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The Network of European Meteorological Services

MeteoSwiss

Progress in Limited Area Modelling and Challenges of the Future

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Trends in Mesoscale Models

- Use of new observing systems
- More resolution
- More complexity
- Ensemble Prediction Systems

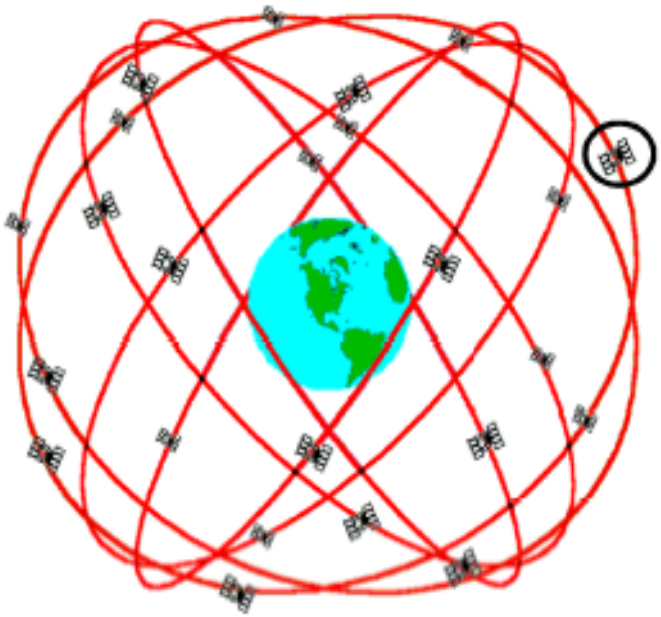
Use of new observing systems

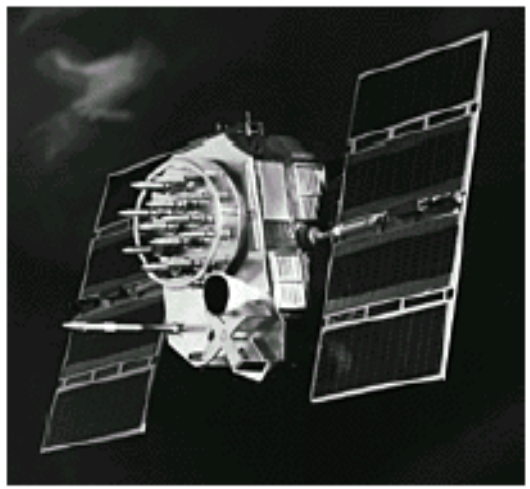
For the determination of the initial conditions of the regional numerical weather prediction models, the use of the following data is, among others, under development:

- Global Positioning System (GPS)
- Meteorological Radar

Global Positioning System (GPS)

- Space base component - GPS satellites
  - 24 active satellites in 6 orbital planes
  - Inclination – 55° (with respect to the Equator)
  - orbit periods ~ 12h and altitude – 20 200 km





Use of the GPS information

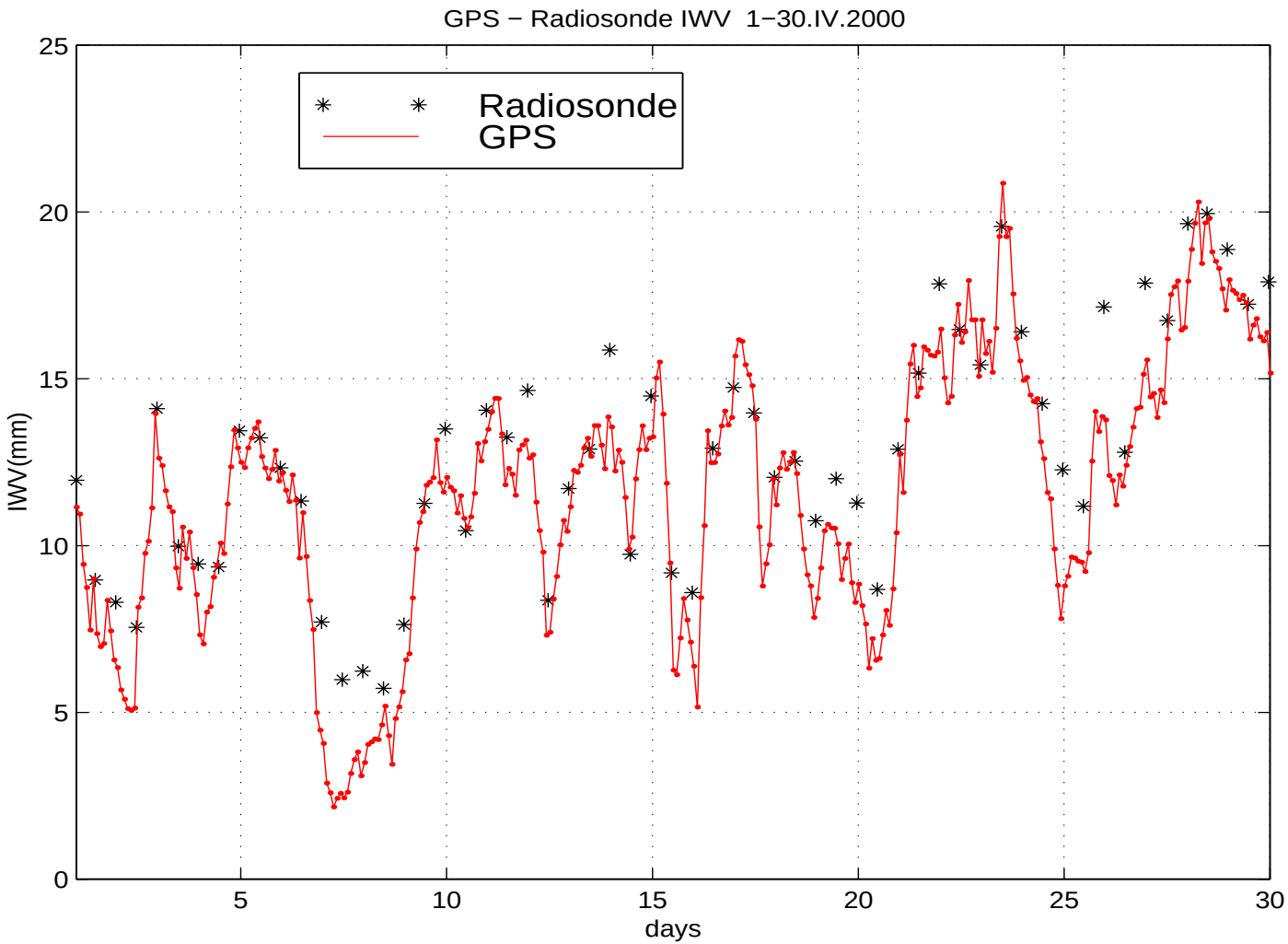
The GPS (Global Positioning System) can be used to determined the amount of humidity in the atmosphere.

