Convection-permitting COSMO model simulations for COPS IOP 8b (15 July 2007)

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Aims of this study

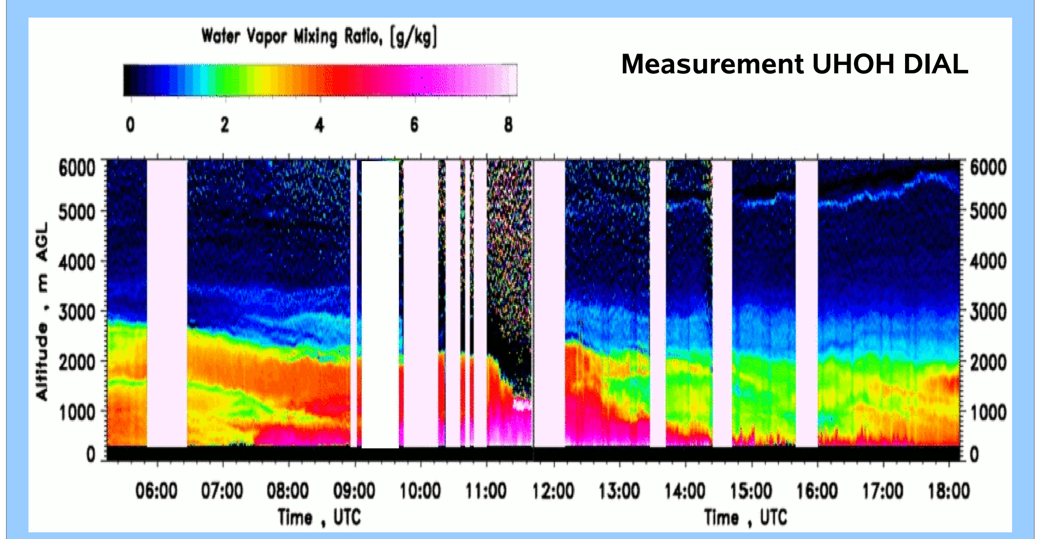
During the COPS field experiment, on 15 July 2007, an isolated convective cell was initiated in the southeastern part of the Kinzig Valley under clear-sky conditions. The cell extended up to the tropopause, formed hail and a substantial amount of surface precipitation before it decayed after about 90 minutes. The operational COSMO model forecasts missed the event and did not form any convective cell in the region of the Kinzig Valley during the afternoon of July 15. In contrast, the forecast provided by the MESO-NH model accurately predicted the convective development.

In this study, a series of hindcast simulations has been performed using the COSMO model with a spatial resolution of 2.8 km without parameterized deep convection. These experiments aim at investigating the influence of

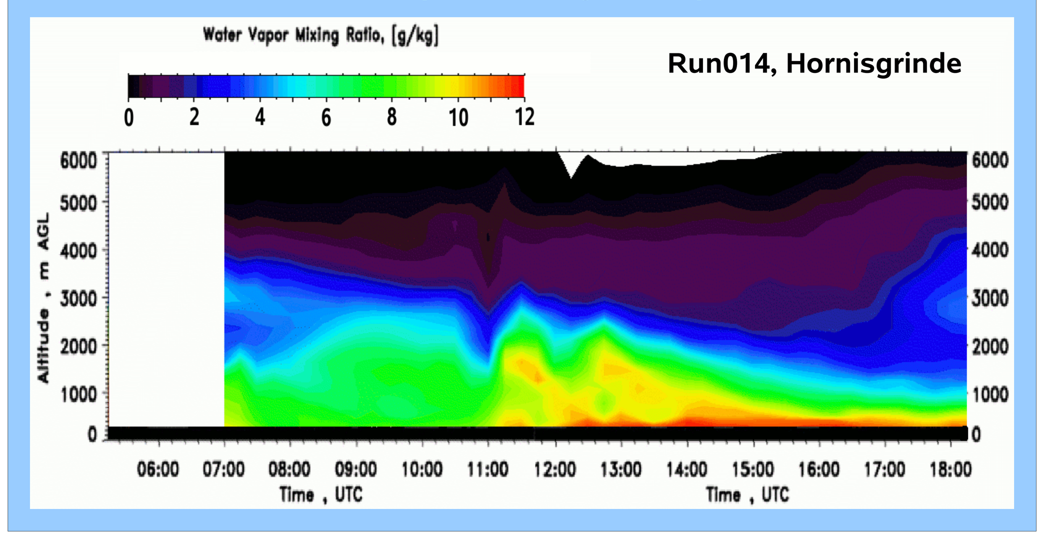
- the initial and boundary conditions (COSMO-EU vs. ECMWF analyses)
- the starting time of the simulation (3-10 hours prior to the event)
- parameters in the boundary layer scheme (that are related to the mixing length scale and subgrid-scale clouds)
- the considerations of topography in the radiation scheme.

