*LandClim Workshop, SMHI 22-24 February2011*

# How can climate model output be used?
## (or what does the RCM data represent?)

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***Content:***

- ***Introduction – regional climate scenarios***
- ***Resolution – what detail is reasonable (to expect)?***
- ***Model output vs. observations: representativity***
- ***Concluding remarks – take home message***

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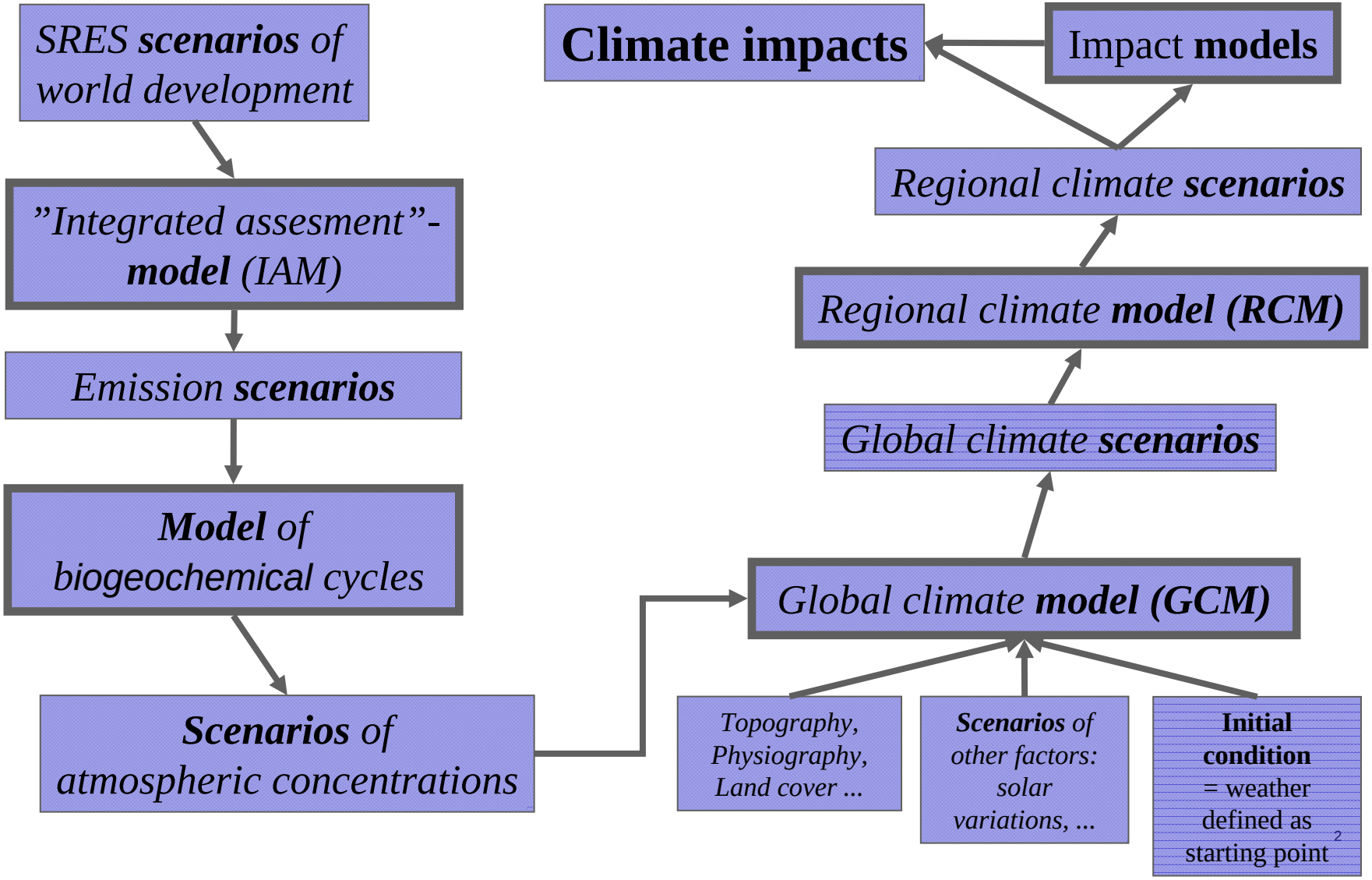
# Future climate scenarios – a chain of models/scenarios



# Future climate scenarios – a chain of models/scenarios

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SRES scenarios of world development

