Predictability Issues in High-Resolution Numerical Modelling of Stratiform and Convective Precipitation

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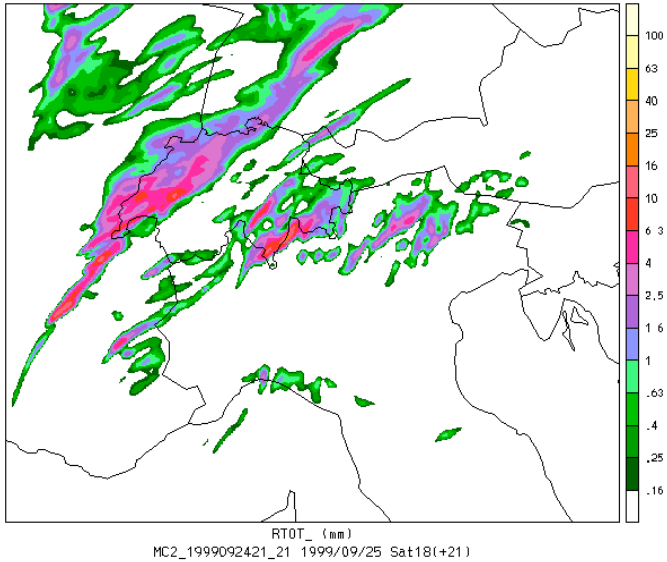
Motivation

Increase in computing power -> finer mesh:

- Higher resolved topography

- Explicitly resolved moist convection



New questions:

- To what extent are small-scale processes such as convection predictable?

- How does the meso-β scale predictability of precipitation depend upon the type of precipitation and its location with respect to topography?

- What are the implications of limited predictability for hydrological forecasts?

Ensemble Methodology

- Isolation of predictability aspects relating to meso-β and smaller scales.

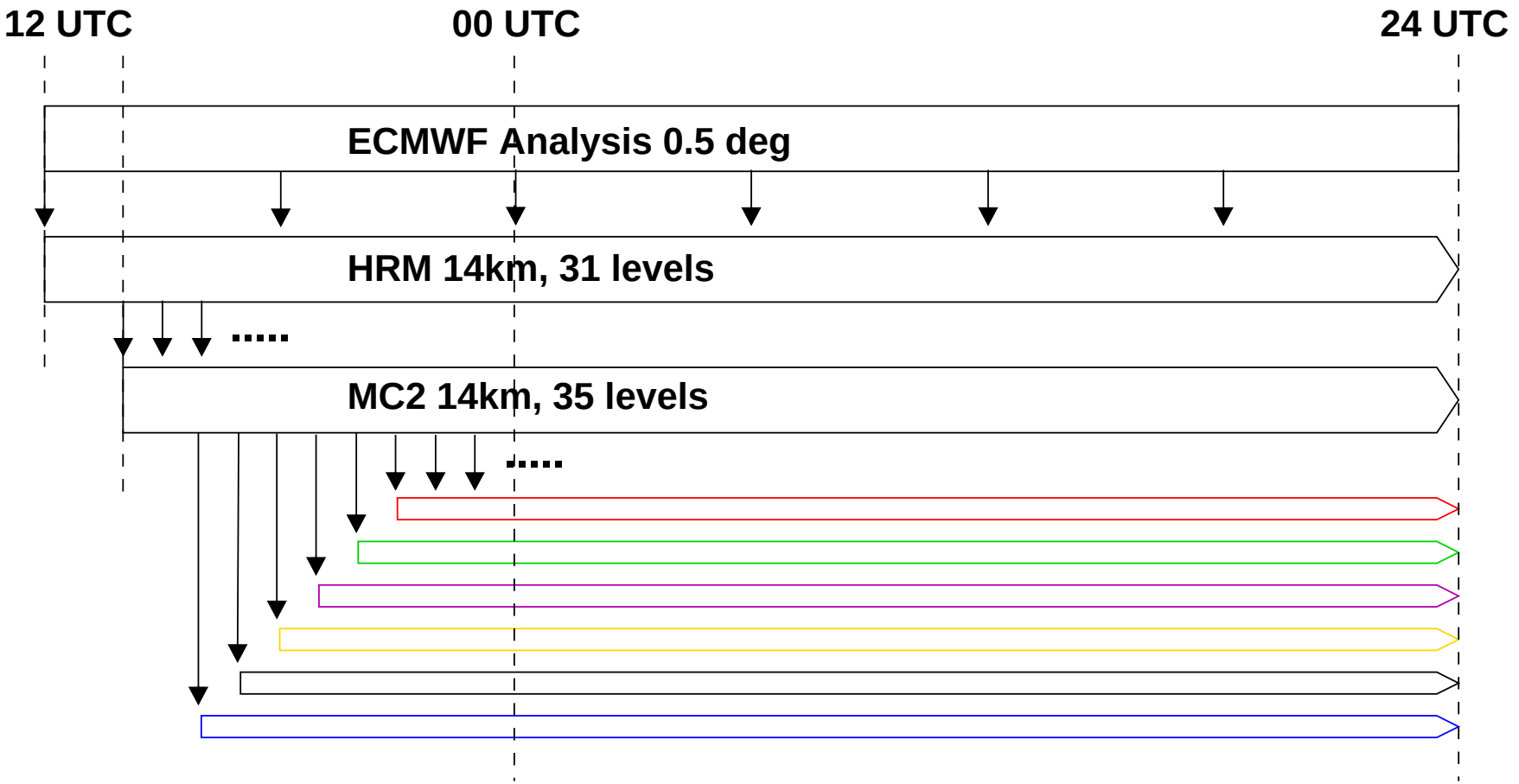
- Assumptions: perfect model and perfectly predictable synoptic conditions.

- Model chain with ECMWF analysis, HRM and MC2.

- Ensemble of 6 similar weather simulations with slightly modified initial conditions (realized by shifted initialization), but identical lateral boundary conditions.

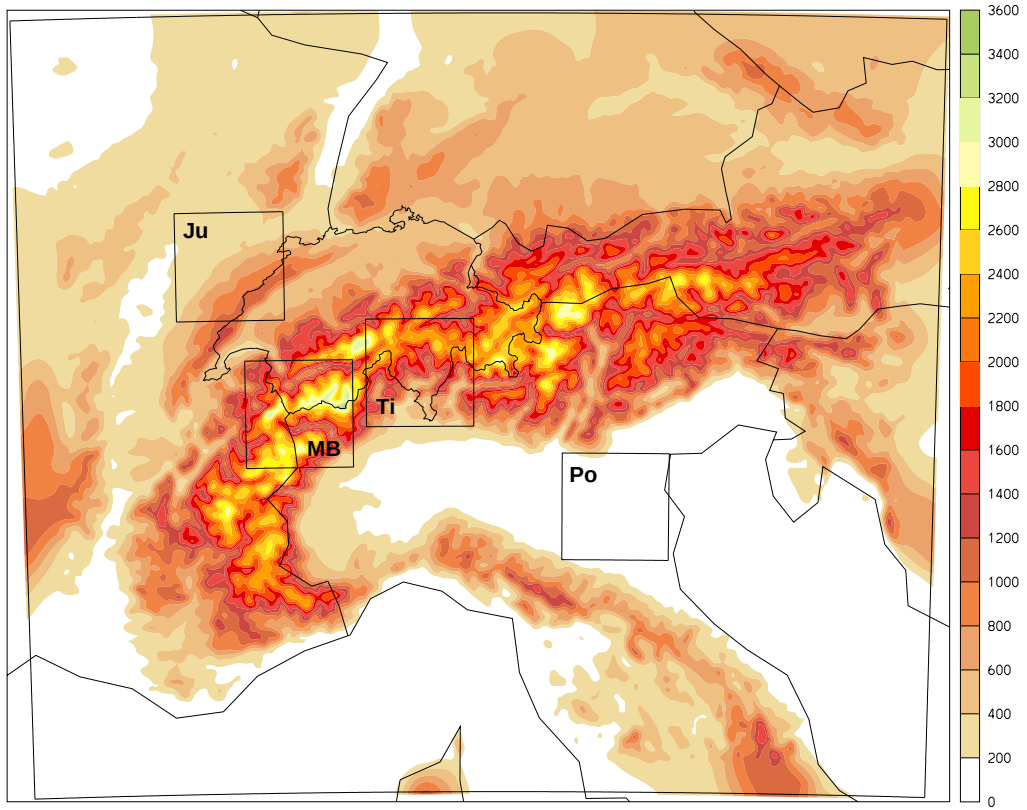
- Amplification of the differences of each member to the ensemble mean by a factor 3 at the beginning of the day of interest (00 UTC). Performed uniformly for temperature, humidity, horizontal wind and pressure.