In addition to presenting results from these model experiments, surface measurements and vertical profiles from radiosondes and lidar are used to validate the accuracy of the model simulations.

Vertical Profiles of Water Vapor Mixing Ratio above Hornisgrinde



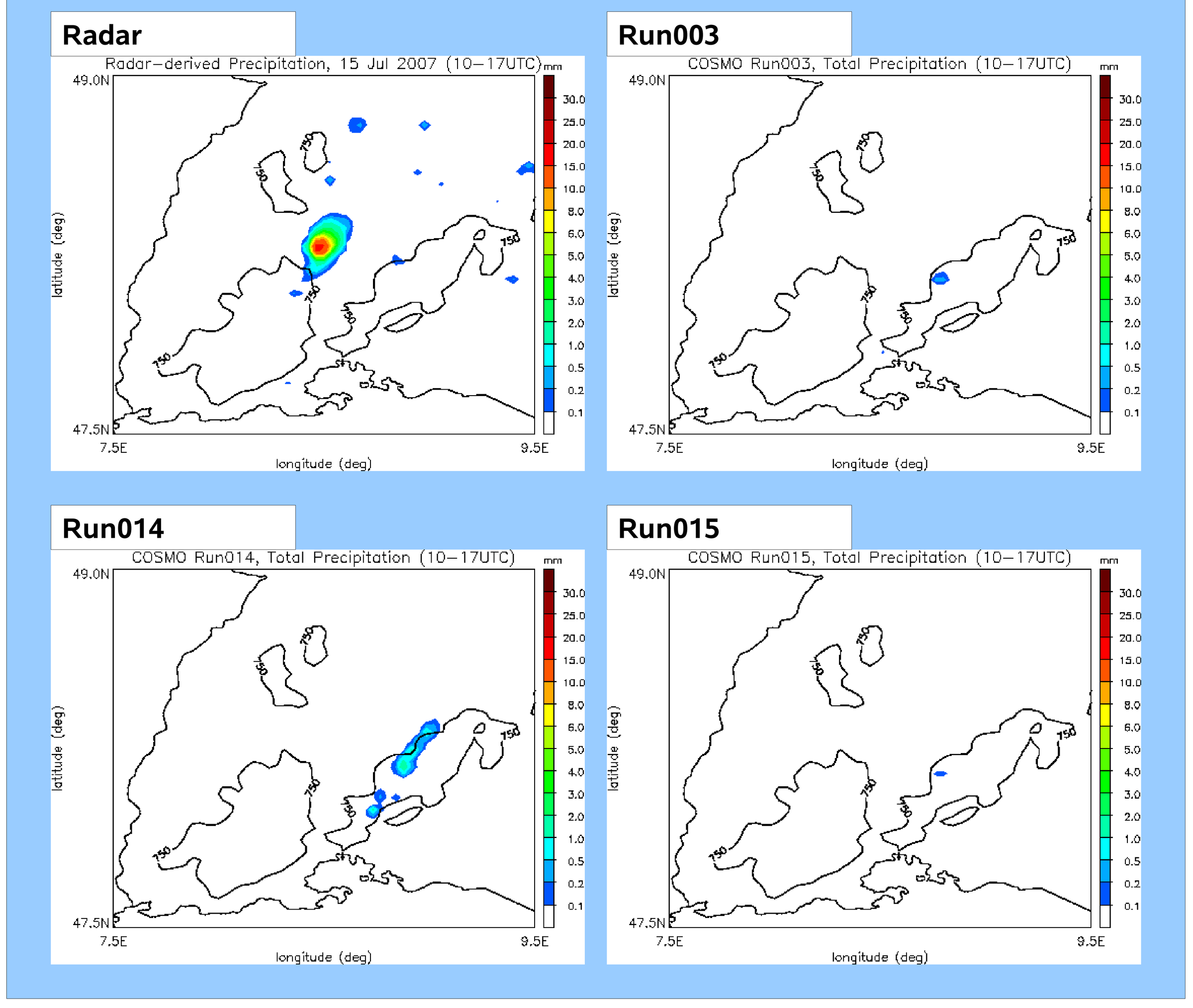
provided by Sandip Pal (U. Hohenheim)



