Current work and DWD

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QPF with COSMO-EU: LF vs RK core

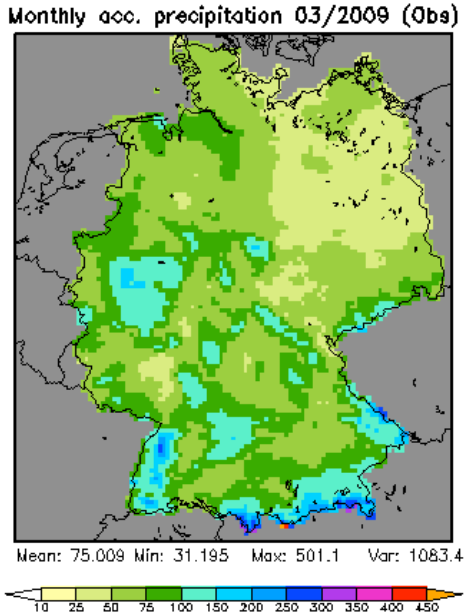
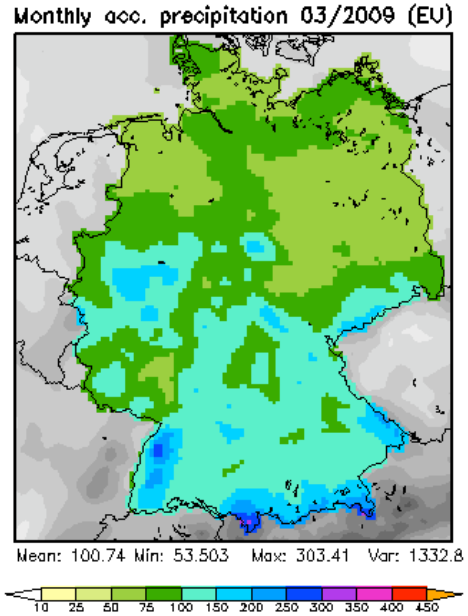
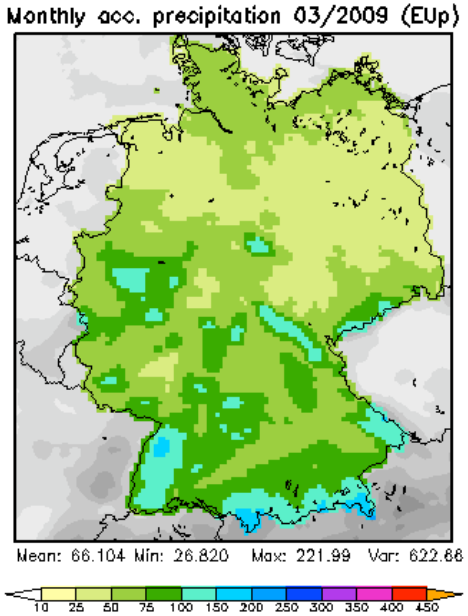
Known problems and biases:

- Operational COSMO-EU shows a strong overestimation of stratiform (grid-scale) precipitation during winter.
- COSMO-EU with most recent version of the Runge-Kutta numerics reduces the wintertime bias, but the reduction seems to be too strong leading to an underestimation of precipitation.

Outline of this talk:

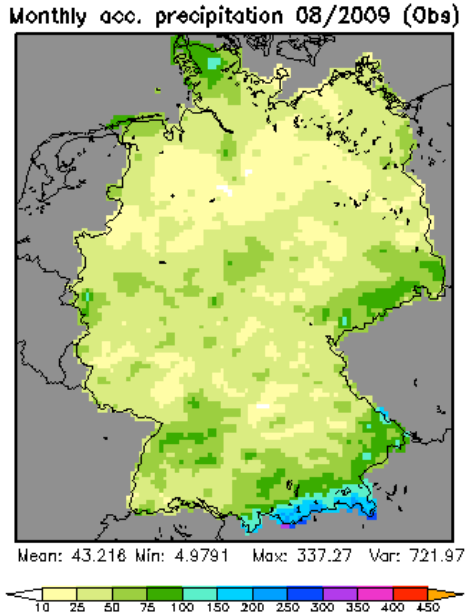
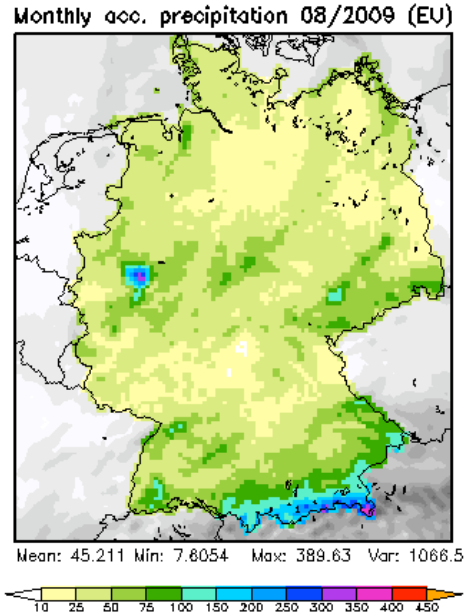
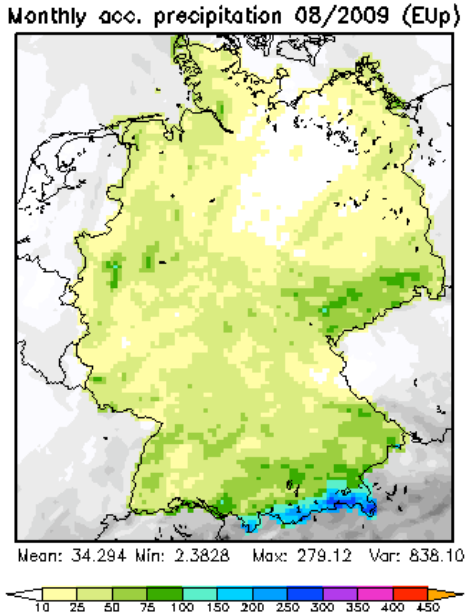
- QPF verification comparing Leapfrog and Runge-Kutta in COSMO-EU
- Microphysics experiments: re-tuning necessary for RK-core?
- Conclusions

Accumulated precip April 2009:

REGNIE	LF COSMO-EU	RK-core suite
		
75 mm	101 mm (+35%)	66 mm (-12 %)

- Operational COSMO-EU with LF shows strong positive bias.
- COSMO-EU with RK-core reduces the precip amount, but leading to a negative bias. Spatial distribution is too smooth, orographic enhancement is underestimated.

