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Doing a mesoscale re-analysis using the WRF-model

Does it matter for the resulting **icing climatology** which version of WRF you use?

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WRF THE WEATHER RESEARCH & FORECASTING MODEL

Winterwind

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Background

Previous results from the Vindforsk project V313 ‘Wind Power in Cold Climate’ showed large differences between:

- Different models – WRF, AROME, COAMPS
- Different WRF schemes regarding:
  - Turbulence closure
  - Cloud physics
  - Large scale weather forcing

Here the WRF model has been used to further investigate these differences.

This was made using WRF-model runs with:

- **3 turbulence schemes –** (MYJ, MYNN, YSU)

- **2 cloud physics schemes –** (Thomson, WSM5/WSM6)

- **3 weather forcing sources**

  FNL – final analysis from GFS (NOAA)
  NNRP – NCEP-NCAR reanalysis project
  ERA Interim – ECMWF reanalysis

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From WRF-model results, icing was calculated using Makkonen's equation:

$$\frac{dM}{dt} = E \cdot w \cdot U \cdot D - Q$$

dM/dt – ice growth on a cylinder (kg/s)

M – mass (kg), t – time (s)

E - collection efficiency

w - liquid water content (kg/m^3)

U - wind speed (m/s)

D - diameter of accreted ice (m)

Q - melting or sublimation (kg/s)

Following the ISO standard for measuring ice accretion D = 0.03 m. (ISO 12494 – Atmospheric icing of structures)

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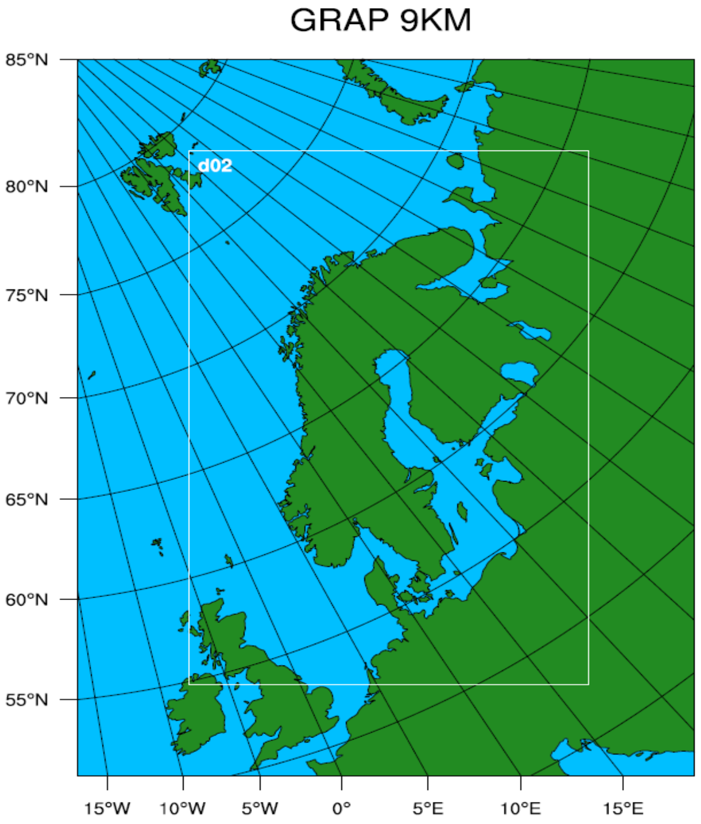
In reality: The diameter D will grow as ice load grows, and it is difficult to model fall-off of ice.

An option is to keep the diameter D at 0.03 m.
The resulting ice growth is then interpreted as a kind of ”**potential icing**”.

The number of hours with ”**active icing**” will then be given by number of hours having dM/dt > 0.01 kg/m with D=0.03 m

Model domains: Scandinavia 9 km 2000-2011 with one turbulence and one cloud scheme (MYJ, WSM6) but with 3 different input for weather forcing.