Only the total amount of water vapour can be derived above a GPS antenna (no profiles)

Principle

The amount of refraction of the electro-magnetic waves sent by the GPS satellites is a function, among others, of the composition of the atmosphere. As the refraction through dry air is known, the amount of water vapour between the satellite and the antenna can be inferred from the measured refraction

GPS (00, 02, 04,.. 24h) and Radiosonde (00,12h) collocated in Payerne (Switzerland)



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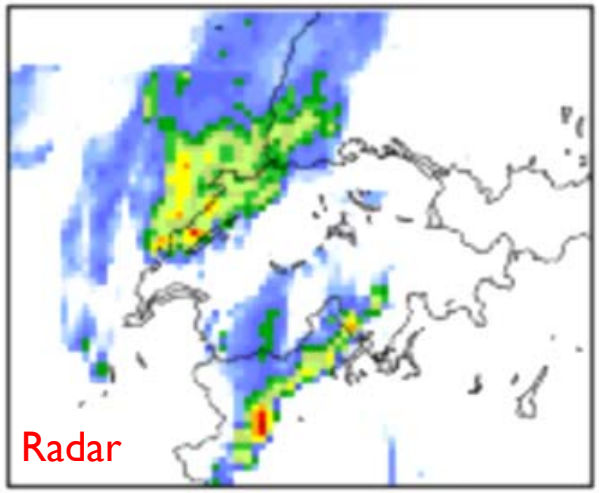
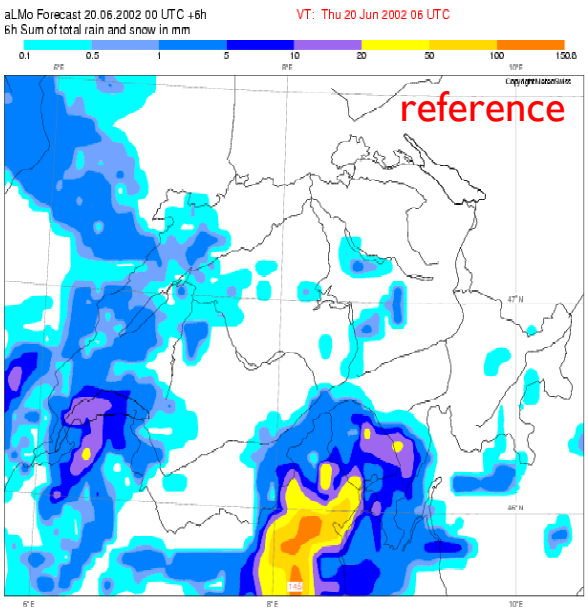
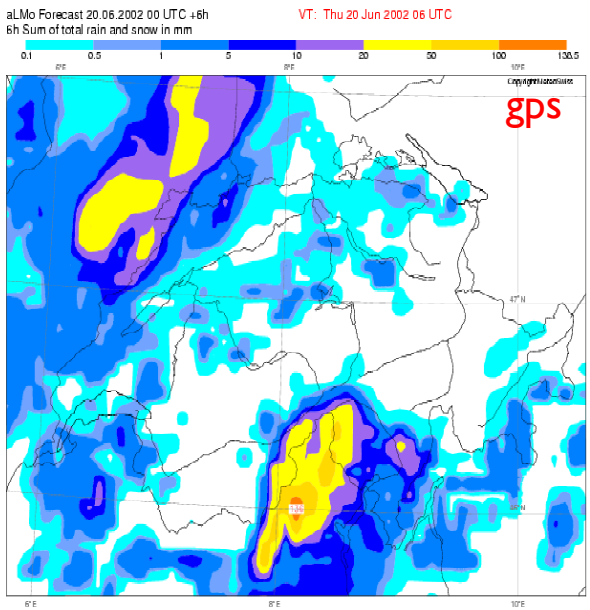
20 June 2002: Accumulated precipitation +00 to +06