Accumulated precip August 2009:

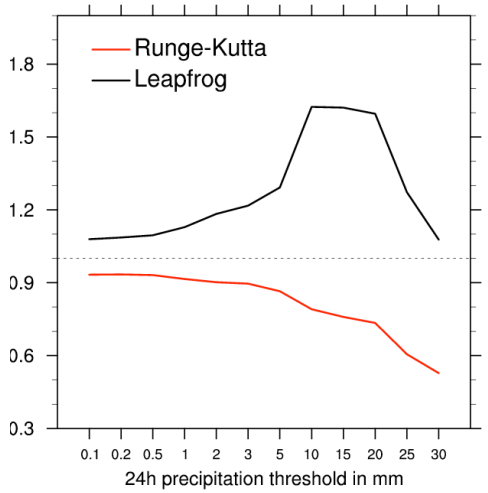
REGNIE	LF COSMO-EU	RK-core suite
		
43.2 mm	45.2 mm (+5%)	34.3 mm (-21 %)

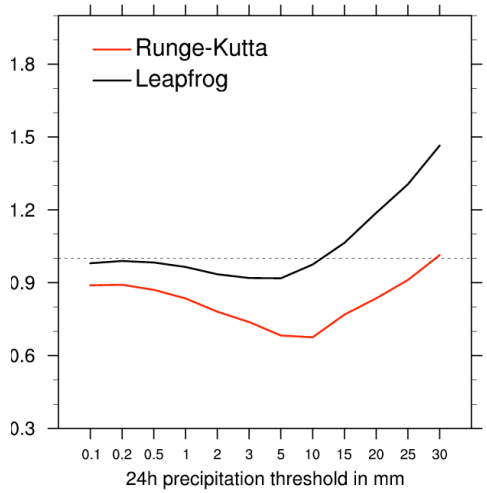
- Operational COSMO-EU with LF shows small positive bias.
- COSMO-EU with RK-core shows again a strong negative bias.

Statistical Scores vs 24h accumulation REGNIE

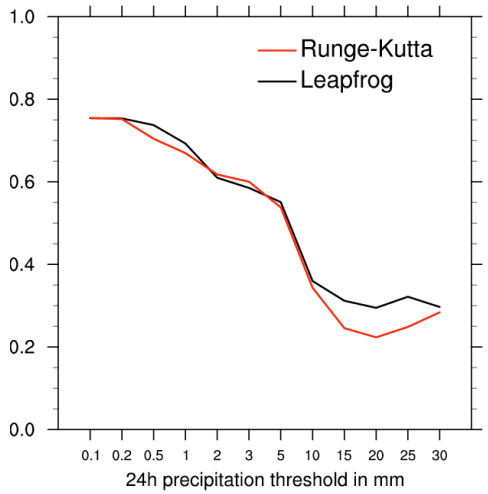
March+April **MJJA2009**

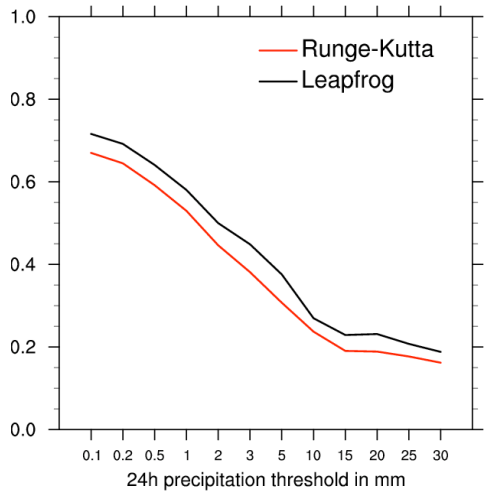
FBI





ETS





- LF-core predicts too many 5-20 mm/24h events during winter.
- RK-core has a dry bias and misses strong events during winter
- During summer numer of strong events is overestimated when using the LF-core, but the RK-core has a dry bias.
- ETS is similar during winter, but during summer RK gives lower ETS.

➔ **Huge difference between both dynamical cores.**

Dynamics and physics in COSMO-EU

Motivation:

- RK core leads to much less precipitation, especially stronger events are underestimated or missing completely.
- Numerics experts tell us:
  '*the vertical velocity in the LF-core simulations is much too noisy due to numerical problems, especially over orography'.*
- Model physics has over the last decade been developed - and tuned - for the LF-core. Do we need to re-tune or completely overhaul our model physics?

Microphysics in COSMO-EU

Possible modifications in cloud microphysics:

- Higher fall speed of snow by changing der pre-factor *a* in

  $v_s = a\,(D/D_0)^b$, (operational a=15, possible range a=15-30)

- Higher autoconversion rate by reducing the number concentration of cloud droplets

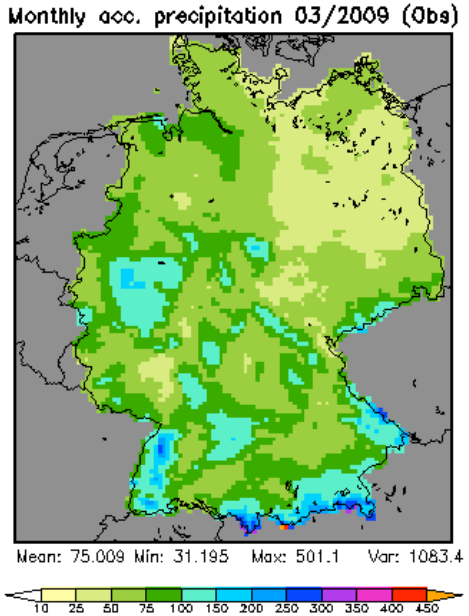
  $AU \sim N_c^{-2}$, (operational N_c = 500 cm^{-3}, possible range 50-1000 cm^{-3})

- Taking into account the density correction of the fall speeds of snow and rain

  $v \sim (\rho_0/\rho)^{1/2}$, (traditionally neglected in the COSMO model).

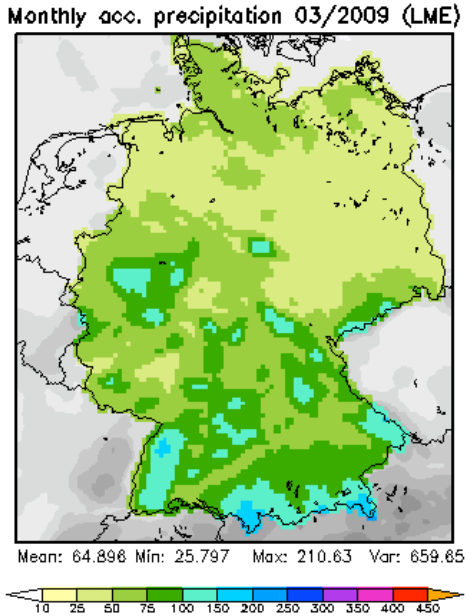
Precipitation accumulation for April 2009

REGNIE



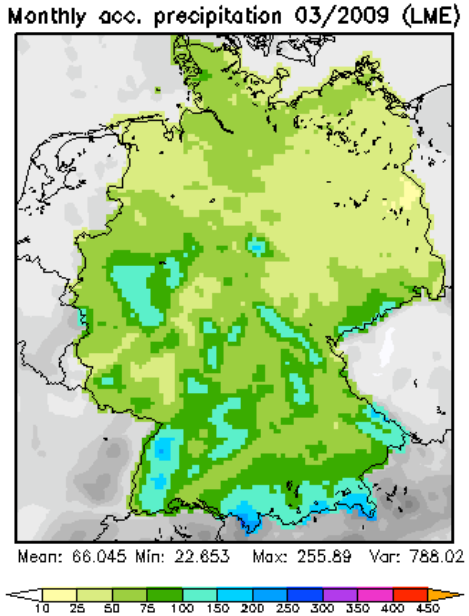
RK control

a=15, N_c=500 cm^{-3}



RK microphysics

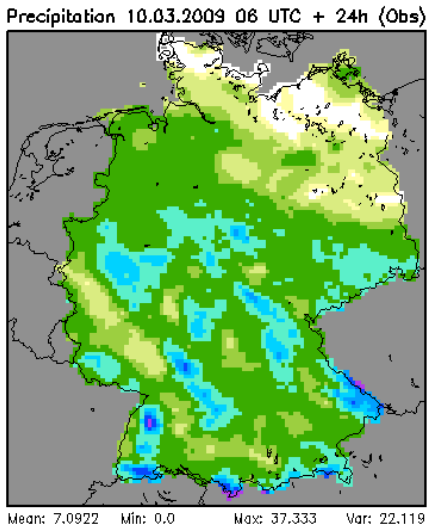
a=25, N_c=200 cm^{-3}



➔ Only a very small effect for the total accumulation over one month.

