Predictability of scales

what NWP can tell us for climate downscaling

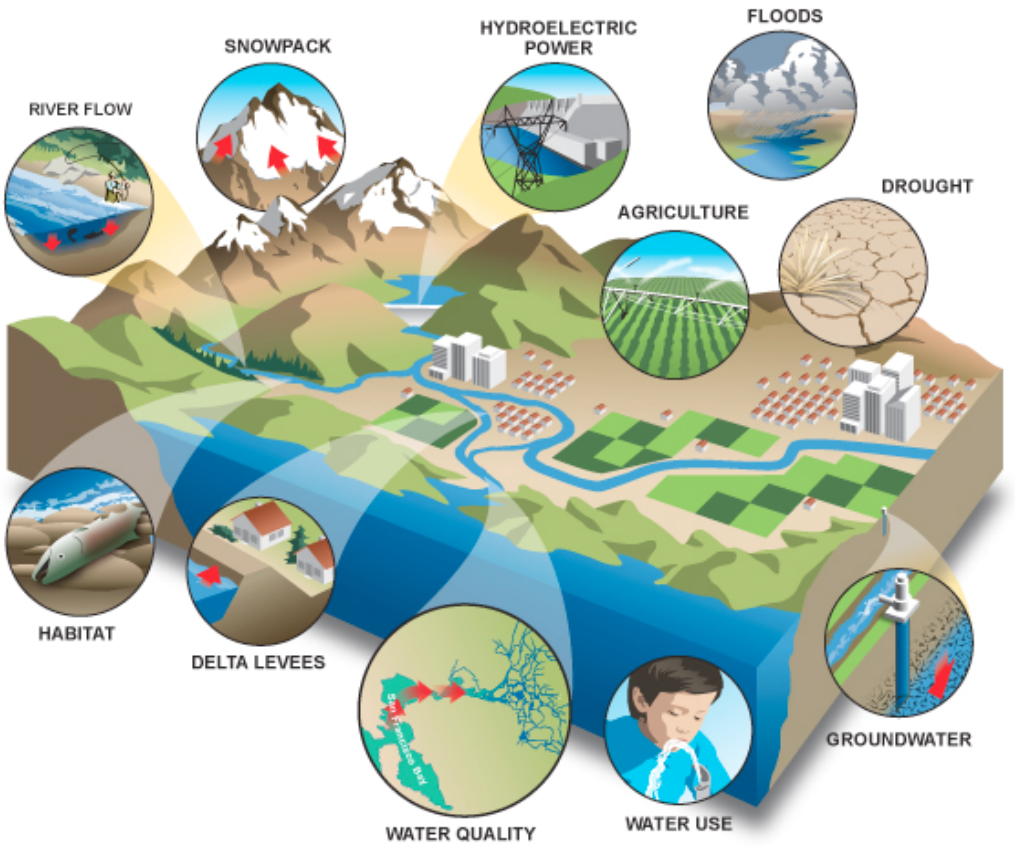
can we really downscale climate usefully and to which resolution?

Does a scale have prognostic, diagnostic (climatological) or no value?

What happens if we just do a downscaled climate based on shortrange NWP forecasts (the day two forecast timeseries)

Mathias D. Müller
University of Basel, Switzerland / meteoblue Ltd.
mathias.mueller@unibas.ch

Why should we downscale Climate?



Climate change is global but its effects impact us on local and regional scales

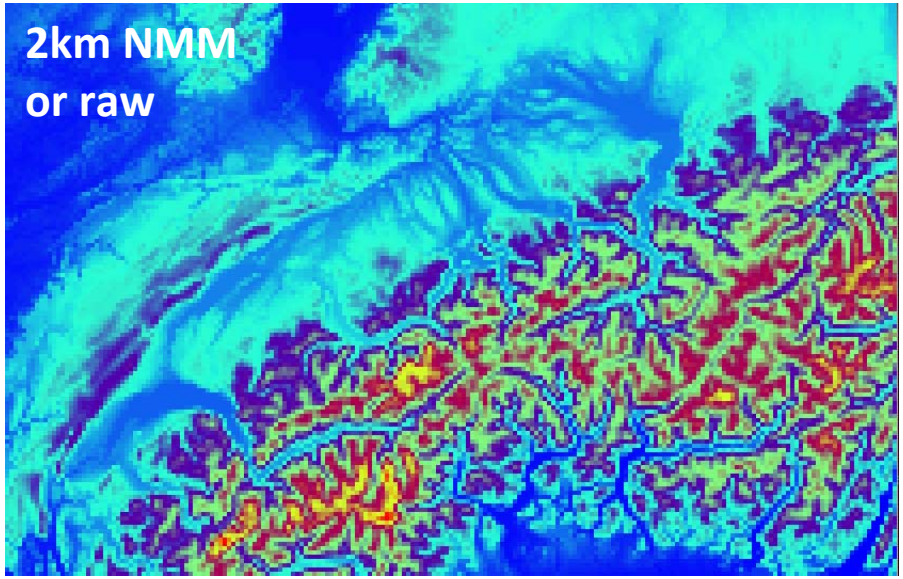
Different scales of integration in time and space depending on activity and climate variable.

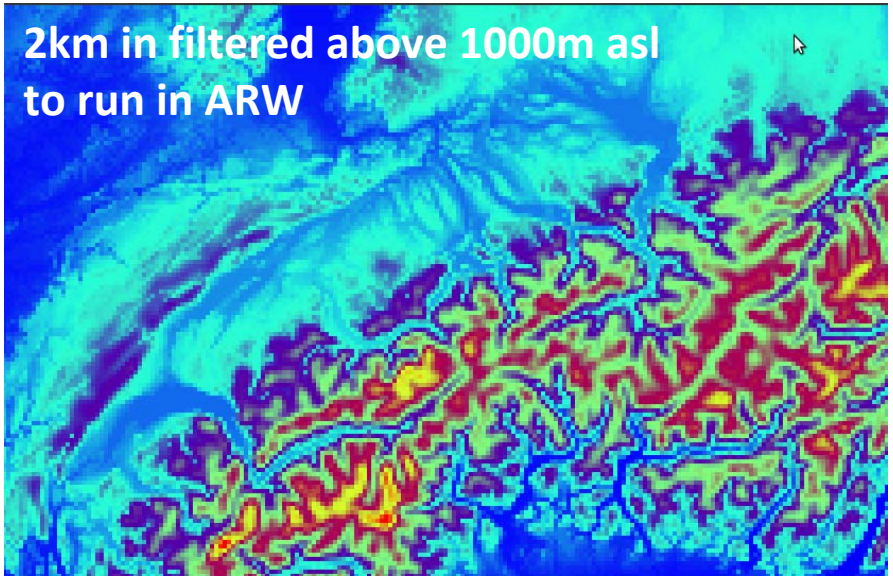
→ Hydropower from snowmelt vs. small farm agriculture

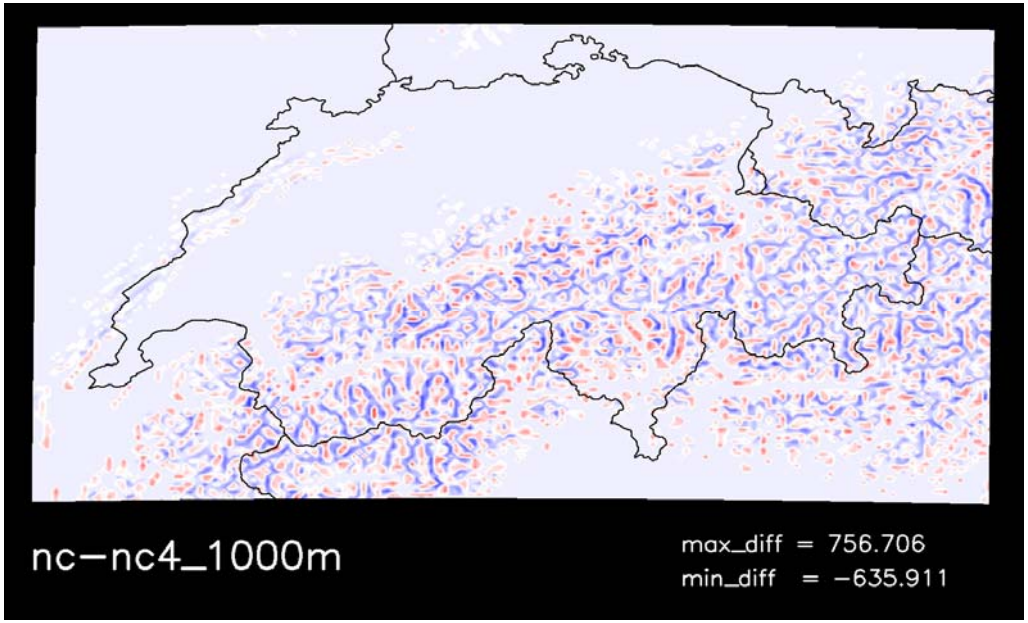
Extreme event statistics (Wind, Temp, Precipitation)

Does the downscaled result have any skill required for planning?

Topography scale is often larger







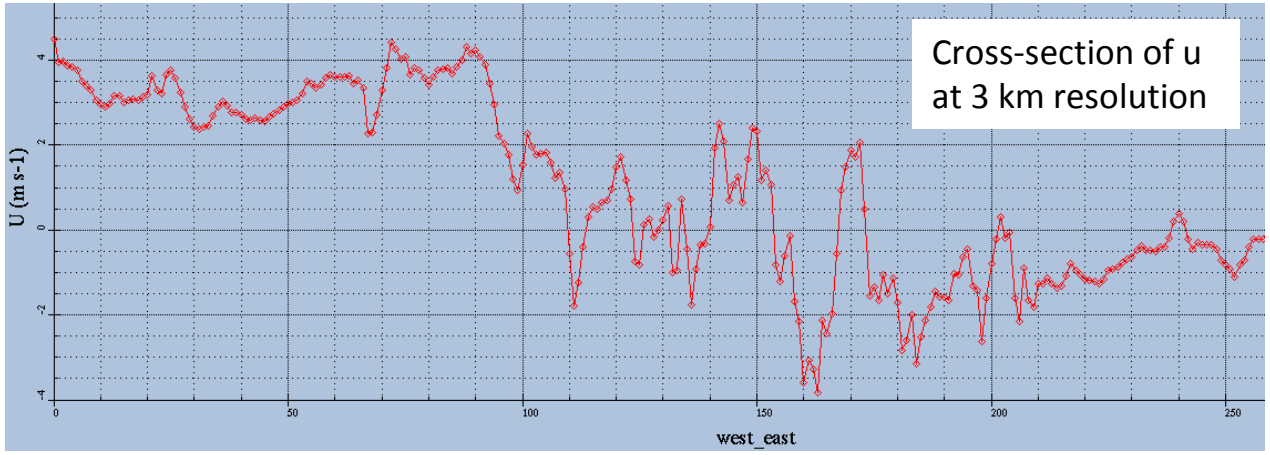
+/- 300-500m
Height Difference

Scale discrepancies due to numerical schemes

Semi-Lagrangian Advection

Usually a timestep 5-6 times larger than for other advection schemes is used due to its stability and formal independence of the CFL criteria.

However the solution has to be **smooth** on the scales of the trajectory, which can be 5-6 dx long (->Jetstream).



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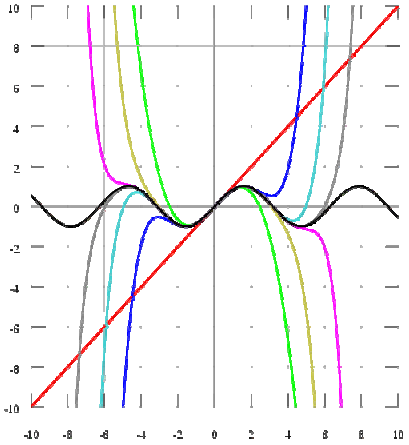
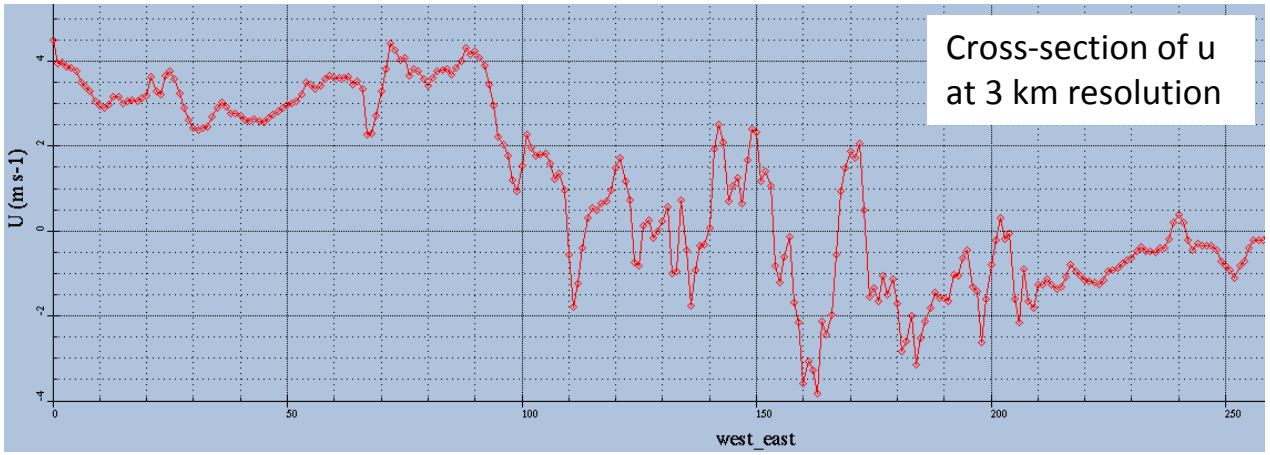
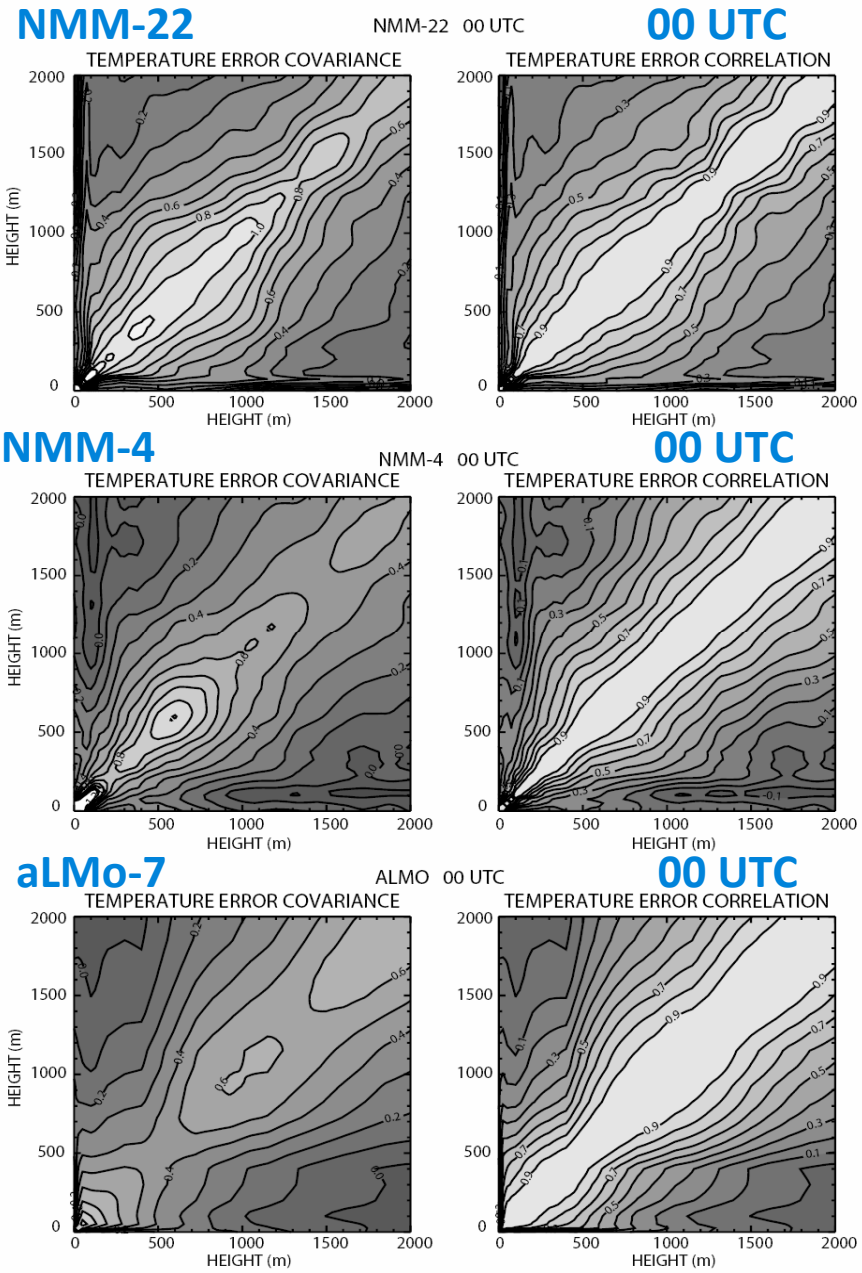
Higher order schemes for spatial derivatives

For mathematical functions (smooth in character) the higher order schemes clearly show a better accuracy. However at high resolutions the meteorological field can look very noisy and unsteady. A higher order scheme than smooths the real data.





