High resolution modelling of the Malmö extreme precipitation event of August 2014 – a sensitivity study.

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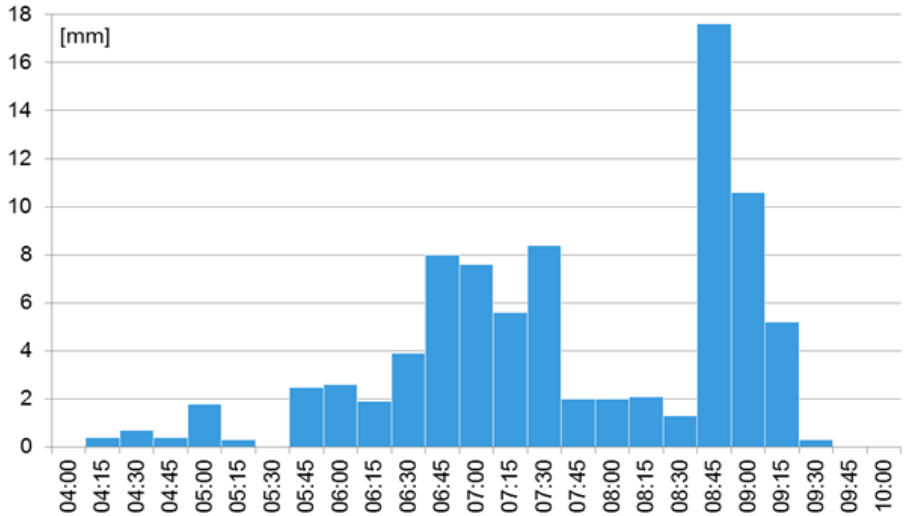
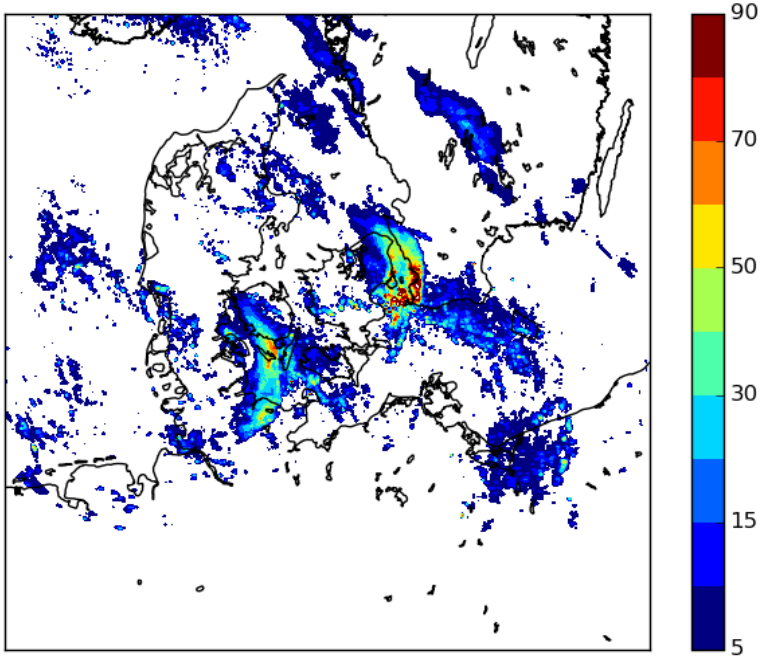
Acknowledgement: Patrick LeMoigne, Meteo-France, Patrick Samuelsson, SMHI, Peter Berg, SMHI, Magnus Lindskog, SMHI.

