

3D experiments at various resolutions with an integrated package handling cloud and precipitation processes.

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18 May 2006



Topics

1. Main ingredients
2. Recent refinements
3. 3D experiments
 - (a) Cyclone over Black Sea
 - (b) Cold Front over Bavaria-Bohemia
 - (c) Thunderstorm in Belgium
4. Prognostic mixing
5. Conclusions

Main ingredients

...refer to previous Aladin Workshop!

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In brief :

- Prognostic approach

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In brief :

- Prognostic approach
 - Prognostic cloud water
 - Prognostic updraught vertical equation
 - Prognostic updraught closure
 - Prognostic downdraught

Main ingredients

...refer to previous Aladin Workshop!

In brief :

- Prognostic approach
- Cascading approach

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In brief :

- Prognostic approach
- Cascading approach
- Mass-flux Transport Scheme

Last refinements

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- Interface through tendencies

Last refinements

- Interface through tendencies
 - Valid for all styles of advection
 - Simplify calls to *cputqy* using *POINTERS*

Last refinements

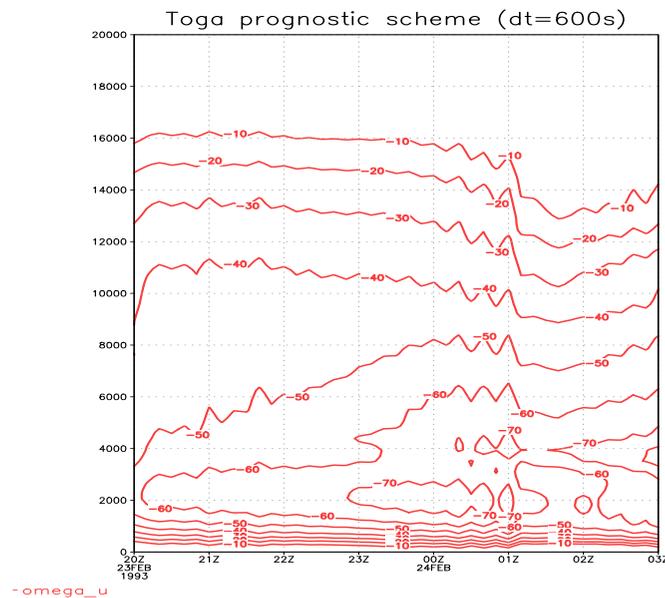
- Interface through tendencies
- Prognostic equation formulation

Last refinements

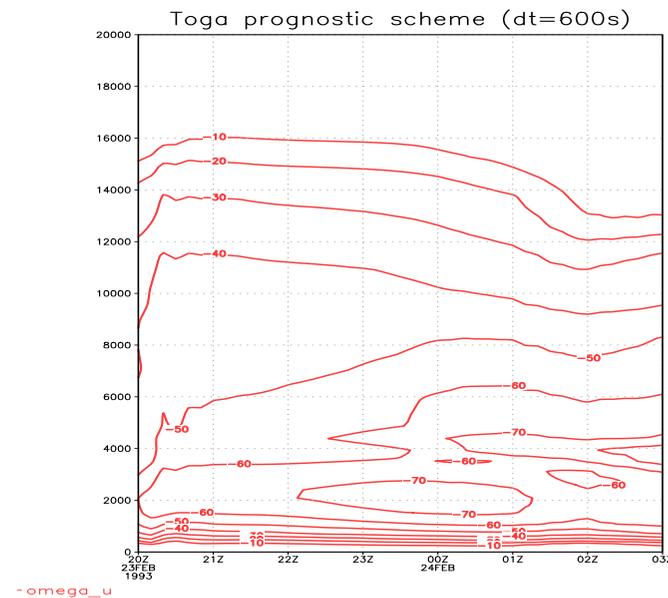
- Interface through tendencies
- Prognostic equation formulation
 - Choice of advected variables and specific terms (thanks to Radmila)
 - Stability of the auto-advection term :
⇒ GGL-type discretization

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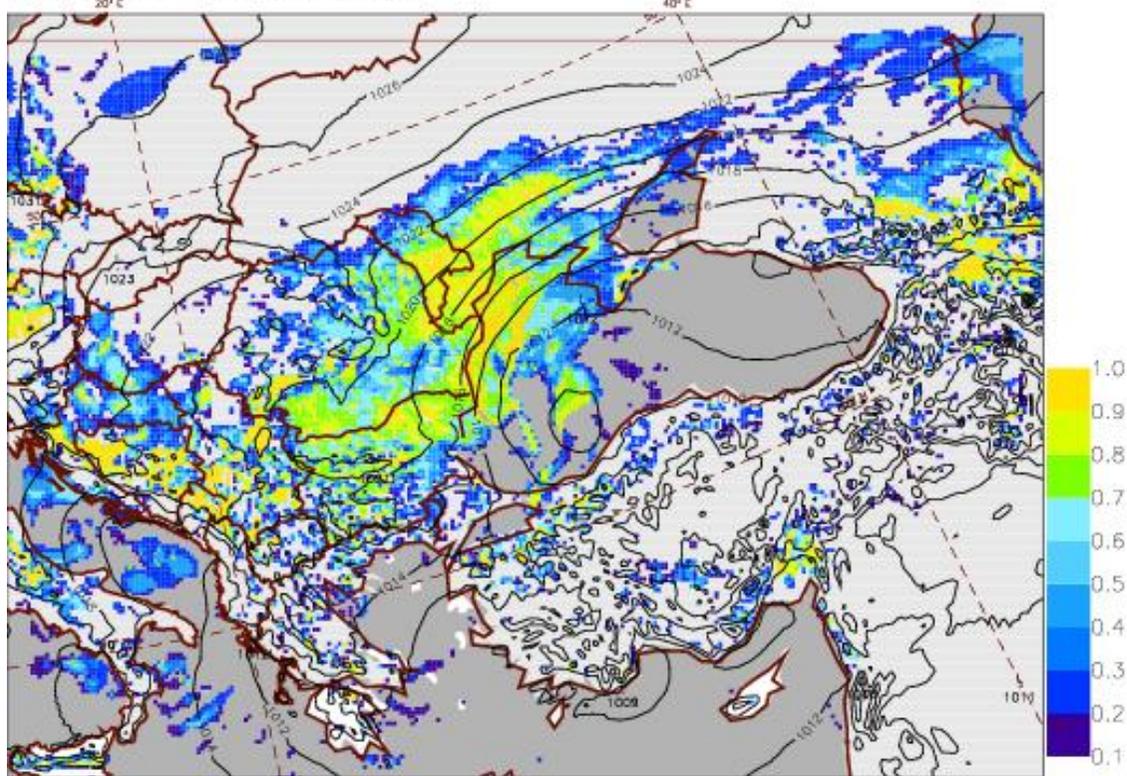
Before...



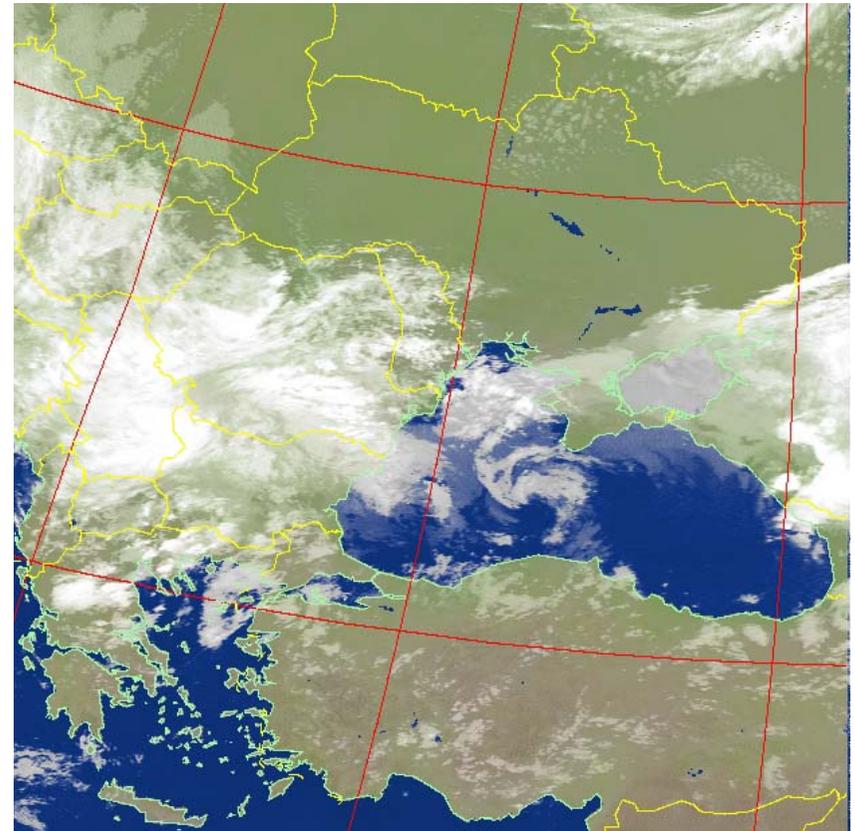
...After

3D experiments : Cyclone over Black Sea

Friday 12 September 2003 0z cC91 Forecast 42 VT: Saturday 13 September 2003 18z
Total cloudiness - Mean sea level pressure