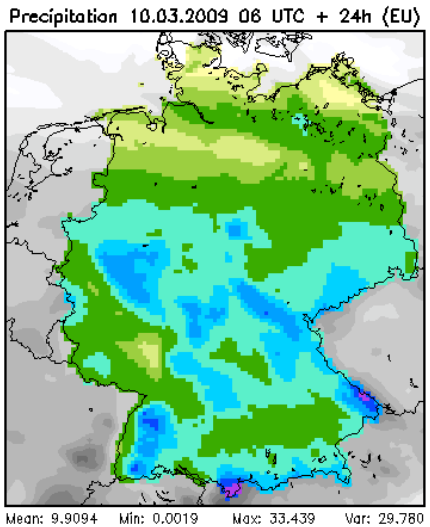
24h accumulated precip 10. March 2009: NUMEX Exp. 6915 vs 6916

REGNIE



Mean 7.1 mm
Max 37 mm

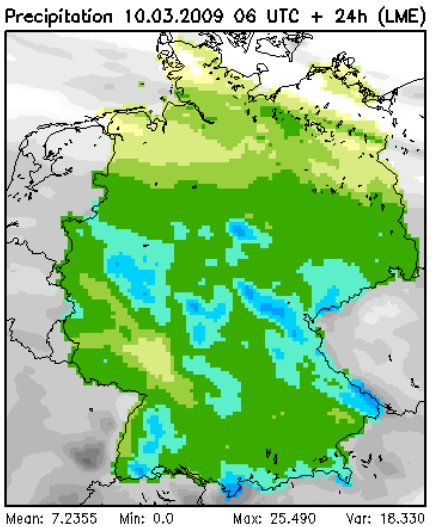
COSMO-EU



Mean 9.9 mm
Max 33.4 mm

RK control

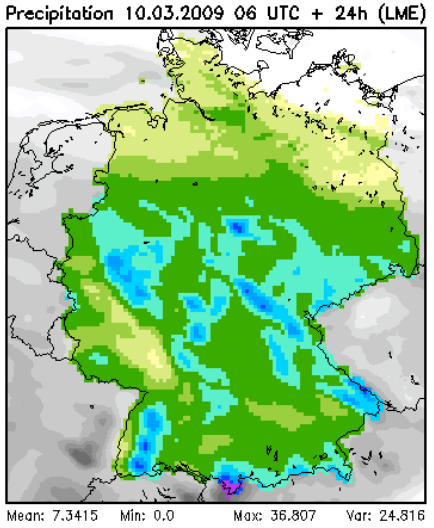
a=15, N_c=500 cm^{-3}



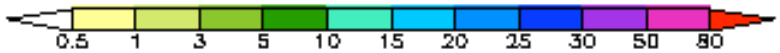
Mean 7.2 mm
Max 25.5 mm

RK microphysics

a=25, N_c=200 cm^{-3}



Mean 7.3 mm
Max 36.8 mm



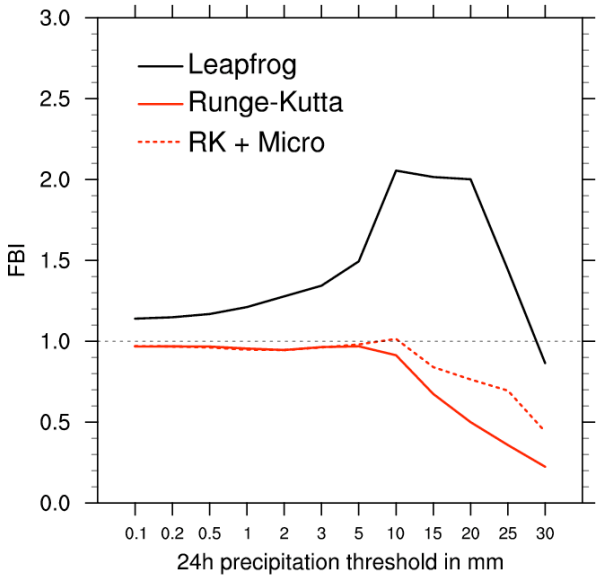
accumulated precip in mm

➔ Orographic precipitation is enhanced by the changes in cloud microphysics

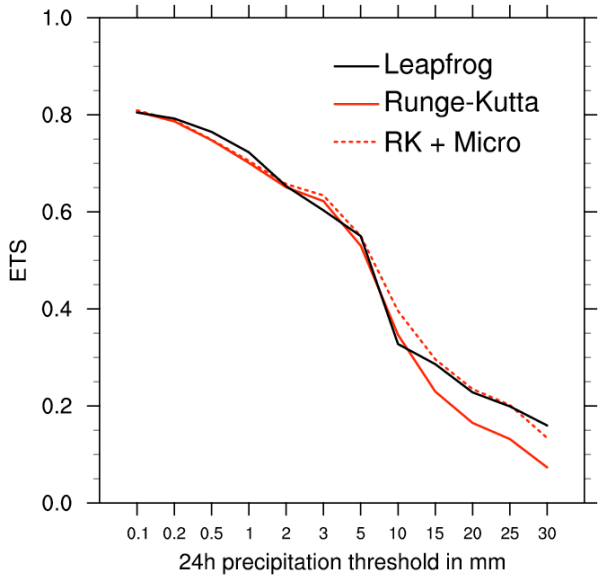
➔ RK microphysics is the best forecast in this case

Statistical Scores 24h accumulation vs REGNIE for Feb + March 2009

FBI



ETS



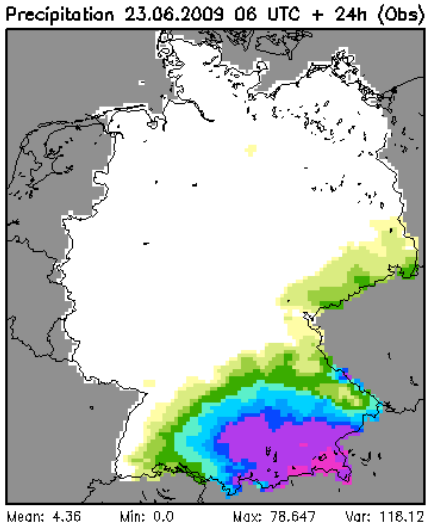
➔ Strong overestimation of precip with LF-core, almost no bias in RK up to 5 mm/24h.