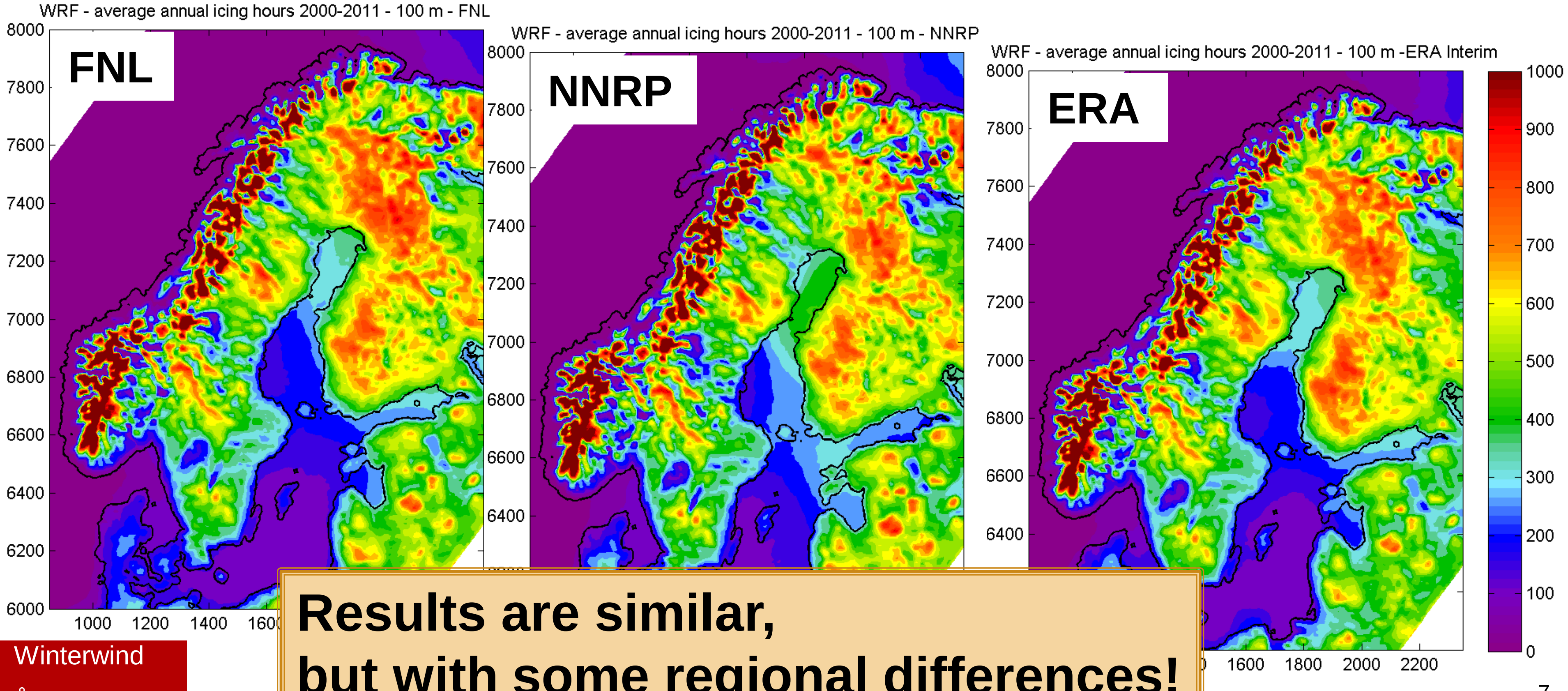


d01: 27 km
(Forced by FNL, NNRP or ERA Interim)

d02: 9 km
(one way nested in d01)

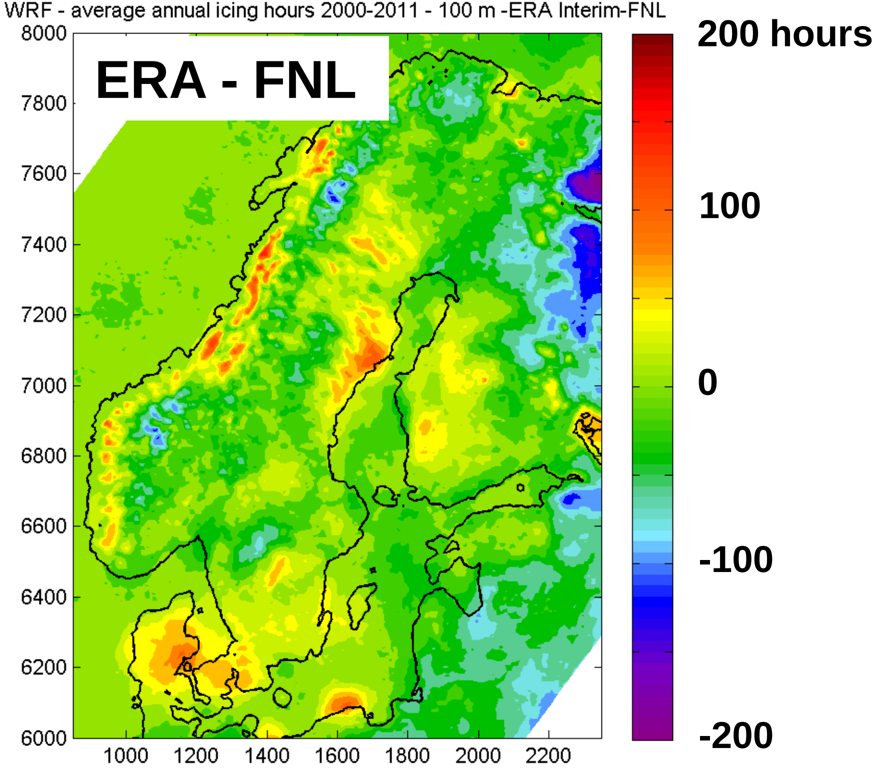
Result: WRF-Scandinavia 9 km – no. of active icing hours

