ALARO Physics Developments

Neva Pristov

LACE area leader for physics

ALARO-0 concept

- continuous transition from ARPEGE/ALADIN to AROME (continuity + improvements)
- to treat ‘grey-zone’ 3-7 km mesh size
- economical computation, numerical efficiency
- algorithmic flexibility → good basis for further developments

ALARO-0 (mid 2005 - mid 2008)

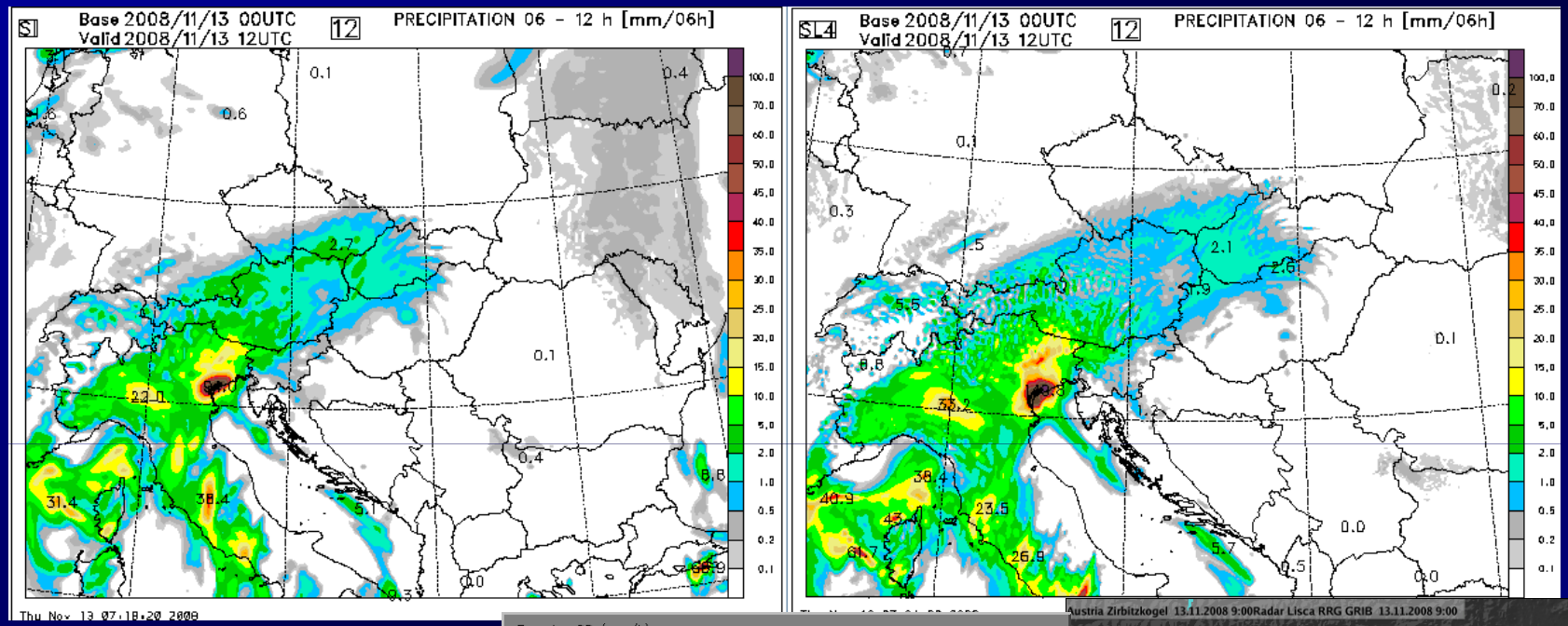
- **Dynamic**
  - **SHLD, *NH***
- **Physics**
  - **New interface (governing equations)**
  - **Radiation: NER scheme, cloud optical properties**
  - **Turbulence: pseudo-prognostic TKE**
  - **Mountains: new GWD and lift scheme**
  - **Moist processes:**
    - **Full prognostic microphysics**
    - **3MT cascade**
    - **Prognostic convection**

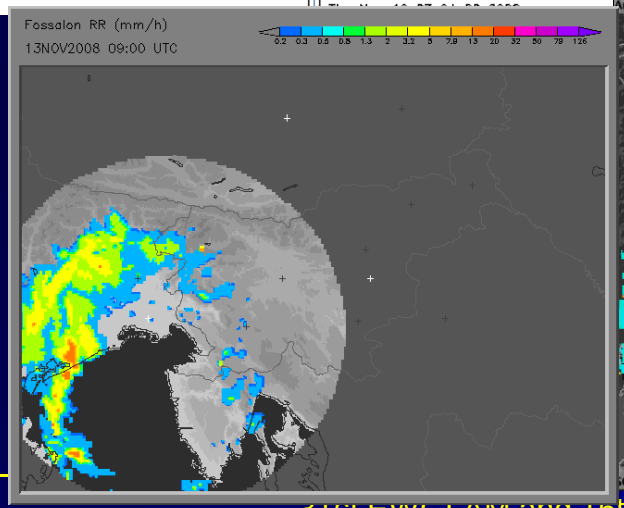
Operational applications of ALARO-0

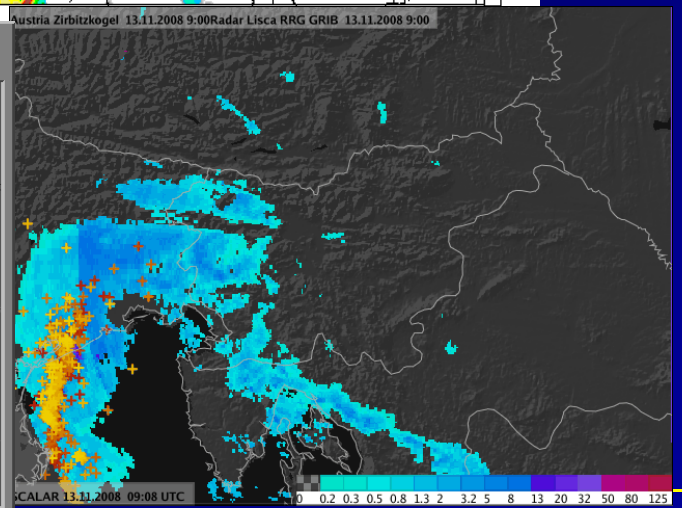
- Benefits exist for resolutions at the upper limit and in the middle of the grey zone
- Be (4km) is already at the initial targetting resolution
- Tests at many scales are ongoing, mostly with encouraging results, but with still too much divergence between the two versions at very high resolution

	ALARO-0 minus-3MT	Full ALARO-0
Cz	30/1/07	**4/6/08**
At	13/9/07	**7/4/09**
Sk	19/2/08	**19/8/08**
Hr	25/2/08	
Si	X	**16/6/08**
Be	X	**15/1/09**

ALARO 10km / 5 km







ALARO-0 (mid 2008 - mid 2009)

- **Deficiencies**
  - Overestimation of cooling rates in lower troposphere
  - Diurnal convection cycle
  - Diagnosed cloud cover (overcast very rare)
- **Further developments/improvements**
  - Radiation
  - Turbulence: eTKE
  - Moist processes:
    - prognotic entrainment
  - Cloudiness

Overview of developments

Contributions from

Doina Banciu, Ivan Bastak, Radmila Brozkova, Luc Gerard, Jean-Francois Geleyn, Tomas Kral, Filip Vana, Christopher Wittmann

1 Turbulence

- **mixing length formulation**
  - **5 possible choices are coded additional to original one**

- **the full TKE scheme in the framework of the existing Louis scheme**
  - **eTKE emulating any turbulent theory CCH02, CBR and QNSE is coded and verified**
  - **solution in 2 steps**

Emulating Full TKE

$\frac{\partial E}{\partial t}$ full

= advection

+ diffusion

+ mechanical or shear production/destruction (I)