Ensemble Methodology



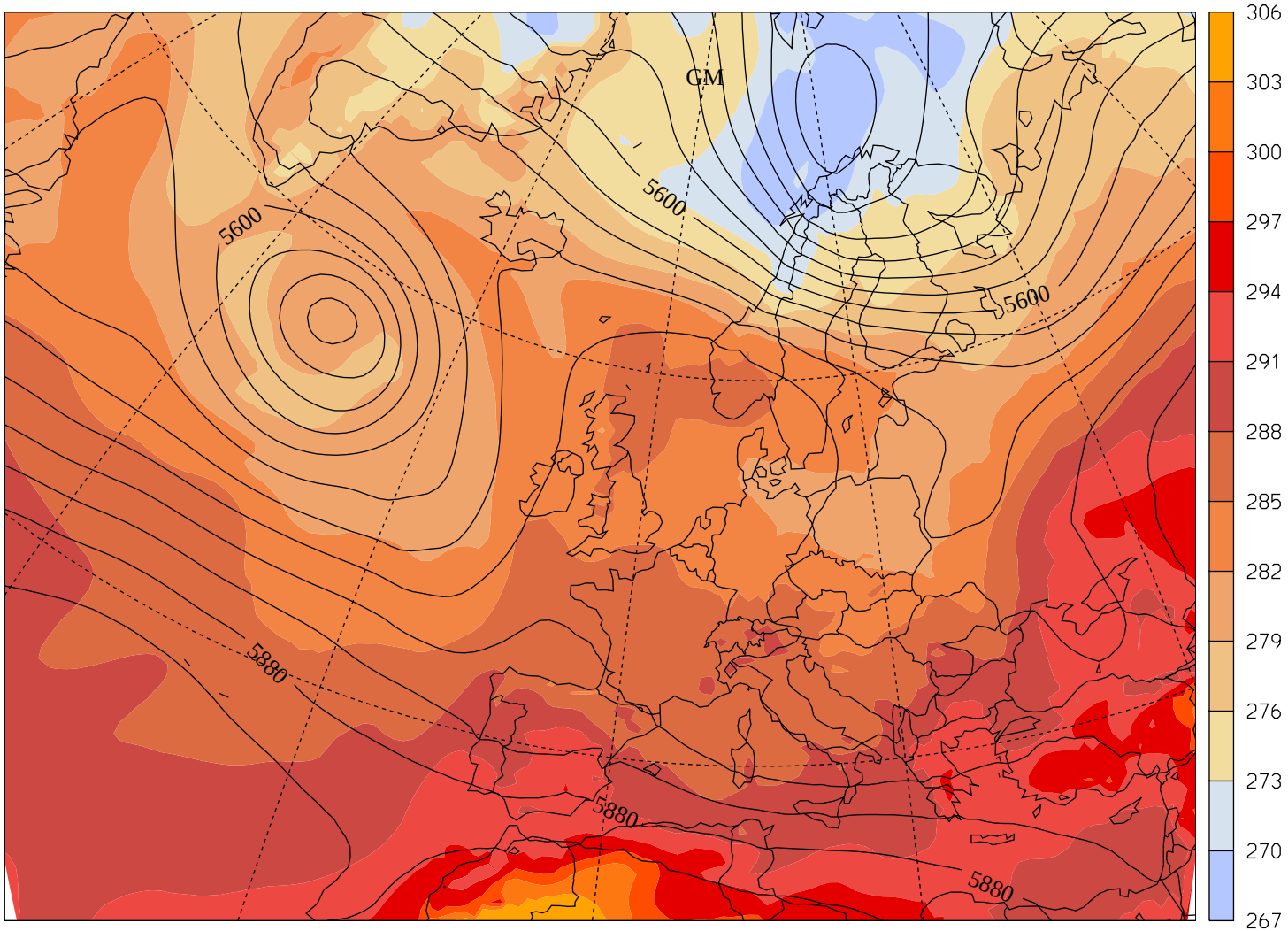
Model chain and setup for the ensemble simulations.

