Regional Cooperation for
Limited Area Modeling in Central Europe

LACE
nwp central europe

ALARO physics developments

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EWGLAM and SRNWP meetings

Talk outline

- ALARO status overview
  - **first ALARO-1 version available**
  - **novelties in radiation scheme**
  - **example with solar eclipse**
  - **shallow convection inside TOUCANS**
- Parameterization of orographic effect on radiation at surface
- Outlook
  - **Enhancement of deep convection**

ALARO status

- In the operational use in ALADIN countries
  - **ALARO-0: at, be, hr, hu, ro, sk, si, tr**
  - **ALARO-1vA: cz, po**
    model resolution between 8 km – 4 km, 2km

National posters

- In EPS systems
  - **ALADIN-LAEF, GLAMEPS, EPS at HMS**
  - **HarmonEPS convection-permitting ensemble system**

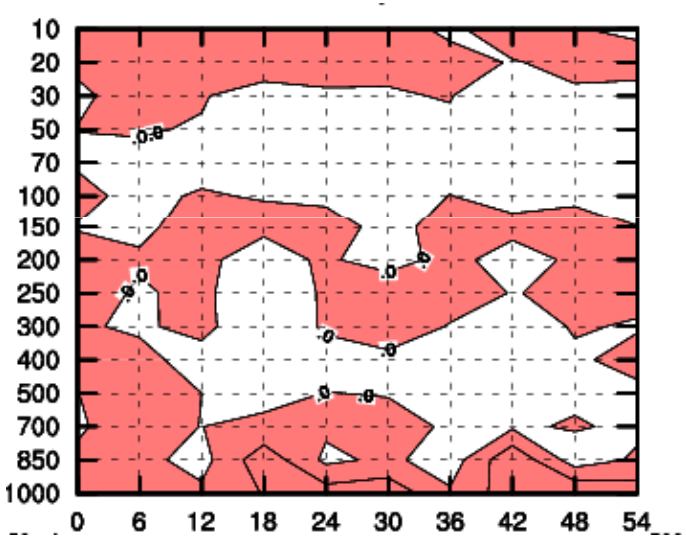
- In climatological simulations
  - **be, cz, se**

First version of ALARO-1

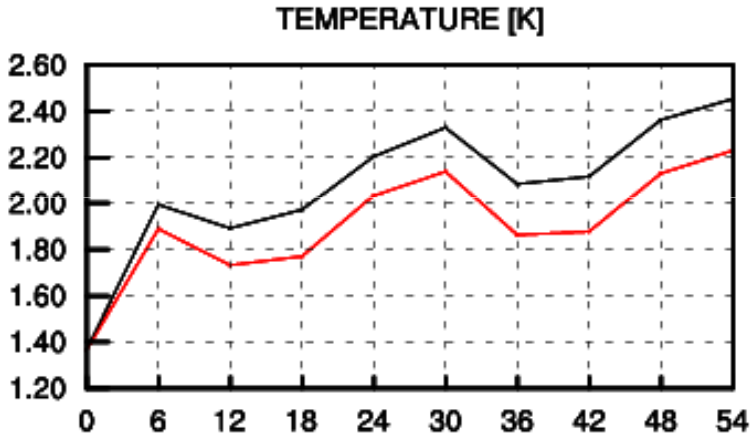
- Assembling
  - **Turbulence and shallow convection scheme TOUCANS**
    - Prognostic TKE and TTE
    - Parameterization of moist third order moments
    - Turbulent diffusion of cloud condensates
    - Mixing length (same as in pTKE)
    - Shallow convection (same as in alaro-0)
  - **Radiation ACRANEB2**
    - Significantly improved
  - **Microphysics**
    - Improved rain drop size distribution
    - More sophisticated vertical geometry of cloud and precipitation
- Retuning (significant effort needed)

First version of ALARO-1

- Is a multi-scale, able to run at various horizontal resolution, across the gray zone of convection, down to 1 km
- Operational
  - **CHMI and IMGW**
- Validation ongoing in several services



winter T RMSE diff, red - improvement



winter T2m STDEV
red – alaro1

- ACRANEB2 radiation scheme

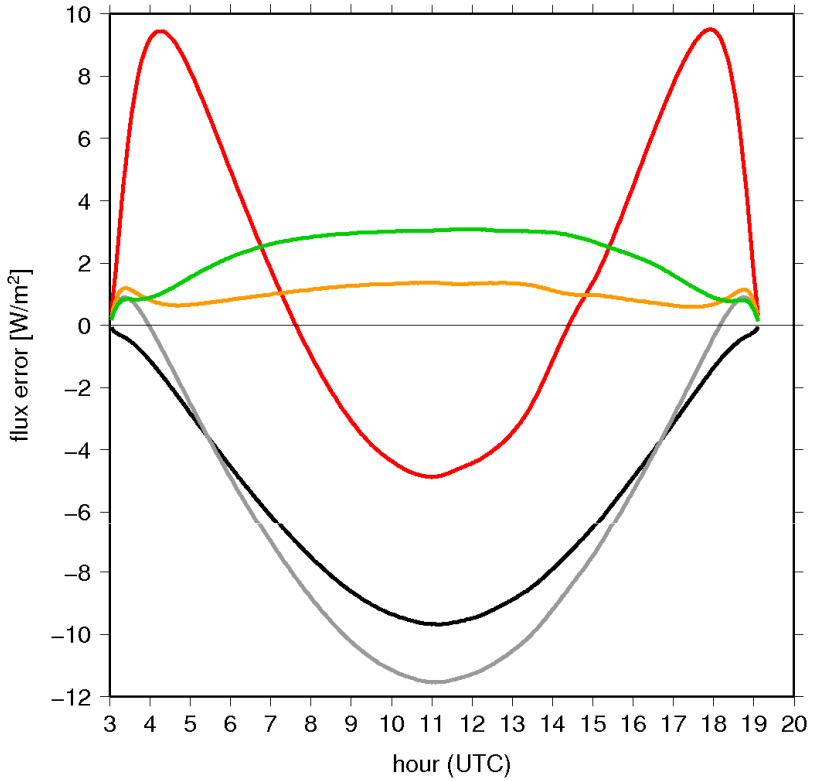
ACRANEB2 novelties

- concept of effective cloud optical depth was revisited
  - **better justified vertical dependency**
- parameterization of SW gas-cloud overlap is included
  - **SW absorption is reduced due to competition between water vapour and clouds**
- description of SW part (Mašek, QJRMS, 2015)