+ buoyancy production/consumption (II)

+ viscous dissipation

$\frac{\partial E}{\partial t}$ emulating

= advection

+ diffusion

+ Newtonian relaxation towards something

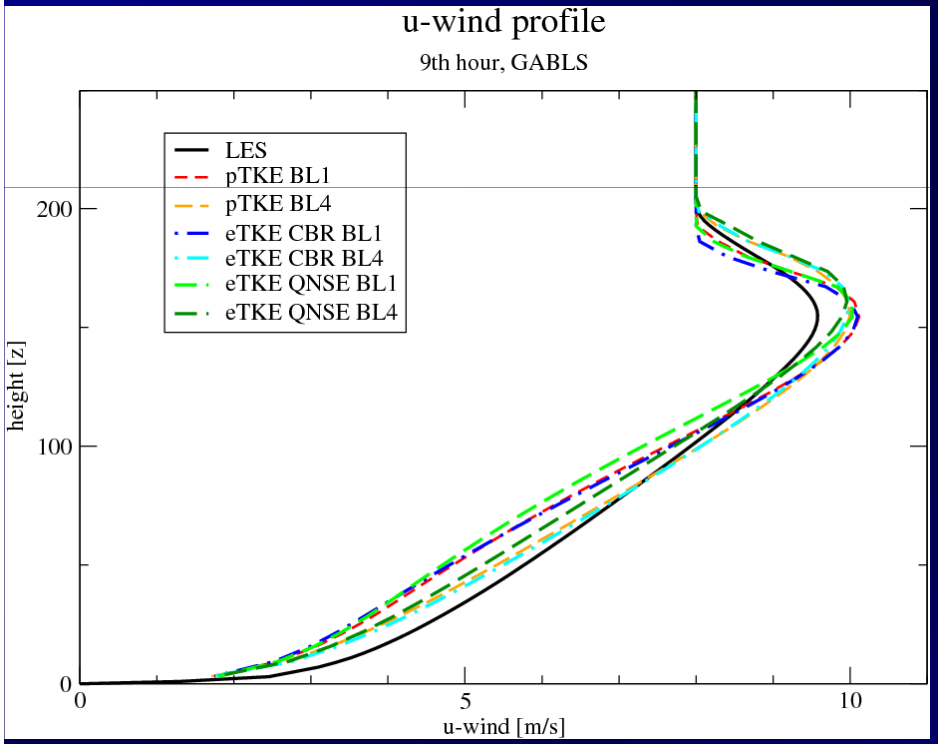
$$\frac{dE}{dt} = -\frac{\partial}{\partial z}\left(-K_E\frac{\partial E}{\partial z}\right) + \frac{1}{\tau_e}\left(\tilde{E} - E\right),$$

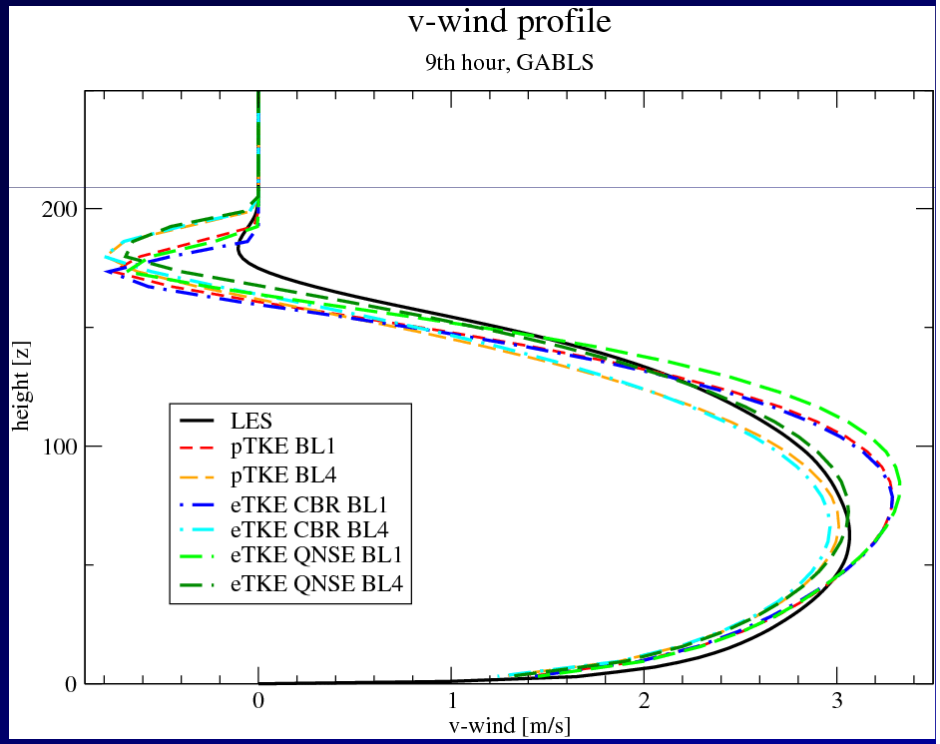
$$\tilde{E} = \frac{E}{\epsilon}(I + II),$$

$$\tau_e = \frac{l_m^2}{\nu^2\sqrt{K_m K_N}}\frac{\chi_3(Ri)^{\frac{3}{2}}}{f(Ri)^{\frac{3}{4}}},\ K_E = \frac{\sqrt{K_m K_N}}{\nu^2}\frac{f(Ri)^{\frac{3}{4}}}{\chi_3(Ri)^{\frac{3}{2}}}.$$

