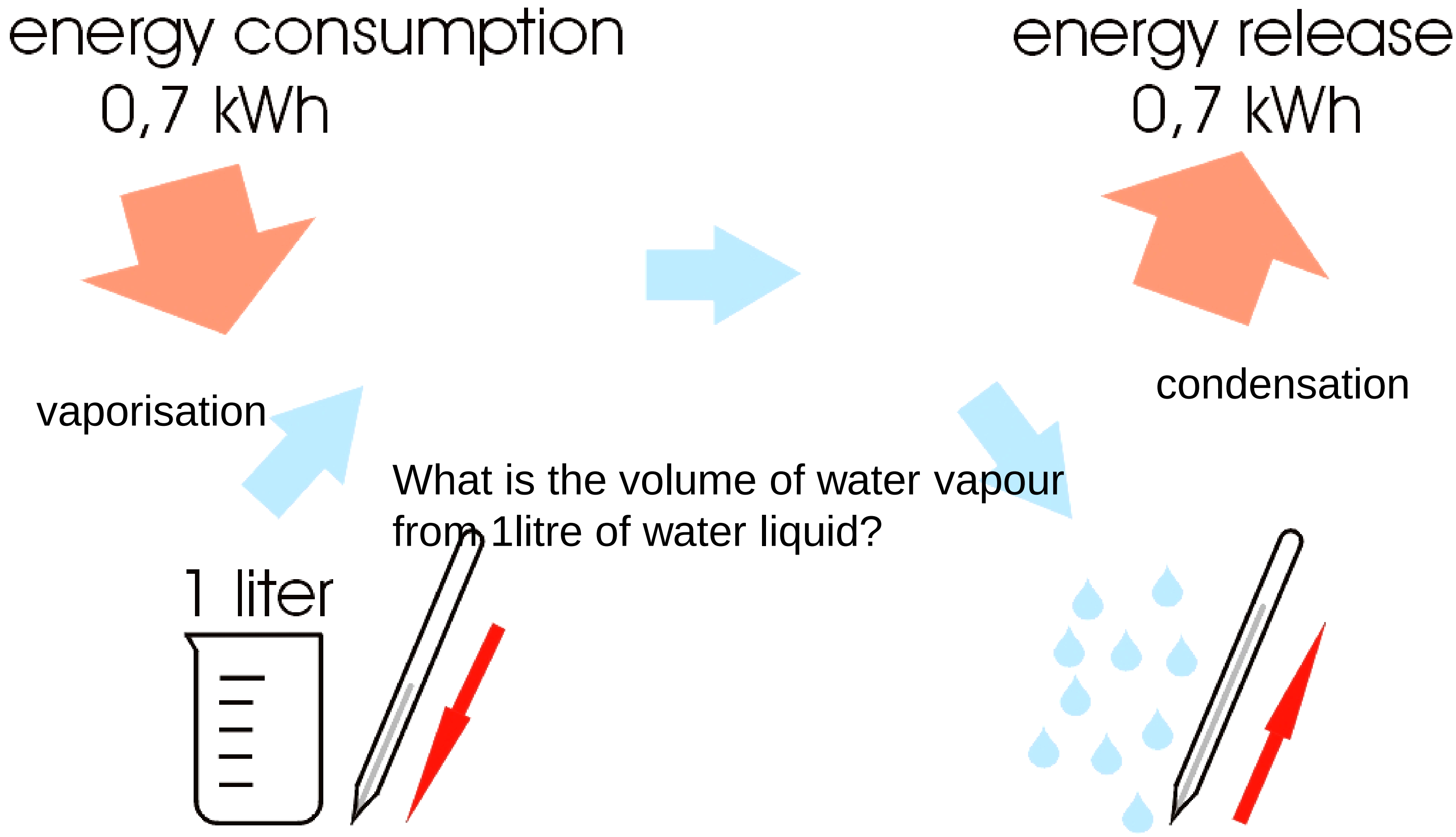
EVAPOTRANSPIRATION COOLS

Biotic regulation of the environment



ET 500W.m-2 - water evaporation 200mg .m-2.s-1, i.e. 2 litres/s/ha

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



To evaporate 1 liter we need 0,7 kWh (2 500kJ)

ET is a powerful cooling process, having a double air-conditioning (gradient reducing) effect upon the landscape

a) evaporation **cools** places, consuming solar energy for transfer of liquid water into water vapour
b) subsequent condensation of water vapour **warms** air where it occurs, releasing latent heat when the dew point is achieved on cool surfaces.

Example:
The decrease in ET from 1 km^2 (100 ha) as a result of drainage is approximately 250 $W.m^{-2}$ (equivalent to 100 mg. s^{-1} of water vapour) and this 250 MW of solar energy in 1 km^2 is thus released into atmosphere as warm air (sensible heat).

