Application of the convection scheme HYMACS at different grid sizes to different meteorological situations

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Motivation:

convection $\longrightarrow$ heavy precipitation, lightning, gusts, hail, ...
models: usually on subgrid scale $\longrightarrow$ parameterize $\longrightarrow$ e.g. mass flux schemes

classical mass flux schemes: no net mass transport

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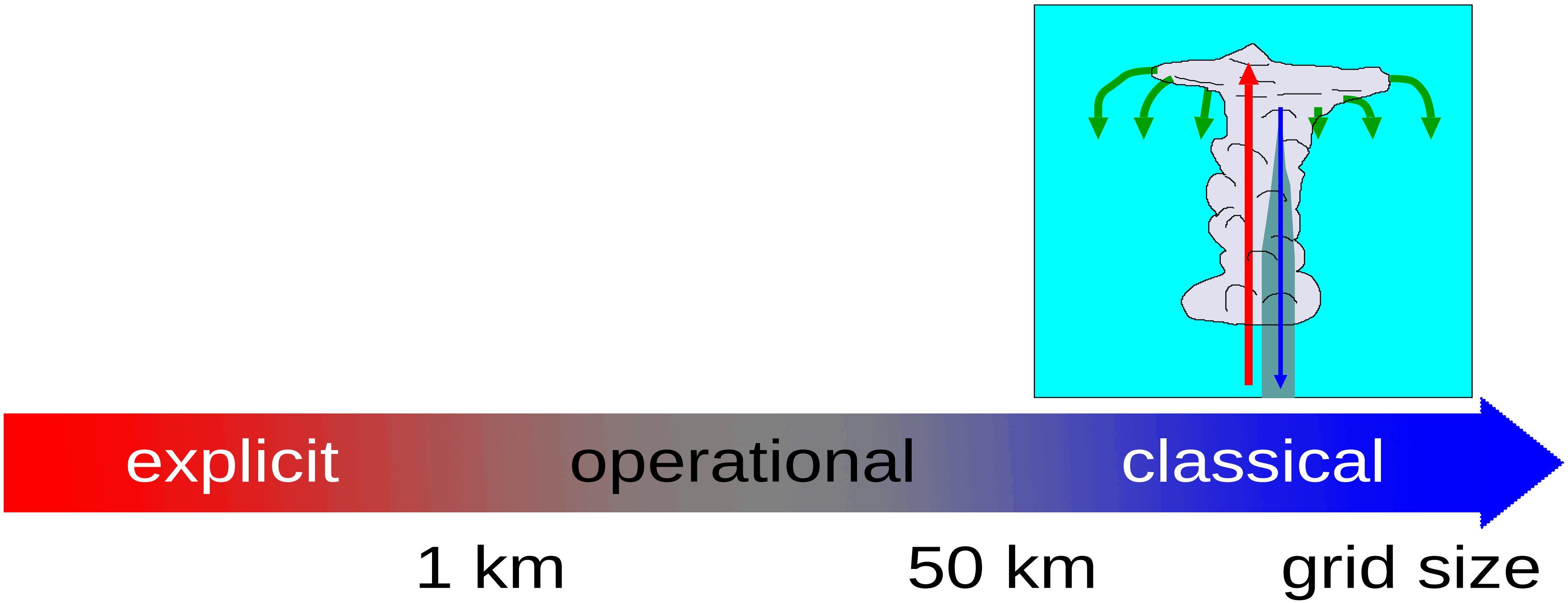

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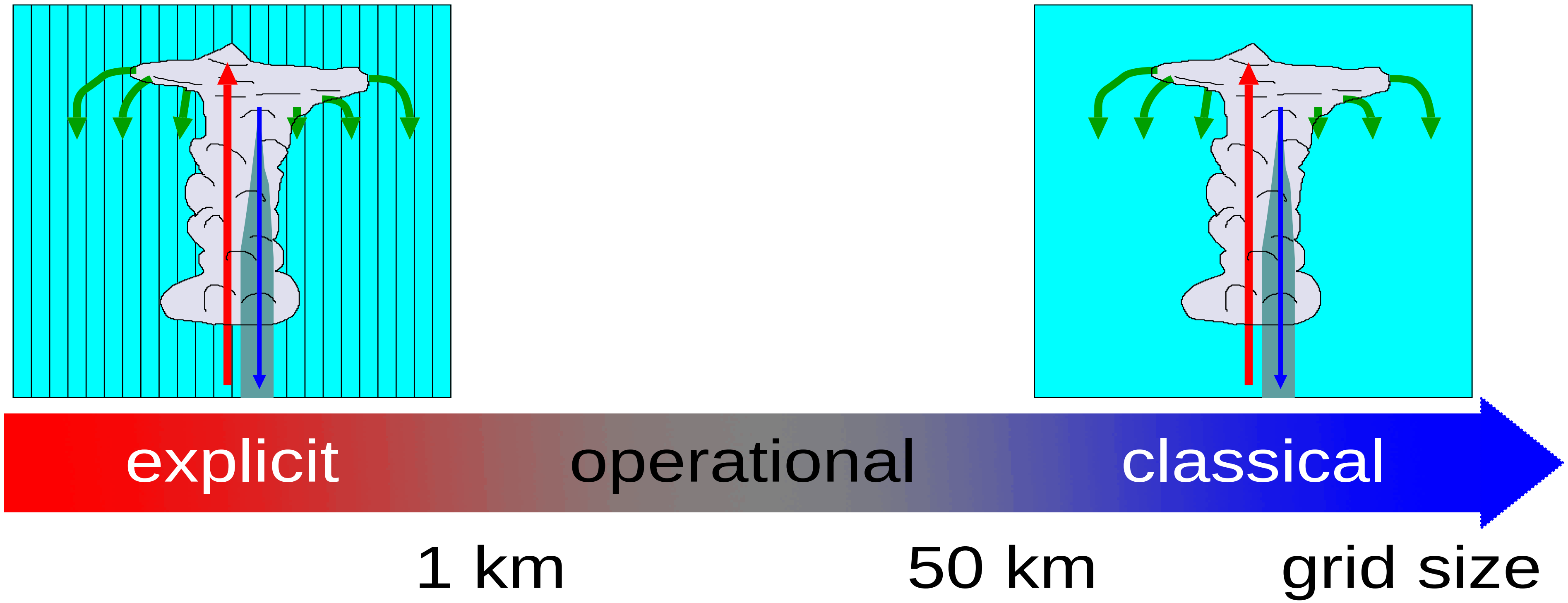

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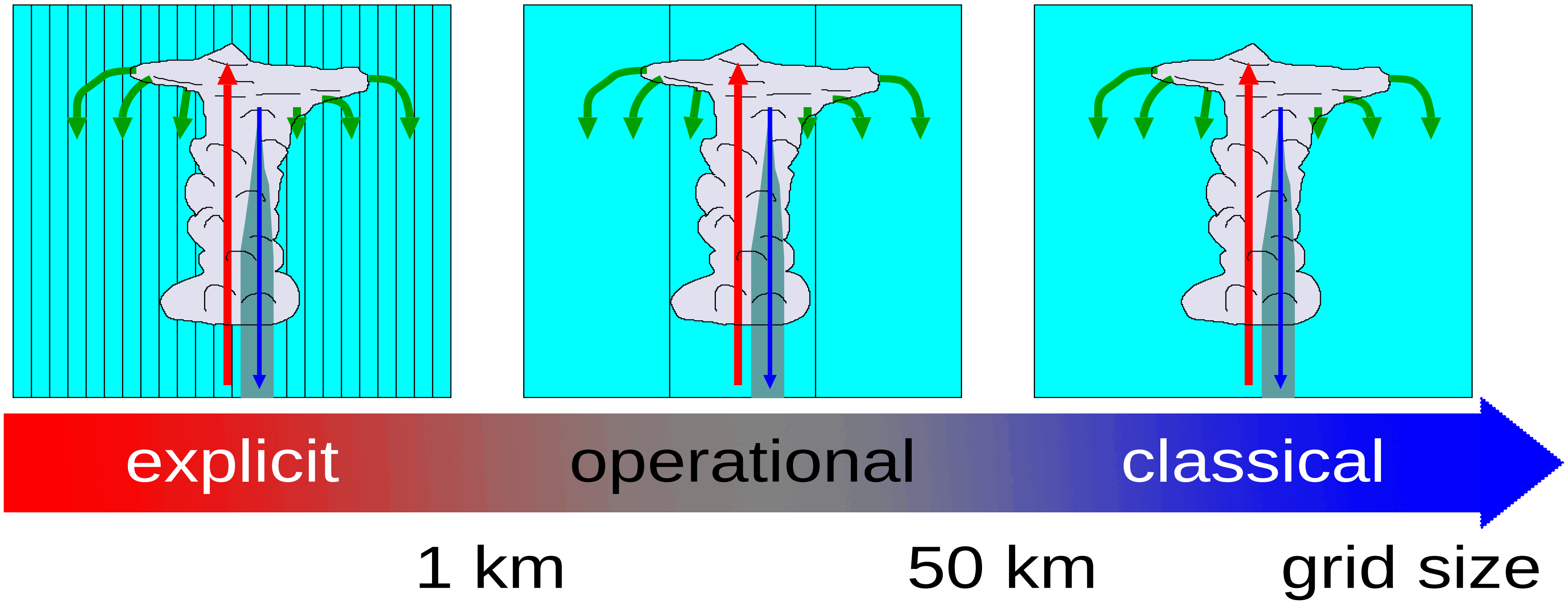