➔ Re-tuning of microphysics can improve model behavior for strong precip events, especially orographic precip, but an underestimation of strong events still remains.

➔ ETS is similar for LF-core and RK+Micro experiment.

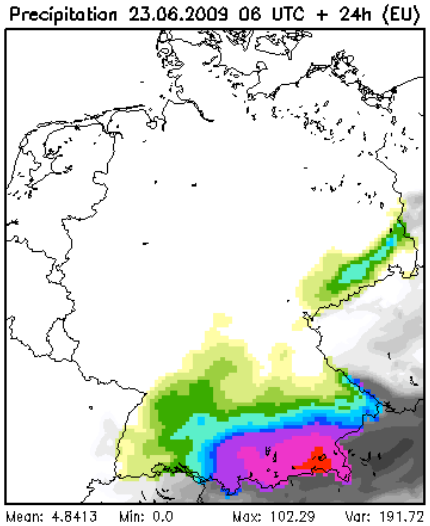
24h accumulation 23. June 2009:
(stand-alone simulations, no data assimilation)

RFGNIF



Mean 4.3 mm
Max 78 mm

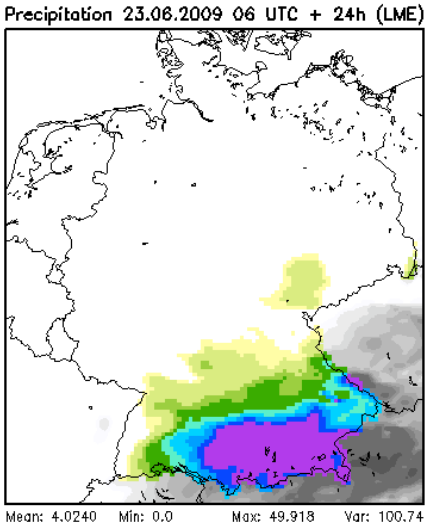
COSMO-EU



Mean 4.8 mm
Max 102 mm

RK control

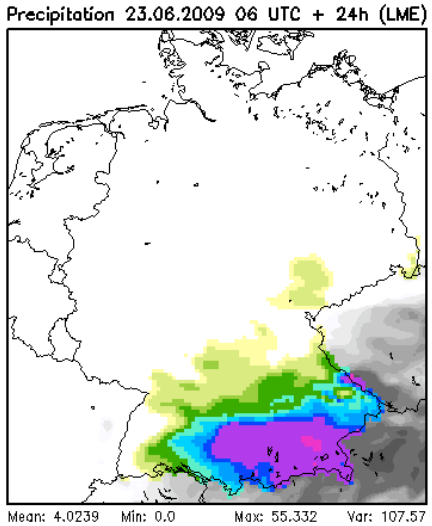
a=15, N_c=500 cm^{-3}



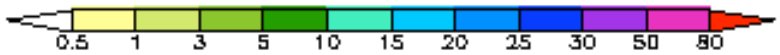
Mean 4.0 mm
Max 50 mm

RK microphysics

a=25, N_c=50 cm^{-3}, $(\rho_0/\rho)^{1/2}$



Mean 4.0 mm
Max 55 mm



accumulated precip in mm

➔ For this extreme event the underestimation by RK is a big issue for warnings!

➔ Changes in microphysics have little impact on this kind of events.

Conclusions

- RK-core can solve the old problem of overestimation of precipitation in wintertime.
- RK-core suffers from a dry bias. Strong and extreme events are underestimated.
- A physically reasonable re-tuning of the microphysics parameterization can reduce some of the biases, i.e., lead to more orographic precip. But a lack/underestimation of strong events remains.
- Re-tuning of convection scheme necessary?

➔ **Numerics experts will have to look into it again, but with a modified microphysics scheme the RK-core seems to give reasonable results.**

➔ **The guidance for extreme precipitation events would change from over- to underforecasting.**

➔ **What can we really expect for a model with 7 km grid-spacing?**

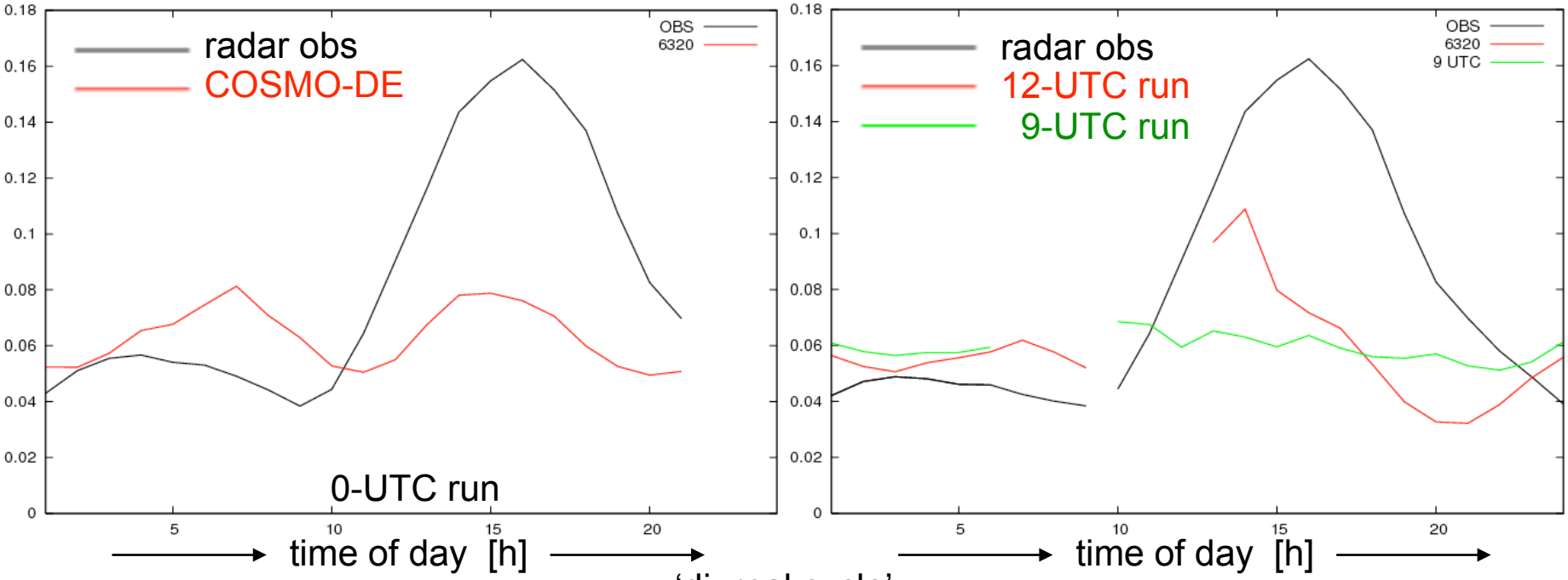
Why do biases in the diurnal cycle of precipitation depend on the initial time of forecasts ?

all experiments by Klaus Stephan

Starting point:

convection-permitting COSMO version as operational in summer 2007
strongly underestimates diurnal cycle of precipitation
in convective conditions

test period : 31 May – 13 June 2007: weak anticyclonic, warm and rather humid,
rather frequent and strong air-mass convection