Extreme precipitation event over Malmö, August 2014





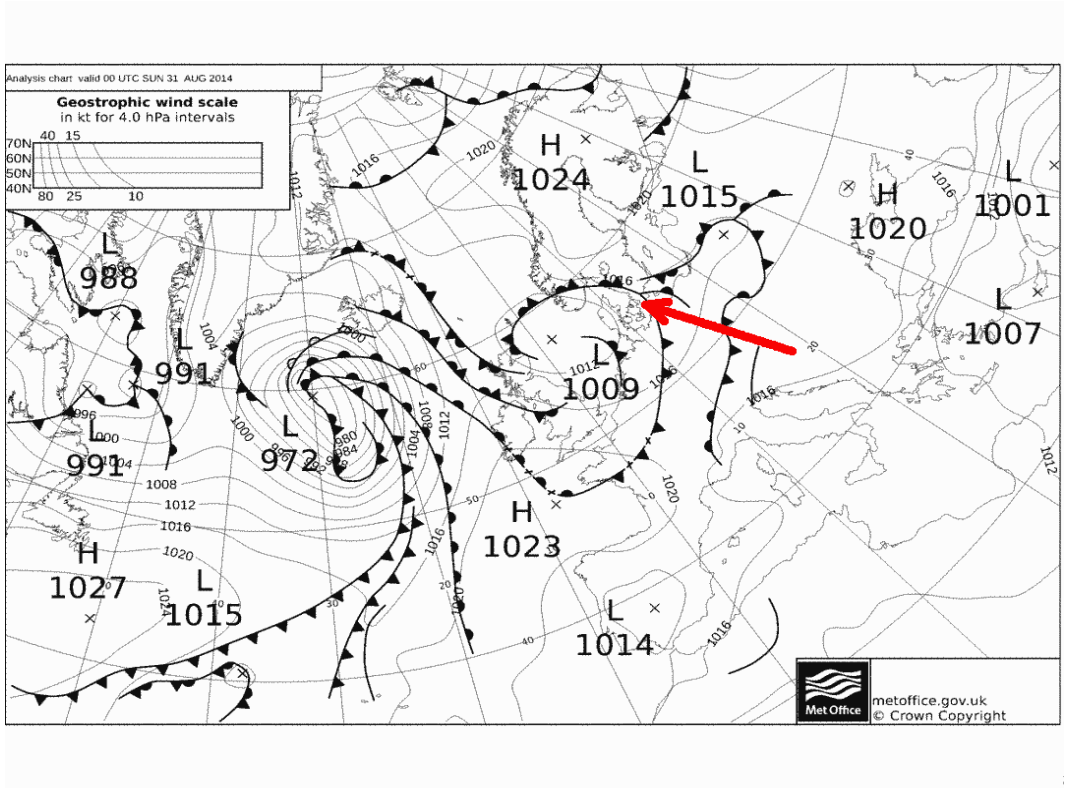
Automatic observations, Malmö. 15 minute acc precip. Lennart Wern, SMHI.