HYMACS (hybrid mass flux convection scheme)

- hybrid: parameterize up- / downdraft only (subgrid scale scheme)
  large scale subsidence: grid scale NWP model

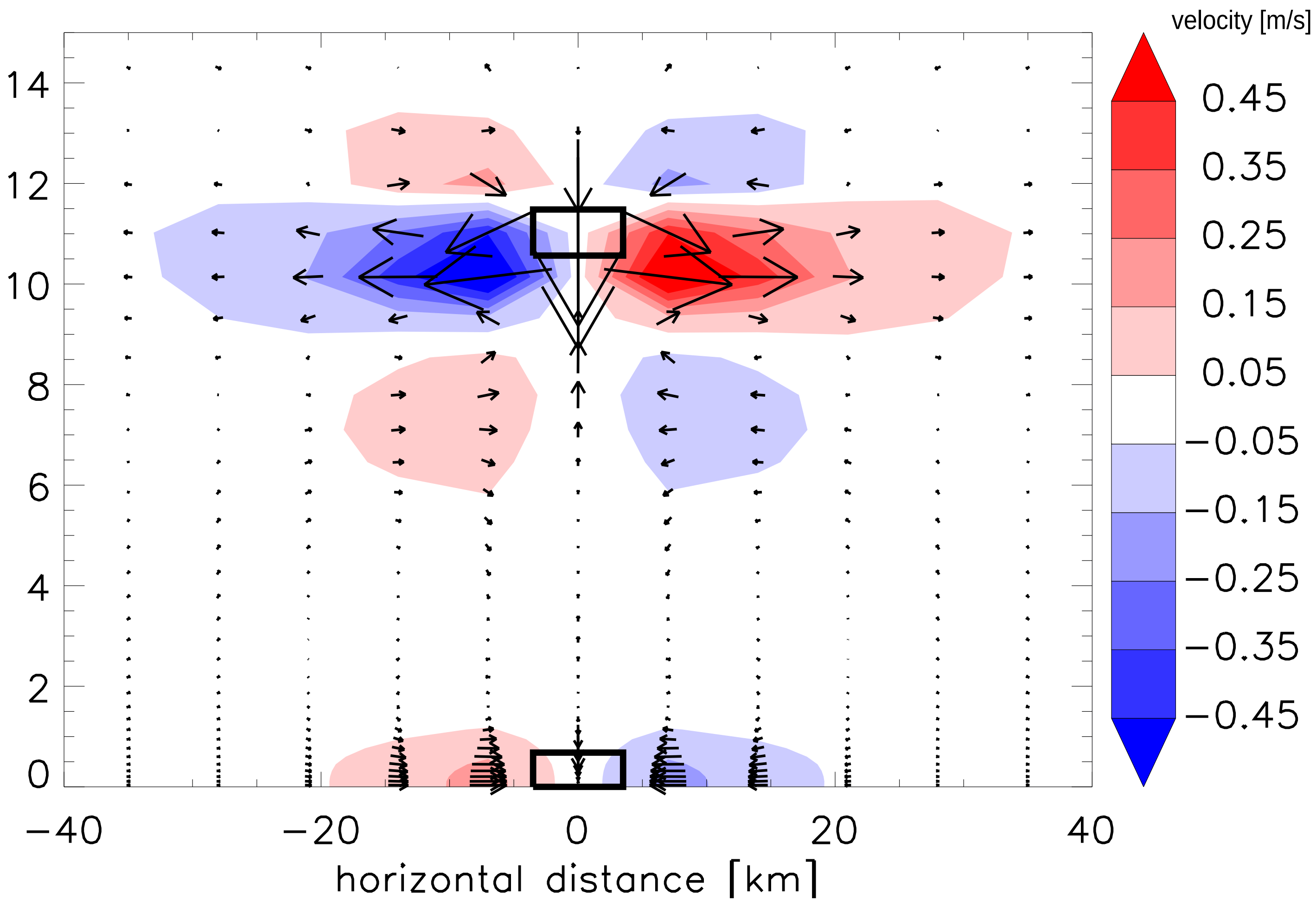
→ new: net mass transport by parameterization scheme

- applicable to wider range of grid sizes of hosting NWP model
- more realistic dynamics and distribution of precip.

- simple cloud model (up- / downdraft, precip., incl. ice phase)
- conv. transport of mass, heat, moisture, momentum
- trigger: adopted from Fritsch and Chappell (1980), Kain (2004)
  and contribution from subcloud TKE
- closure: horiz. mass flux convergence

subgrid scale mass transport:

idealized conv. transp. of mass, heat, moisture in single grid column

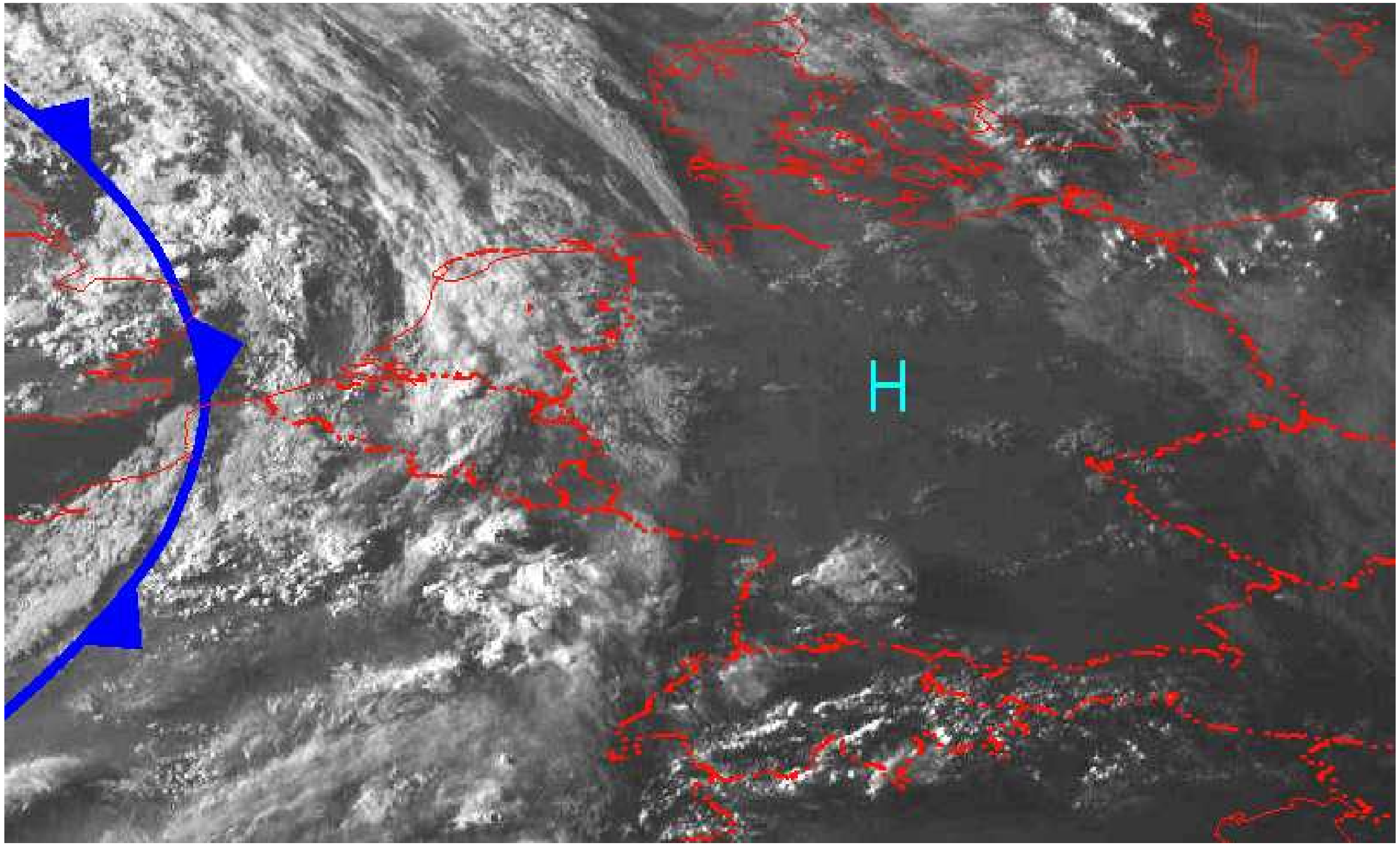


real case: 12.8.2007, air mass convection (day), cold front (night)

free forecast, COSMO model, V4.8 (DWD)

