Meteorologisches Institut

Universität Bonn

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Nesting of COSMO and WRF into various global models - a comparitive case study analysis

COSMO-User Seminar
07.03.2013

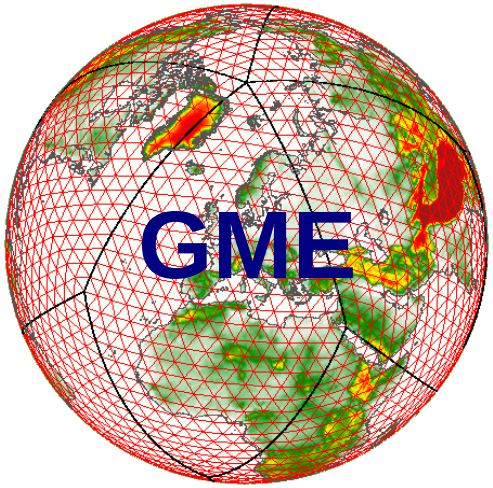
Sebastian Knist
(Prof. A. Bott)

CONSORTIUM FOR SMALL SCALE MODELING
COSMO

WRF

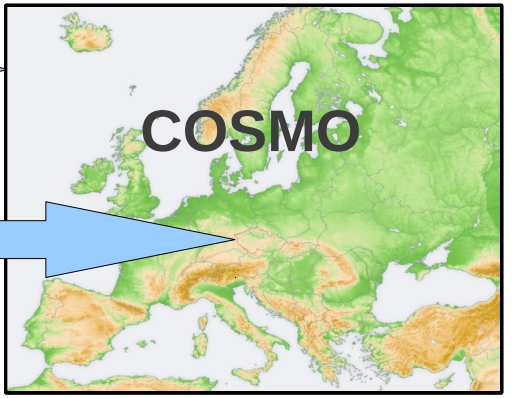
Usual nesting

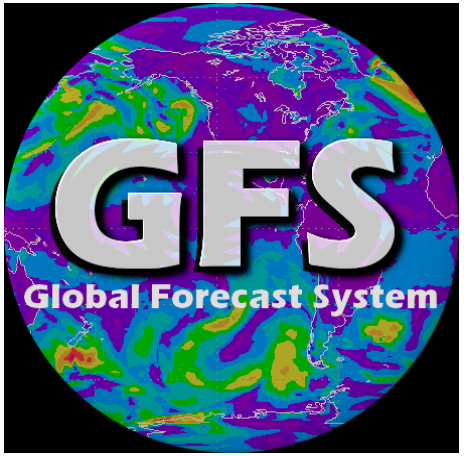
global model **local model**



boundary conditions

initial values





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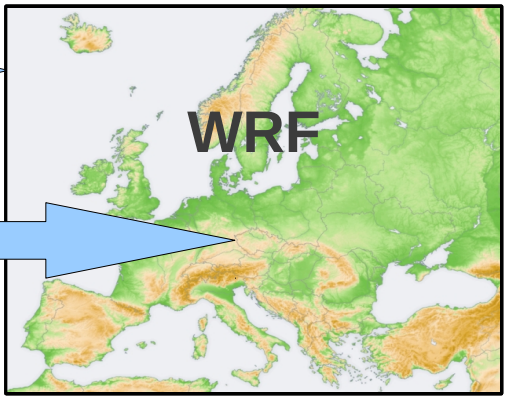
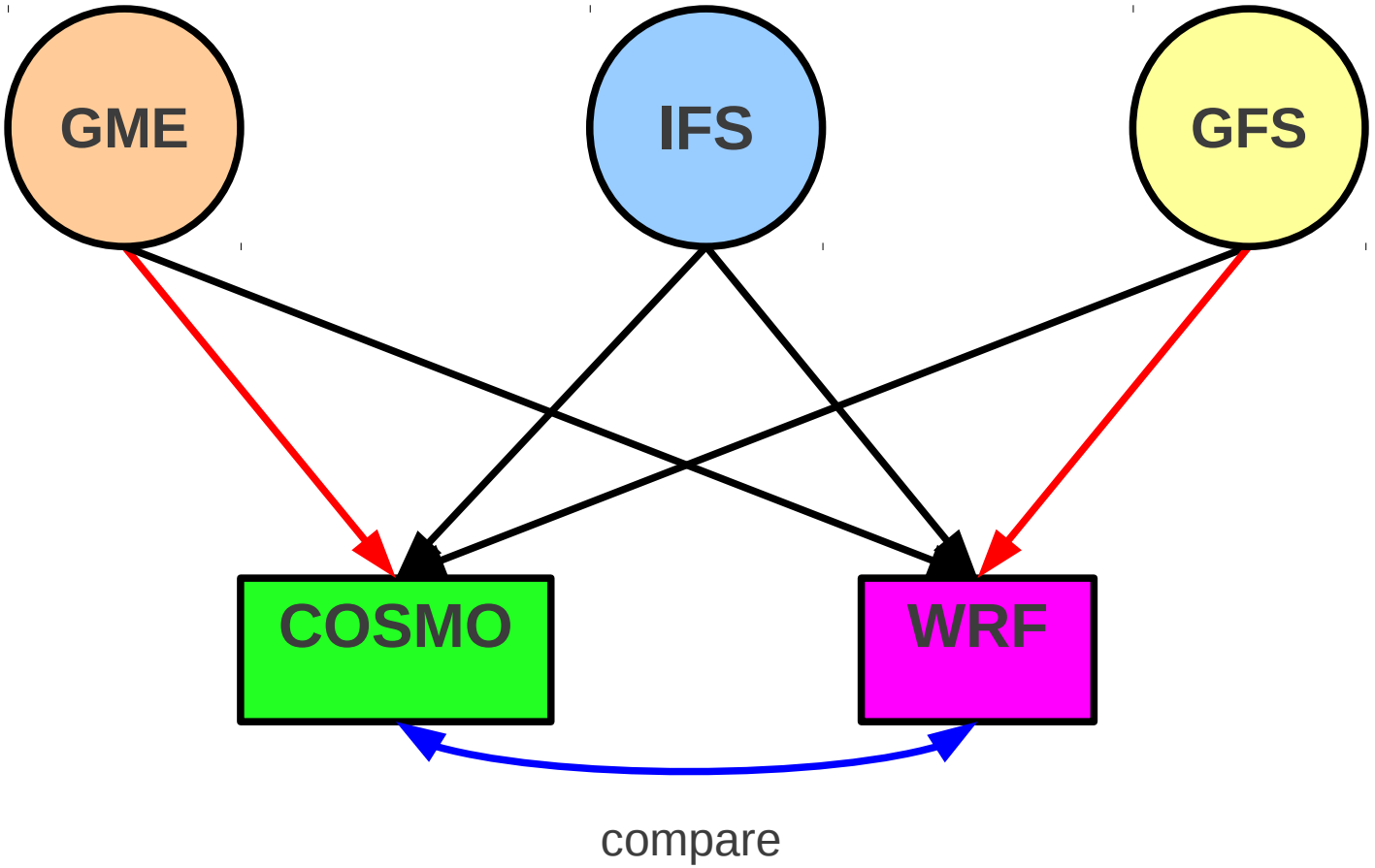


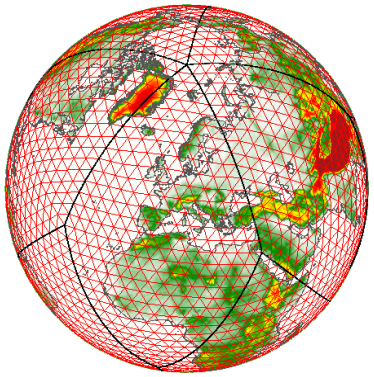
Various model nesting



➔ **6 possible combinations**

Technical challenges

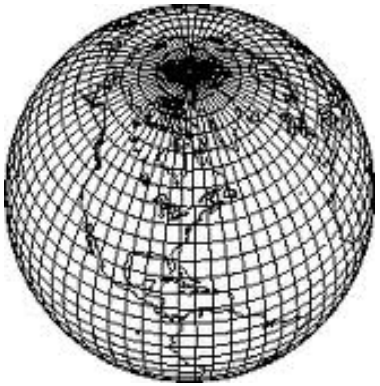
- Different global model grid structures, data format, parameters, parameter Ids, etc.



GME

triangular
~30km

60 levels



GFS

lat-lon
0.5°

26 p-levels

- **Preprocessing**:

WRF: **WPS** optional for GFS and IFS data,
for GME first interpolation on lat-lon grid

COSMO: **INT2LM** optional GME and IFS data,
for GFS (GRIB2 format) some additions to the **int2lm_1.18**
(reading of humidity, interpolation of soil variables)

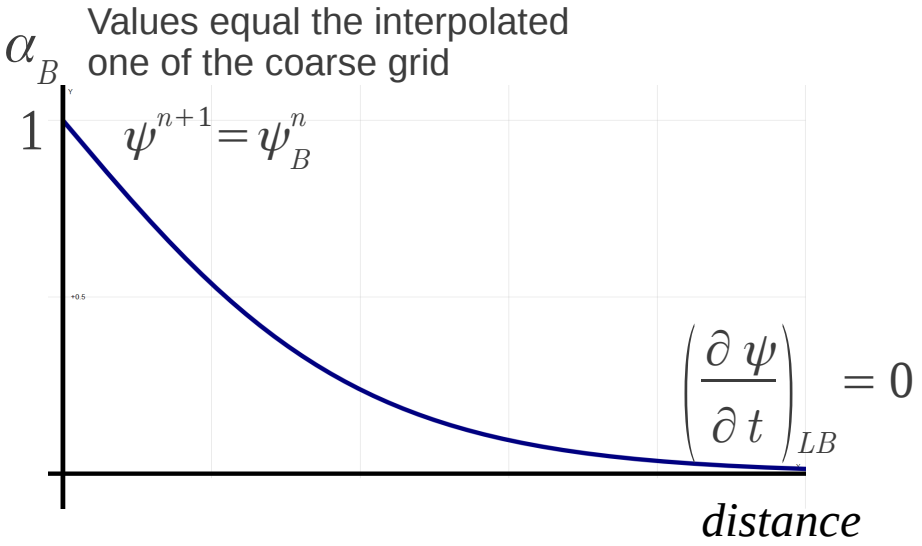
Lateral boundary conditions

- For **real** cases: special lateral boundary conditions supplied by coarser model
- Problem: non-unique information transfer between the models at the boundary due to different spatial resolution and model equations, wave reflexion and numerical noise
- **Relaxation zone** at the boundary:

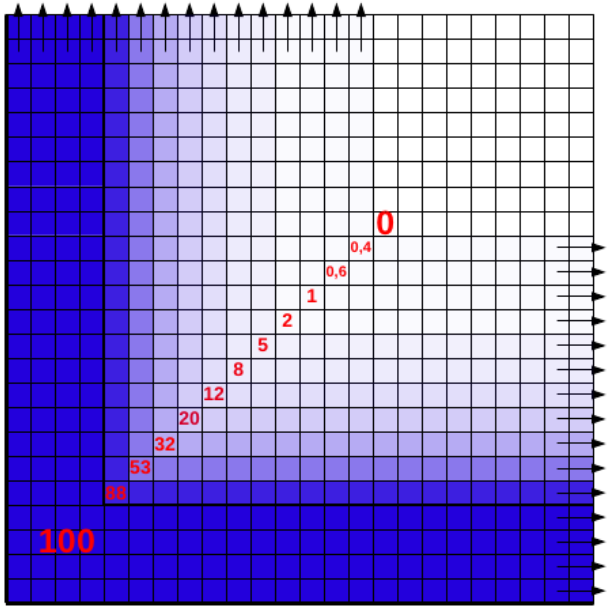
  COSMO and WRF use **Davies-type** LBC
- additional **lateral forcing term** in the progn. equations, which is active only in the relaxation zone:

$$\left(\frac{\partial \psi}{\partial t}\right)_{LB} = -\mu_B(\psi - \psi_B), \qquad \psi^{n+1} = \psi^n - \alpha_B(\psi^n - \psi_B^n), \qquad \alpha_B = \frac{\Delta t \mu_B}{1 + \Delta t \mu_B}$$

Lateral boundary conditions



No influence of the boundary



COSMO relaxation zone

$$\psi^{n+1} = \psi^n - \alpha_B\left(\psi^n - \psi_B^n\right)$$

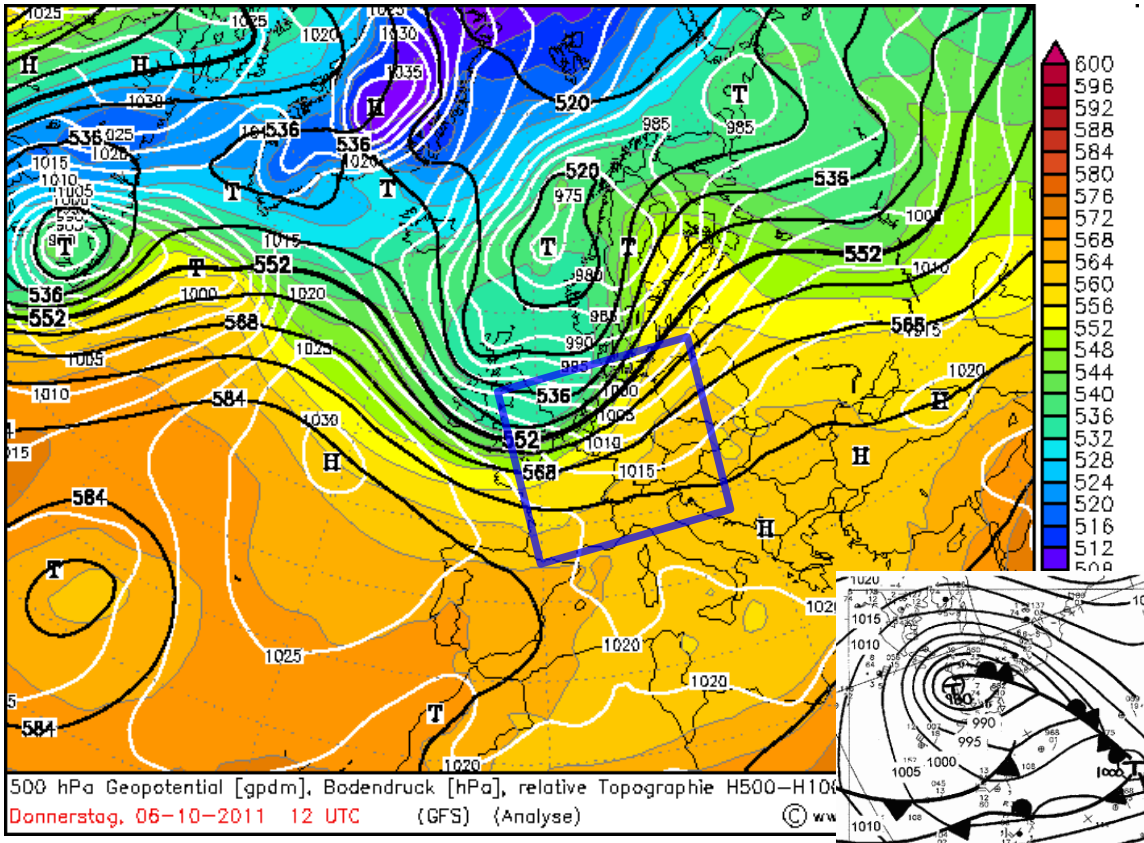
Attenuation coeff.:

$$\alpha_B(d) = \exp(-\gamma\, d/L)$$

Comparison of the 6 model combinations

- Modelling different distinctive synoptic situations
- Qualitative analysis based on characteristic parameters
- How successful is the transformation of the synoptic structure from the lateral boundary to the interior of the local model domain?
- How compatible is the different global model data with each of the local models?
- What differences arise for WRF and COSMO?