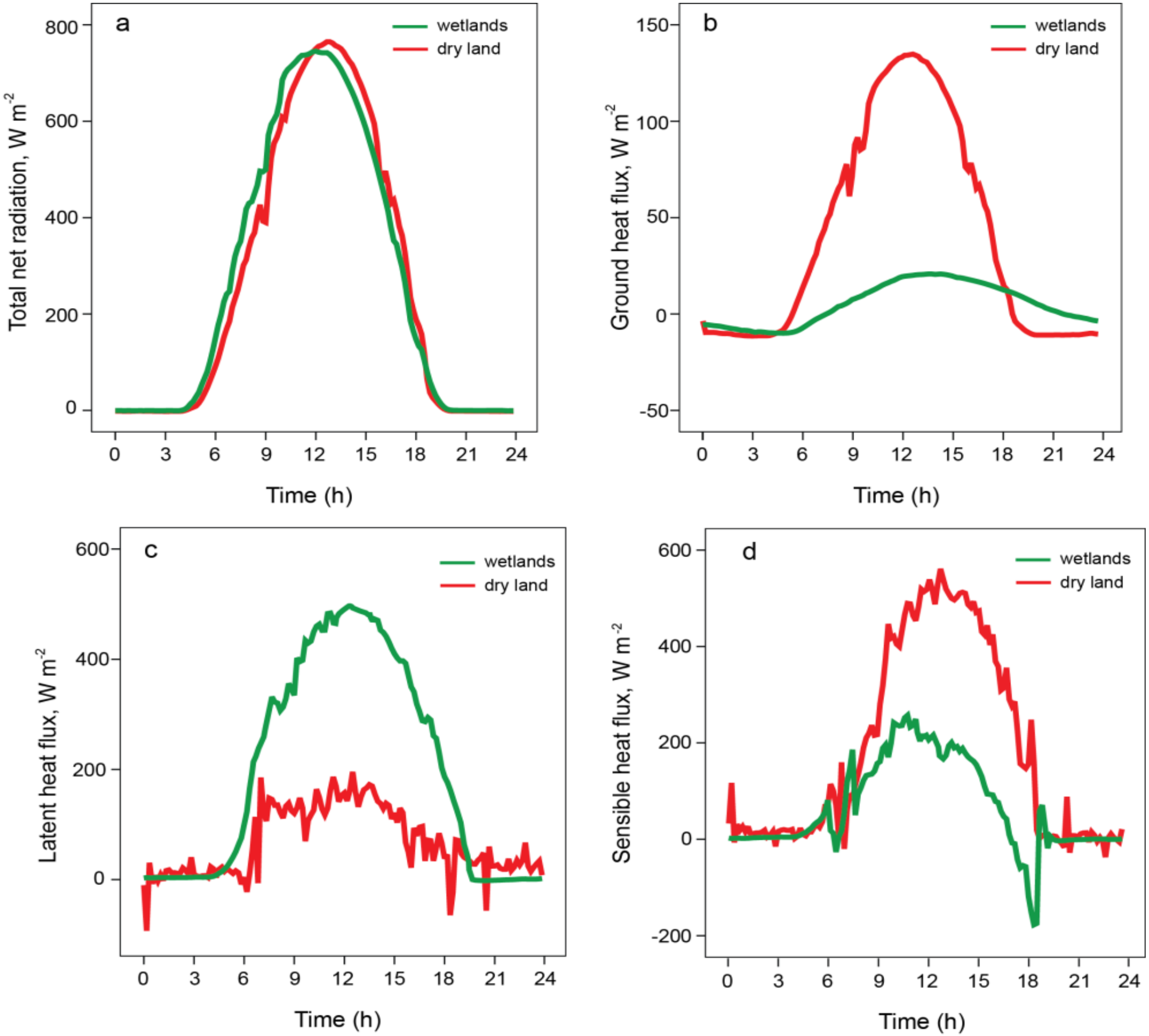
In August 2015 in the Czech Republic, the total surface area of harvested wheat and rape seed fields was about 18 000 km^2 (1,800,000 ha) and sensible heat released from this dry surface area was thus at least 4,500,000 MW. Human generation of such heat in electricity production would require 4500 Nuclear Power Stations, each of 1000 MW.

- process of evapotranspiration-condensation, slows down when there is water shortage; solar energy is consequently converted into sensible heat (H)
- The H warms air, which rises up in a turbulent motion creating atmospheric instability.
- Drainage of wetlands and deforestation bring about a large shift from latent heat flux (air-conditioning, temperature gradient equalizing via evapotranspiration) into sensible heat flux (increase of local temperature and turbulent motion of air, strong wind, cyclones).