Δx=7 km, 2.8 km; Δt=40s, 25s; convection scheme called every 10min

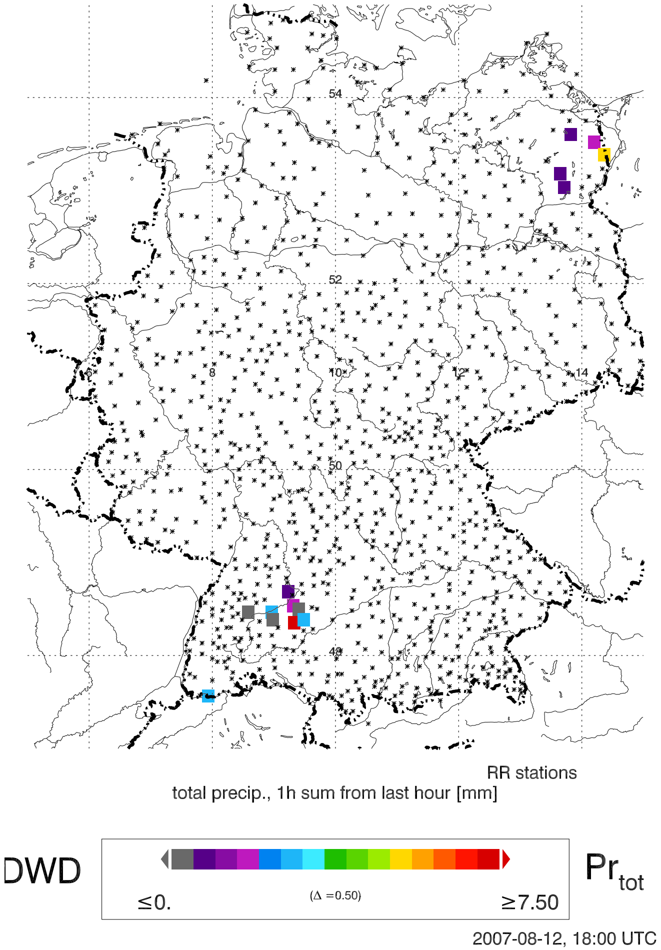
init. at 6:00 UTC, hourly bound. data from op. COSMO–EU analyses (DWD)



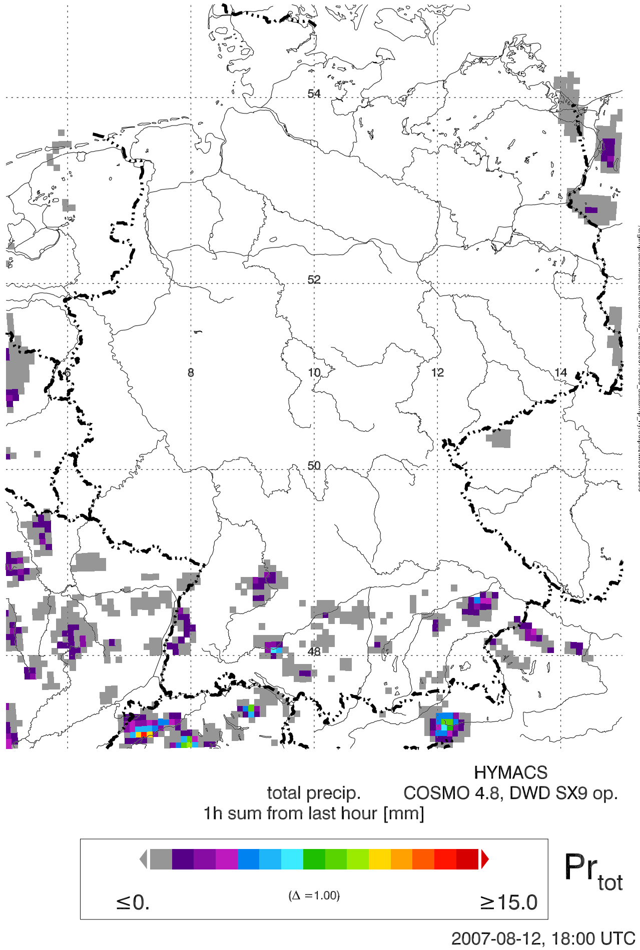
(MSG rapid scan, 12.8.2007, 18:00 UTC; front, H: DWD)

12.8.2007, 18:00 UTC (air mass convection)

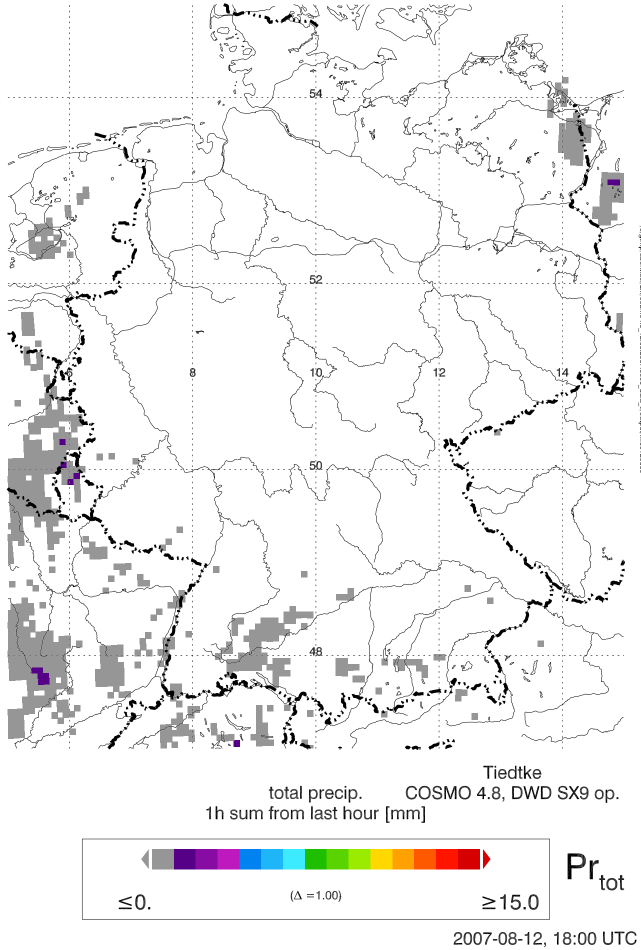
hourly precipitation sums



rain gauges
DWD network



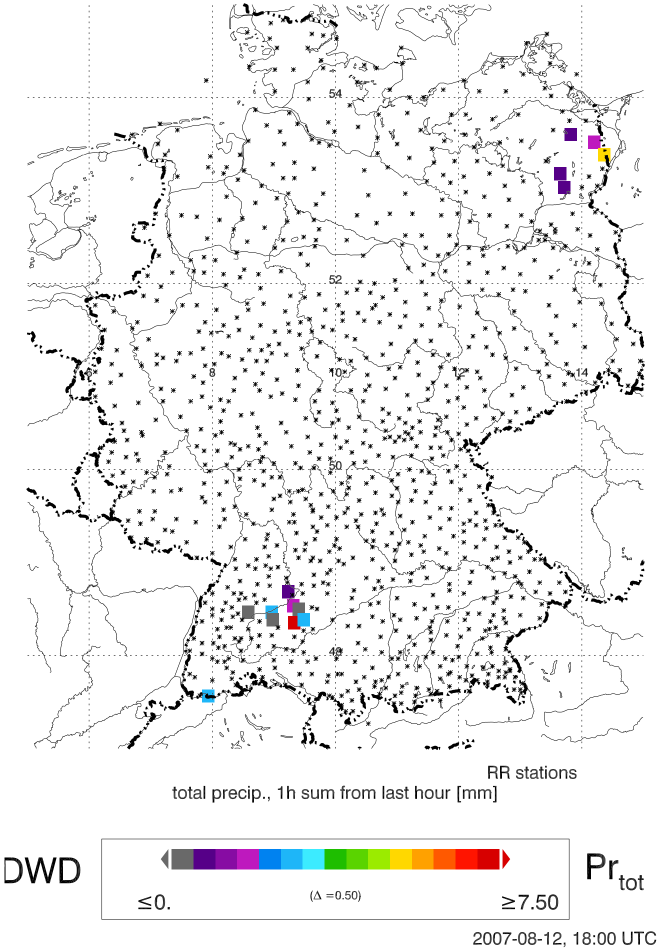
COSMO 4.8
HYMACS
7 km



COSMO 4.8
Tiedtke
7 km

12.8.2007, 18:00 UTC (air mass convection)