The MC2 Model

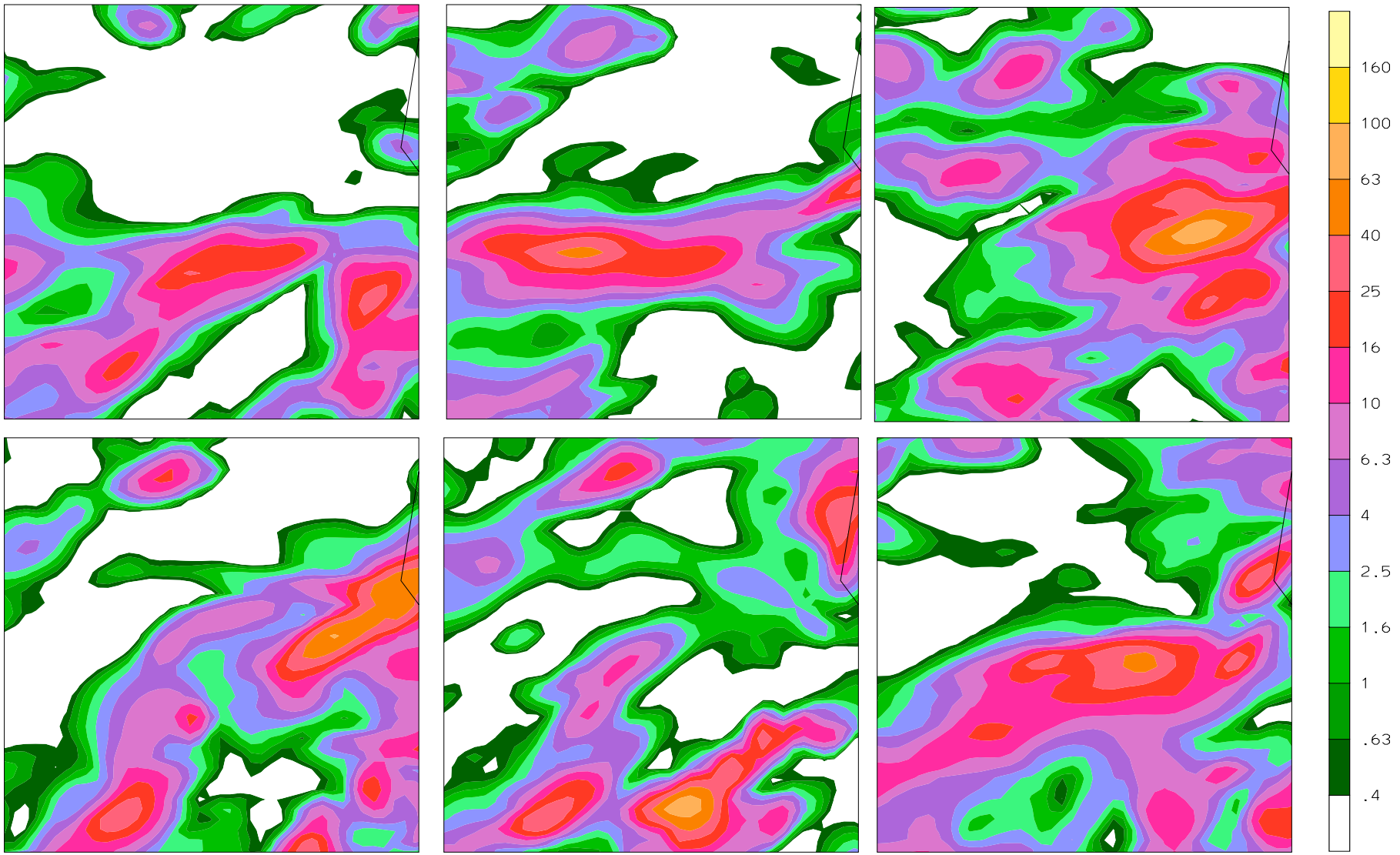


- 3 km horizontal grid-spacing
- 50 vertical levels
- 1030 x 880 km domain over the European Alps
- non-hydrostatic
- semi-lagrangian and semi-implicit
- convection treated explicitly (no parameterization)
- surface scheme: simplified force-restore method.

29 July 1999, 12 UTC, ECMWF analysis: Temperature (850 hPa) and geopotential (500 hPa)

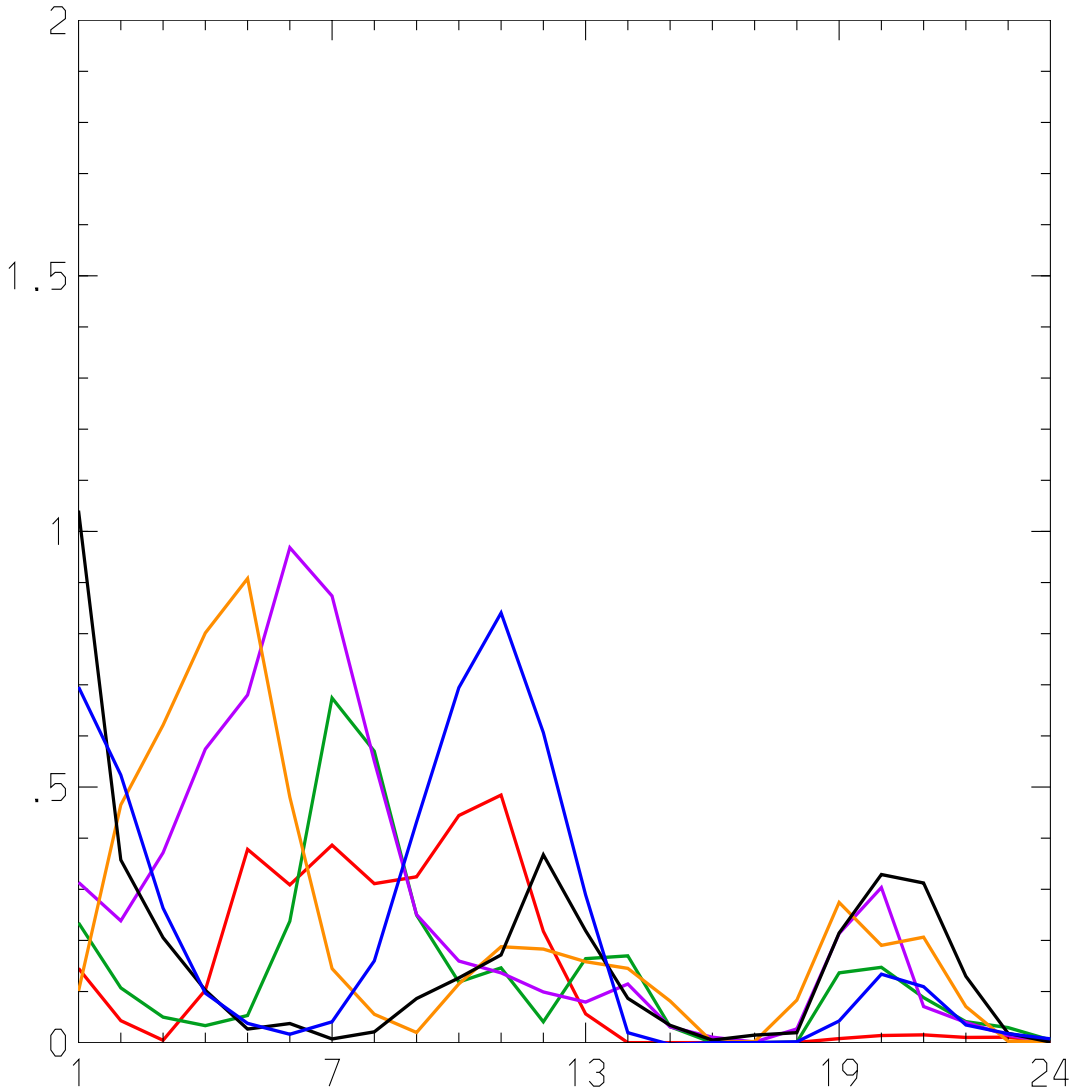


29 July 1999 subdomain Po: thermal convection



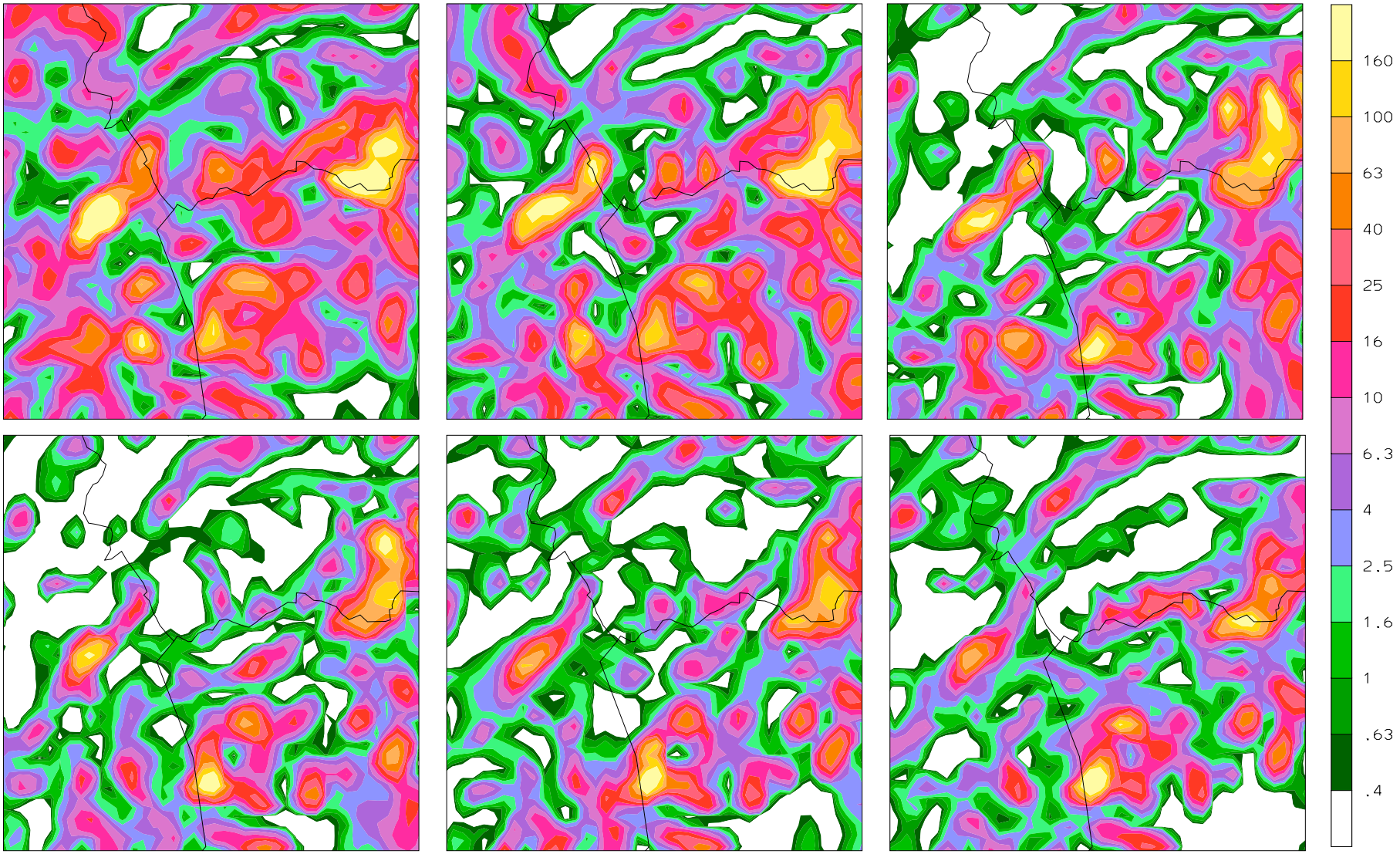
Daily precipitation sum [mm] for members 1-6.