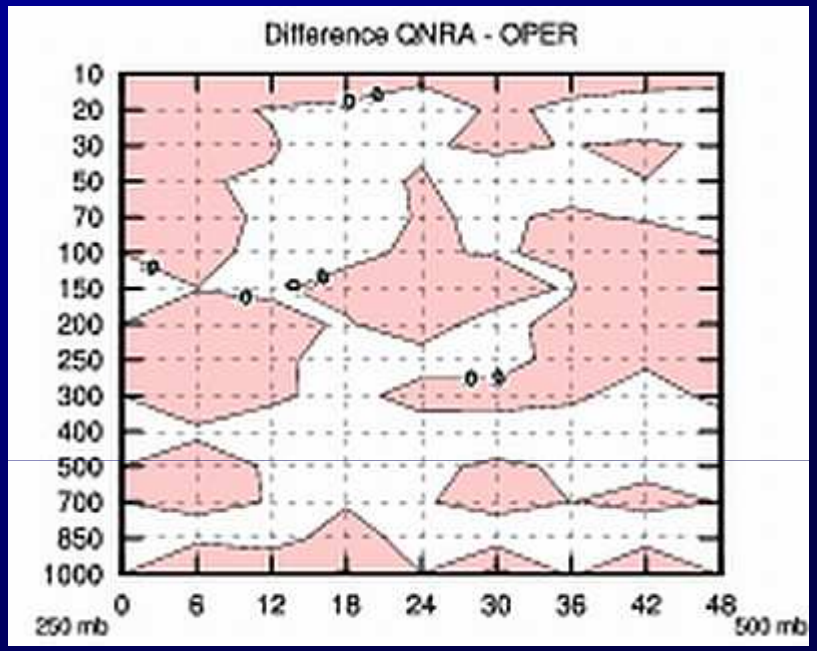
1D test: comparison against LES models

eTKE various algoritmic solutions with 2 formulations of the mixing length

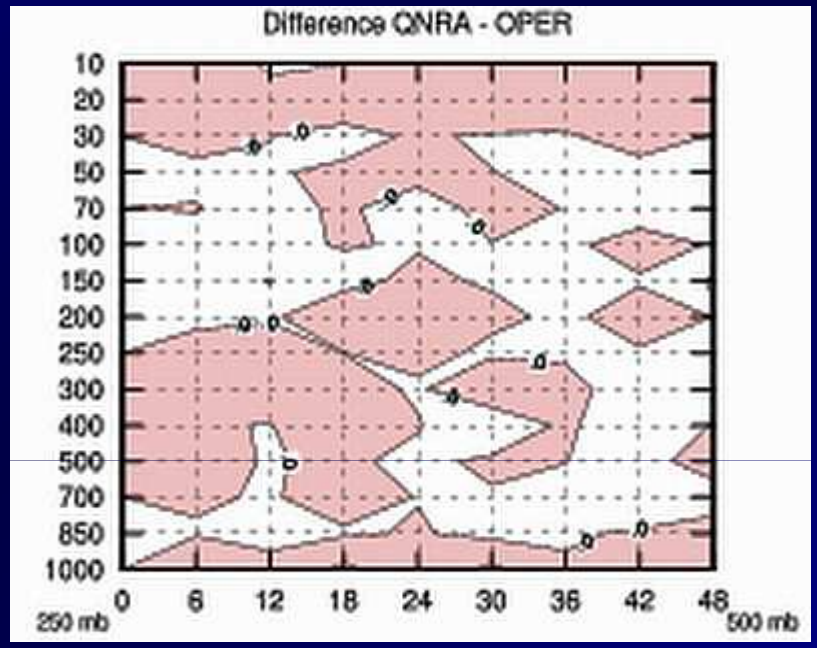




3D test: eTKE(QNSE) against pTKE



RMSE temperature



RMSE wind

Improvement of scores in lower atmosphere

Bougeault-Lacarrere Mixing length
eTKE based on QNSE theory

2 Radiation

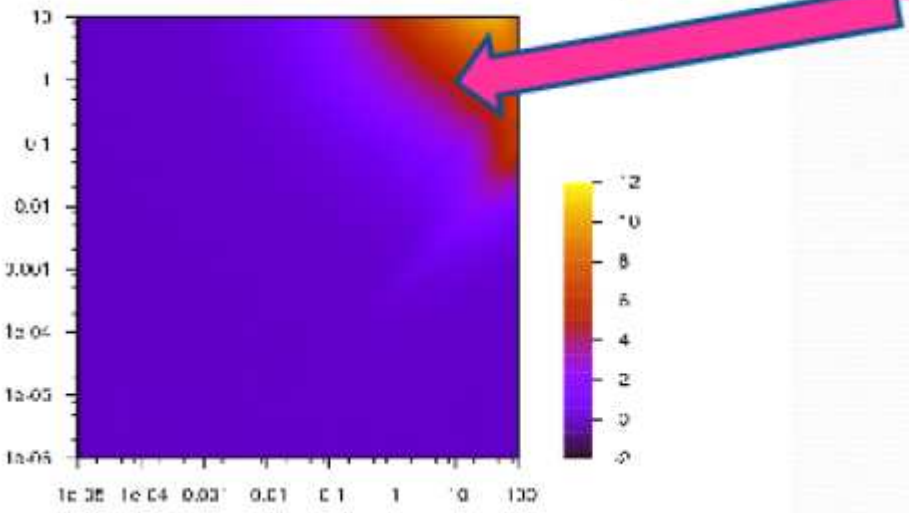
- **New transmission functions**
  - **gaseous transmissions from RRTM (Rapid Radiative Transfer Model) are used as a data set for fitting**
  - **revision of the fitting procedure**
  - **the impact is small**

2 Radiation

- **assumption for composite of gases is not valid for higher absorber amounts**

$$\delta_{tot} = \delta_1 + \delta_2 + \delta_3$$

relative error for H2O + CO2 composite



2 Radiation

- **assumption for composite of gases**
  - **corection for the optical depth computation (H2O, CO2, O3)**

proposed solution:

$$\delta_{tot} = \delta_1 + \delta_2 + \delta_3 + X_{12} + X_{13} + X_{23} + \ldots (?)$$

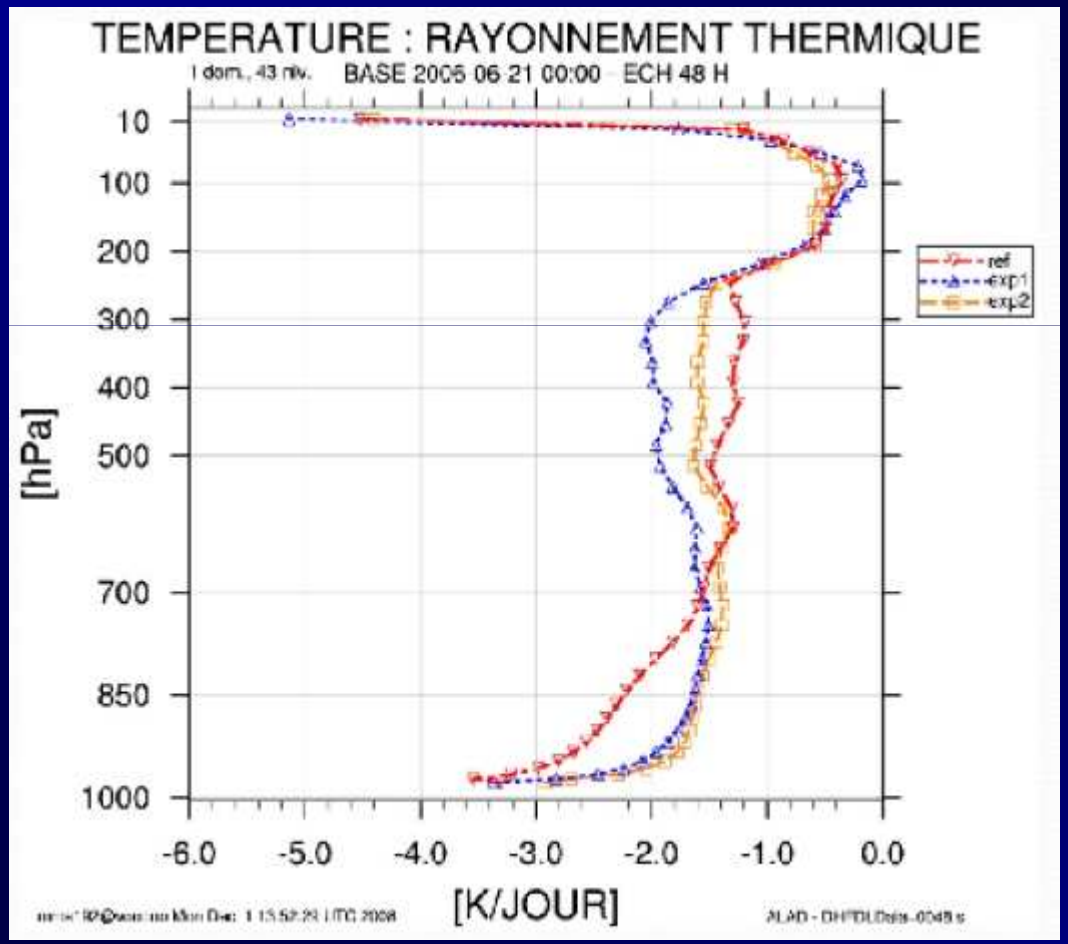
current solution | new correction terms

$X_{ij} = \delta_{ij} - (\delta_i + \delta_j)$ … 'double-composite' correction

$$X_{ij} = \sqrt{e \frac{u_i}{(u_i + f)} \frac{u_j}{(u_j + g)}}$$

u – *absorber amount*
e, f, g – fitting coeffs

2 Radiation



red - operational

blue – RRTM

yellow – with modifications

2 Radiation

- **Aerosol model:**
  - **6 types (continental, maritime, desertic, urban, volcanic, stratospheric)**
  - **optical depth from climatology**
  - **for thermal and solar bands**