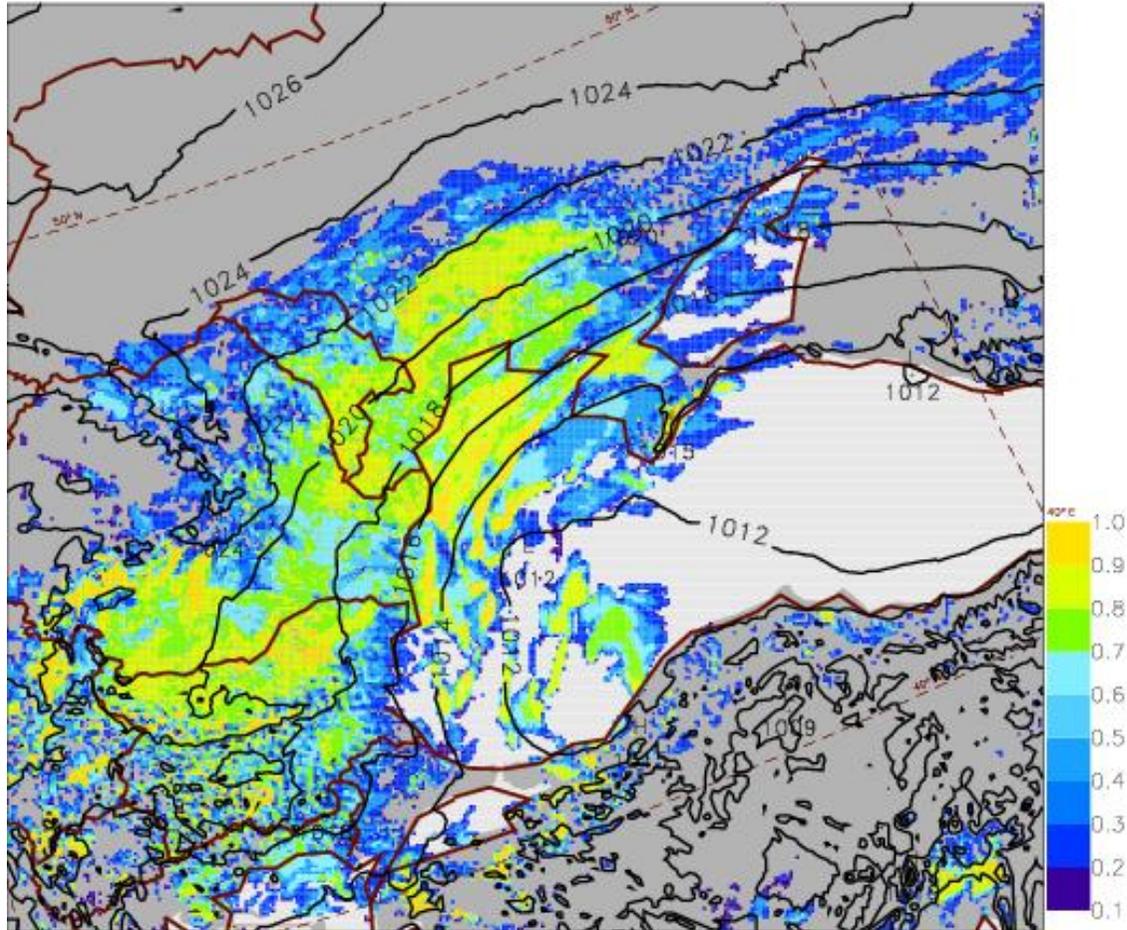
9.00km 13/09/2003 18 :00 utc cloud



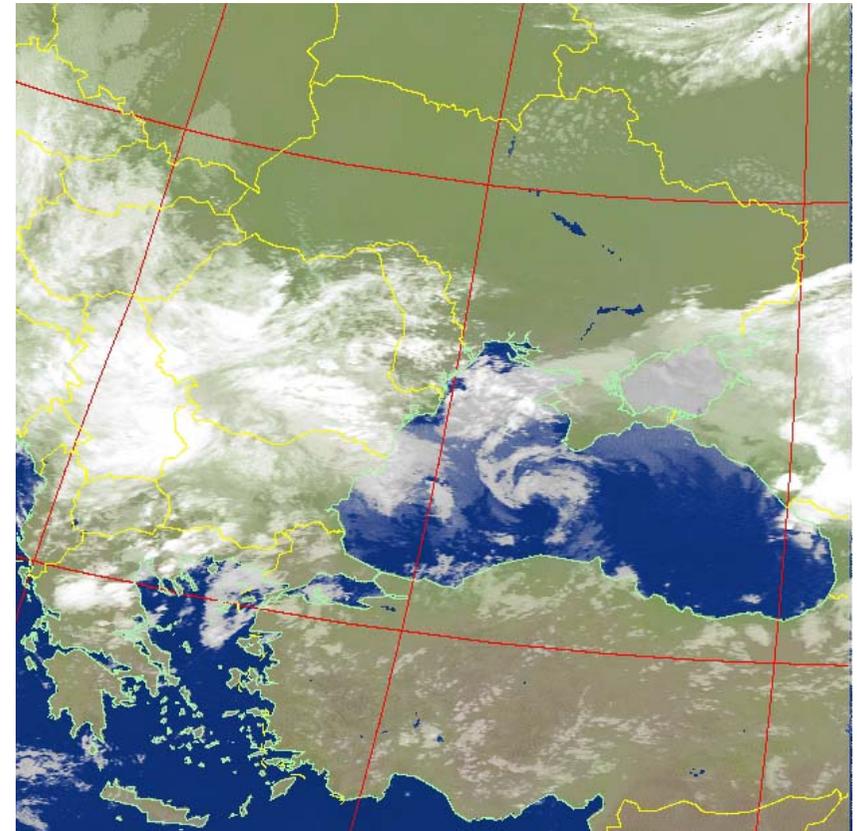
noaa ir 17 :18 utc

3D experiments : Cyclone over Black Sea

Friday 12 September 2003 0z cC41 Forecast 1+ 42 VI: Saturday 13 September 2003 18z
Total cloudiness - Mean sea level pressure

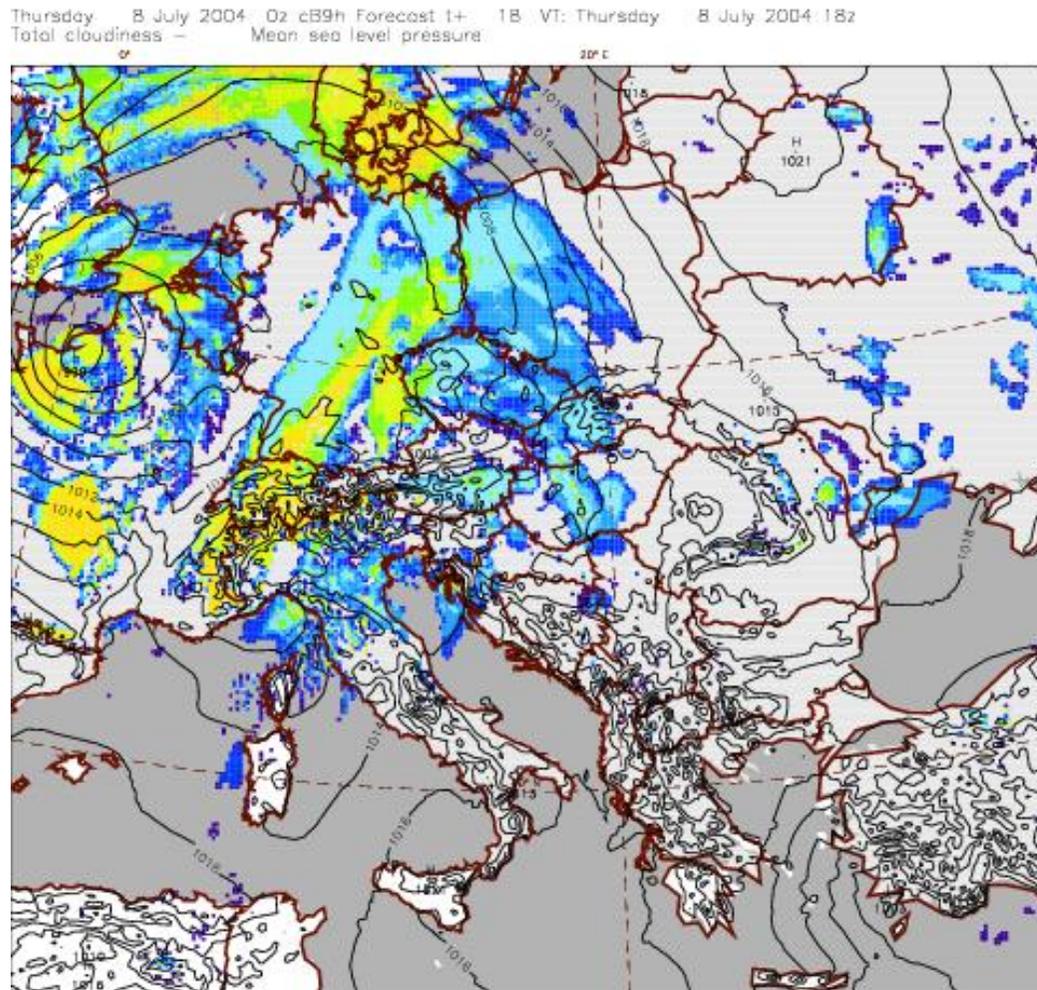


4.00km 13/09/2003 18 :00 utc cloud
... SLHDA0 = 0.0007 !!