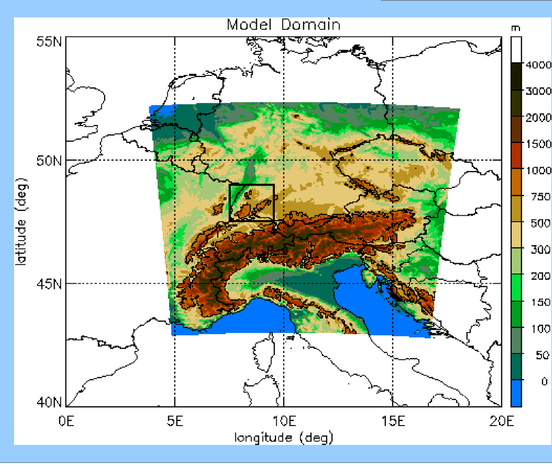
COSMO Simulations (Δx=2.8km)

Number	Start	Boundary-/ Initial Data	Parameters	Precipitation
001	07 UTC	ECMWF	original	-
002	07 UTC	COSMO-EU	original	-
003	07 UTC	ECMWF	new tuning	+
004	07 UTC	ECMWF	without shallow convection	-
006	10 UTC	ECMWF	original	-
009	07 UTC	COSMO-EU	new tuning	-
010	12 UTC	COSMO-EU	new tuning	-
011	12 UTC	ECMWF	new tuning	-
012	10 UTC	COSMO-EU	new tuning	-
013	10 UTC	ECMWF	new tuning	-
014	07 UTC	ECMWF	new tuning, Iradtopo	+
015	10 UTC	ECMWF	new tuning, Iradtopo	+
016	07 UTC	COSMO-EU	new tuning, Iradtopo	-
017	10 UTC	COSMO-EU	new tuning, Iradtopo	-

Total Precipitation (10 – 17 UTC)



COSMO Model Setup



Model	COSMO, v4.3
hor. resolution	Δx ≈ 2.8 km
shallow convection	mod. Tiedke – scheme
turbulence	prognostic TKE scheme
microphysics	graupel scheme
radiation	calculated every time step

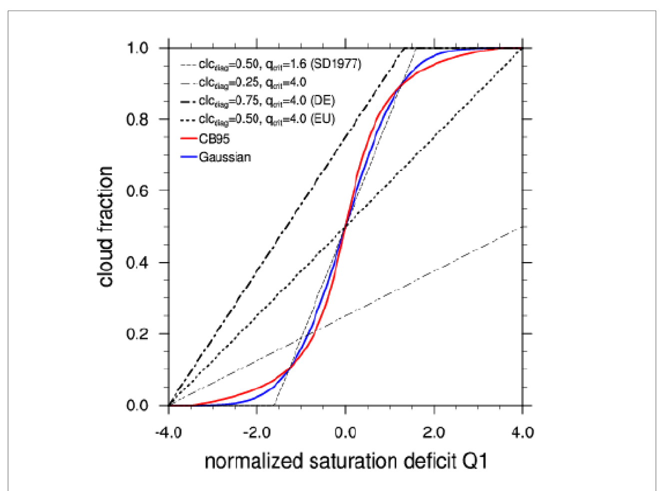
"New Tuning Parameters"