Summary about the use of GPS (1)

- Impact on Numerical Weather Prediction
  - There is definitely an impact in the humidity and precipitation fields of the models
- Feasibility
  - Experiments made at several NWS (for example in Japan, Sweden, Germany, UK) show that it will be possible in the future to use operationally the GPS data

Summary about the use of GPS (2)

- Operational aspects
  - for the short-range NWP, the main problem will be to receive the processed data from the GPS Data Centers not later than, say, one hour after observing time. Geodesists and meteorologists will have to work together

Use of the Radar in Data Assimilation

- For many years meteorological radars have been very important instruments for nowcasting and very short range weather prediction
- Only since a few years have development works started to put the radar information into the numerical weather models. This field is today object of intensive development

Correction of the model precipitations with latent heat

A conceptually simple way of correcting the model precipitation is to act on the temperature field by addition (heating) or subtraction (cooling) of latent heat.

The latent heat will be computed from the radar images

Essence of the method

Suppose that at a time t (in the model time step n) and at a location P (in the model the grid point [x,y]) we have:

Radar: precipitation; model: no precipitation

-> *the latent heat corresponding to the amount of observed precipitation by the radar is given to the model (heating)*

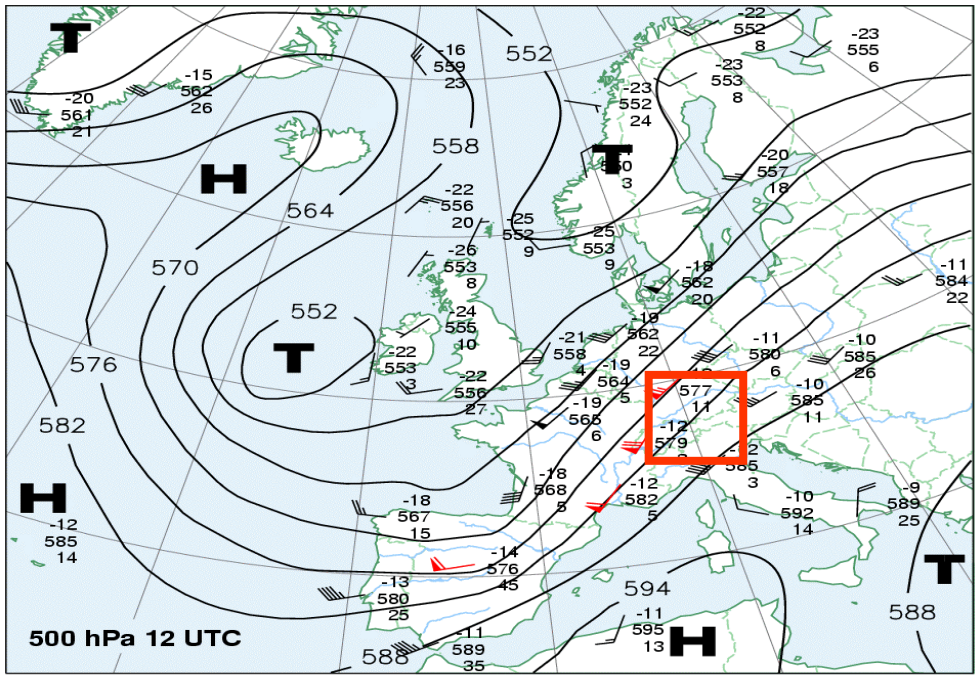
Radar: no precipitation; model precipitation

-> *the latent heat produced in the model during the last time-step is subtracted at the same grid point at the next time step (cooling)*

The model precipitations are corrected by acting on the temperature field only

Example: Convection of the 21 August 2000

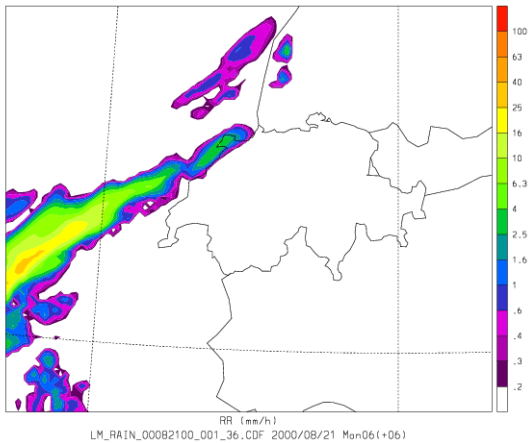
- Severe nocturnal summer convection
- Produced damaging surface wind gusts