29 July 1999 subdomain Po: thermal convection



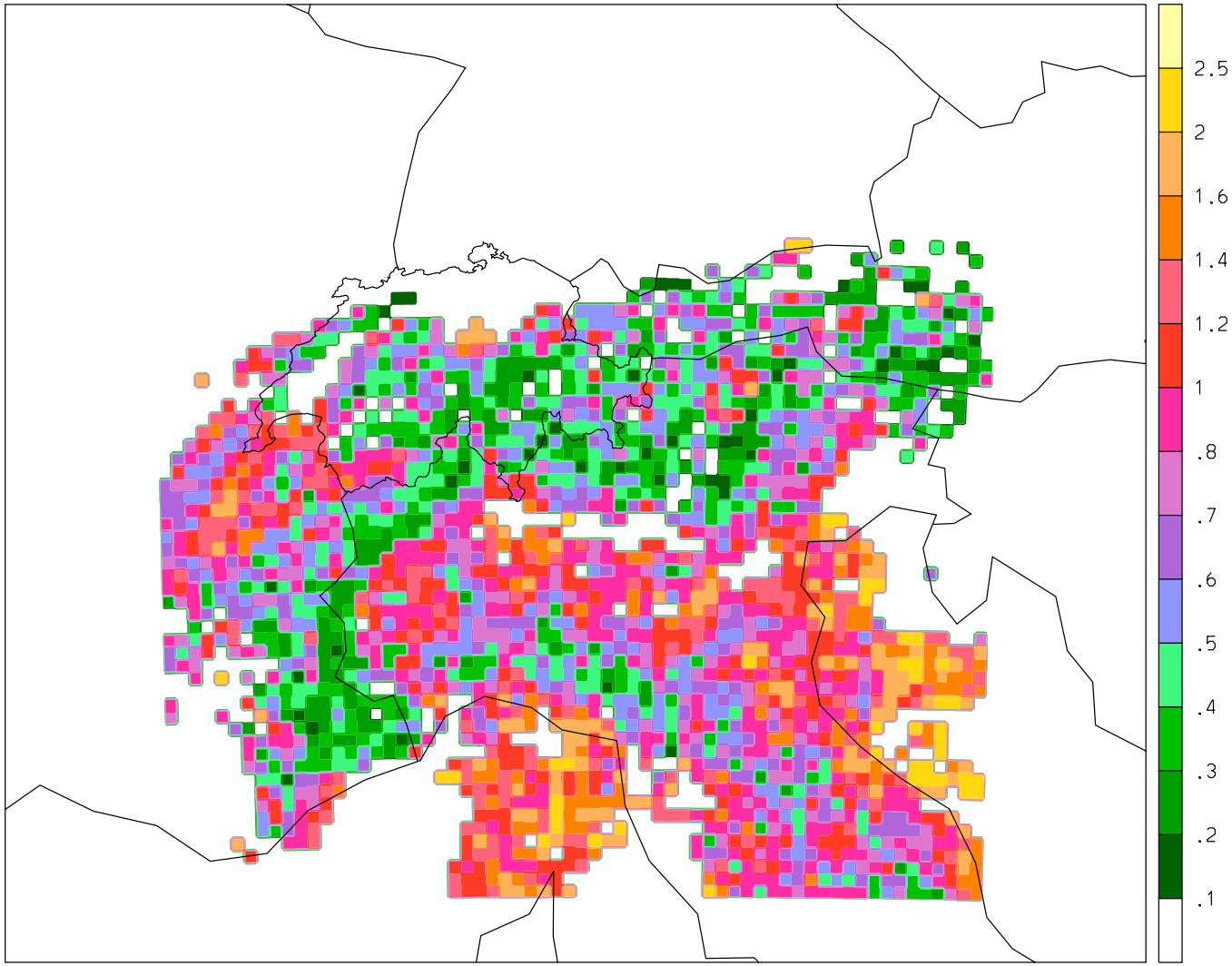
Evolution of mean precipitation [mm/h], horizontal axis indicates time (UTC).