- Analysis data: GFS (0.5°, 6h), IFS (0.5°, 6h), GME (~30km, 3h)
- WRF and COSMO same model domain, 200x200x40 GP, 7km resolution, Kain-Fritsch convection, relaxation zone 85km

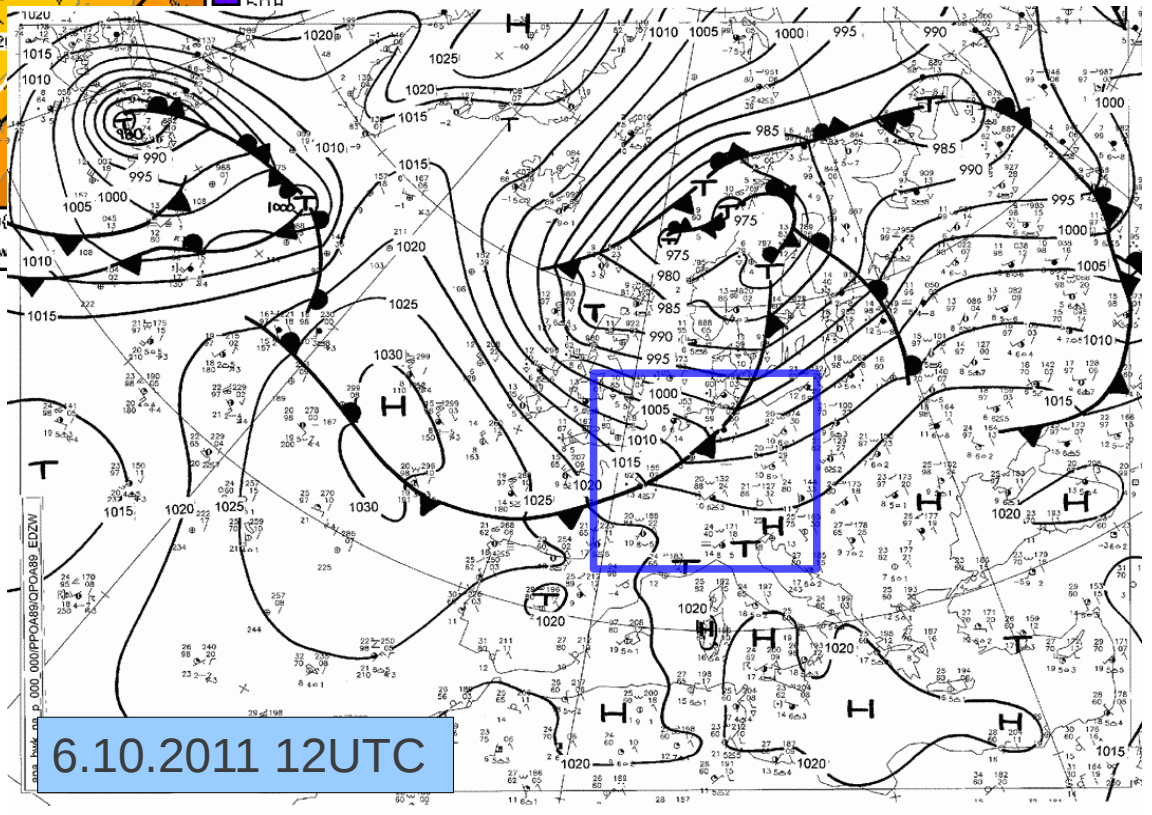


Model test runs of the 6 model combinations

Synoptic situation:

cold front
5.10.2011 12UTC – 7.10.2011 00UTC

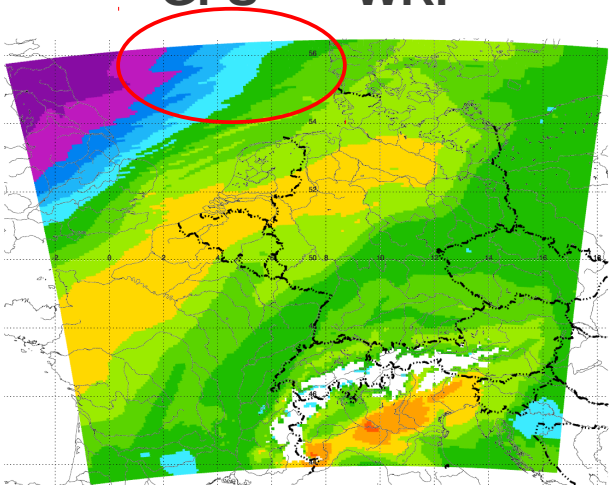
- cf passes model domain from NW to SE
- Driving low pressure system outside the model domain



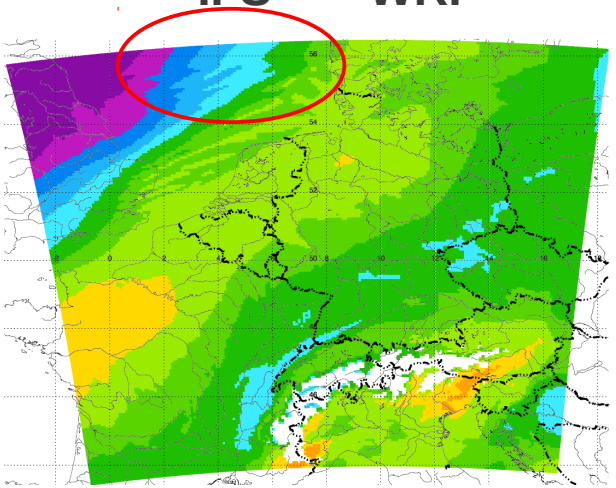
5.10.2011 12UTC **+ 15h**

Model comparison

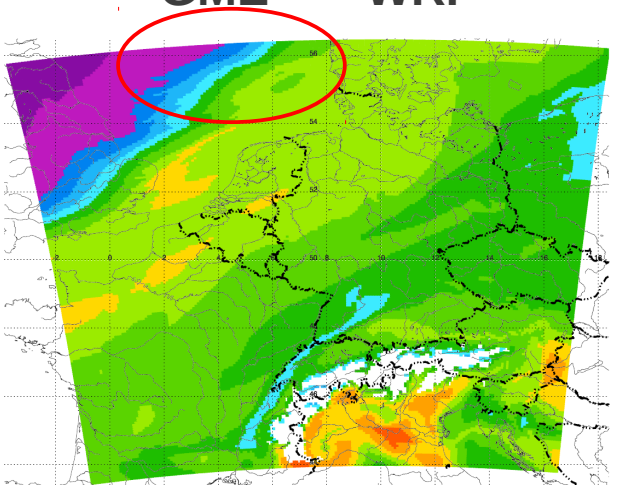
GFS → WRF



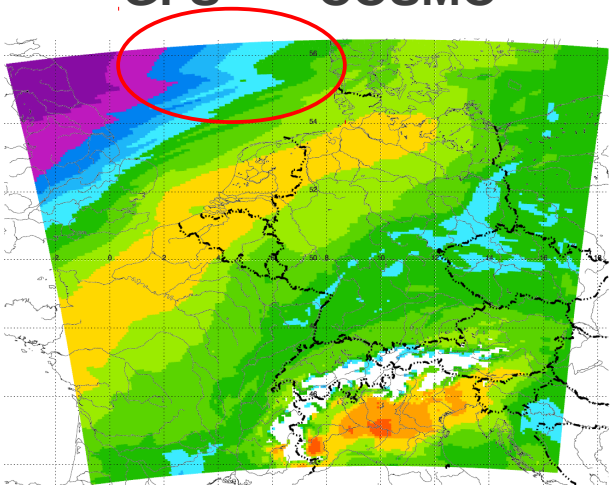
IFS → WRF



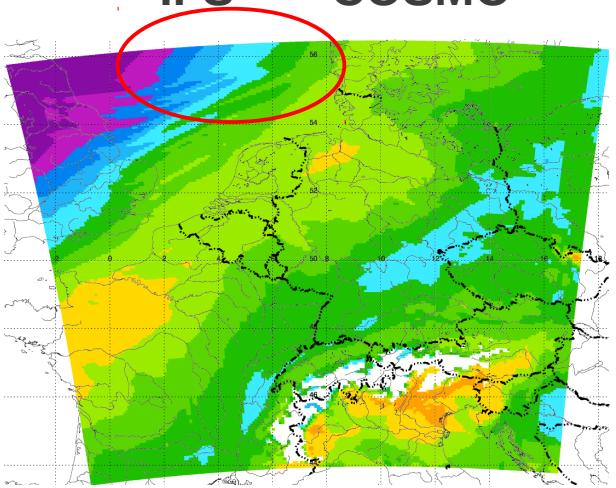
GME → WRF



GFS → COSMO



IFS → COSMO



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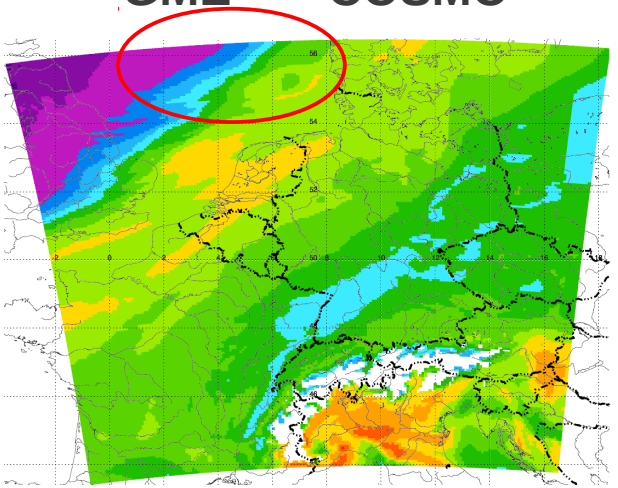
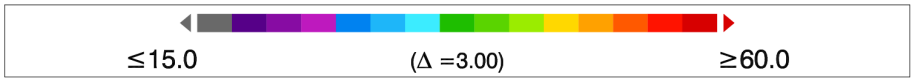


eq. pot. temperature in 850hPa



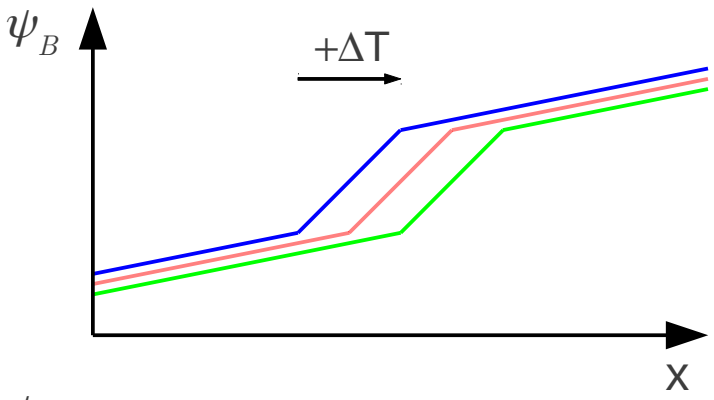
θ_e [°C]

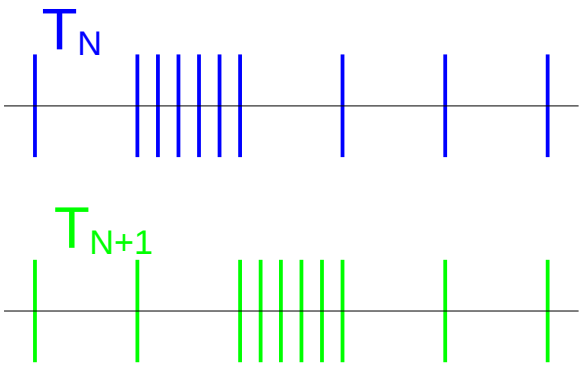
Effect of linear temporal interpolation at the lateral boundary

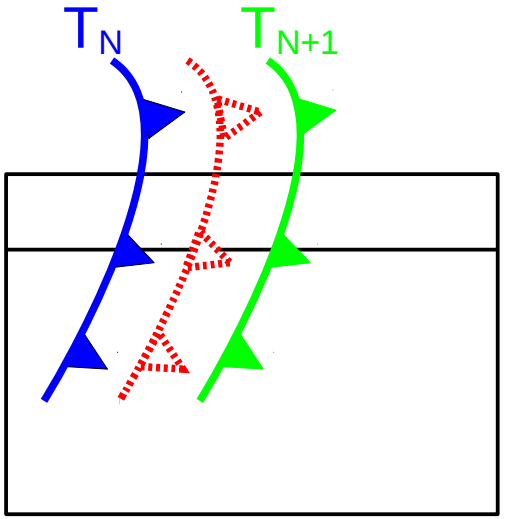
- Data of coarse grid available at times every 3 or 6 hours

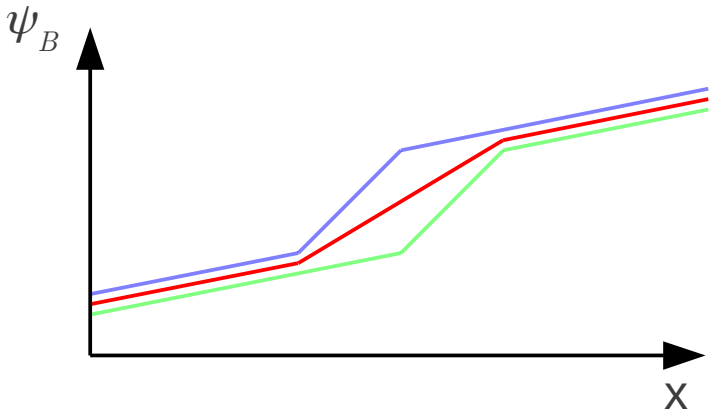
  ➔ **temporal linear interpolation** for every timestep n:

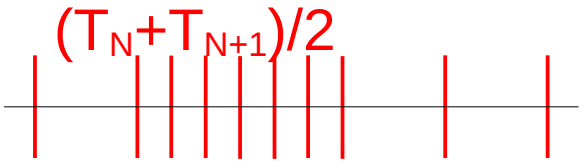
$$\psi_B^n = \psi_B(T_N) + \frac{\psi_B(T_{N+1}) - \psi_B(T_N)}{\Delta T}(n\Delta t - T_N)$$