'diurnal cycle':
areal mean precip over radar domain

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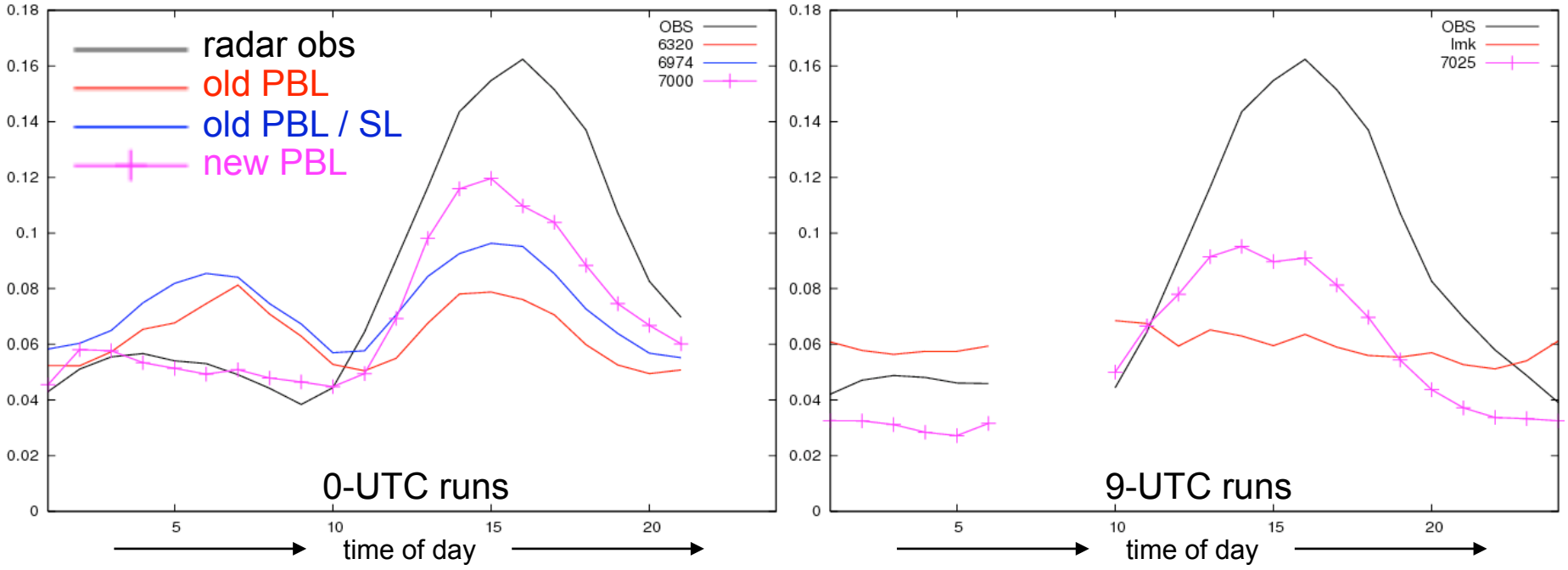
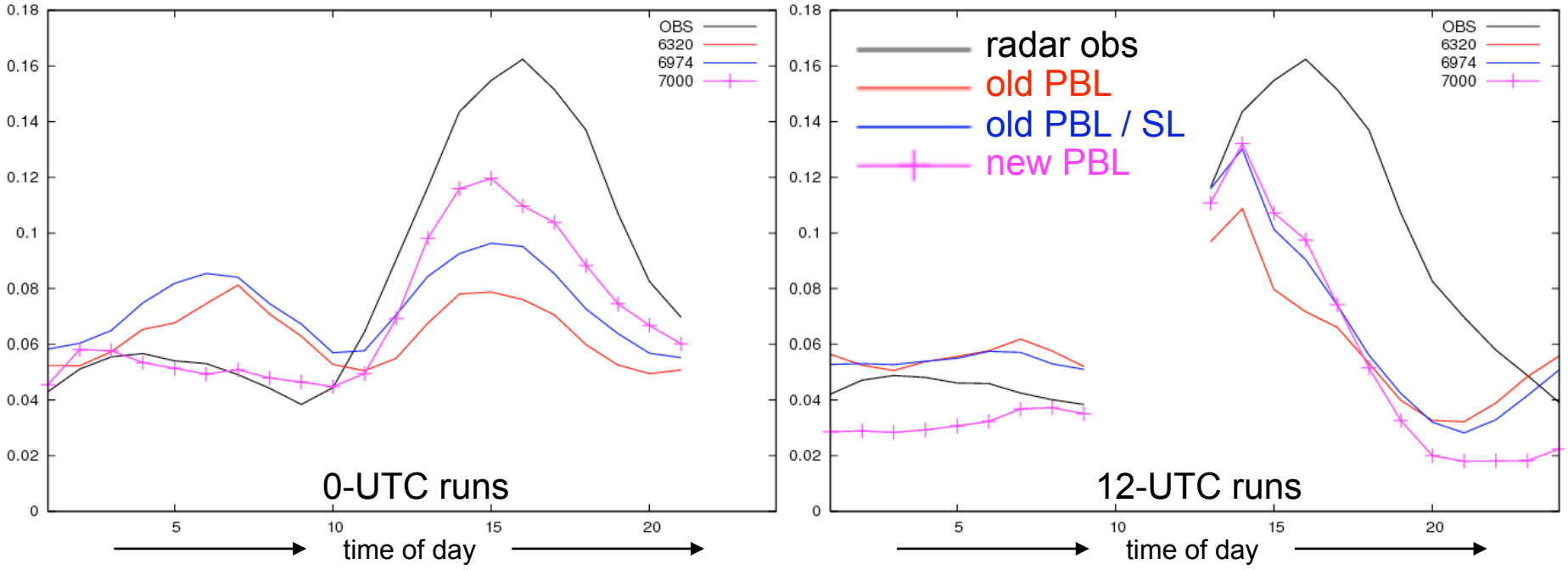
Model changes

- 'old PBL' : COSMO V4_0 , 'original' model version (operational in summer 2007)
- 'old PBL / SL' : COSMO V4_8 , with Semi-Lagrange instead of Bott advection for humidity, hydrometeors, turbulent kinetic energy (opr. during winter 08/09)
- 'new PBL' : COSMO V4_8 , with Bott advection and reduced turbulent mixing (opr. summer 09):
  - reduced max. turbulent length scale (Blackadar length : 200 m → 60 m)
  - reduced subgrid cloud fraction in moist turbulence



Why do biases in the diurnal cycle of precipitation depend on the initial time of forecasts ?

