The Role of the Land Surface in Fog Modelling – Simulations with COSMO-FOG

Isabel Alberts, Matthieu Masbou and Andreas Bott

Meteorological Institute – University of Bonn,

ialberts@uni-bonn.de

Research Training Group 437
LANDFORM
a structured and variable boundary layer

universitätbonn

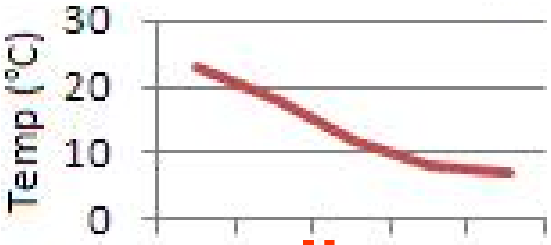
What is FOG ?

World Meteorological Organisation (WMO) definition

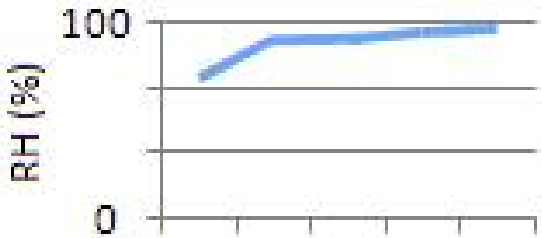
“Suspension of very small, usually microscopic water droplets in the air, generally reducing the horizontal visibility at the earth´s surface to less than 1km”

Webcam: http://www.loewenburger-hof.de/

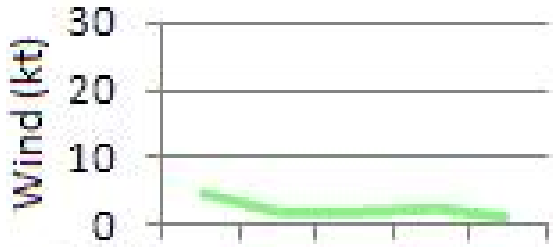
Ingredients for Fog Formation



cooling

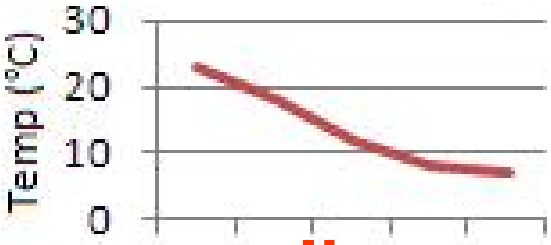


increase in humidity

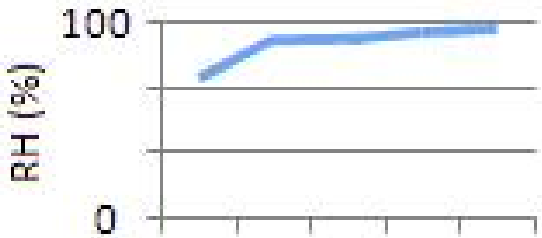


calm or light winds

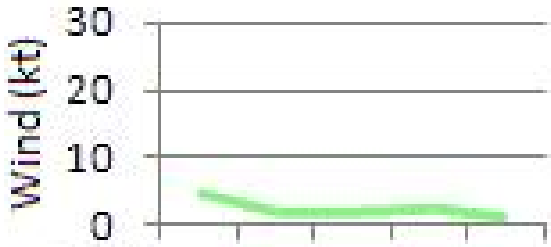
Ingredients for Fog Formation



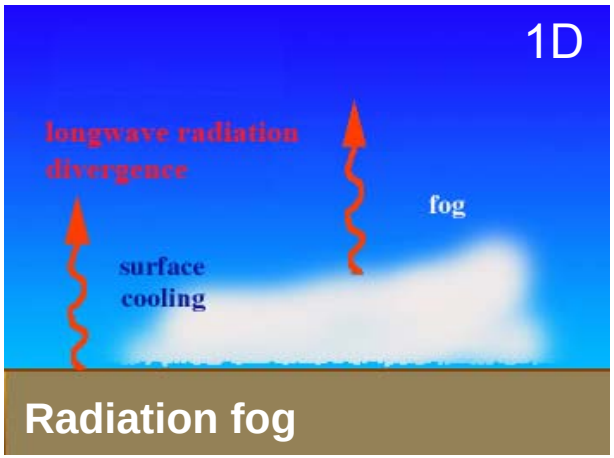
cooling

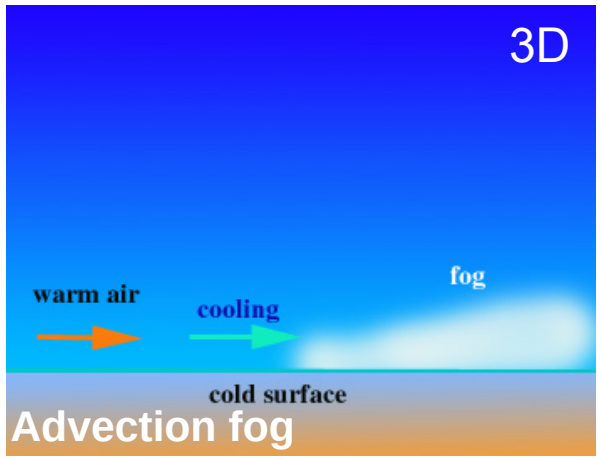


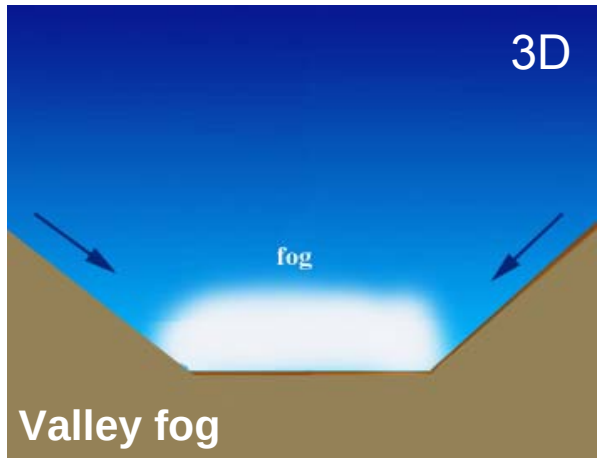
increase in humidity



calm or light winds







Fog Formation and the Land Surface

What is the role of the surface?