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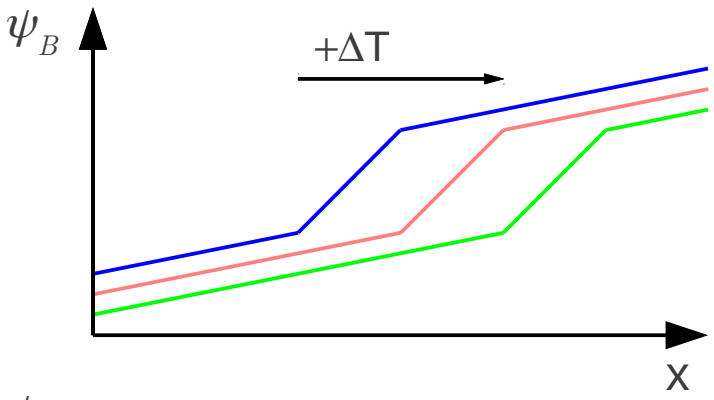
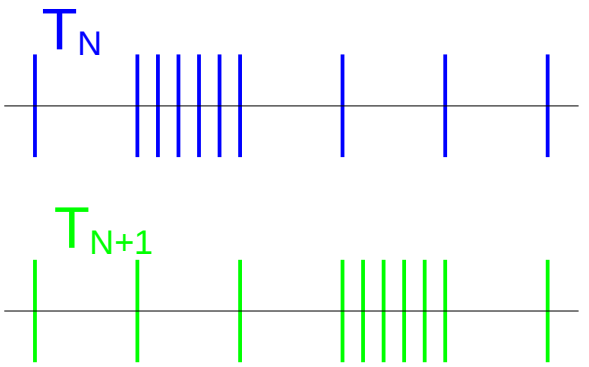
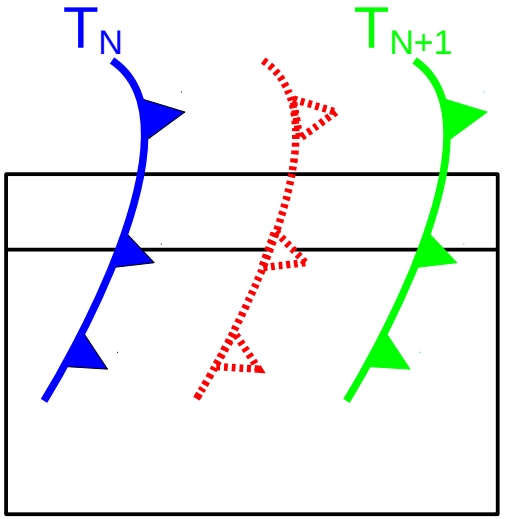
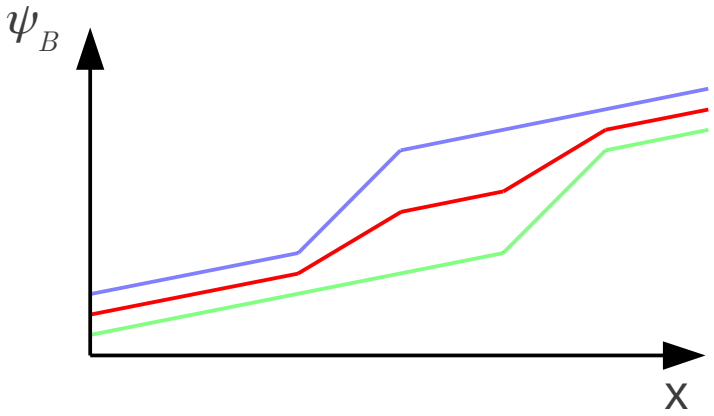
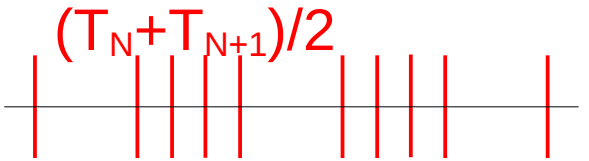






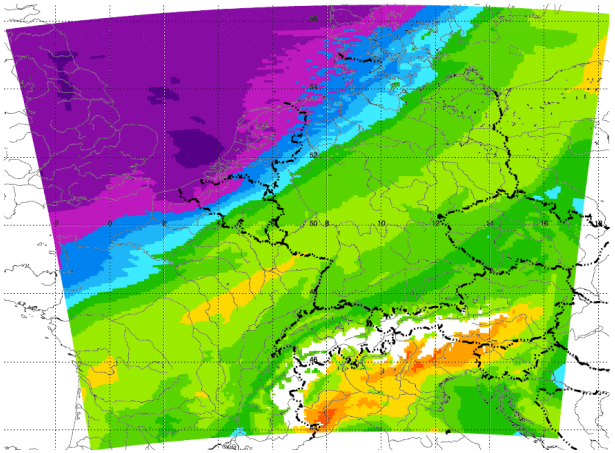




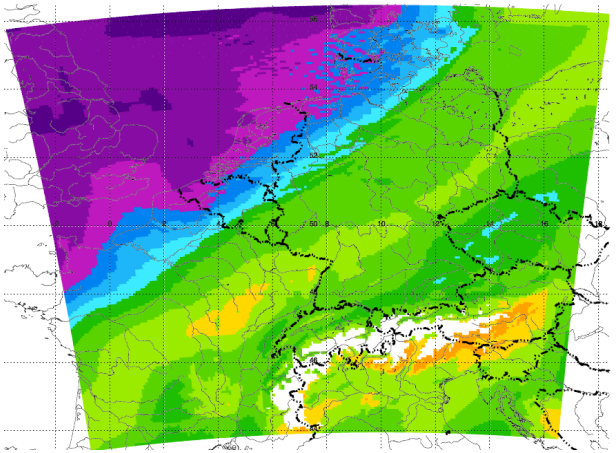
5.10.2011 12UTC **+ 24h**

Model comparison

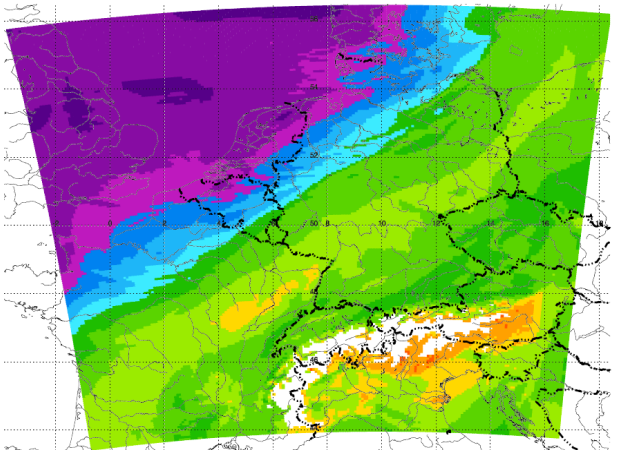
GFS → WRF



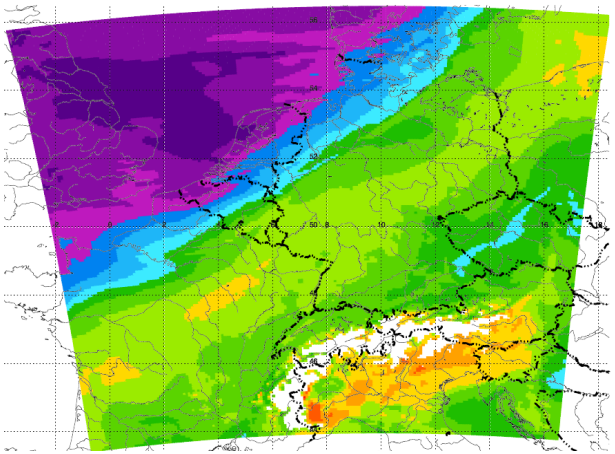
IFS → WRF



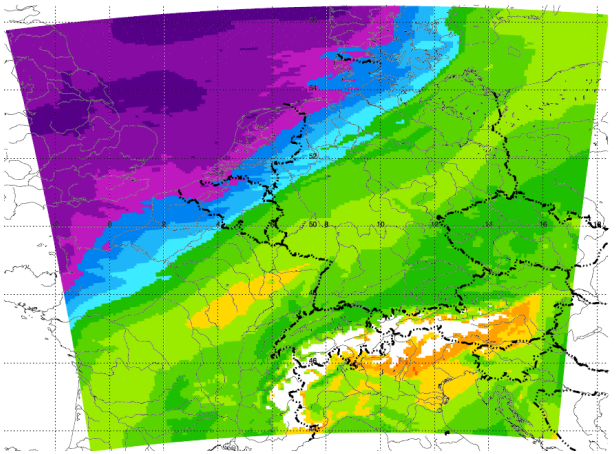
GME → WRF



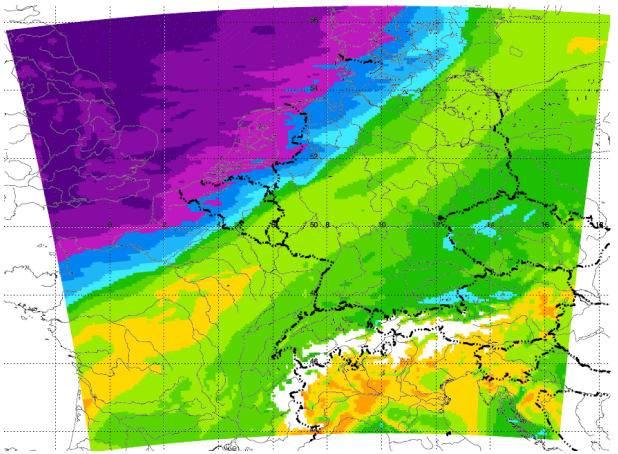
GFS → COSMO



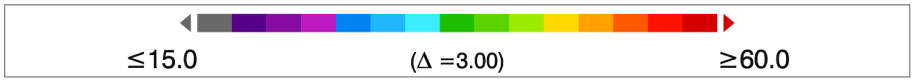
IFS → COSMO



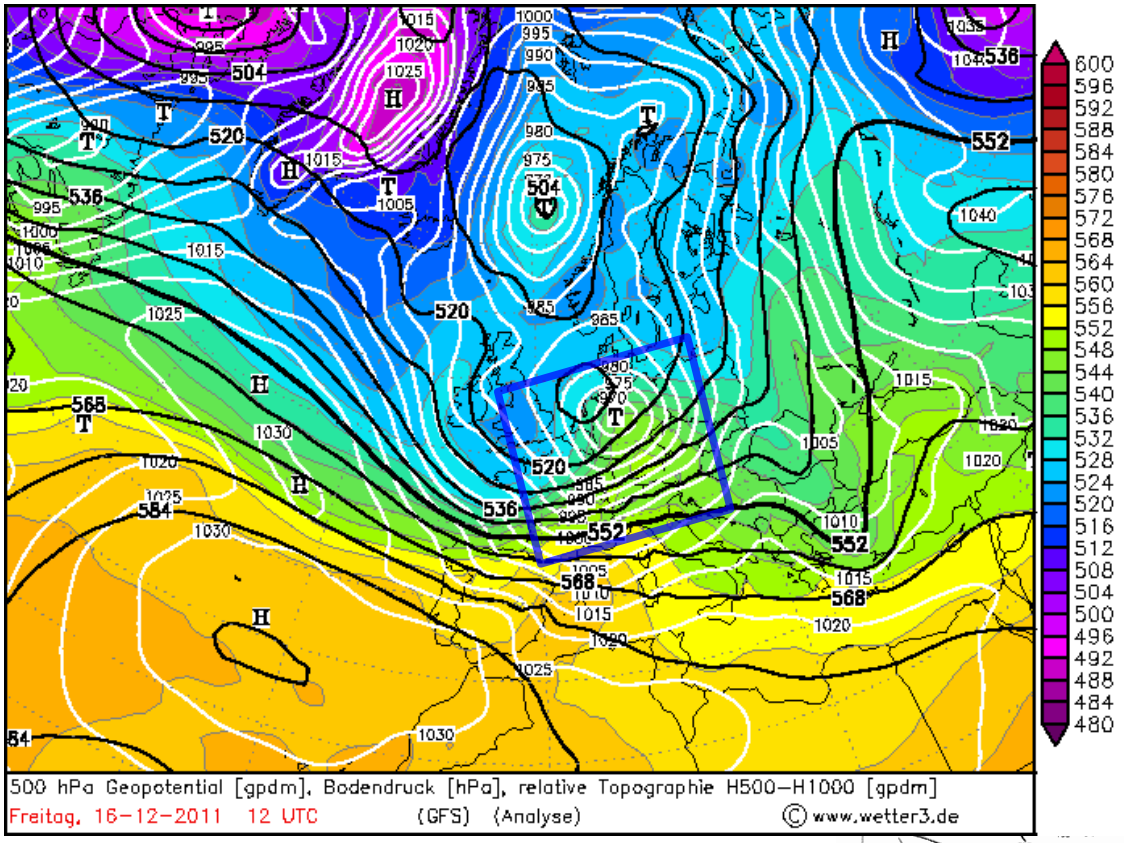
GME → COSMO



eq. pot. temperature in 850hPa



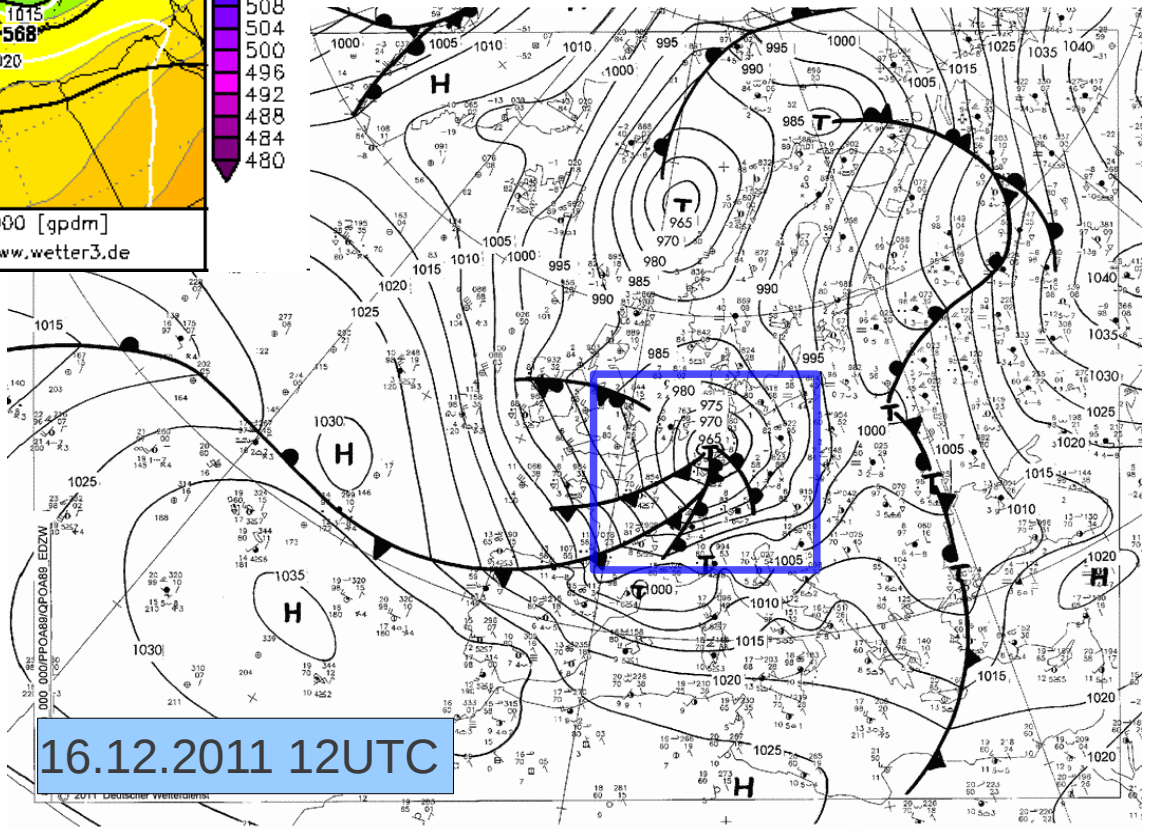
θ_e [°C]



Model test runs of the 6 model combinations

Synoptic situation:

cyclogenesis
15.12.2011 12UTC – 17.12.2011 0UTC

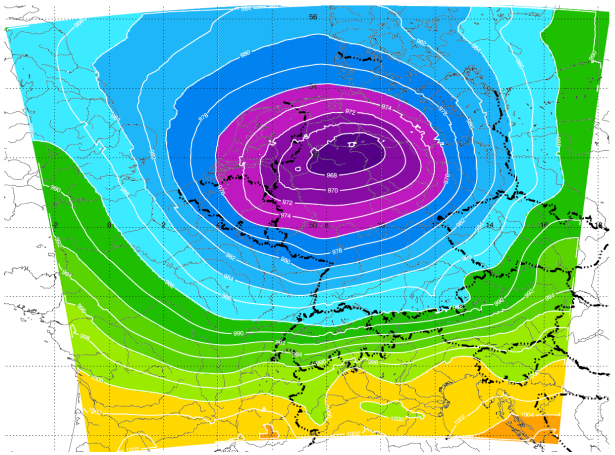


- Cyclone passes model domain
- massiv moisture transport into model domain,
  heavy precipitation