hourly precipitation sums



rain gauges
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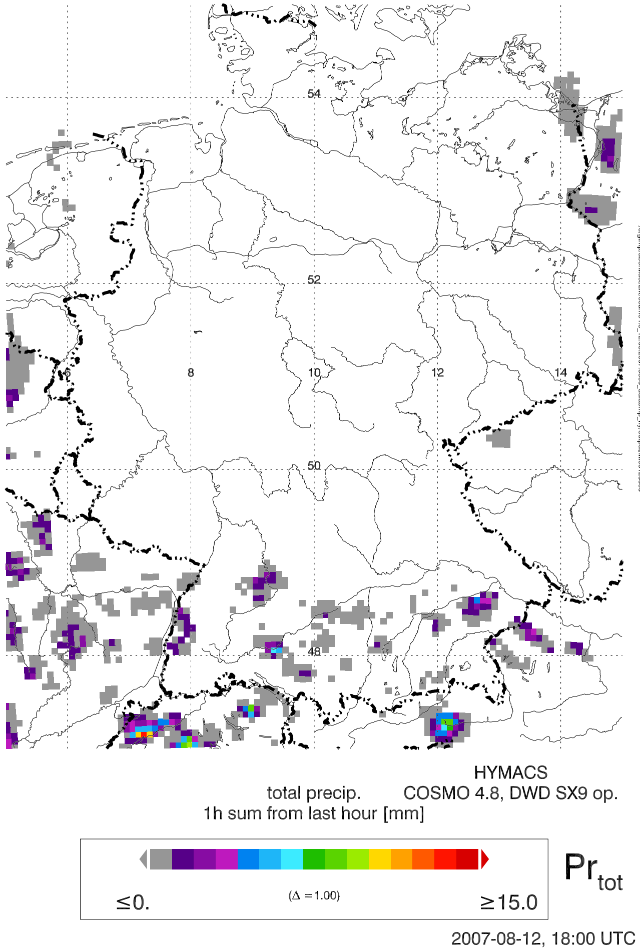

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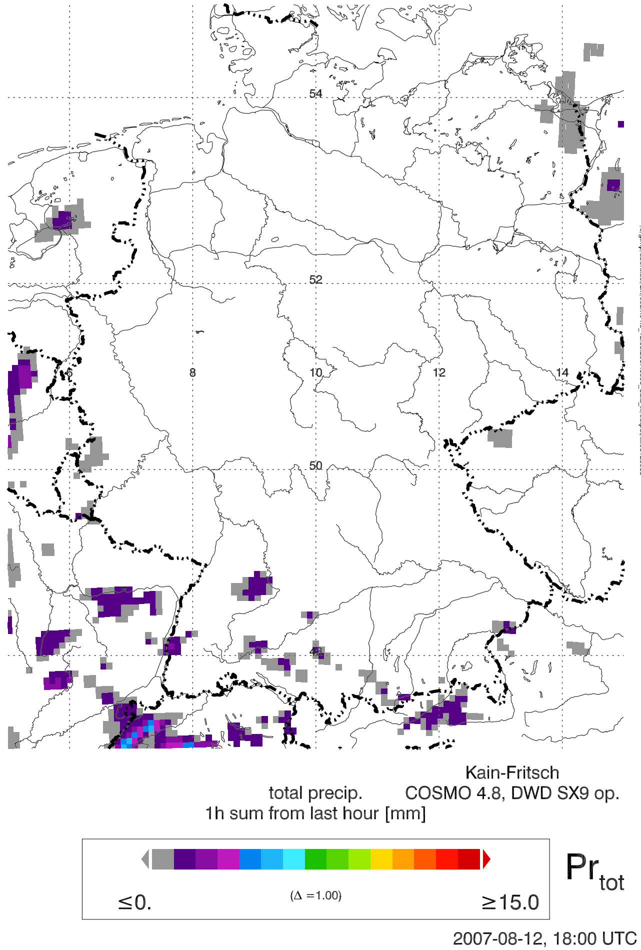
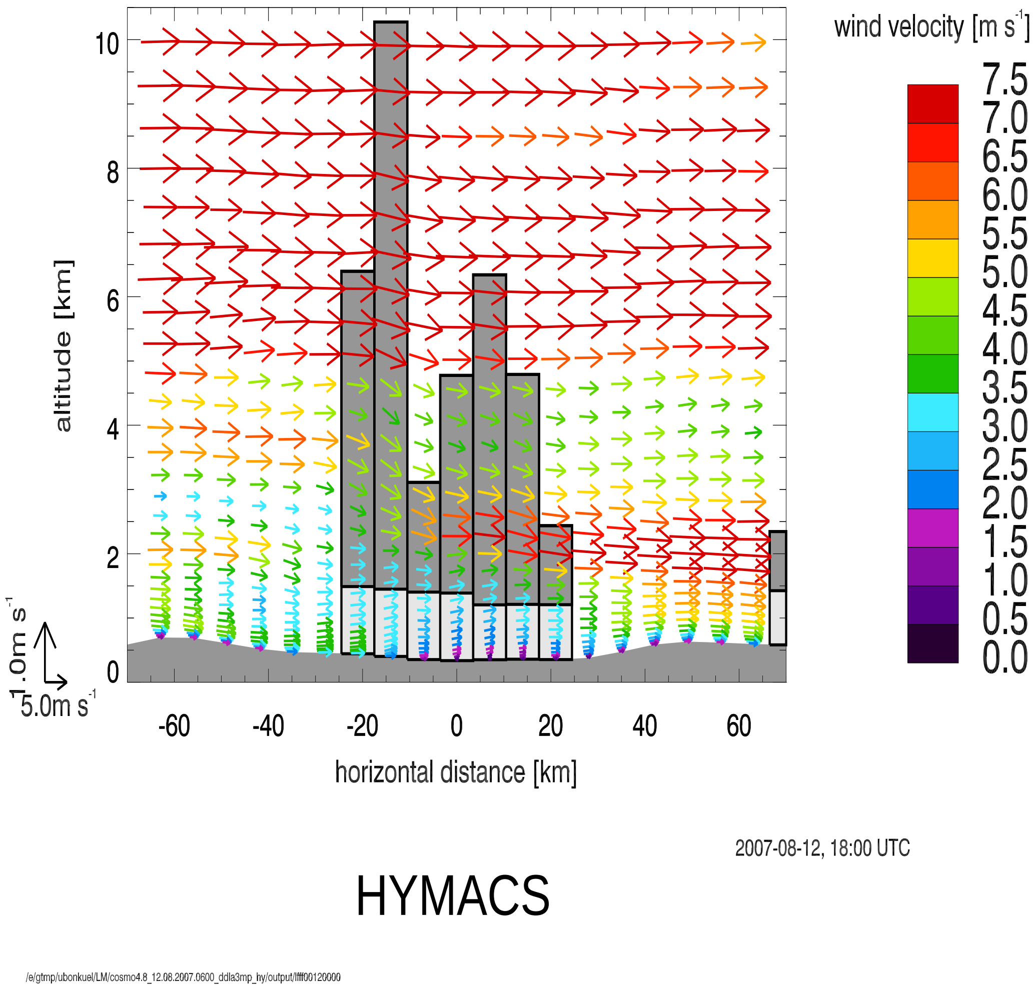


COSMO 4.8
Kain-Fritsch
7 km

12.8.2007, 18:00 UTC (air mass convection)

wind field across convective cluster ...



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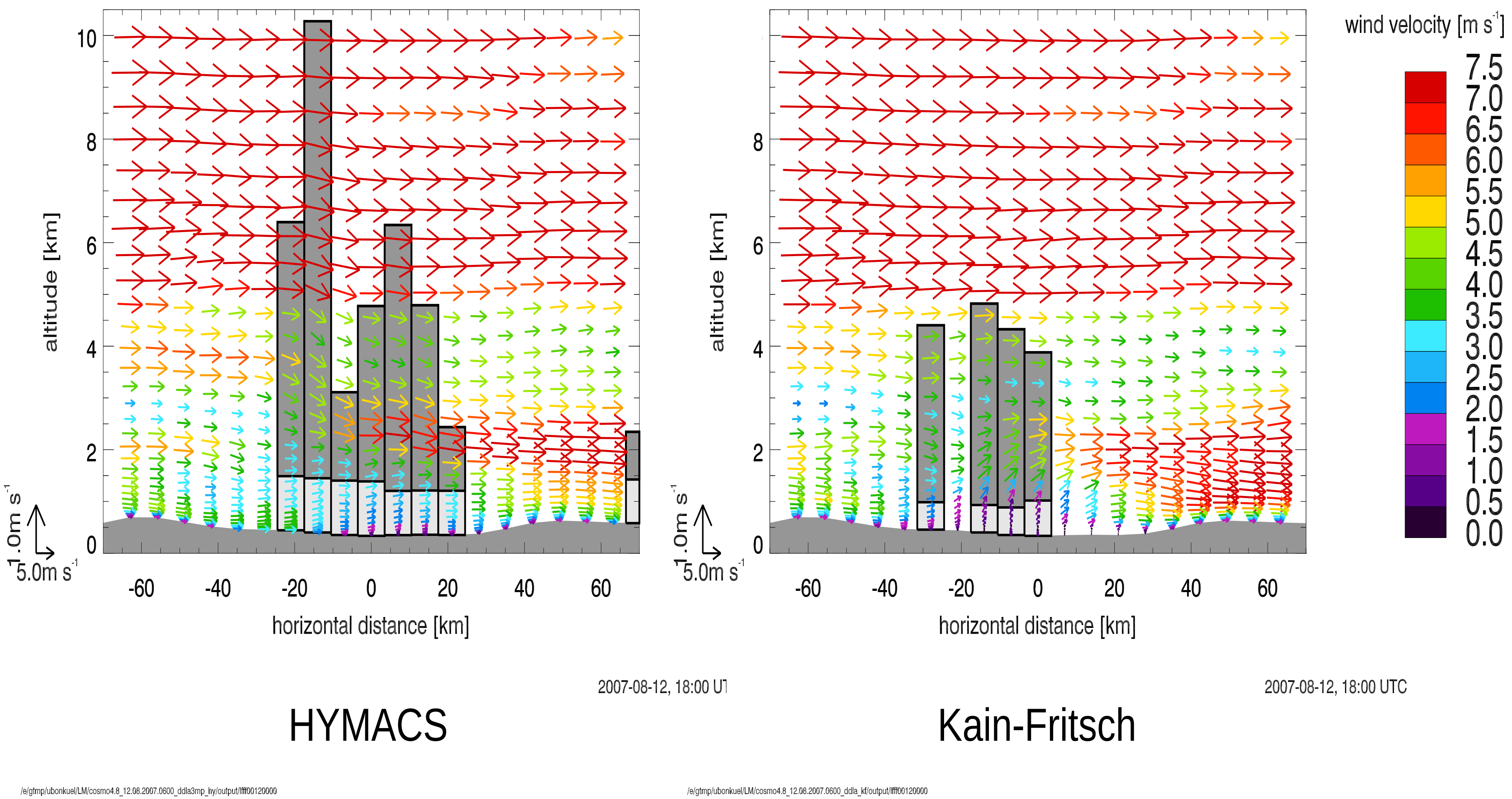