Scale discrepancies due to numerical schemes



Diffusion (explicit or implicit by numerical scheme)

Eg. visible in correlations between vertical Levels.

High correlations between different levels indicate statistically significant the presence of an unstructured smooth vertical profile in the PBL.

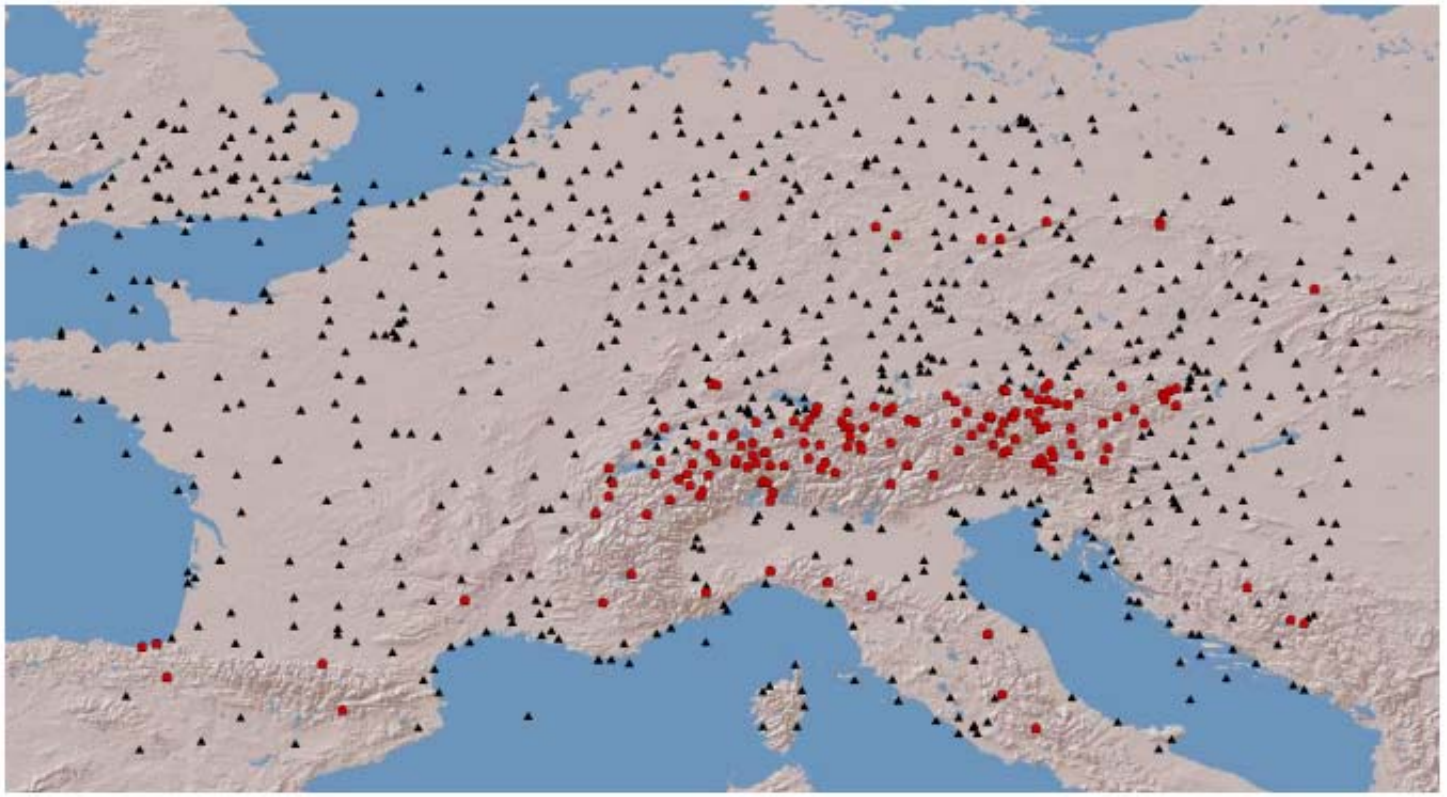
Semi-Lagrangian Advection

Usually a timestep 5-6 times larger than for other advection schemes is used due to its stability and formal independence of the CFL criteria.

However the solution has to be **smooth** on the scales of the trajectory, which can be 5-6 dx long (->Jetstream).

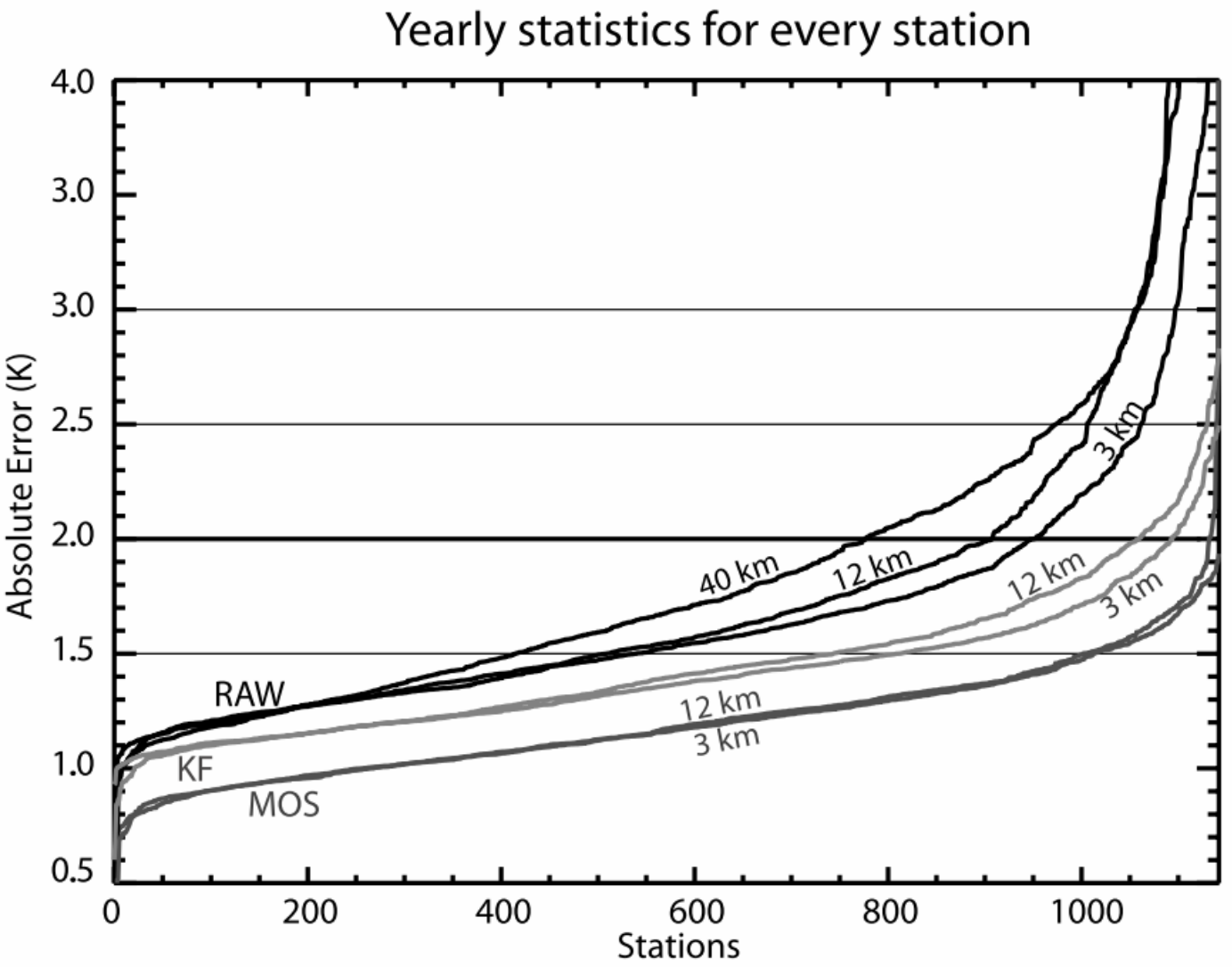
Predictability of Temperature and Wind

1 year of 1h/3h observations at 1150 stations



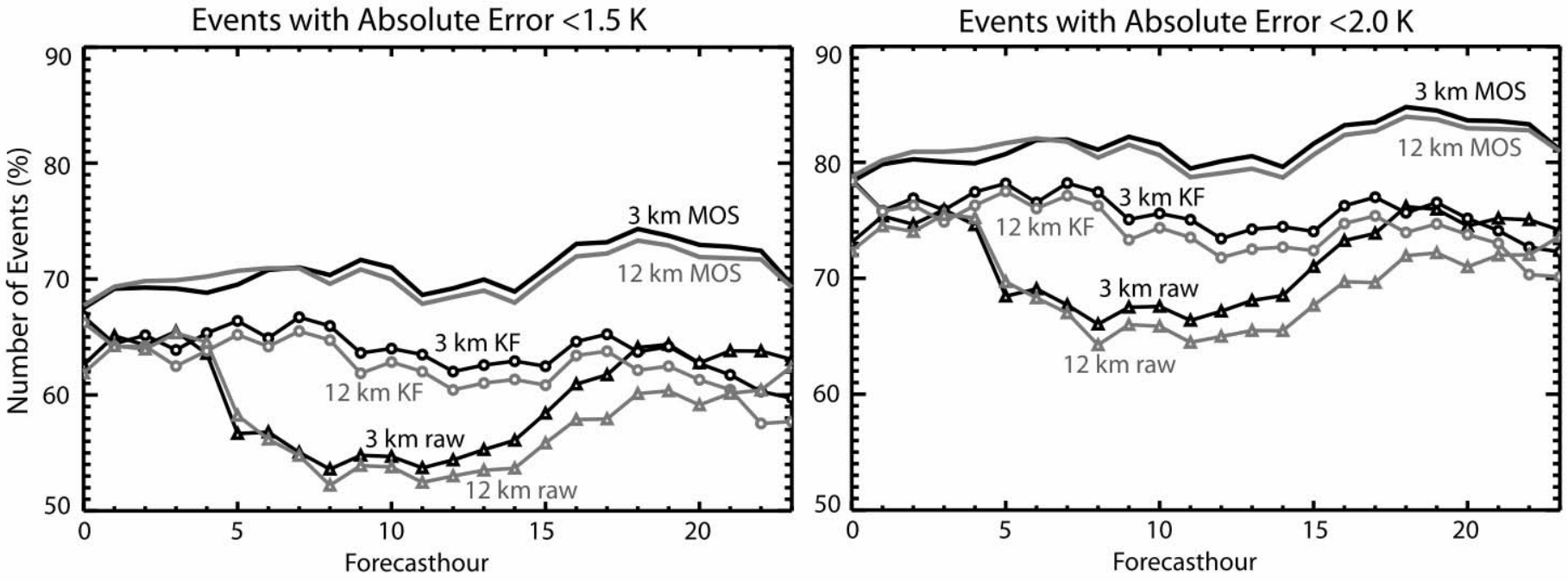
MOS, Kalman Filtering and raw model output at 40,12 and 3 km resolution