29 July 1999 subdomain Mont Blanc: thermal convection



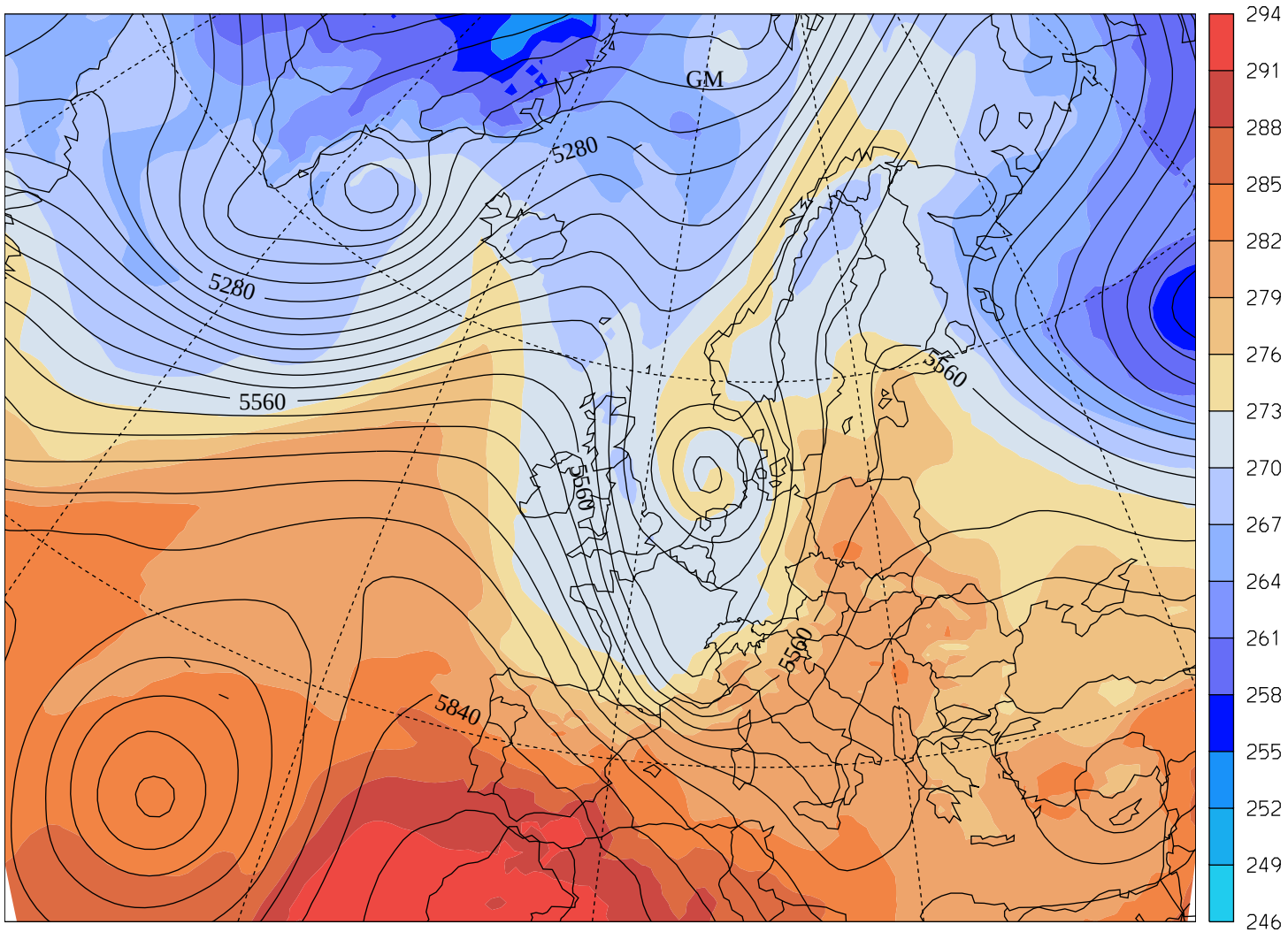
Daily precipitation sum [mm] for members 1-6.

29 July 1999: Geographical variability of predictability

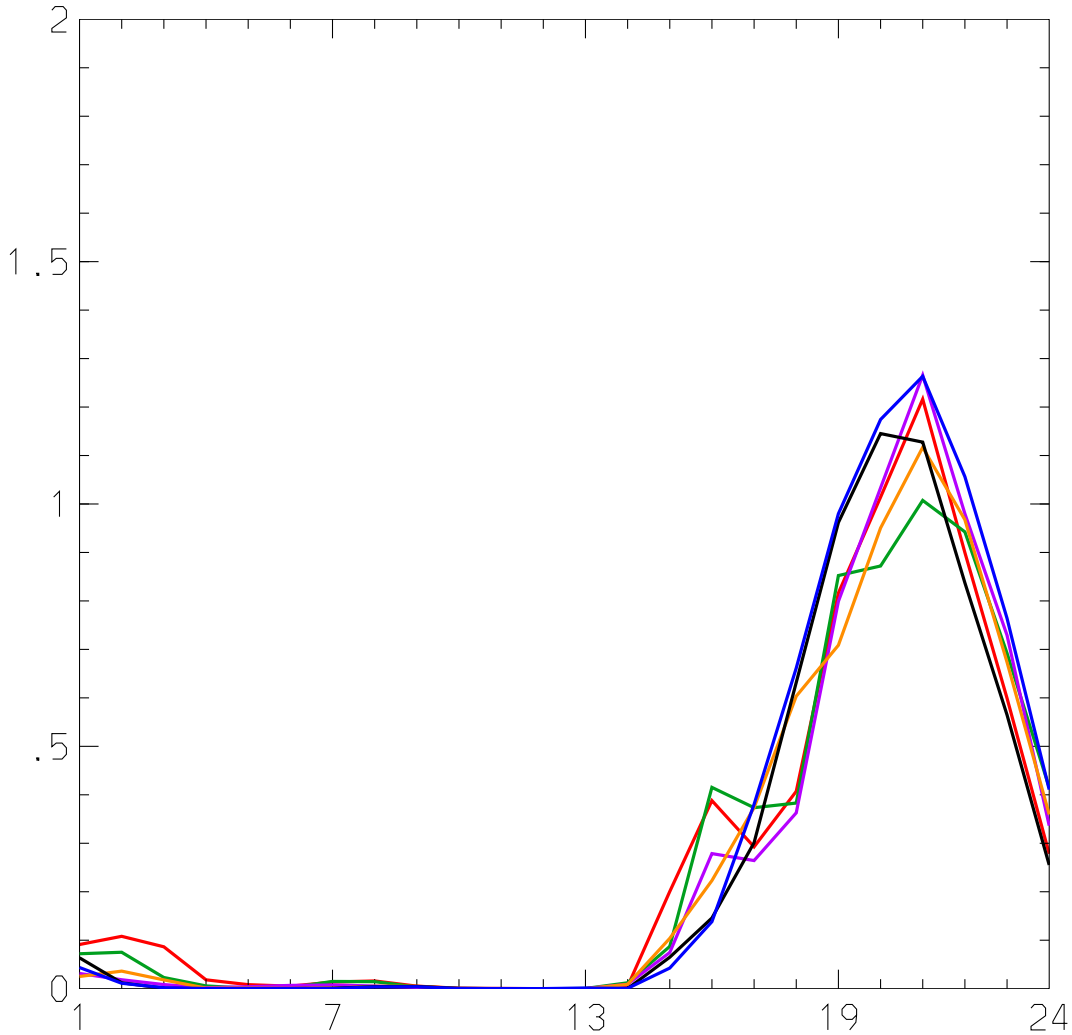


Ratio of standard deviation to the ensemble mean (threshold 1mm) of daily precipitation.

November 6 (MAP IOP 15) 12 UTC, ECMWF analysis: Temperature (850 hPa) and geopotential (500 hPa)