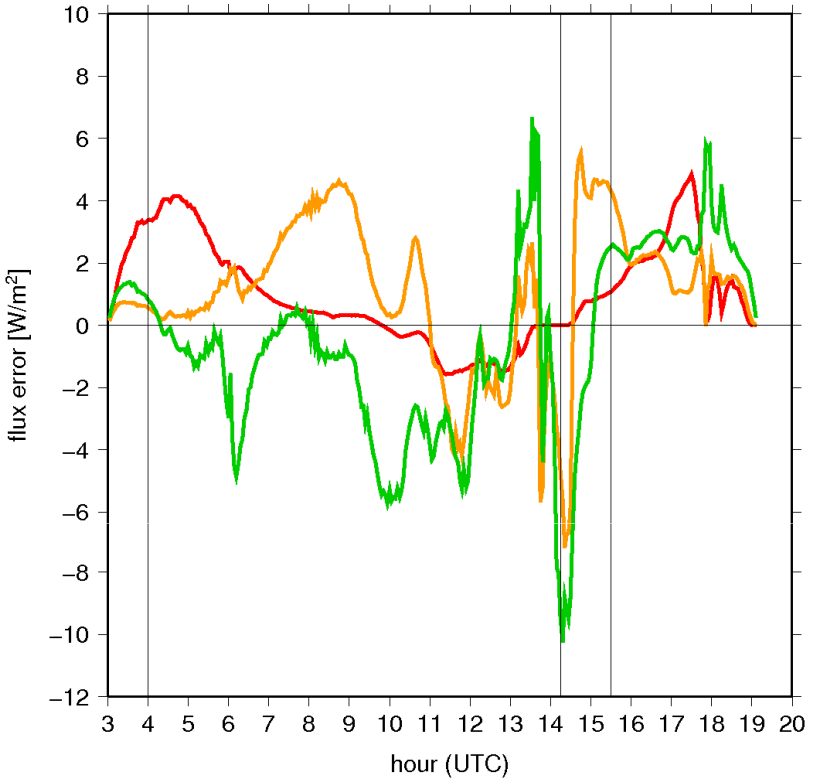
ACRANEB2

- Accuracy of the new SW radiation
  - Few % for fluxes at surface and at top of atmosphere

summer day, clear sky



summer day, cloudy



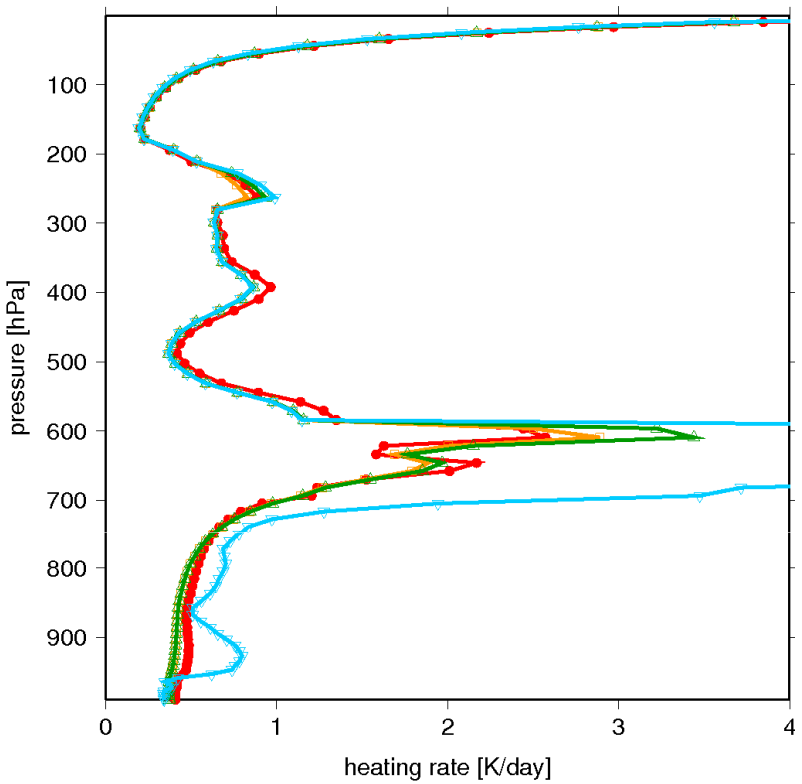
error of direct flux at surface, error of downward diffuse flux at surface
error of upward diffuse flux at the top of atmosphere

ACRANEB2

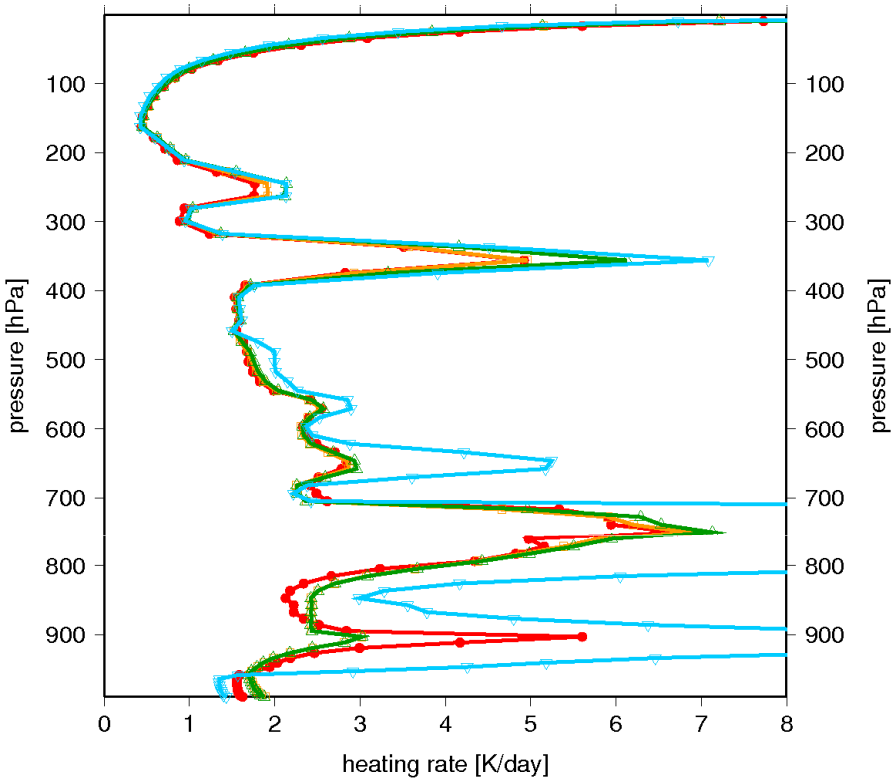
- Accuracy of the new SW radiation

  SW heating rates for summer convection day in Prague (29 June 2009)

morning (low sun)



noon (high sun)



narrowband reference

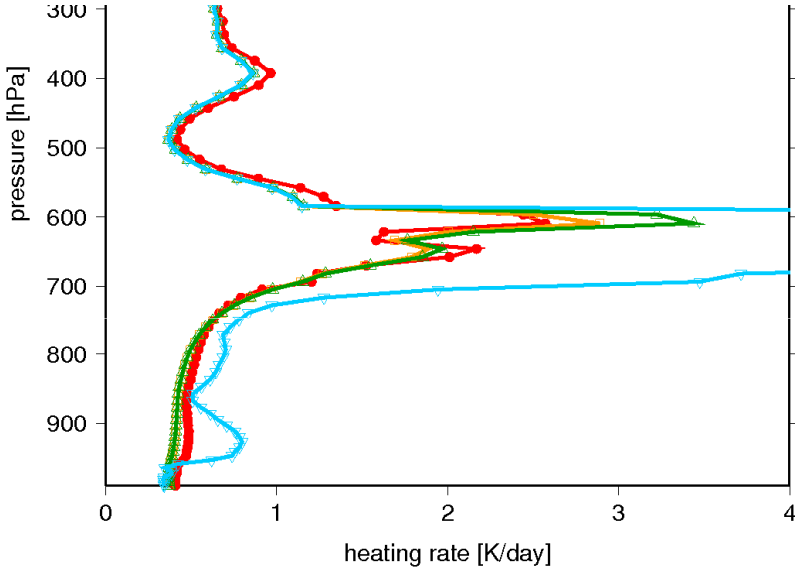
ACRANEB2 (broadband)