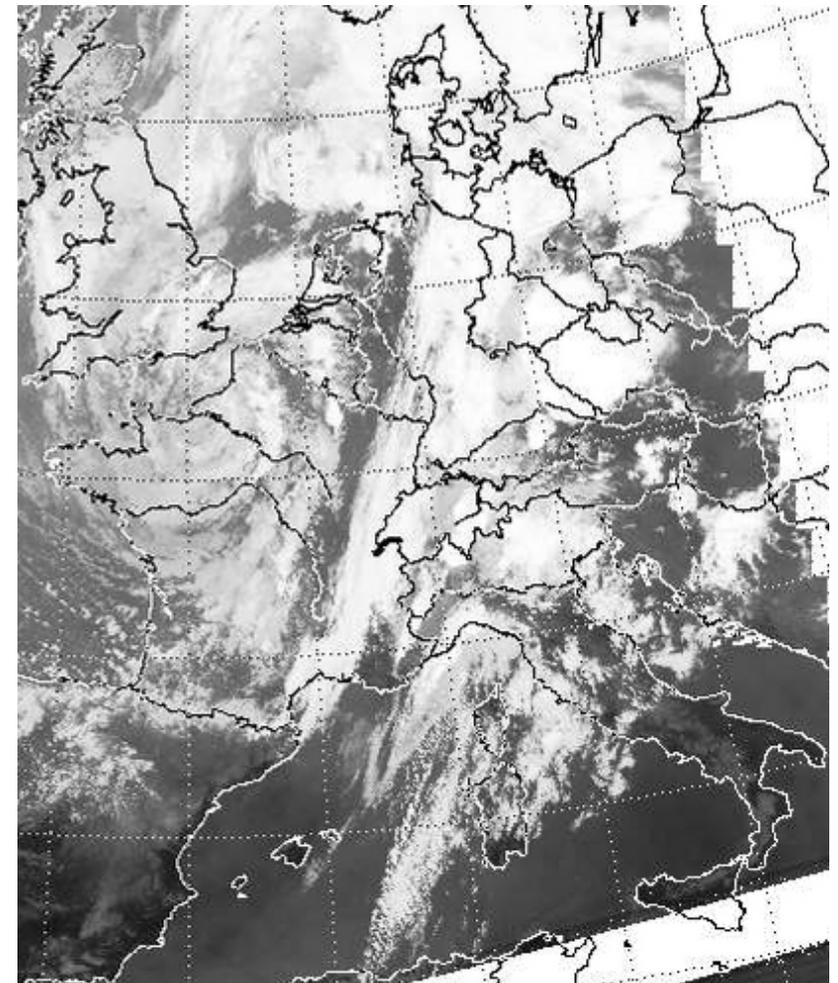


noaa ir 17 :18 utc

3D experiments : Cold front Bavaria-Bohemia

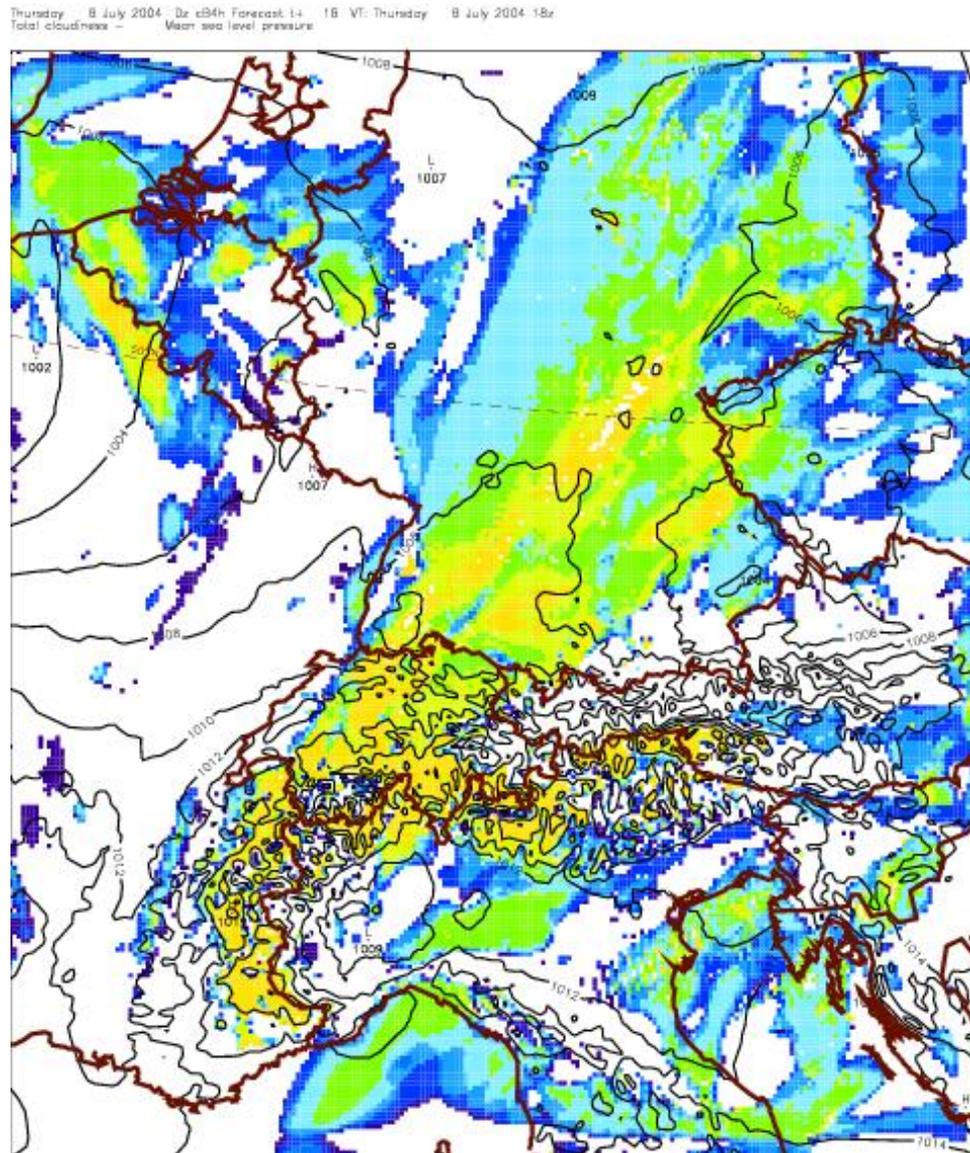


9.00km 08/07/2004 18 :00 utc cloud

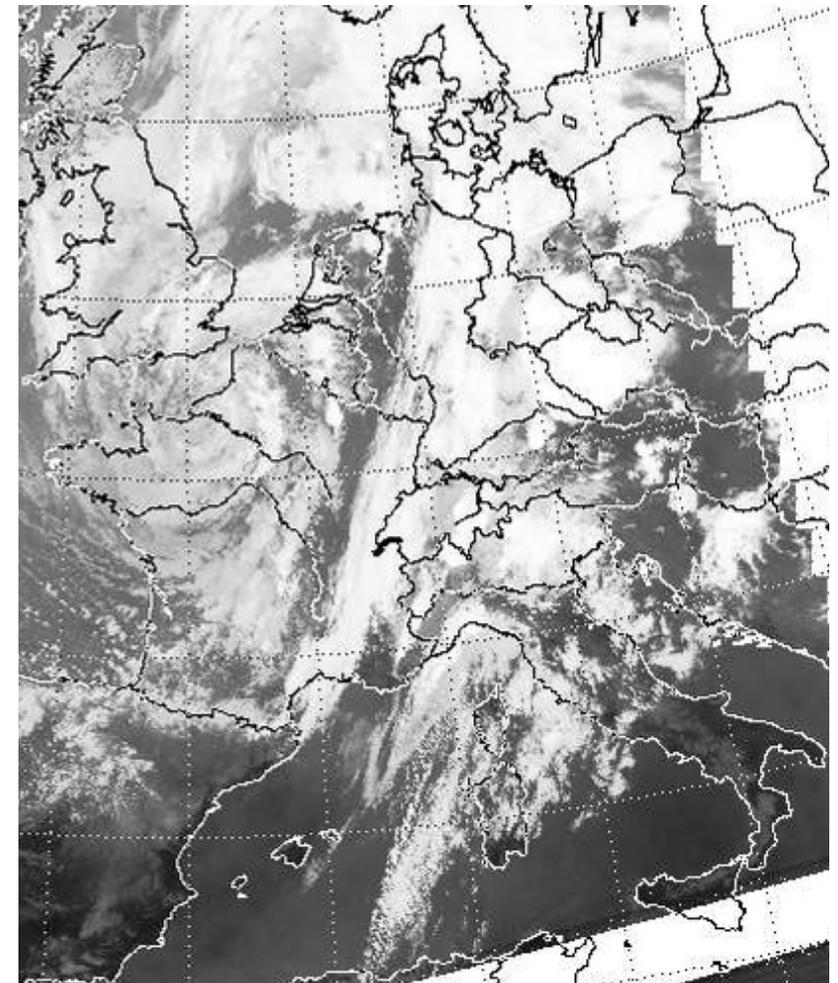


noaa ir 17 :40 utc

3D experiments : Cold front Bavaria-Bohemia

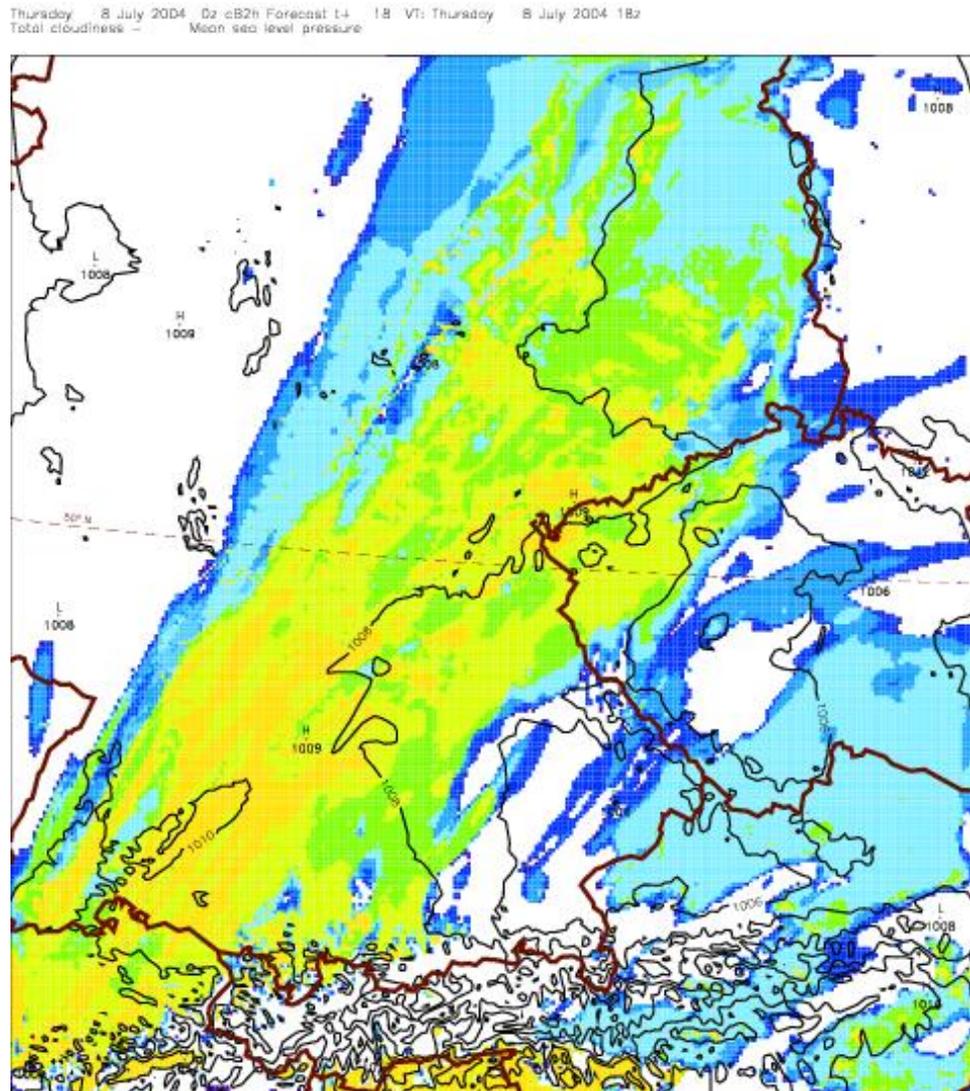


4.54km 08/07/2004 18 :00 utc cloud

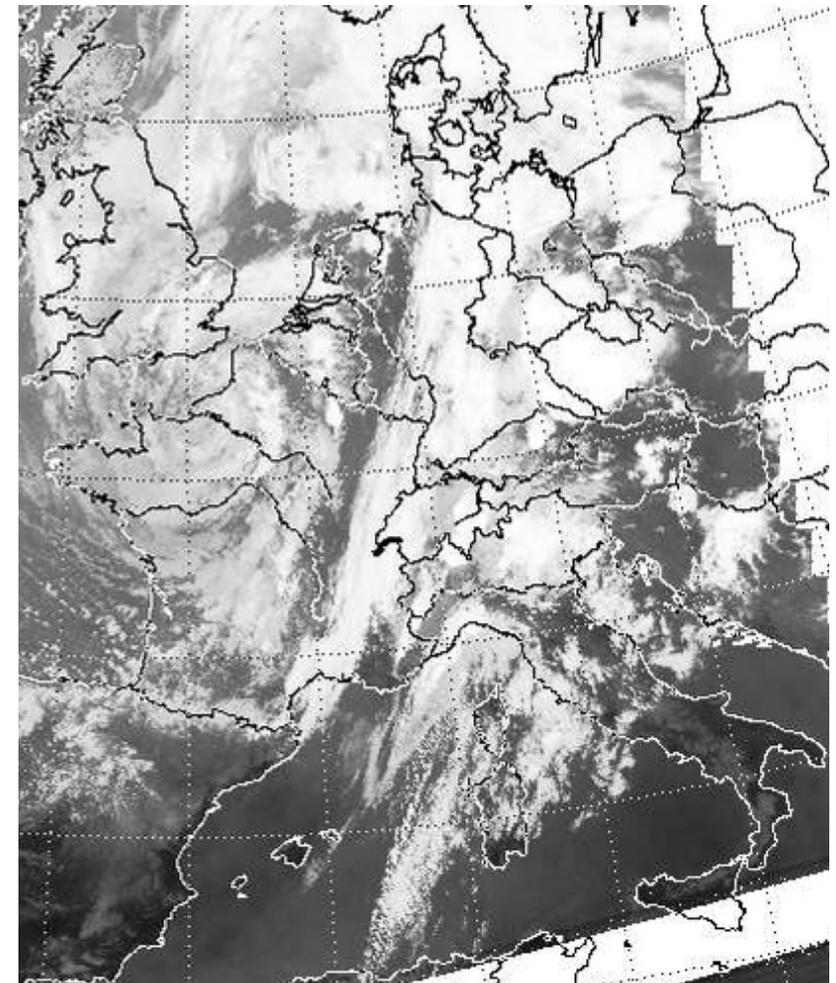


noaa ir 17 :40 utc