IPCC Special Report on Emission Scenarios

"Integrated assesment" – IMAGE

**SRES scenarios A2, B2 A1B**

Natural biogeochemical cycles

**...**

Scenarios of atmospheric GHG concentrations

**Climate impacts**

Impact **models**

*Regionala climate **scenarios***

*Regional climate **model (RCM)***

*Global climate **scenarios***

*Global climate **model (GCM)***

*Topography, Physiography, Land cover ...*

***Scenarios** of other factors: solar variationer, ...*

**Initial condition** = weather defined as starting point

# Holocene climate scenarios – a chain of models/scenarios

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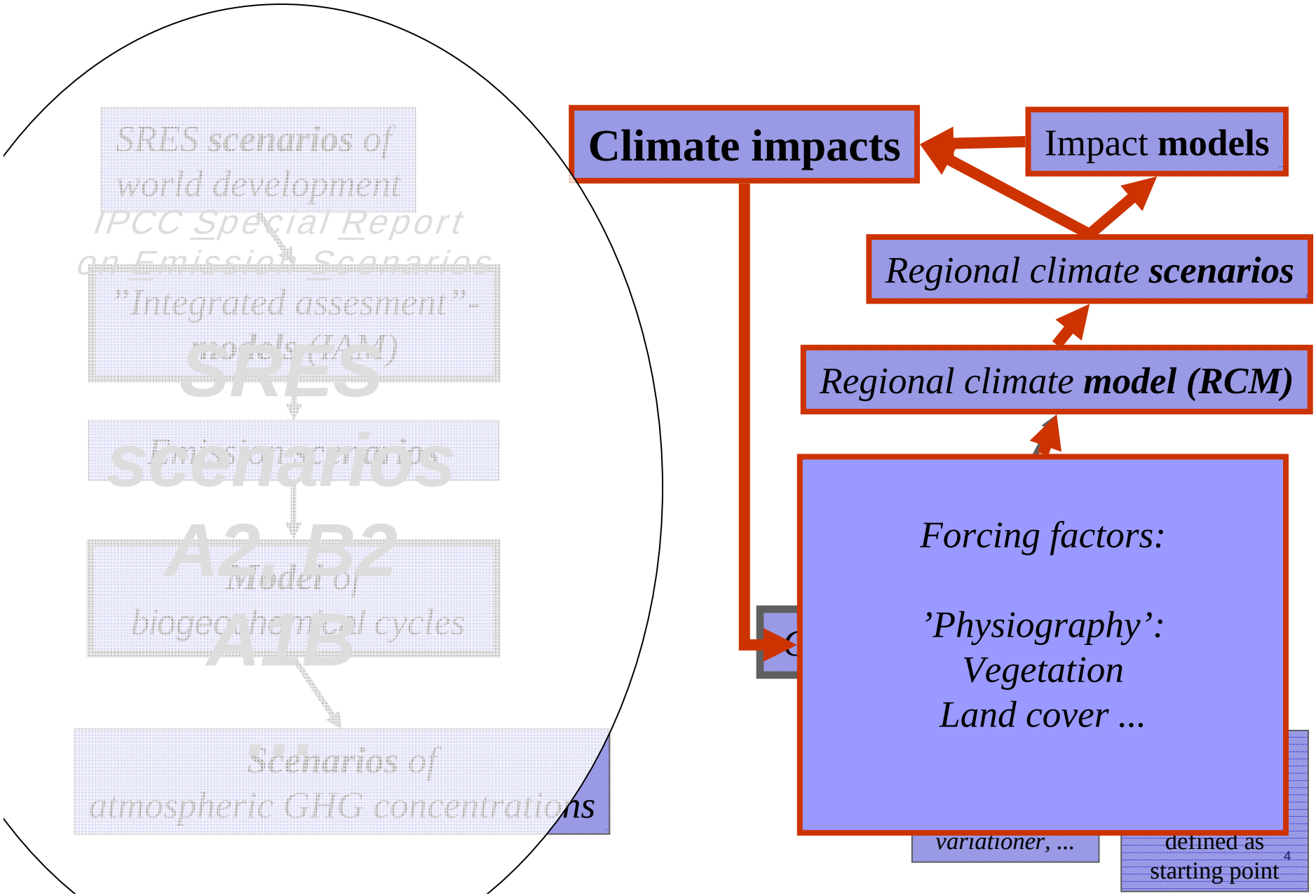