We can measure and than calculate the energy fluxes

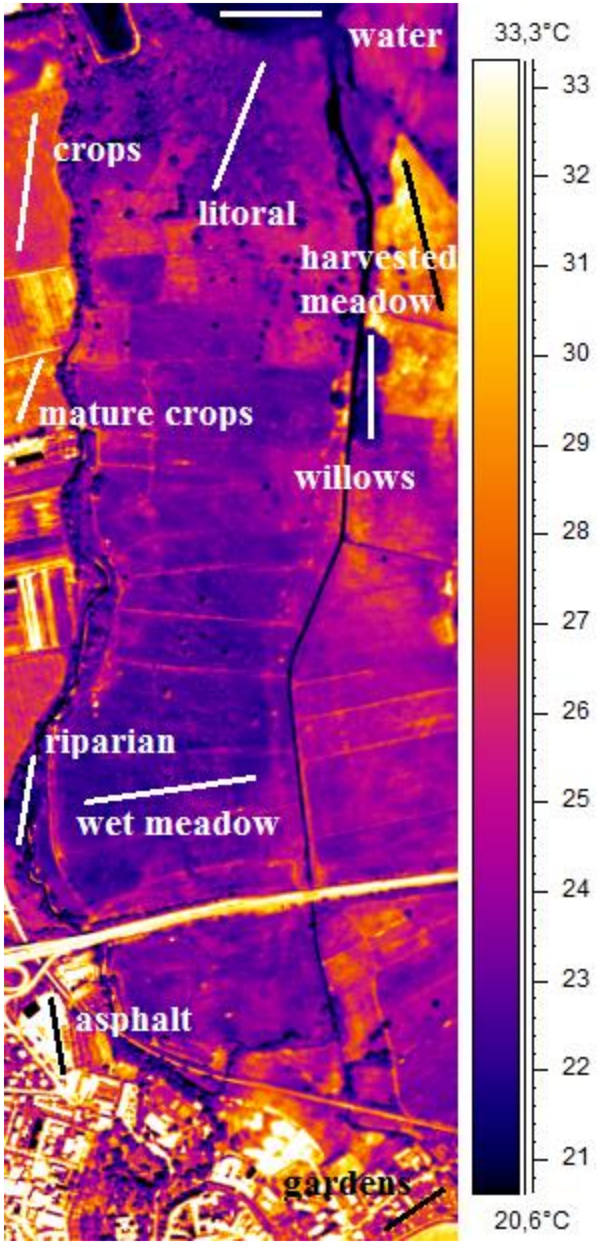
The distribution of incoming solar radiation in two types of ecosystems (according to Pokorny et al. 2010b; Huryna et al. 2014)

	wetlands		dry lands	
	W m-2	%	W m-2	%
reflectance	155	18	235	28
evapotranspiration	452	54	65	8
sensible heat flux	173	20	400	47
ground heat flux	50	6	150	17
biomass	20	2	-	-



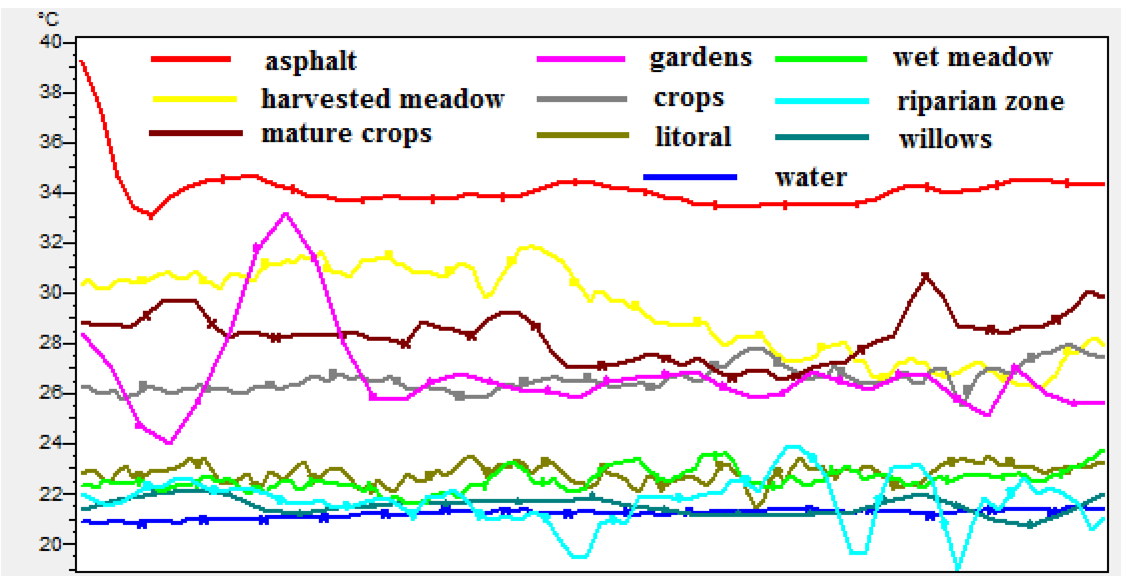
a
wetlands
dry land
Total net radiation, W m^{-2}
Time (h)
b
wetlands
dry land
Ground heat flux, W m^{-2}
Time (h)
c
wetlands
dry land
Latent heat flux, W m^{-2}
Time (h)
d
wetlands
dry land
Sensible heat flux, W m^{-2}
Time (h)

Surface temperature distribution in a cultural landscape with wetlands – an example