HYMACS

Kain-Fritsch

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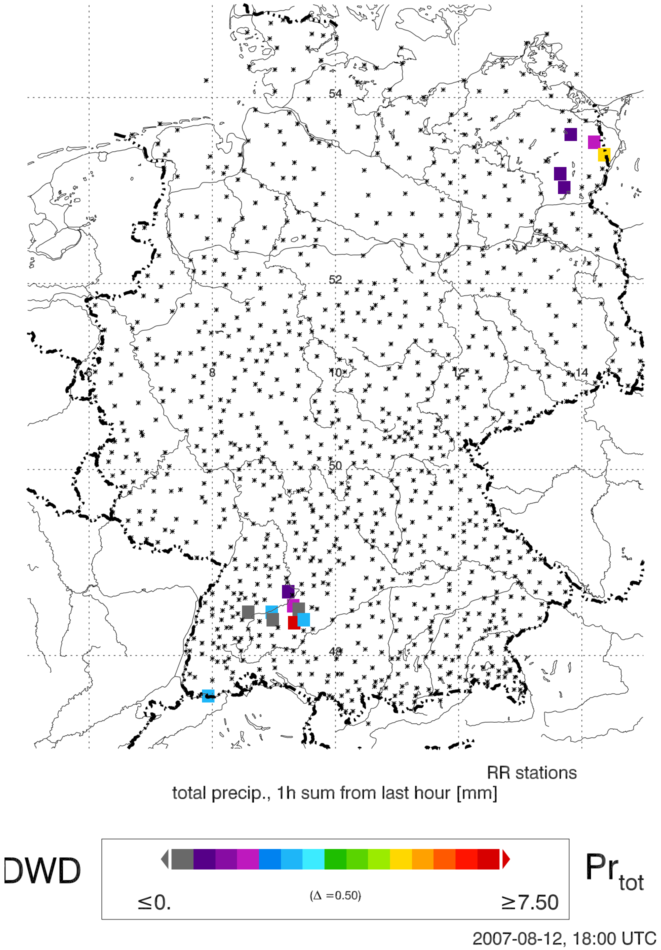
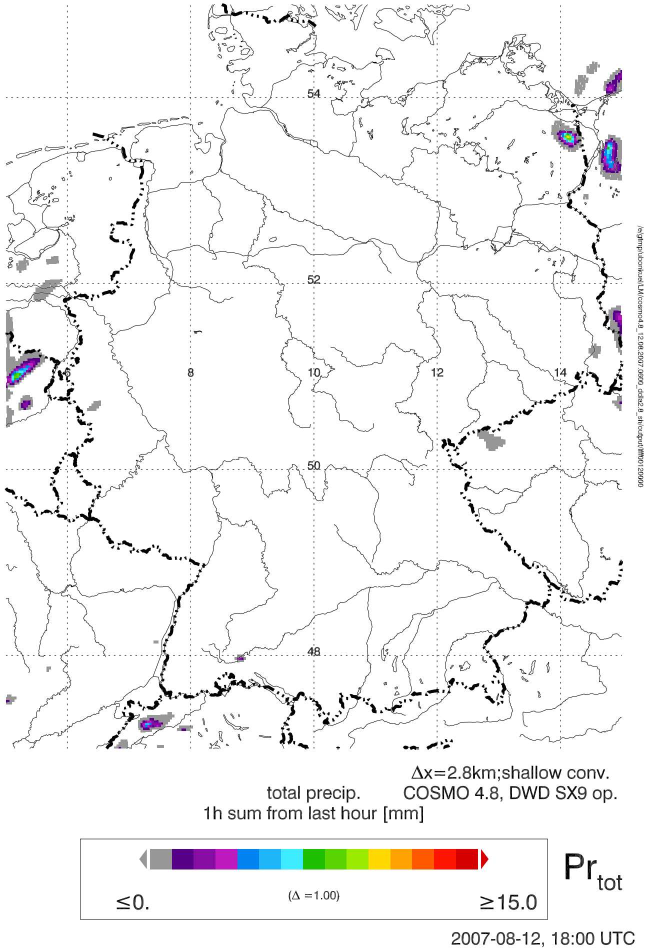
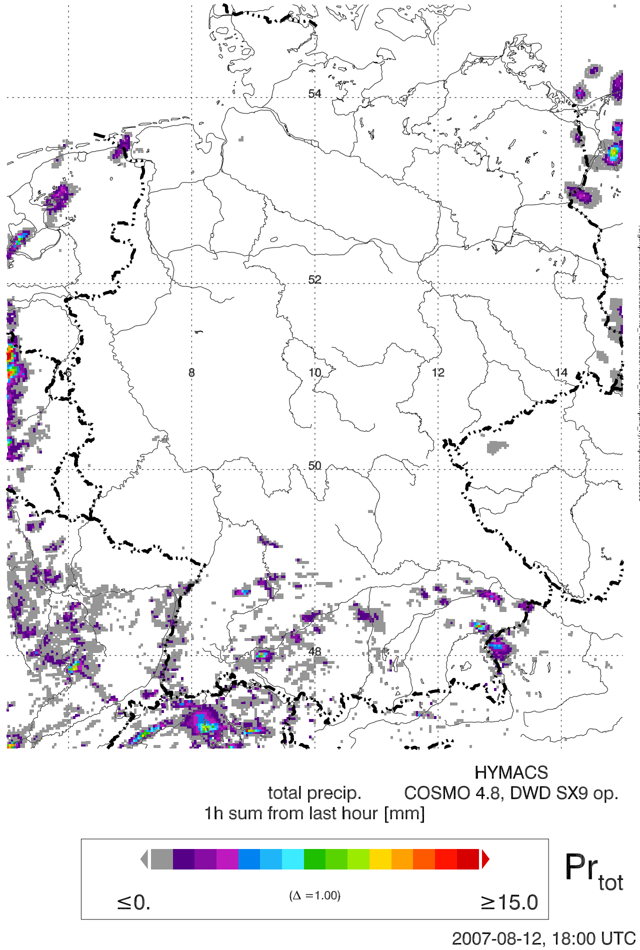
hourly precipitation sums