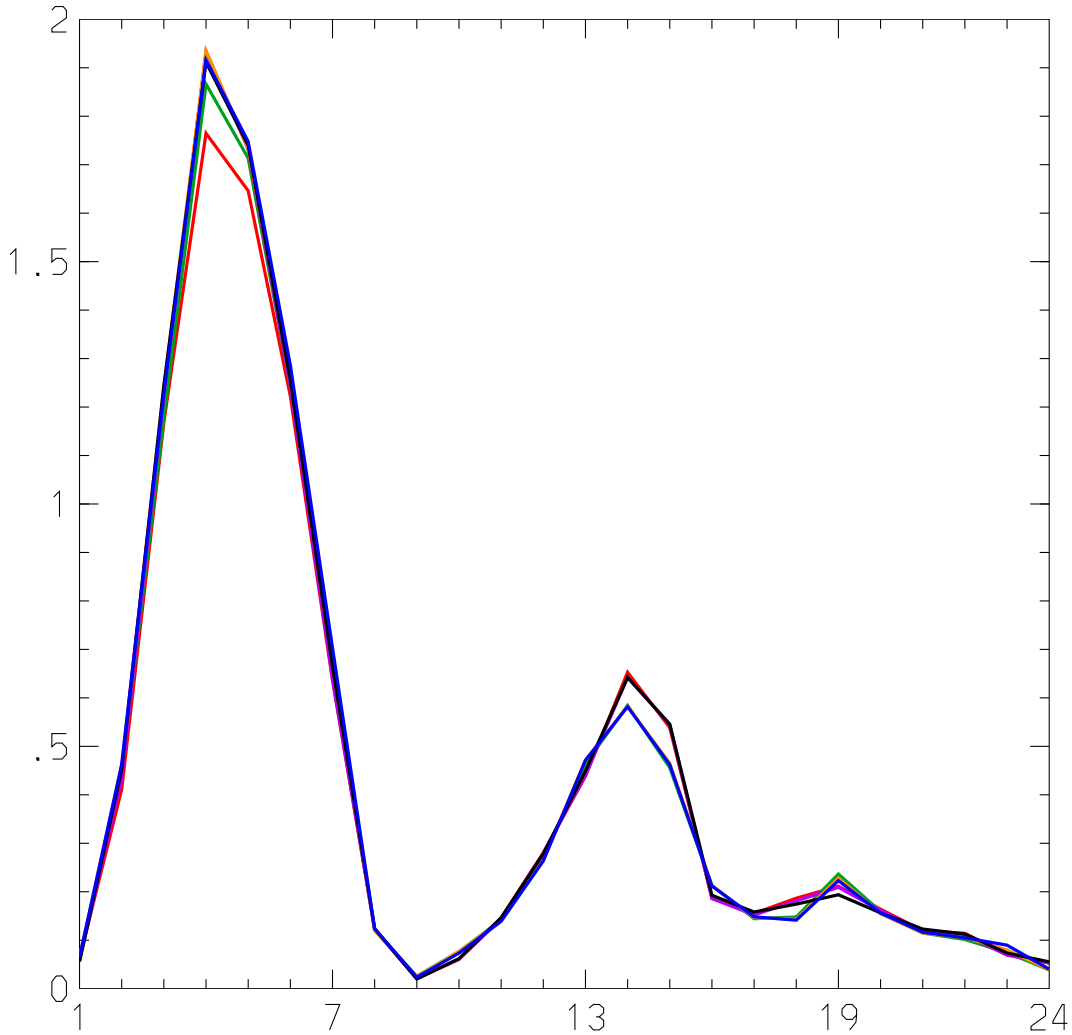


6 November 1999 subdomain Po



Evolution of mean precipitation [mm/h], horizontal axis indicates time (UTC).

6 November 1999 subdomain Ju: Stratiform precipitation



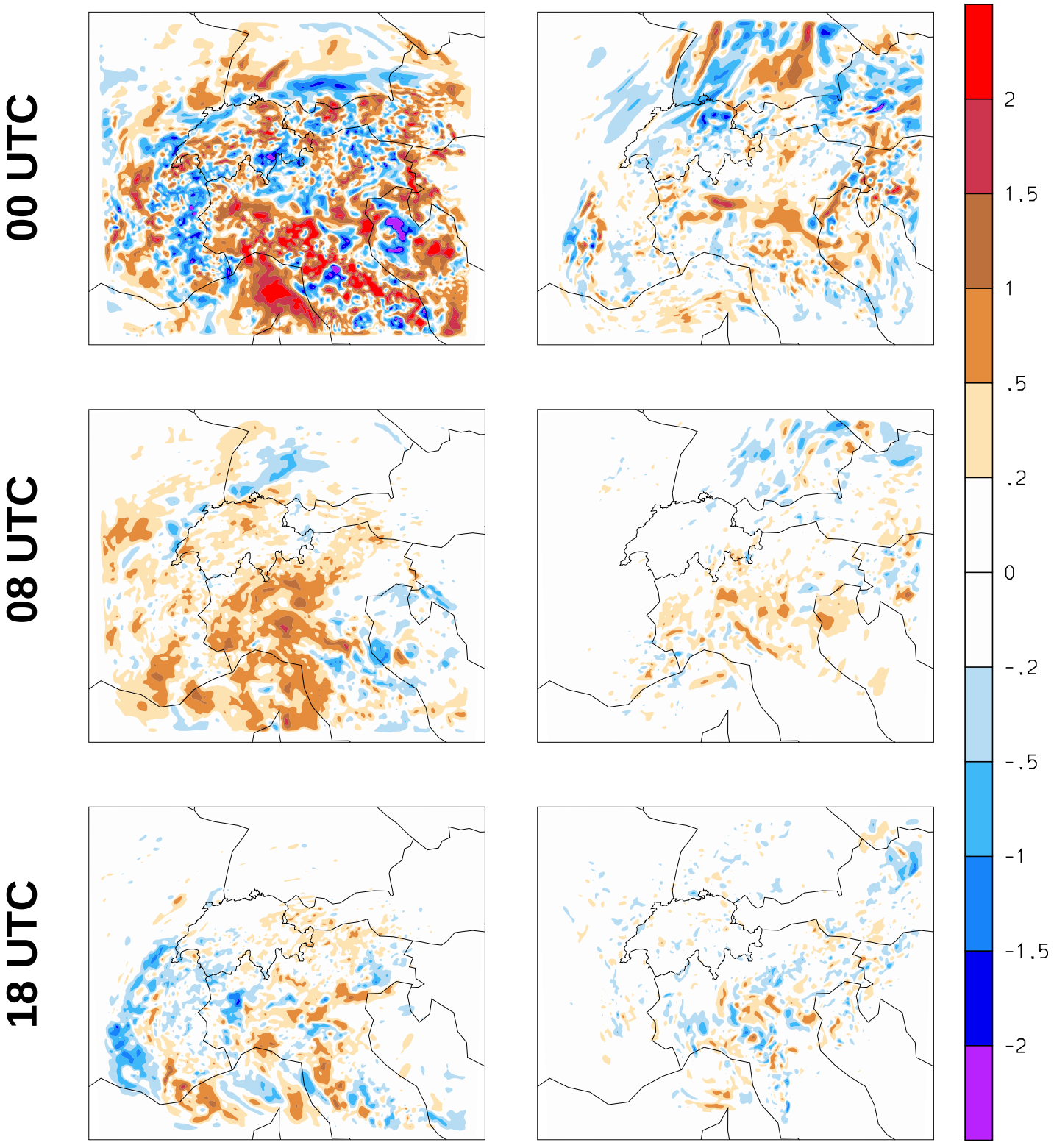
Evolution of mean precipitation [mm/h], horizontal axis indicates time (UTC)