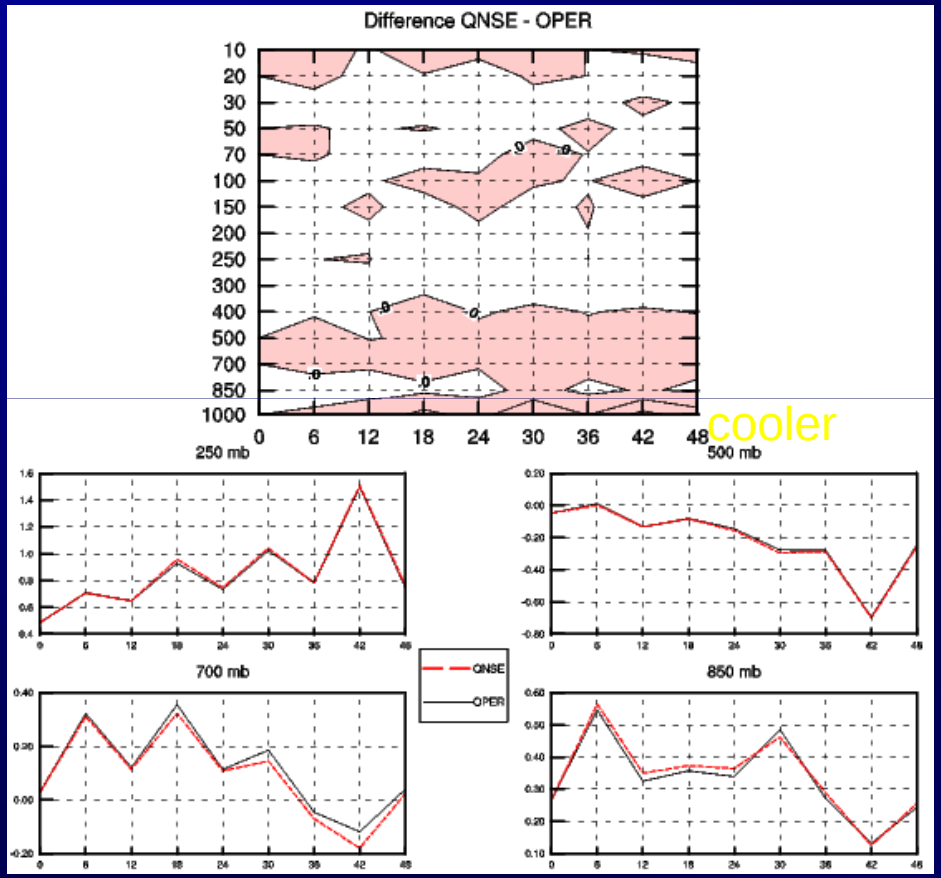
2 Radiation

- transmission functions
- optical depth computation
- aerosol model

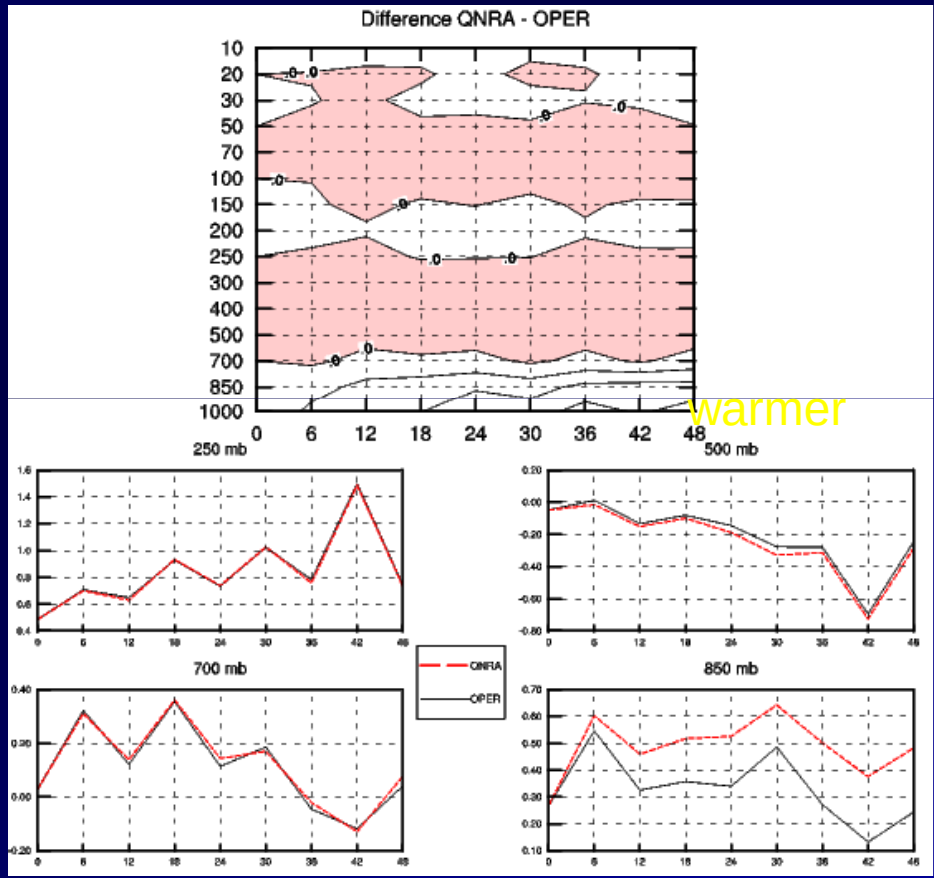
- cooling rates are closer to the one in RRTM
- minimal extra computation cost,

3D test: eTKE and eTKE&radiation

eTKE BIAS Temperature eTKE&radiation



cooler

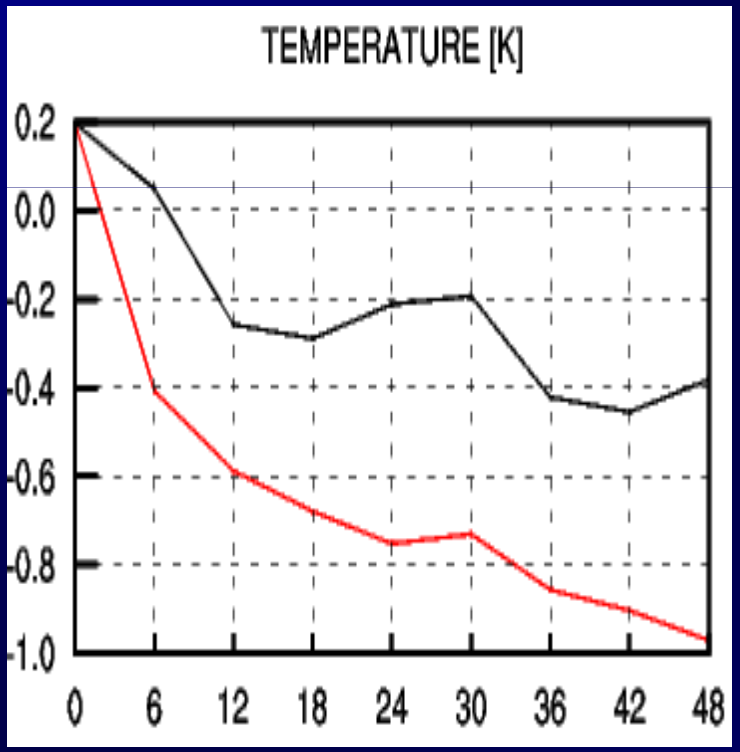


warmer

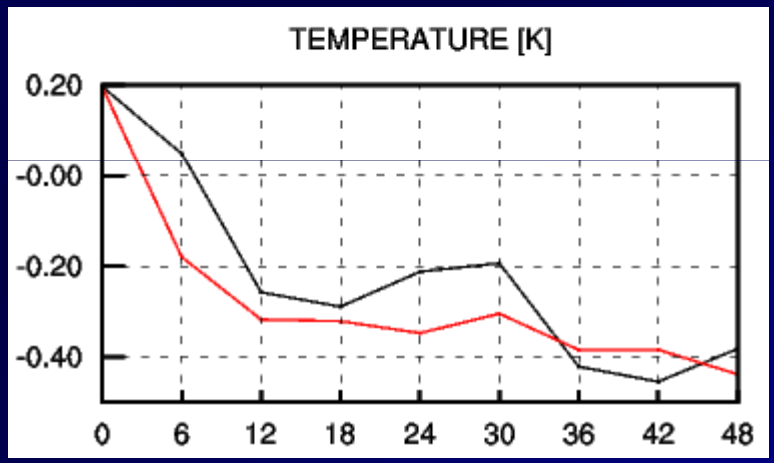
rather big warm resulting bias –
is this consequence of the compensating errors