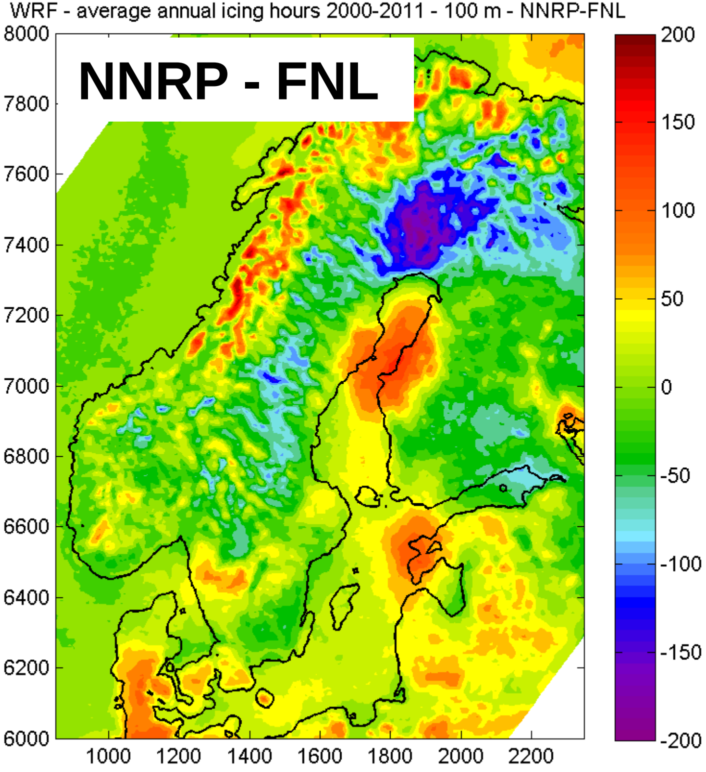
Annual averages 2000-2011, 3 different forcing.



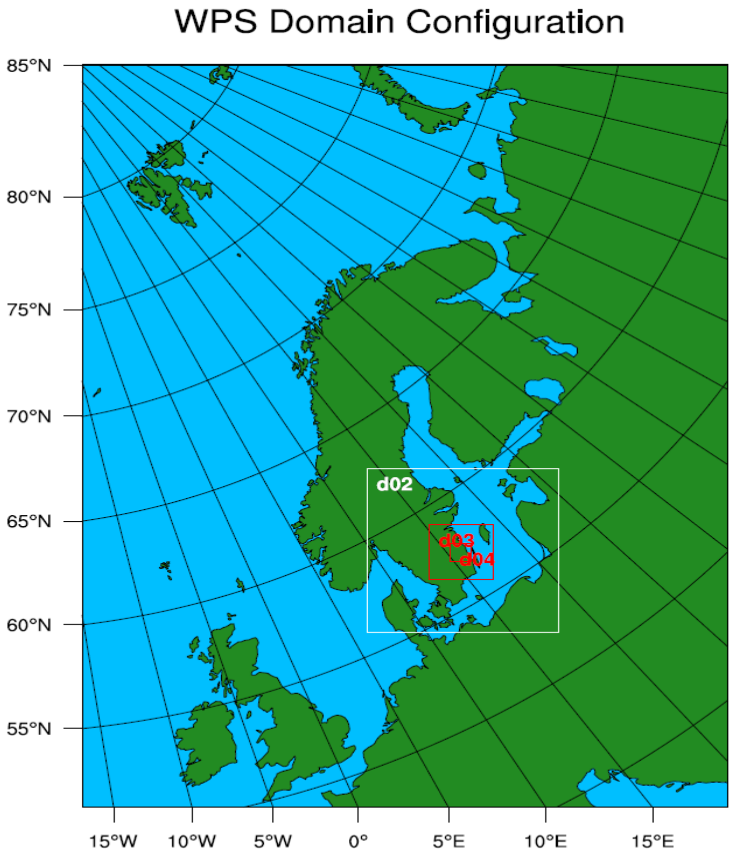
Results are similar,
but with some regional differences!