Local Surface Influences

Soil type

Vegetation

Surface characteristics

Soil moisture

Terrain Influences

Topography

Mountain valley breeze

Accumulation of cool air

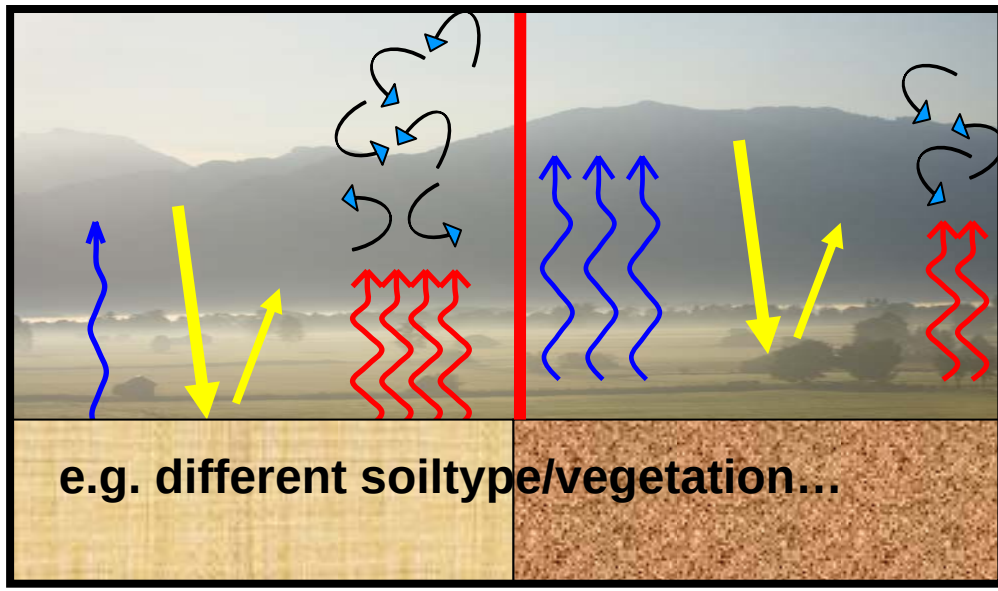
What processes does the surface affect?

Radiative cooling

Advection

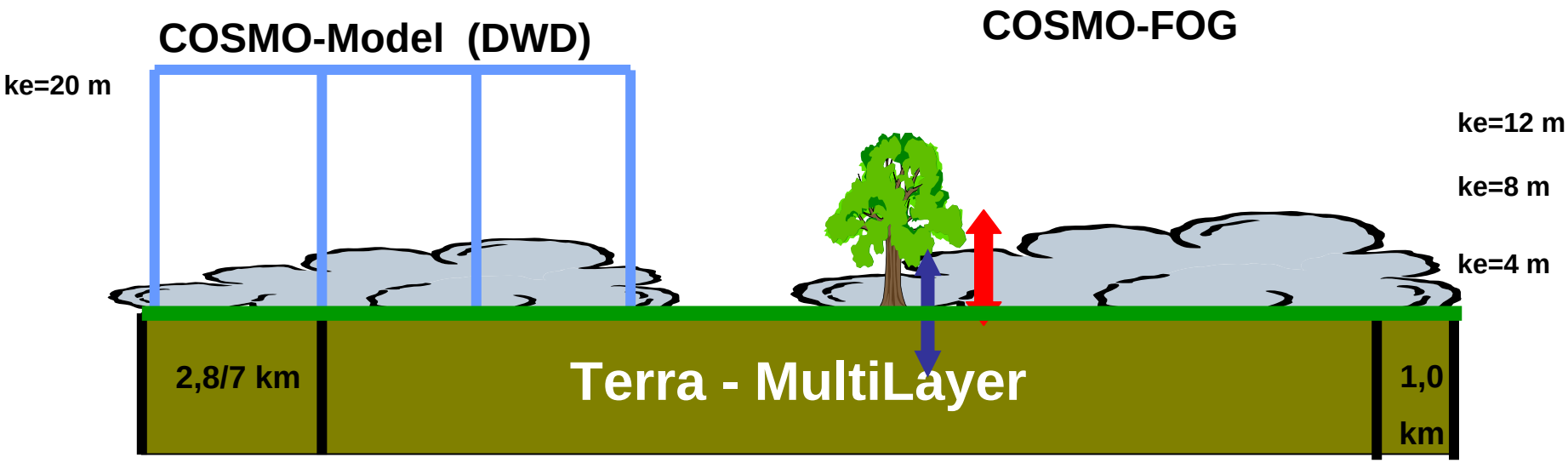
Vertical mixing of heat and moisture

Heat and moisture transport in the soil



Fog Model: COSMO-FOG

Coupling of **COSMO Model** and **PAFOG** (PArametrized FOG) (Bott & Trautmann (2002))