6 November 1999 subdomain Ju: Stratiform precipitation

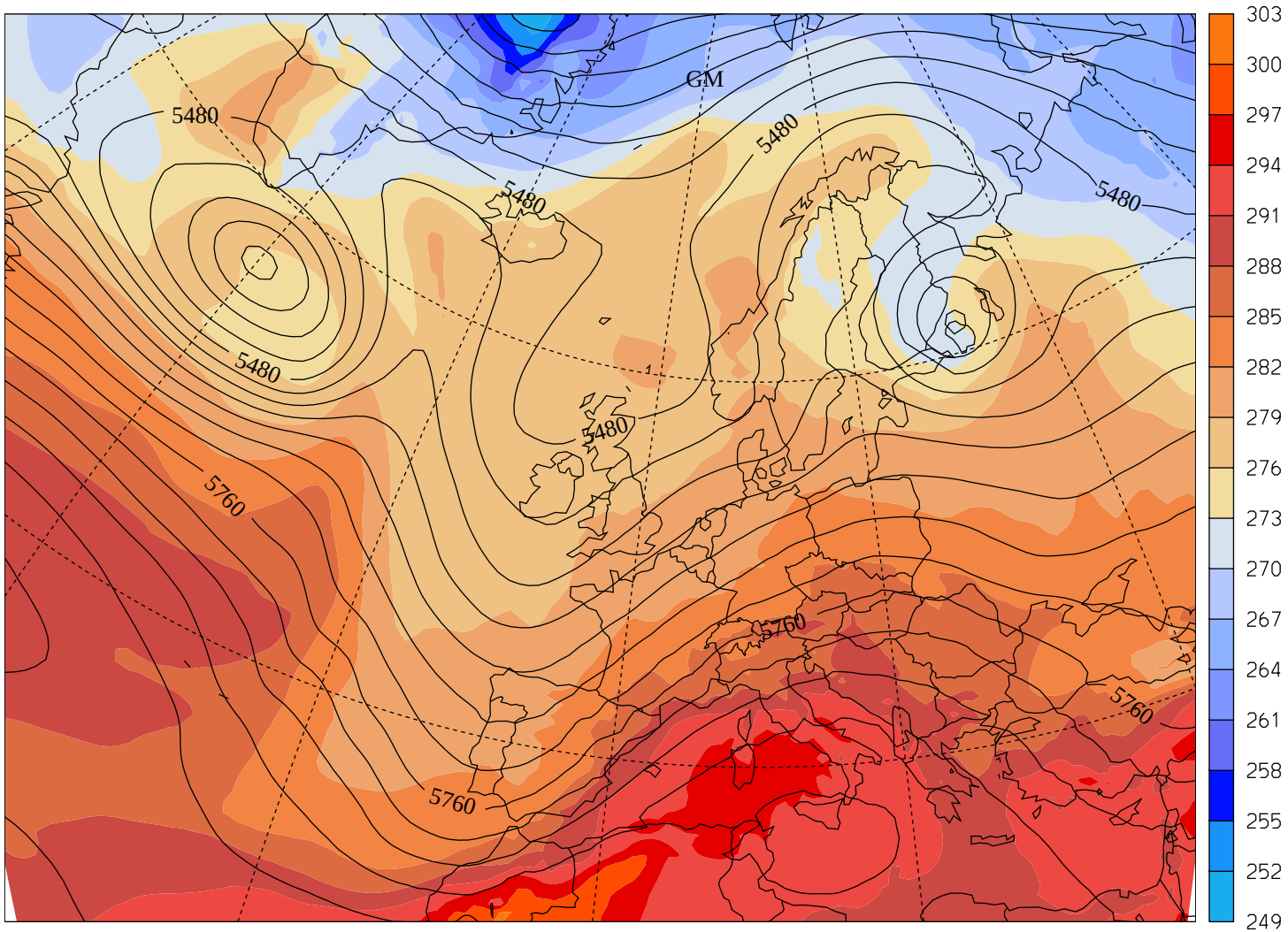
Daily precipitation sum [mm] for members 1-6.

Temperature difference to ensemble mean

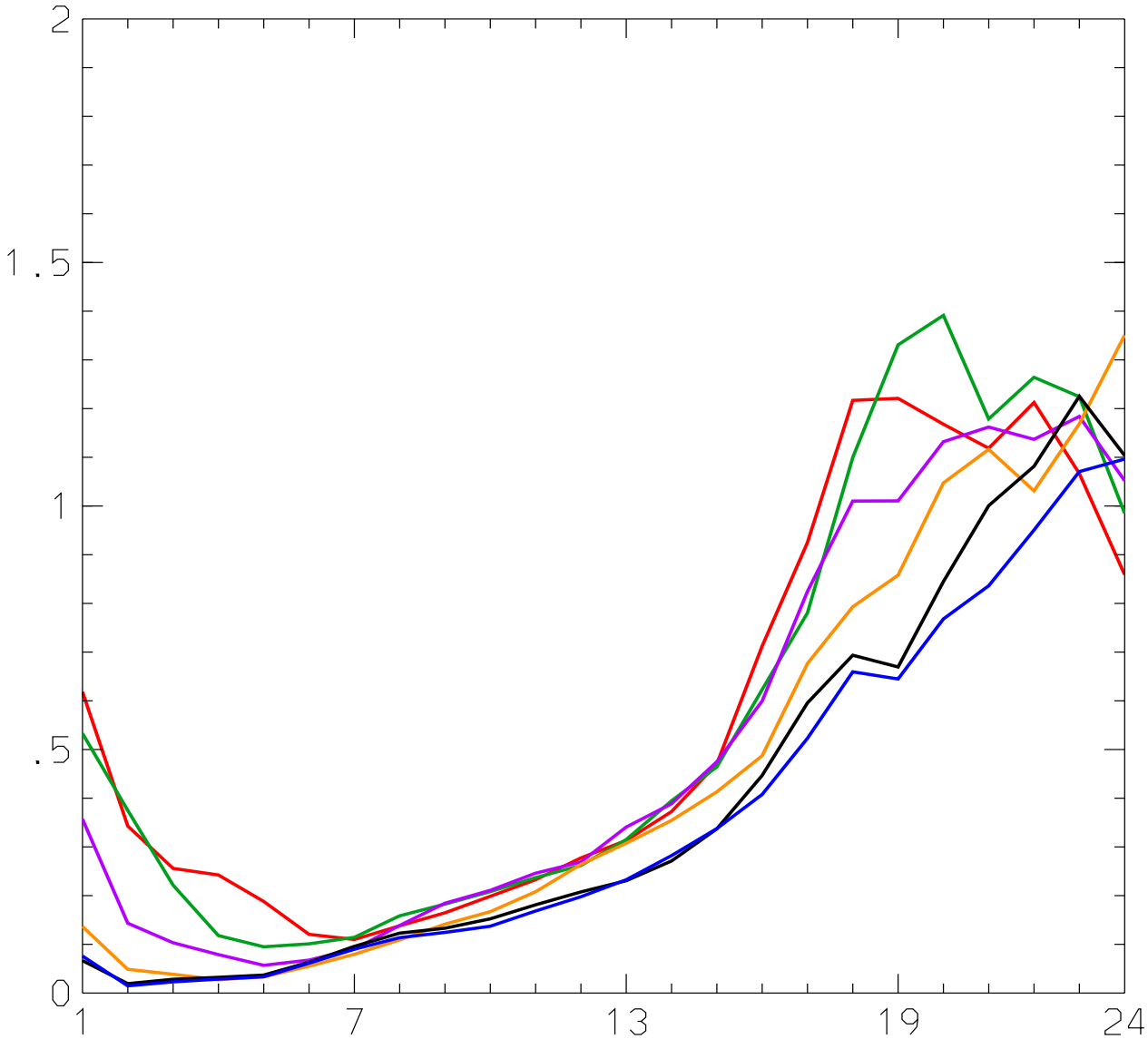
model level 8 (about 900 m above ground)