rain gauges
DWD network



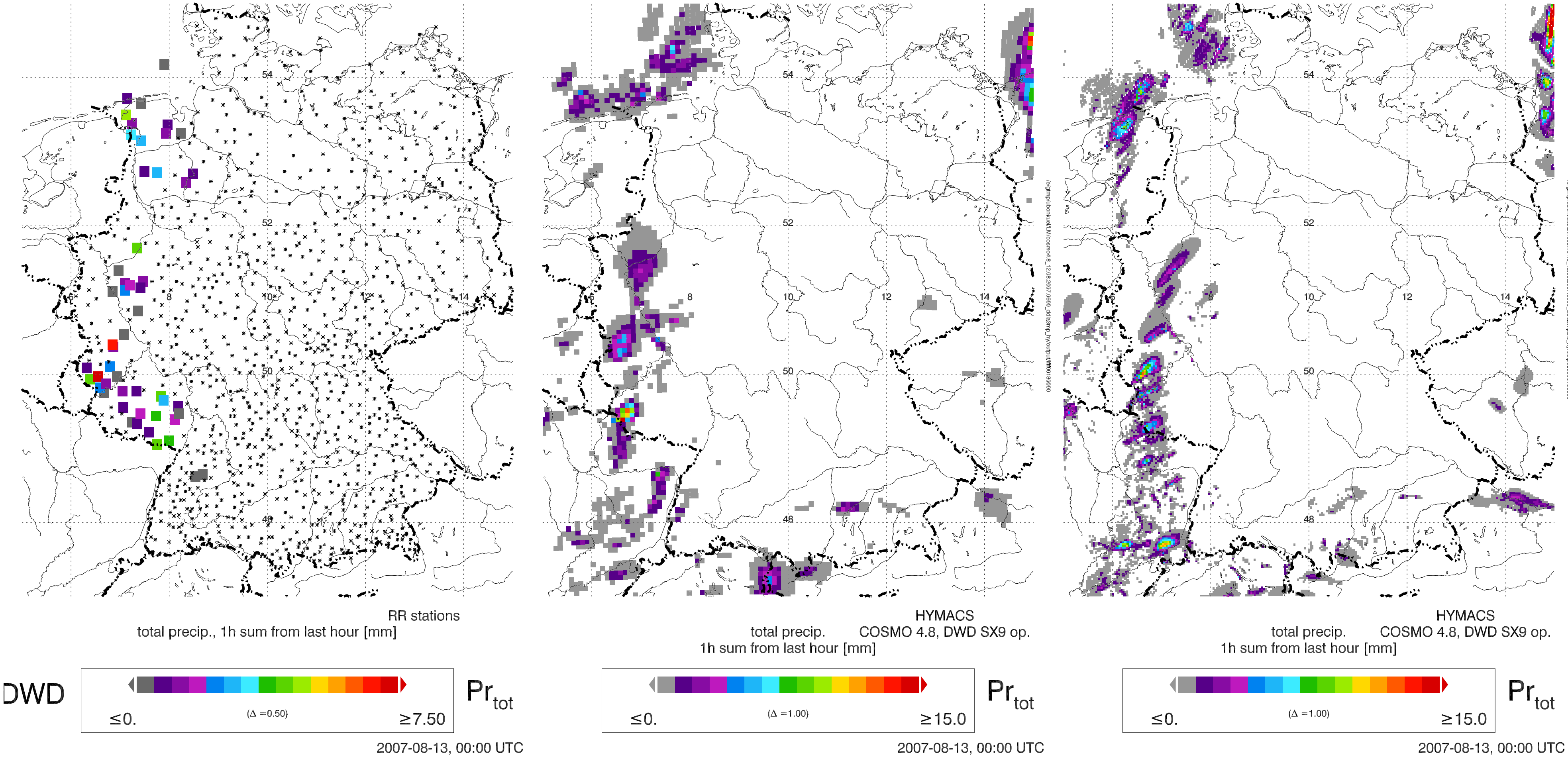
COSMO 4.8
shallow conv.
2.8 km



COSMO 4.8
HYMACS
2.8 km

13.8.2007, 0:00 UTC (frontal convection)

hourly precipitation sums



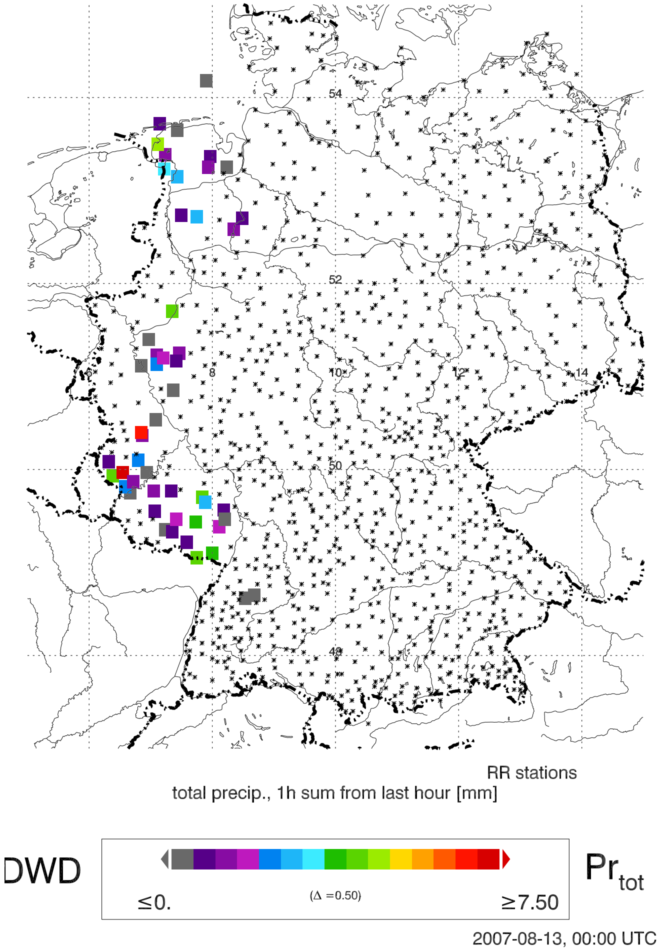
rain gauges
DWD network

COSMO 4.8
HYMACS
7 km

COSMO 4.8
HYMACS
2.8 km

13.8.2007, 0:00 UTC (frontal convection)

hourly precipitation sums



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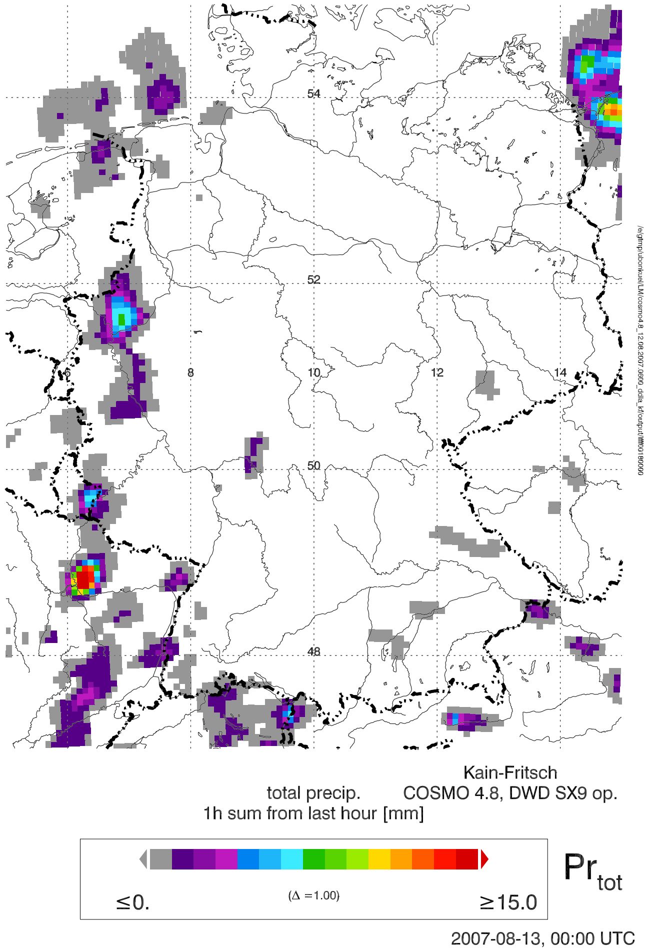
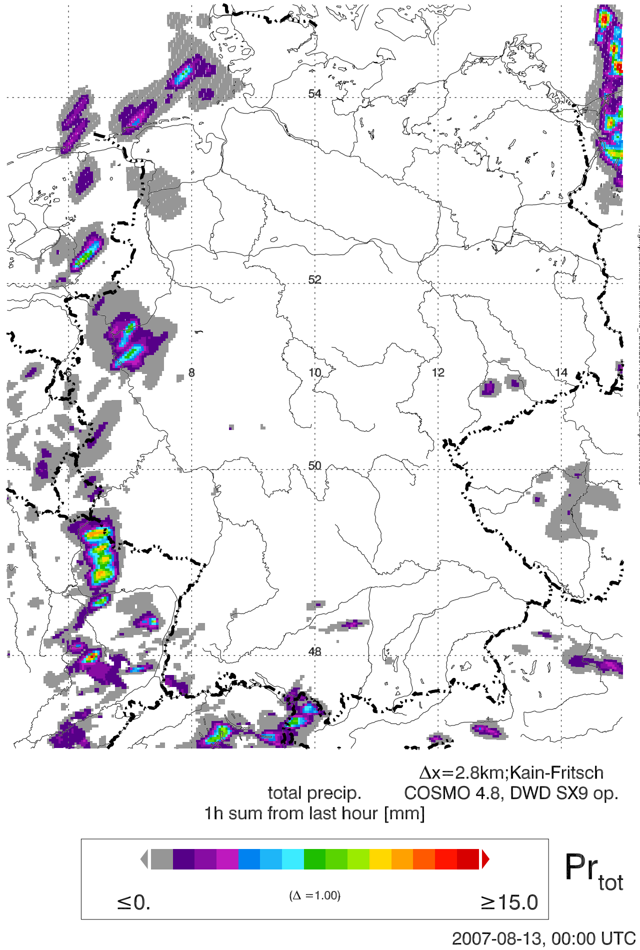