ACRANEB2 no gas-cloud overlap

ACRANEB2 no cloud optical saturation

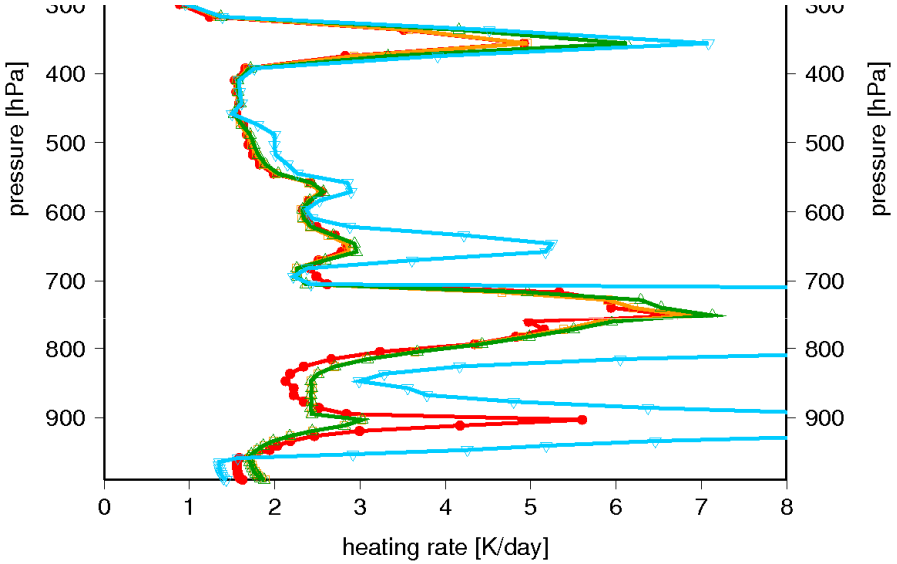
ACRANEB2

- Accuracy of the new SW radiation
  - **Cloud optical saturation is crucial**
  - **Gas-cloud overlap gives minor improvement**
  - **Typical error of ACRANEB2 against narrowband reference is 0.1K/day for clear sky and below 1K/day for cloudy**



narrowband reference

ACRANEB2 (broadband)



ACRANEB2 no gas-cloud overlap

ACRANEB2 no cloud optical saturation

ACRANEB2 for the operational use

- Validation outcomes
  - **diurnal cycle of convective precipitation is significantly improved**
    - this is possible because cloud optical properties are updated at every time step
  - **still present known weakness underestimated low inversion cloudiness in the cold season strongly influences radiative fluxes**

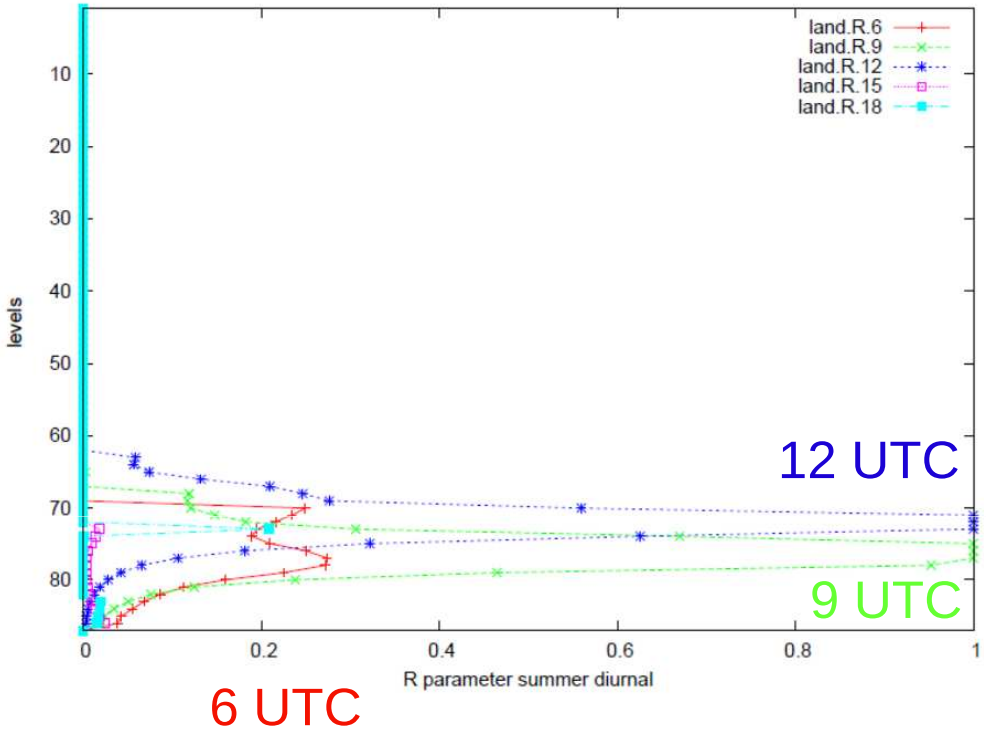
Shallow convection

- Developments:
  - **shallow convection within turbulence scheme TOUCANS**
    - a simple mass flux model with simplified entrainment profiles
    - validation is ongoing
  - **shallow convection cloudiness for radiation**

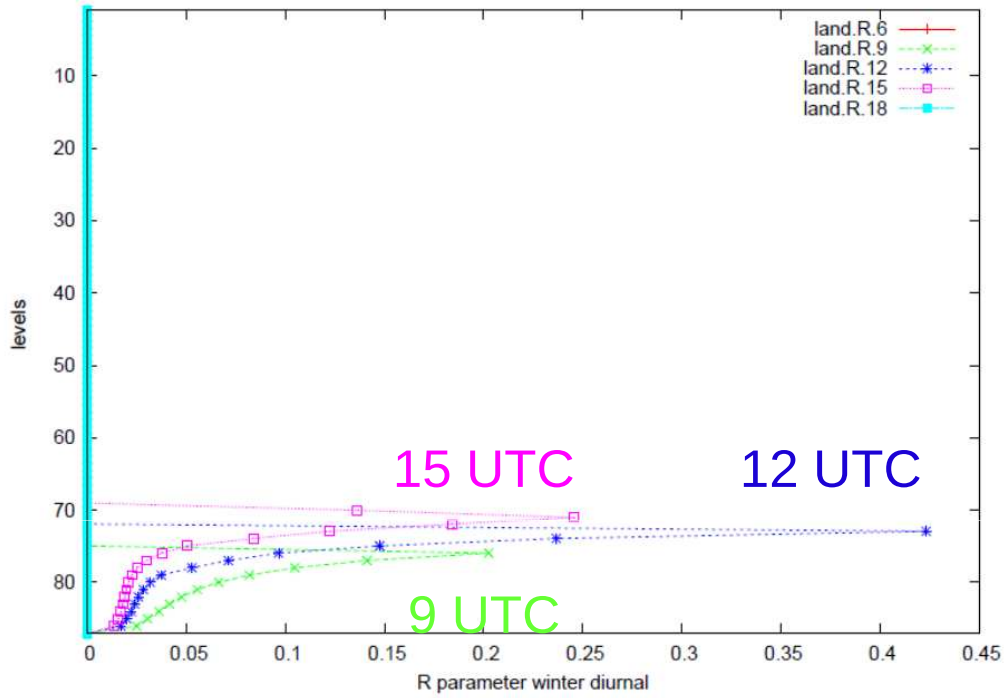
Shallow convection

Ratio between dry and saturated case of shallow convection
at 6 9 12 15 and 18 UTC