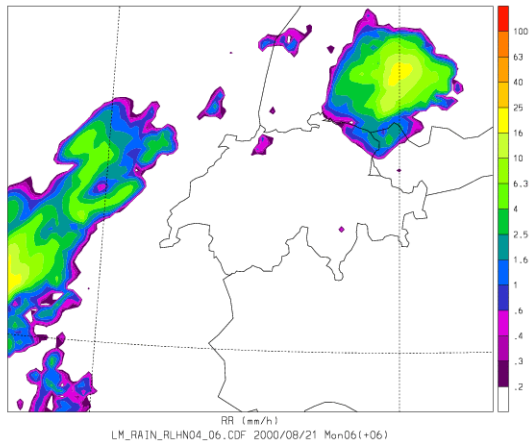


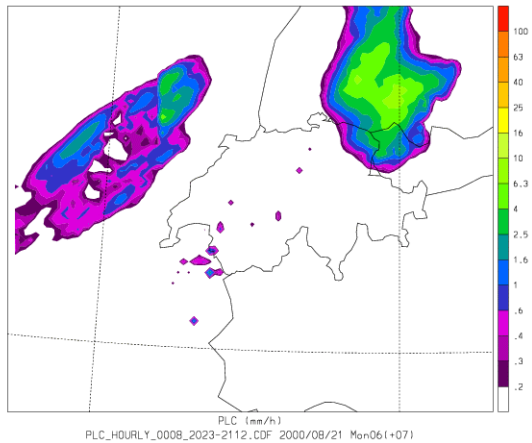
Example: Convection of the 21 August 2000

No radar **With radar** **Radar**

06







Latent heat assimilated between 00-06 UTC

Hourly sums of precipitation

Trends in Mesoscale Models

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- More resolution
- More complexity
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More resolution (1)

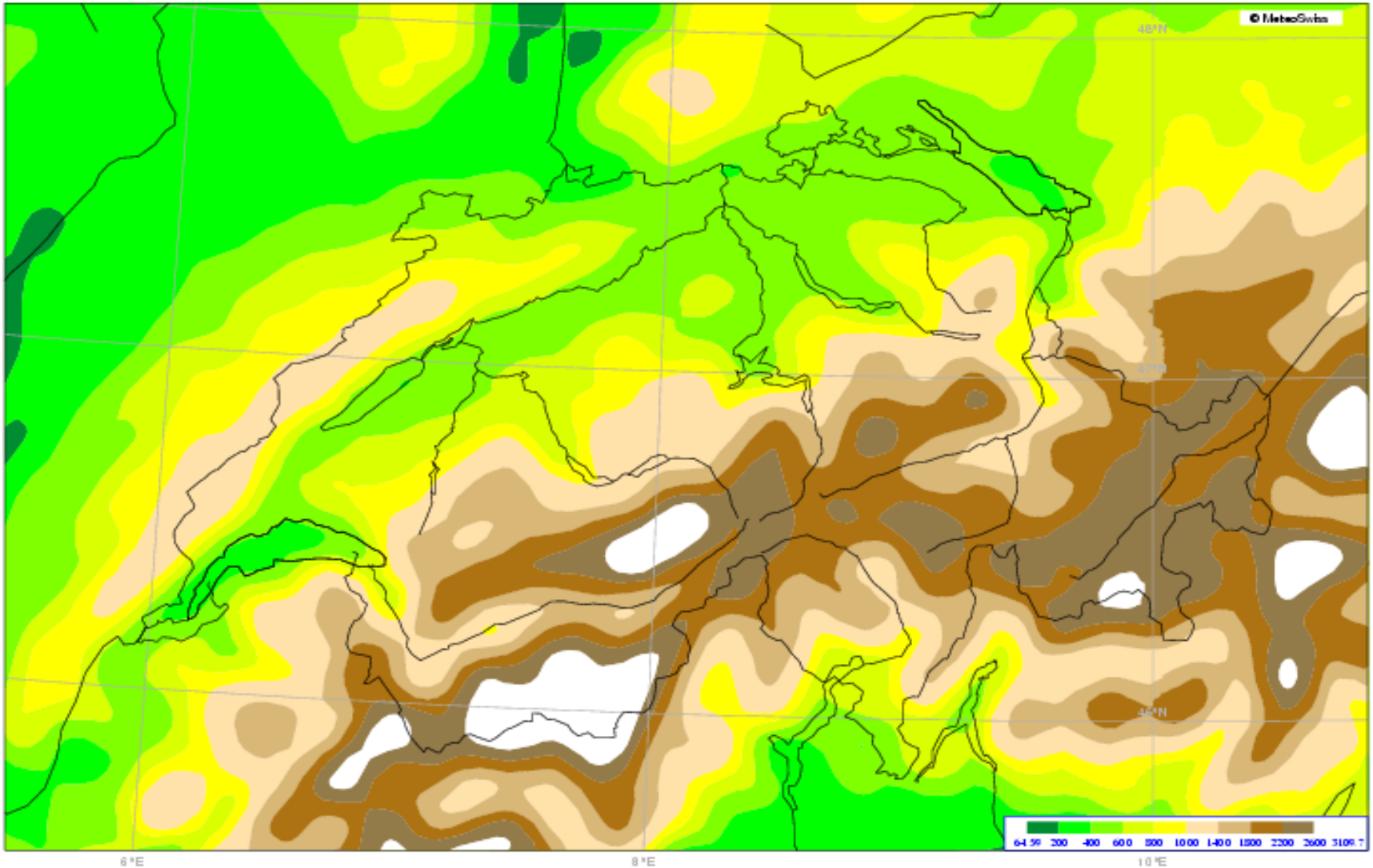
The trend to more model resolution - that is shorter distances between the grid-points – is very strong everywhere. Most of the NWS are planning or have already started to develop so called high resolution models with grid distances of 2 to 3 km.