3D experiments : Cold front Bavaria-Bohemia



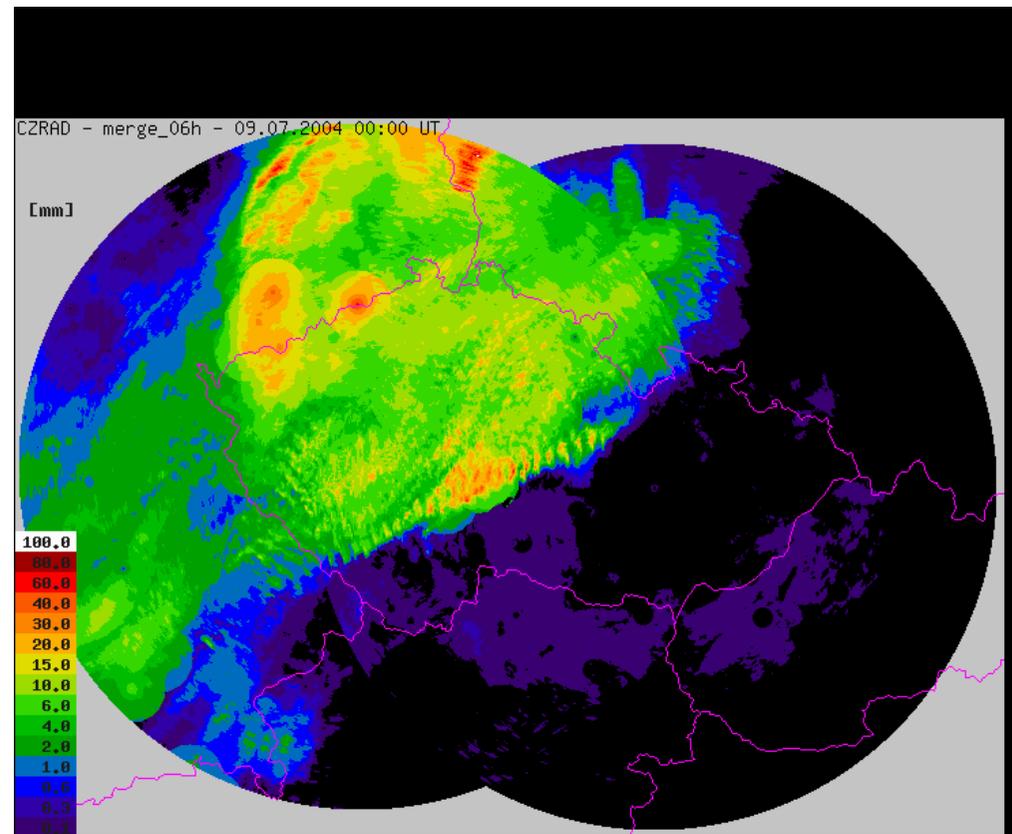
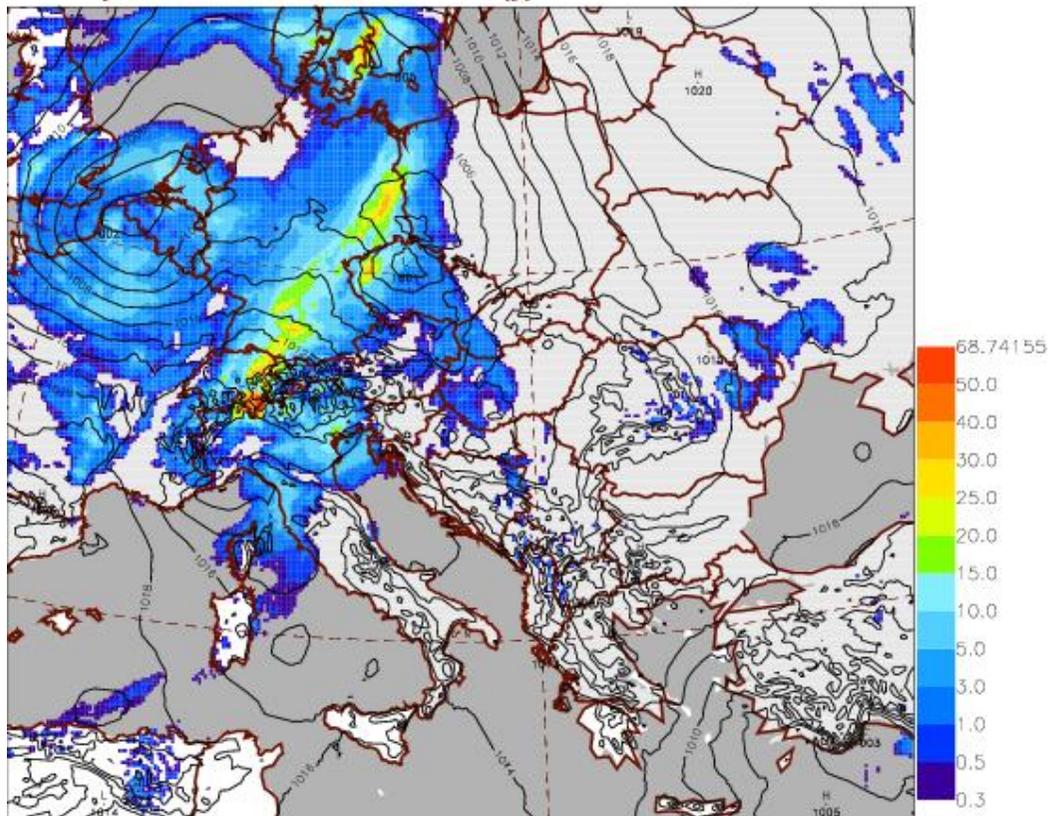
2.28km 08/07/2004 18 :00 utc cloud



noaa ir 17 :40 utc

3D experiments : Cold front Bavaria-Bohemia

Thursday 8 July 2004 02:00 UTC Forecast 1+ 24 VT: Friday 9 July 2004 02:00 UTC
6h-cumulated surface precipitation (mm) - Mean sea level pressure (hPa)

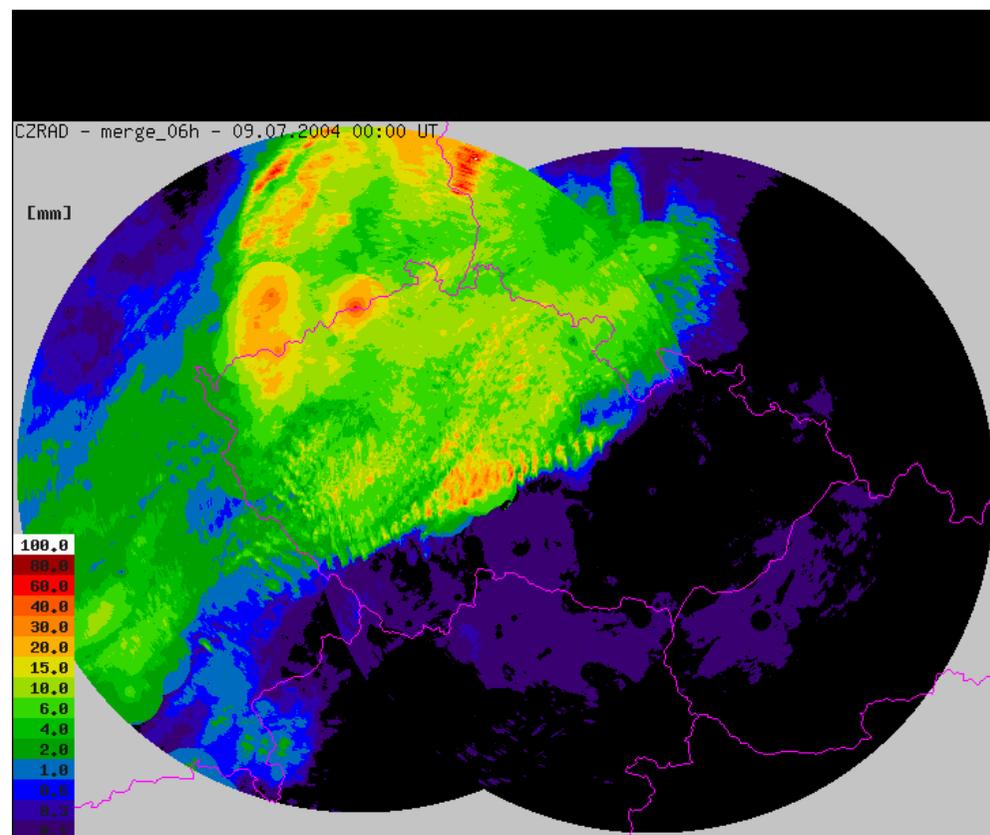
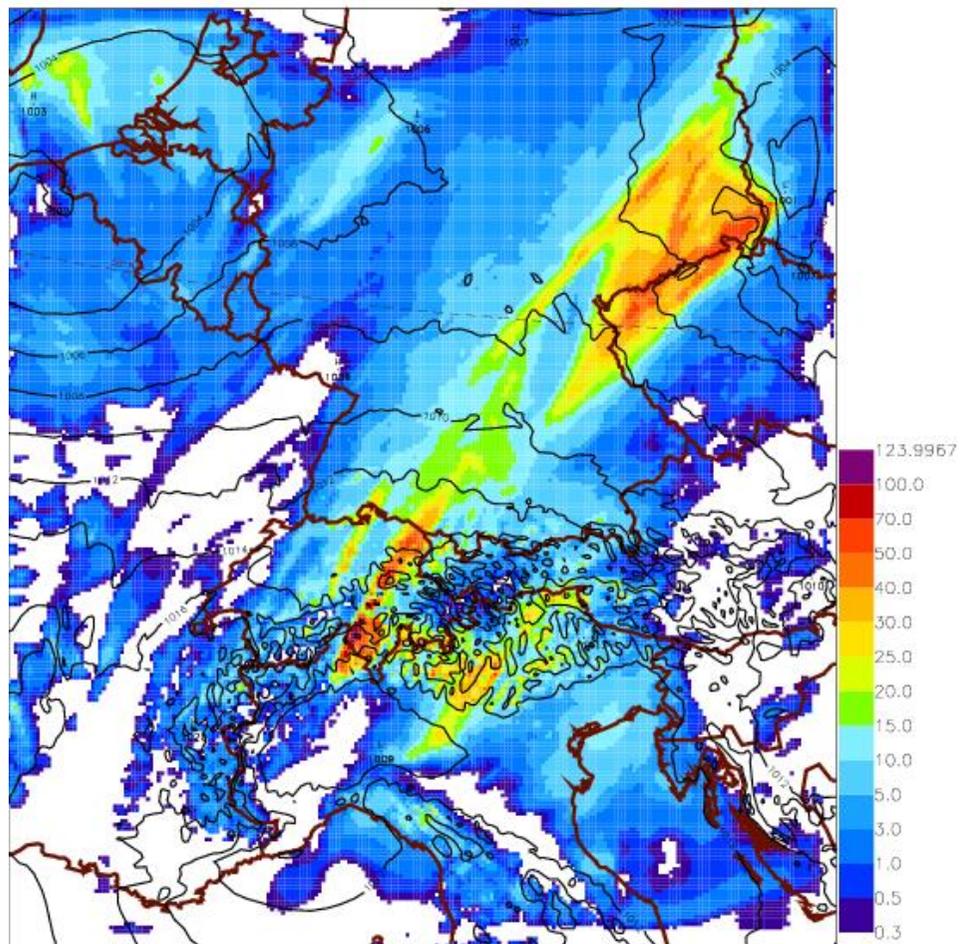