summer day

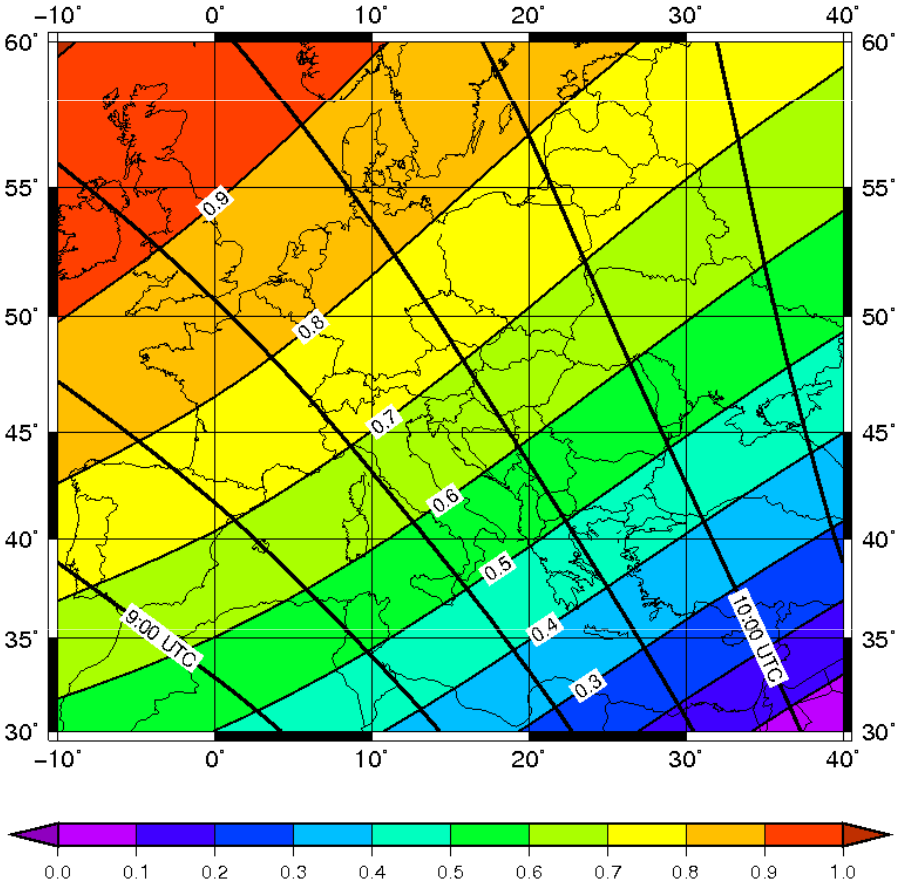


winter day



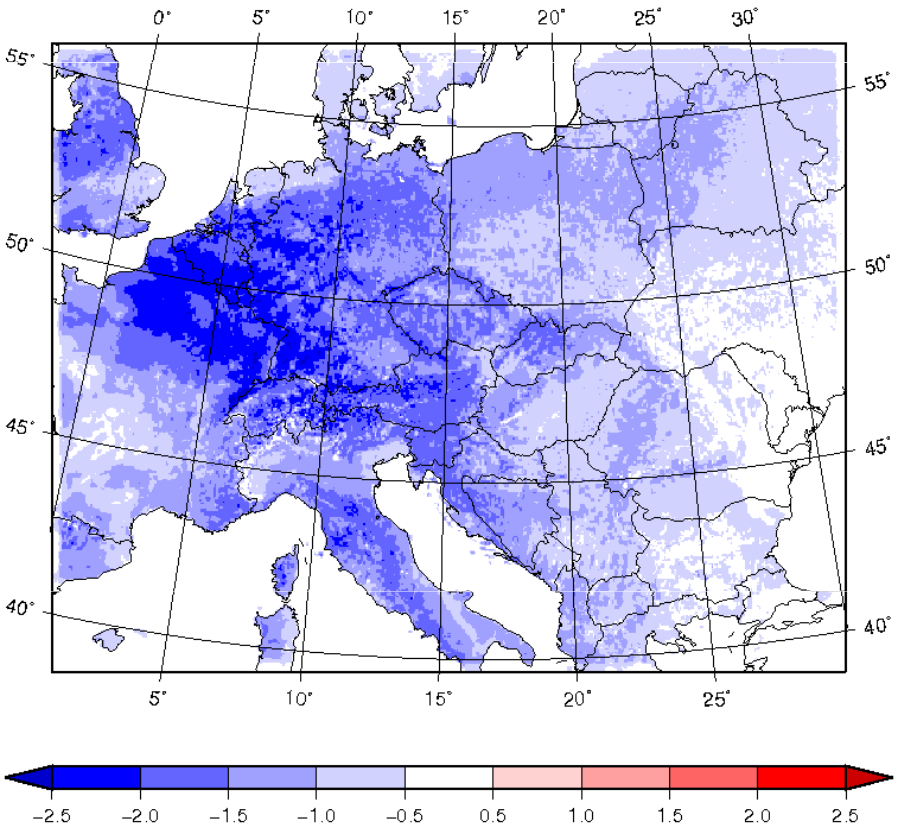
Solar eclipse on 20 March 2015

- eclipse was implemented in operational version of ALADIN/CHMI
- incoming solar radiation at the top of atmosphere was modulated according to actually covered part of solar disc