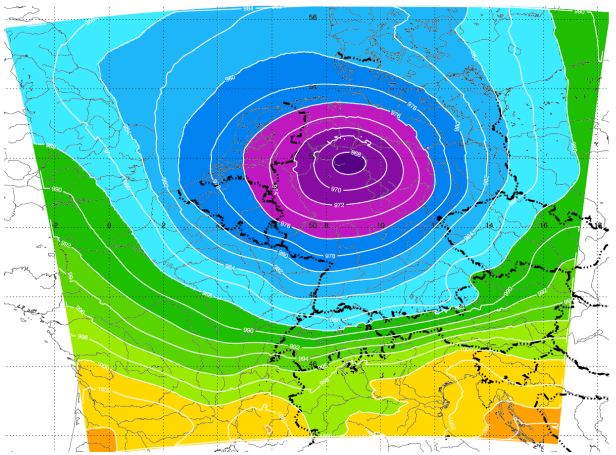
15.12.2011 12UTC **+ 24h**

Model comparison

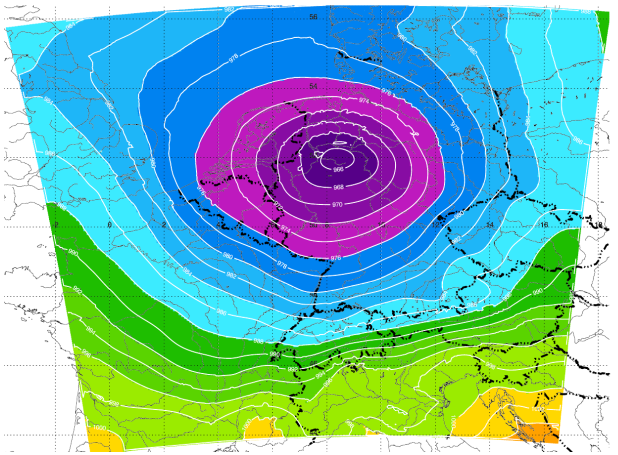
GFS → WRF



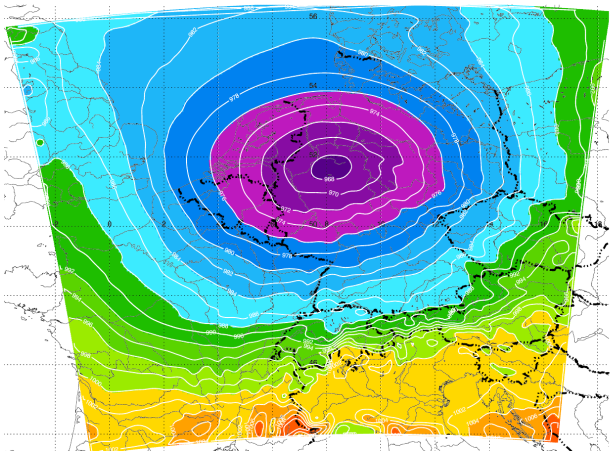
IFS → WRF



GME → WRF



GFS → COSMO



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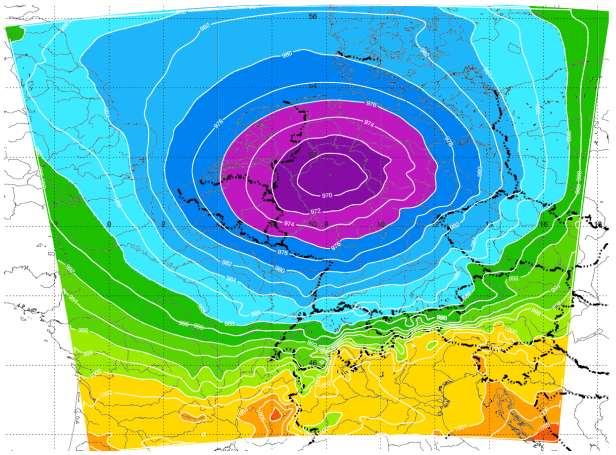

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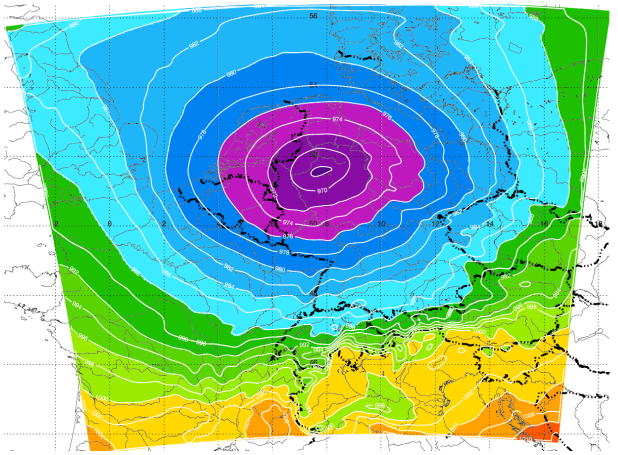
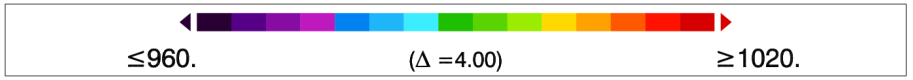


Sea level pressure

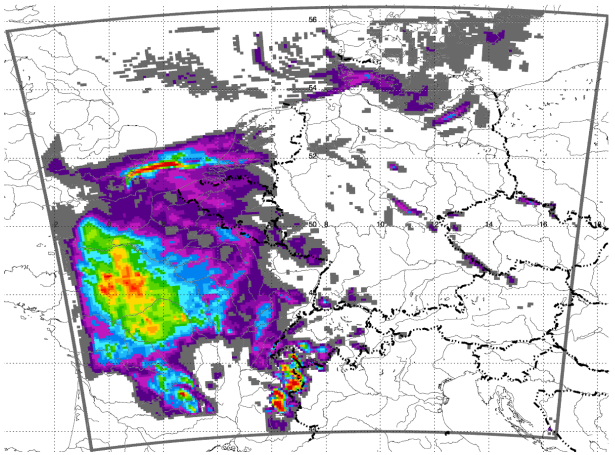


p_{NN} [hPa]

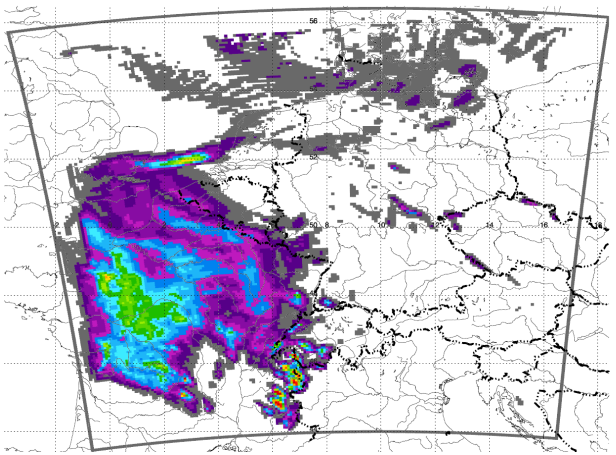
15.12.2011 12UTC **+ 12h**

Model comparison

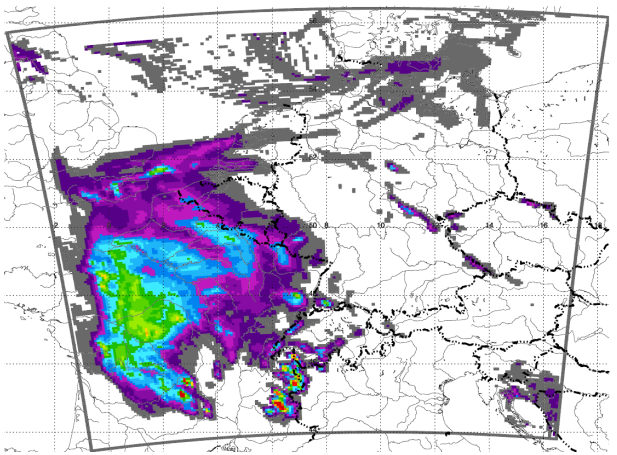
GFS → WRF



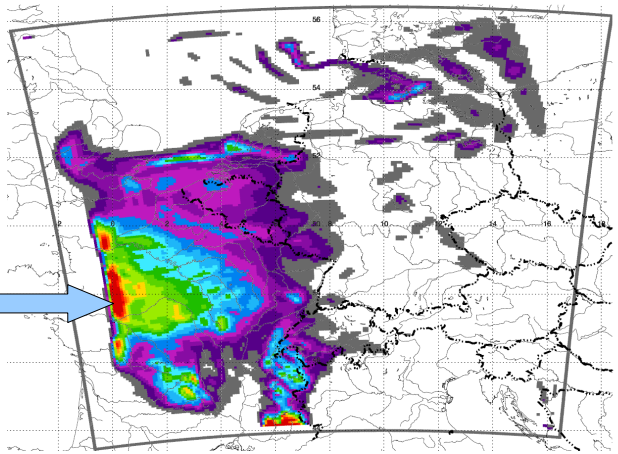
IFS → WRF



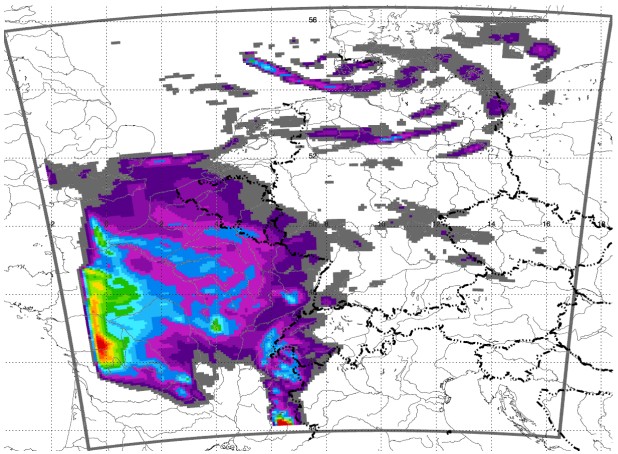
GME → WRF



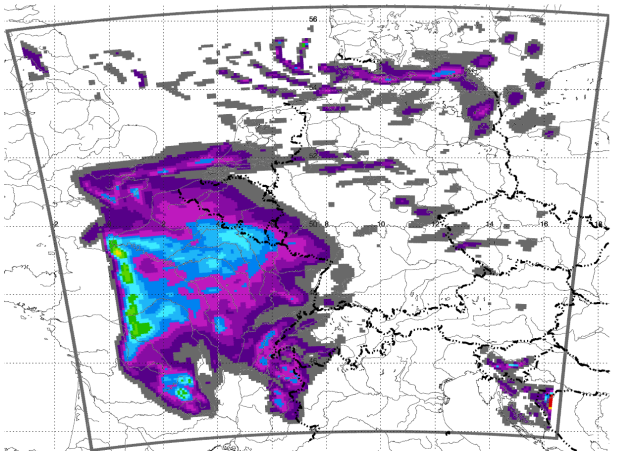
GFS → COSMO



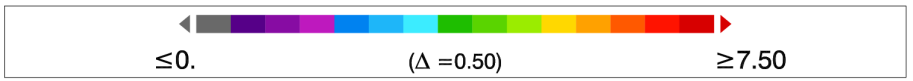
IFS → COSMO



GME → COSMO



Precipitation 1h-sum

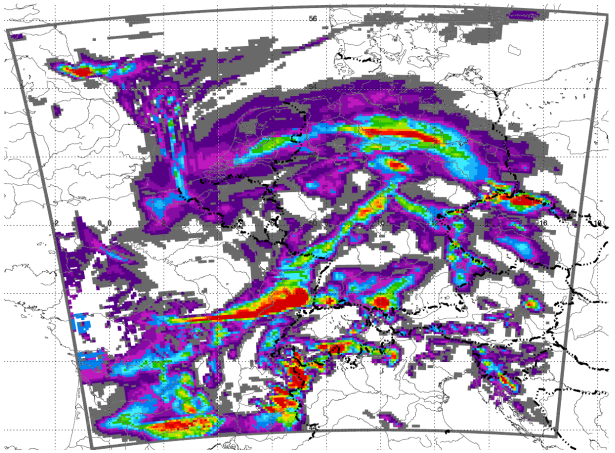


Pr [mm]

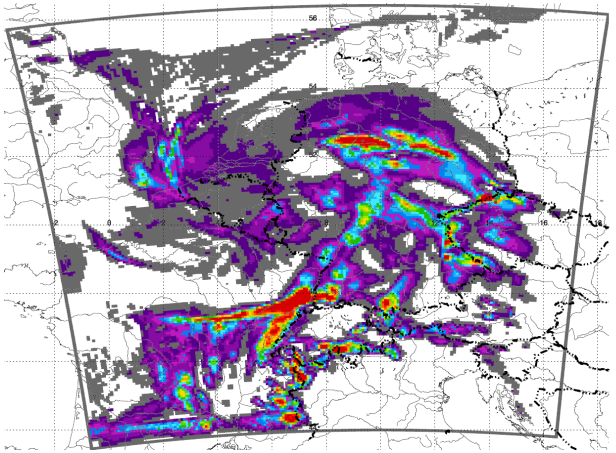
15.12.2011 12UTC **+ 24h**

Model comparison

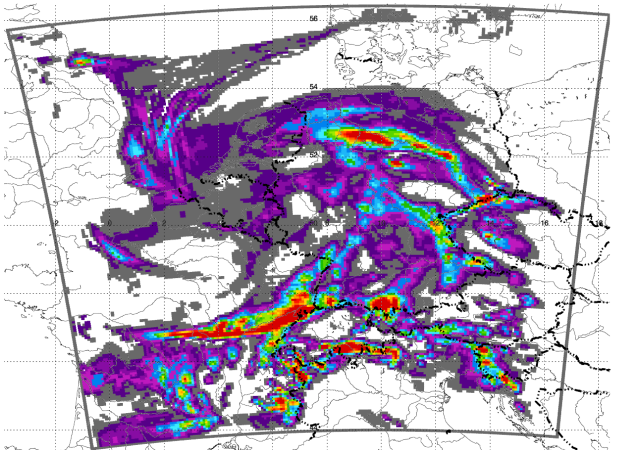
GFS → WRF



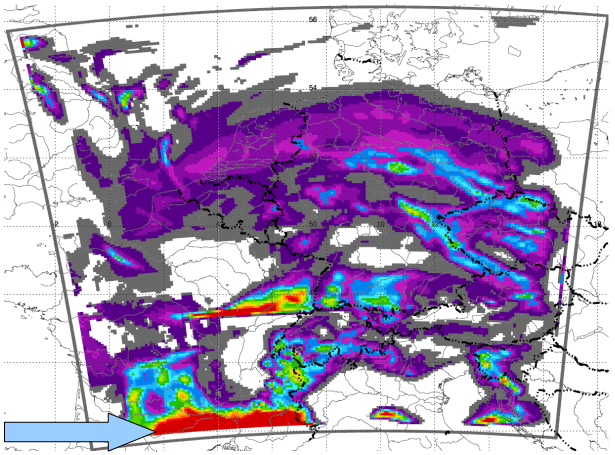
IFS → WRF



GME → WRF



GFS → COSMO



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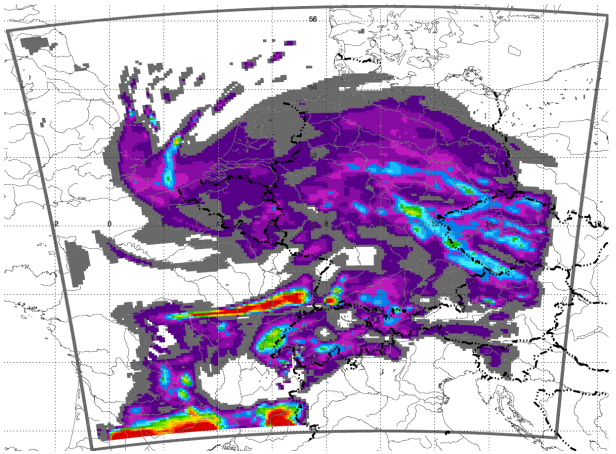
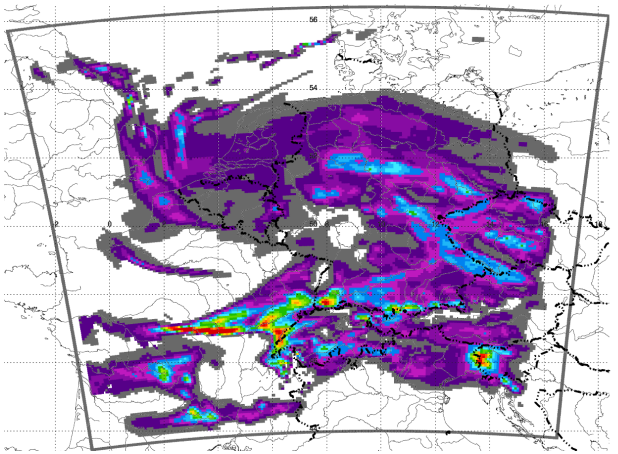
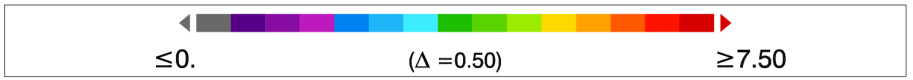