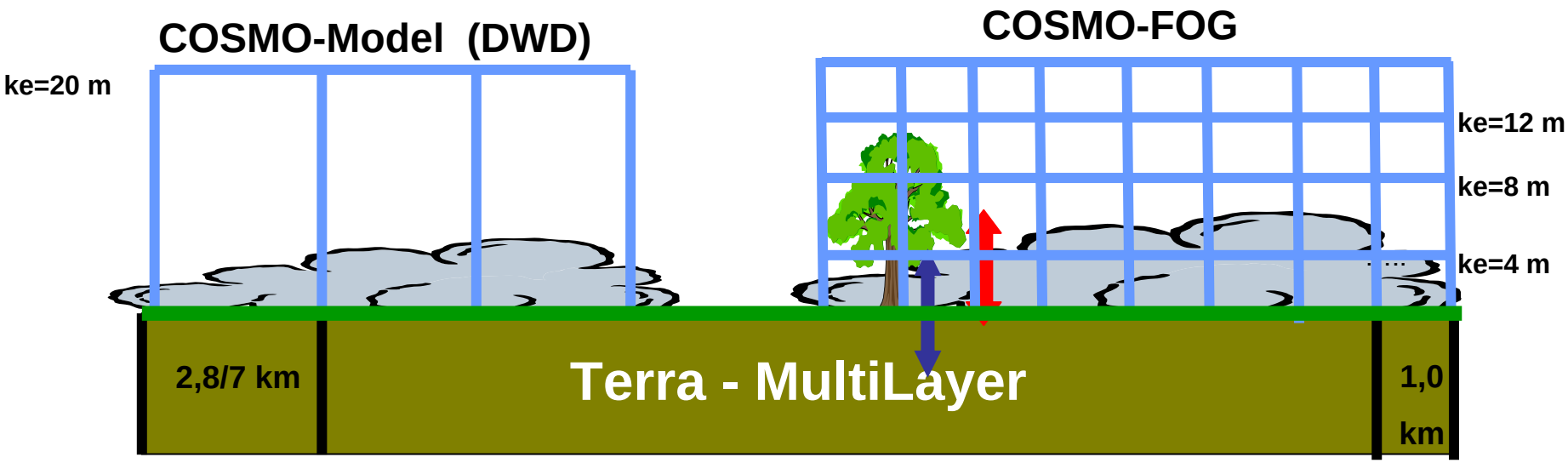
Fog Model: COSMO-FOG

Coupling of **COSMO Model** and **PAFOG** (PArametrized FOG) (Bott & Trautmann (2002))

Current NWP models run at **resolutions** that are **too coarse** for simulation of fog

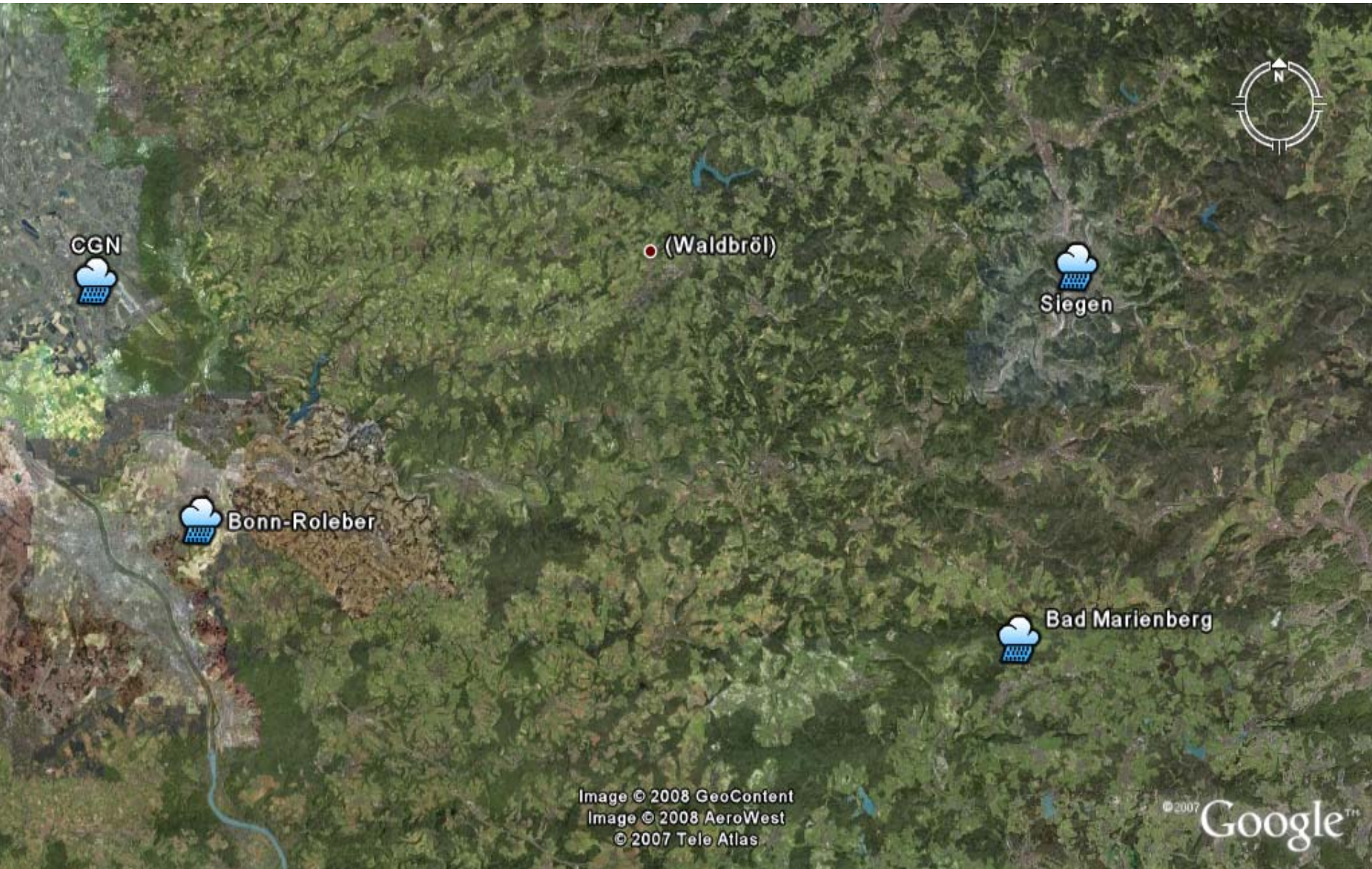
Microphysics of PAFOG limited to the **lower part of the atmosphere (2000m)**

Introduction of a new prognostic variable: **Concentration of Cloud Condensation Nuclei (CNN)**