3D test: eTKE and eTKE&radiation

eTKE



eTKE&radiation



BIAS Temperature 2 m

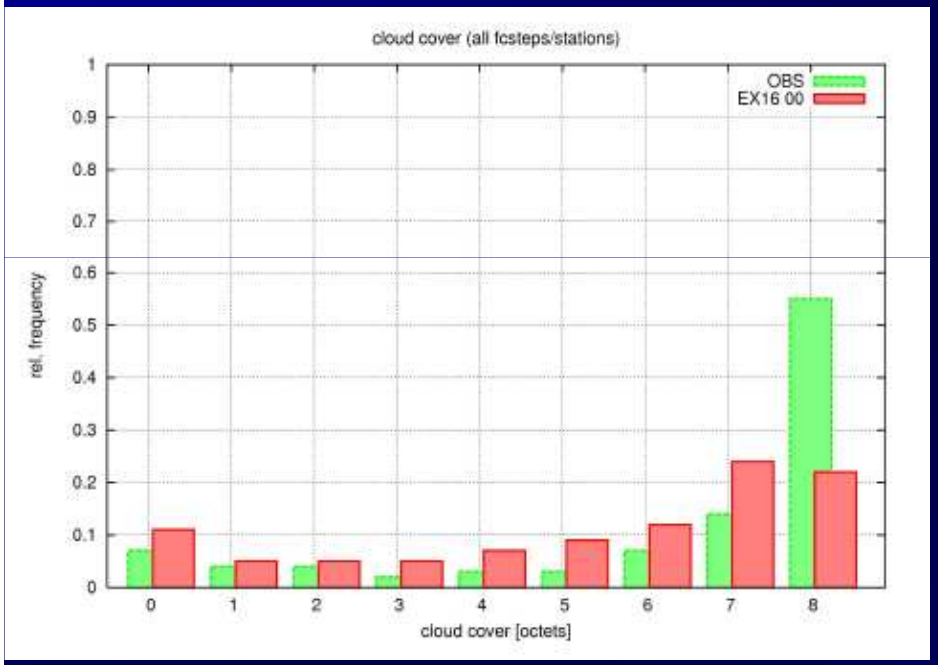
red - parallel

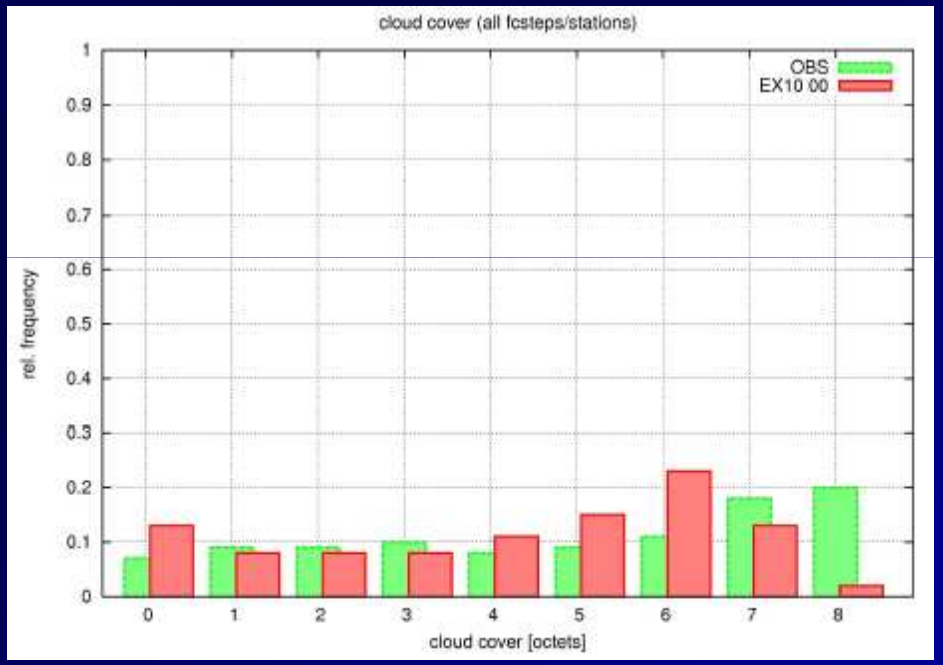
black - operational

3 Cloudiness

Diagnostic of cloud cover:

cases with cloudiness near 100% are underestimated





January 2009 9 stations in Austria June 2008

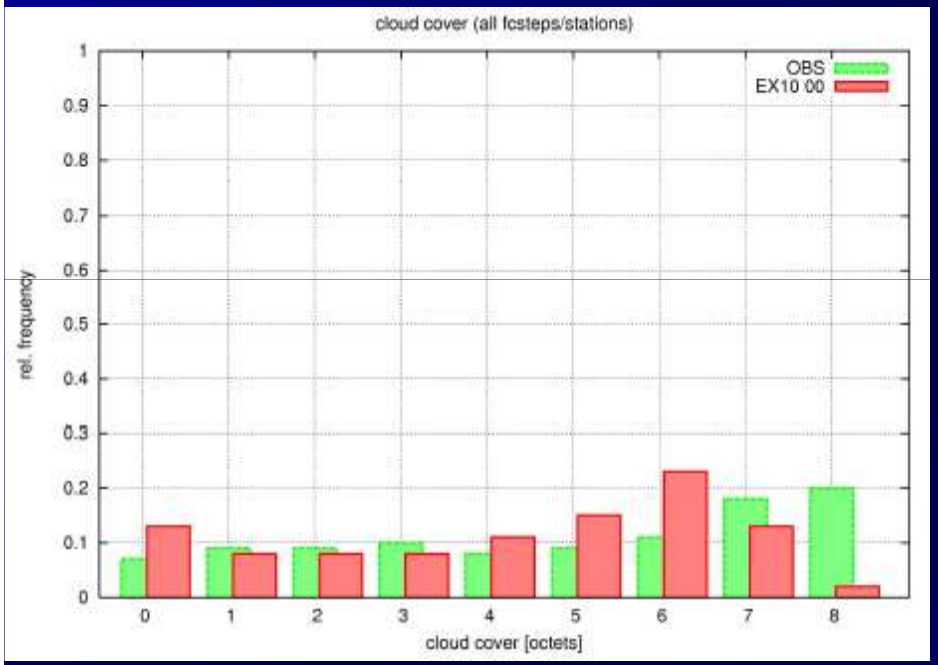
3 Cloudiness

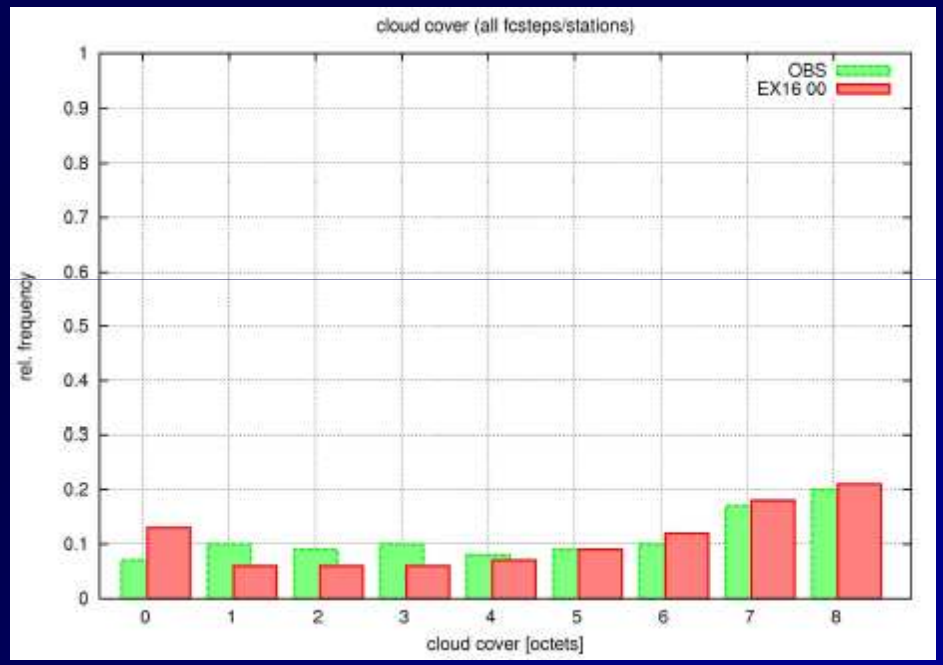
- **Diagnostic for cloud cover**
  - **a near maximum overlap method**
  - **without any impact on other model fields and processes**

$$PFPLC[X] = 1 - \prod_{l=n_{[X]}}^{m_{[X]}} \frac{min(1-n^l, 1-\epsilon n^{l-1})}{1-\epsilon n^{l-1}}$$