'new PBL' : improves diurnal cycle of precip, except for first 12 hrs of 12-UTC runs



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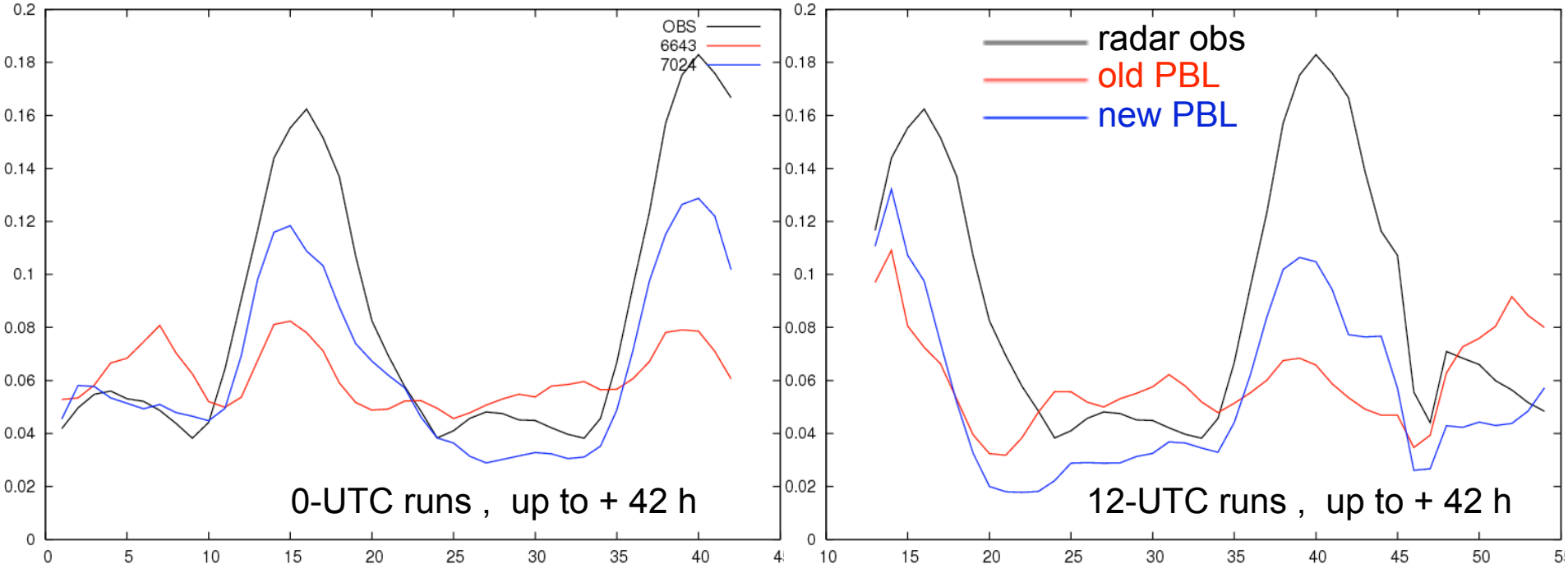
Why do biases in the diurnal cycle of precipitation depend on the initial time of forecasts ?

42-hour forecasts: ‘new PBL’ greatly improves diurnal cycle of precip,
except for first 12 hours (incl. peak in afternoon) of 12-UTC runs



Possible reasons for problems with 12-UTC runs:

- Latent Heat Nudging ?
- radiosonde humidity (daytime RS92 dry bias) ?
- radiosonde / aircraft temperature ?
- other ?

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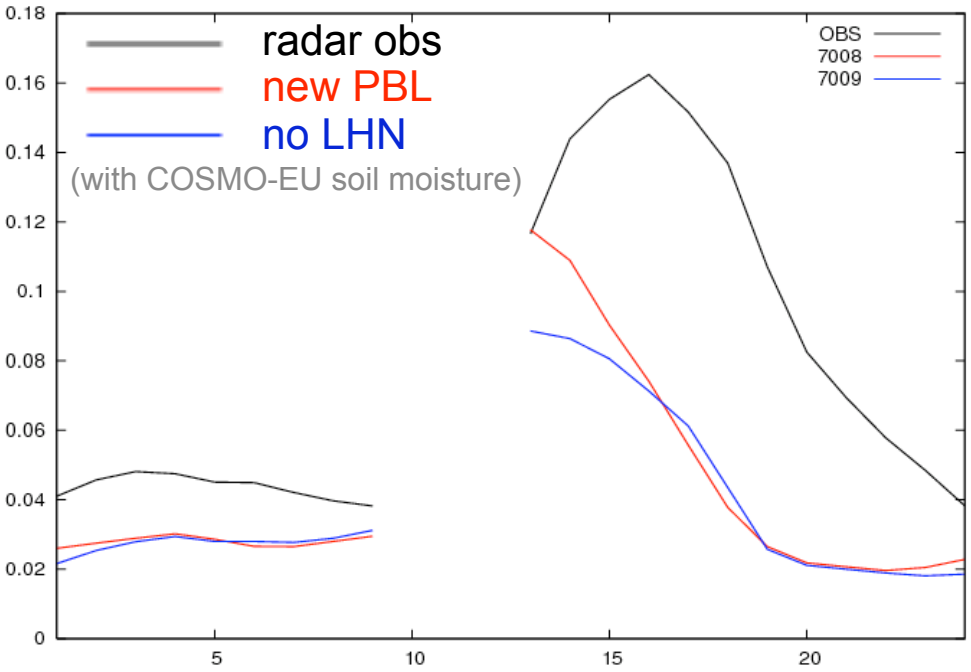
Why do biases in the diurnal cycle of precipitation depend on the initial time of forecasts ?

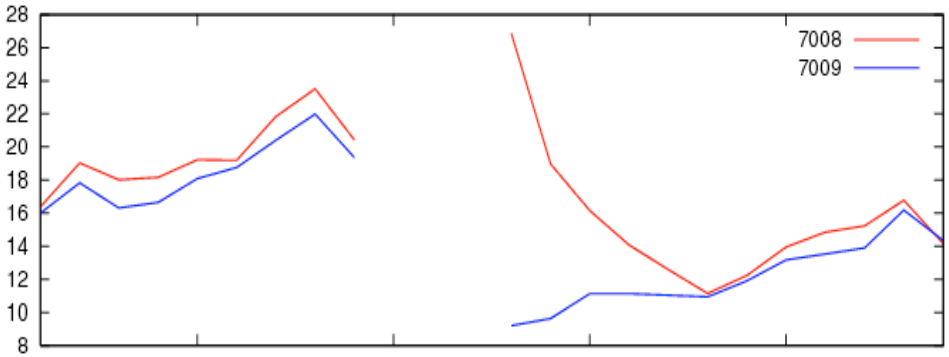
LHN: impact on diurnal cycle negligible

(improves scores mostly during first hours)