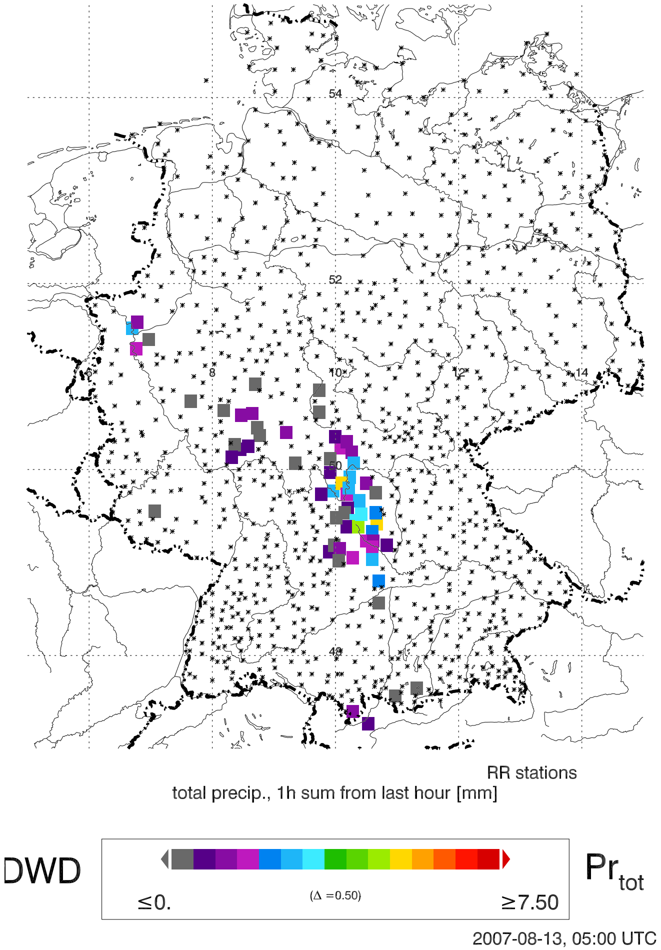
COSMO 4.8
Kain-Fritsch
7 km



COSMO 4.8
Kain-Fritsch
2.8 km

13.8.2007, 5:00 UTC (frontal convection)

hourly precipitation sums



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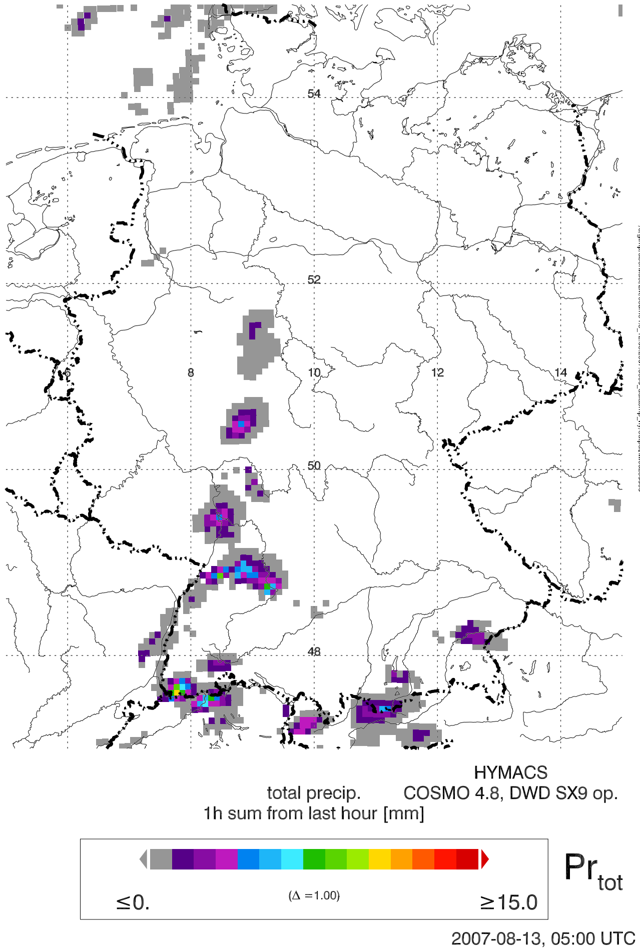

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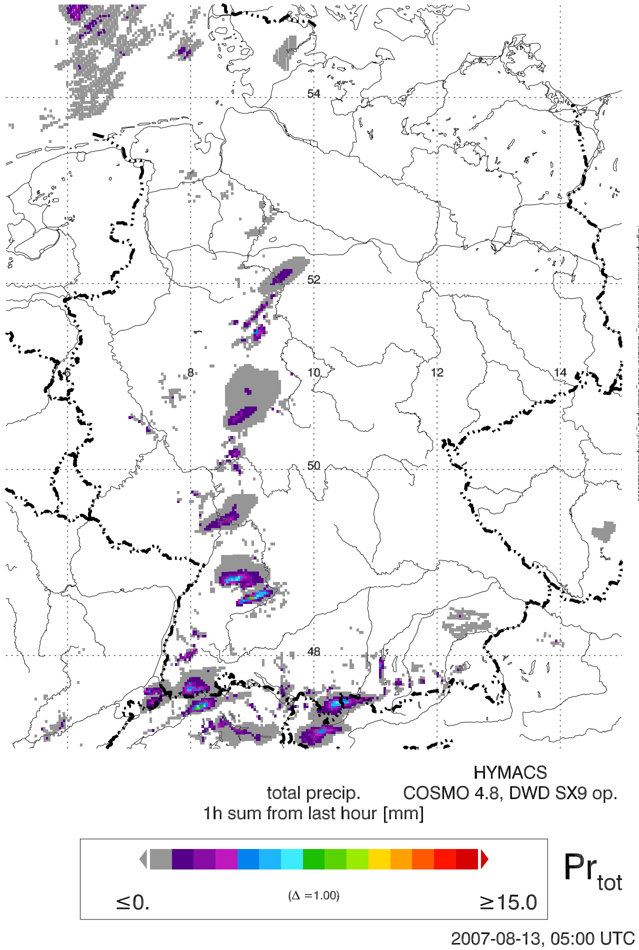

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2.8 km

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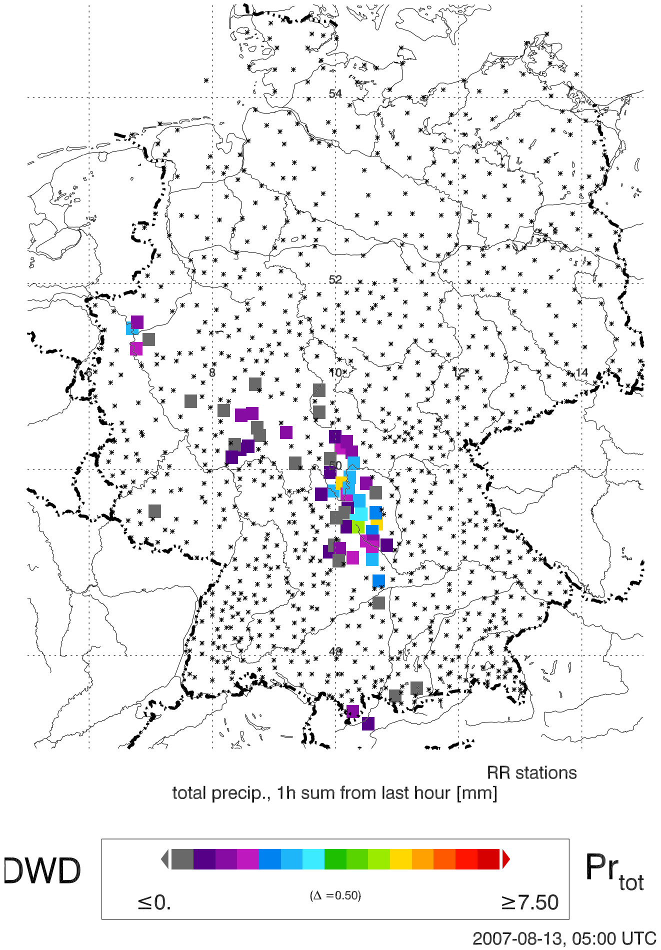
hourly precipitation sums