GME → COSMO



Precipitation 1h-sum



Pr [mm]

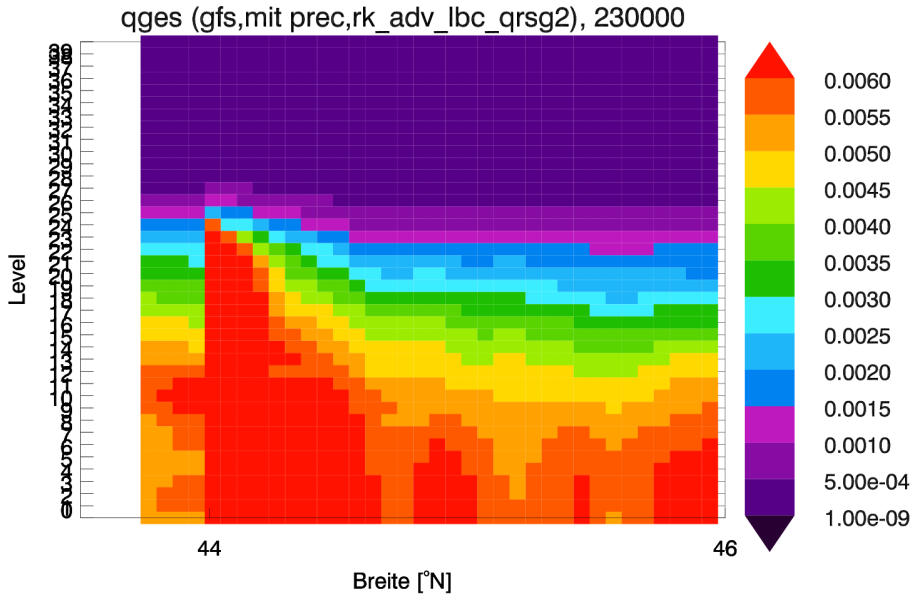
Conclusions

- Mostly consistent simulation of the synoptic situations with observations in the interior of the local model domain
- Less a coarse spatial interpolation than a coarse temporal interpolation leads to bad manipulation of boundary data
- Similarities for model runs with each the same global model input data
- Differences between COSMO and WRF, especially in precipitation pattern
- Intensive *grid scale* precipitation in the COSMO relaxation zone, especially with GFS input, probably multiple reasons

Outlook

- Investigation and improvement of the unrealistic intensive precipitation in COSMO relaxation zone
- More tests for other, less distinctive synoptic situations
- Statistical validation of the six different model combinations

Thank you
for your attention!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0.0055
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0.0035
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0.0020
0.0015
0.0010
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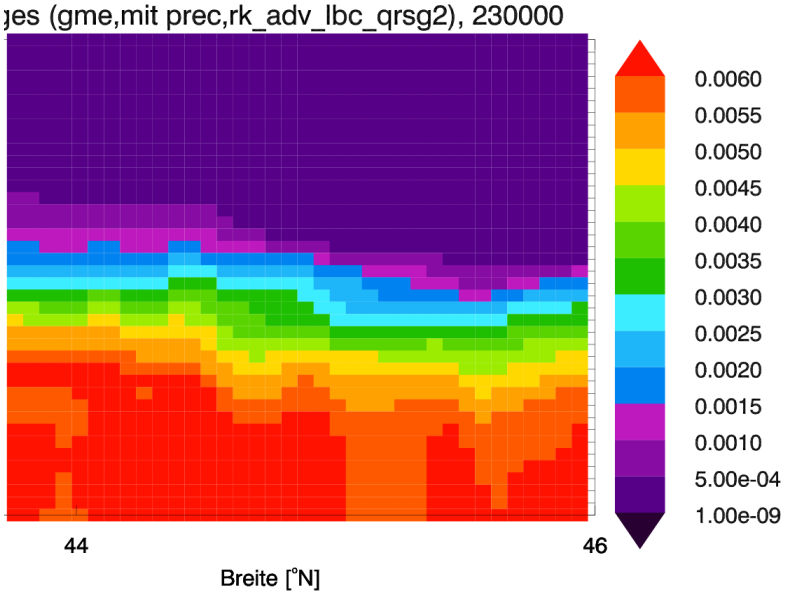
1.00e-09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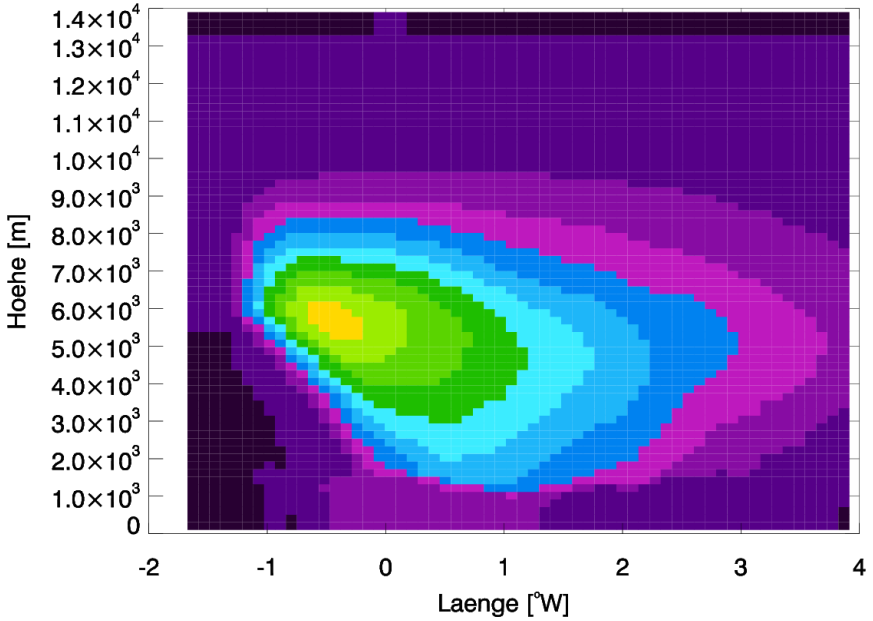
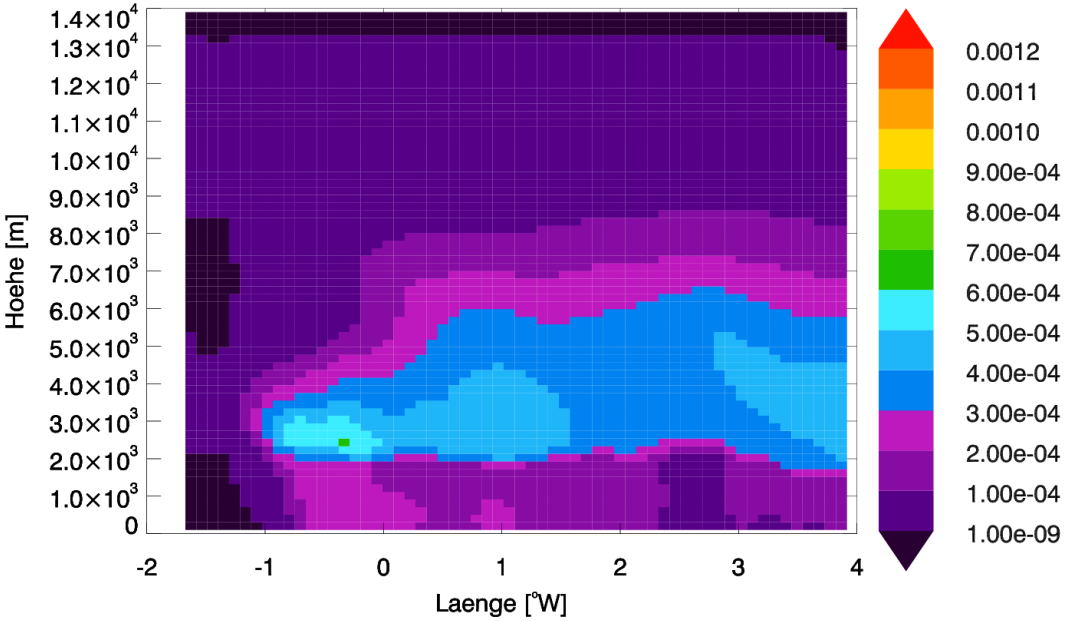
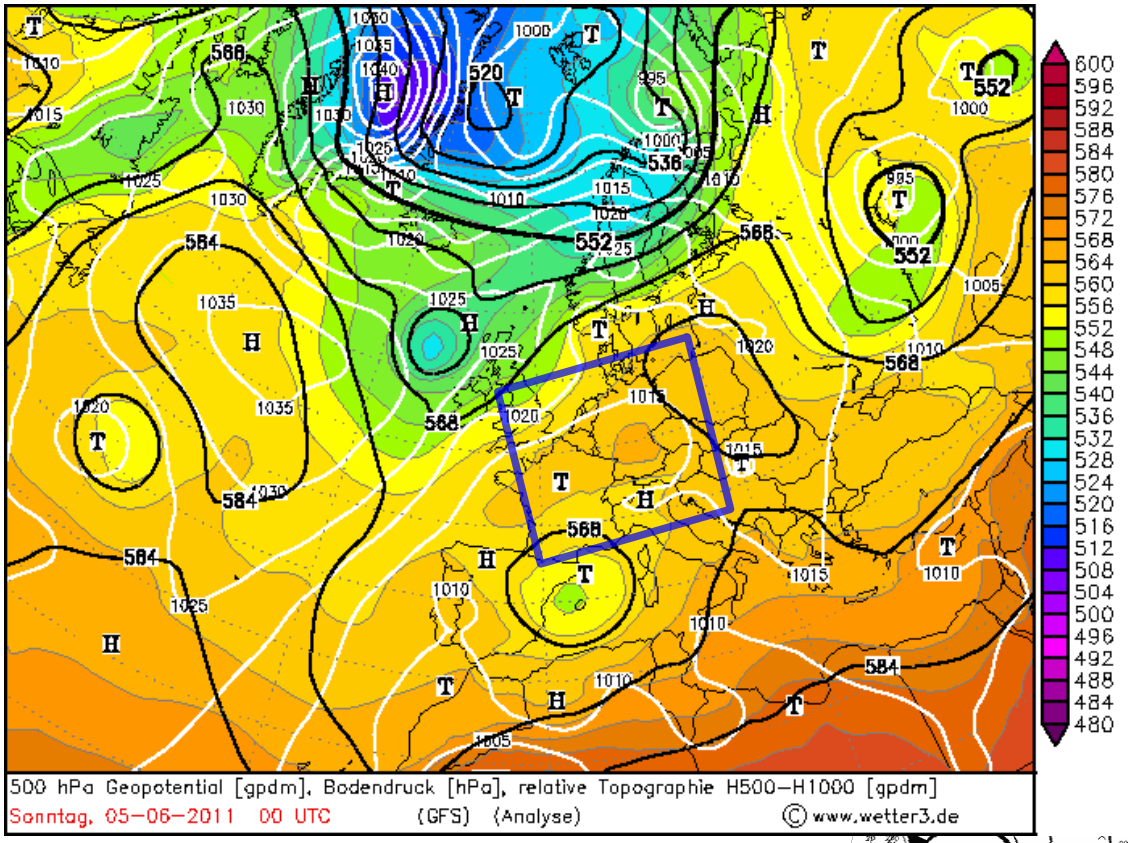
GFS → COSMO



IFS → COSMO

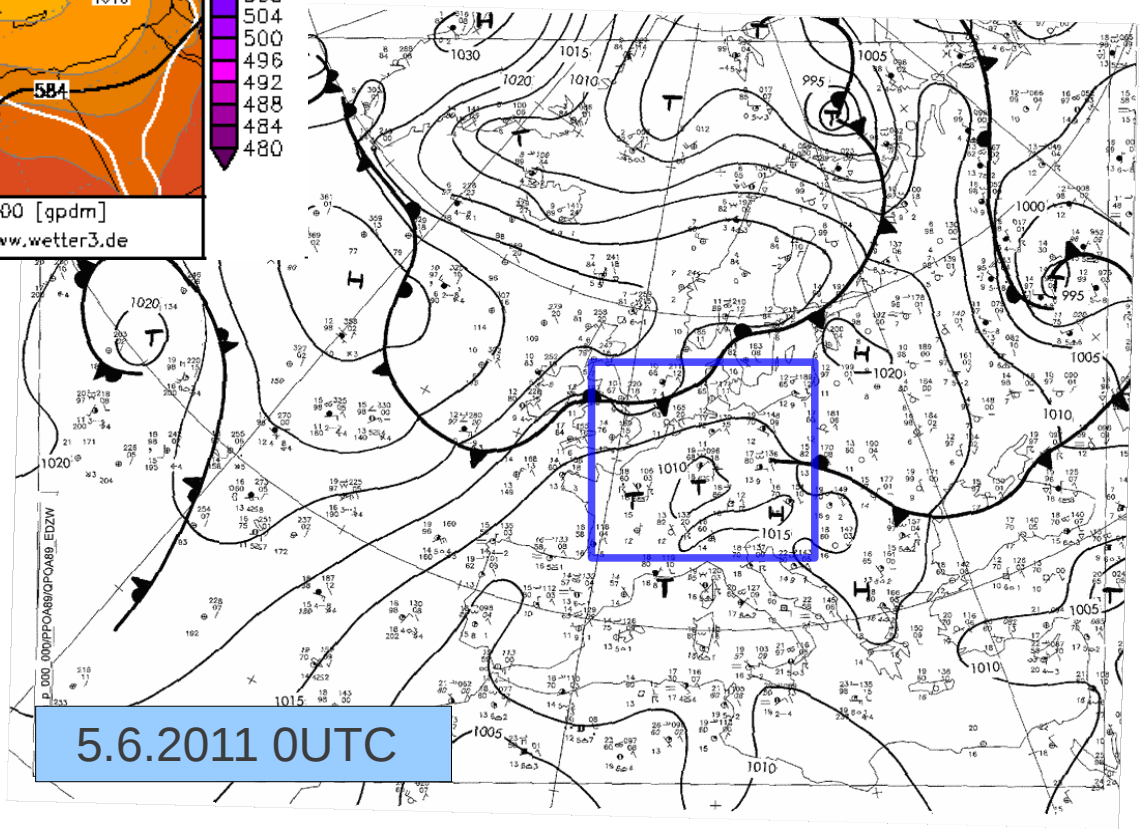




Test runs of the 6 model combinations

synoptic situation:

convection
4.6.2011 00UTC – 5.6.2011 18UTC

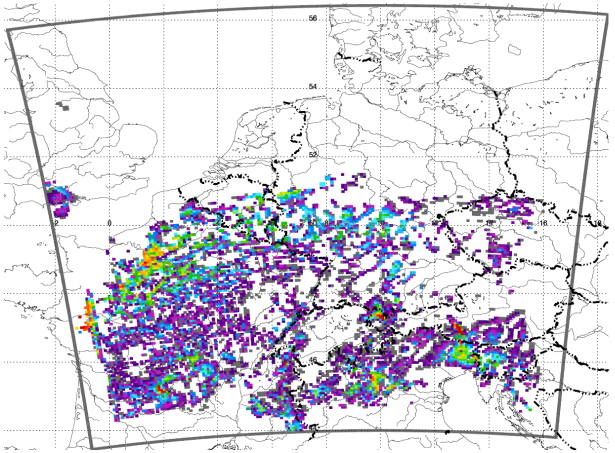


- Weak gradients, labile air mass
- Strong convective activity on both days

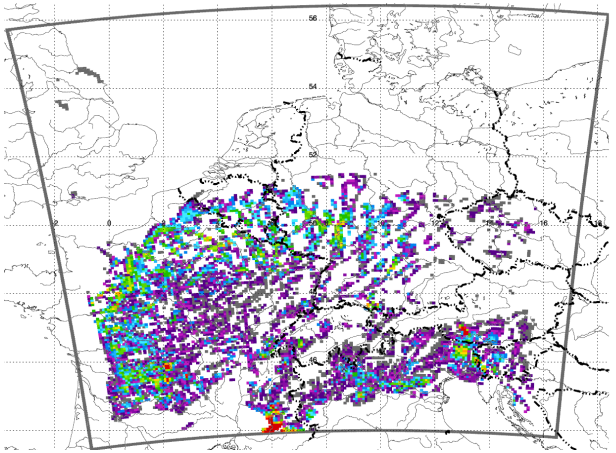
4.6.2011 00UTC **+ 18h**

Model comparison

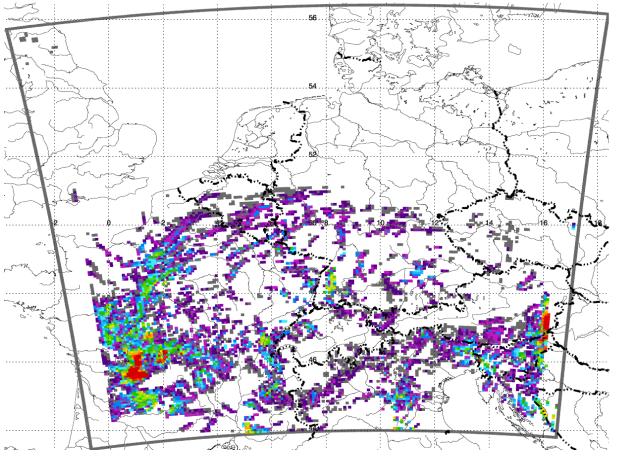
GFS → WRF



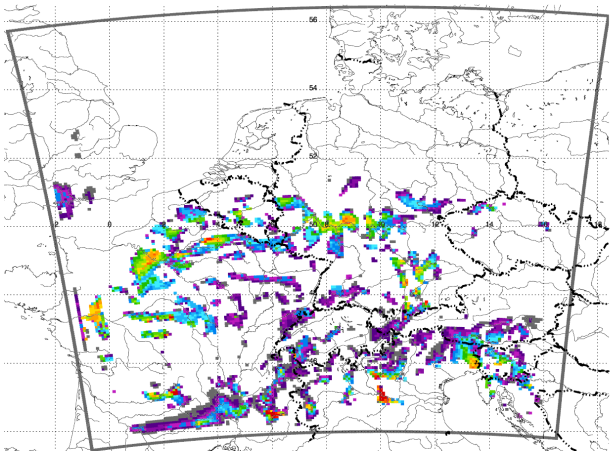
IFS → WRF



GME → WRF



GFS → COSMO



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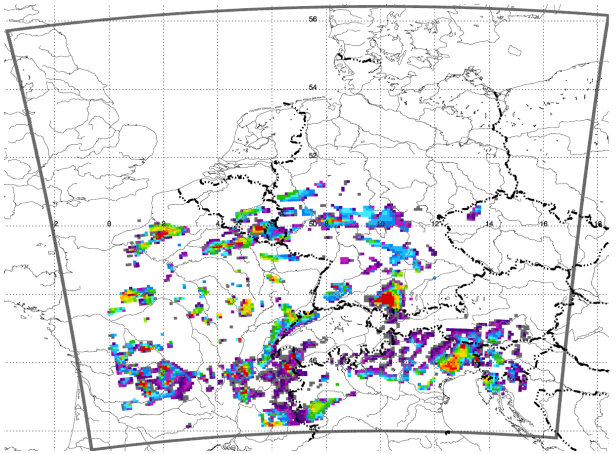
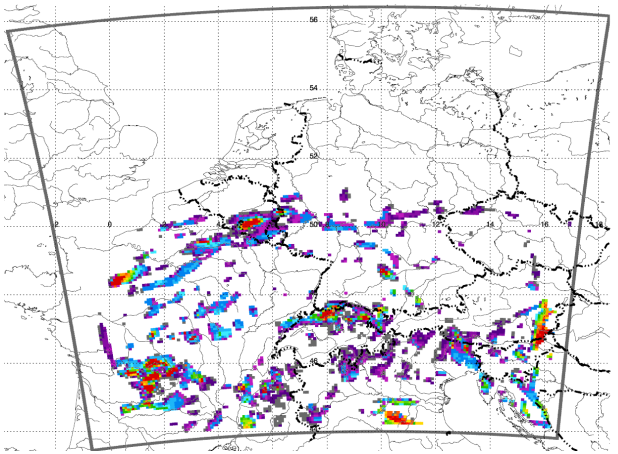
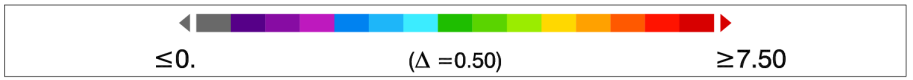


GME → COSMO



precipitation 1h-sum

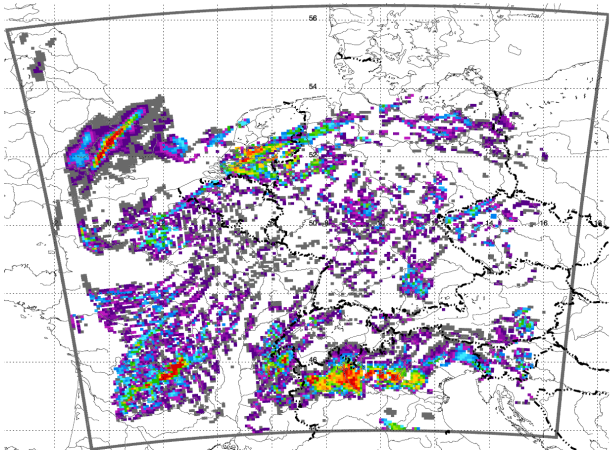


Pr [mm]

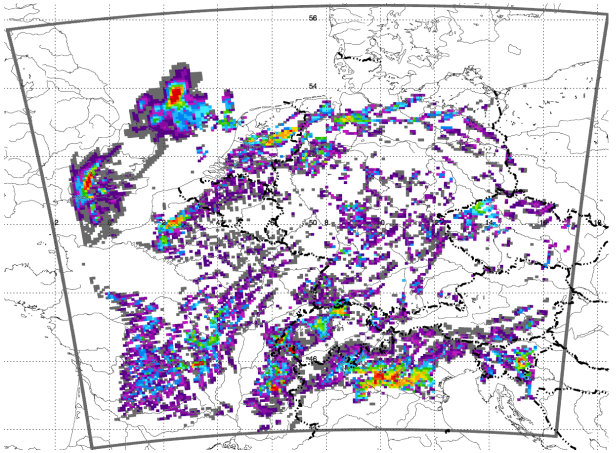
4.6.2011 00UTC **+ 42h**

Model comparison

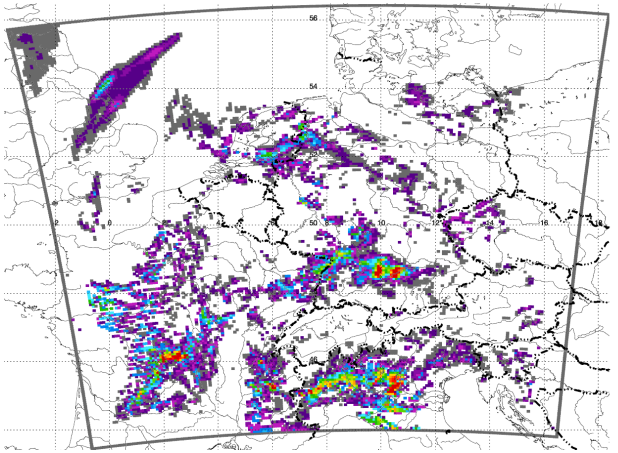
GFS → WRF



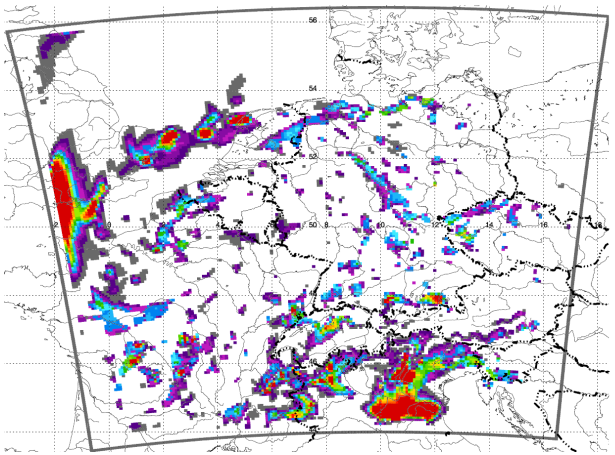
IFS → WRF



GME → WRF



GFS → COSMO



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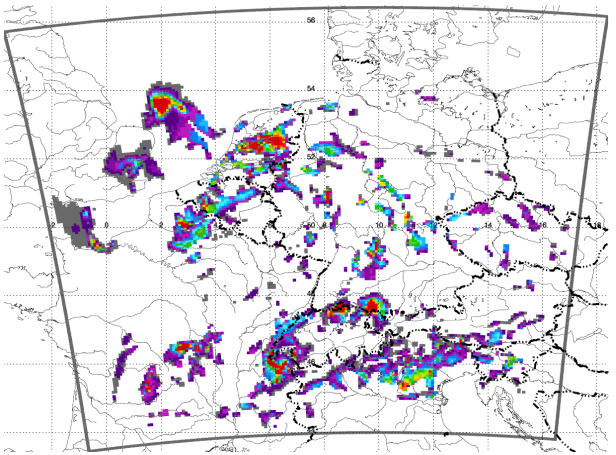
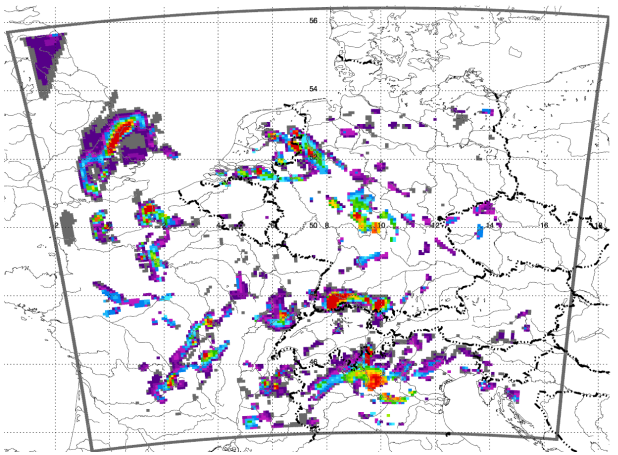
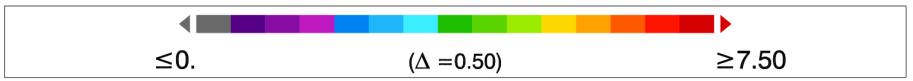


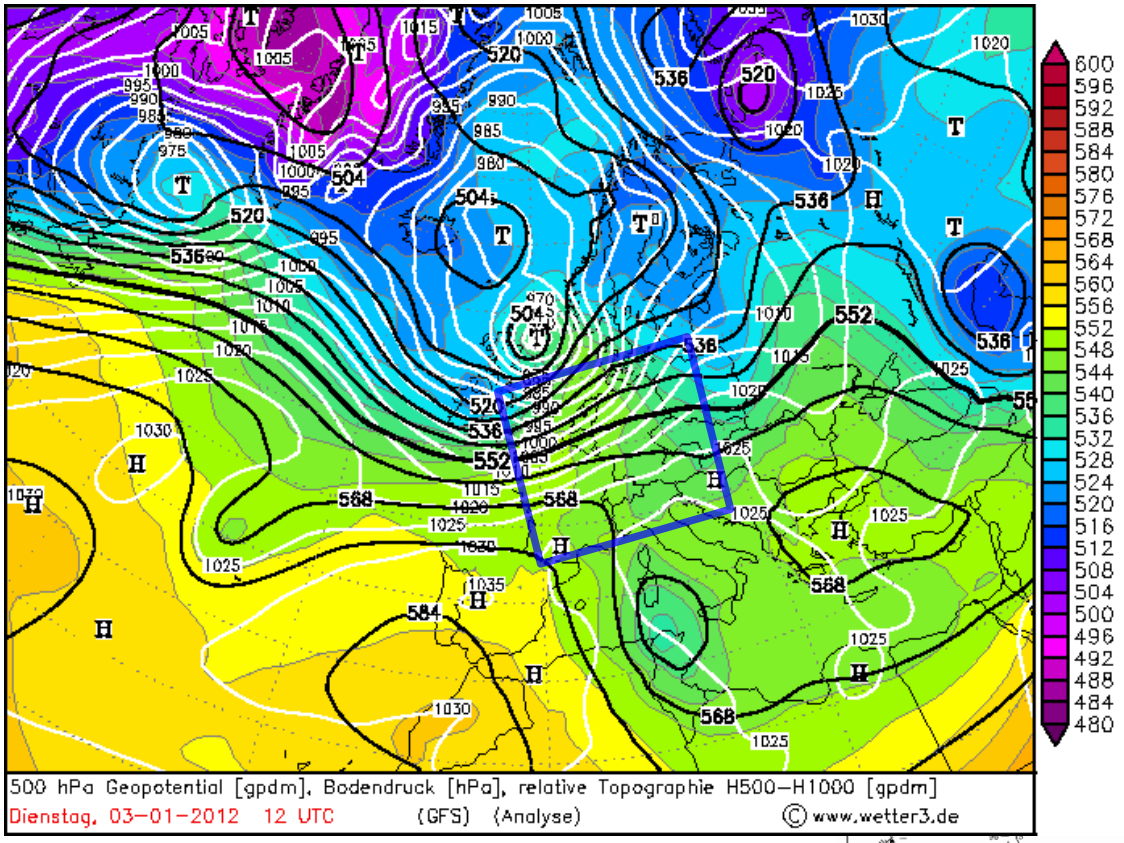
GME → COSMO



Niederschlag 1h-Summe



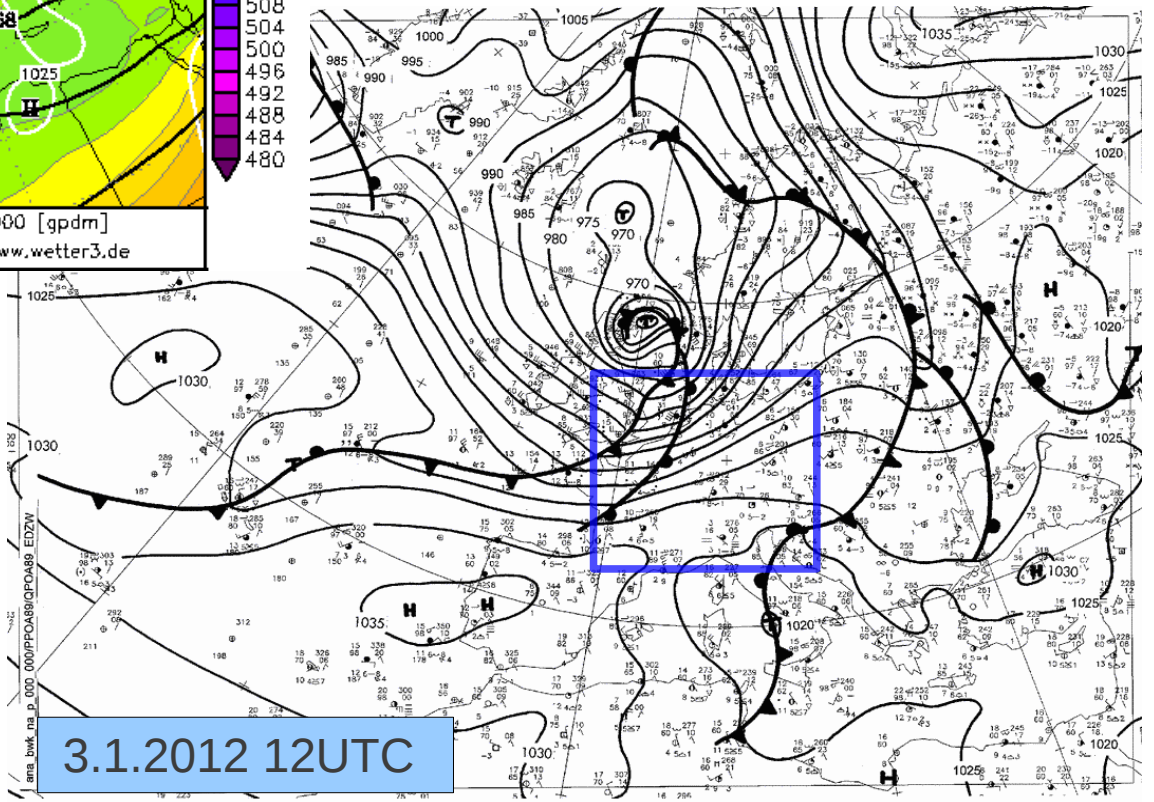
Pr [mm]