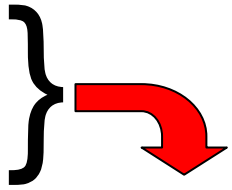
Research Area

Research Area



Needed **DATA** for description of the surface

Soil type
Vegetation
Topography



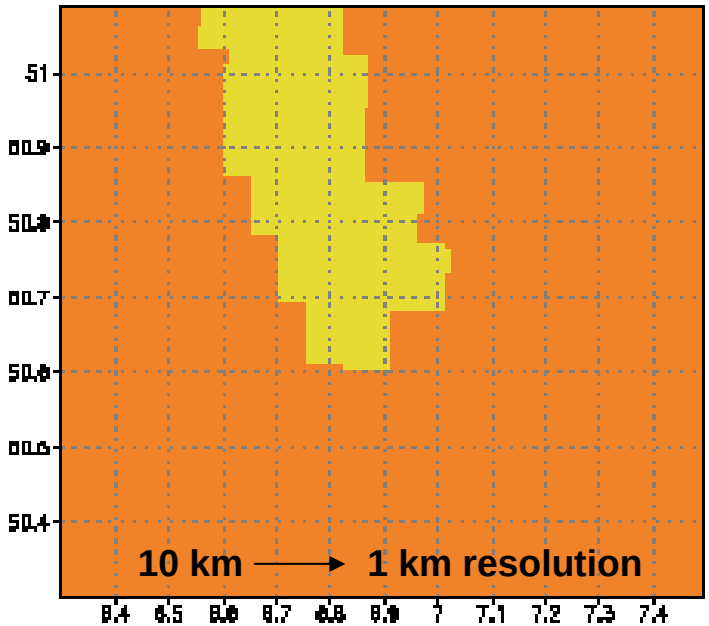
Surface roughness
Root depth
Plant cover
Leaf area index

Needed **DATA** for description of the surface

Soil type
Vegetation
Topography

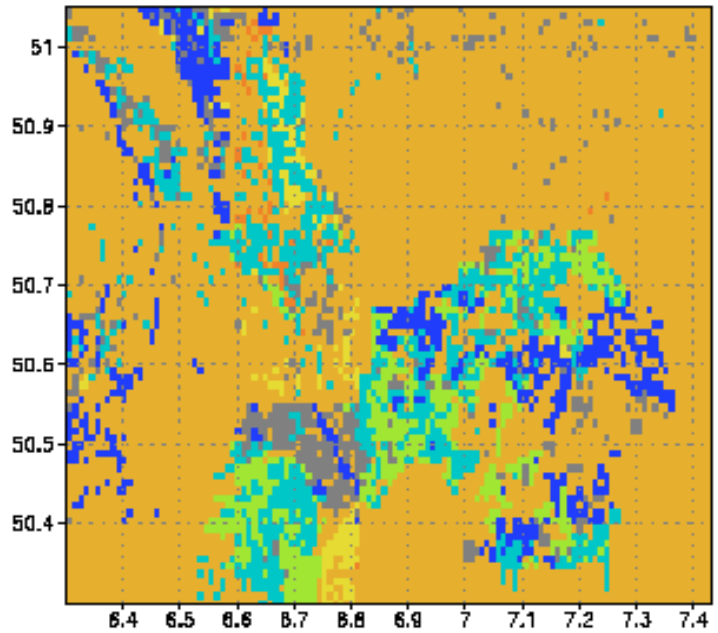
Surface roughness
Root depth
Plant cover
Leaf area index

To take the high heterogeneity into account:
set of modified external parameters implemented into
COSMO- FOG; resolution 1 km



Source: FAO/UNESCO Soil map of the world (Food and Agricultural Organization of UNO, **10 km resolution**)

50 m → 1 km resolution



Source: Soil map 1:50 000 (BK50, Geologisches Landesamt NRW and Rheinland Pfalz, **50 m resolution**)

COSMO-FOG-VEGETATION

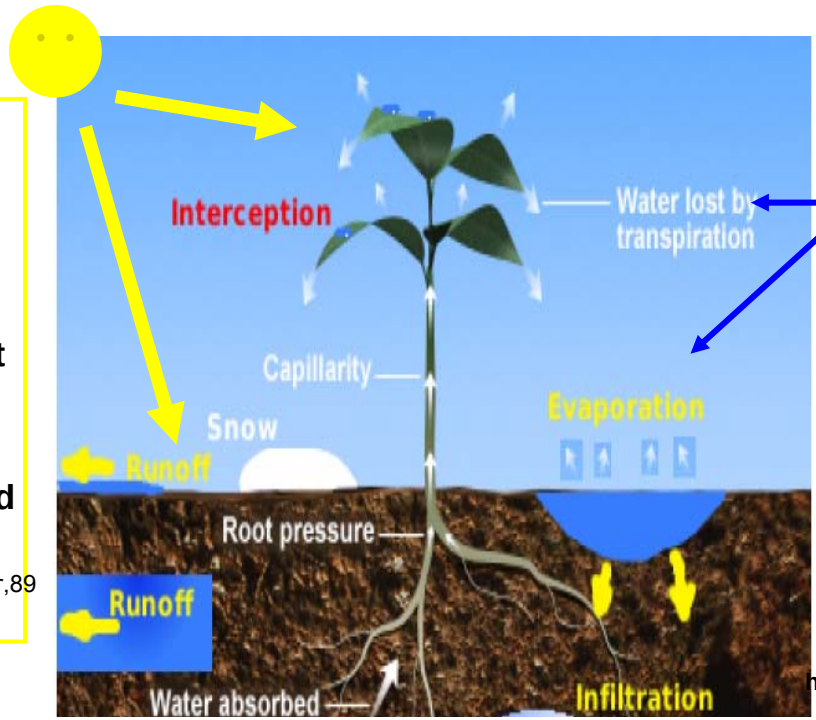
Explicit modelling of vegetation layer as one „big leaf“ which is situated between atmosphere and surface: e.g. vegetation temperature, humidity, wind,... Deardorff (1978); Schädle (1989); Siebert et al. (1992); von Glasow and Bott (1999)

Modifications of:

…radiation -> ground surface albedo

α_{veg} **Land use dependant values** Ament, 06

$\alpha_{baresoil}$ **Water content and soil / veg parameters** Schädler,89



http://meted.ucar.edu

…water fluxes:

Evapotranspiration controlled by -> atmospheric resistance r_a

stomata resistance r_s

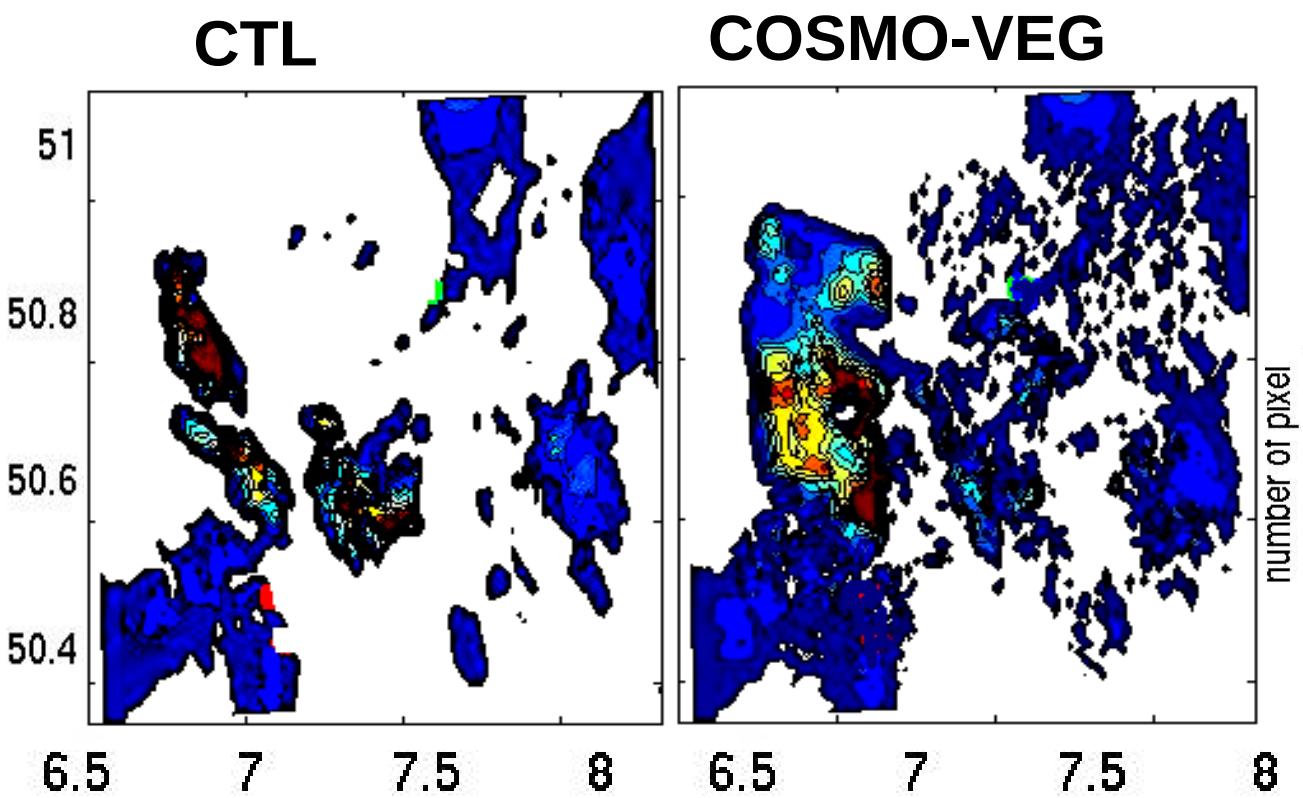
=> Expect a more detailed simulation of e. g. temperature and humidity over vegetation

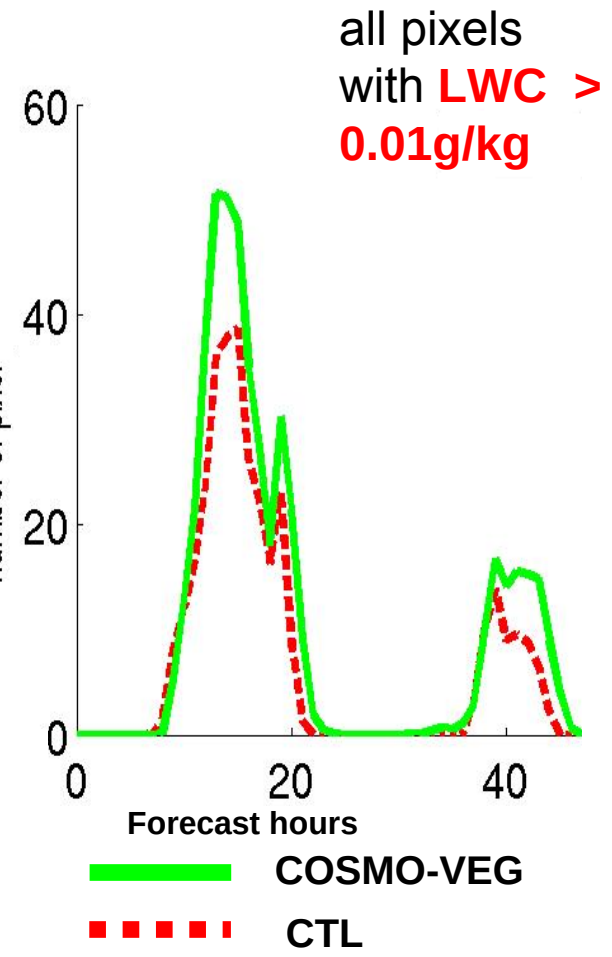
Model Setup

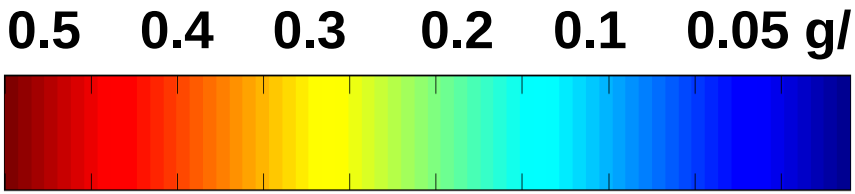
Sensitivity Study: Two model runs with different data set of external parmeters and parameterizions concerning boundary layer: **CTL and COSMO-VEG**