9.00km 09/07/2004 0h utc 6h-accumulated precipitation

radar + rain gauges 09/07/2004 0h utc

3D experiments : Cold front Bavaria-Bohemia

Thursday 08 July 2004 12:24h Forecast 14:24h VT: Friday 09 July 2004 00:00h
6h-accumulated surface precipitation (mm) - Mean sea level pressure (hPa)

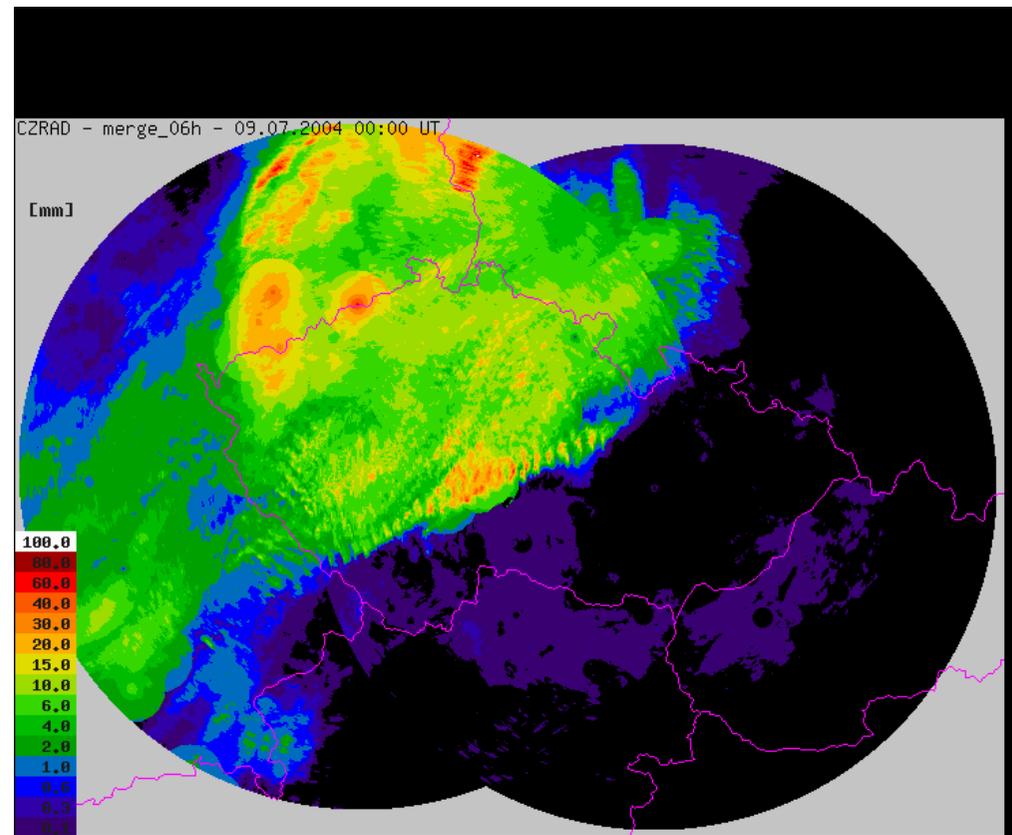
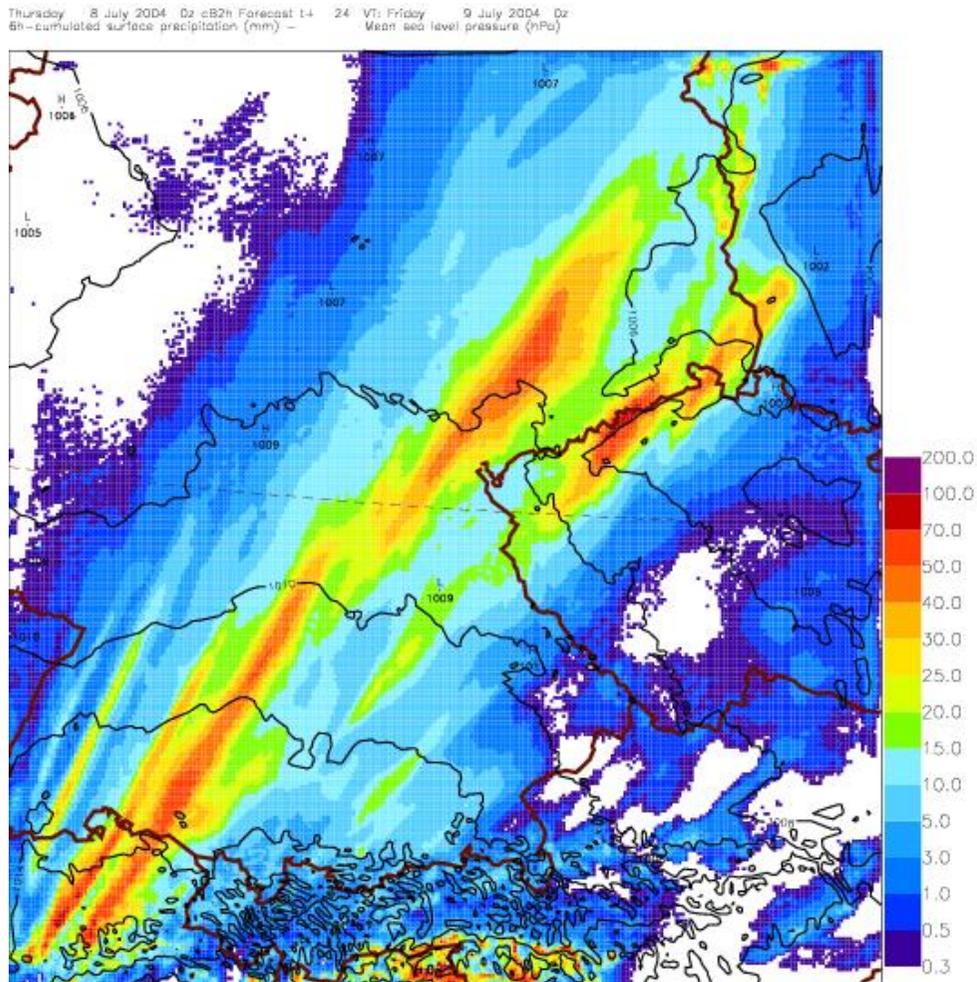


4.54km 09/07/2004 0h utc 6h-accumulated precipitation

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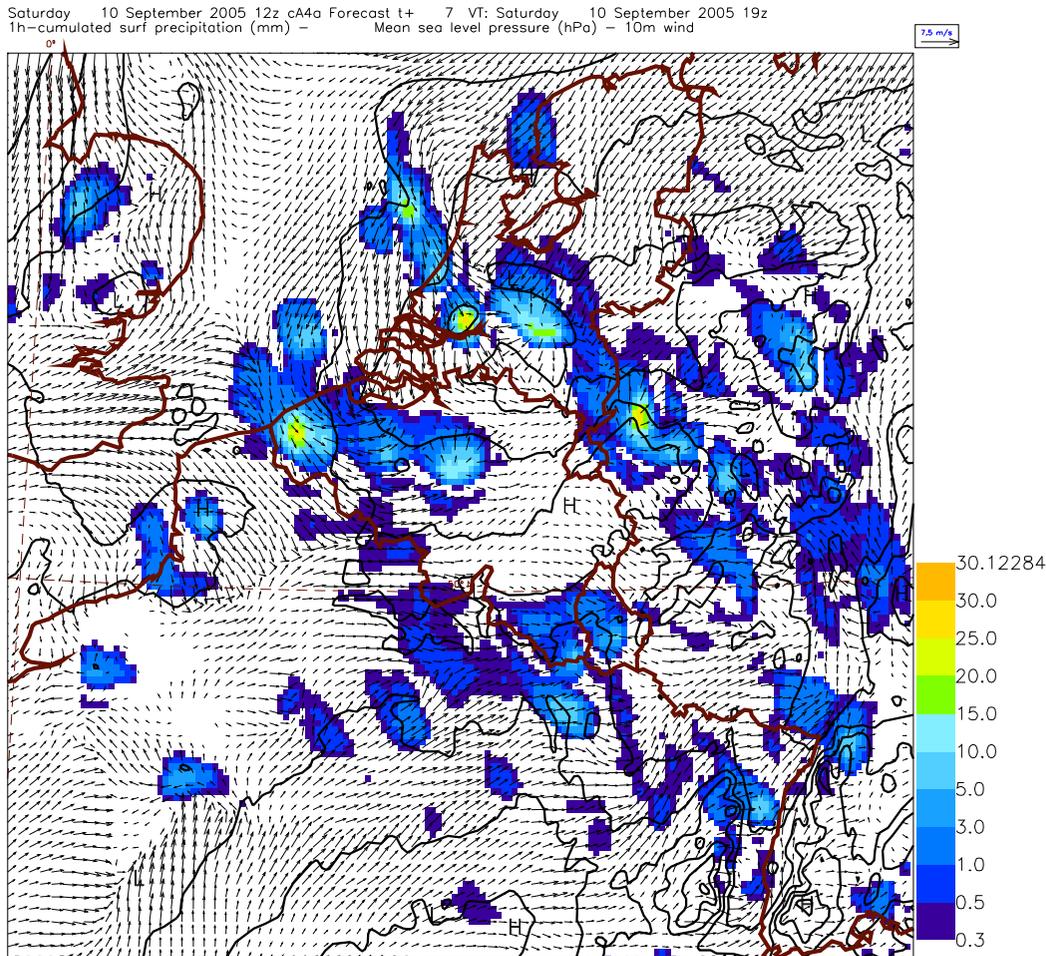
3D experiments : Cold front Bavaria-Bohemia