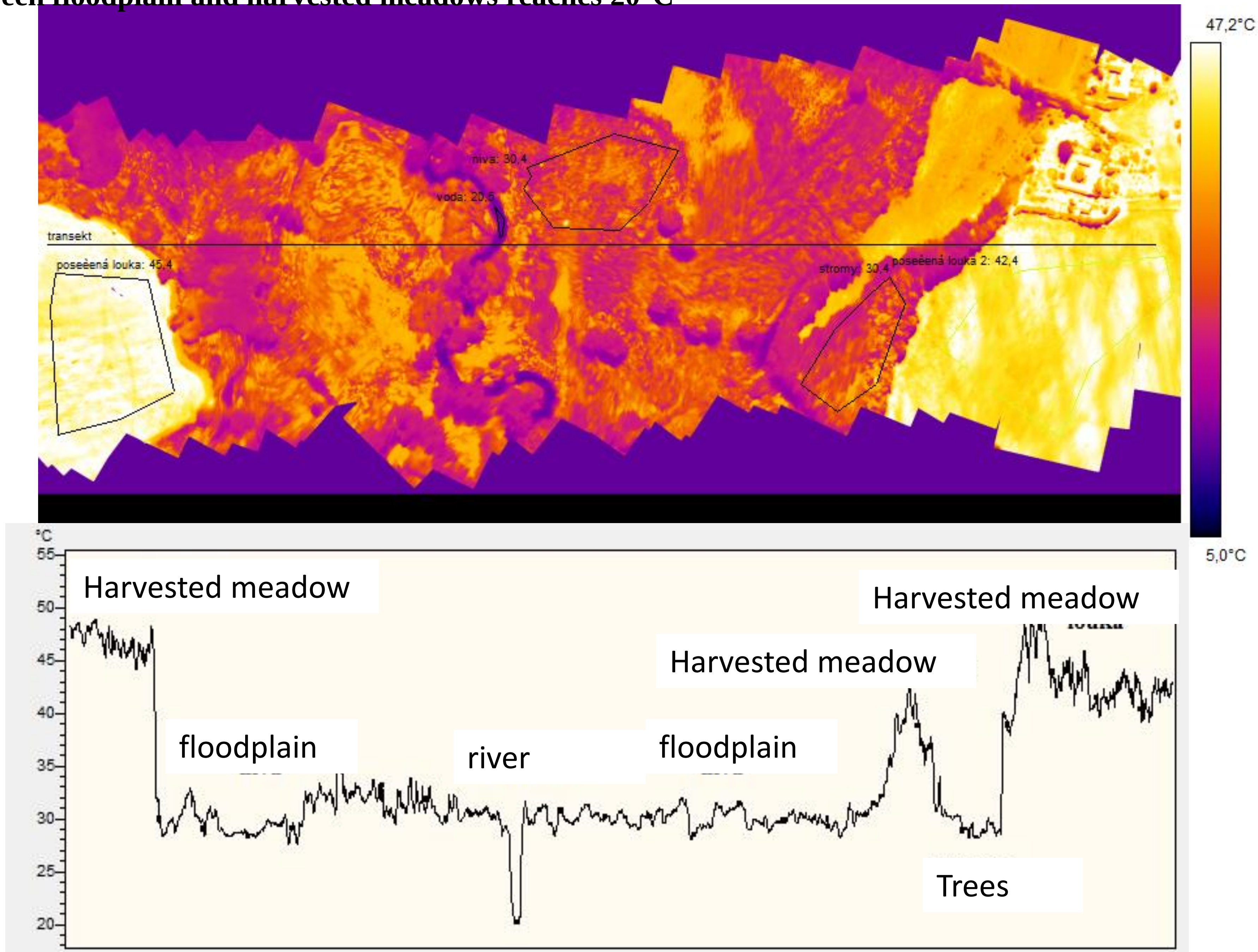


Aerial thermovision picture of wetlands, landscape showing direct effect of water and vegetation on temperature/local climate