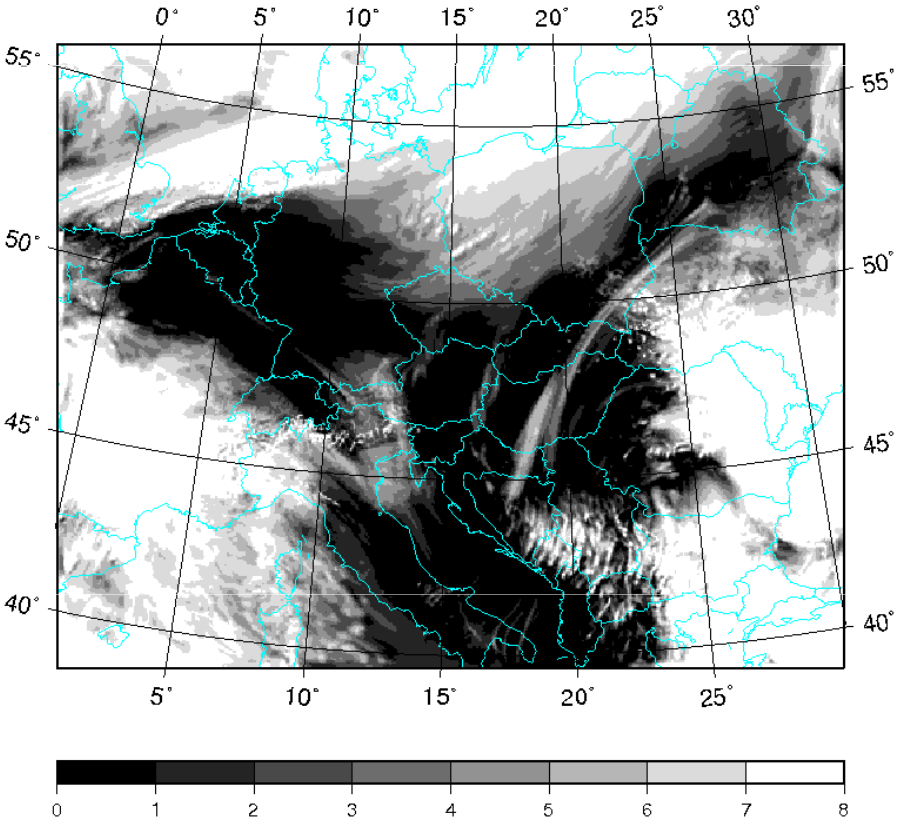


Solar eclipse on 20 March 2015

Change of ALADIN T_{2m} [K] due to eclipse
(base: 19–03–2015 00 UTC, valid: 20–03–2015 10 UTC)



ALADIN total cloud cover [1/8]
(base: 19–03–2015 00 UTC, valid: 20–03–2015 10 UTC)

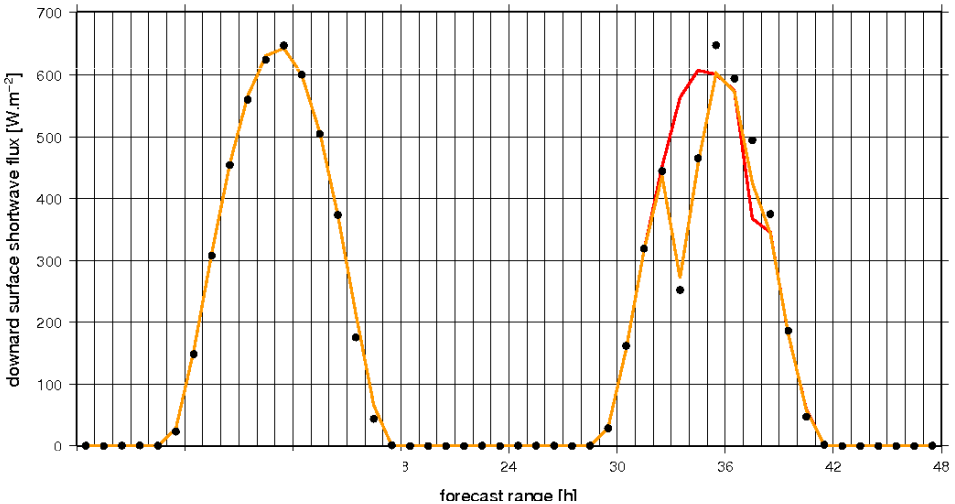


Czech area: 1h sum of surface global radiation was reduced by ~ 50%,
daily sum by ~10%, impact on T2m exceeded -1K