Predictability of Temperature at different scales

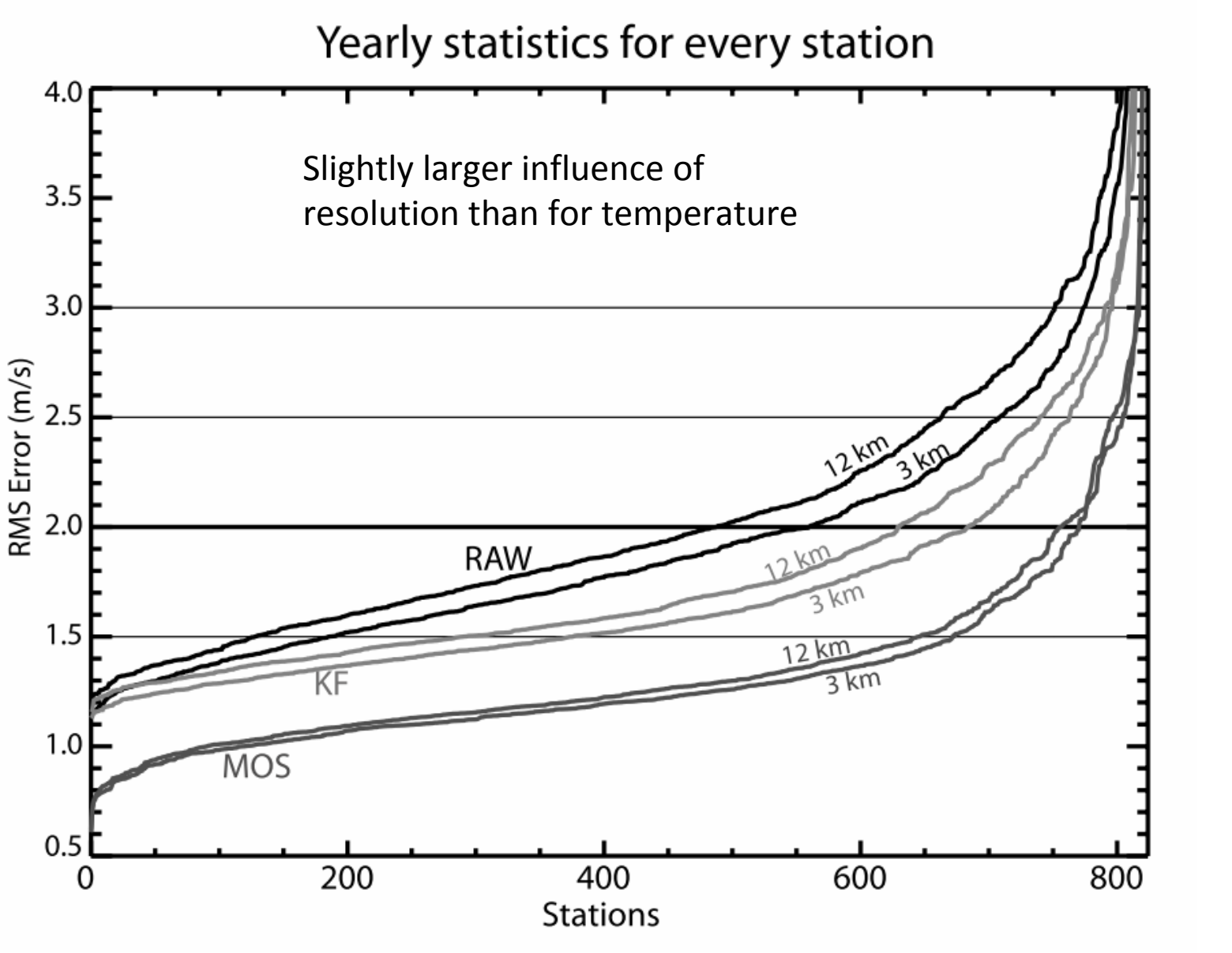


With postprocessing
3 and 12 km are equal

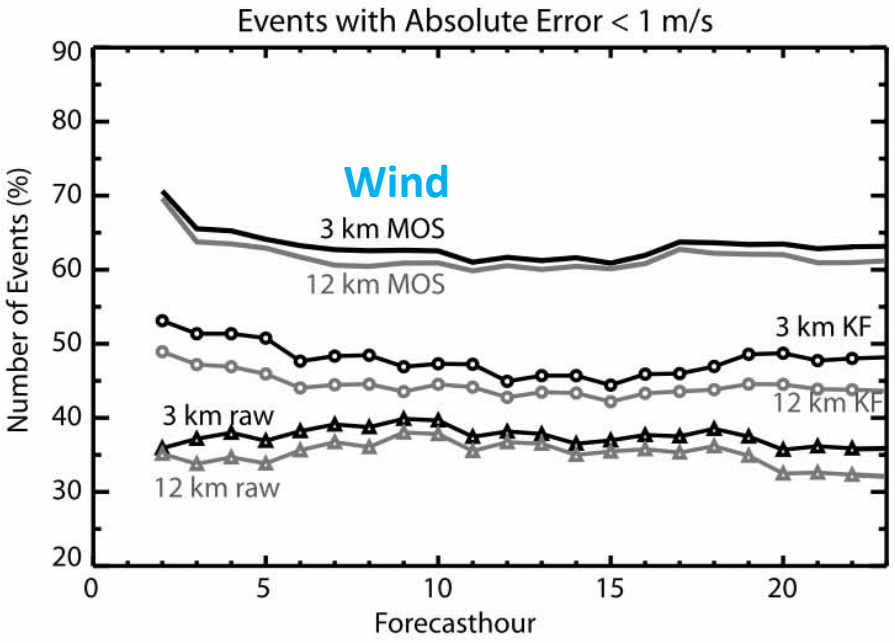
Predictability of Temperature at different scales

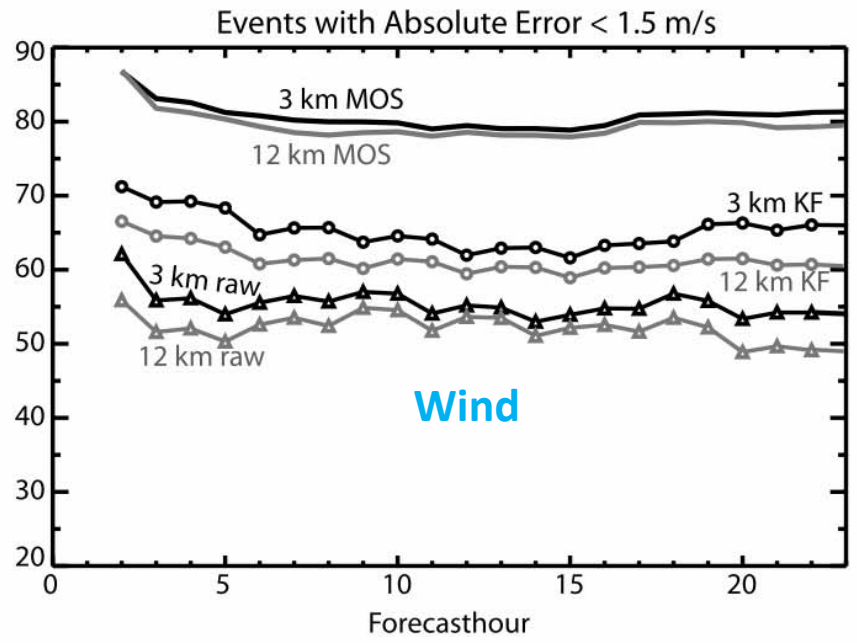


Predictability of Wind at different scales

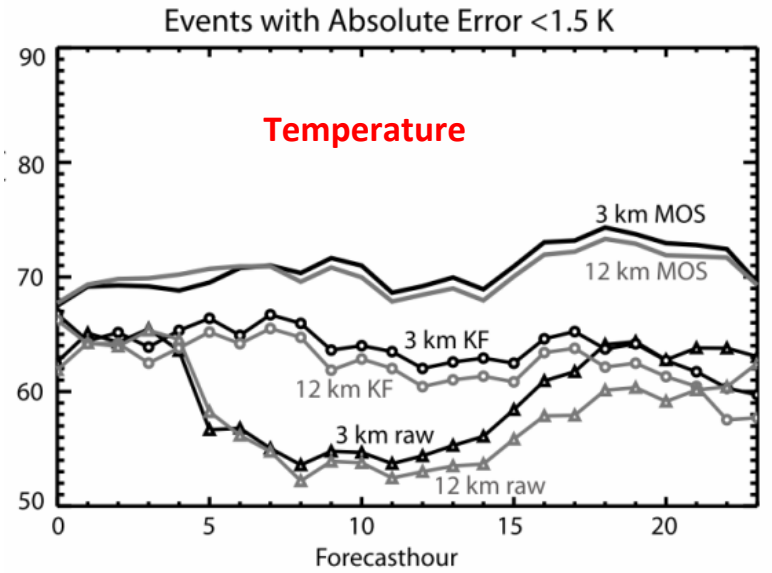


Predictability of Wind at different scales



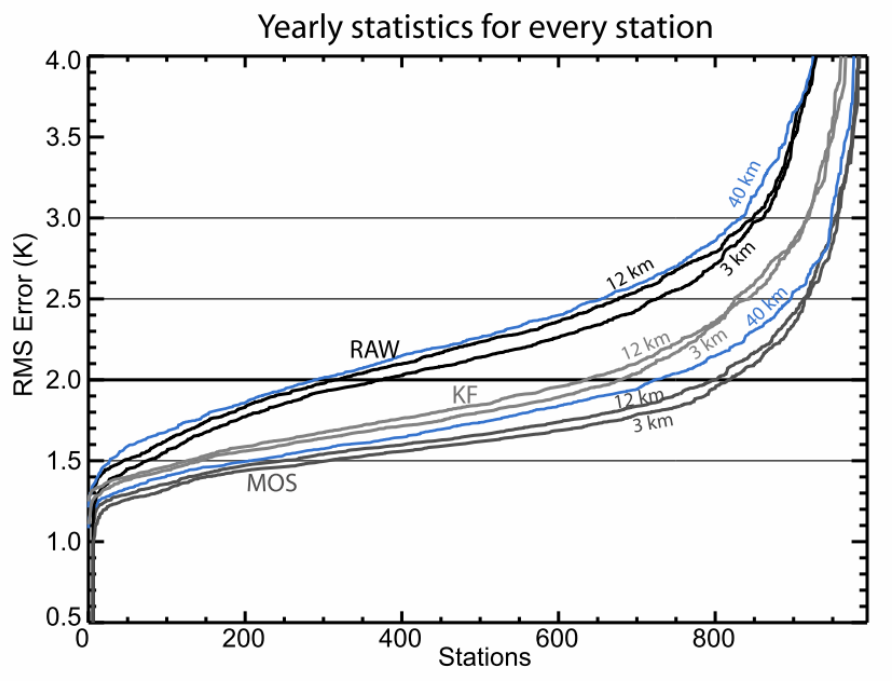


Slightly larger influence of resolution than for temperature



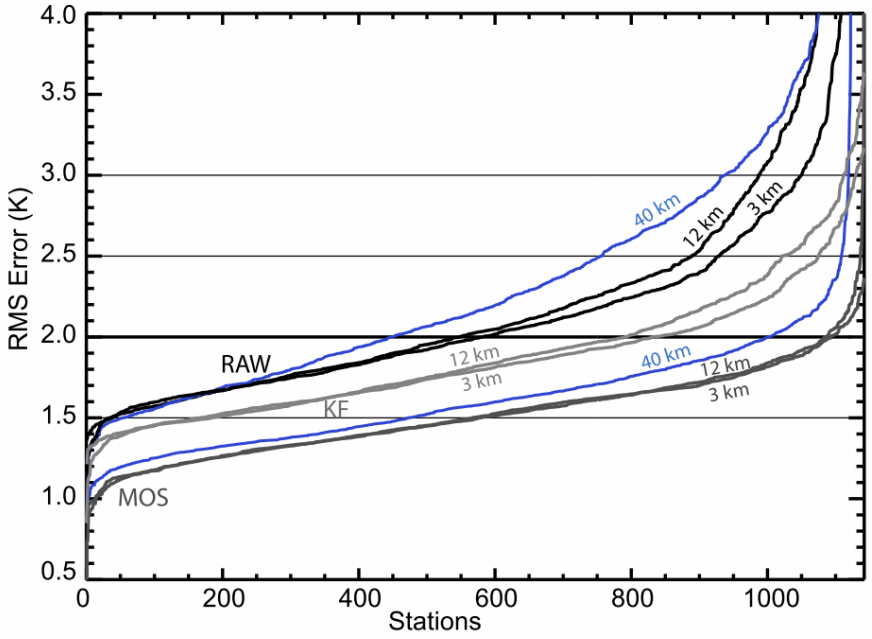
Predictability of Dewpoint at different scales

Dewpoint



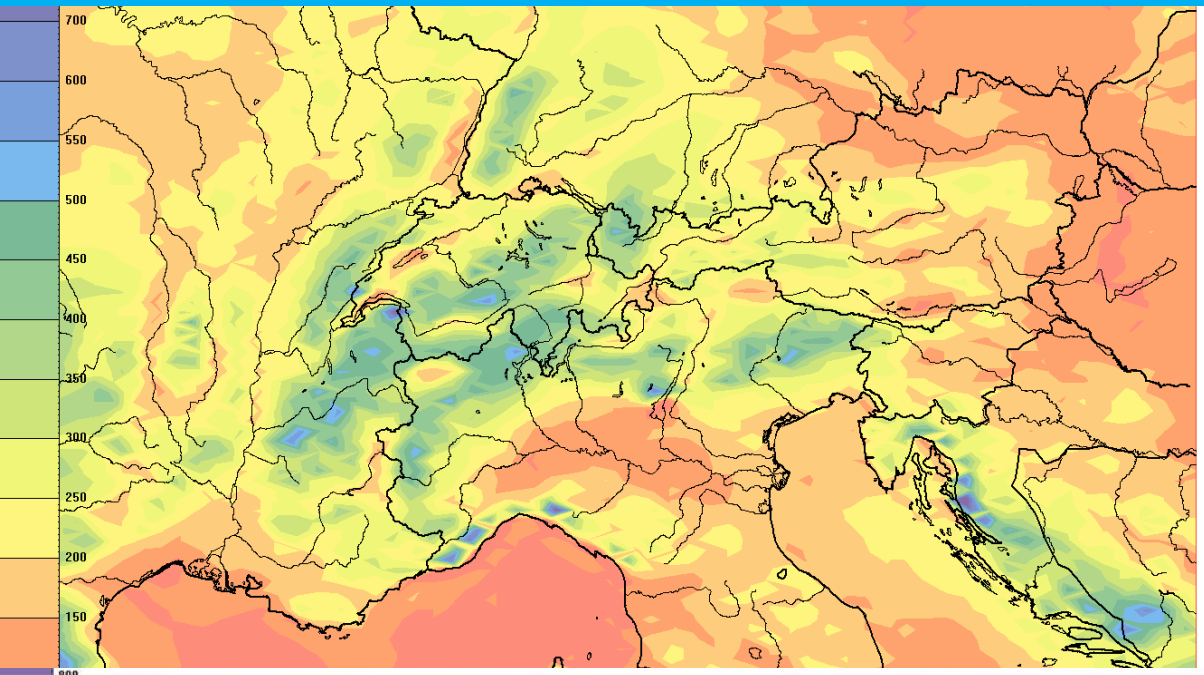
Raw 40 km forecast almost same as 12 km but difference in MOS

Temperature



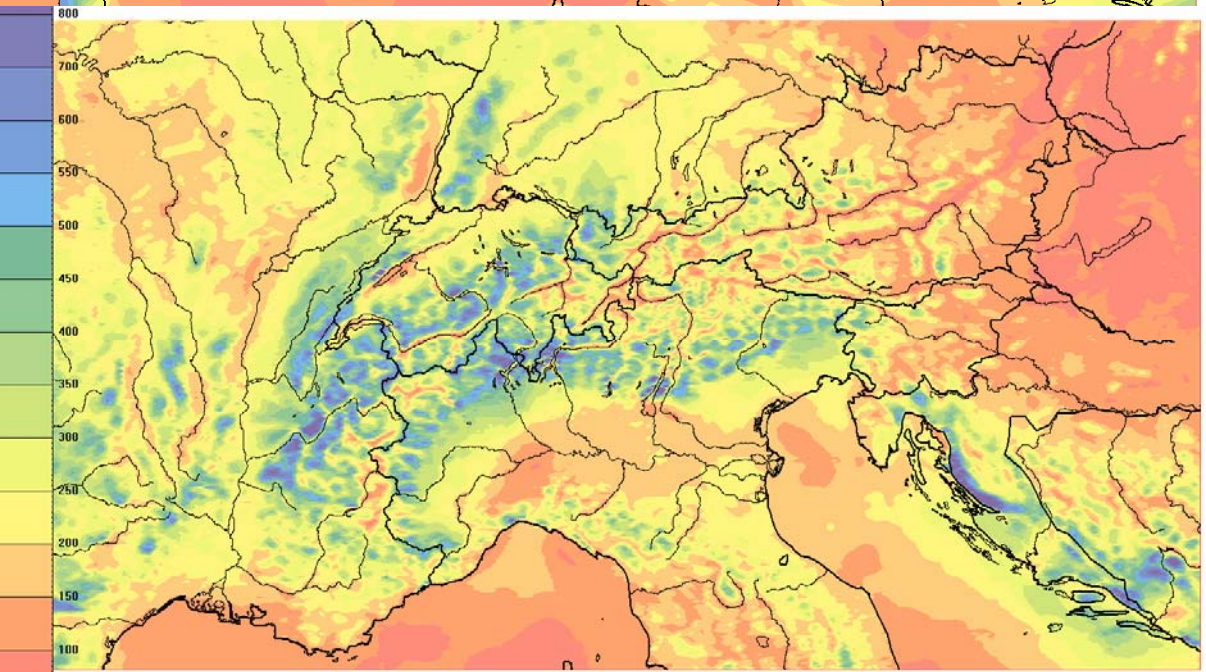
consistent difference between scales down to 12 km