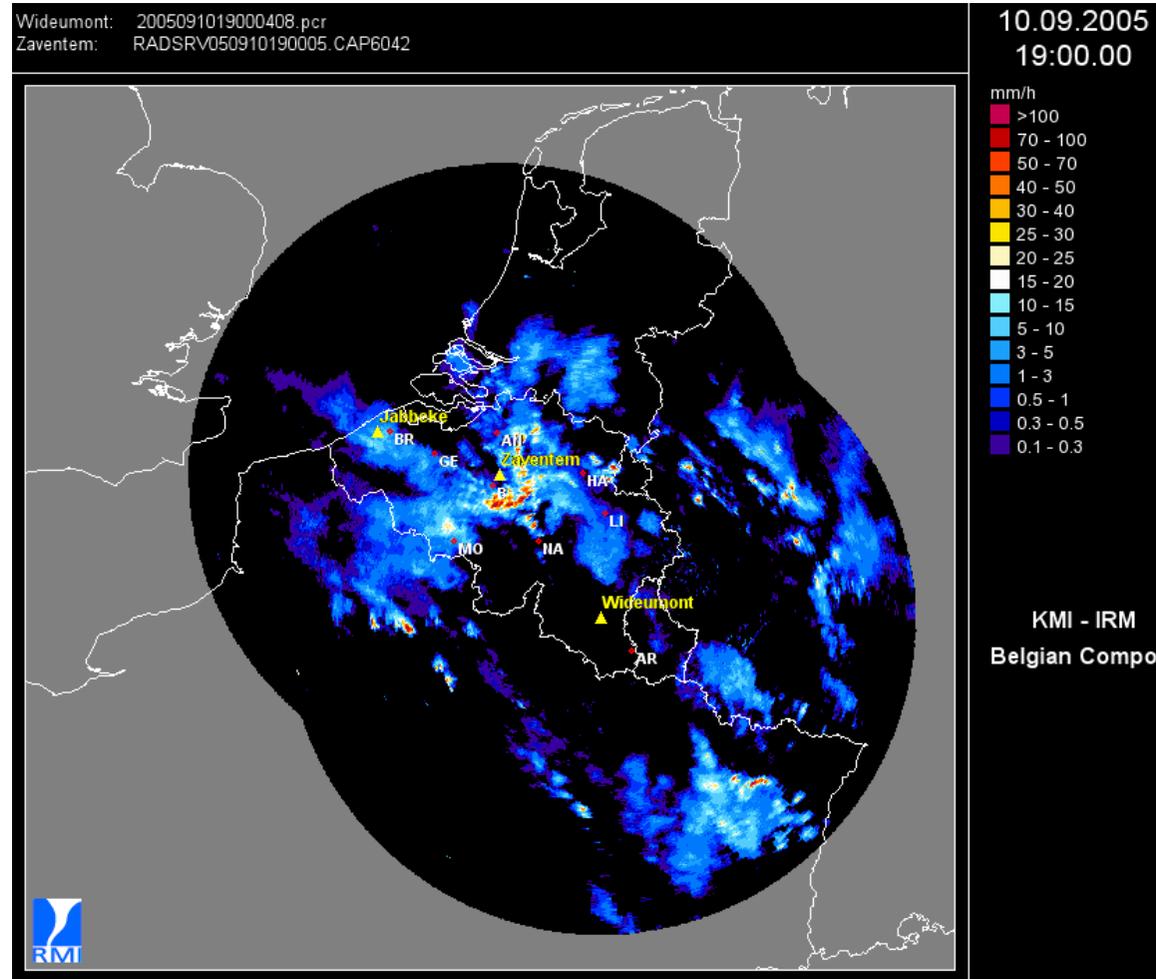
2.28km 09/07/2004 0h utc 6h-accumulated precipitation

radar + rain gauges 09/07/2004 0h utc

3D experiments : Thunderstorm over Belgium



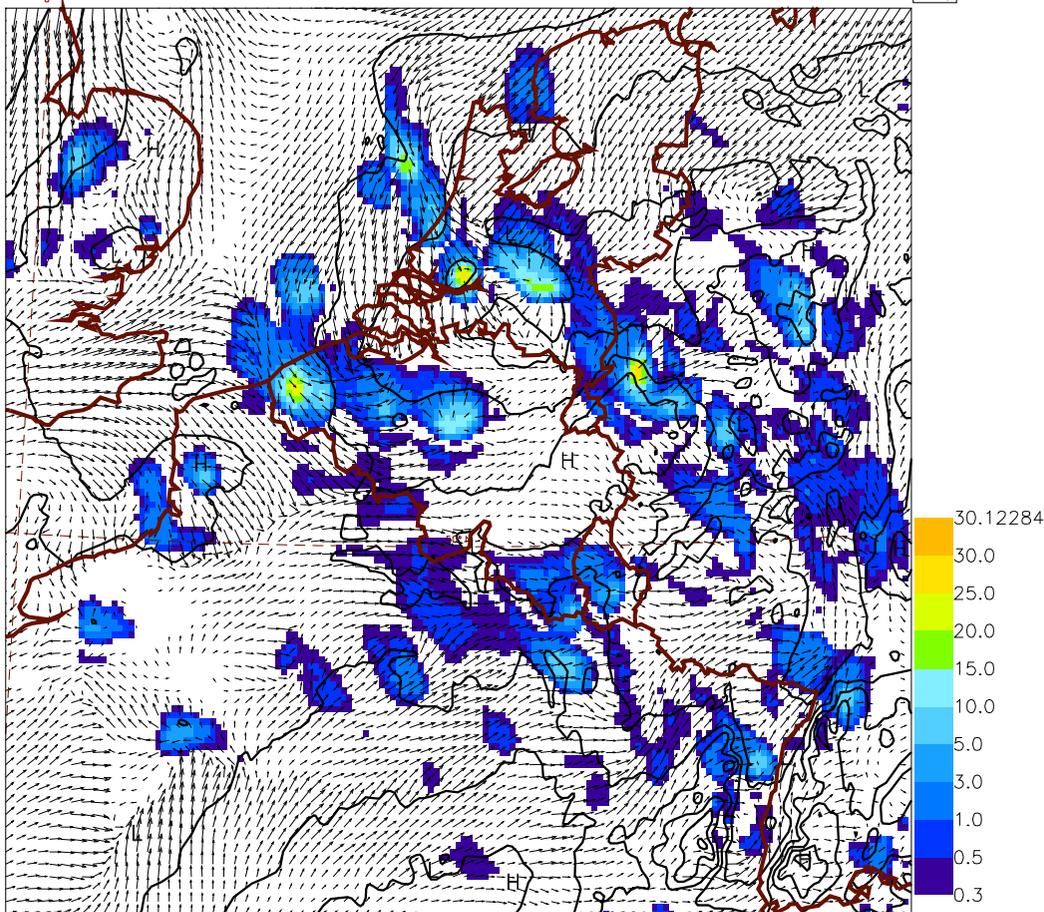
4.01km 19 :00 utc



Instantaneous radar image 19 :00 utc

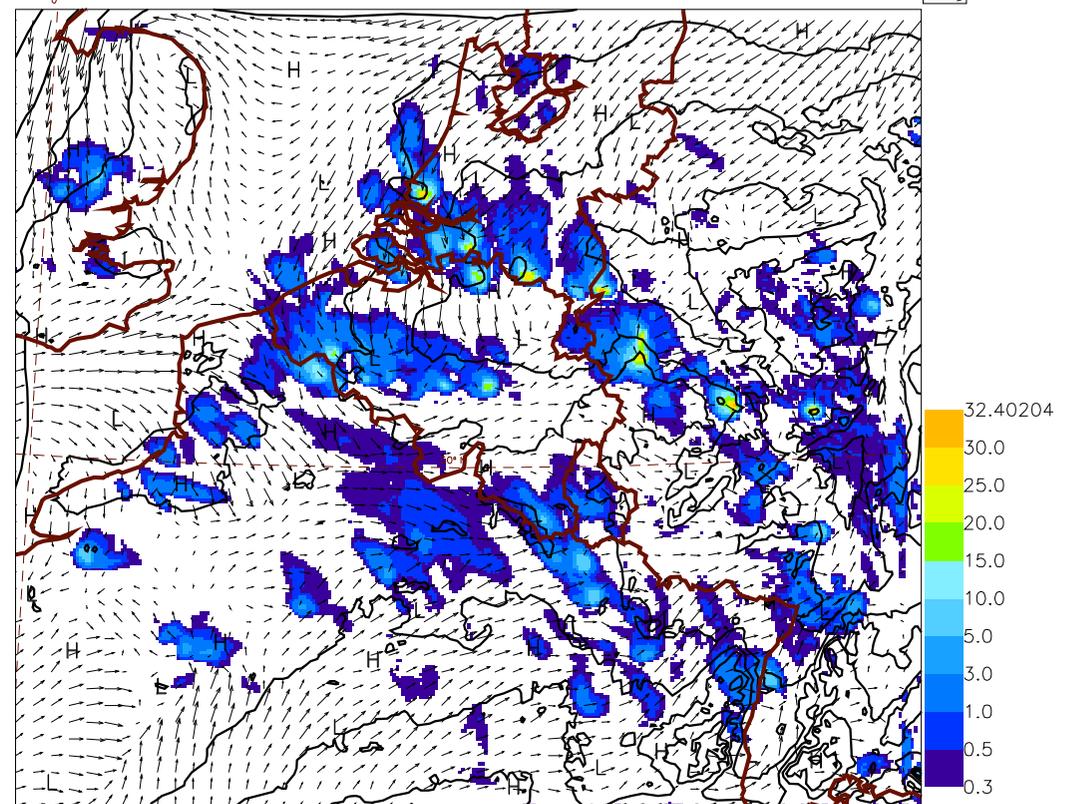
3D experiments : Thunderstorm over Belgium

Saturday 10 September 2005 12z cA4a Forecast t+ 7 VT: Saturday 10 September 2005 19z
1h-cumulated surf precipitation (mm) - Mean sea level pressure (hPa) - 10m wind