There are two reasons for it:

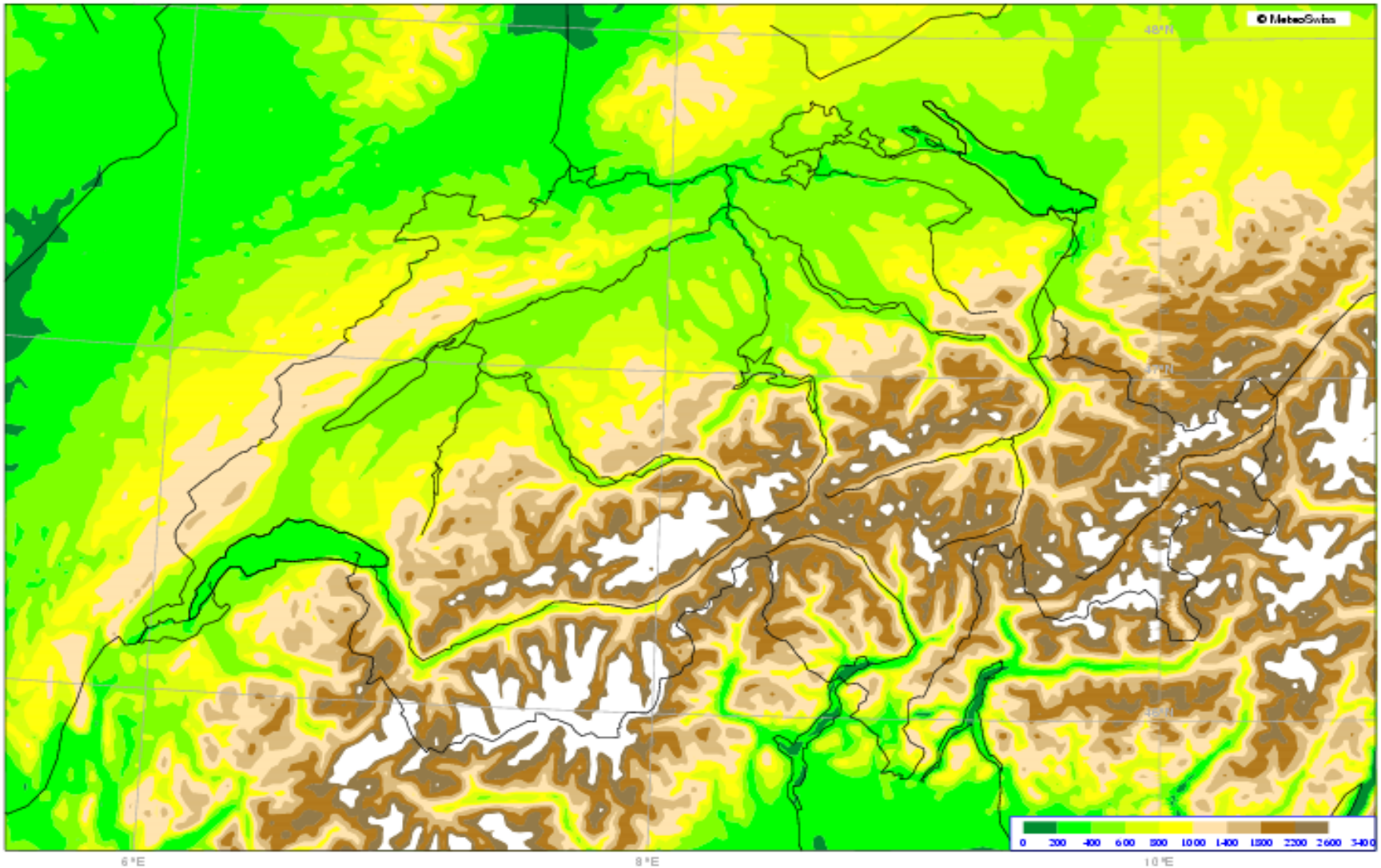
More resolution (2)

- To produce more accurate and detailed regional, even local, weather forecasts
- A more physical reason is to have the longer waves, as for example a front or a small low pressure area, more accurate

Operational Orography with a resolution of 7 km (0.01 degrees) Min. 65m Max. 3110m