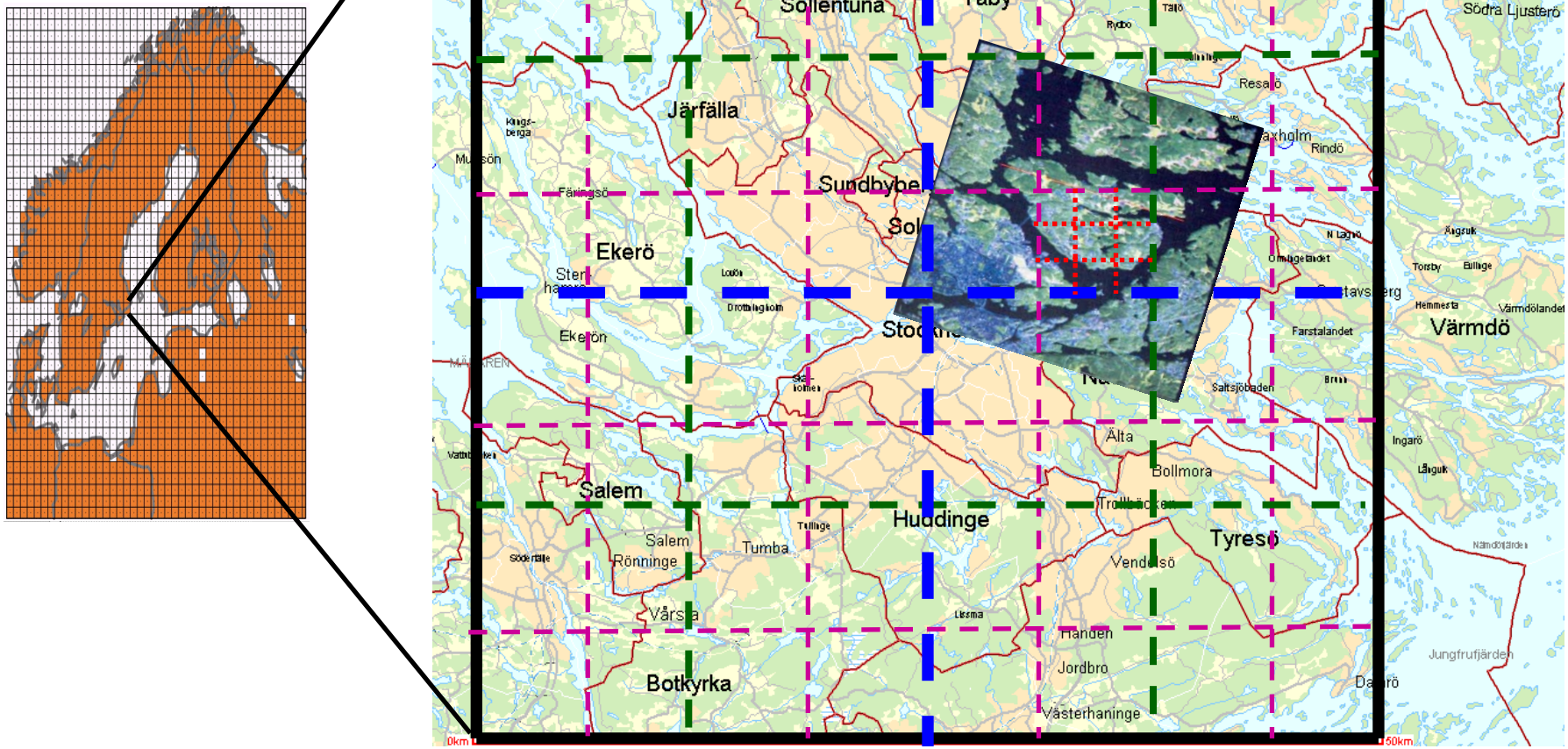
After this brief introduction ....