24h acc. Precipitation – (1.3.2007-31.5.2007)



Is high resolution necessary?

operational NMM 12 km
(meteoblue)

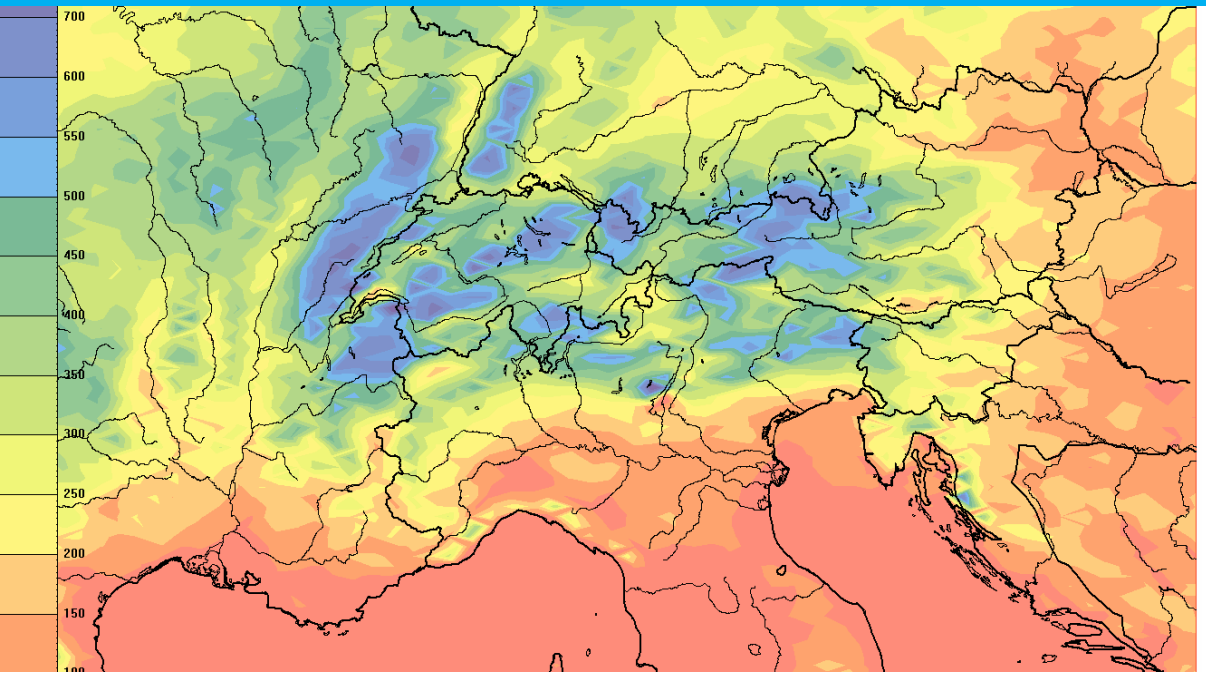


25 to 48 hours forecast

operational NMM 3 km
(meteoblue)

High resolution still has
Realistic amounts !!!!

24h acc. Precipitation – (1.6.2007-31.8.2007)



Is high resolution necessary?

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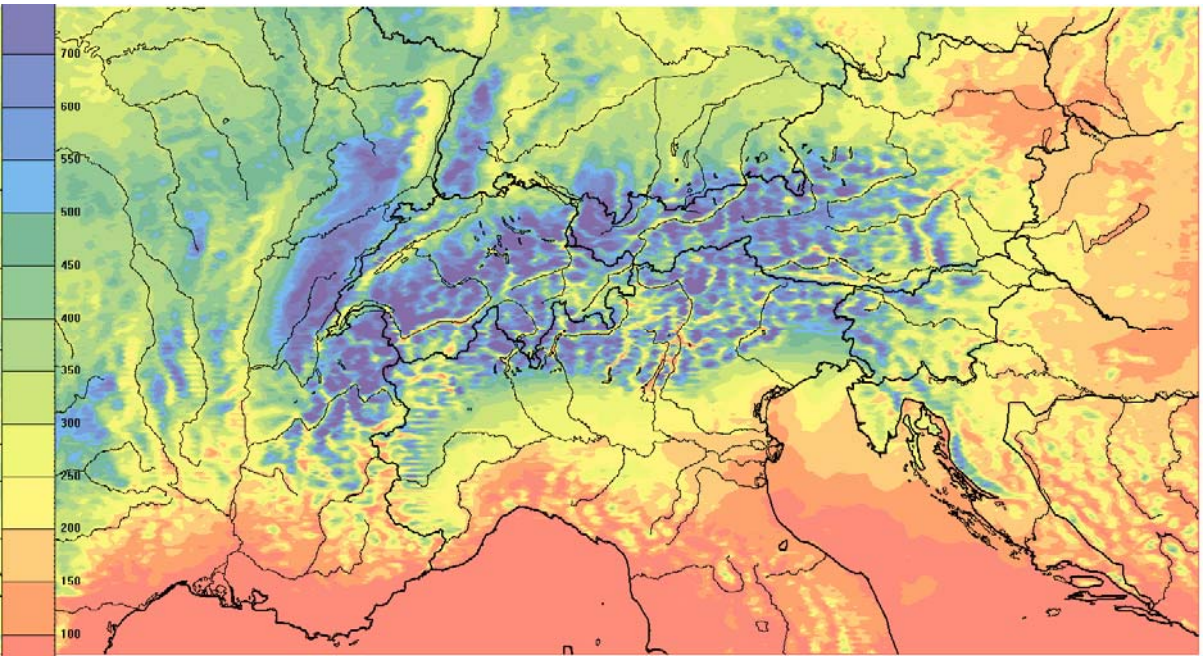
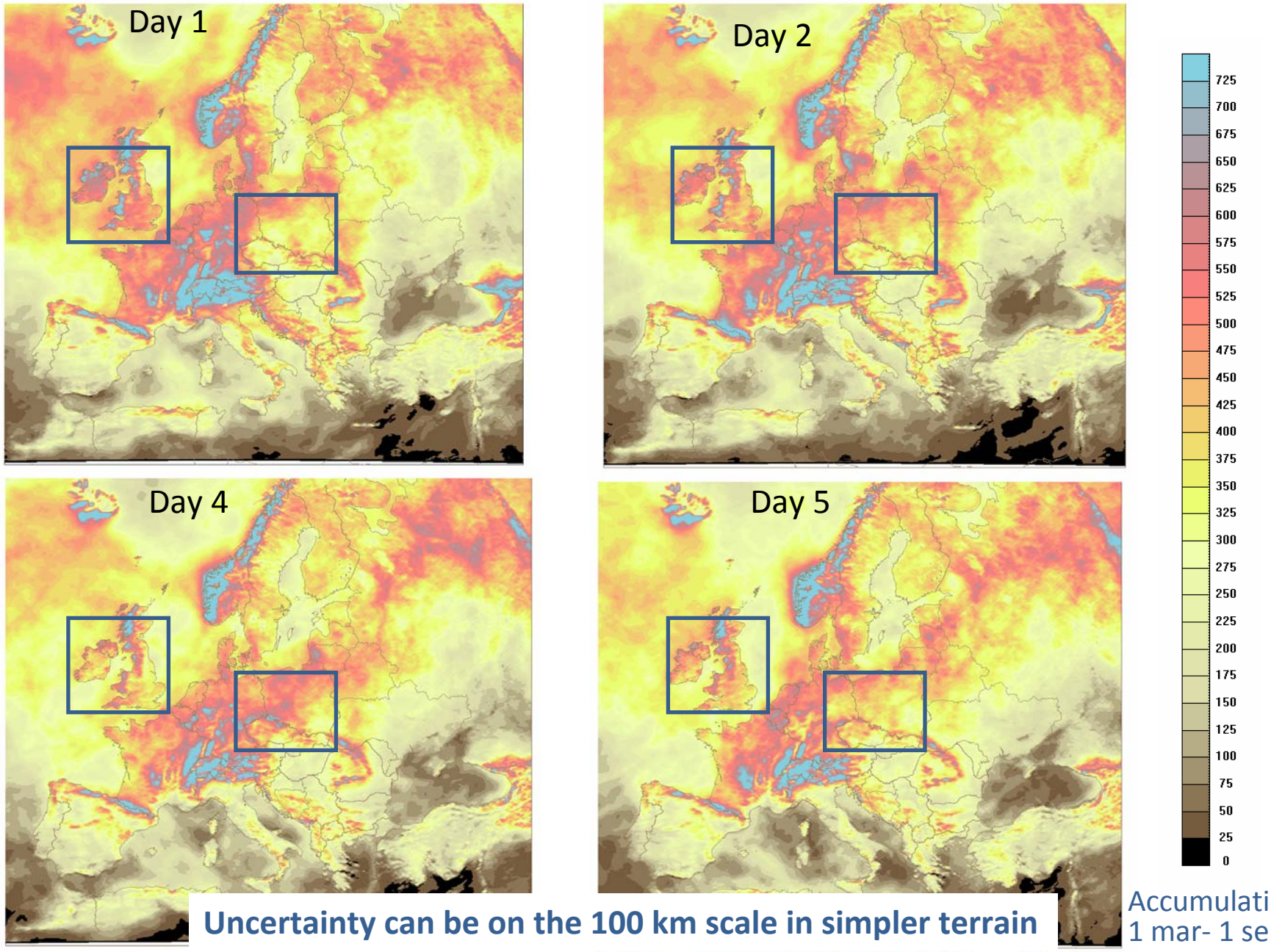


25 to 48 hours forecast

operational NMM 3 km
(meteoblue)

High resolution still has
Realistic amounts !!!!

Uncertainties visible in accumulation (regional)

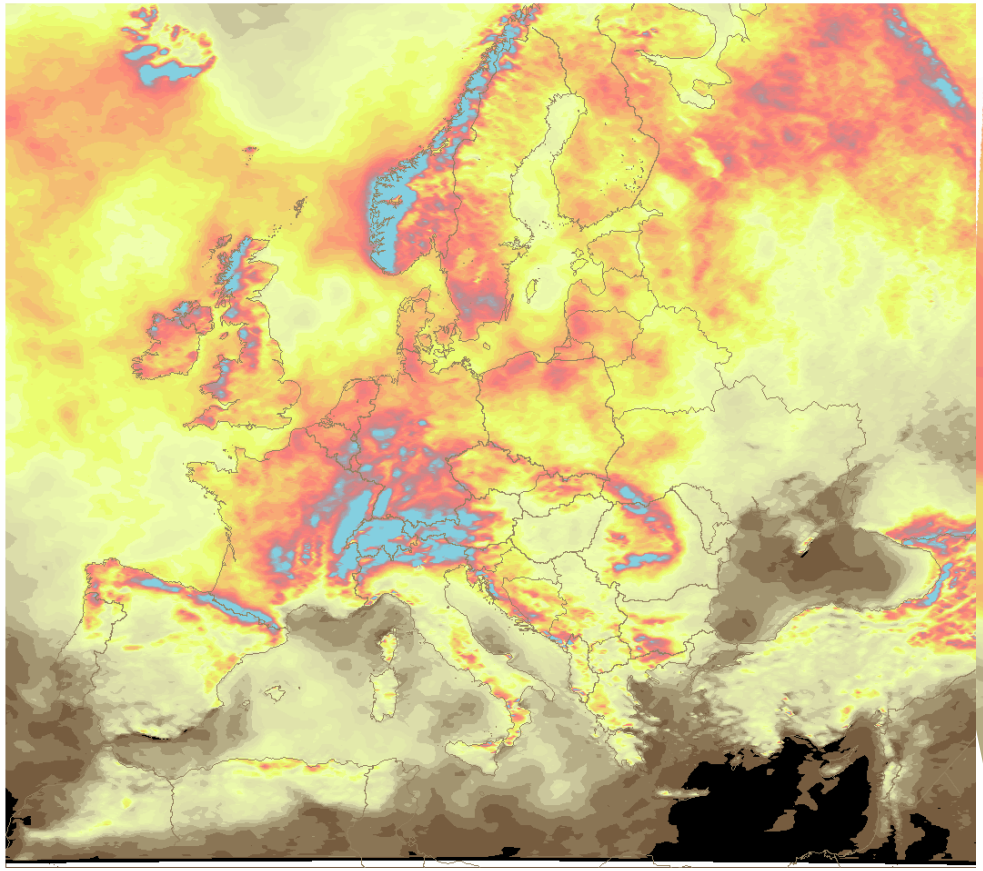


Uncertainty can be on the 100 km scale in simpler terrain

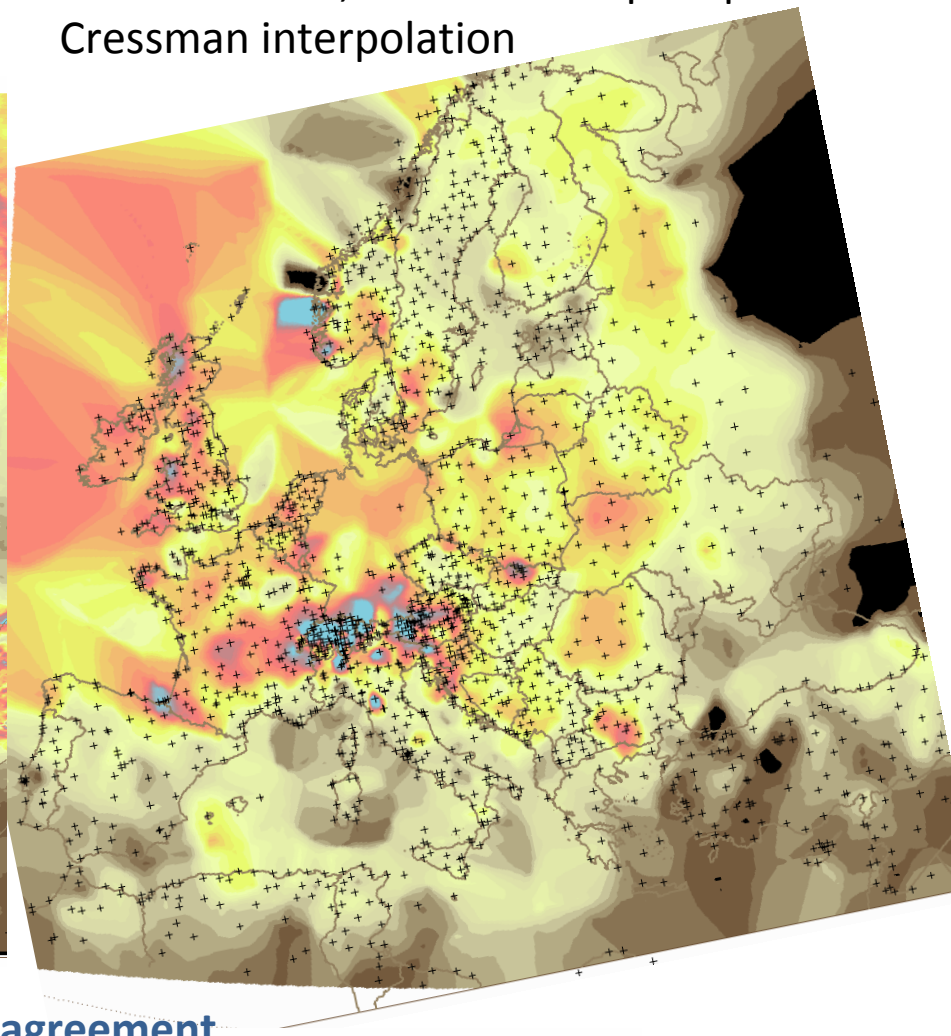
Accumulation:
1 mar- 1 sep 2007

24h acc. Precipitation – (1.3.2007-31.8.2007)