diurnal cycle

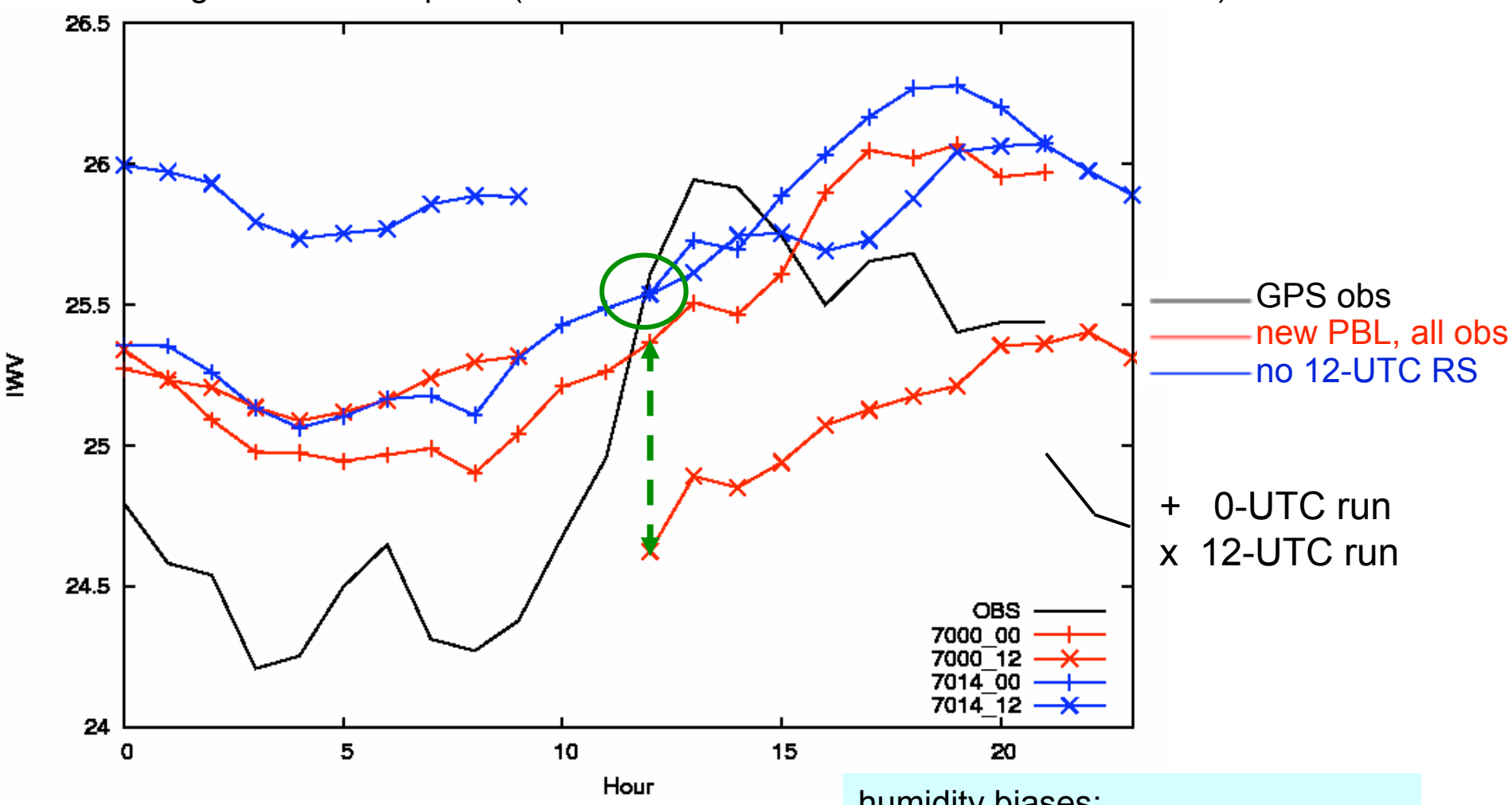


ETS 0.1 mm



Why do biases in the diurnal cycle of precipitation depend on the initial time of forecasts ?

integrated water vapour (at ~ 25 GPS stations near radiosonde stations)



humidity biases:
- daytime dry bias of Vaisala RS92
- moist bias of model

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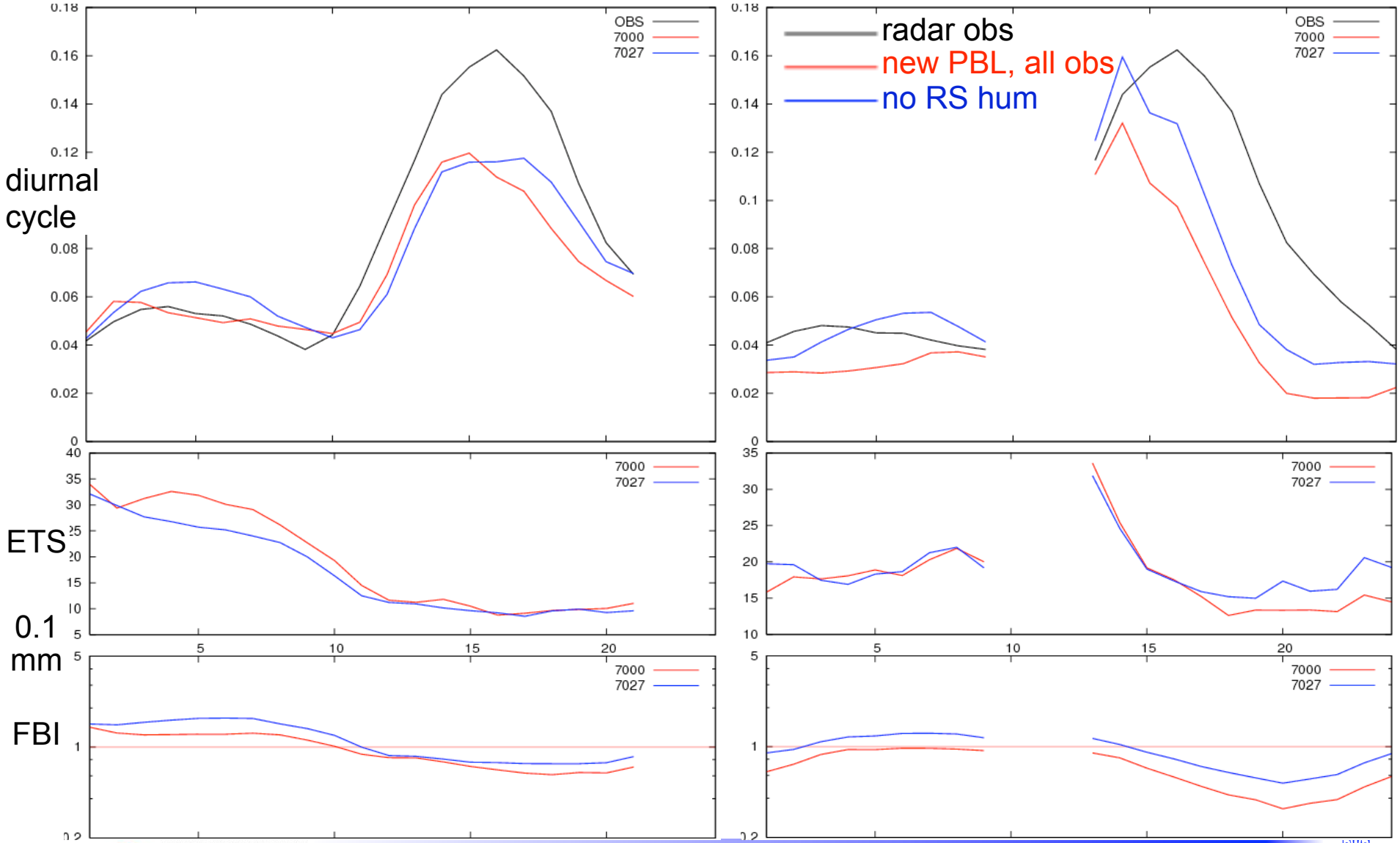
Why do biases in the diurnal cycle of precipitation depend on the initial time of forecasts ?