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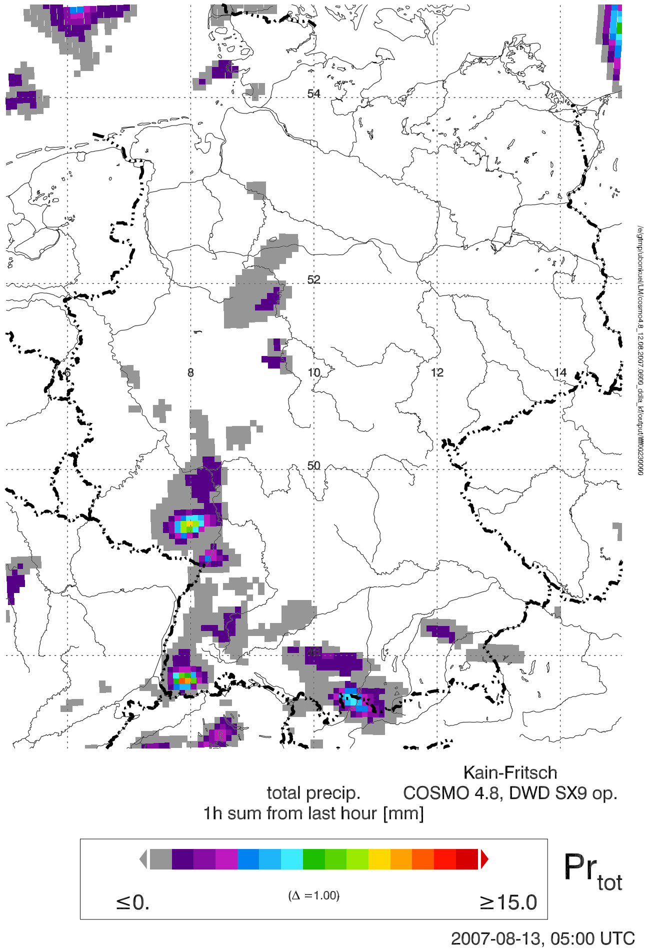

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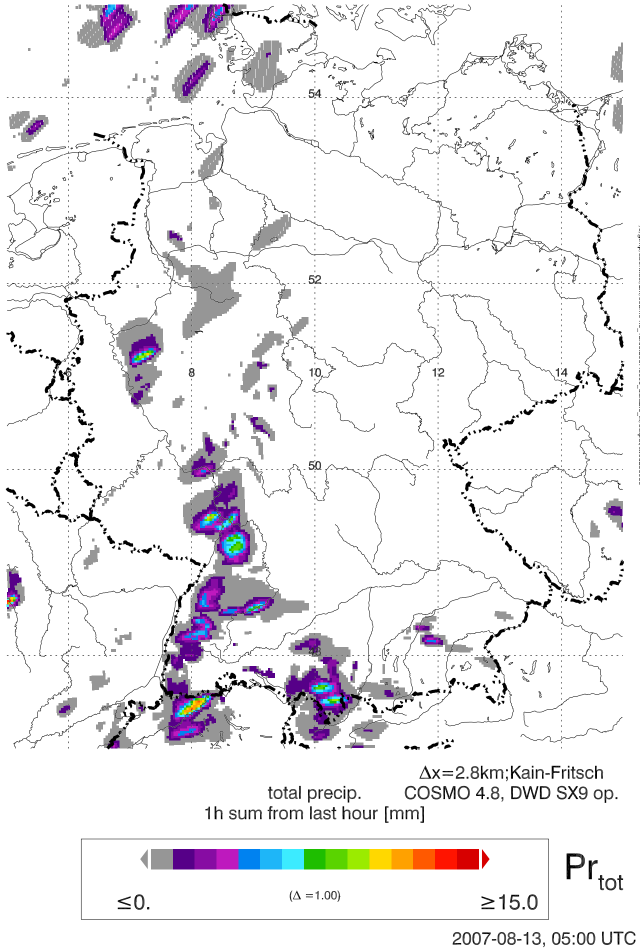


COSMO 4.8
Kain-Fritsch
2.8 km

Summary:

comparison with classical conv. schemes:

HYMACS: realistic dynamics in environment of conv. cells

comparison with rain gauges and classical conv. schemes/explicit conv.:

HYMACS: realistic spatial distribution of precipitation

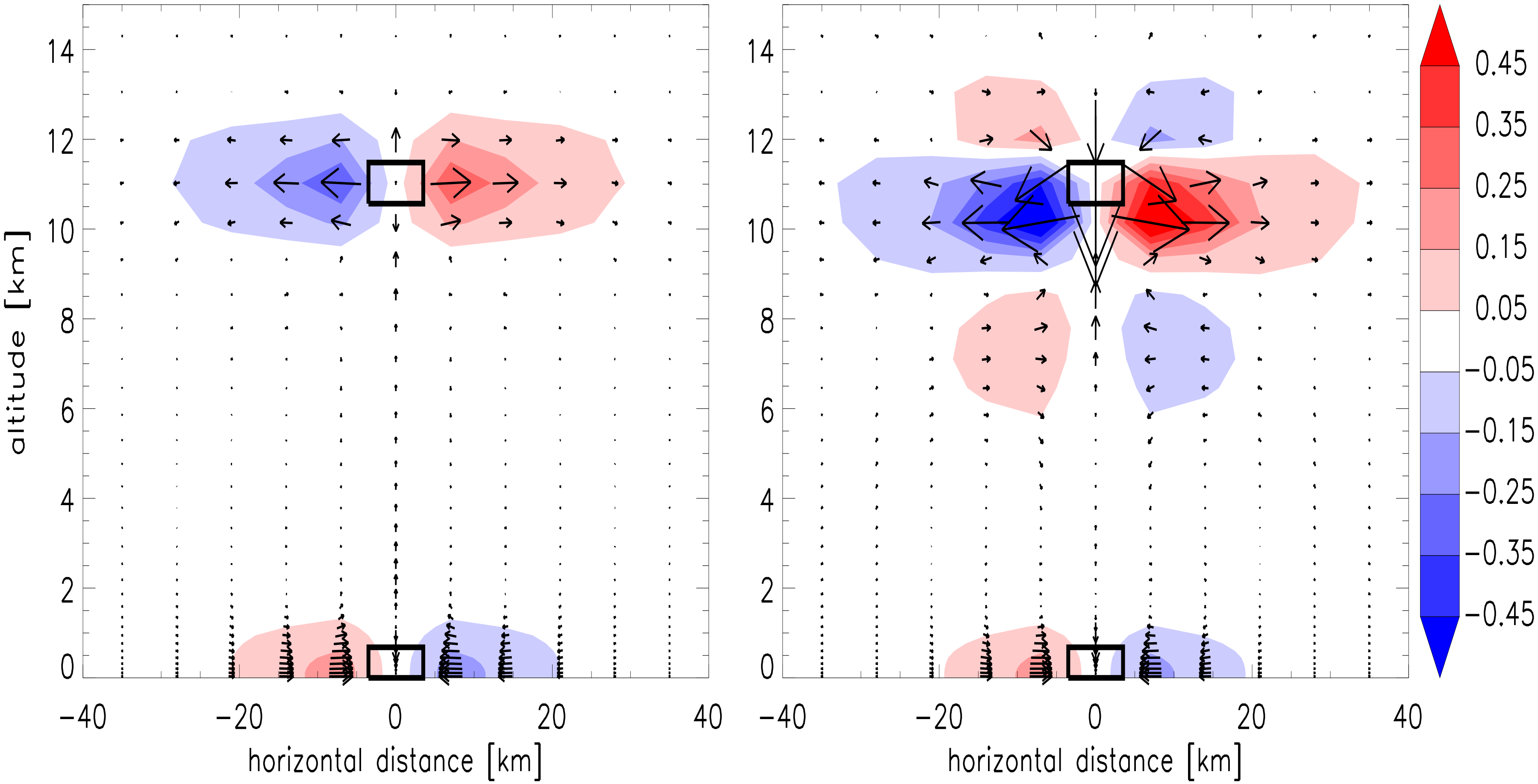
$\longrightarrow$ more independent of grid size of hosting model

Publications:

- Kuell, V., and A. Bott, 2009:
  Application of the hybrid convection parameterization scheme HYMACS to different meteorological situations, Atmos. Res., DOI: 10.1016/j.atmosres.2009.04.002, in press.
- Kuell, V., and A. Bott, 2008:
  A hybrid convection scheme for use in non-hydrostatic numerical weather prediction models, Meteorol. Z., 17, 775-783.
- Kuell, V., A. Gassmann and A. Bott, 2007:
  Towards a new hybrid cumulus parameterization scheme for use in non-hydrostatic weather prediction models, Q. J. R. Meteorol. Soc., 133, 479-490.

subgrid scale mass transport:

idealized conv. transp. in single grid column



transport of mass only transp. of mass, heat, moisture

convection scheme:

subgrid scale transport of mass, heat, moisture + ...

- cloud model (up–/downdraft, precip., incl. ice phase)
- trigger: analoguously to Fritsch and Chappell (1980), Kain (2004):
  at LCL: $\Delta T^u_{v,FC} = \sqrt[3]{\gamma(\bar{w} - w^*)}$ with w^* as threshold
  and: $\Delta T^u_{v,TKE} = T^* \sqrt[3]{v_{TKE}} - T_0$ with $v_{TKE} = \sqrt{2\,\overline{TKE}}$
  LFC reached / CIN overcome ?

- closure: at first moisture convergence closure (Tiedtke, 1989)
  $\longrightarrow$ several cases with too weak stabilization $\longrightarrow$ grid scale convection
  $\longrightarrow$ better: horiz. mass flux convergence closure
  $M^u_{LCL} = (\Delta x)^2 \int_{USL} \nabla_h \cdot (\rho \mathbf{v}_h) dz$

$\longrightarrow$ effective suppression of grid scale convection