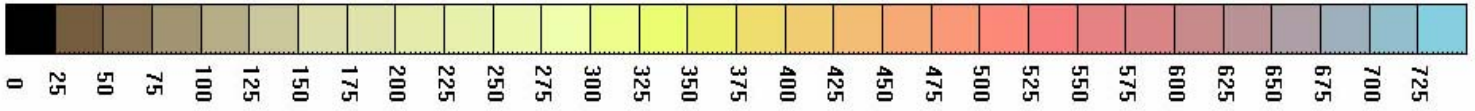
12 km operational NMM
forecast hour 48-71



WMO stations, accumulated precipitation
Cressman interpolation

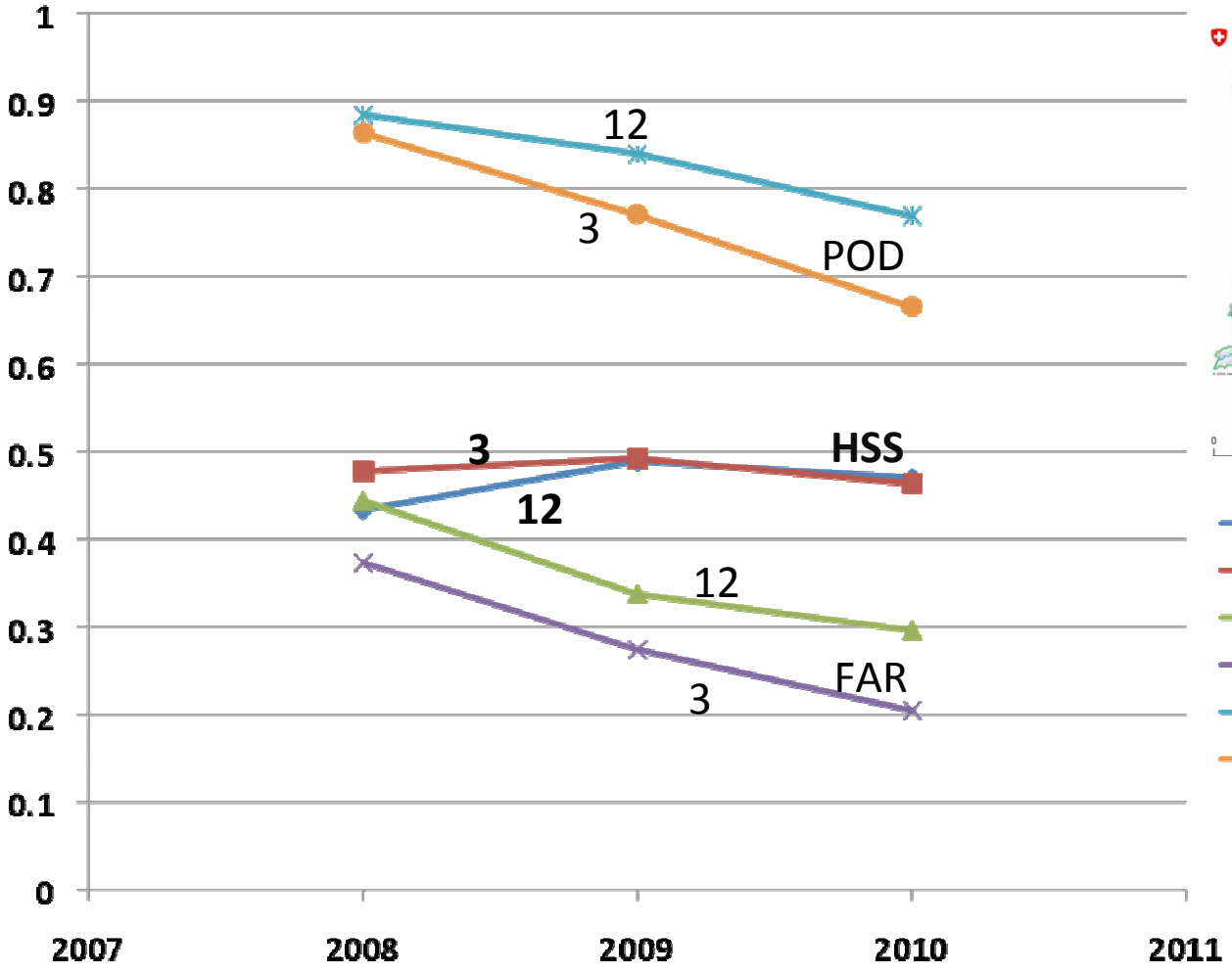


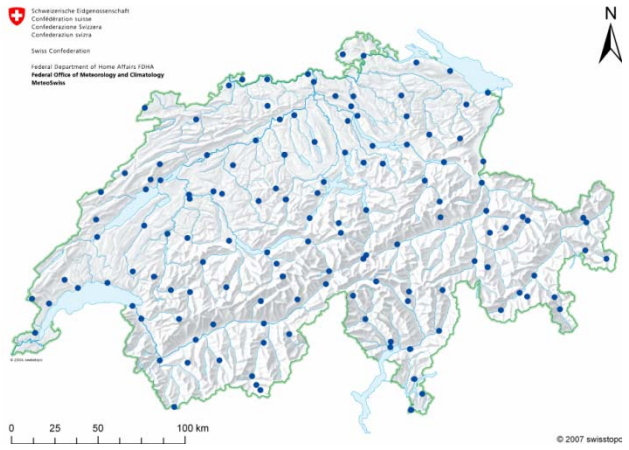
Overall amounts are in good agreement



Precipitation in complex topography - Switzerland

event based verifications (rain event within 24 hours)

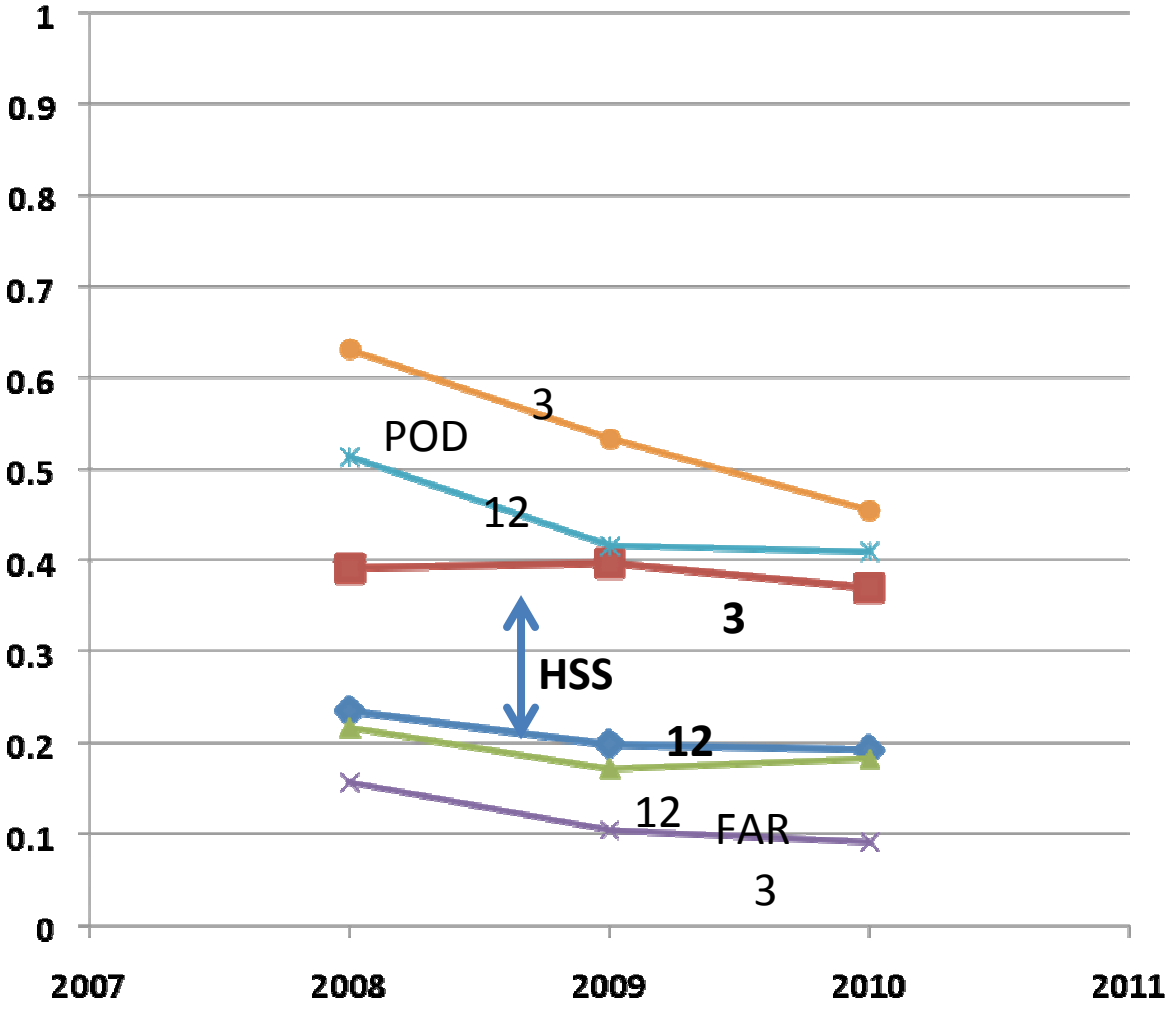


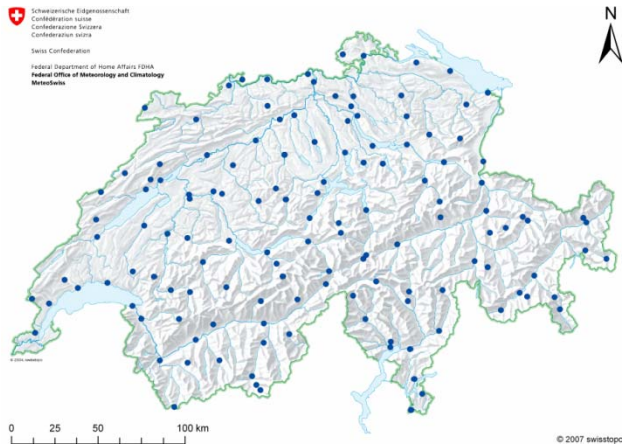


12 km HSS
3 km HSS
False Alarm 12 km
False Alarm 3 km
POD 12 km
POD 3 km

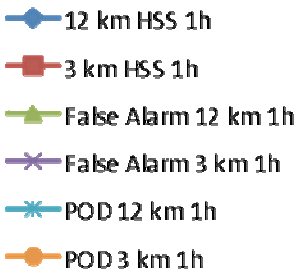
Precipitation in complex topography - Switzerland

event based verifications (rain event within a single hour)





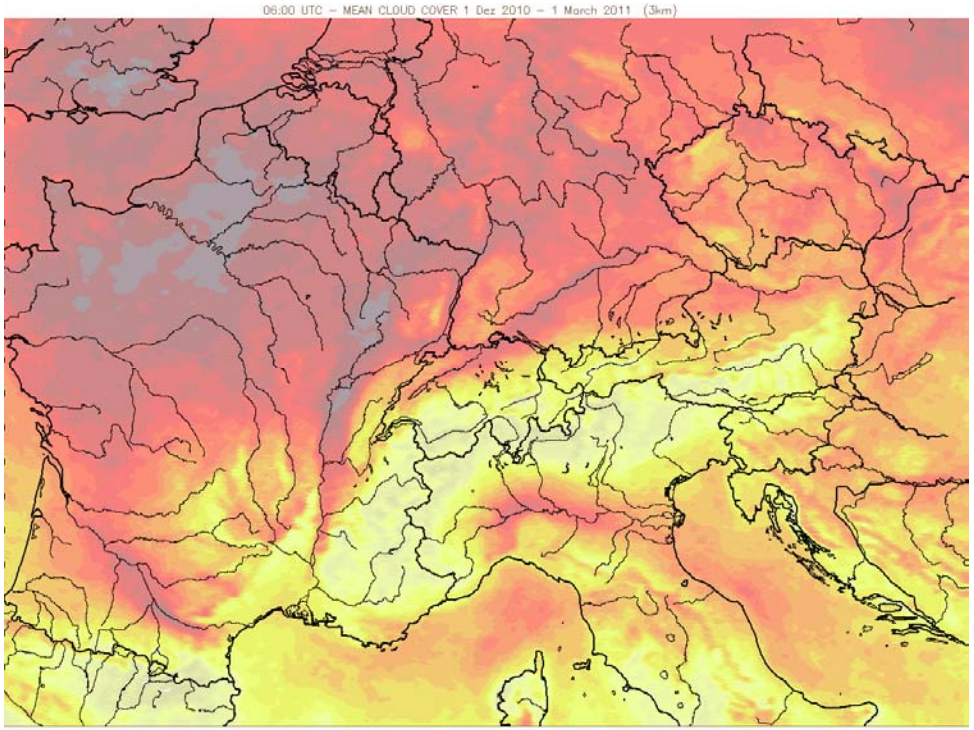
The high resolution has almost double Skill!