Surface temperature transects of ten different surfaces as displayed in graph

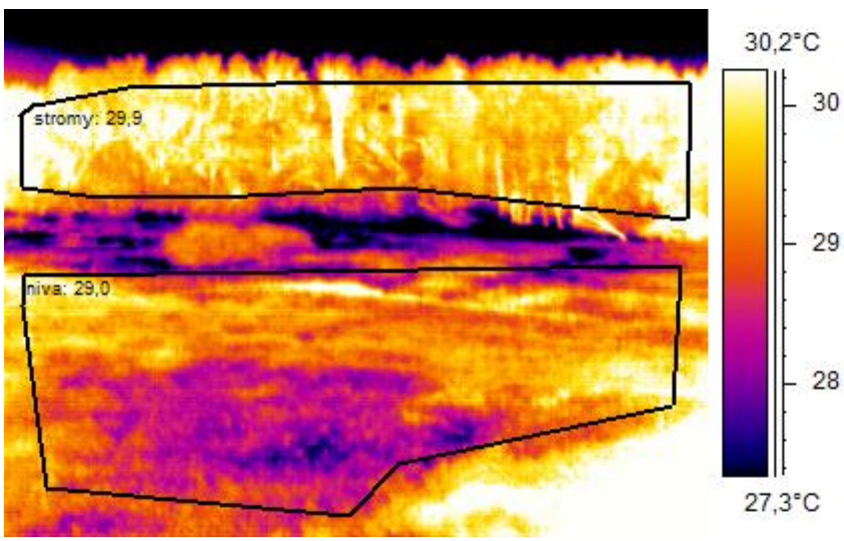


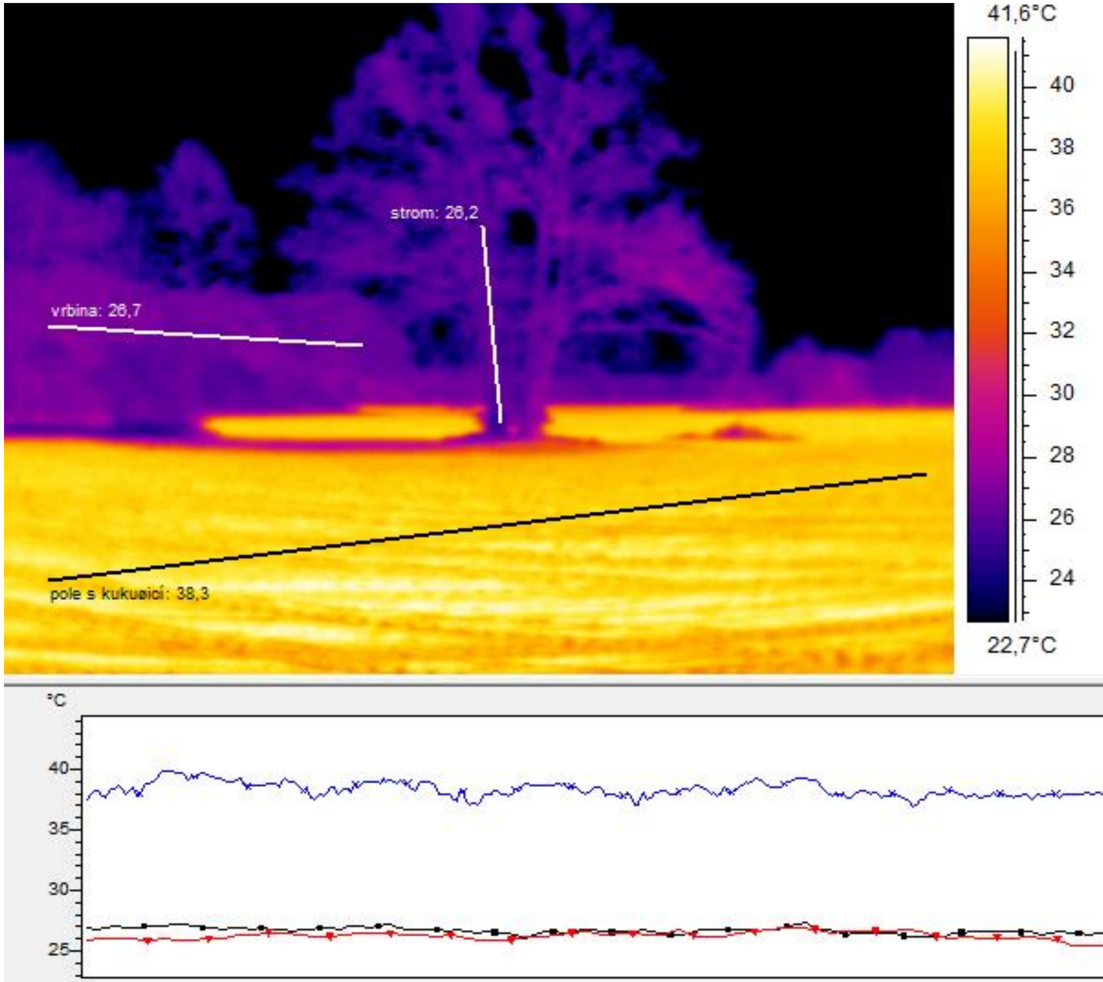
Aerial thermovision picture of Lužnice river with temperature transect. The temperature difference between floodplain and harvested meadows reaches 20°C



Ground thermal measurements

Lužnice floodplain; 10.6. 2010, 12:00, air temperature 30 ℃; Floodplain – balanced temperature regime





Label	Min	Max	Avg	Cursor X	Cursor Y
vrbina -...	26,0	27,3	26,7	-	-
strom -...	25,4	26,9	26,2	-	-
pole s kukuřicí -...	36,9	39,9	38,3	-	-

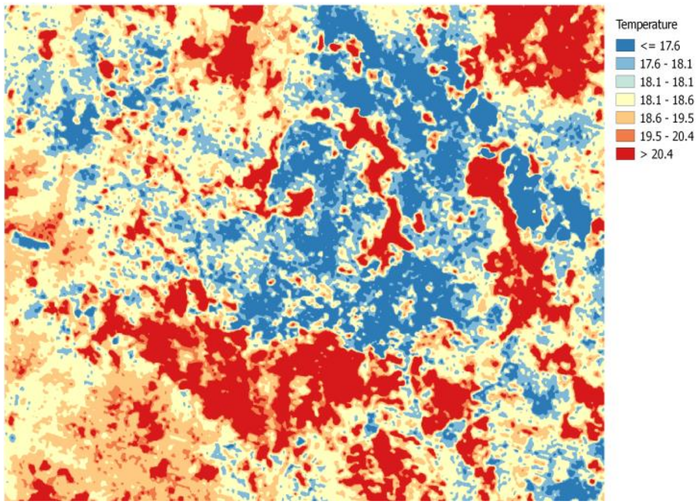
Bare field 38°C,
willow 27°C
Tree 26,9°C