WRF - Scandinavia 9 km – number of active icing hours Differences in annual averages 2000-2011 are typically ±50 hours, but up to ±200 hours





Model domains: Ryningsnäs 1 km, July 2011-June 2012 using 2 forcing sorces, 3 turbulence and 2 cloud schemes.



d01: 27 km
(Forced by FNL or ERA Interim)

d02: 9 km
(one way nested in d01)

d03: 3 km
(one way nested in d02)

d04: 1 km
(one way nested in d03)

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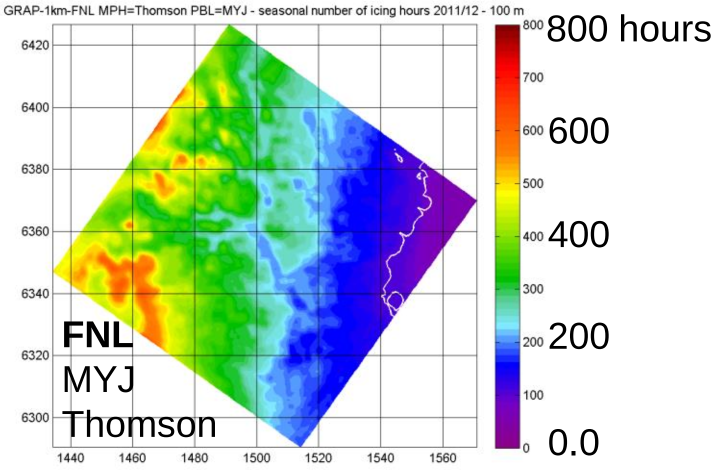
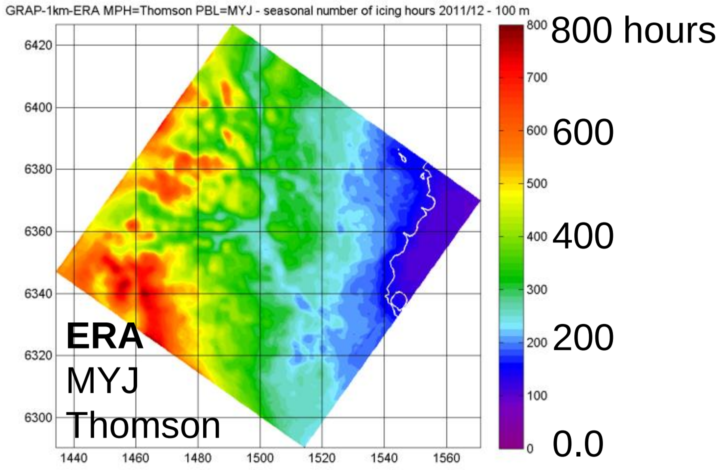
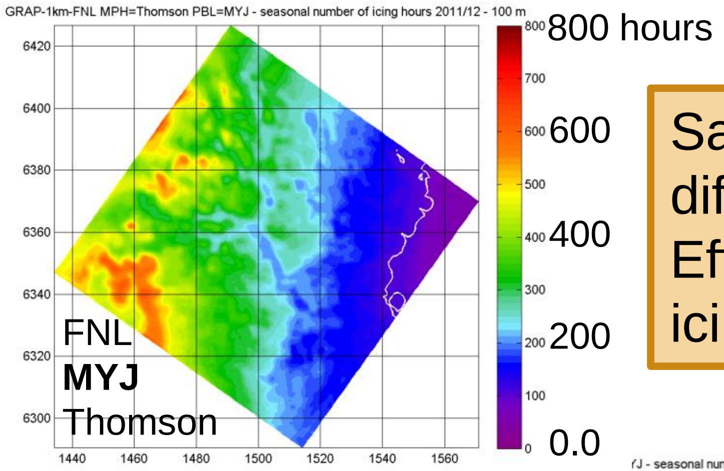
WRF – Ryningsnäs 1 km – icing hours winter 2011/12