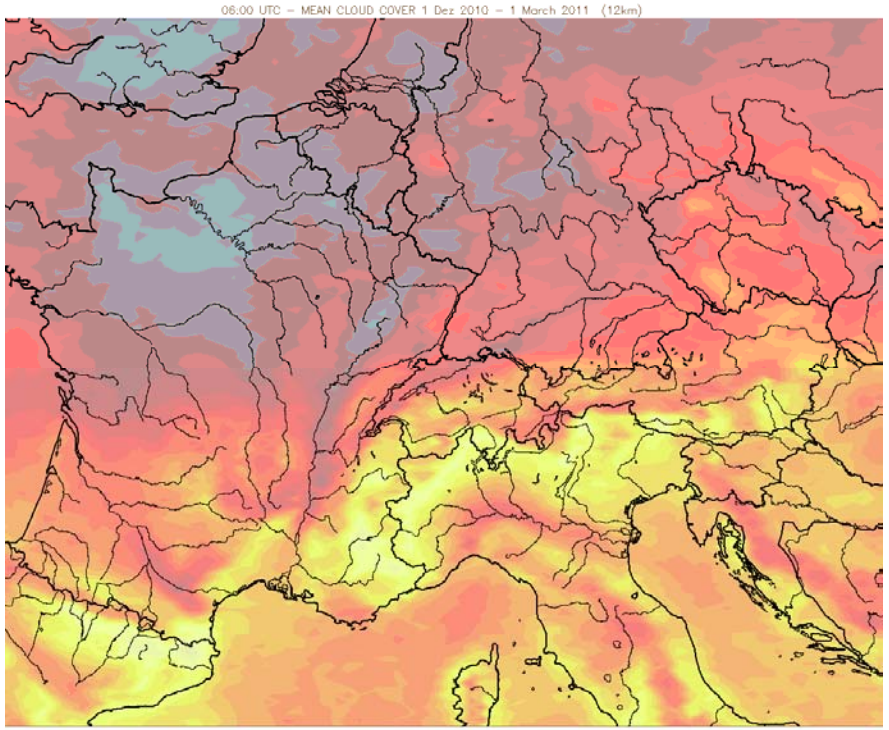
Mean «low» cloud cover

1 Dec 2010 – 1 March 2011 at 07:00 LST

3 km



12 km

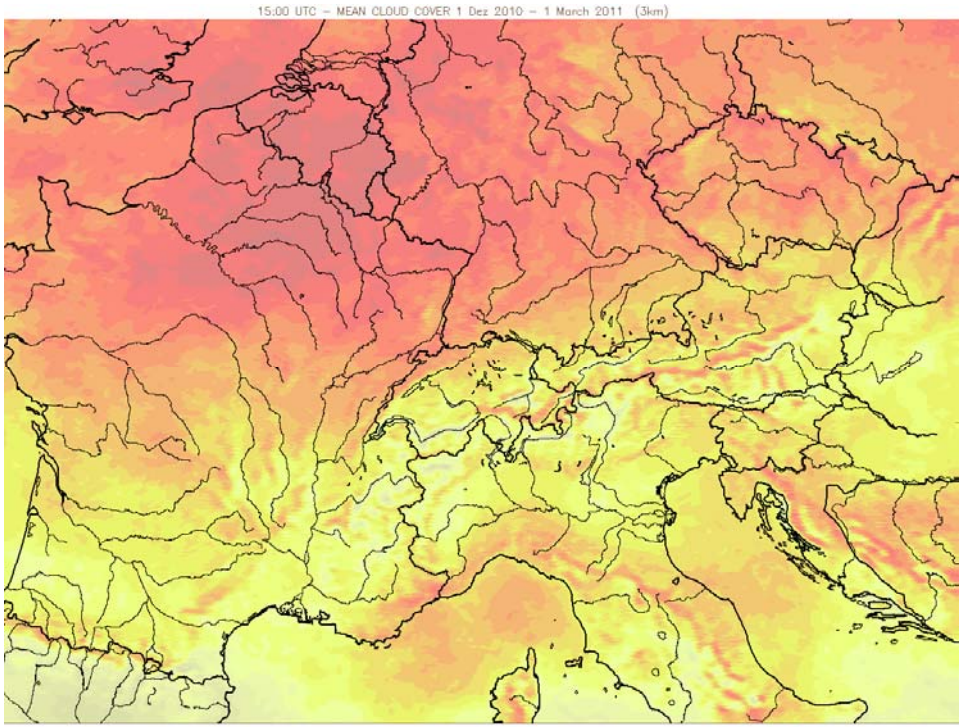


Tendency to slightly more cloud cover at coarser resolution, especially in complex terrain

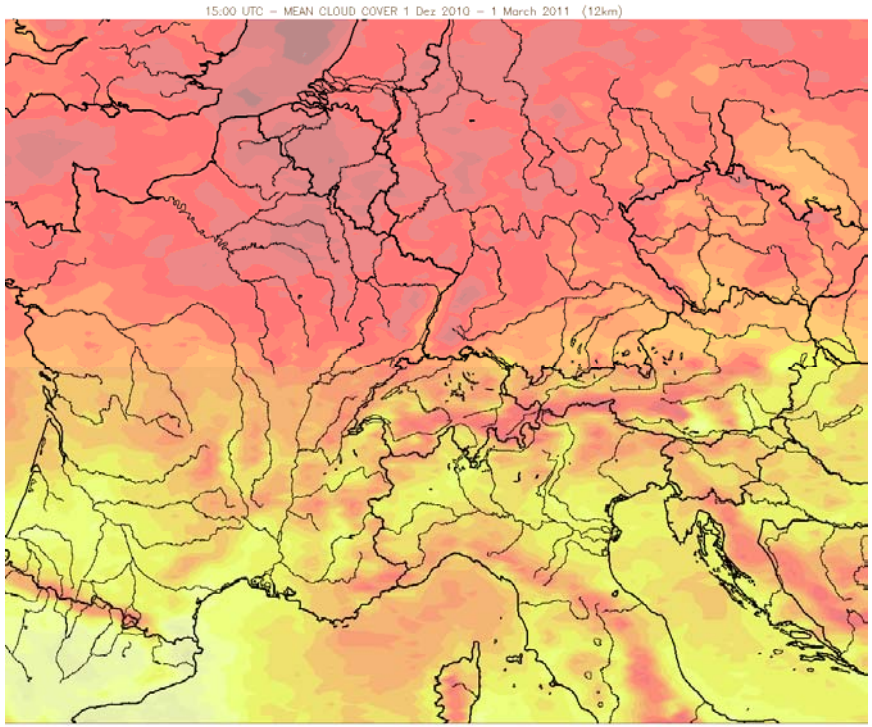
Mean «low» cloud cover

1 Dec 2010 – 1 March 2011 at 16:00 LST

3 km



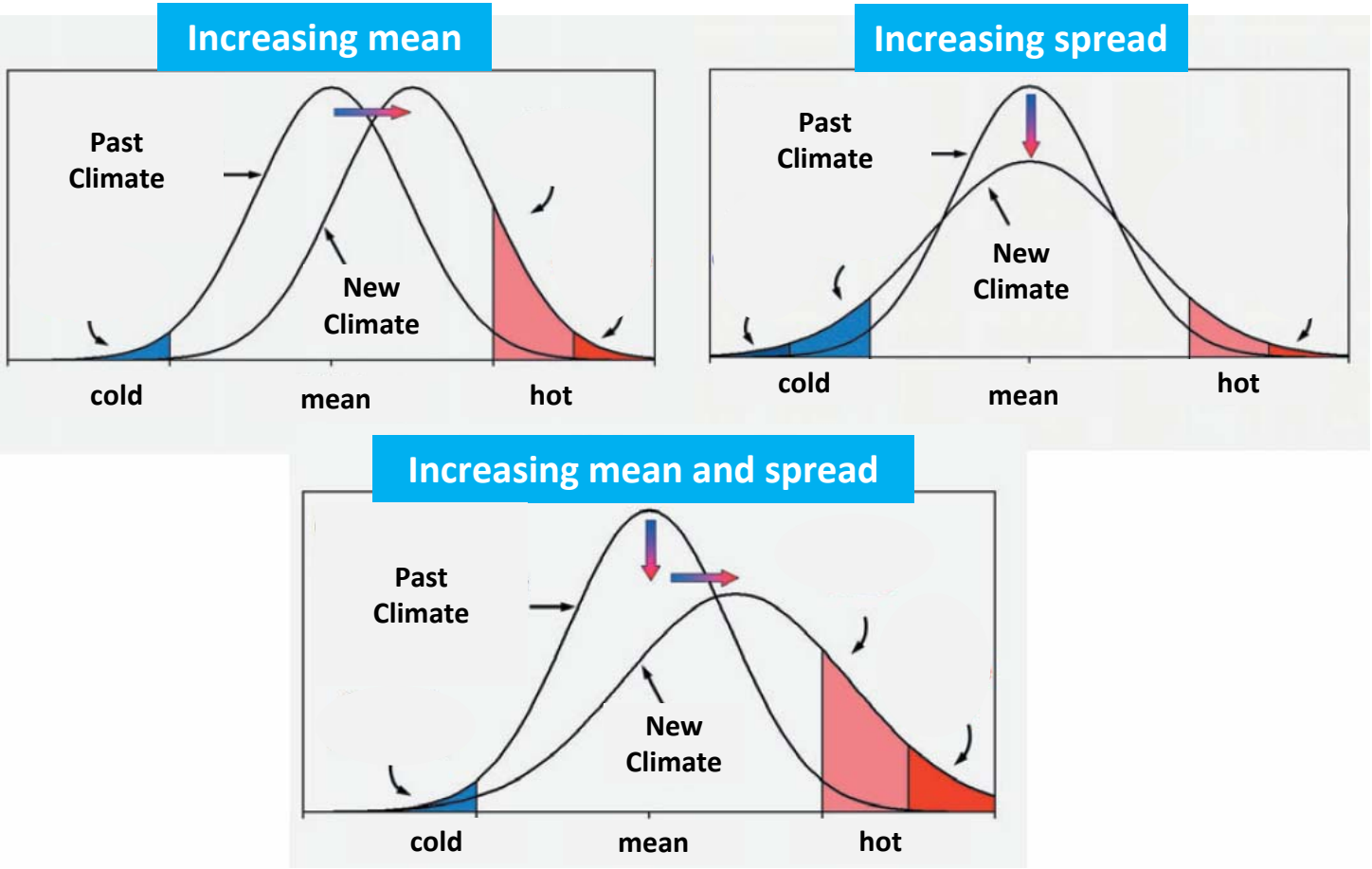
12 km



Tendency to sligthly more cloud cover at coarser resolution, especially in complex terrain

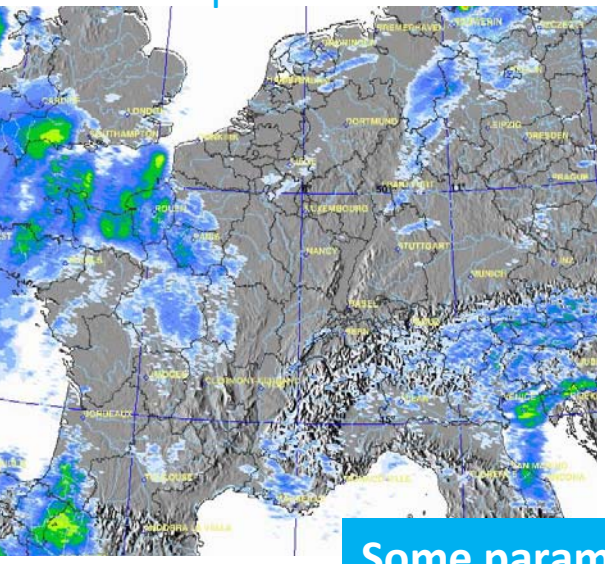
Can we downscale to get extreme event statistics?

Climate downscaling with NWP could predict extreme events and thus the PDF - or maybe **not**!

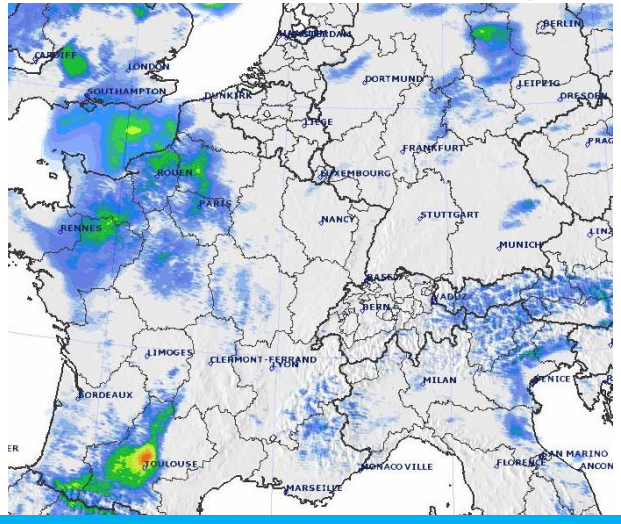


Can we downscale extreme event statistics ?

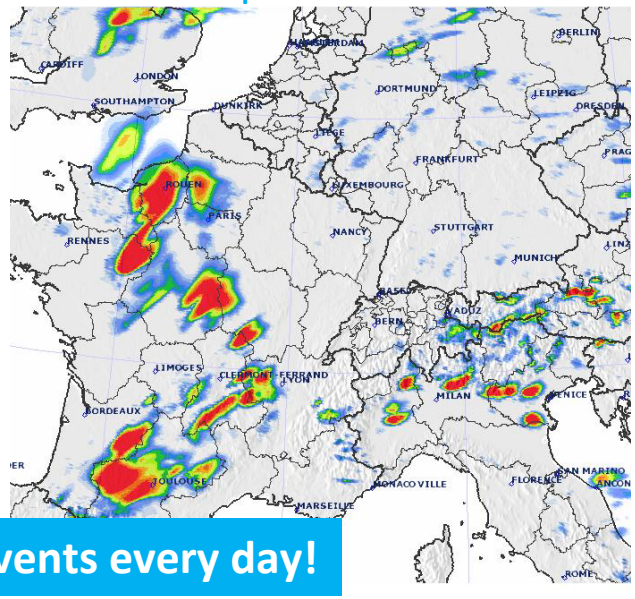
Thompson



Reference (BMJ-Ferrier)

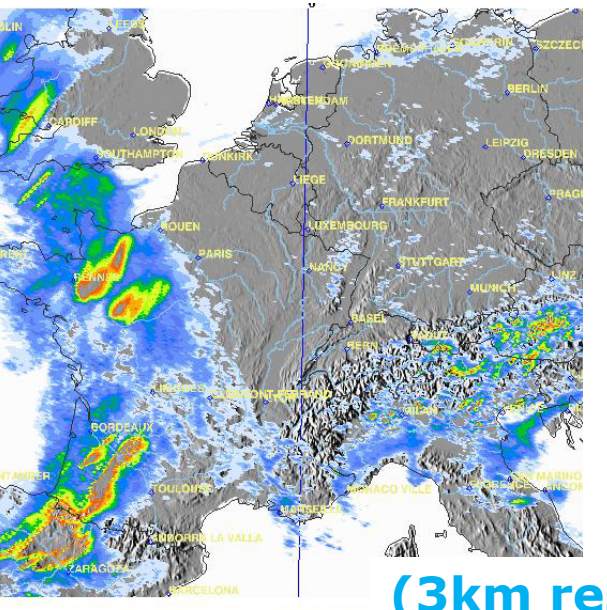


Explicit

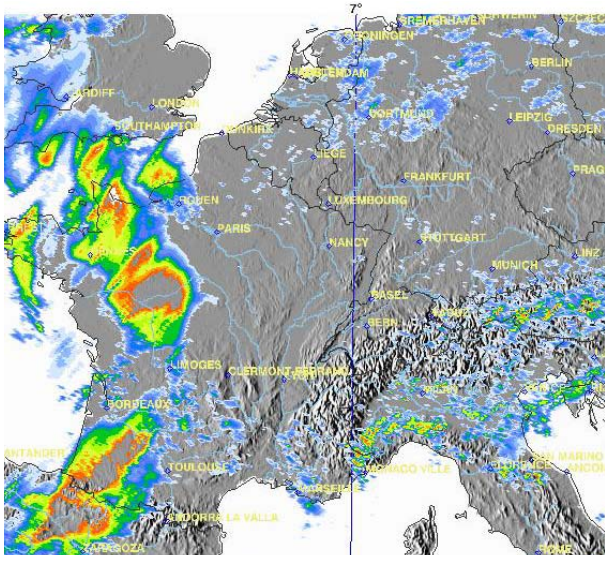


Some parameterizations predict extreme events every day!