Orography with a resolution of 2.2 km (0.02 degrees) Min. 30m Max. 4174m



More resolution gives problems

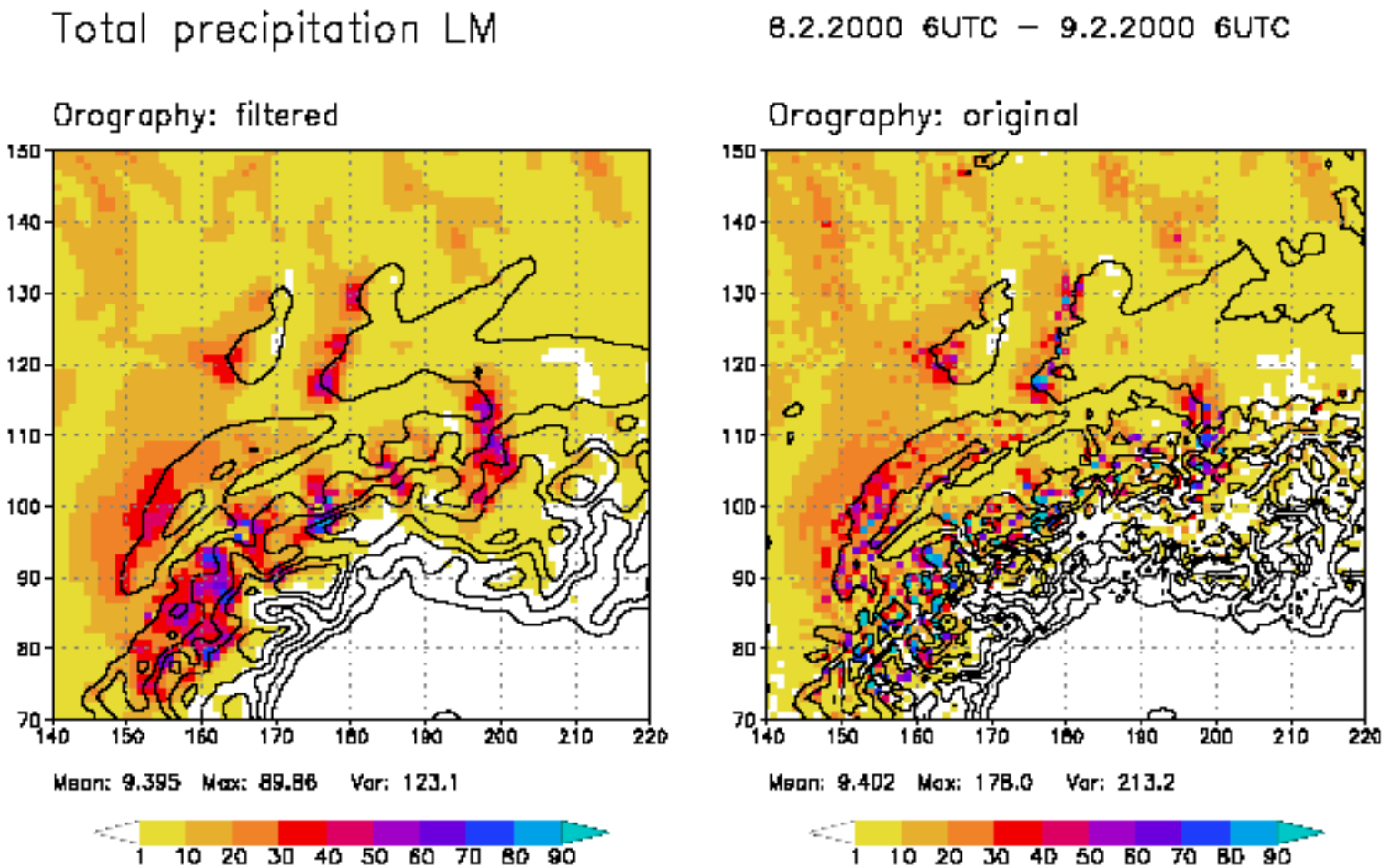


Figure 7: *Precipitation fields of experiments with and without filtered orography.*