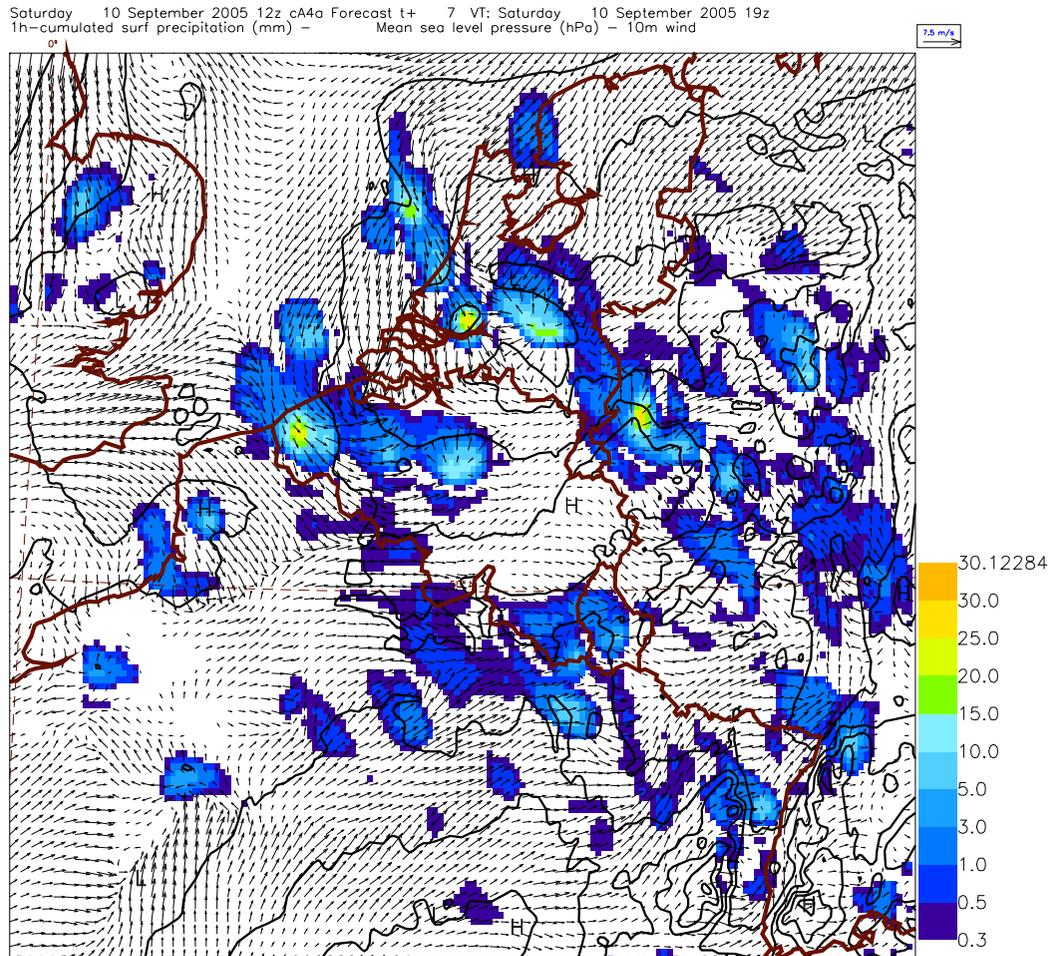
4.01km 19 :00 utc

Saturday 10 September 2005 12z cA2f Forecast t+ 7 VT: Saturday 10 September 2005 19z
1h-cumulated surf precipitation (mm) - Mean sea level pressure (hPa) - 10m wind

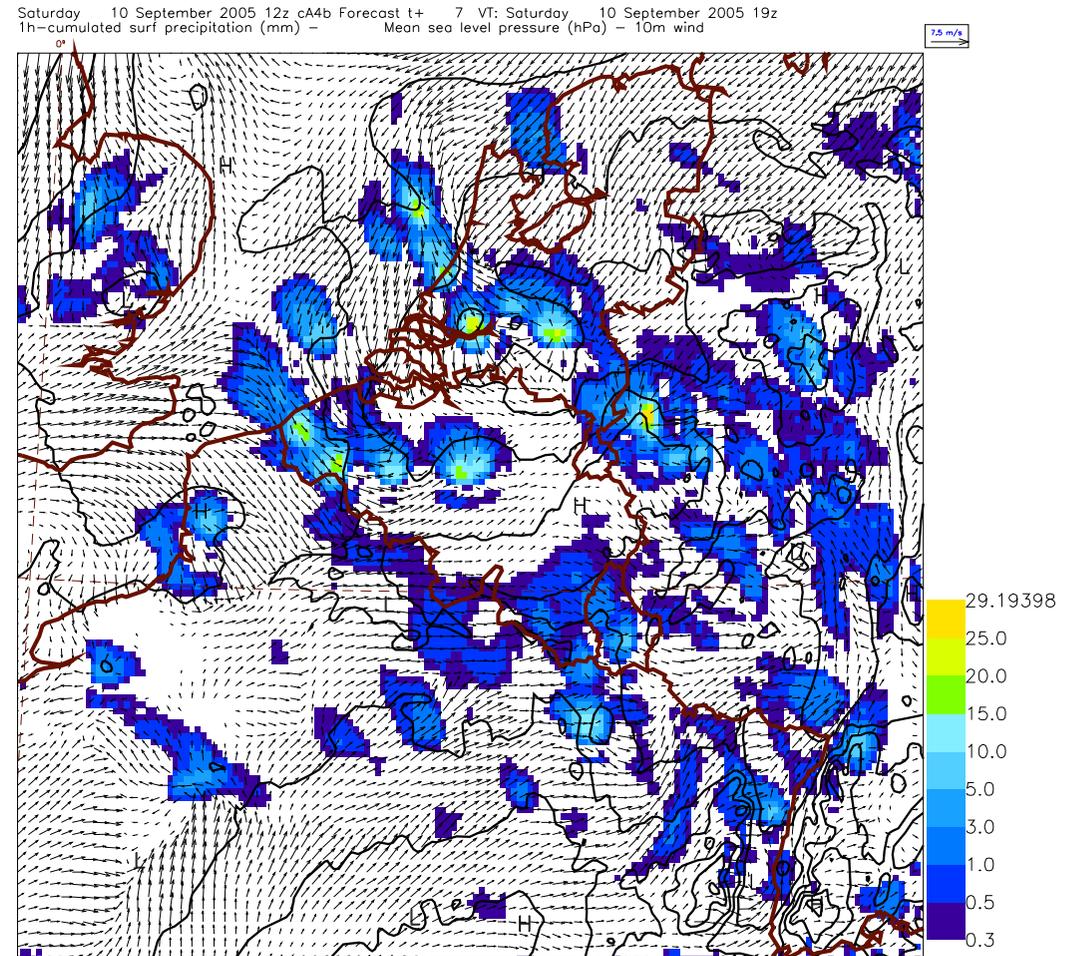


2.18km 19 :00 utc

3D experiments : Thunderstorm over Belgium



4.01km 19 :00 utc



4.01km 19 :00 utc with prognostic mixing

Prognostic Mixing

Real prognostic approach,
revision and synthesis of ideas of Piriou (2005) and Mironov (2005)

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$$\lambda = \left\{ \begin{array}{l} \lambda_{tx} \end{array} \right.$$

– Turbulent contribution

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$$\lambda = \left\{ \lambda_{tx} + \frac{\beta_E}{\Delta\phi} \max\left(0, \frac{\Delta\omega_u}{\omega_u}\right)^{\gamma_E} \right\}$$

- Turbulent contribution
- Acceleration with assumed constant mesh fraction induces additional mixing

Prognostic Mixing

Real prognostic approach,

revision and synthesis of ideas of Piriou (2005) and Mironov (2005)

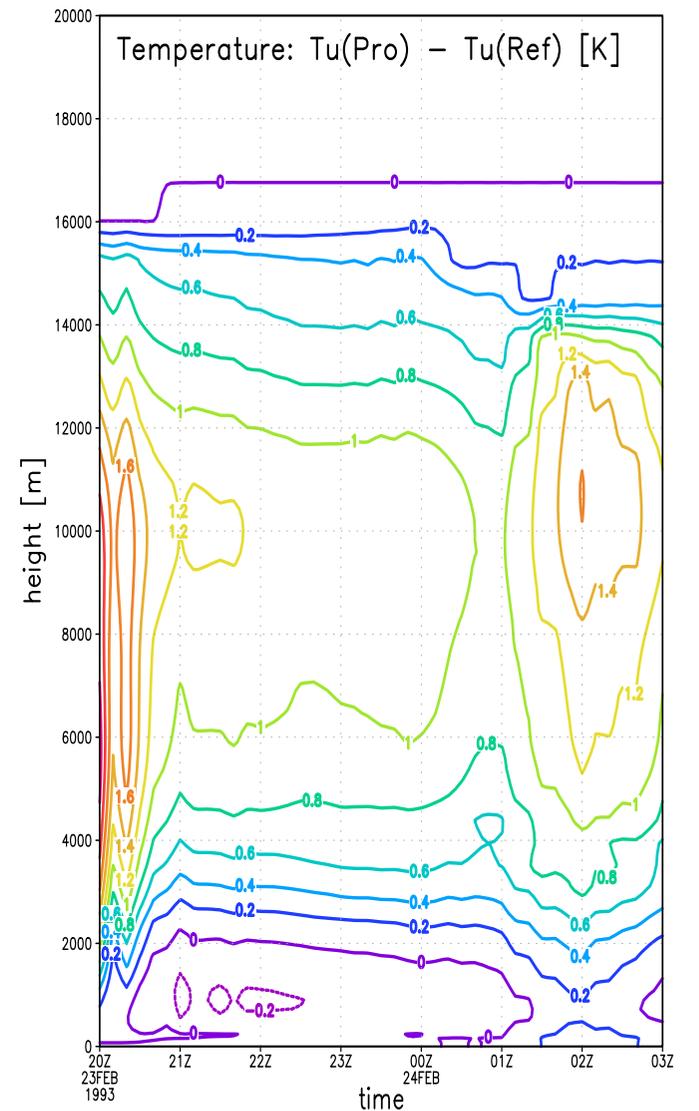
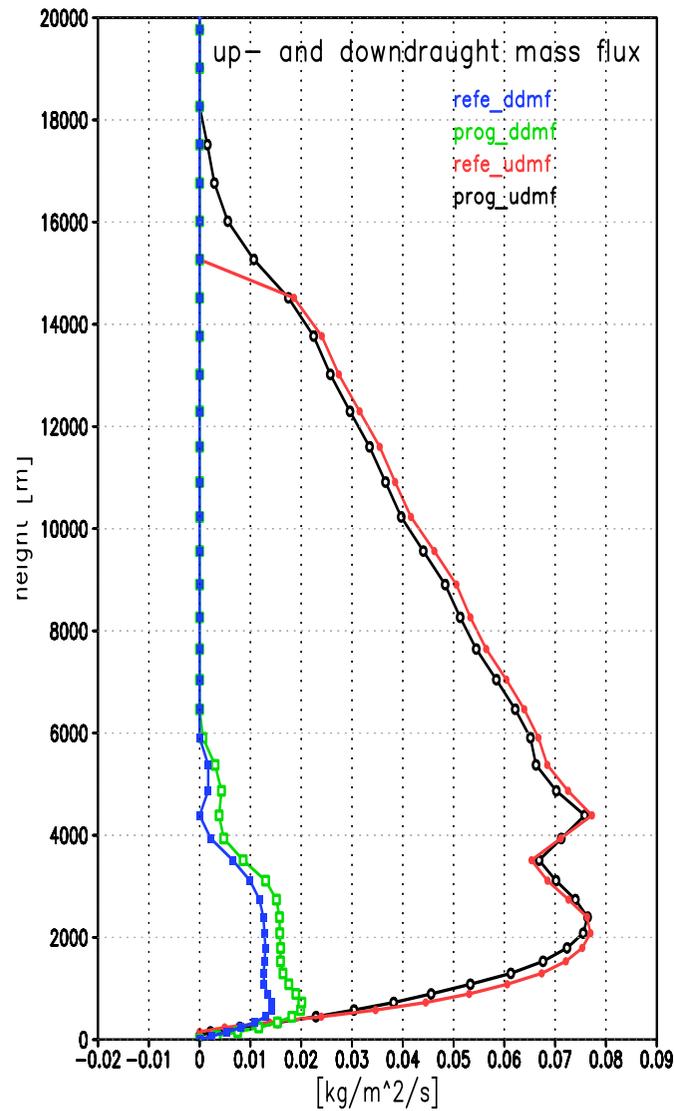
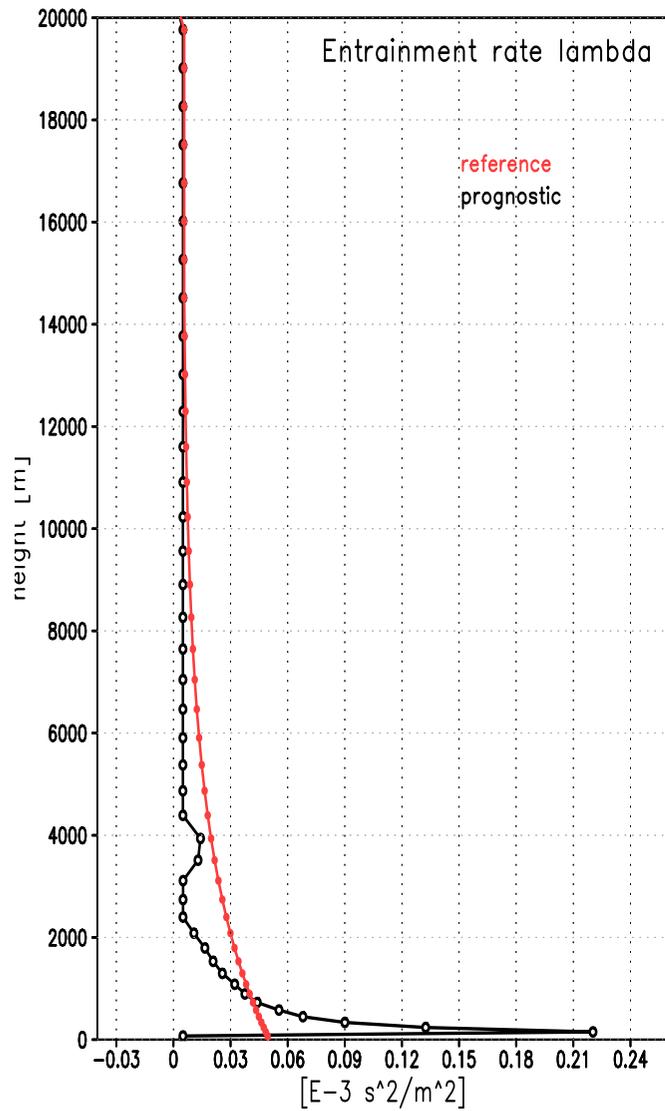
$$\psi_b = \psi_u + \lambda \Delta\phi (\psi_u - \bar{\psi}) \quad , \quad \text{with } \lambda \Delta\phi = \frac{\Delta M}{M}$$