... we are getting into details

# Spatial resolution of RCMs:

**50km ➔ 25km ➔ 12 km ➔ 6km ➔ 2 km**

**each step requires at least an 8-fold increase in computing**



# Spatial resolution

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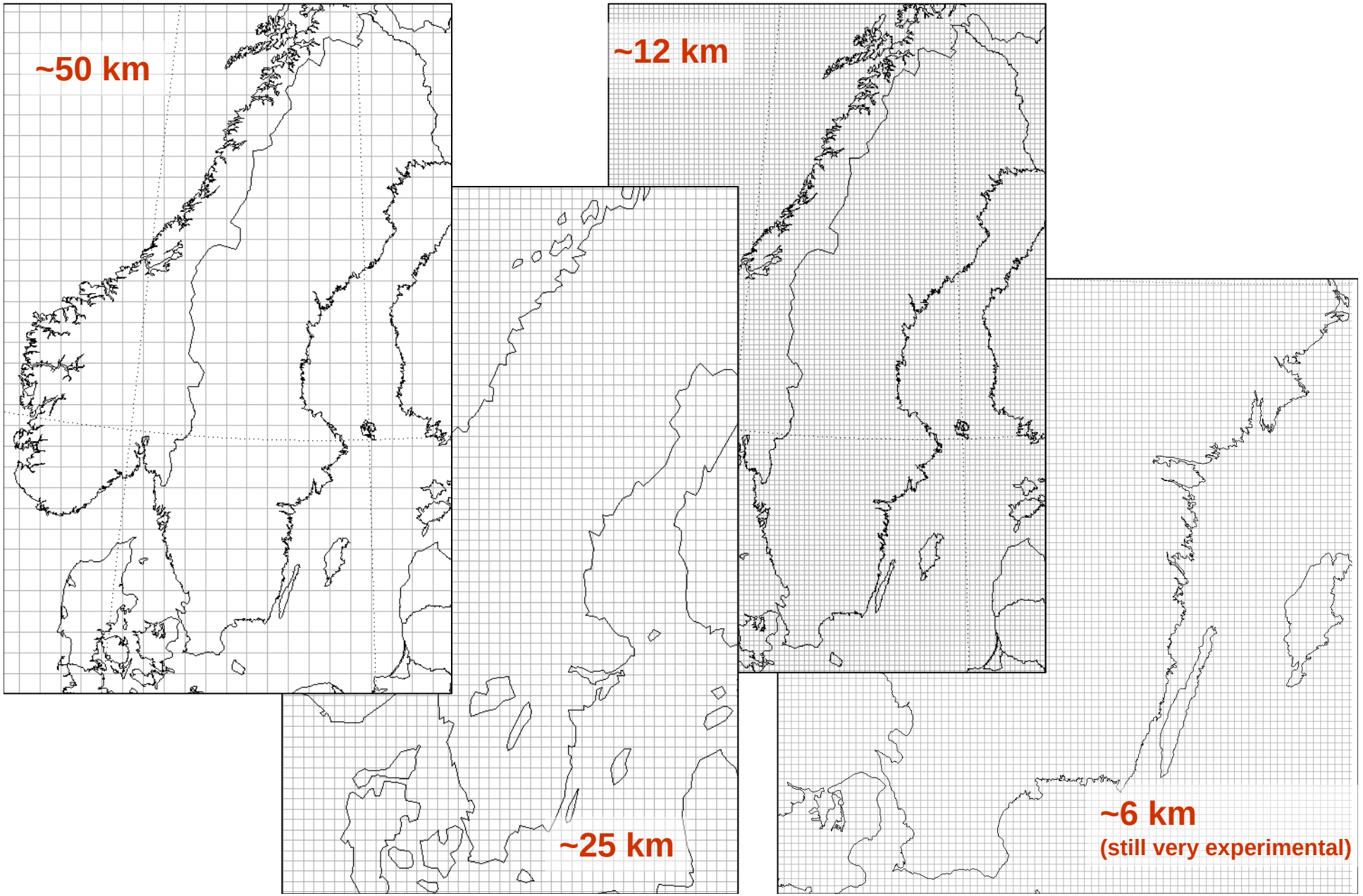
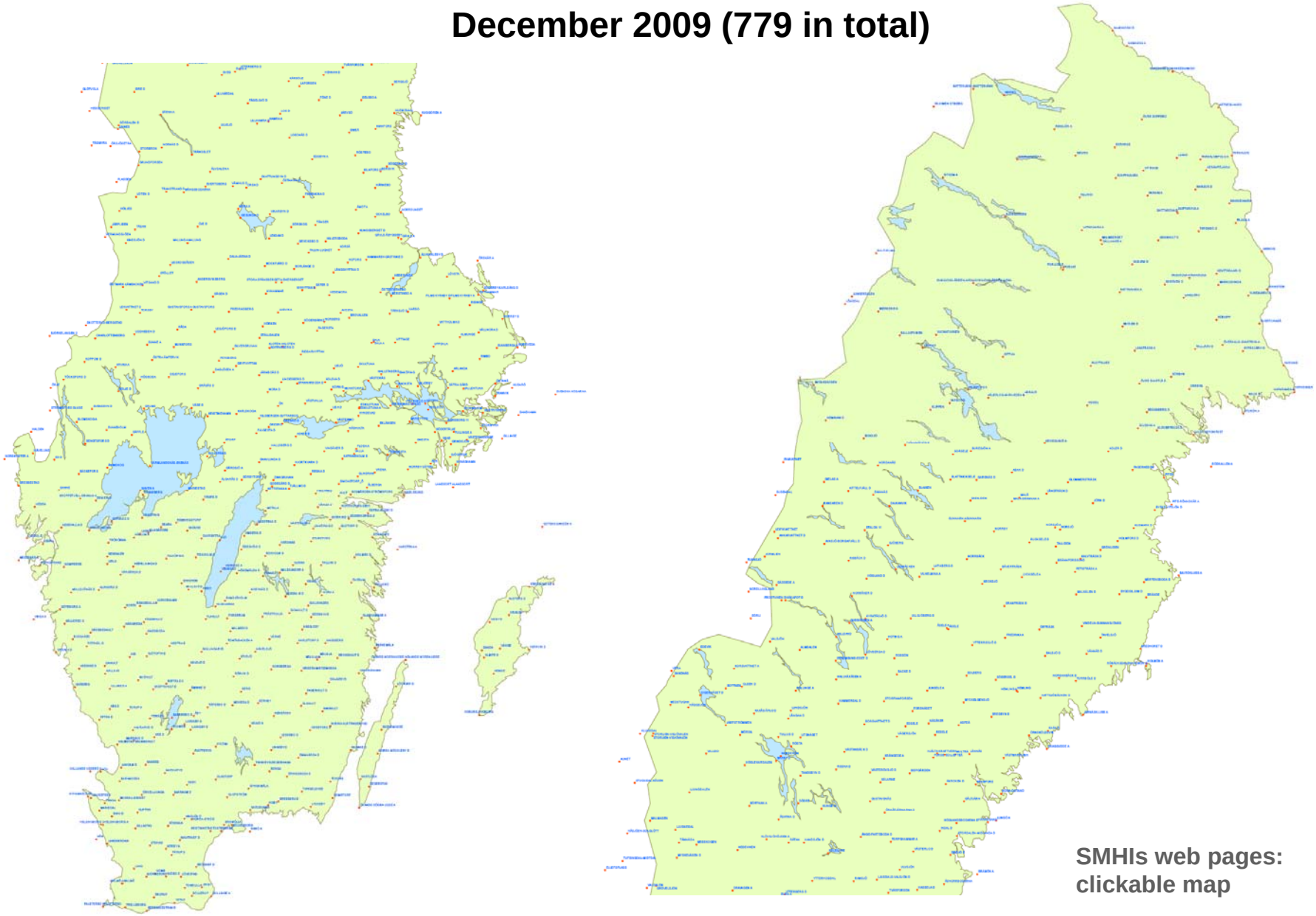