parameter	old value	new value	definition
q_crit	4.0	1.6	critical value for normalized over-satuartion
clc_diag	0.75	0.5	cloud cover at saturation in statistical cloud diagnostic
tur_len	500.0	150.0	maximal turbulent length scale

$$l_{turb} = \frac{\kappa z}{1 + z/l_{turlen}}$$

Blackadar's mixing length scale in the PBL. With κ=0.4 the von Karman constant.

The COSMO model contains a "tuning" section in the NAMELIST-input. Parameters of this section can be used to tune parametrizations and dynamics. In September 2008 the DWD changed three of these tuning parameters for the operational COSMO-DE model (Seifert 2008). In the model runs marked as "new tuning" the new values of the parameters are used.

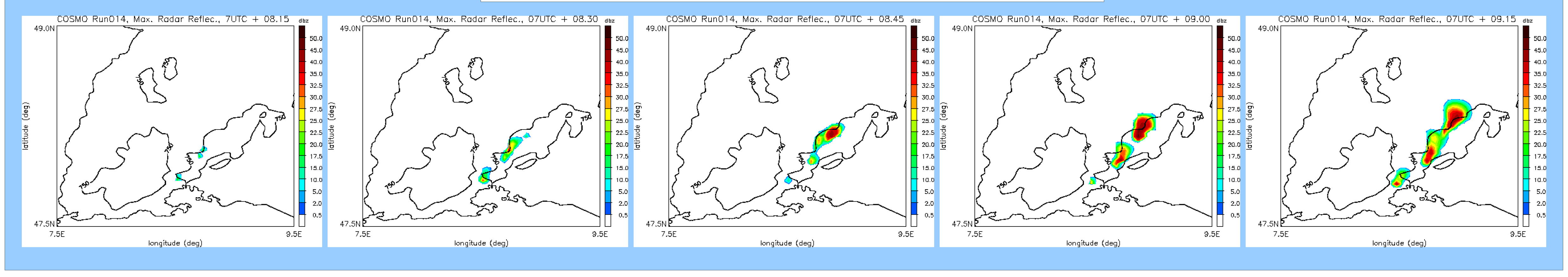


Parametrization of subscale cloud cover as function of the normalized saturation deficit. The new parameters now fit the Gaussian distribution function after Sommeria and Deardorff (1977) (Seifert, 2008)