$$\lambda = \left\{ \lambda_{tx} + \frac{\beta_E}{\Delta\phi} \max\left(0, \frac{\Delta\omega_u}{\omega_u}\right)^{\gamma_E} \right\} (1 - \zeta) + \lambda_{tn}\zeta$$

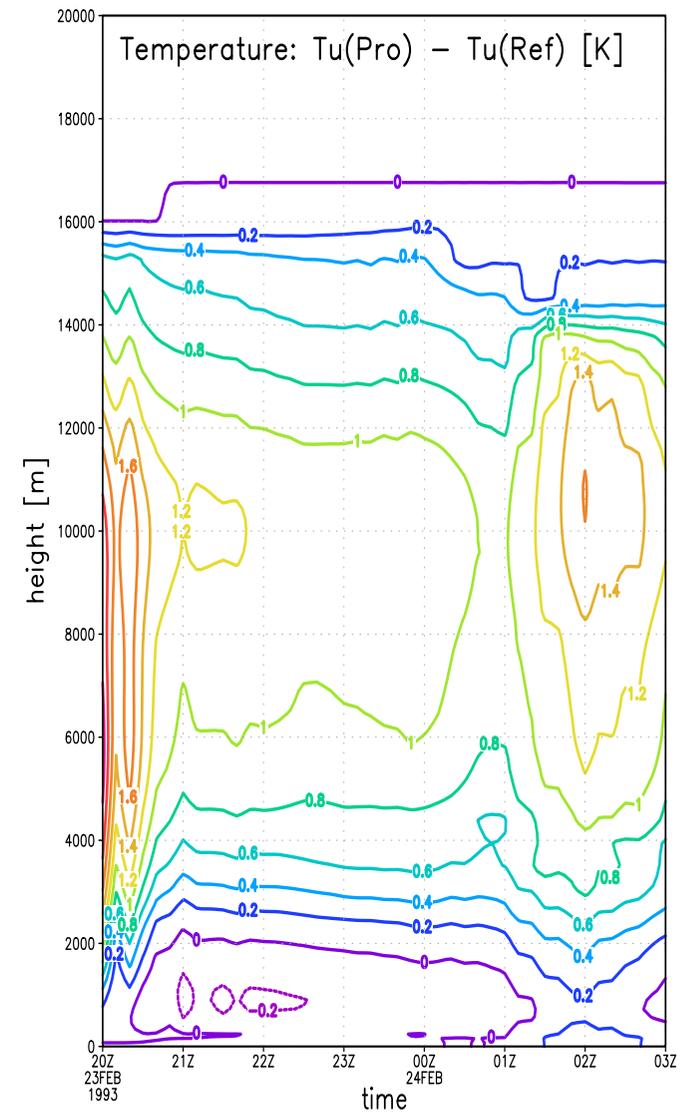
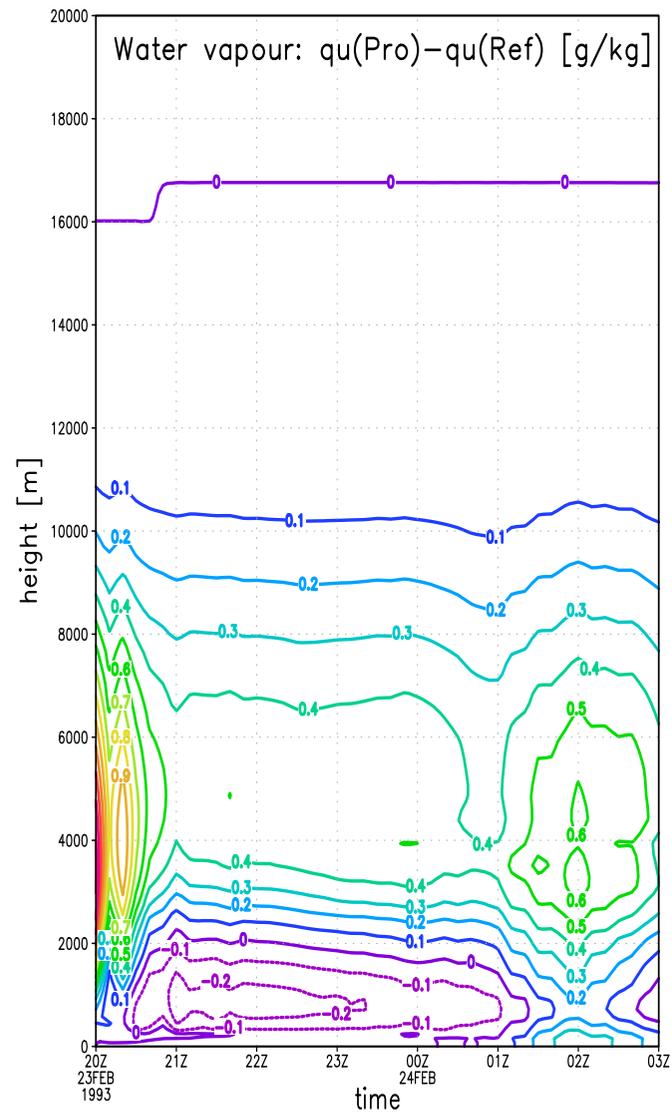
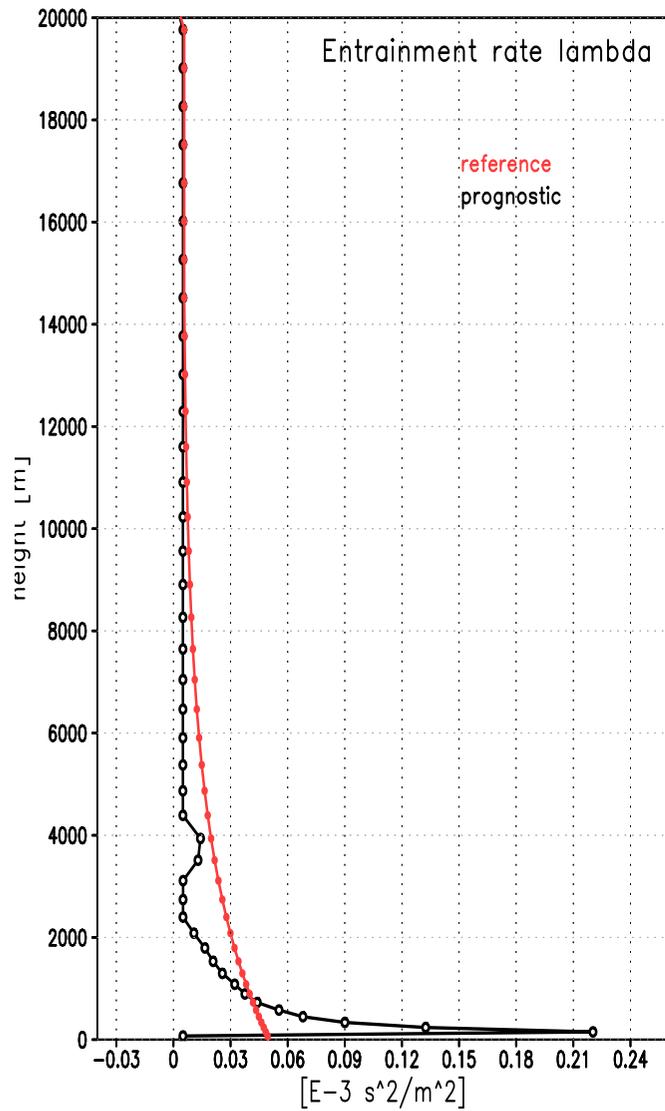
$$\frac{\partial\zeta}{\partial t} = \alpha_E \sigma_d - \frac{\zeta}{\tau_E}$$

- Turbulent contribution
- Acceleration with assumed constant mesh fraction induces additional mixing
- Downdraught activity reduces the mixing

Prognostic Mixing



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Conclusions

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 - very beneficial
 - Very small diffusion

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 - Very small diffusion
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- Further work on triggering, shallow convection, diurnal cycle and links with turbulent scheme