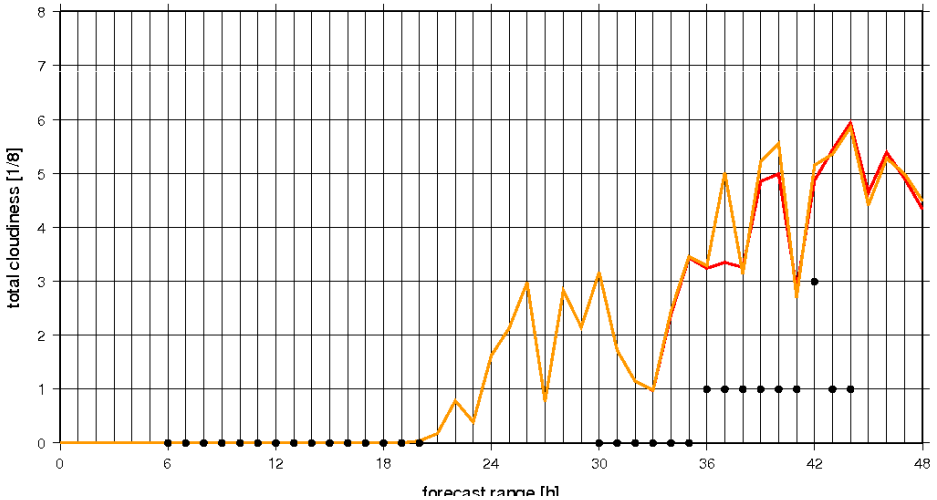
Solar eclipse on 20 March 2015

2 days ALADIN forecast and observation for Prague

downward surface shortwave flux



cloud cover

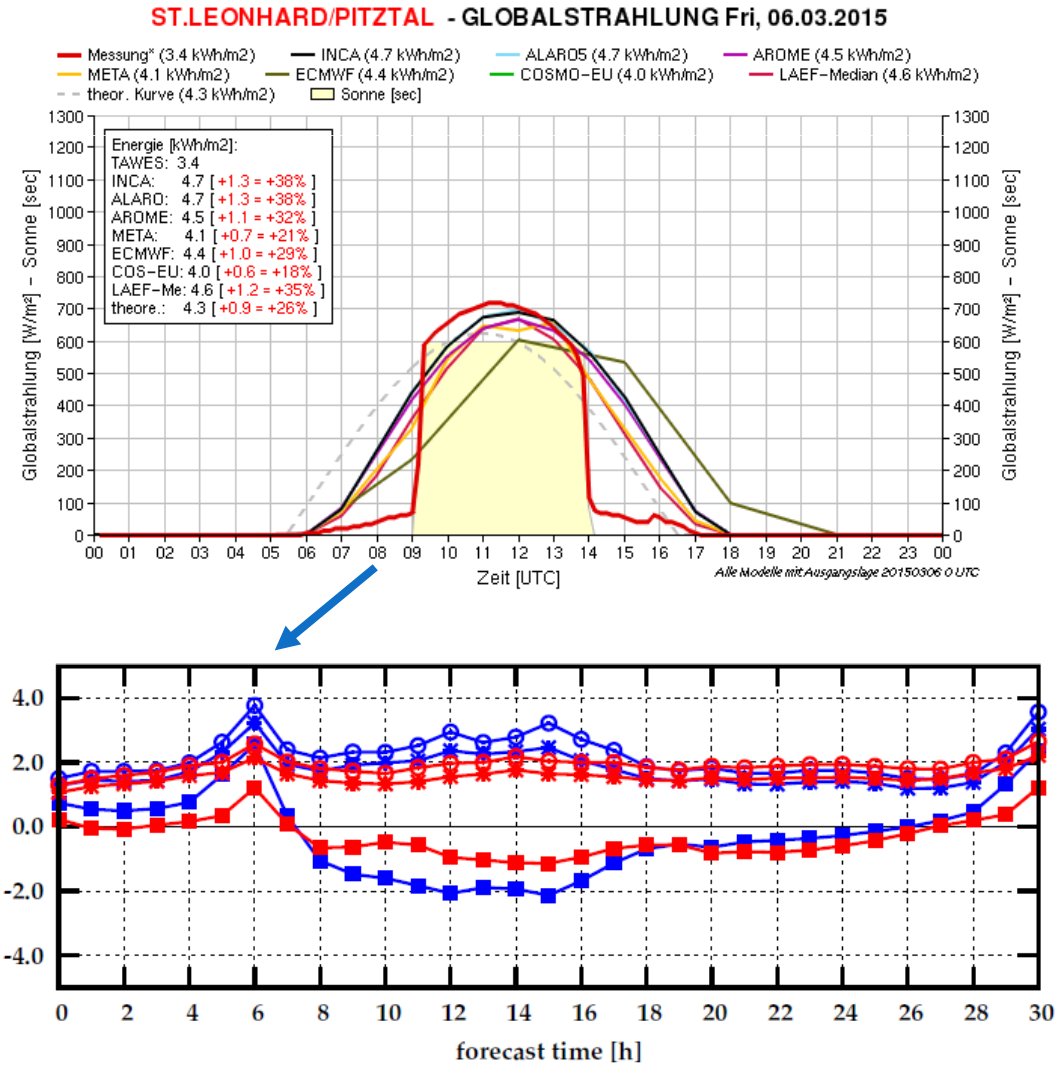


control run without eclipse
operational run with eclipse
observation

- Parameterization of orographic effects on surface radiation

Orographic effects parametrization for radiation

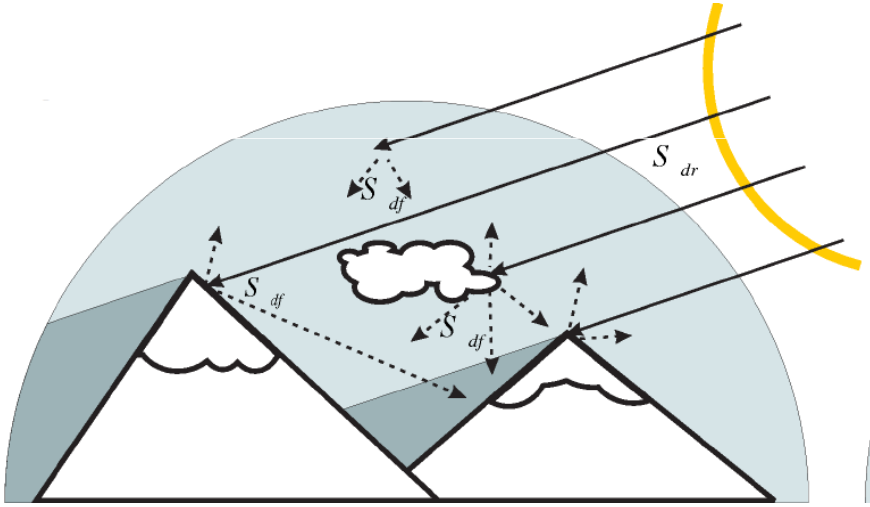
Motivation



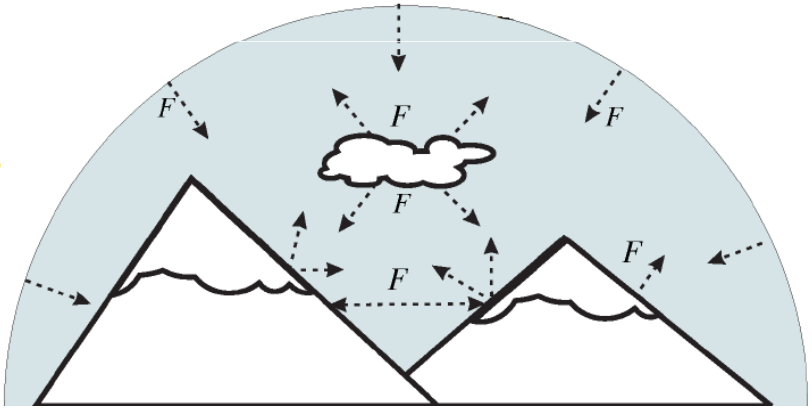
Pytztal, Tyrol, Austria

Orographic effects parametrization for radiation

short wave radiation



long wave radiation



- **Taking into account**
  - SW direct: shadowing of direct solar radiation by orography
  - SW direct: angle/direction of slope with respect to sun
  - SW diffusive: reduced fraction of sky visible
  - LW: reduced fraction of sky visible
- Basic orographic factors: **sky view factor, slope aspect, shadow fraction**

Orographic effects parametrization for radiation

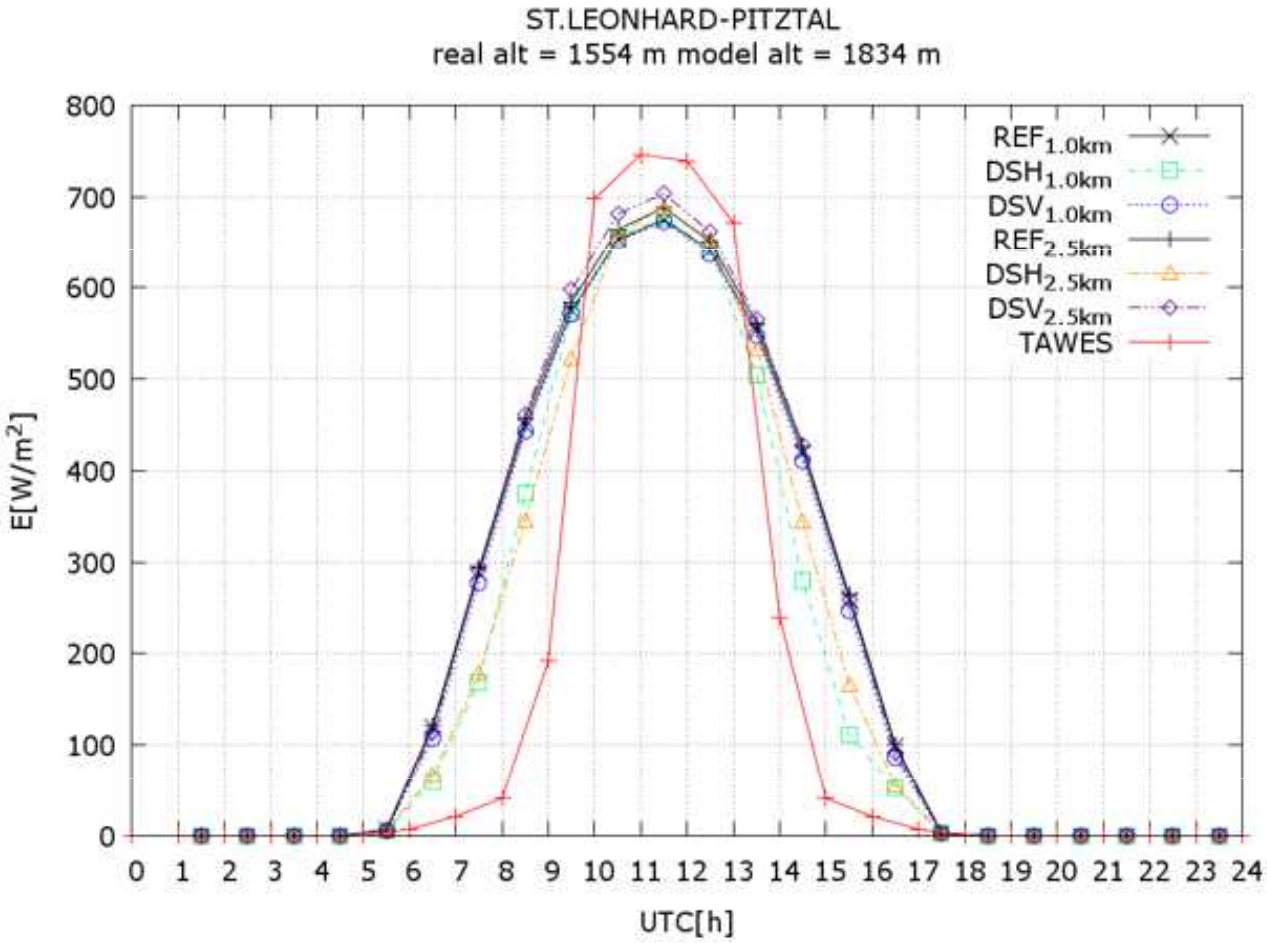
- Implemented inside SURFEX
  - **Orographic parameters from SRTM (90m) data**
  - **Slope, shadow, sky view factors are computed**
  - **Radiation fluxes at surface are modified**