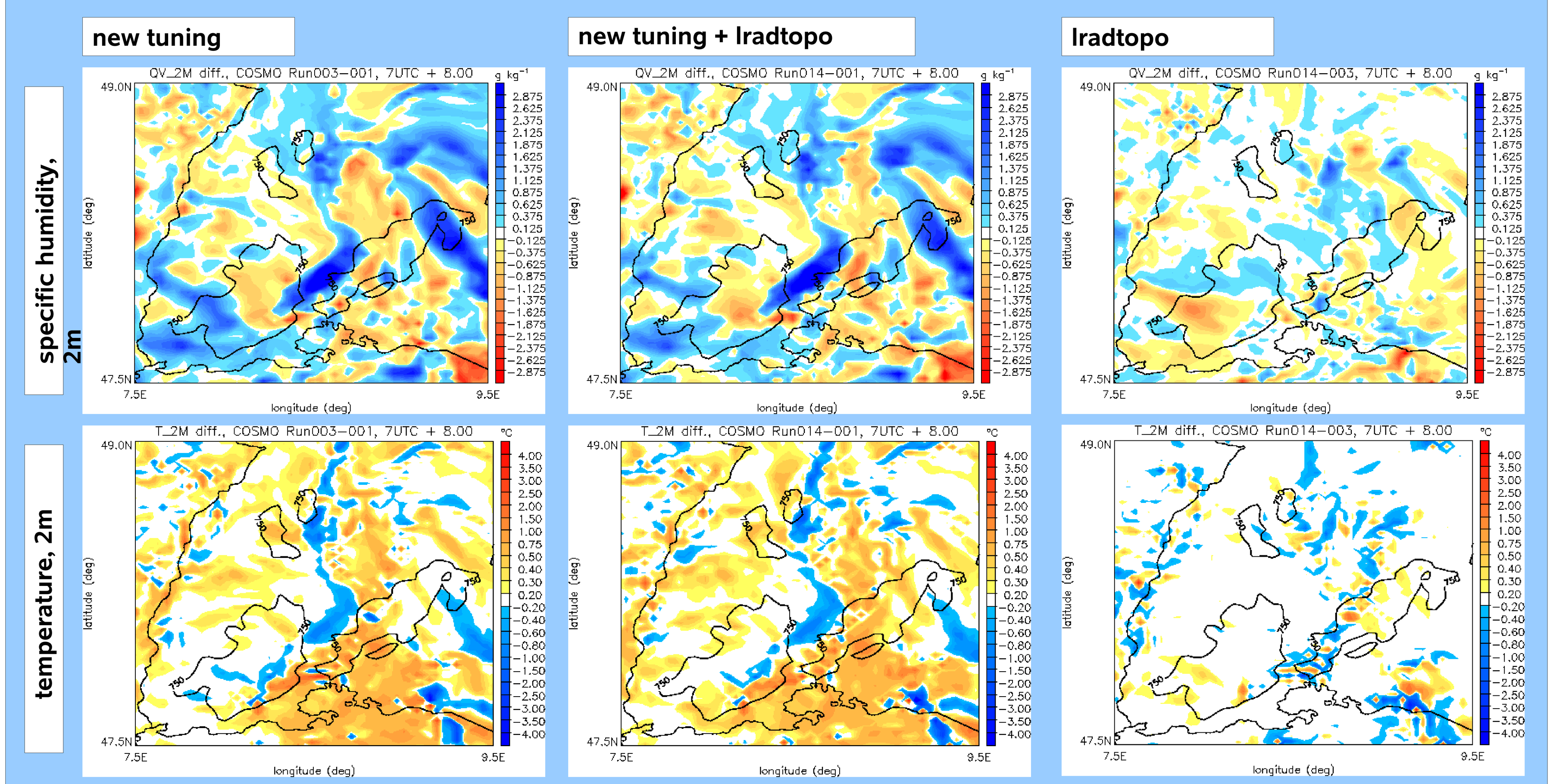
"Iradtopo": Topographic Corrections for the Radiation

For high resolution models a correction of radiation fluxes in complex topography becomes important. Following the study by Müller and Scherer (2005), effects induced by the terrain slope aspect, slope angle, sky view factor, and shadowing have to be considered. In the model runs marked as "Iradtopo", these topographic corrections for the radiation are included.