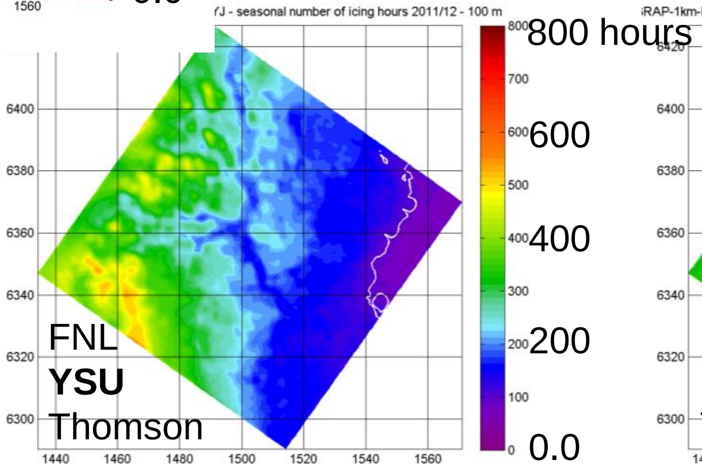


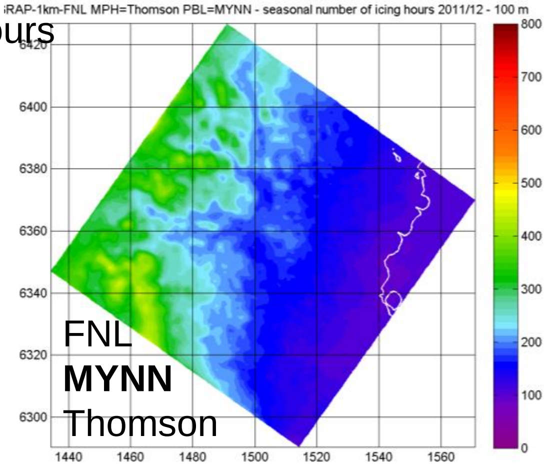
Same turbulence closure and cloud physics – different forcing.
Effect: ~25 % differences in number of icing hours.

WRF – Ryningsnäs 1 km – icing hours winter 2011/12

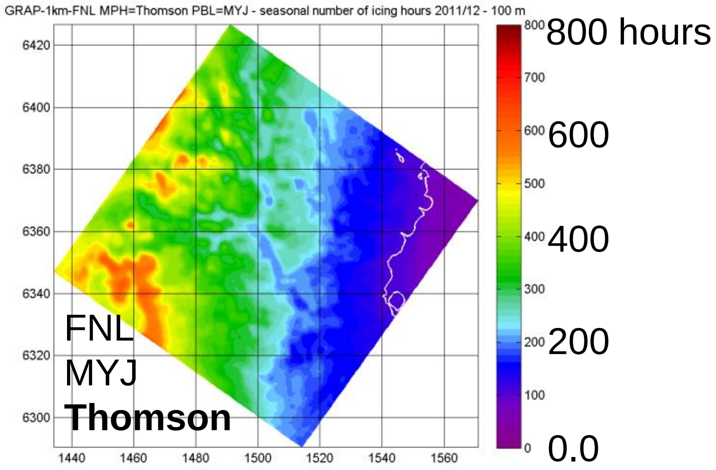


Same cloud physics and forcing – three different turbulence closures schemes. Effect: ~50 % differences in number of icing hours.