- Tests in AROME 2.5 and 1 km show strong benefit
  - **Alpine valleys are colder, mountain slopes warmer**
  - **Differences between sunny and shady slopes**
  - **e-suite in Météo-France and ZAMG**

Orographic effects parametrization for radiation

DSH – shadow effect
DSV – sky view effect
12.3.2014

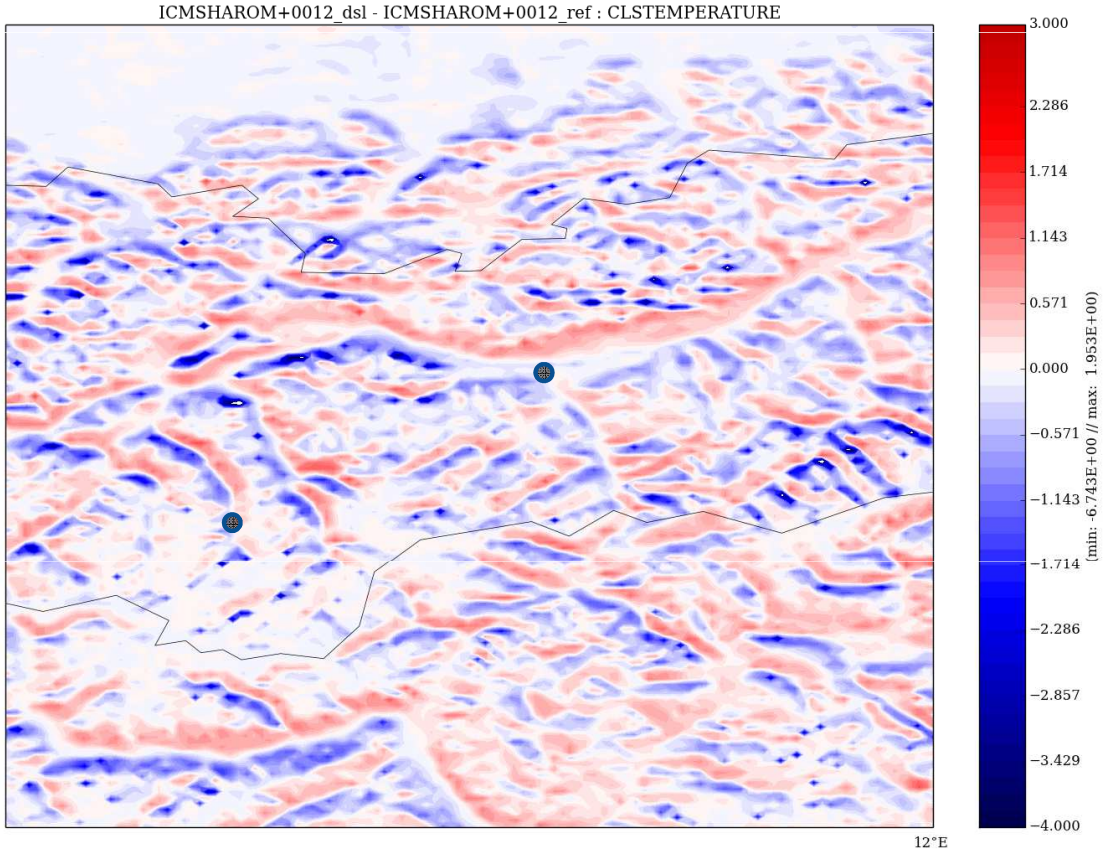
Short wave
global radiation



DSH - a significant effect in the morning and evening hours
Effect is generally higher on the 1km grid

Orographic effects parametrization for radiation

Differences for 2m temperature between AROME using orographic radiation parameterization and AROME reference for sunny day over Central Europe, 12.3.1014, at 12UTC on zoom around Innsbruck