Cloud cover octets

June 2008, 9 stations in Austria

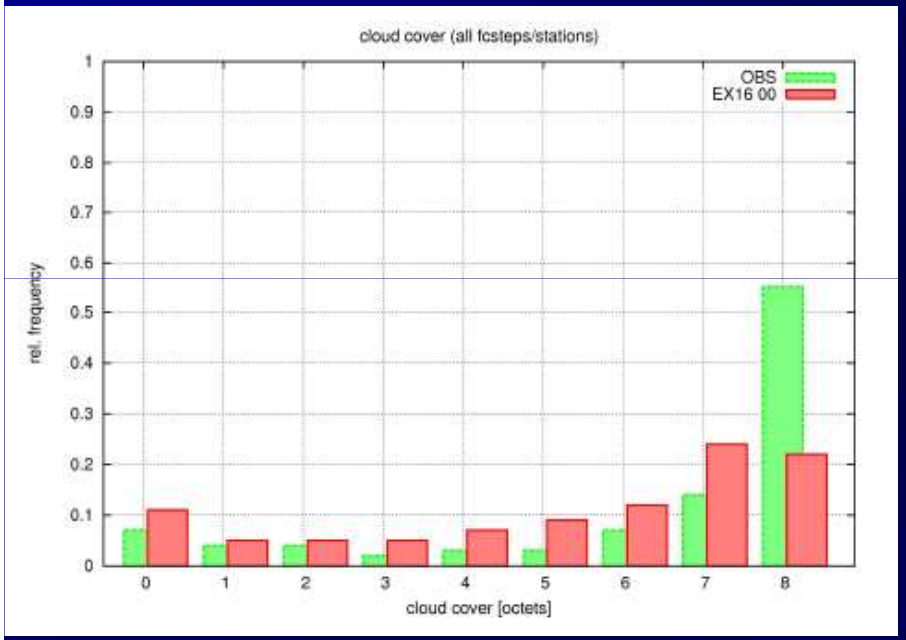


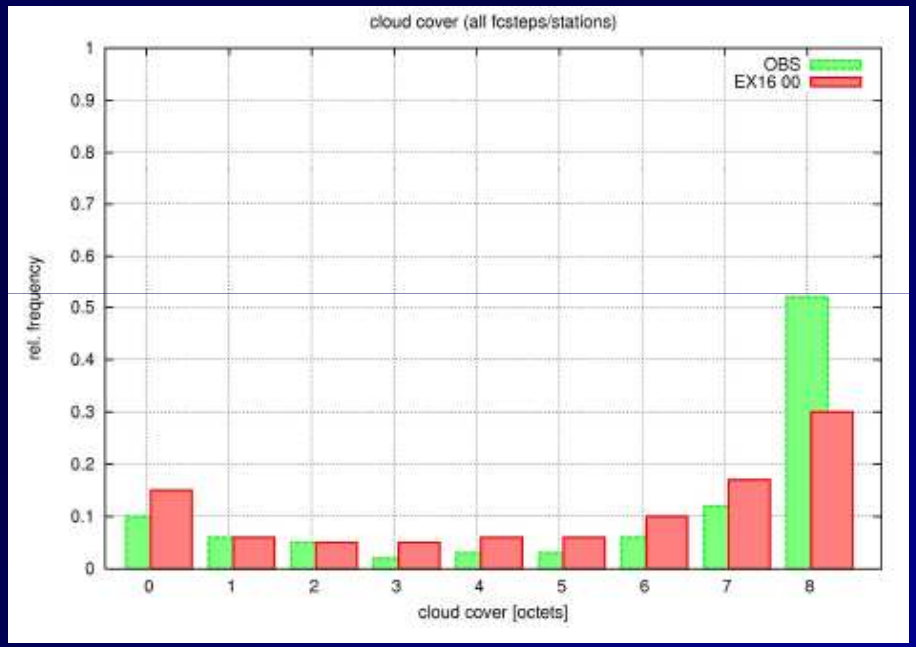


new diagnostics

Cloud cover octets

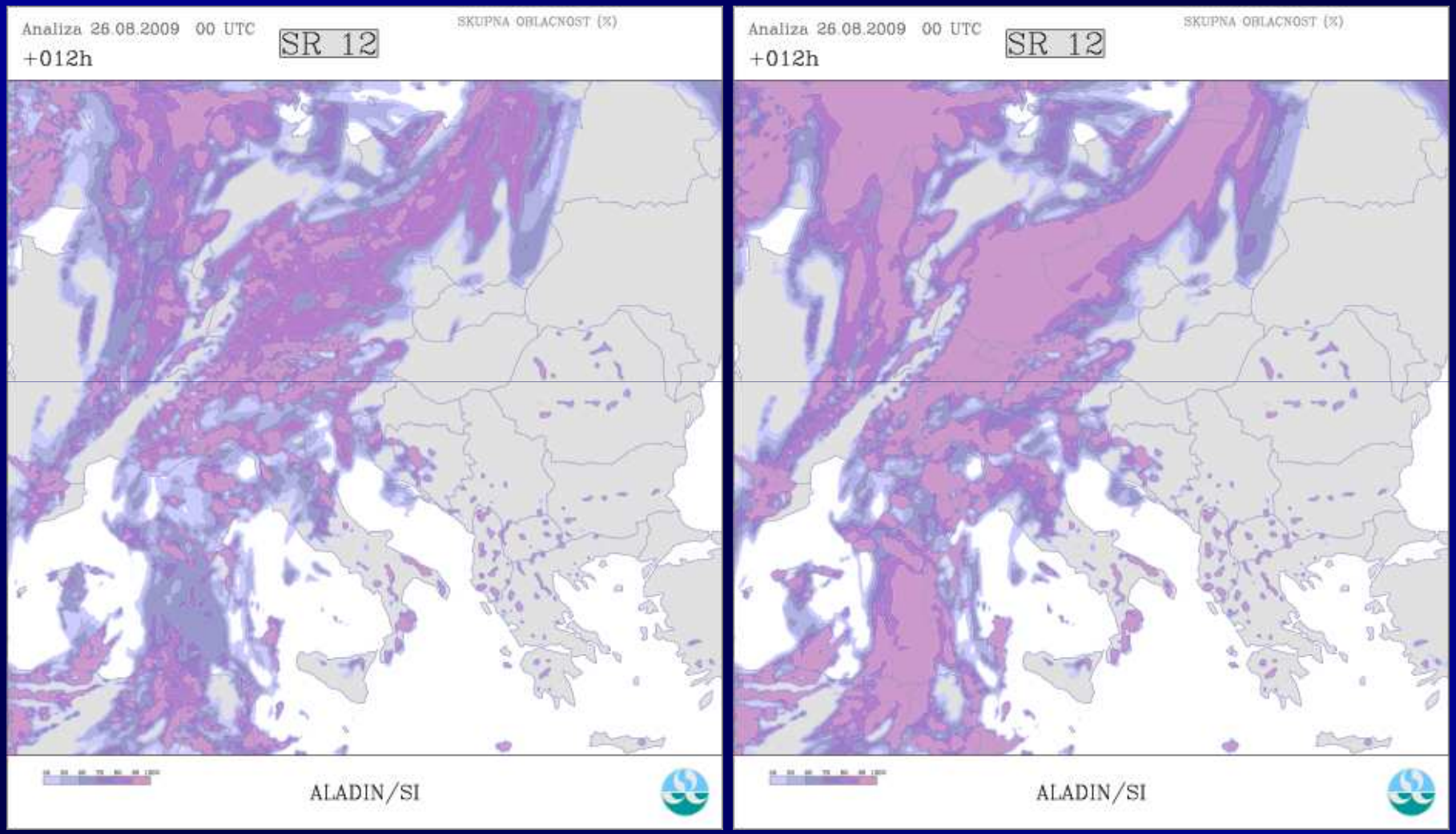
January 2009, 9 stations in Austria





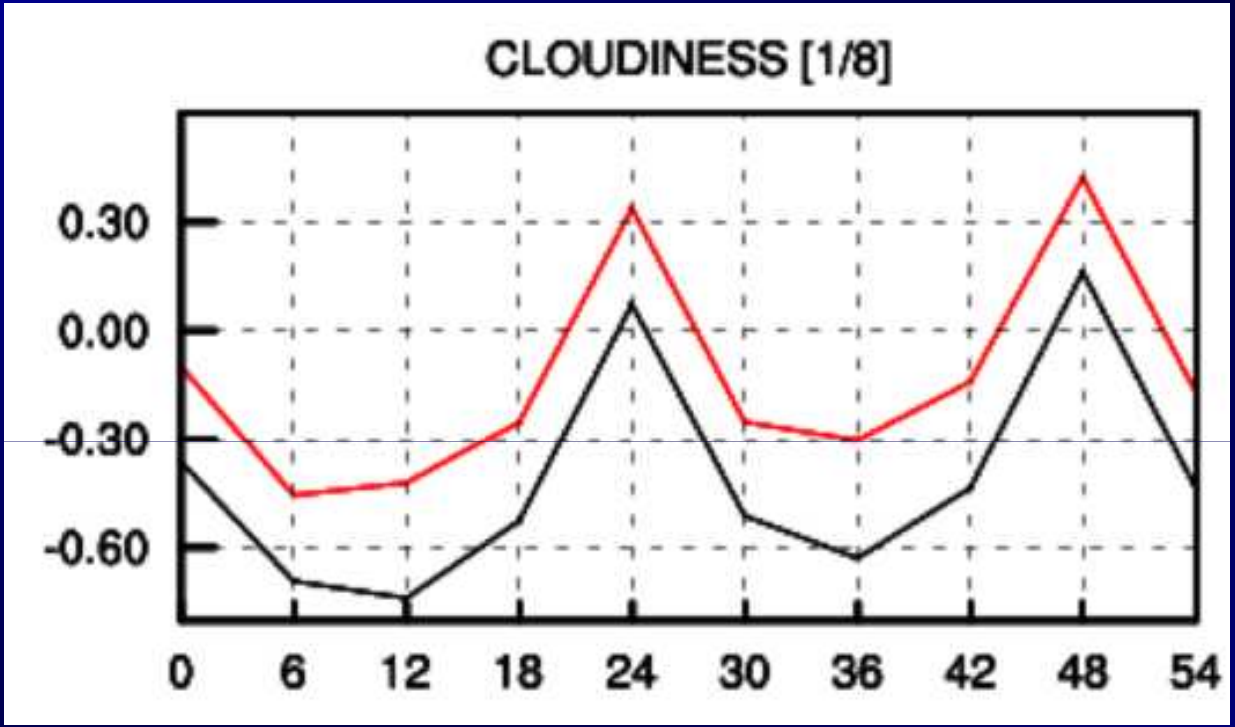
new diagnostics

Total cloud cover – an example



new diagnostics

Total cloud cover – cz parallel suite



BIAS total cloud cover

red - new diagnostics

black - operational

3 Cloudiness

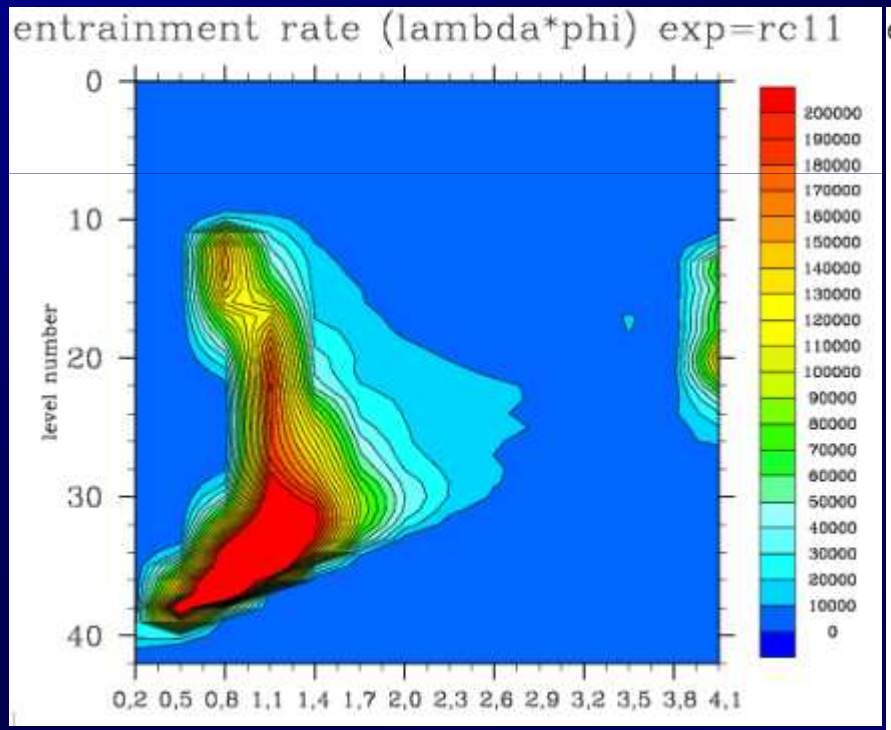
- diagnostic for cloud cover
- a unique description of cloudiness (in all schemes radiation, turbulence, 3MT) is still big aim