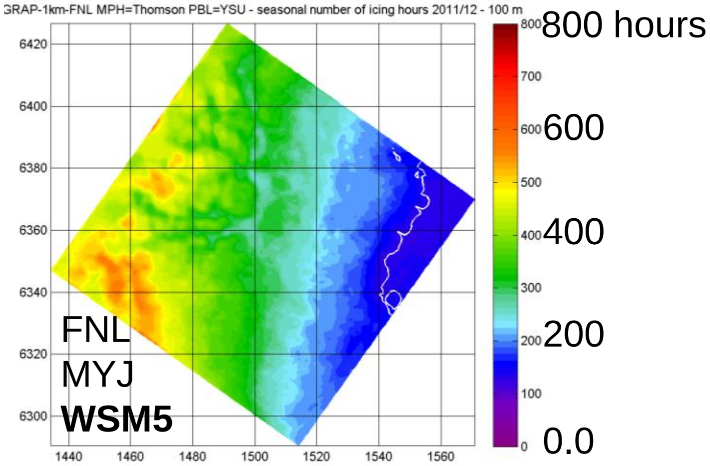




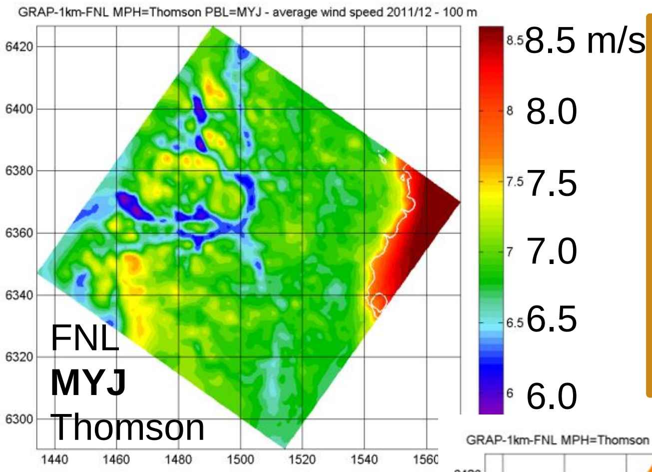
WRF – Ryningsnäs 1 km – icing hours winter 2011/12



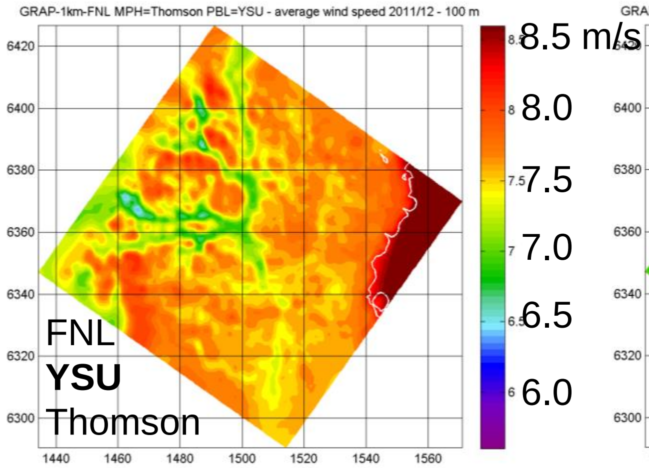
Same turbulence scheme and forcing – two different cloud physics schemes.
Effect: ~25 % differences in number of icing hours.

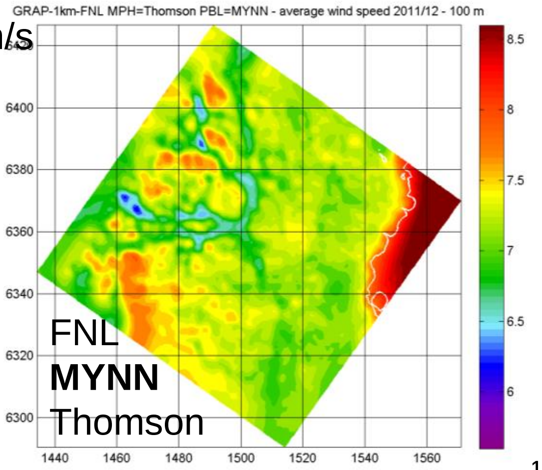


WRF – Ryningsnäs 1 km – average wind speed 2011/12



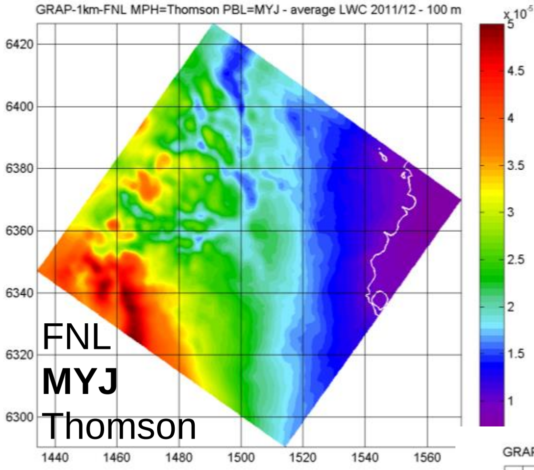
Effects on wind speed:
Same cloud scheme and forcing – three different turbulence closures schemes. Differences up to ~0.5-1 m/s in annual average wind speed.