# Met. stations (precip.) in Sweden

## December 2009 (779 in total)



SMHIs web pages:
clickable map

# Spatial resolution in practice

**Sweden as an example:**

| coverage | number | distance | area |
|---|---|---|---|
| Climate scenarios 50 km | ~200 grid cells | 50 km | 2500 $km^2$ |
| Climate scenarios 25 km | ~780 grid cells | 25 km | 625 $km^2$ |
| Climate scenarios 12 km | ~3000 grid cells | 12 km | 144 $km^2$ |
| Climate scenarios 6 km | ~12100 grid cells | 6 km | 36 $km^2$ |
| Met. stations (precip.) | ~780 locations | 25 km (average) | 625 $km^2$ (average) |

# Spatial representativity

- A gridcell is ‘large’ and represents the average of different local landscapes
- A met. station ‘sees’ the local climate of its surroundings

  … although there are standards for how and where they should be located

- Some variables are more sensitive to local conditions than others, e.g.:

  … a raingauge has an orifice area of 200 $cm^2$, and rainfall is very variable in space

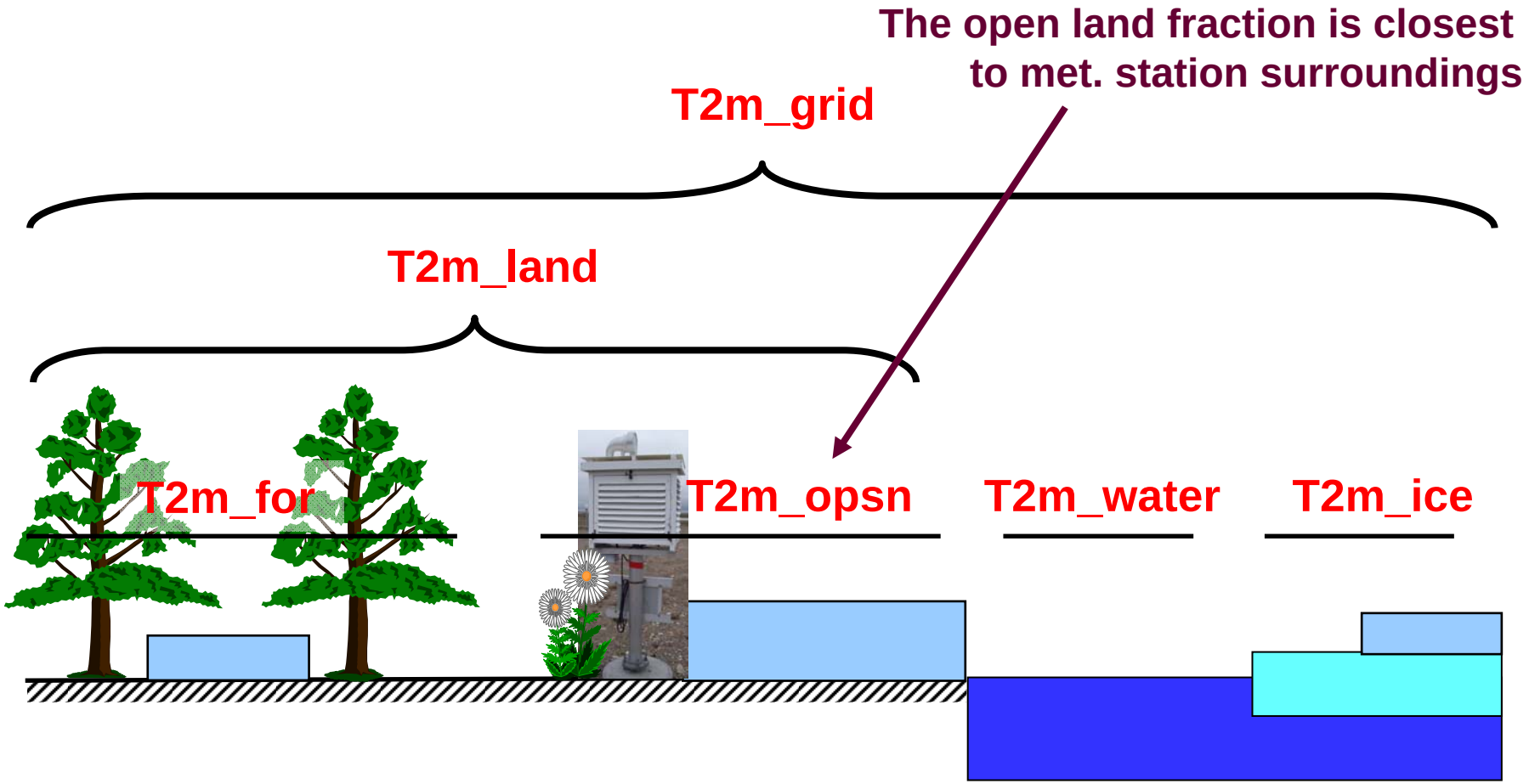
  … wind measurements are very sensitive to changes in the local environment

- Spatial representativity becomes more of an issue the more extreme or short-term specific the data is
- Often RCM data will need to be calibrated and ‘further downscaled’ → *Fredrik*
- Are your study objects related to the average climate of the ‘gridcell’, or some specific micro-climate ?

  … sunny south-facing slopes, moist depressions, or patches where the snow pesists late in spring…?

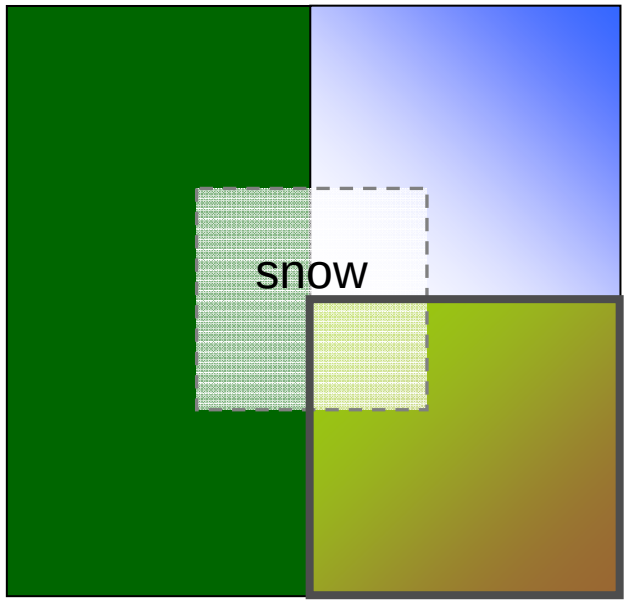
# In RCA3 each gridcell has different tiles of land cover

**The energy balance is solved separately for each tile and then aggregated to the gridcell average**



# Another way at looking at the gridcell tiles

FOREST
(different categories)
possibly partly
covered by snow




LAKE
possibly with lake ice,
and the lake ice may be partly covered by snow

OPEN LAND
(different vegetation categories, or bare soil
possibly partly covered by snow

## Spatial resolution: some comments

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- The principal gain with higher resolution is :
  – a more realistic representation of physical processes in the atmosphere
  GCM (>100 km) → RCM (50–10 (5) km) → future hi-res RCM (3–1 km)
  – better representation of the landscape and related processes

  … however, the change signal is typically large-scale
  … knowledge of present day local climate and its links to physiography and landscape factors are useful to interpret local variations within RCM gridcells.