Initalization:	05.10.2005 12 UTC
Forecast hours:	48 hours
Time step:	10s
Boundary conditions:	COSMO-DE
Horizontal resolution:	120 x 80 Pixel resolution: 1.0 km
Vertical resolution:	Atmosphere – 40 layers Δz_{min}= 4m 25 layers in the lower 2000 m of the atmosphere Soil: 8 Layers TERRA-ML

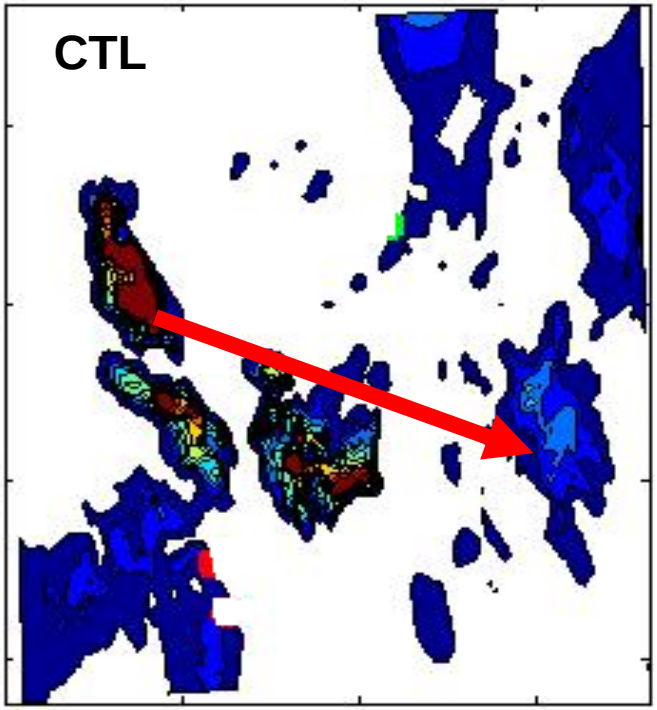
2m Liquid Water Content g/kg 2 UTC

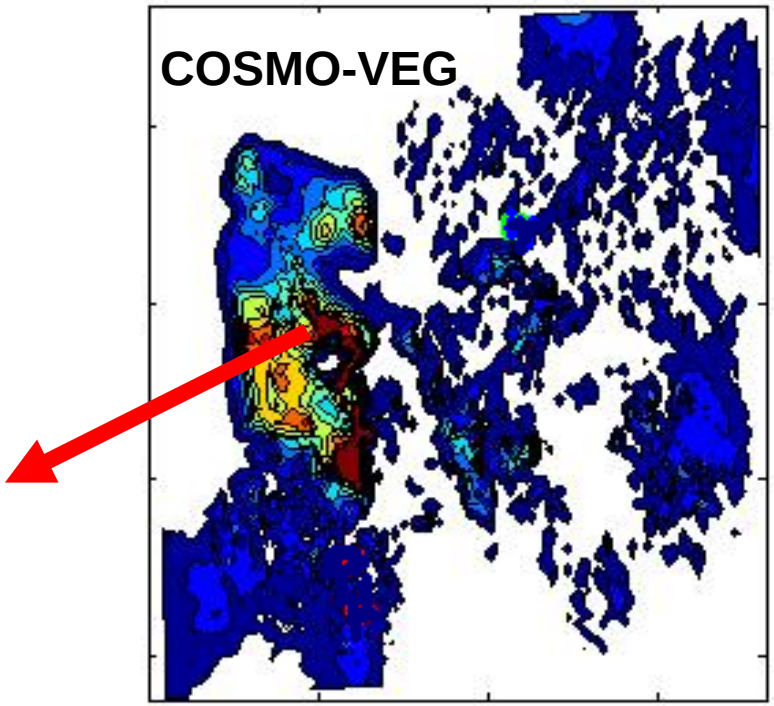






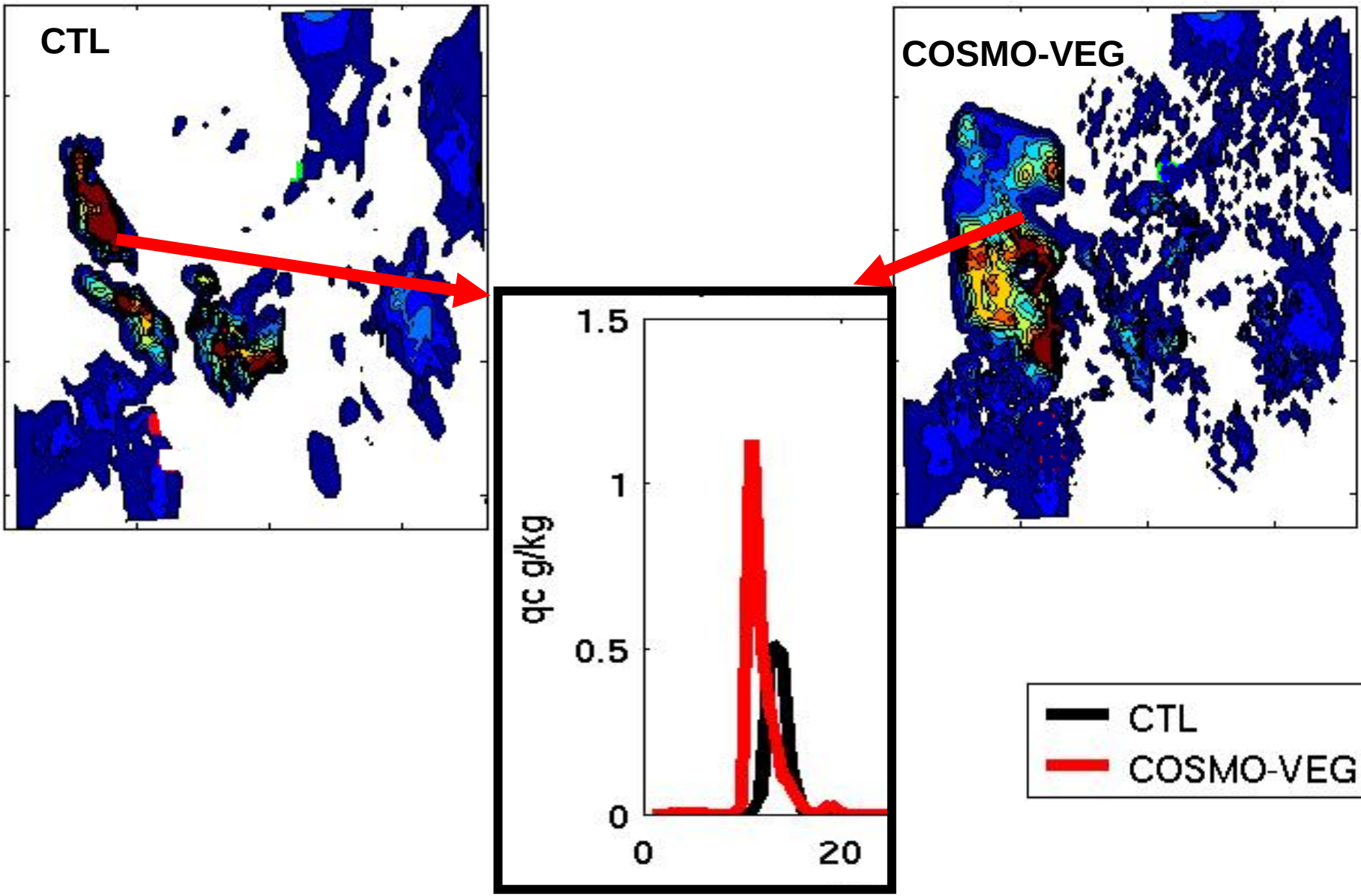
2m Liquid Water Content g/kg 2 UTC



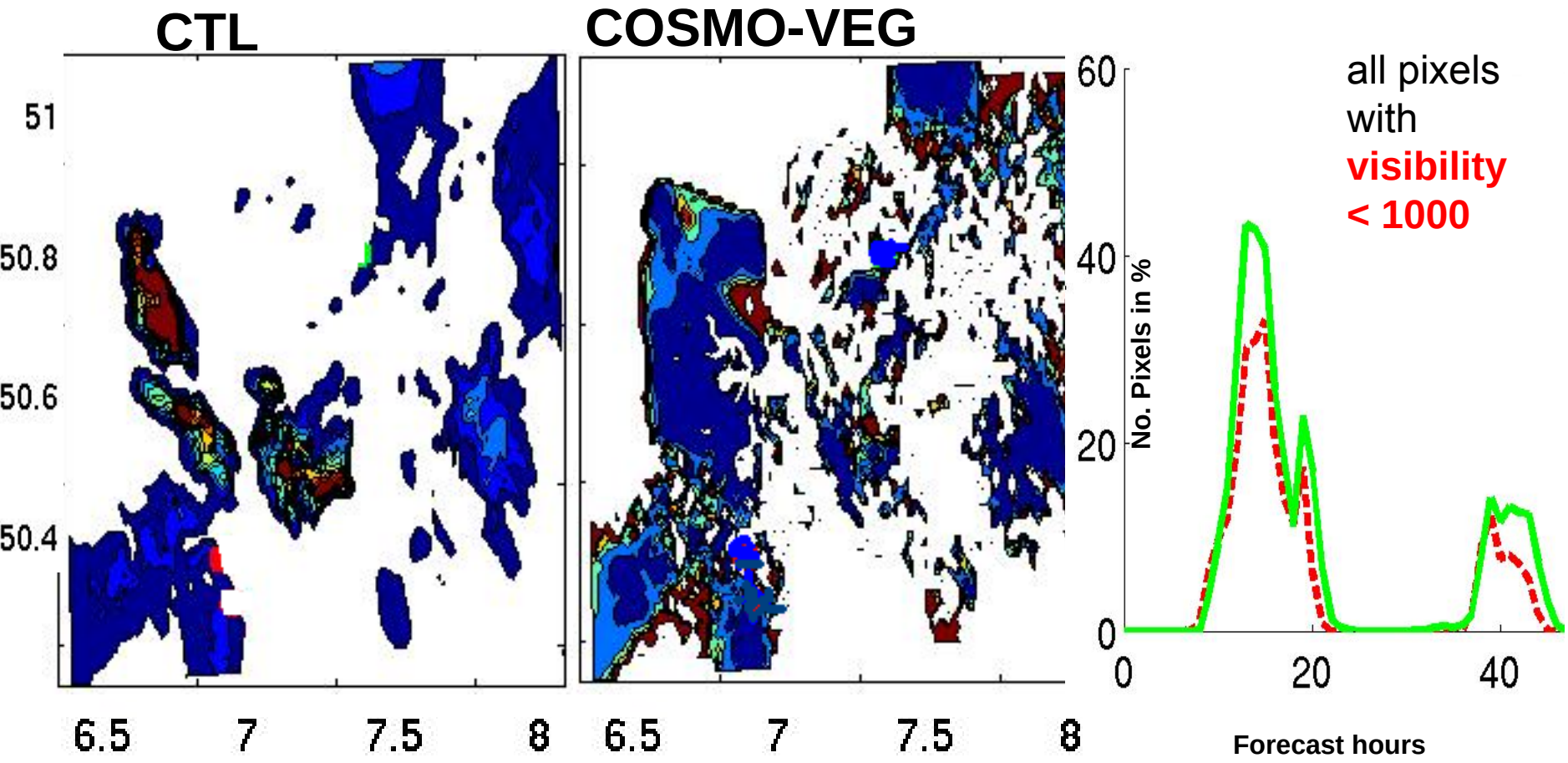


CTL