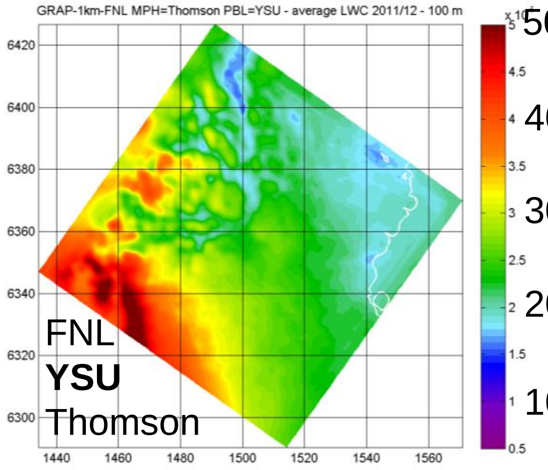


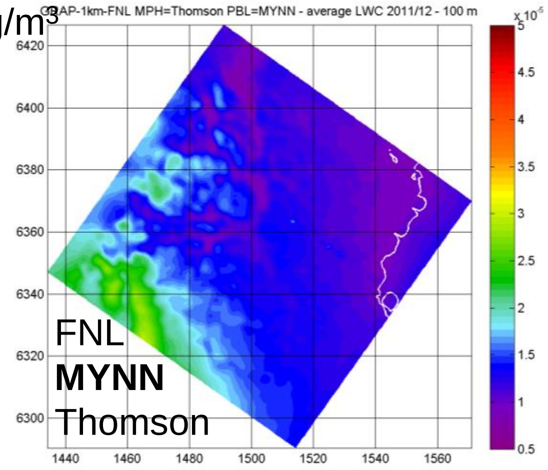
Different forcing sources and different cloud schemes of less importance.

WRF – Ryningsnäs 1 km – average LWC 2011/12

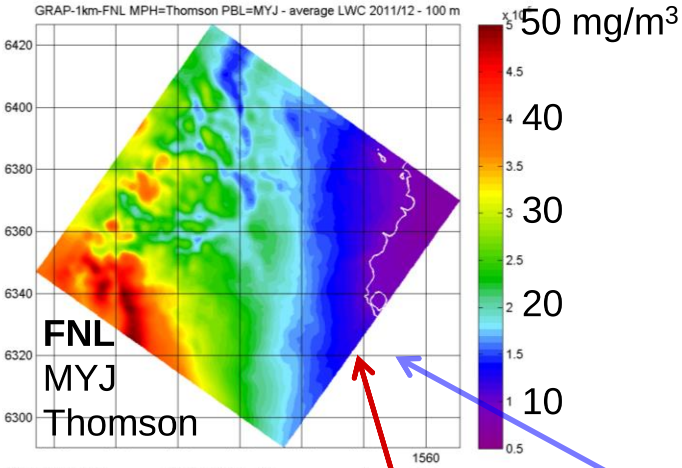


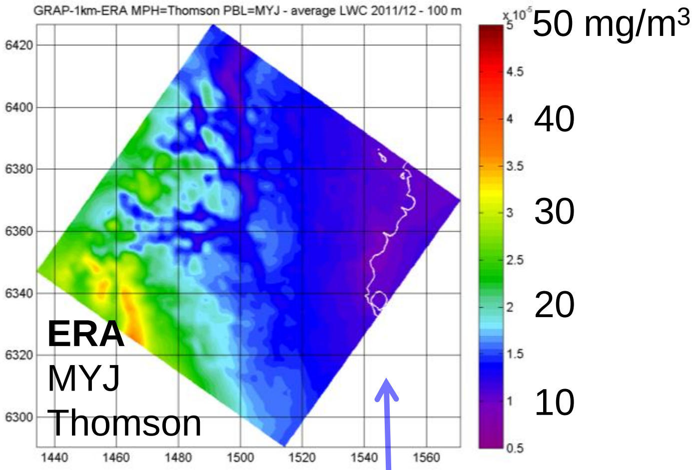
Effects on Liquid Water Content:
Same cloud scheme and forcing – three different turbulence closures schemes. Differences up to ~25 mg/m^3 in annual average LWC, ~50 % difference.