Test runs of the 6 model combinations

synoptische situation:

Multiple air mass changes
3.1.2012 00UTC – 5.1.2012 12UTC

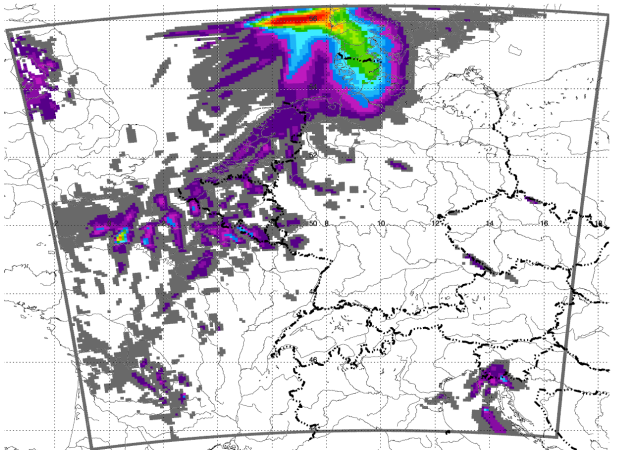


- multiple WF und CF pass the model domain from NW to SE
- Each driving cyclone slightly outside the model domain

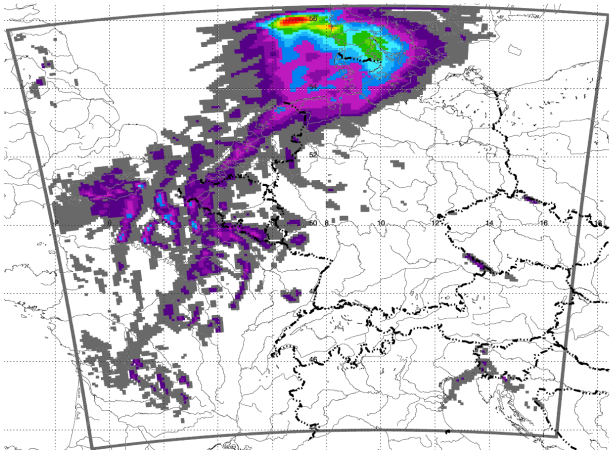
3.1.2012 00**+12UTC**

Model comparison

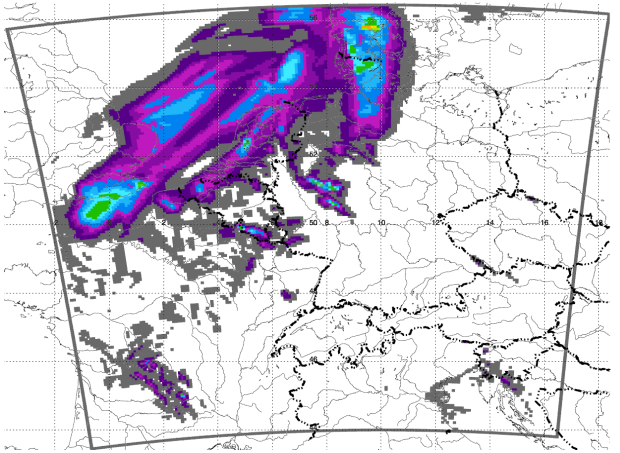
GFS → WRF



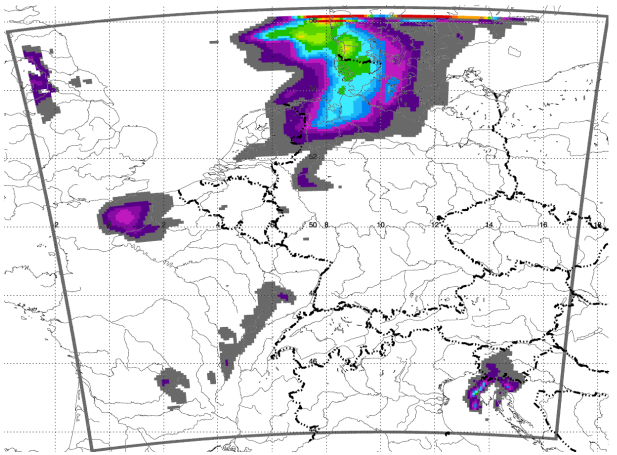
IFS → WRF



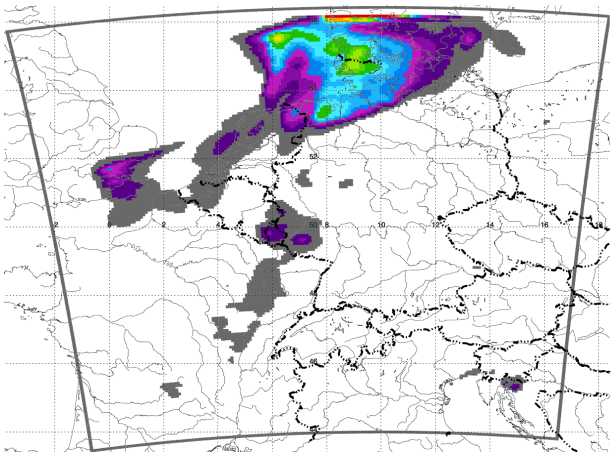
GME → WRF



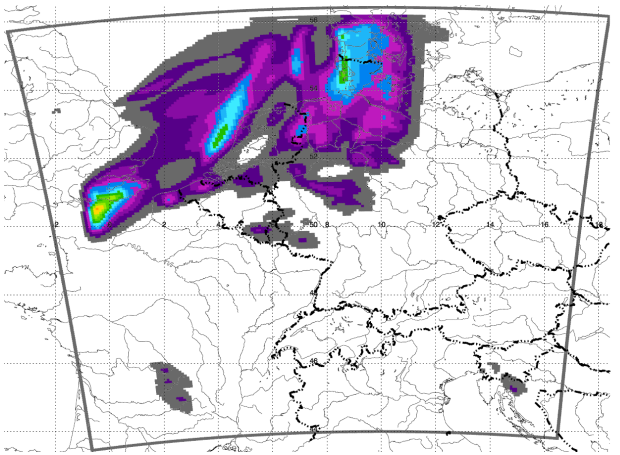
GFS → COSMO



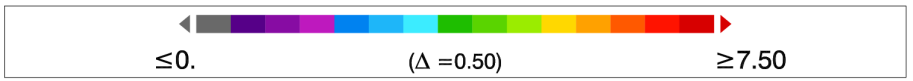
IFS → COSMO



GME → COSMO



precipitation 1h-sum

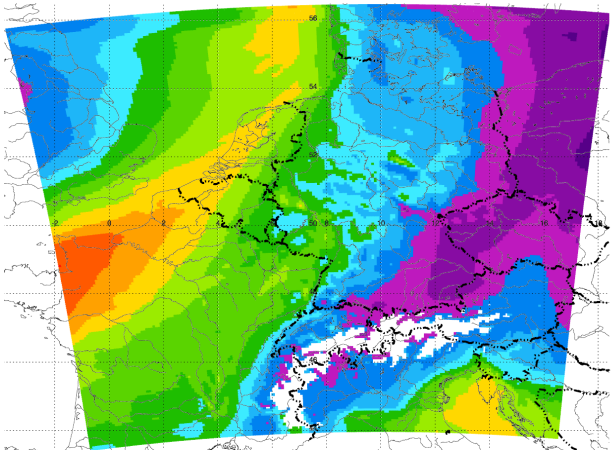


Pr [mm]