COSMO-VEG

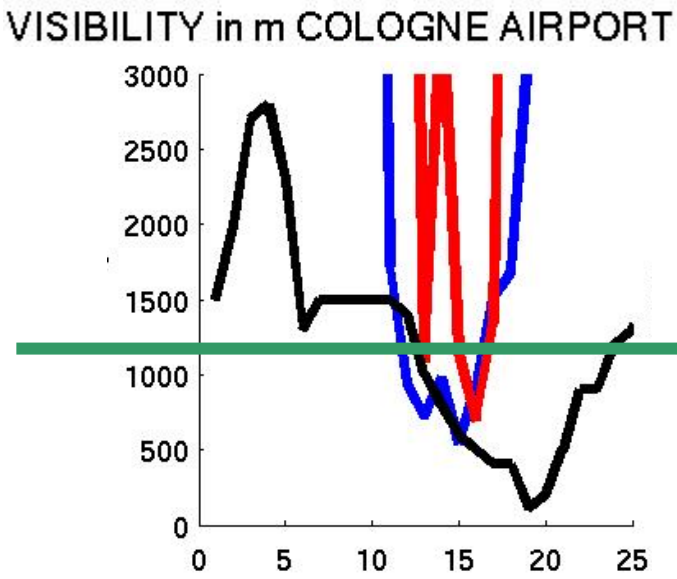
2m Liquid Water Content g/kg 2 UTC

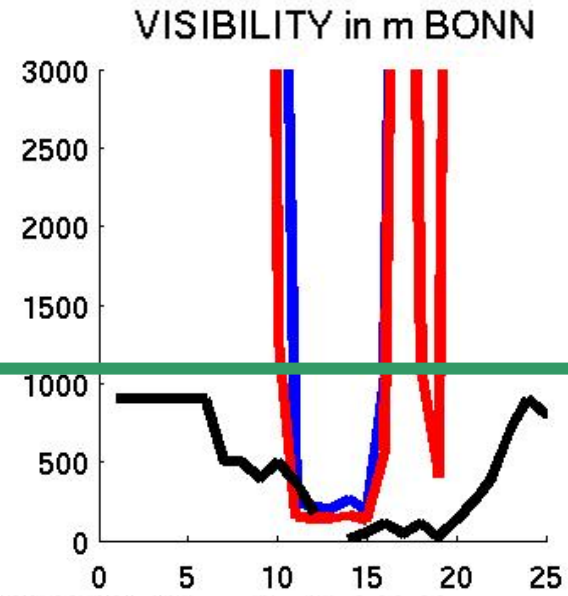


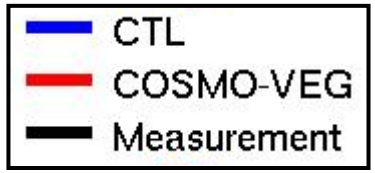
2m-VISIBILITY in m 2 UTC

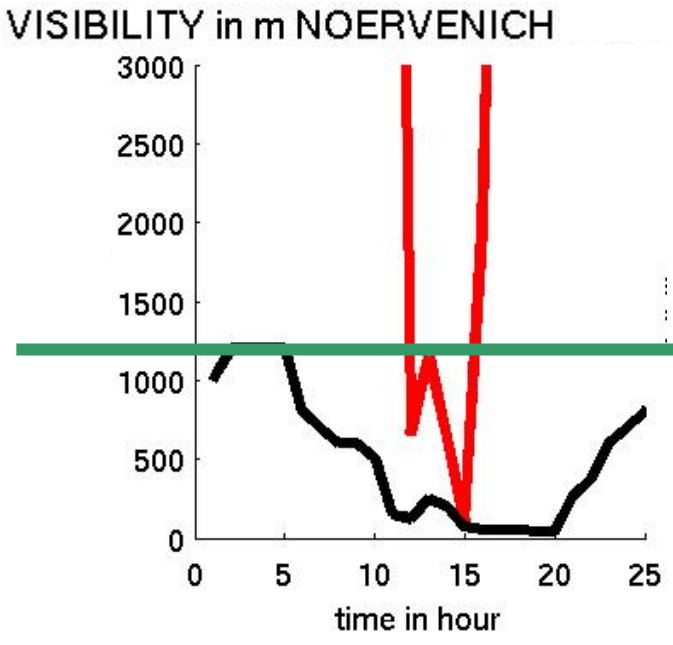


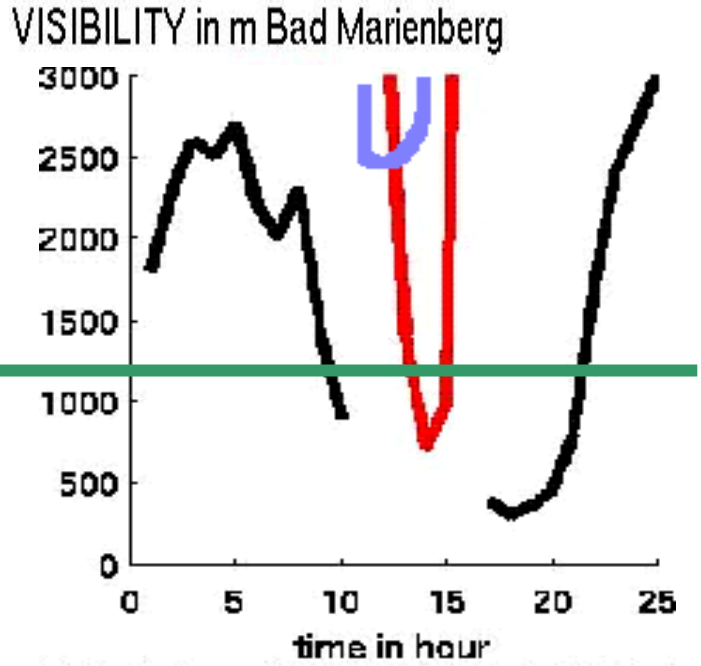
2m-VISIBILITY in m Measurements











Conclusion and Outlook

- **COSMO-FOG is sensitive to surface characterisitics**
- **The new implemented surface parameters plus Vegetation module have an impact on the surface fluxes, the surface temperature, and accordingly on the fog formation.**
- **Characteristic spatial patterns are similar, but results of the simulation with the modified parameters are more heterogenous**
- **Differences of 2m-temperature are between +2°C and -3,5°C**
- **Differences of latent heat flux are in the range of +30 and -40 W/m^{-2} and of sensible heat flux in the range of +20 and -50 W/m^{-}**
- **TERRA 2-m temperature as well as surface temp. is higher than COSMO-VEG temp.**
- **Modifications of TERRA-ML concerning vegetation (canopy temperature, canopy humidity, ...)**