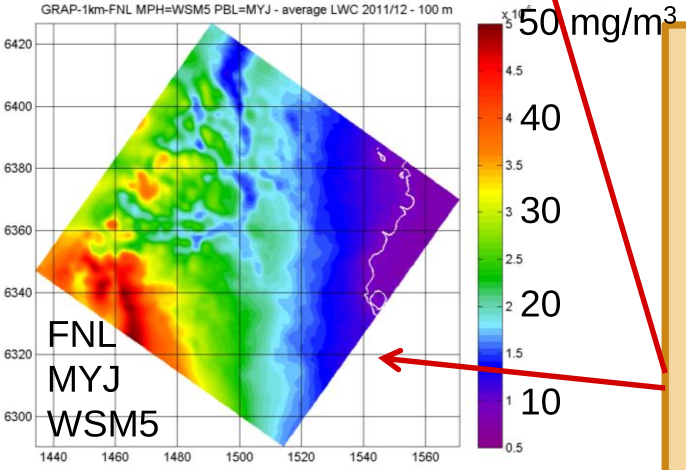




WRF – Ryningsnäs 1 km – average LWC 2011/12







Effects on Liquid Water Content:

Same turbulence and cloud scheme – different forcing.

Differences up to ~15 mg/m^3 in annual average LWC.

Using different cloud physics gave smaller differences in average LWC.

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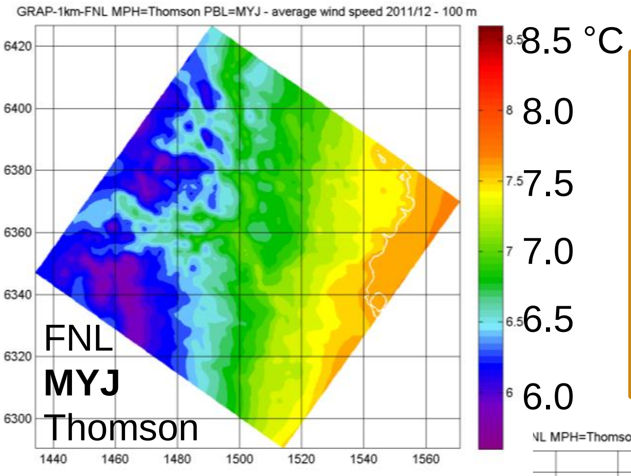
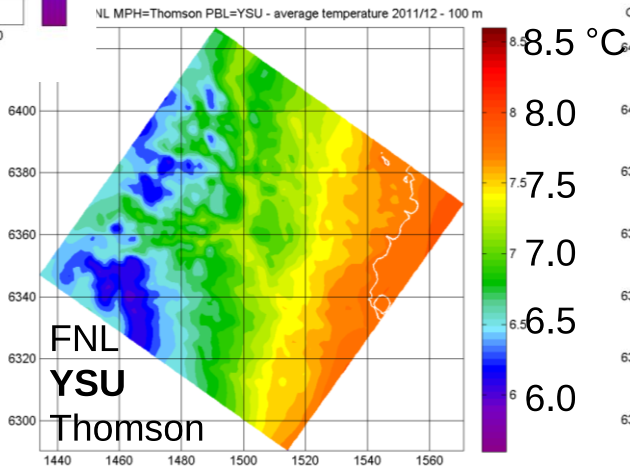
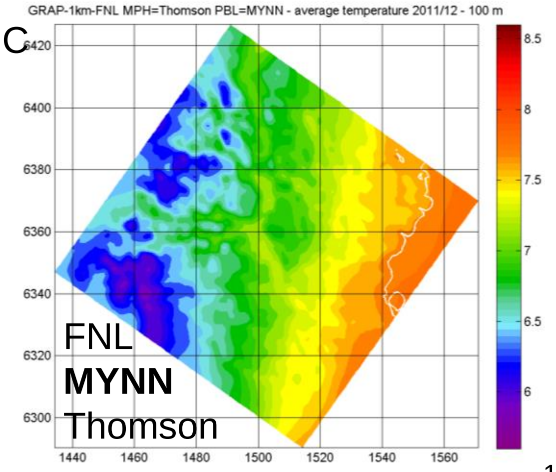
WRF – Ryningsnäs 1 km – average temperature 2011/12



Effects on temperature:
Same cloud scheme and forcing – three different turbulence closures schemes. Differences up to ~0.3°C in annual average temperature.

Different forcing sources and different cloud schemes of less importance.





Conclusions

- It definitely matters which WRF we use!
- The difference in number of active icing hours was found to be up to:
  - ~50 % due to choice of turbulence scheme
  - ~25 % due to choice of cloud physics scheme
  - ~10-20 % due to choice of forcing data
- Our preliminary findings indicate that FNL and ERA Interim give quite similar results, while NNRP deviates somewhat more.
- Typical differences due to choice of turbulence and cloud physics closure, and to choice of forcing data:
  - For annual hours with active icing ~±200 hours
  - For average wind speed ~1 m/s
  - For average temperature ~0.3°C