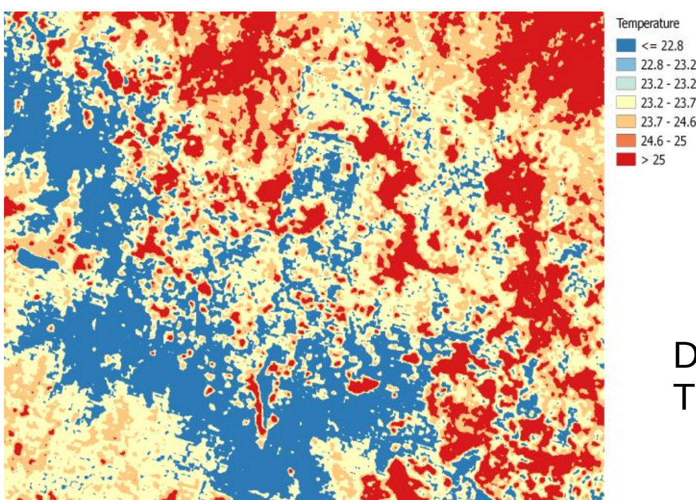
5.5.2015 13:40

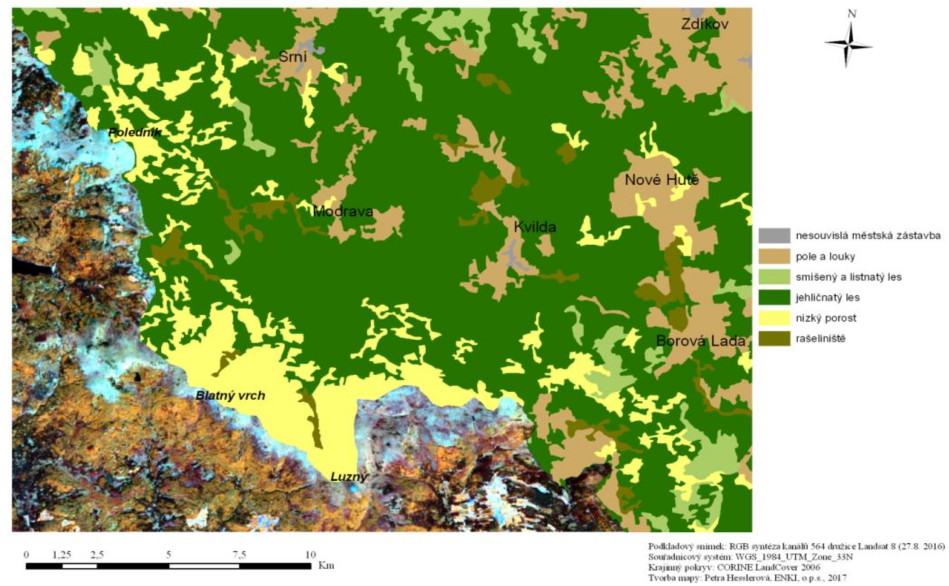
The assessment of surface temperature in relation to land cover changes in Šumava National Park

Surface temperature increase as a potential threat to wetlands

Surface temperature retrieved from Landsat 5 image a) 29.7. 2005 b) 9.8.1991







Deforestation = surface temperature increase can reach 10°C
The same problem – overheated agriculture landscape

- The drainage of wetlands causes a shift from latent heat to sensible heat flux, which results in an increase of temperature and thus water loss from the landscape.

- The distribution of latent and sensible heat between a wetland and dry (drained) land differ by several hundred Wm-2 during a sunny day.

- In wetland ecosystems, latent heat prevails and uses about 60-80 % of net radiation, sensible heat uses about 20-30 % while ground heat flux 10-20 %

- The amount of sensible heat released as a consequence of land cover changes is very much higher than heat caused by increased carbon dioxide concentrations creating the greenhouse effect.

- Wetlands influence the local climate through evapotranspiration; wetlands moderate extreme day and night temperature like forests

The recommendations for the wetlands management and conservation in terms of climate change and current agriculture practice

- The Czech Republic experienced a period of collectivization, causing increased field block areas and large scale drainage; the ramified hydrological web of the agricultural landscape disappeared

- need to retain water in the landscape, its good quality; low and balanced temperatures in the landscape

- high need to change landscape structure – involve natural and technical landscape features to retain water and nutrients, decrease soil erosion, improve climate

- wetlans as important part of landscape reconstruction

- EU subsidies do not support restructuring of the agricultural landscape

(Common Agriculture Policy – biodiversity and welfare support, greening???)

- Farmers are directly responsible for water retention and its quality, nd local climate, however they do not know it...

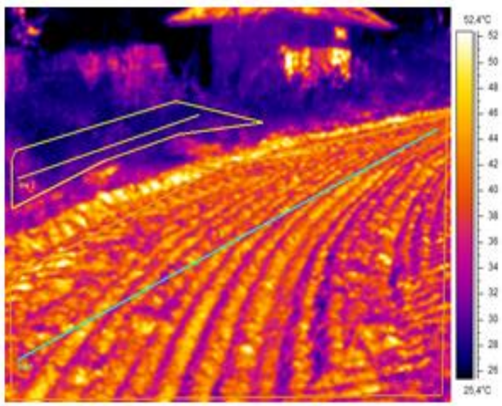
NEED TO:

- set up subsidies directly supporting realization of complex landscape adaptations within the catchments area, including soil compensations, funds for adaptations maintenance, big problem – land owners

– legislation amendments, cross-sector cooperation (EU, Ministry of: Environment, Agriculture, Industry and Trade, water catchments management, local and regional authorities,...)