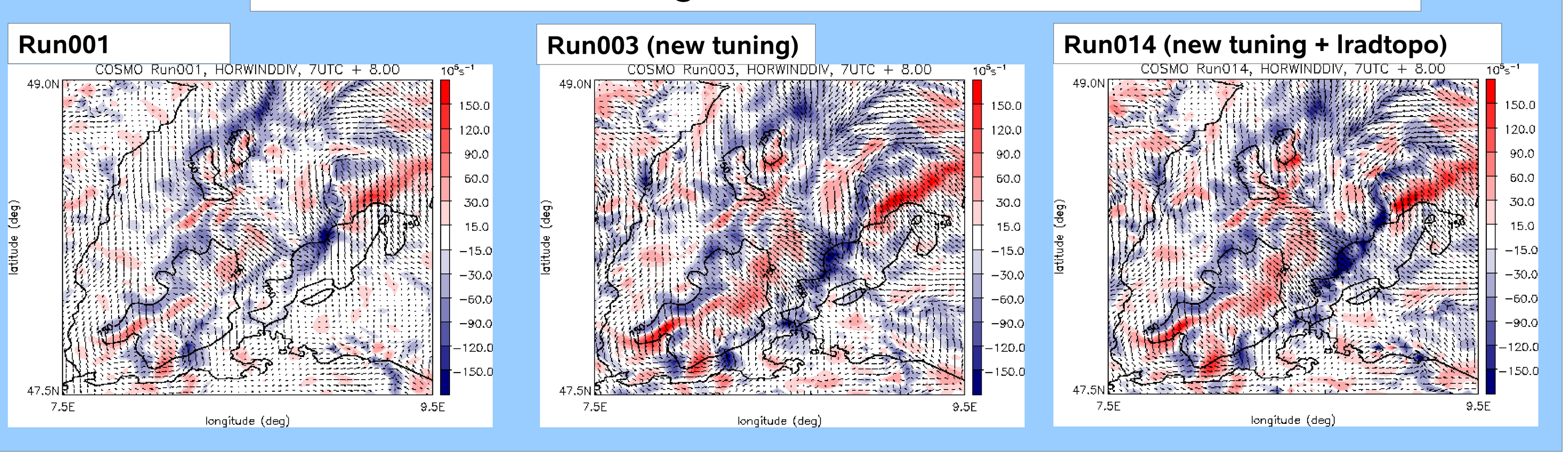
Temporal Evolution of Deep Convection in Run014



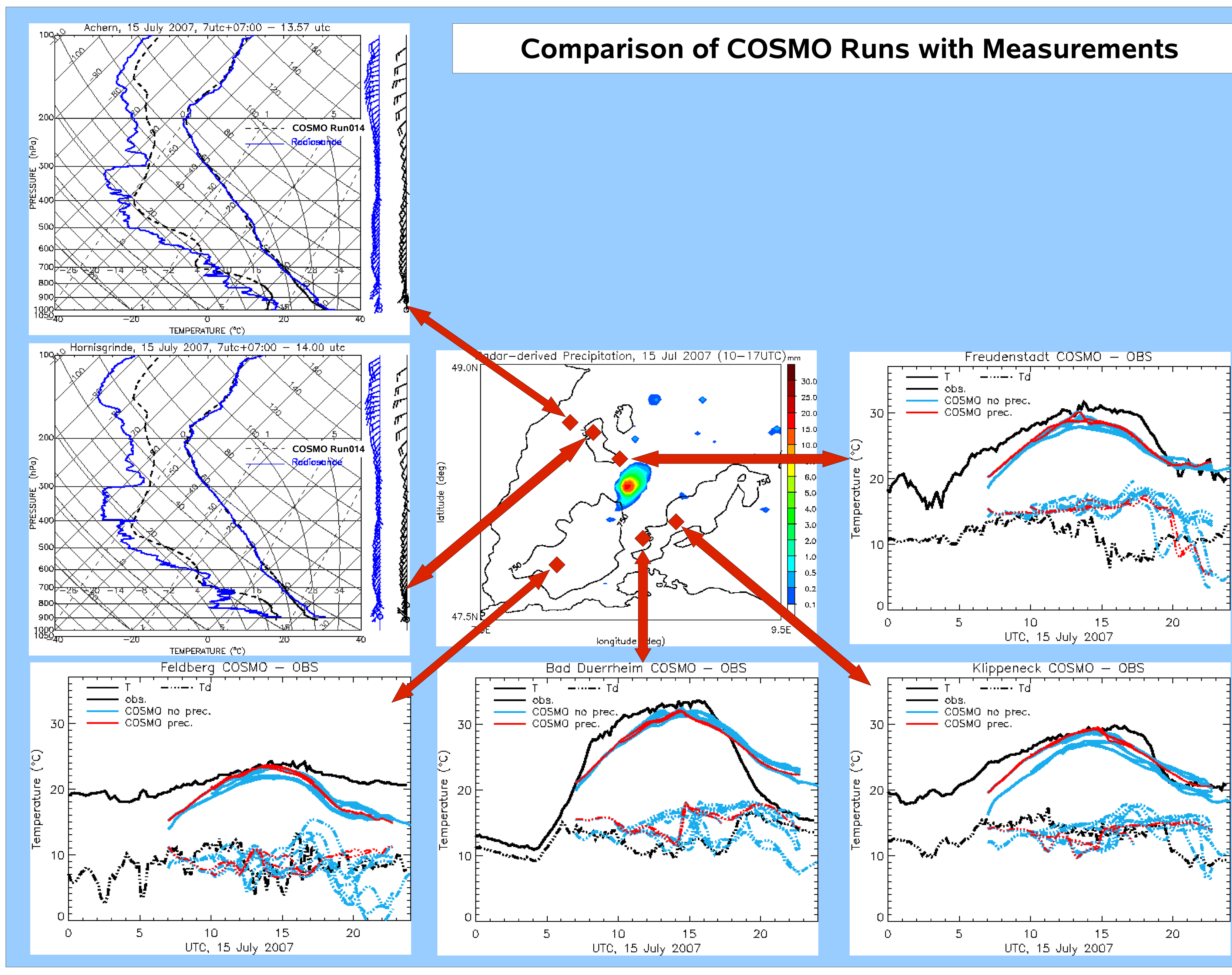
Near-Surface Effects of Parameterizations at the Time of Convection Initiation