25 September 1999 (MAP IOP 3) 12 UTC, ECMWF analysis: Temperature (850 hPa) and geopotential at (500 hPa)

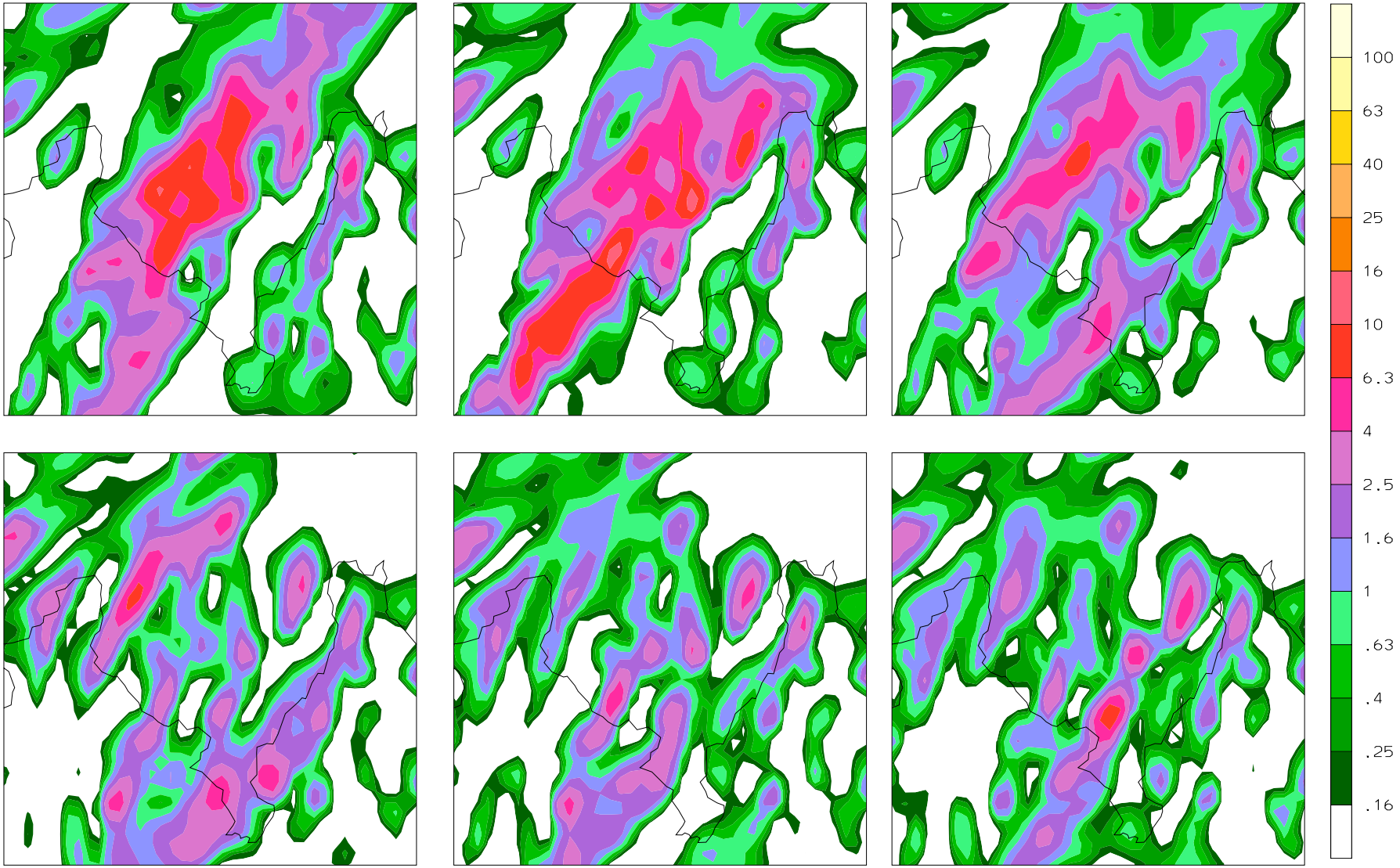


25 September 1999 subdomain Ti: pre-frontal precipitation



Evolution of mean precipitation [mm/h], horizontal axis indicates time (UTC)

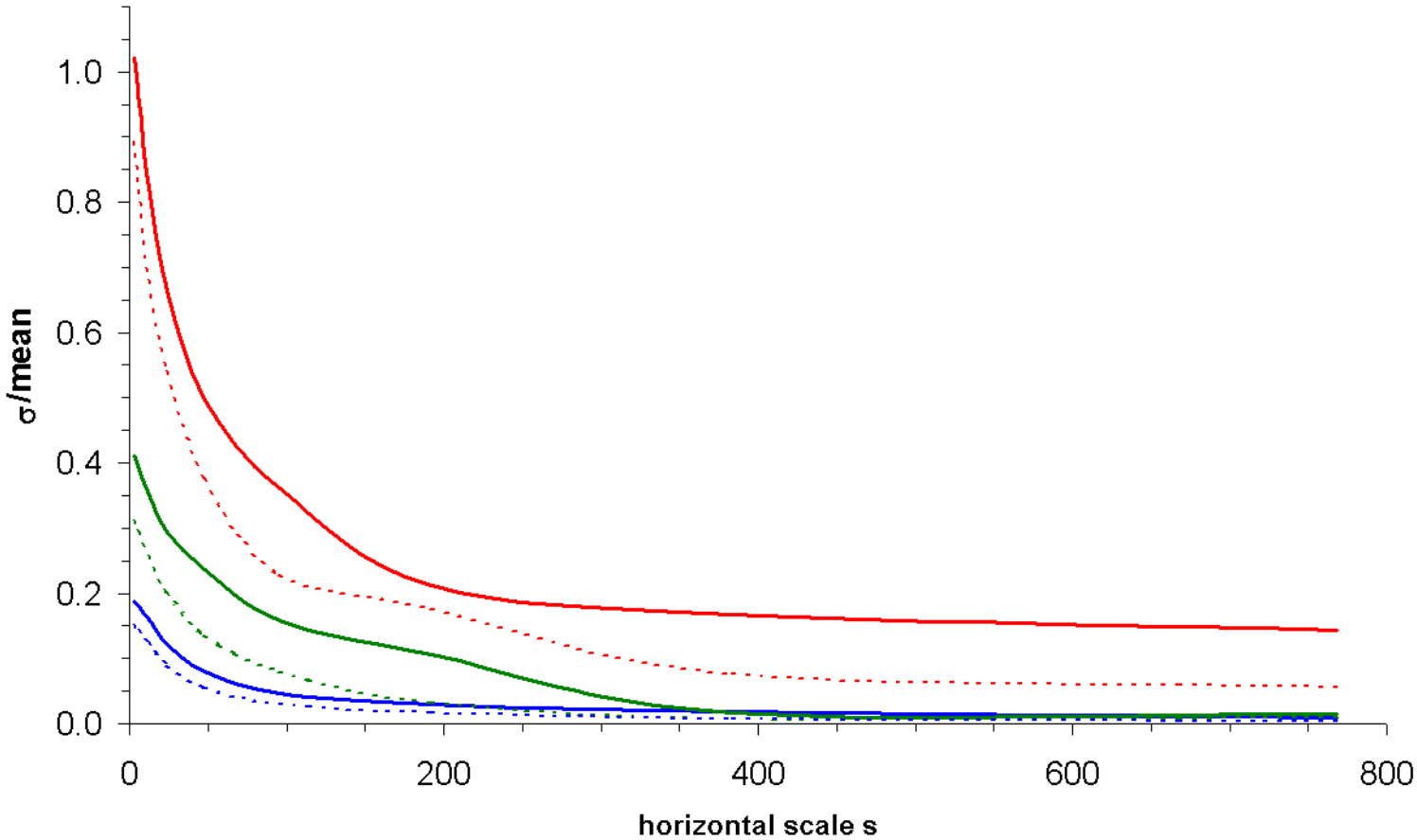
25 September 1999 19 UTC subdomain Ti: pre-frontal precipitation



Hourly precipitation [mm/h] 25 September 1999 19 UTC for members 1-6.

Scale dependence of the predictability of daily precipitation

(threshold 1mm)



Ratio of ensemble standard deviation and ensemble mean of daily precipitation for 29 July 1999 (red), 25 Sept. 1999 (green), and 6 Nov. 1999 (blue). Solid lines: α=3, dotted lines: α=1.

Conclusions

- Predictability of precipitation at meso-β scale differs strongly depending upon the weather type:

  - Convective activity reduces predictability substantially.
  - Thermal convection can be completely unpredictable in flat regions.

- Orography affects predictability of convective precipitation.

- Predictability limitations can be crucial even at scales exceeding 100 km.

- For scales less than 100 km the uncertainty in short-range forecasts of convective precipitation increase rapidly with decreasing scale.