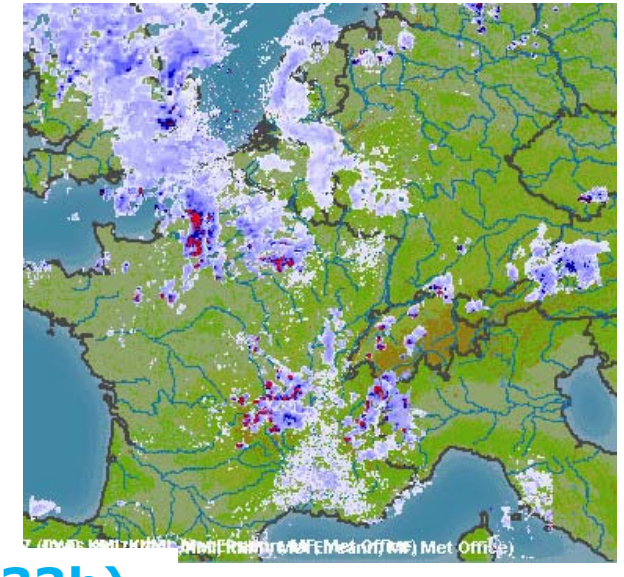
Arakawa-Schubert



Kain-Fritsch



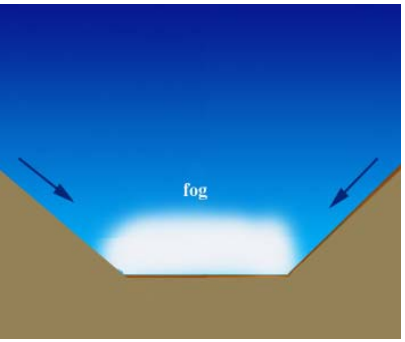
Radar

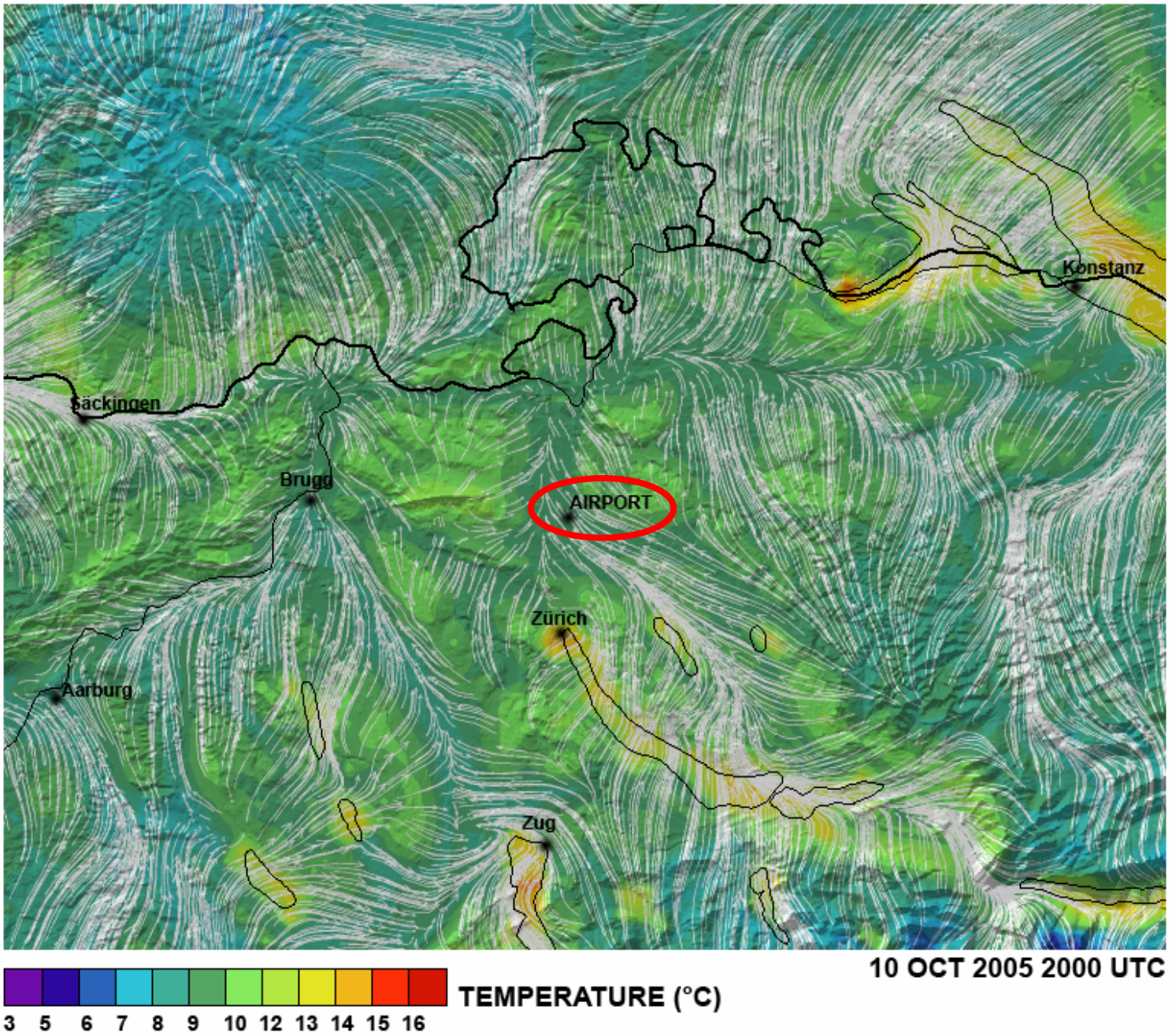


(3km resolution 13.6.07 21Z – 33h)

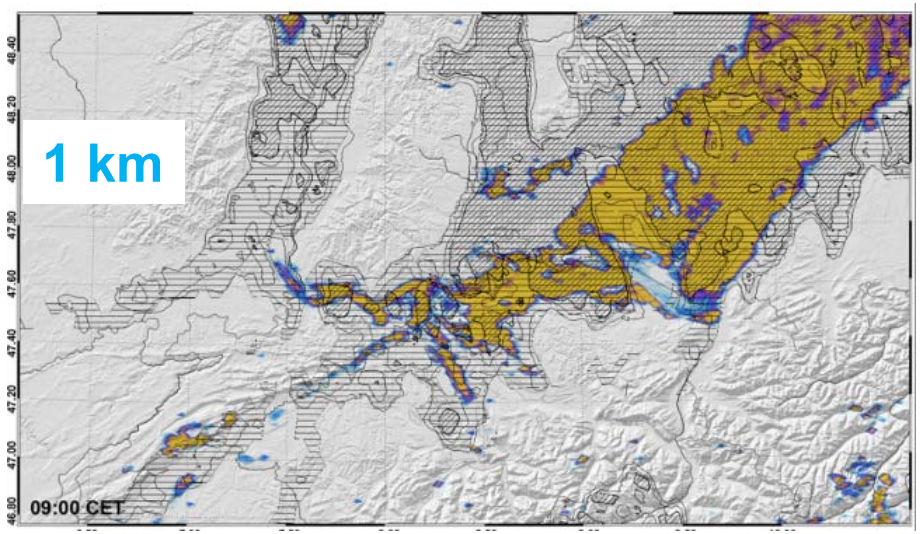
Wind and Temperature – 10 Oct 2005

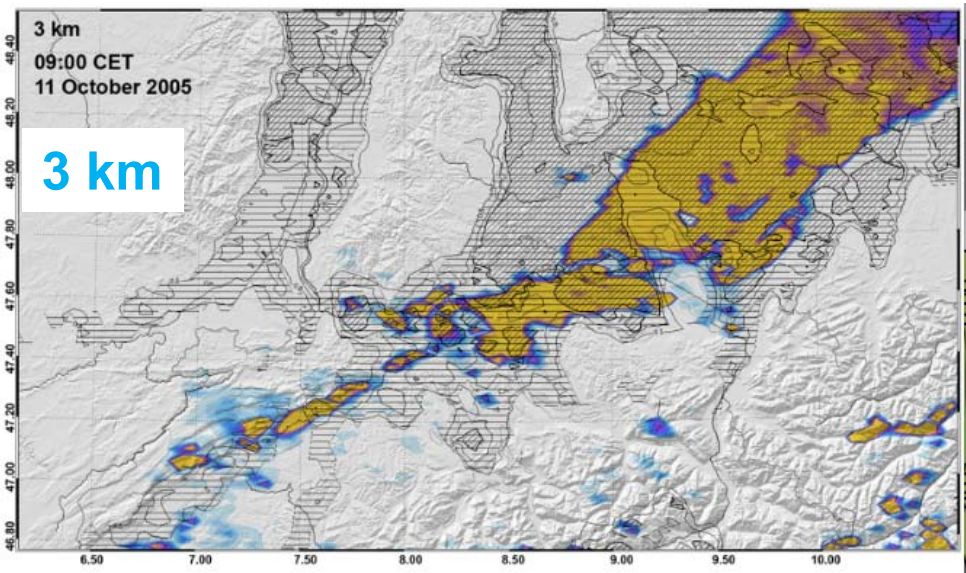
Requires high Resolution (1 km)!

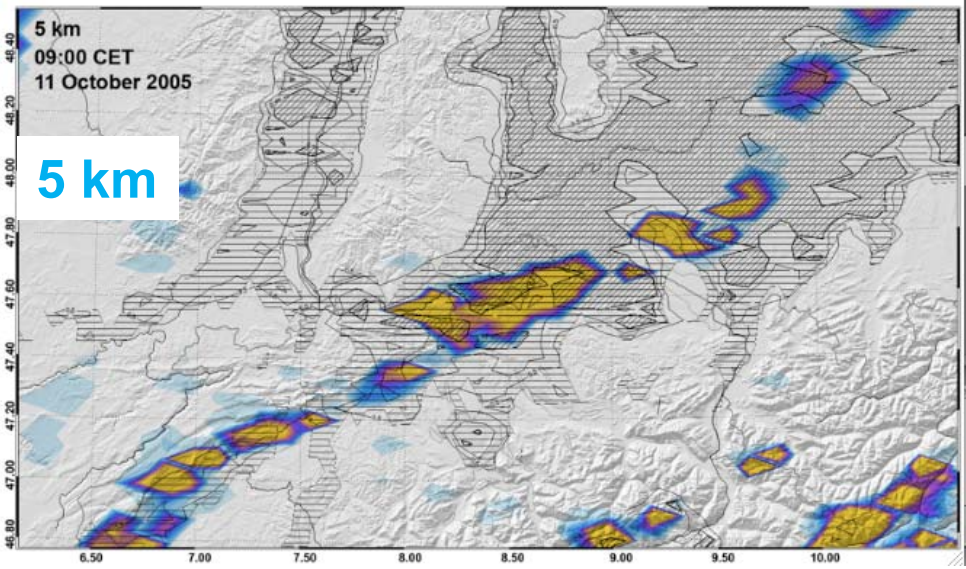




Some processes are very sensitive to resolution







A climatology based on a coarse resolution would significantly underestimate fog

Can statistics compensate for the lack
In resolution?
As with the height dependence of precipitation

Putting it all together...

Post processing is a very effective and cheap way for some variables (Wind, Temp, Dewpoint) if observations exist. (more effective than increasing the resolution)

These variables seem to have a **predictive** skill of around 10 km

Resolution has the largest impact on clouds and precipitation on an **event basis (hourly)**
-> i am not aware of a useful postprocessing

On a 24h event basis the hihger resolution is pretty useless, which is also true for climatological precipitation amounts. -> statistical downscaling possible

For precipitation the high resolution can be very dangerous in a climatological sense

Predicting extreme events will require very high resolution (especially for precipitation) but a strong dependency on microphysics and convective parameterizations exists.

Low stratus clouds are often missing in forecasts

For the future...

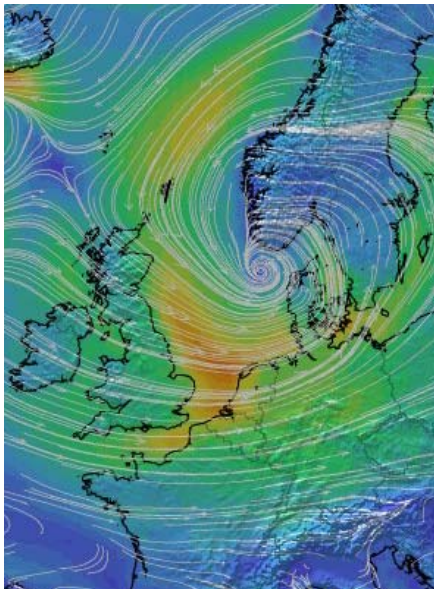
Modeling:

NWP physics used for climate studies have to be carefully evaluated in NWP climatologies on the 12-36h horizon, especially at high resolution.

Ensembles at lower resolution rather than few high resolution forecasts?

In combination with statistical postprocessing.

Communicate predictive skill of downscaling. (it might look better than it is!)



Observations:

Close the data void with more observations.

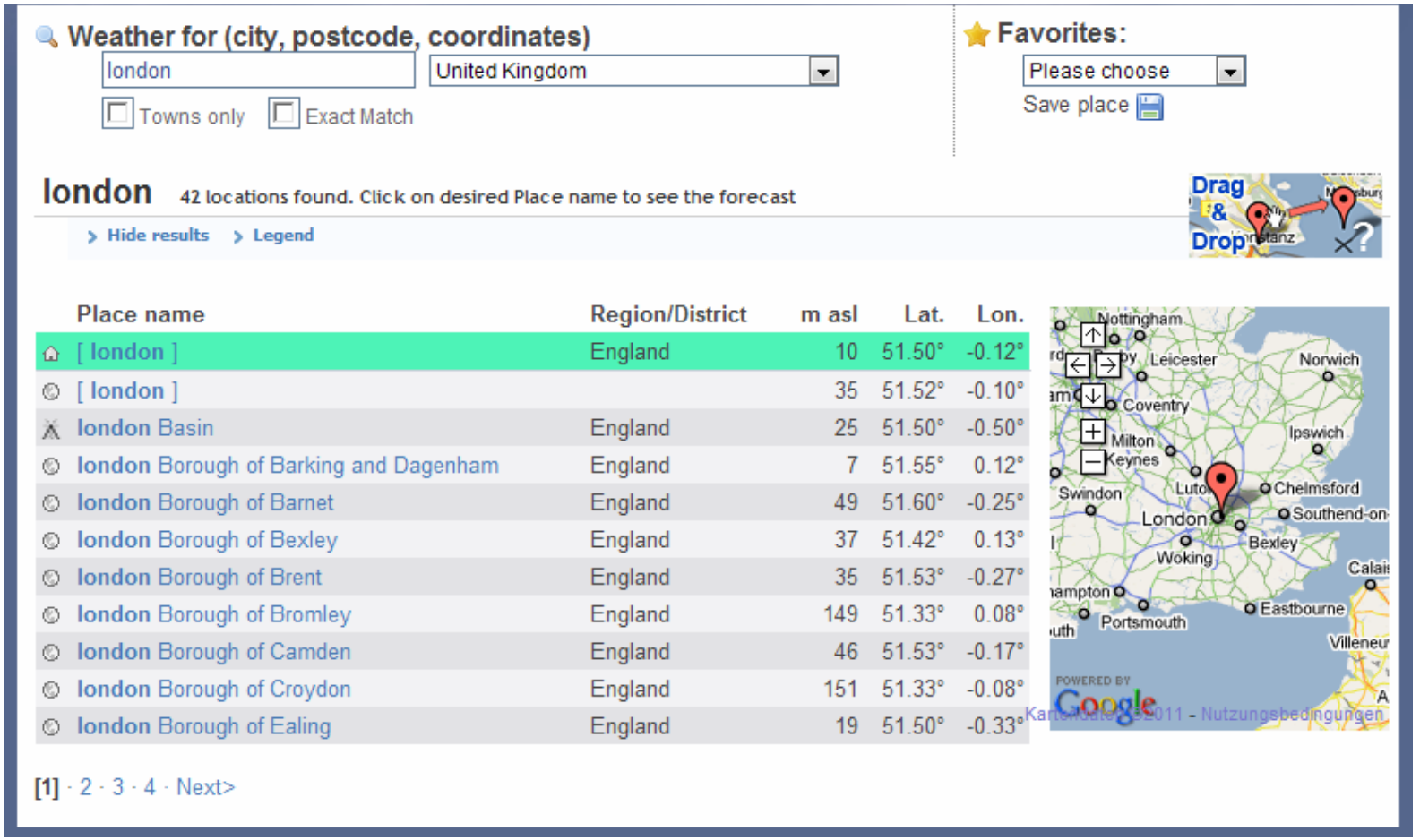
relatively **low level equipment** is good enough for downscaling purposes. (Statistical postprocessing and extreme events)

Integration of non-WMO networks in a climate database. (offering infrastructure or funding)

Easier access to already available observations (at hourly resolution!)