- Because of the numerical algorithms used in the models it is not meaningful to analyse single gridcells and time-steps at the same time

  … max. time resolution requires spatial averaging (3 x 3 grid cells)
  … max. spatial resolution requires temporal averaging (e.g. at least over 3 or 6 hours)
  … Fundamental relationship between spatial and temporal resolution

## Spatial resolution: a view from the other end

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- Environmental change:
  – many forcings; climate is just one possible factor

- Links are established through process studies:
  – often involving field studies

  … that make use of climatological time series from the ‘nearest’ met. station which is representative of its surroundings rather than the environment at the field site.

  … sometimes a research weather station is established at the field site, but linking these measurements to the long-term climate is non-trivial

- Much of these issues would be easier to handle if process studies would use gridded climate data to establish links between environmental changes and climate forcing

  … limited availability at present, probably going to change within a couple of years

# RCA3: 50, 25, 12 och 6 km

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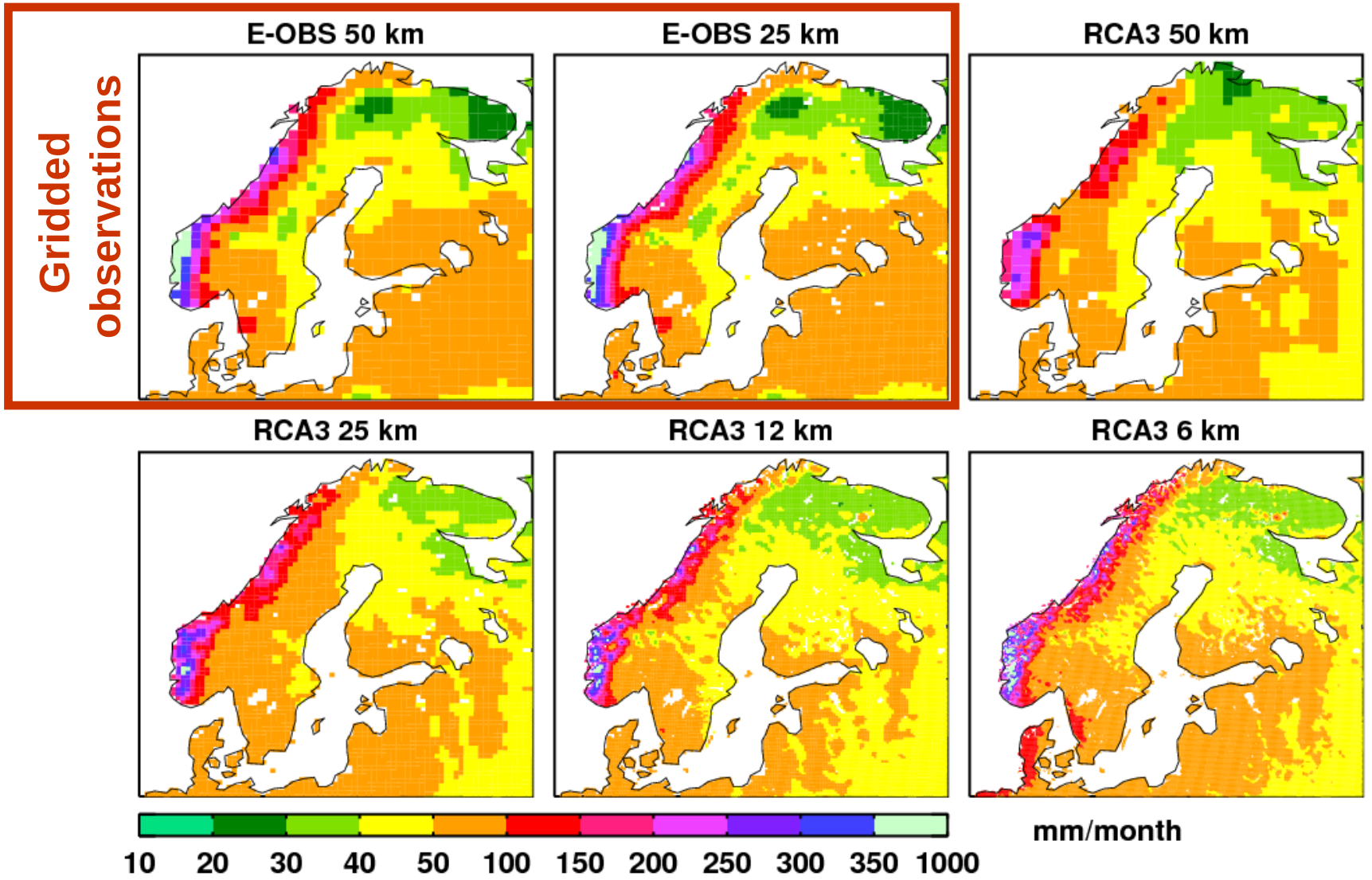
## Winter precipitation (DJF, 1987-2007) at different resolutions