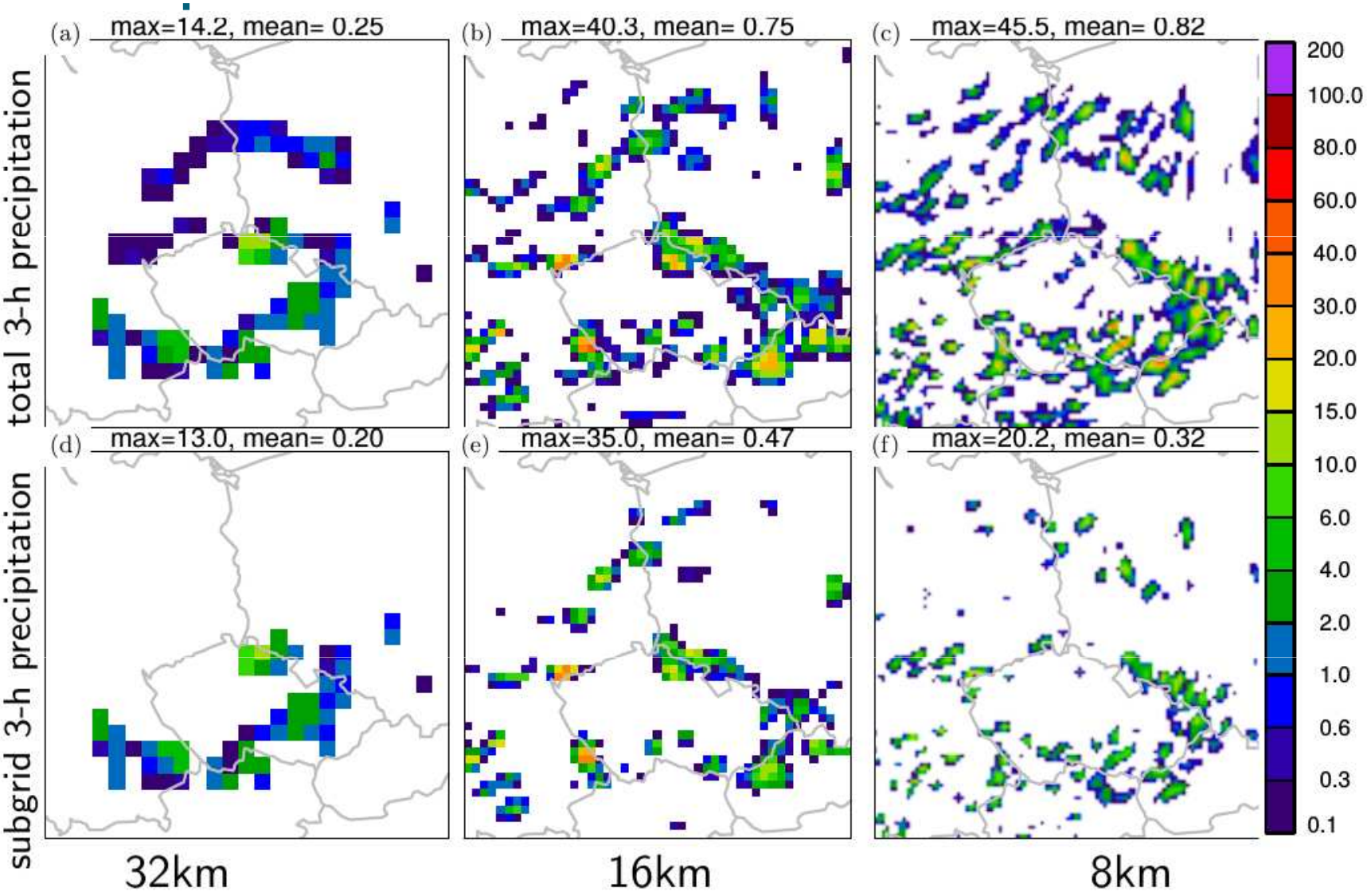


a very realistic slope effect: warmer slopes (directed to sun), colder slopes in the shadow

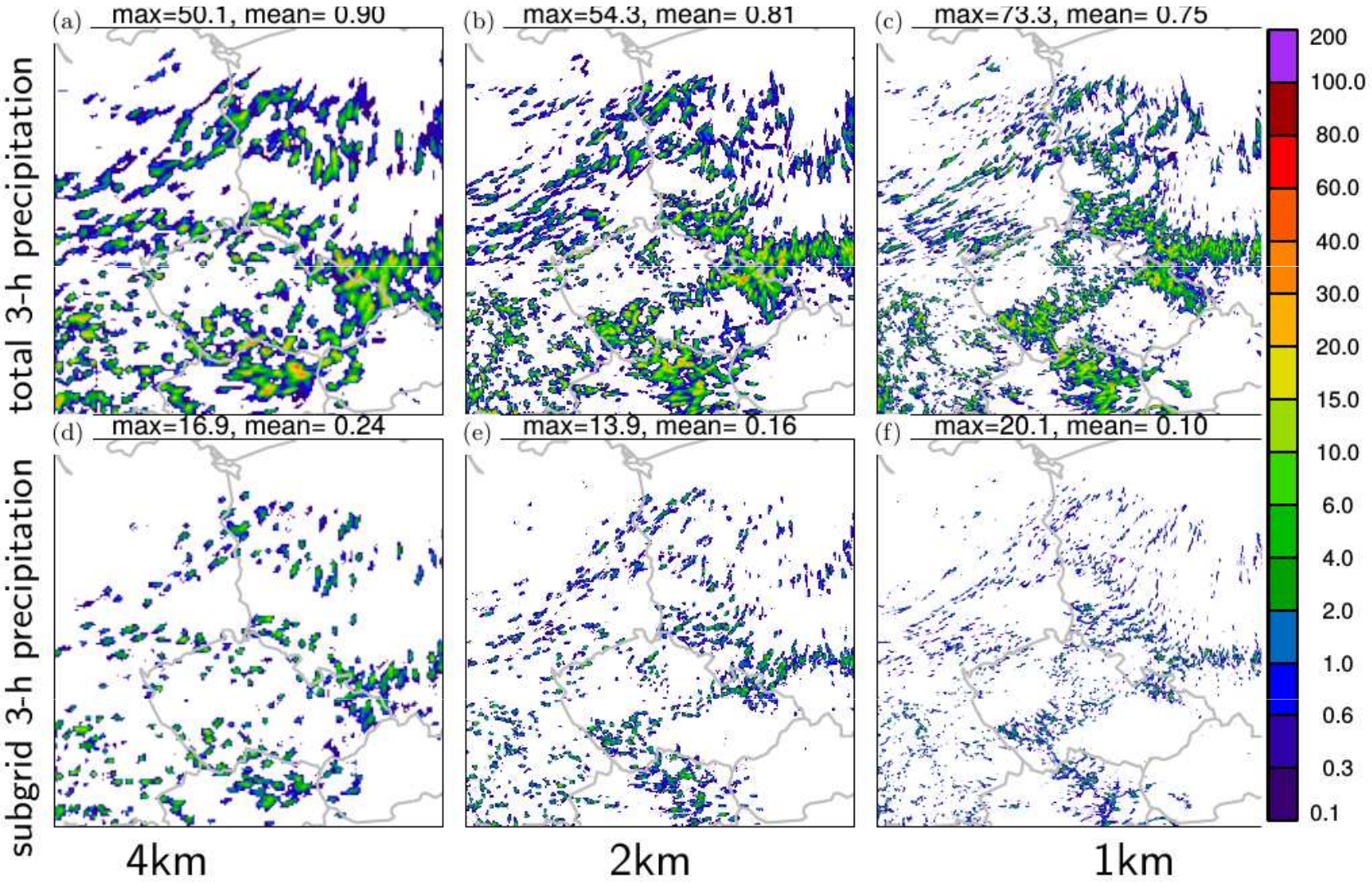
Deep convection

- A new deep convection scheme (Gerard, Mon. Wea. Rev. October 2015)
  CSD (Complementary Subgrid Draft) in testing
  - **showed an improved behaviour at high resolution**
  - **the execution time of the model with CSD is around 10% longer than with 3MT**
  - **uses the signal of shallow transport from the turbulence scheme**
  - **allows a gradual fading out of the parameterized signal at high resolution**

Summer convection 2 July 2009 (3-hour precipitation at 18 UTC)



Summer convection 2 July 2009 (3-hour precipitation at 18 UTC)



Sub-grid precipitation are reduced

Lack of meso-scale structure

Deep convection

- Expectation
  - **improvement of the diurnal cycle**
  - **the multi-scale behavior**
  - **the potential to produce realistic forecasts at fine resolution**

- How to keep meso-scale organization below 2 km?
  - **sometimes can be too weak when the deep convection is represented explicitly**
  - **with some re-tuning of diffusion**
  - **with the use of cellular automata**

Outlook

- Enhancement of the 3MT downdraft parameterization towards unsaturated downdraft option
- Adding aspects of Complementary Sub-grid Drafts to new radiation, turbulence and microphysics
- Further enhancements of the shallow convection and mixing length scale parameterization in TOUCANS
- Steps towards the unification of cloud cover representation
- Linking with the SURFEX scheme