Orography filtering

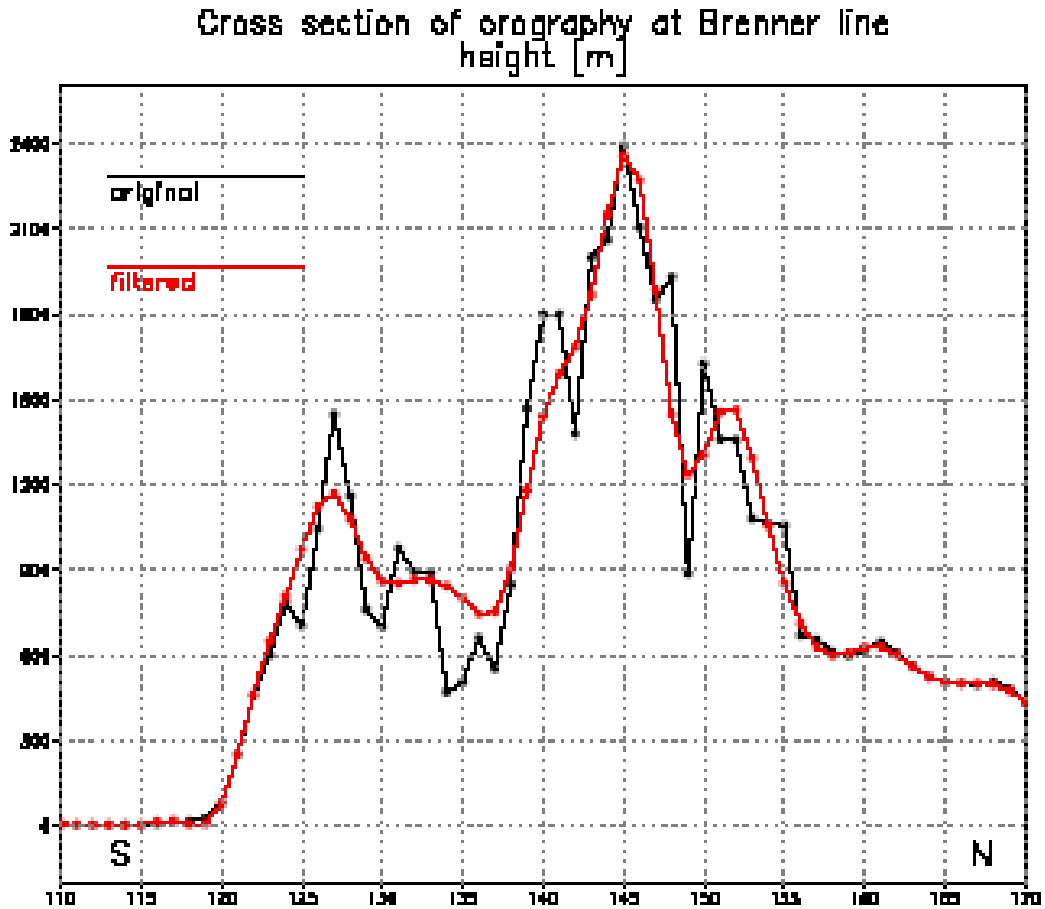


Figure 6: *Cross section of orography in the Alps along the Brenner line*

Trends in Mesoscale Models

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More complexity

- A good example is the new treatment of the precipitations: the so-called advective precipitations