Horizontal Wind-Divergence at the Time of Convection Initiation



Comparison of COSMO Runs with Measurements



Summary and Conclusions

Comparison of the simulations with observations and analysis of the triggering of deep convection in the model runs leads to the following conclusions:

1) Only few COSMO simulations simulate the occurrence of a deep convective cell in approximately the right area on the afternoon of July 15. All these simulations are driven by ECMWF analyses and use the new tuning parameters of the operational model COSMO-DE as suggested by Seifert (2008).

2) The simulation with the most intense convective cell uses in addition a subgrid-scale radiation parameterization of topographic effects suggested by Müller and Scherer (2005).

3) It appears that for the triggering of the convective cell both enhanced near-surface humidity (mainly due to the new tuning parameters) and wind convergence (due to both the new tuning parameters and inclusion of subgrid-scale effects on radiation) play an important role.

4) Comparison of model simulations with local measurements of 2-m temperature and vertical profiles from radiosondes indicate that the simulations tend to be too cold (at 2m) and too moist in a layer up to 750 hPa. This is confirmed by a comparsion with the Hornisgrinde water vapour lidar.

5) The representativity of surface measurements is an issue. Model vs. observation comparisons, in particular of T2m and TD2m show significant variability from one location to another.

Literature:

Müller, M. D. and D. Scherer, 2005: A grid- and subgrid-scale radiation parameterization of topographic effects for mesoscale weather forecast models. Mon. Wea. Rev., 133, 1431-1442.

Seifert, A., 2008: Parametertunning im Grenzschichtschema zur Verbesserung der Vorhersagen hochreichender Konvektion. Presentation, 27.08.2008.

Sommeria, G. and J. W. Deardorff, 1977: Subgrid-Scale Condensation in Models of Non Precipitating Clouds. J. Atmos. Sci., 34, 344-355.

Trentmann, J., C. Keil, M. Salzmann, C. Barthlott, H.-S. Bauer, T. Schwitalla, M. G. Lawrence, D. Leuenberger, V. Wulfmeyer, U. Corsmeier, C. Kottmeier and H. Wernli, 2008: Multi-model simulations of a convective situation in low-mountain terrain in central Europe. Meteorol. Atmos. Phys., in press.

Acknowledgement:

We thank Sandip Pal for providing the figure of the water vapour mixing ratio measured with the UHOH DIAL.