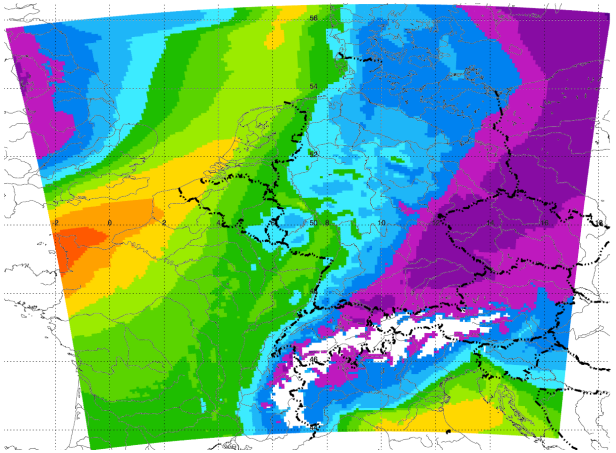
3.1.2012 00**+12UTC**

Model comparison

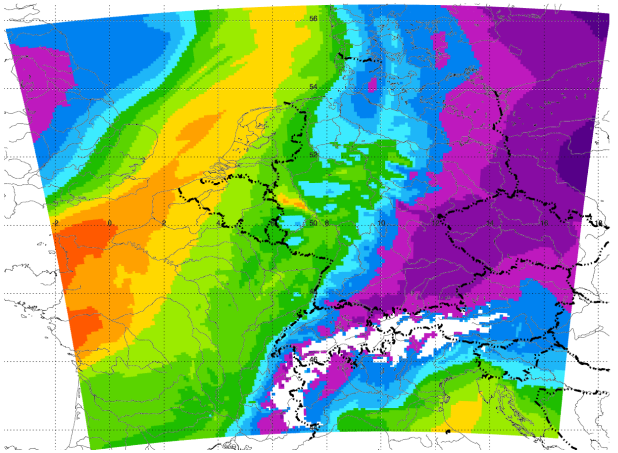
GFS → WRF



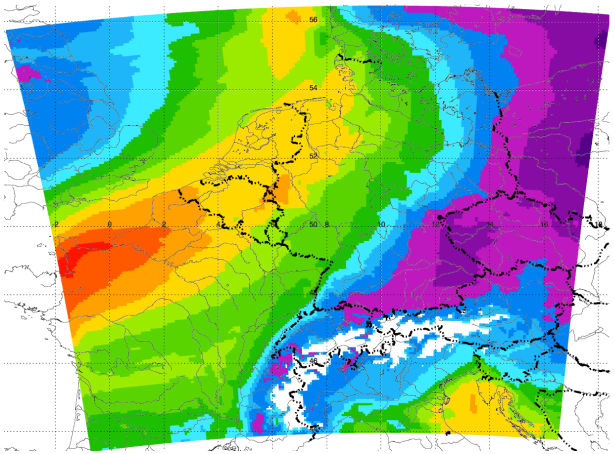
IFS → WRF



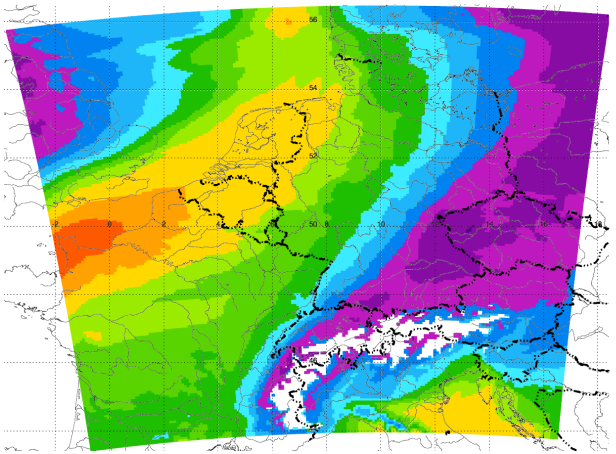
GME → WRF



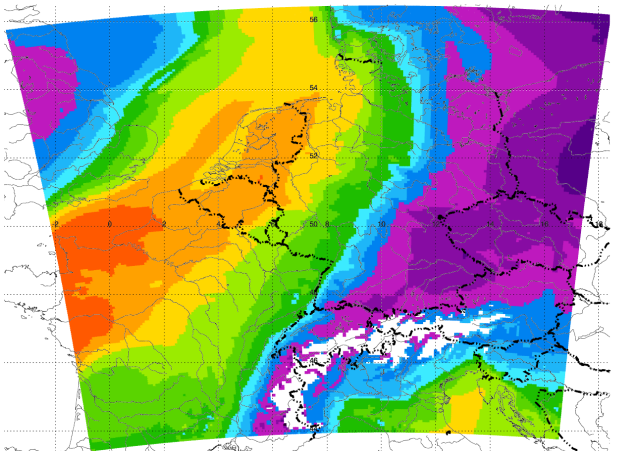
GFS → COSMO



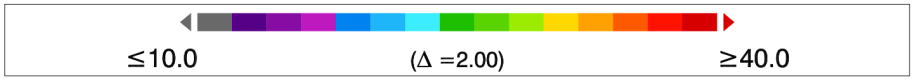
IFS → COSMO



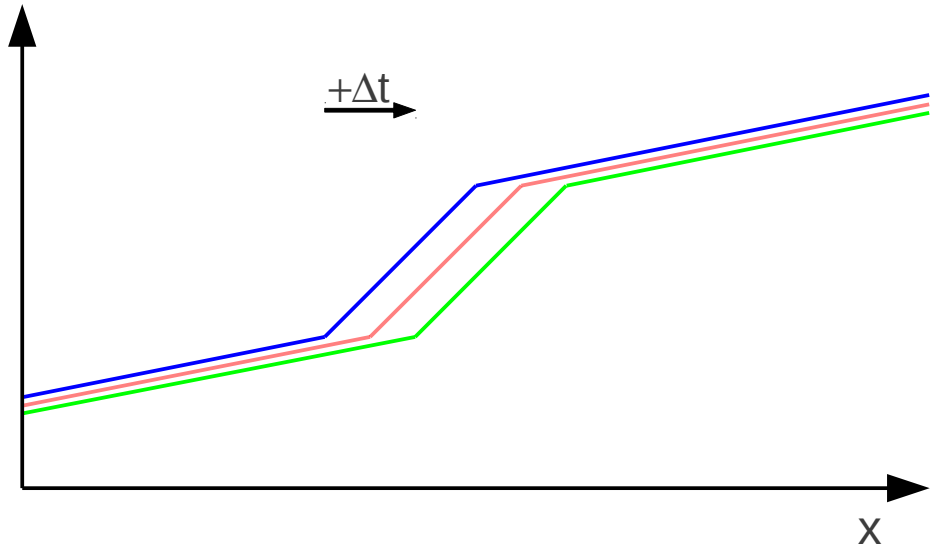
GME → COSMO

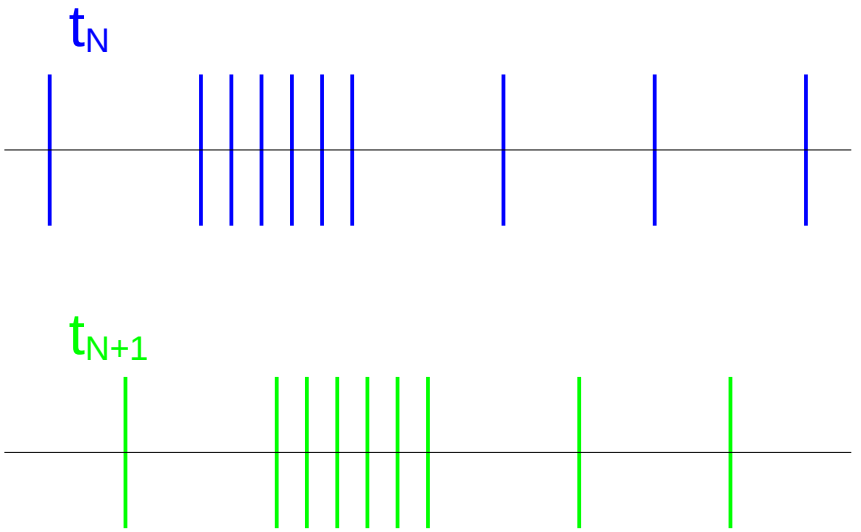


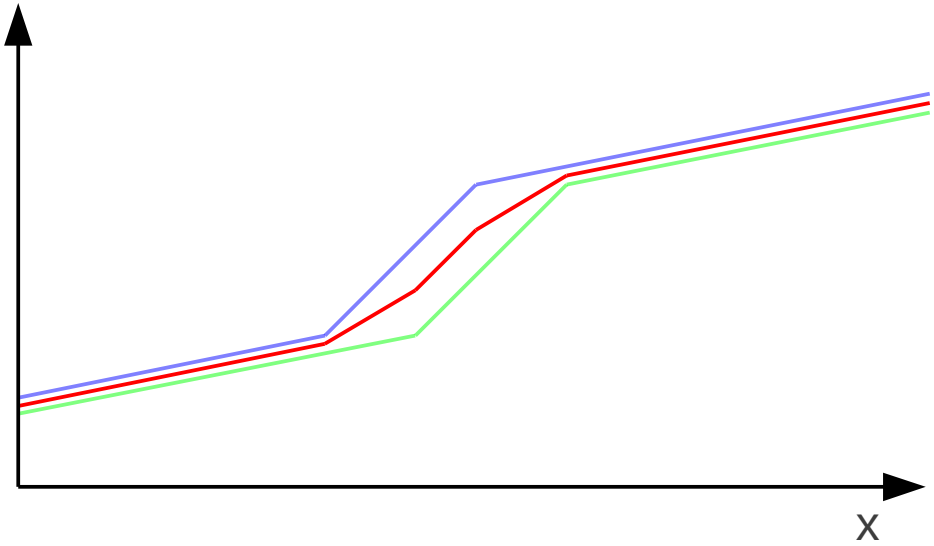
eq. pot. temperature in 850hPa



θ_e [°C]


+Δt
x


t_N
t_{N+1}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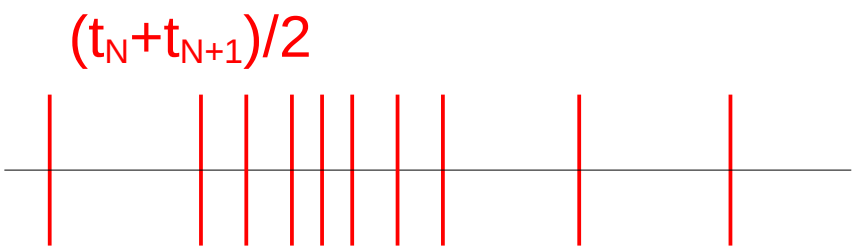
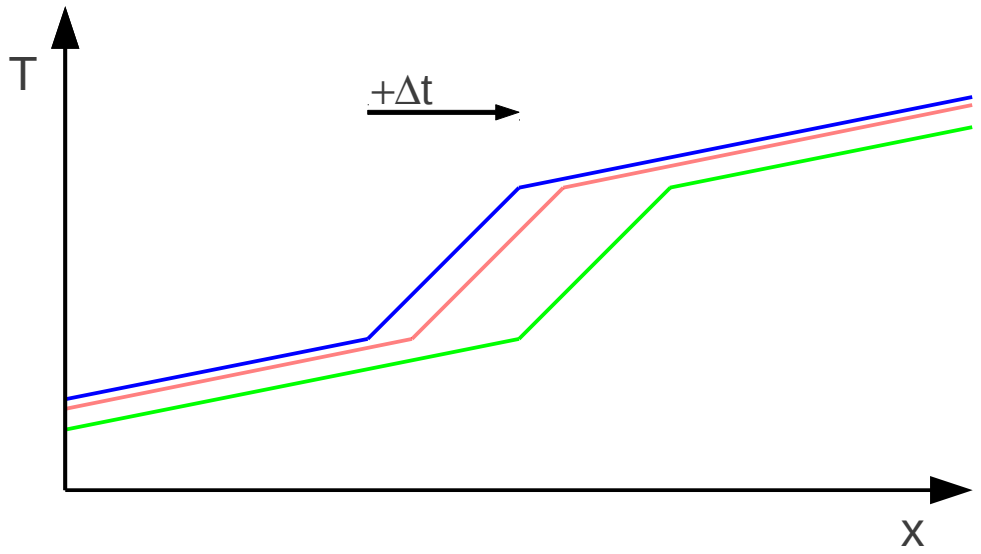
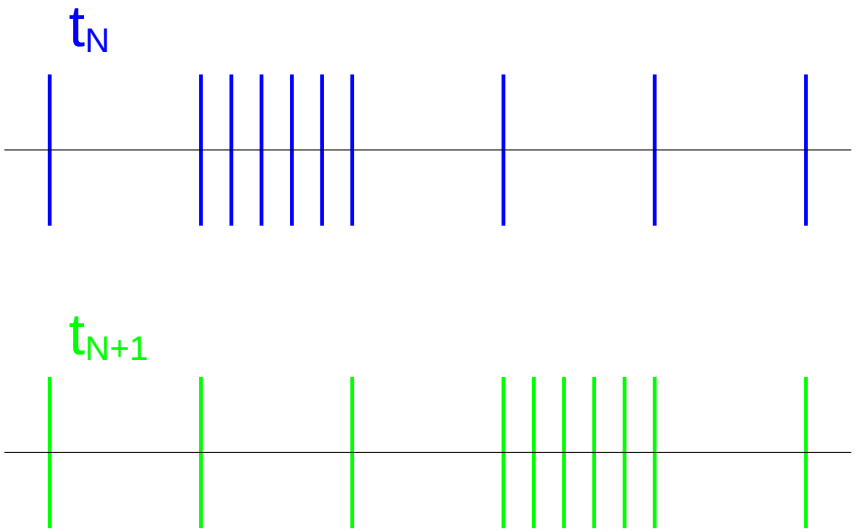
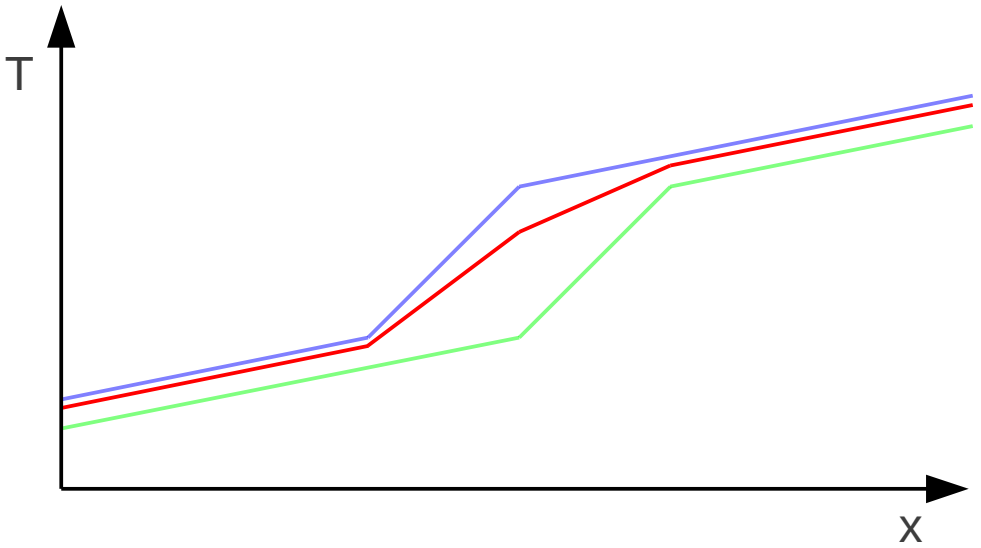
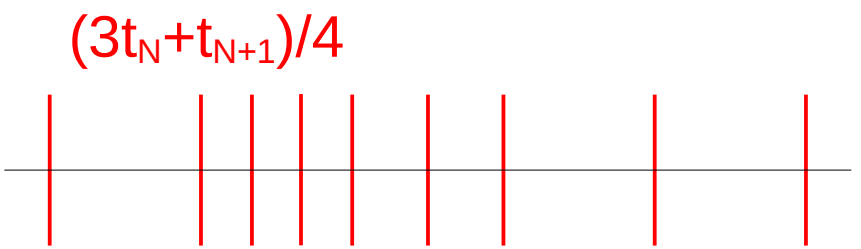
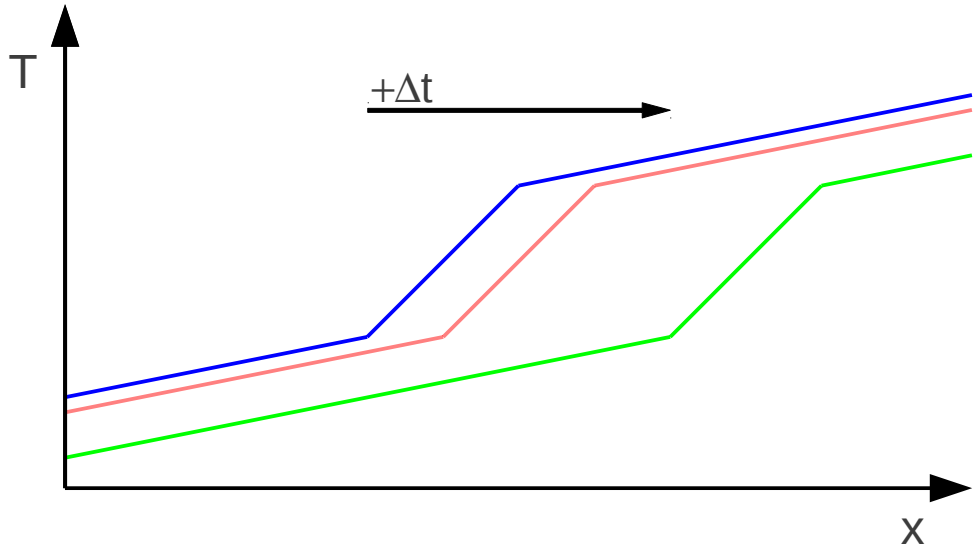

$(t_N+t_{N+1})/2$

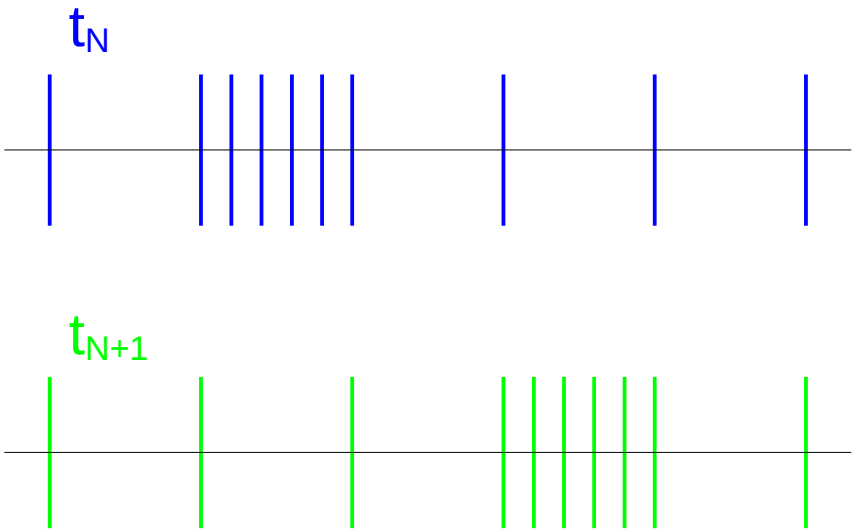

T
+Δt
x

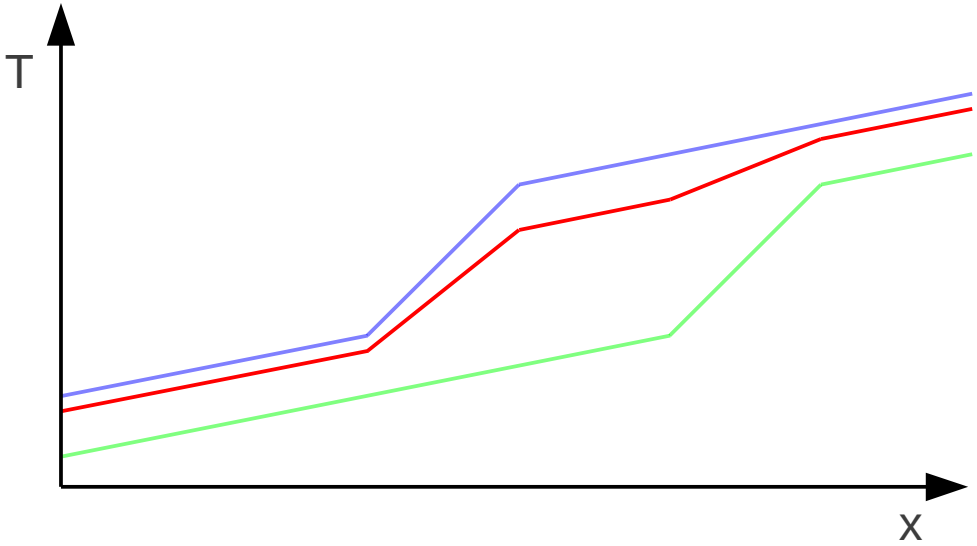

t_N
t_{N+1}

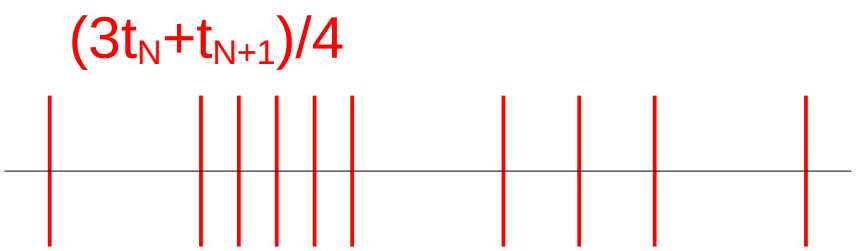

T
x


$(3t_N+t_{N+1})/4$


T
+Δt
x


t_N
t_{N+1}


T
x


$(3t_N+t_{N+1})/4$