4 Convection

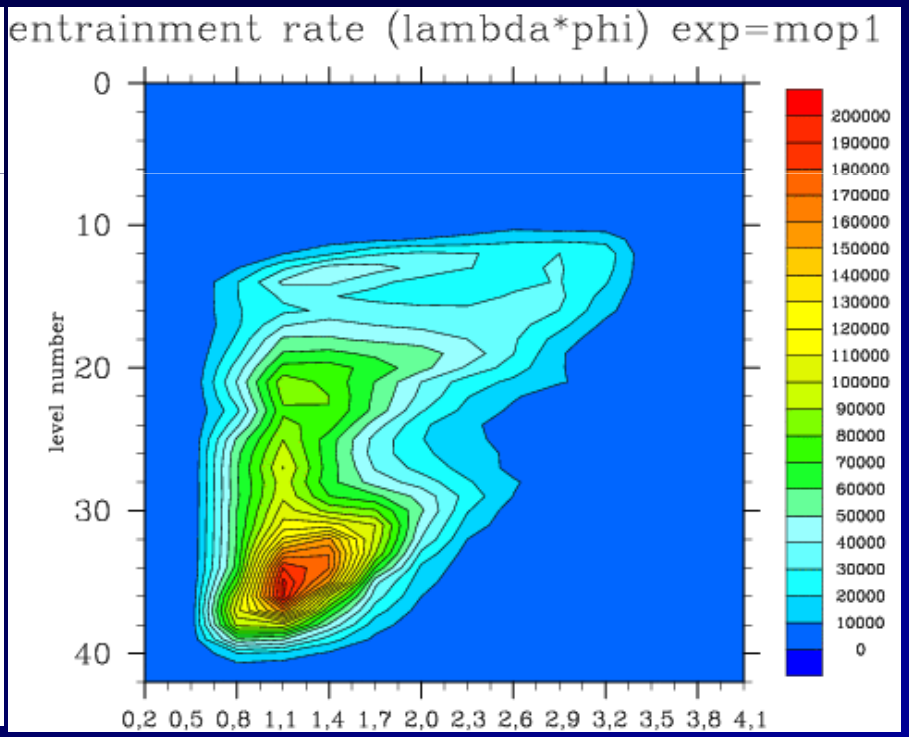
- **Developments are around a more complete approach of the transient (growing/decaying) cloud, together with additional effort in closure and mesh fraction expression.**
- **Validation of the prognostic entrainment**
  - **still problems (mid-troposphere is to warm)**
  - **a way to improve diurnal cycle of convective precipitation**
    - **retuning the free parameters**

Distribution of scaled entrainment rate

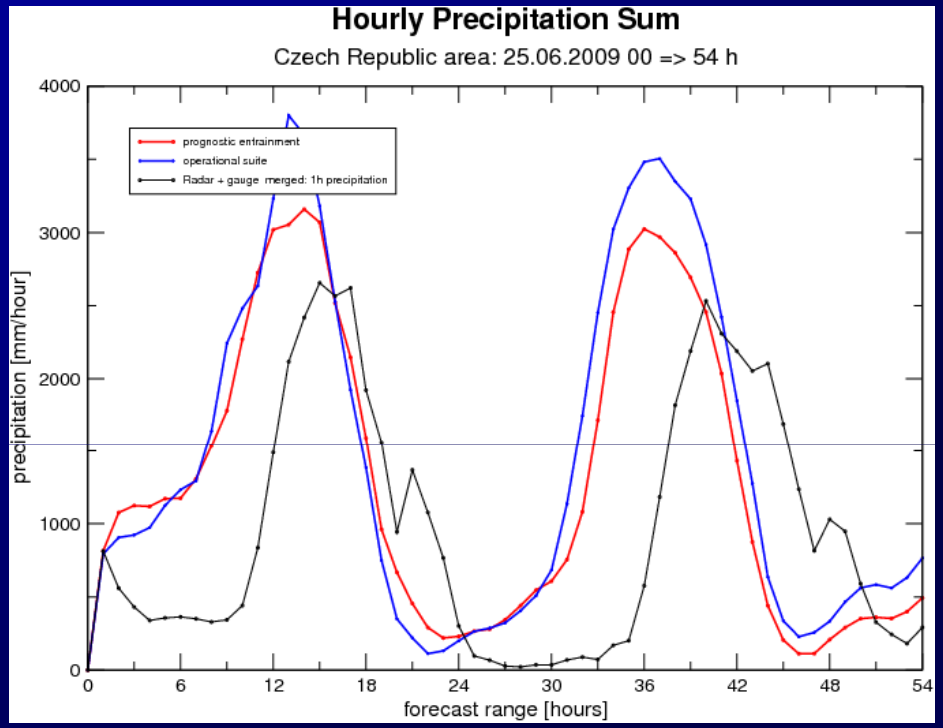
3MT diag. entrainment

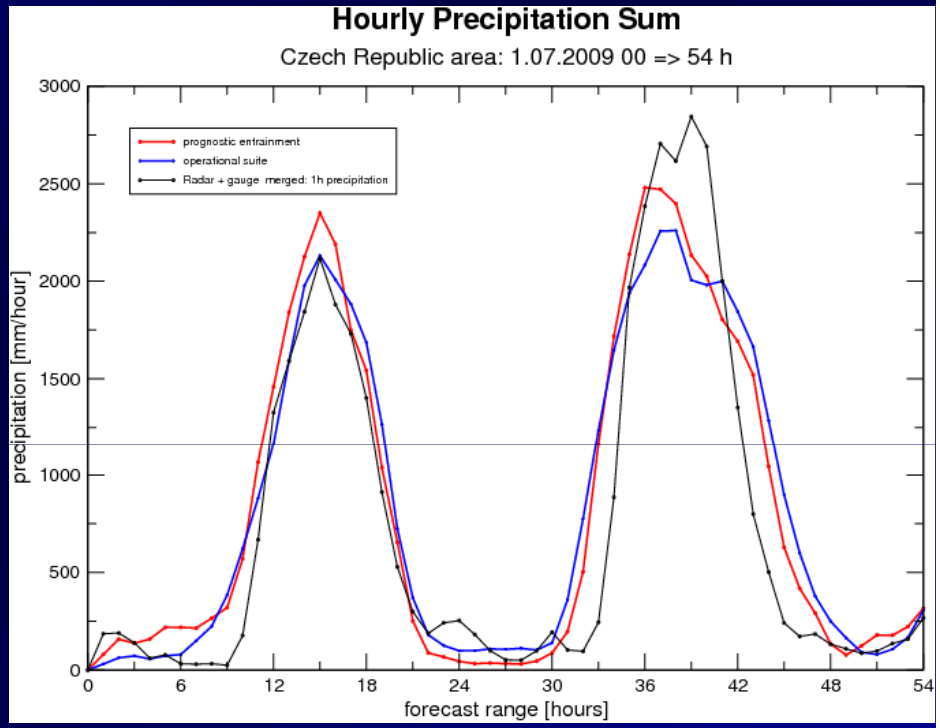


3MT prog. entrainment (with reinitialization)



Diurnal cycle - 1h precipitation





red – prognostic entrainment

blue – diagnostic entrainment (operational setup)

black – aproximation on the basis of radar data

2009

- **Article:**
  - **Gerard, L., J.-M. Piriou, R. Brožkova, J.-F. Geleyn, D. Banciu, 2009: Cloud and precipitation parameterization in a meso-gamma scale operational weather rediction model , Monthly Weather Review: In Press http://ams.allenpress.com/perlserv/?request=get-abstract&doi=10.1175/2009MWR2750.1**
- **PhD thesis:**
  - **Ivan Bastak, 2009: "Turbulent scheme eTKE"**

Outlook for 2009/2010

ALARO-1

- TKE scheme (moist effect and TOM terms)
- Microphysics – include the option of ICE3 equations
- Convection
  - improving convergence of 3MT to CRM
  - continuing work on prognostic entrainment
- Adjustment
- Shallow convection

LACE project

Name: **Operational ALARO configuration at scales around 5km mesh-size (ALARO 5km)**

Responsible person: Neva Pristov

Responsible center: CHMI

Project duration: 2008-2010

50 person months

10 LACE scientists