# Some practicalities (vs. GIS based analyses)

- RCMs (and GCMs…) typically assumes a **spherical Earth**:

  … i.e. the rather precise geographical positioning ('geocoding')
  usually expected by GIS is not relevant or necessary

  … The inprecision is several hundreds of meters or even kilometers.
  (GIS often asks for specs. down to few meters)

- RCA3 – as most RCMs – make use of a '**rotated pole map projection**'

  … **oblique** equirectangular proj. / equidistant cylindrical proj., …

  … i.e. define a new N/S pole so that the model domain is centred at
  rotated latitude/longitude 0ºN, 0ºE

  … can supposedly be handled in PROJ.4 library (and ArcGIS), example of a proj.4 string:
  +proj=ob_tran +o_proj=eqc +o_lat_p=30.0 +a=57.29578 +lon_0=-15.0 (change the blue numbers!)

- A very useful standard format for climate model data is **NetCDF + CF-convention**

  … can be directly imported into ArcGIS

  … the rotated pole projection may still cause problems

## Conclusions – take home message (1)

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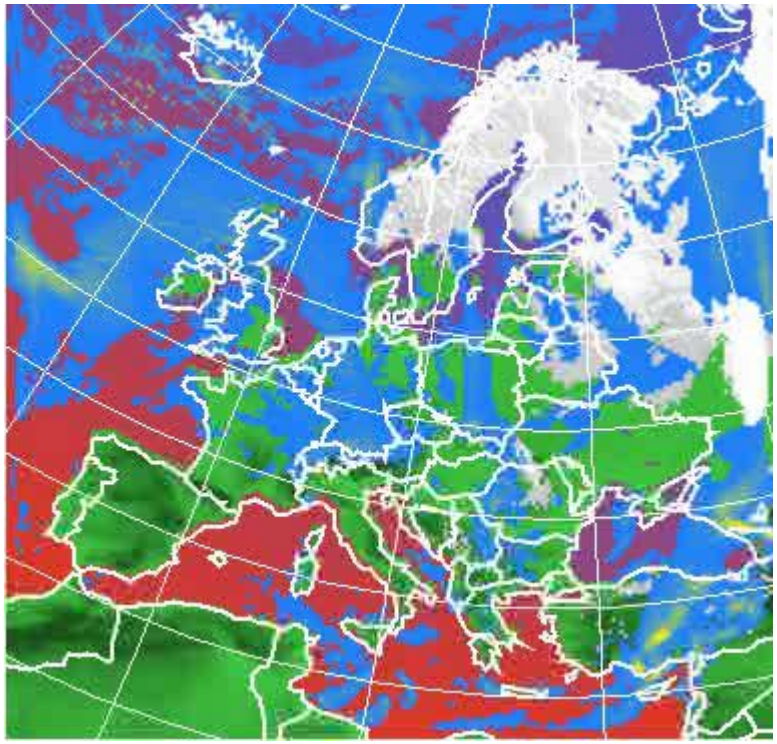
- Increasing spatial resolution improves atmospheric processes and processes related to the land surface / vegetation / landscape…
- … but the climate change signal is typically large scale, until there are local / regional changes to land surface / vegetation / hydrology that introduce feedbacks

- Even with high resolution RCM data calibration / 'further downscaling' will (typically) be needed …
- … especially it the explicit or implied reference data is taken from a met. station and the variable is scale-sensitive (e.g. precip)
- … long-term goal could be to use upcoming gridded climate datasets as climate data input for process studies, rather than 'nearest station'

## Conclusions – take home message (2)

- Only analyse averages in space (3 x 3 gridcells) and/or in time (at least 3-6 h data)
- Take the time to look at the NetCDF file format, it is quite useful for working with climate model data
- State-of-the art climate models produce a lot of data: think more of what is interesting in terms of the physical / chemical / ecological processes underlying what you are analysing, rather than just grabbing the usual monthly / seasonal / annual averages etc.

# Movie time: what an RCM does (or part thereof…)



Courtesy:
Jens Hesselbjerg Christensen
DMI, Denmark
2004