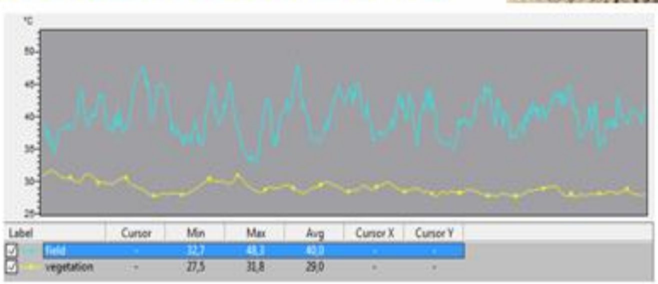
BIG CHALLENGE FOR FUTURE

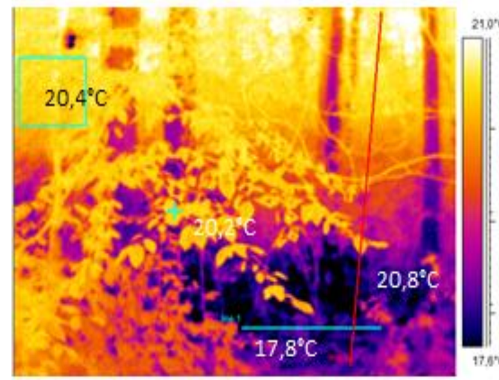
Wetlands keep water a cool landscape.
Warm air from drained areas dries landscape



Zorané pole

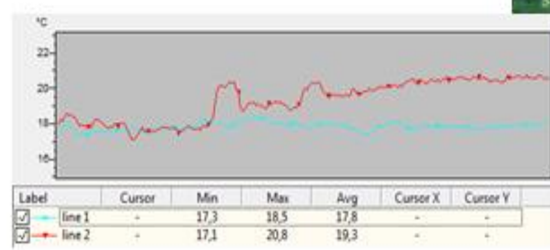
Průměrná teplota 39,5°C
Sousední vegetace 29,3 °C





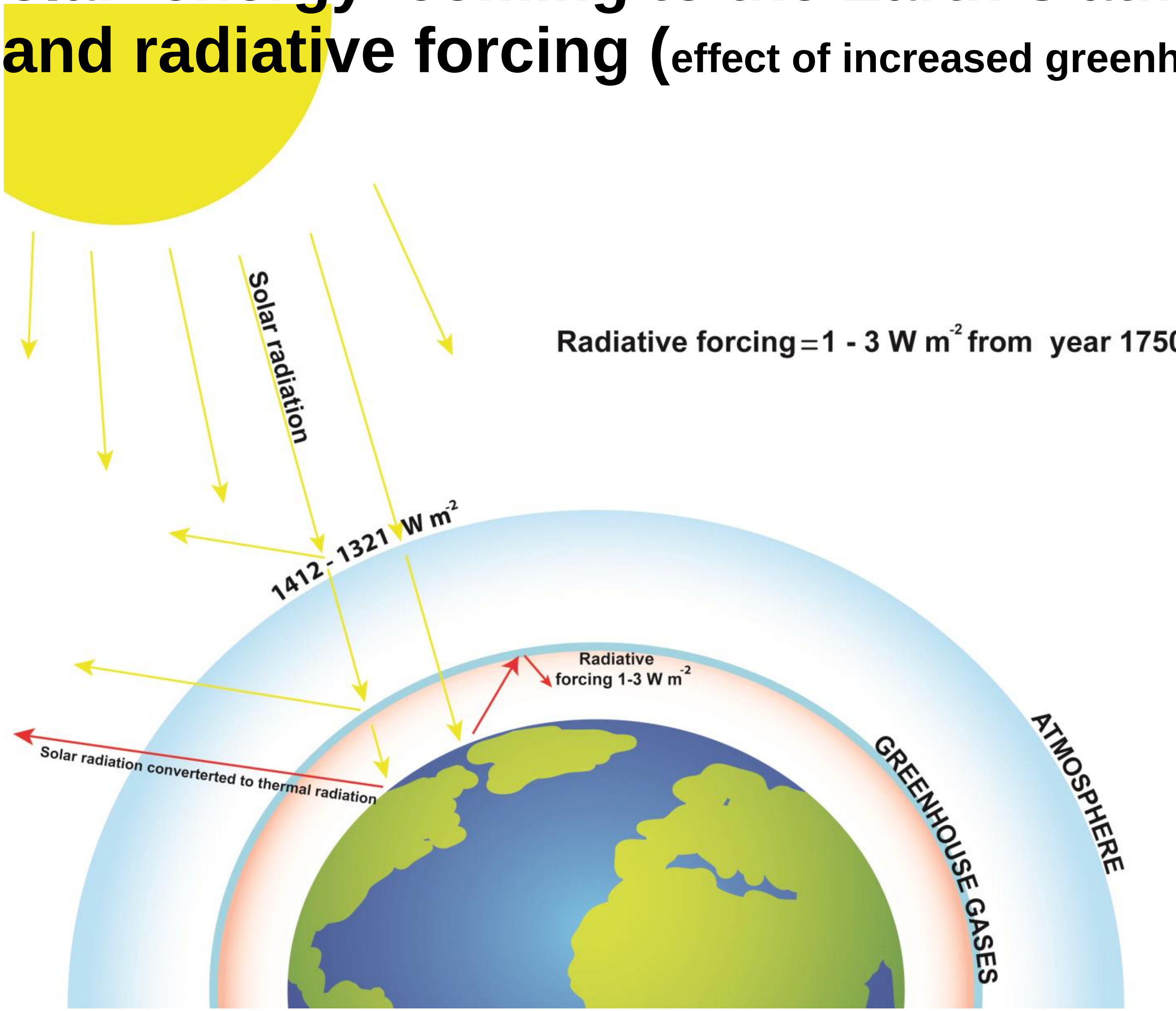
Olšina

Průměrná teplota 19,5°C
Min. 15,7°C
Max. 22°C



20.4.2017

Solar energy coming to the Earth´s atmosphere and radiative forcing (effect of increased greenhouse gases)