Advective precipitations

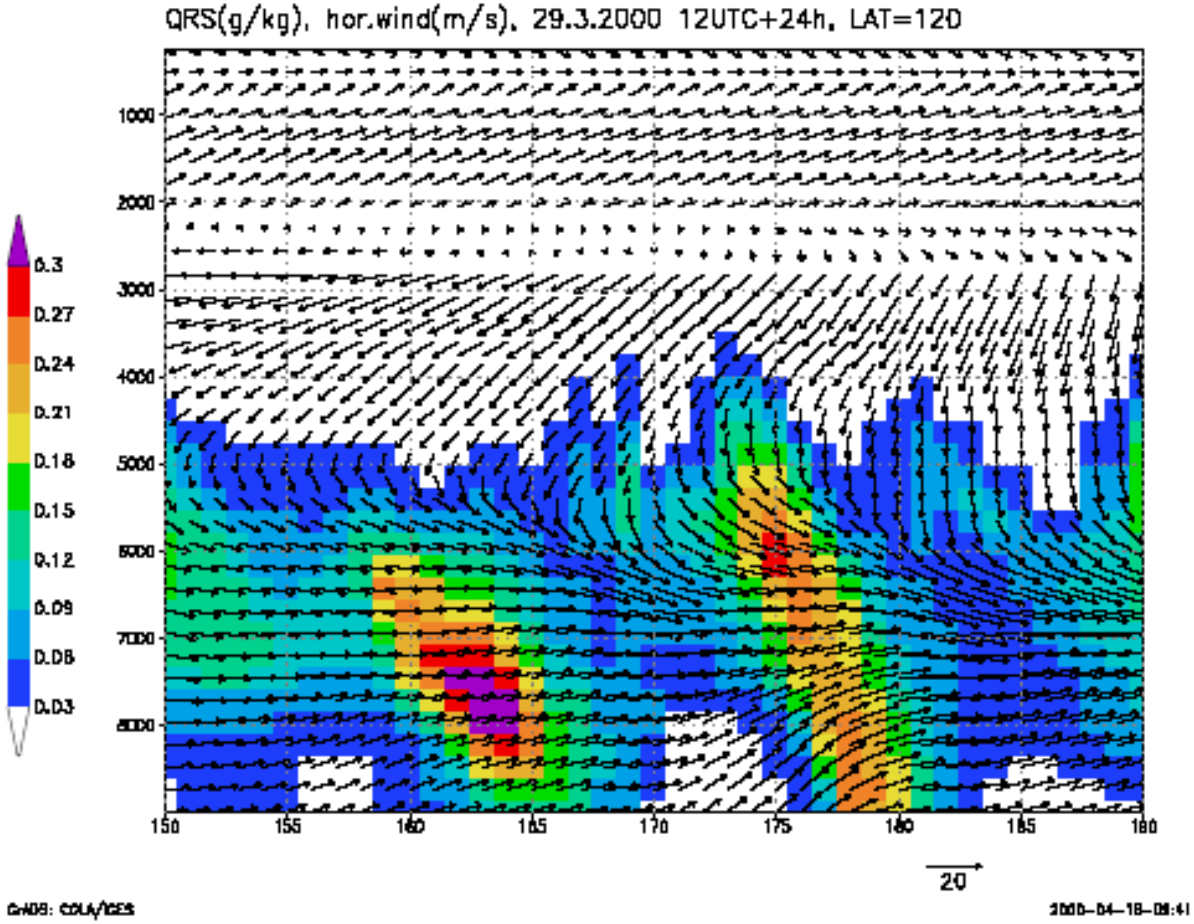
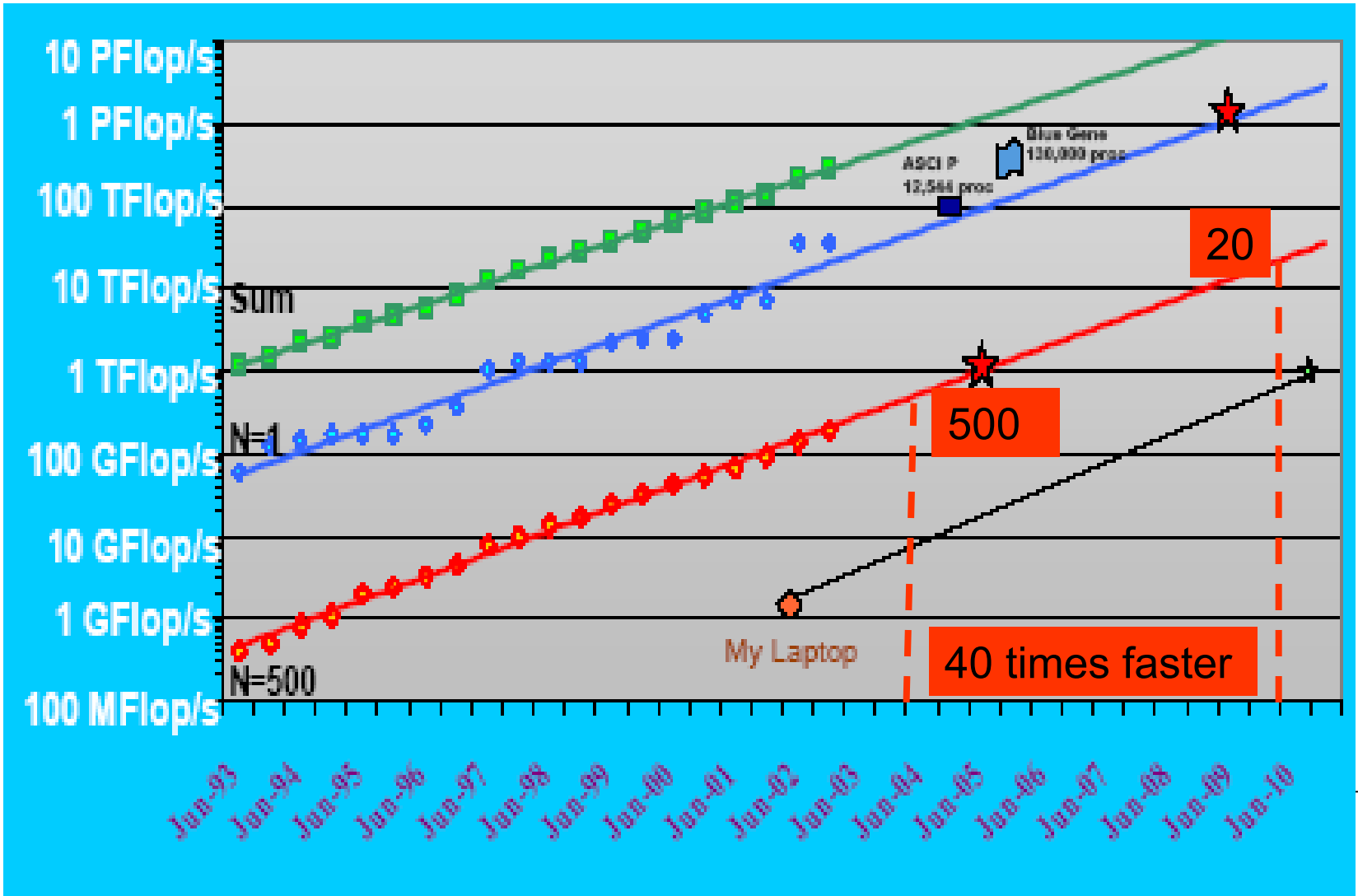


Figure 5: Vertical west–east cross section over the Rhine valley near Freiburg

What will the future of regional NWP be? (1)

- In 10 years, computers will be 50 times faster

Computer Performance Extrapolation



After Jack Dongarra, NUC Meeting 2003

Computing Cost of the High Resolution

In one horizontal plane:
From 6.9 km (0.0625° or 1/16°) to 2.2 km (0.02° or 1/50°)
-> 9.8 times more grid points

From 45 to 60 levels:
1.3 more points in the vertical direction

Reduction of the time-step: proportional to 6.9km / 2.2 km
-> 3.1 more time step for the same range

Together: 9.8 x 1.3 x 3.1 = 39.5 times more computations!

What will the future of regional NWP be? (2)

- Our operational regional models will have resolutions of 1-2 km over a whole continent like Europe or North America and they will compute more parameter than today: hail and visibility will be numerically simulated.

  => huge amount of details

What will the future of regional NWP be? (2)

- Will be the numerical weather forecasts better than today?
- Yes, but improvement will be slow and become each year more difficult.

  A 1% improvement in yearly average requires today already an enormous work, and not only in model design but equally in the use of the computers. Good efficiency on today's supercomputers is hard to obtain.

Thank you for your attention