Radiosonde humidity: neglection increases precip (at noon),
(new PBL) but does not mitigate afternoon drop



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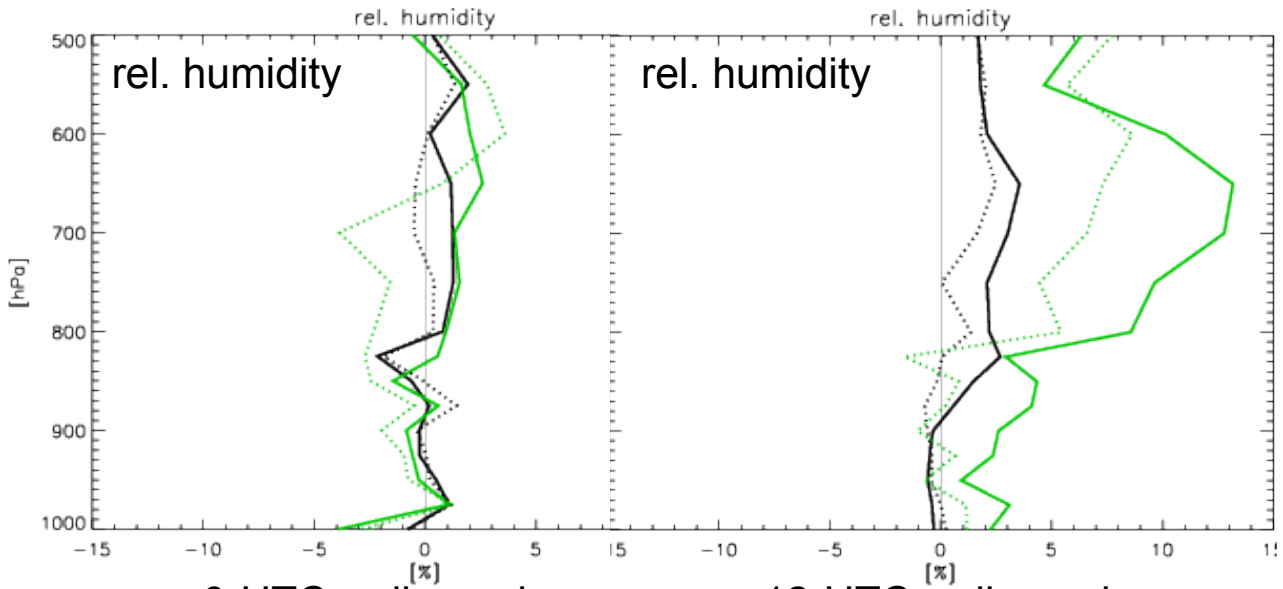
Why do biases in the diurnal cycle of precipitation depend on the initial time of forecasts ?



0-UTC radiosondes

12-UTC radiosondes

old PBL new PBL

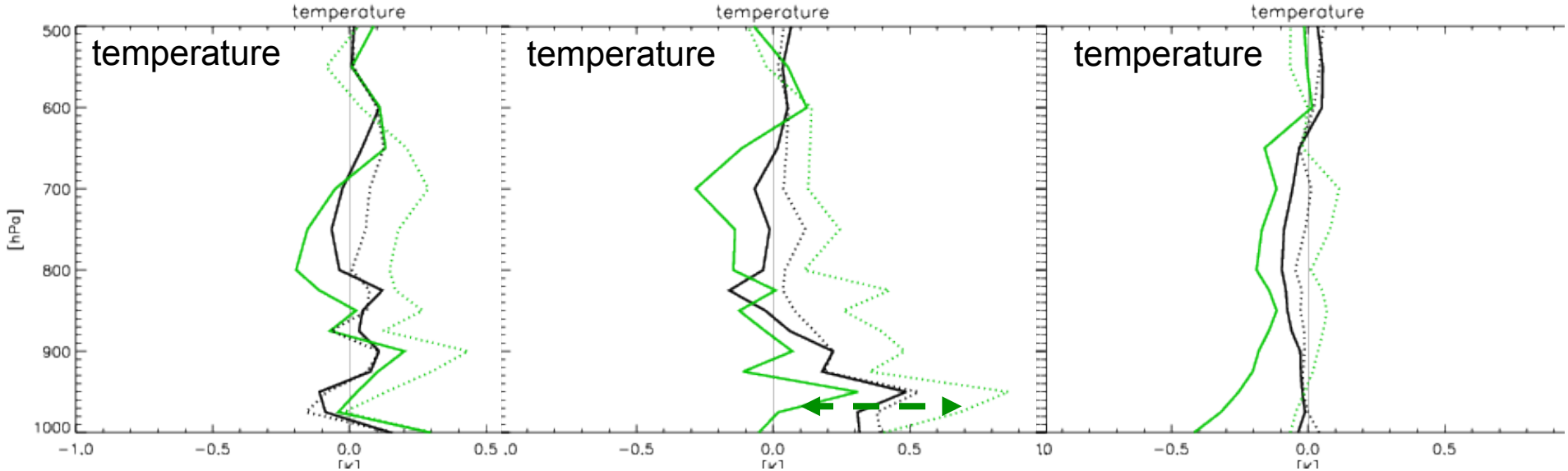
+ 0 h

+ 12 h

old PBL at 12 UTC:
- too moist above PBL
- temperature ok

new PBL at 12 UTC:
- still too moist above PBL
- too warm / unstable in PBL

6- to 12-UTC aircrafts



warm bias of aircrafts

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Summary

- obs biases
  - Vaisala RS92 : dry bias at daytime
  - aircraft : warm bias (mainly ascents, dep. on aircraft type)
- model biases:
  - old PBL:
    - diurnal cycle of precip far too weak, dep. on initial time of forecast
    - much too humid above PBL , little T-bias
  - new PBL:
    - much better diurnal cycle of precip (still too weak), except first 12 h of 12-UTC runs
    - still too humid above PBL
    - too warm and unstable in low troposphere at daytime
- sensitivity tests done:
  - little impact of LHN on biases
  - no RS humidity: improves precip of 12-UTC run only with old PBL, hardly with new PBL
  - no temperature (only old PBL): slight further improvement

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Why do biases in the diurnal cycle of precipitation depend on the initial time of forecasts ?

- further tests:
  - no T (+ ps) obs with new PBL
  - bias correct Vaisala RS92 obs: total error, or only radiation error
    → not likely to cure problem

- what to do with T-obs ?
  - correct obs bias : aircraft-T (→ worse ?)
  - adjust T-obs to model T-bias ? (→ hides model problems)
  - omit daytime T-obs at low troposphere (up to which height ?)
    (→ loss of info)

- model biases: make the job for data assimilation very hard,
  will not get better with advanced DA methods that make stronger use of the NWP model (LETKF)

→ (should we investigate) reason for these model biases ?

- insufficient resolution (to resolve convection) ?
  → look at runs with resolution ≤ 1 km ? (and vertical resolution ?)
- parameterisations not fully adequate ?
  could they still be improved at current resolution ?
  (also have biases in PBL in absence of convection (small dep. on resolution)

→ or should we adjust DA (correct obs to model bias (T, q), omit obs) ?

→ or should we live with the problem ? (do other COSMO members have it too ?)

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