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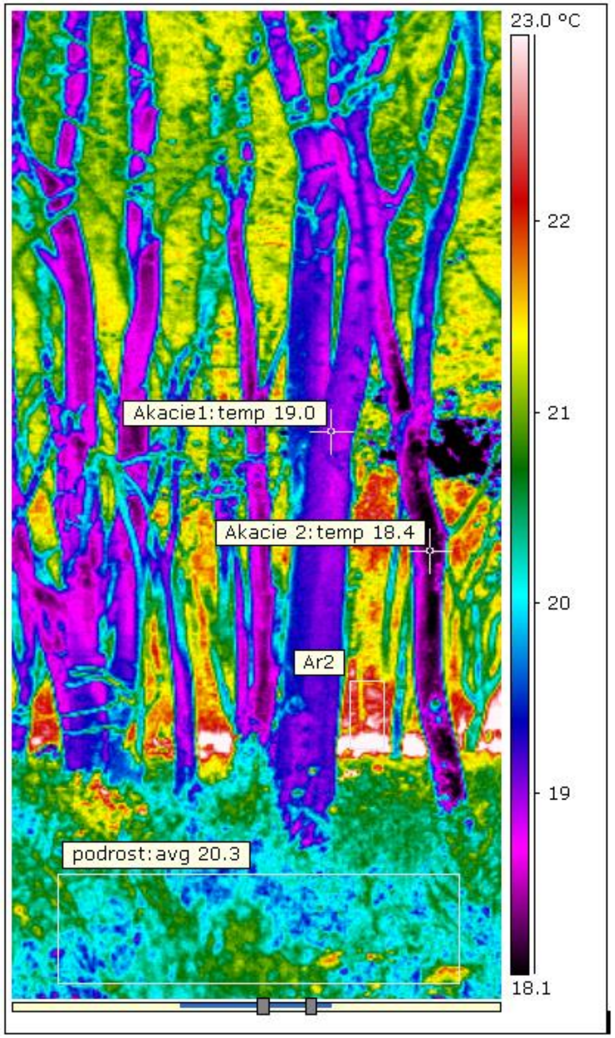

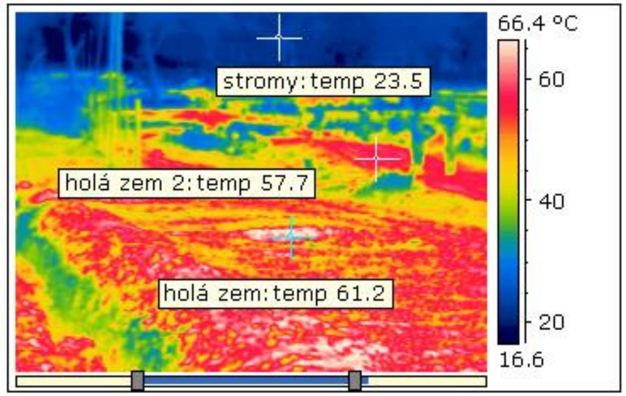

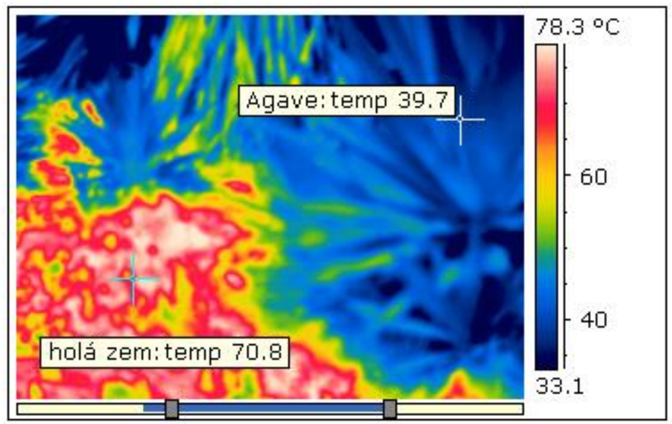

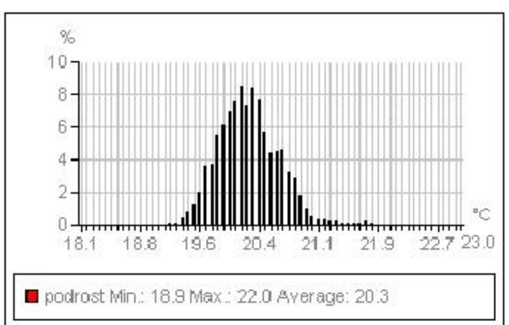

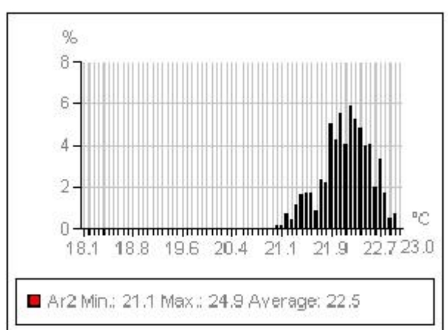

Accacia forest about 20 C
bare land up to 70 C