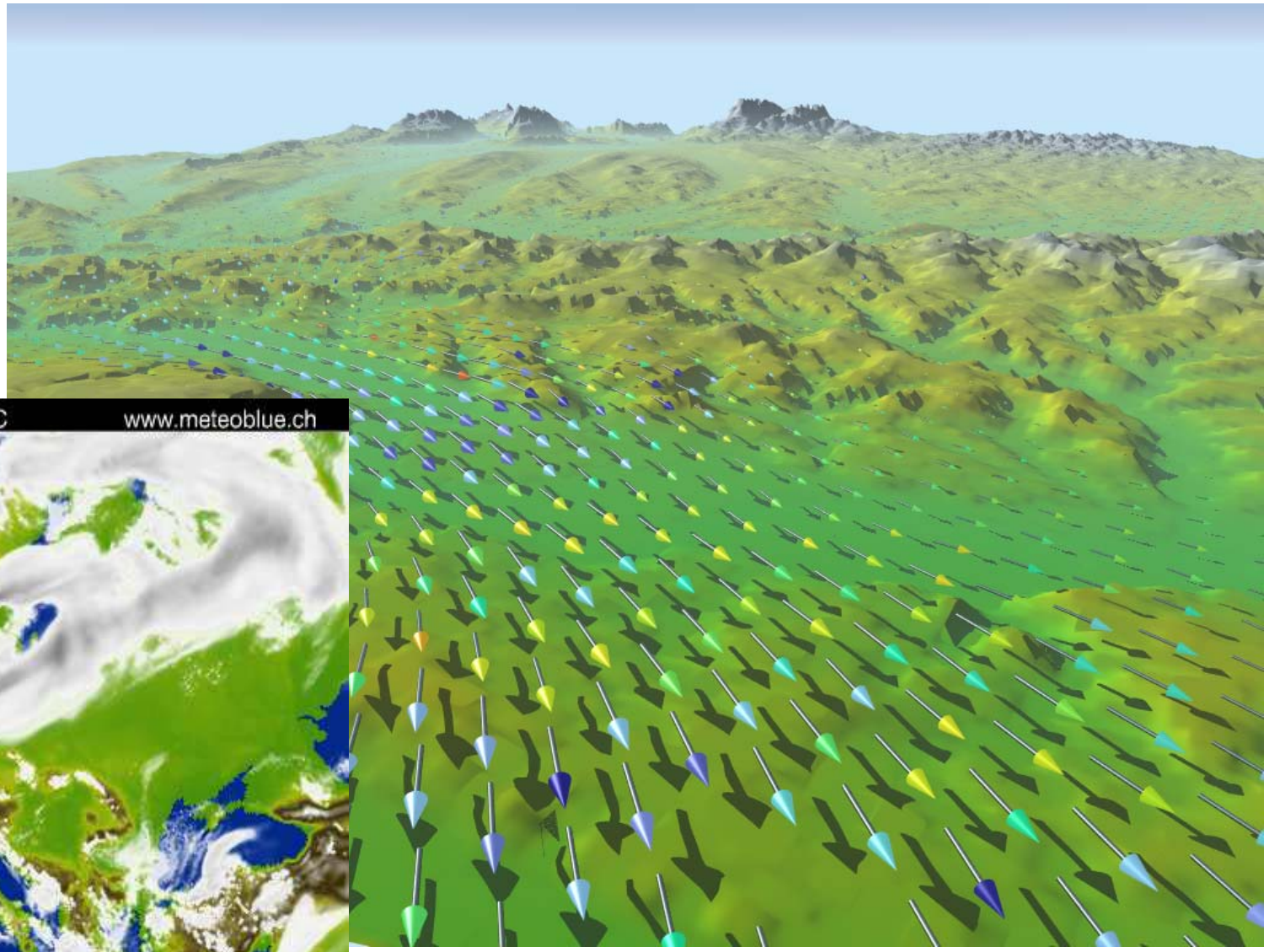
Accessing downscaled climate locally!

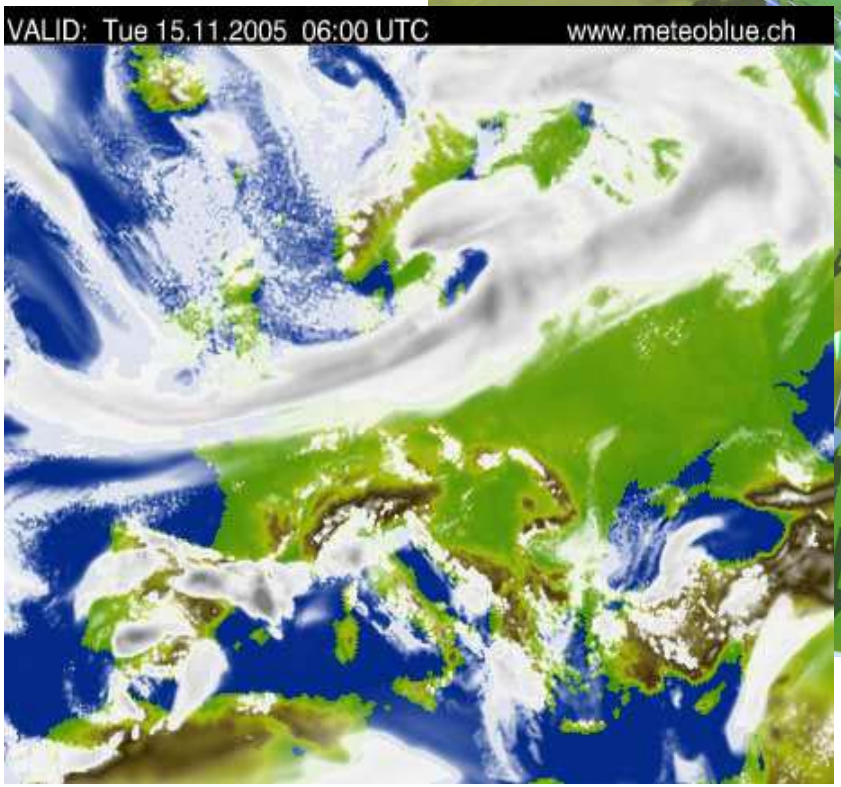
If climate is downscaled to the local scale it should be «experienced» at the local scale



Keep the key information of climate simulations in an online storage for realtime local queries.

Maps





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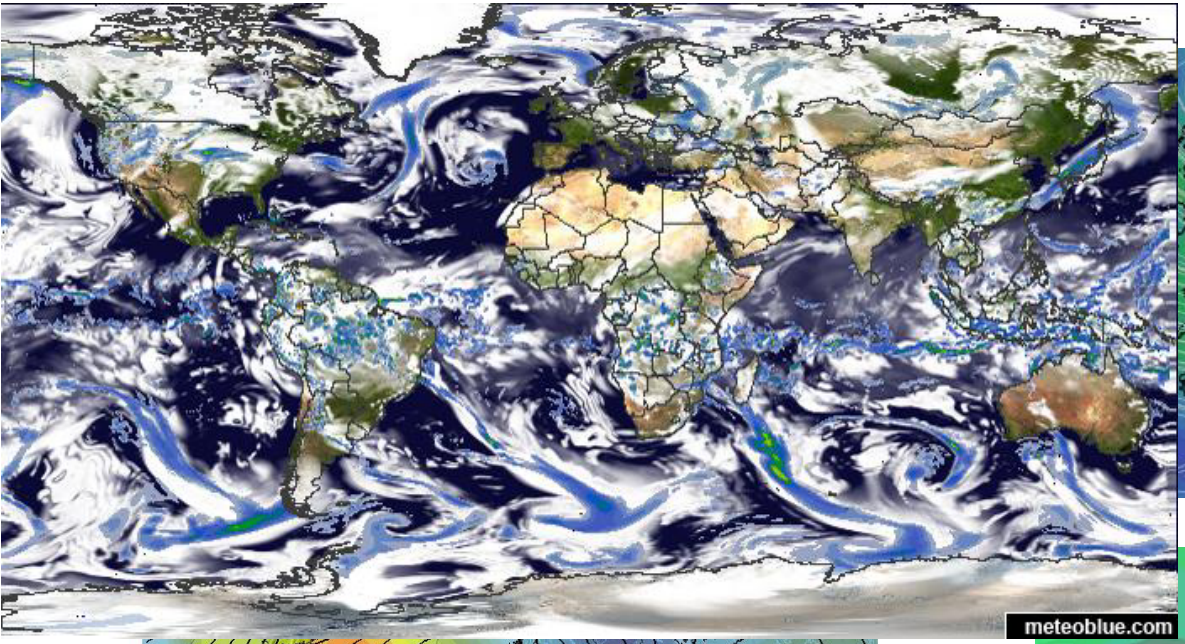

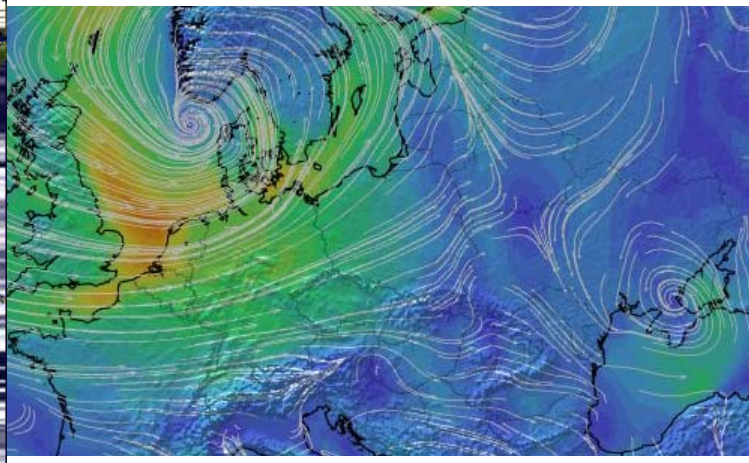

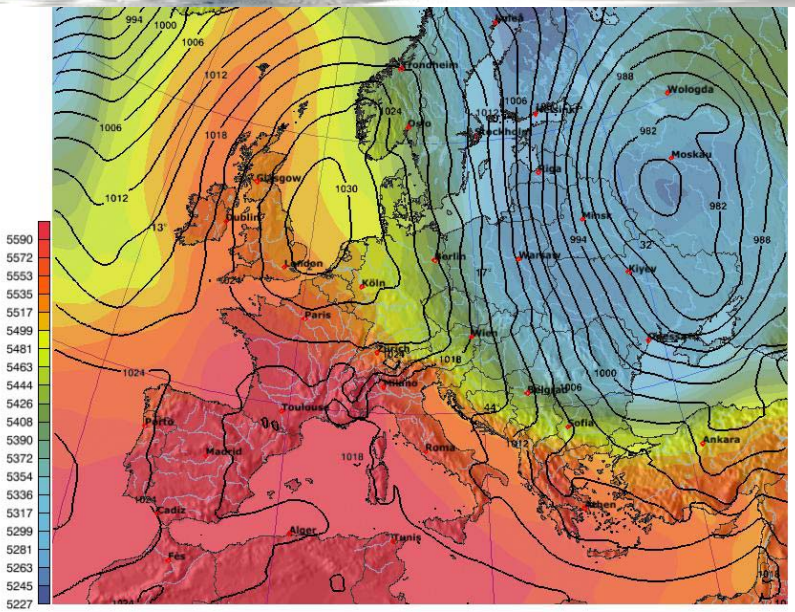

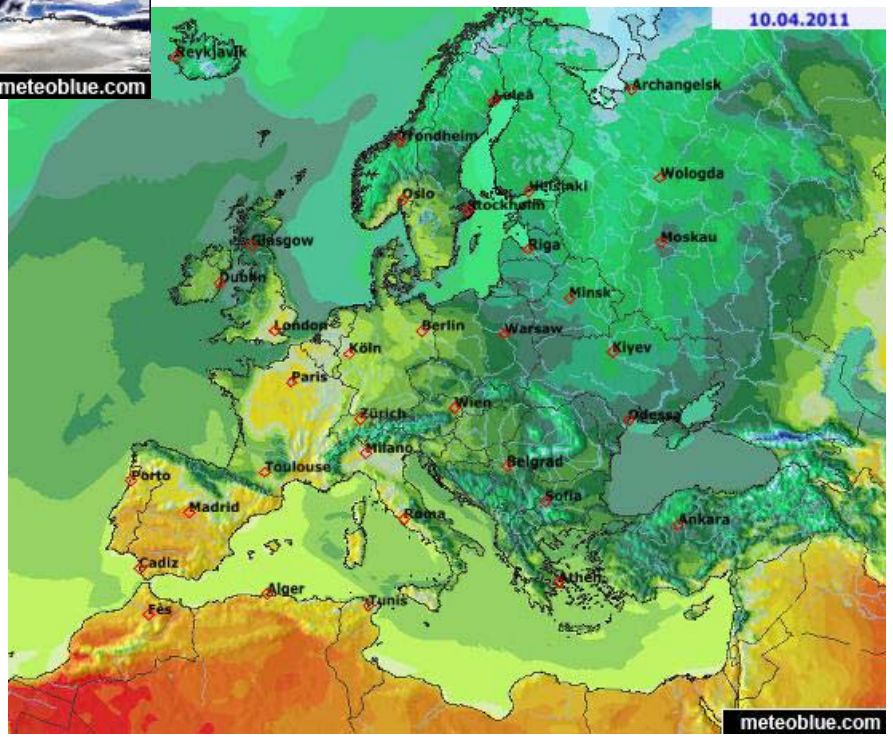

Single points