85 mm in 6 hours (!)
107.4 in the 24 hour period

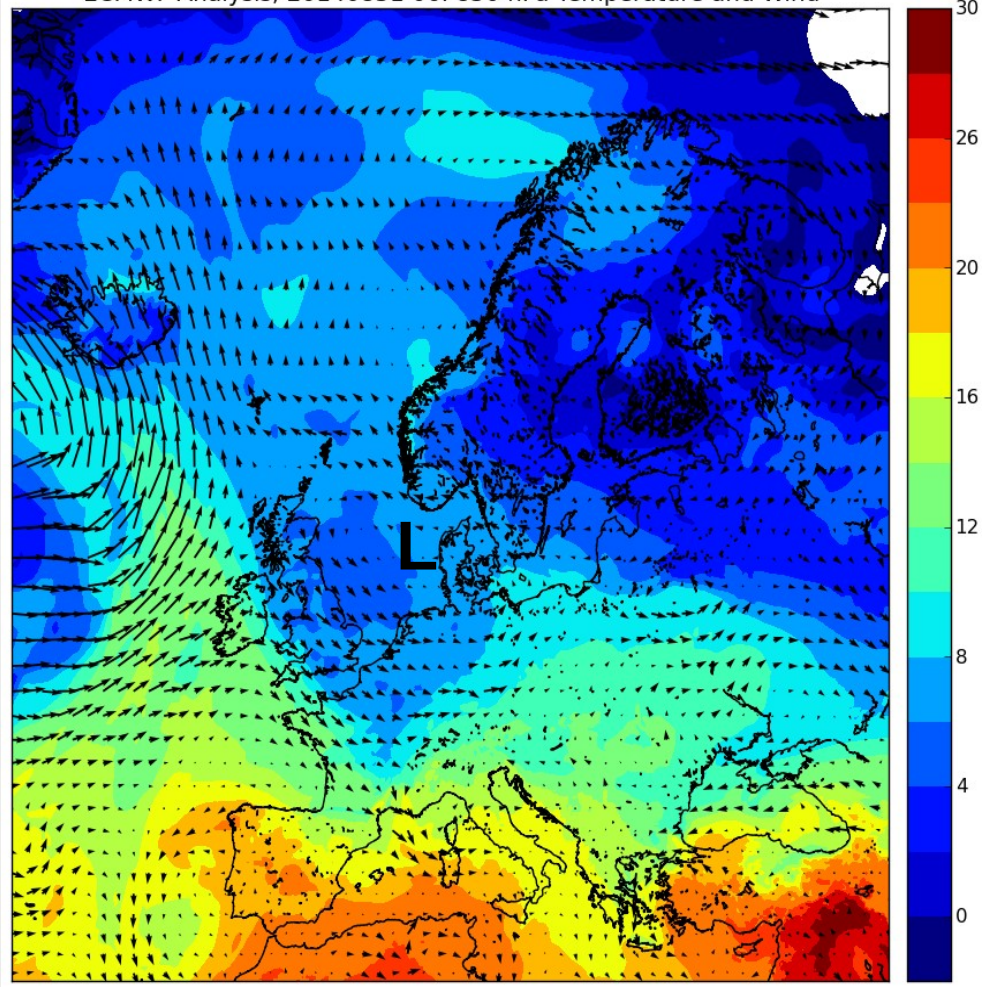
Foto: Stig-Åke Jönsson / TT

Motivation

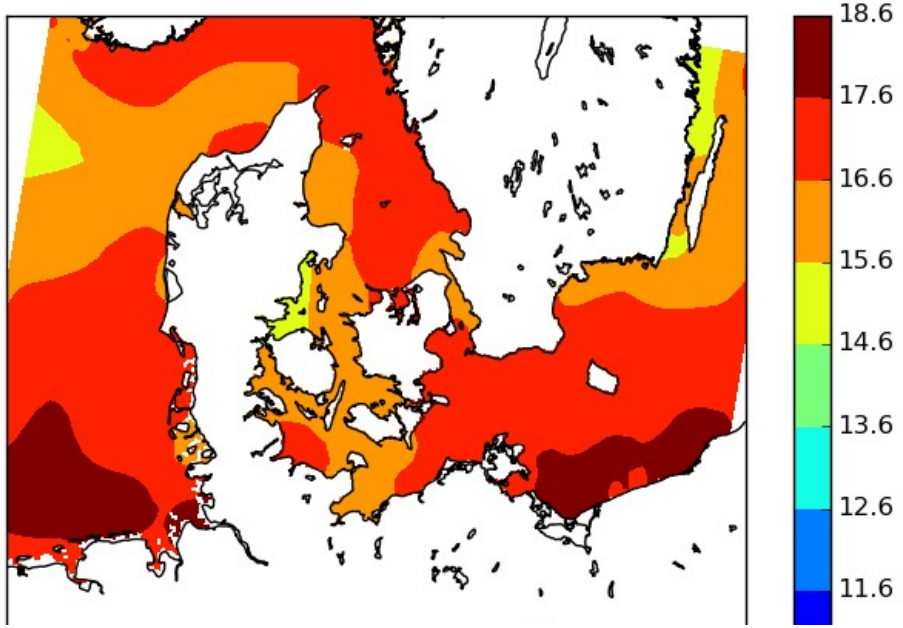
- What aspects of the numerical simulations are most important in order predict the event?
  - Horizontal resolution
  - Physical parameterizations
  - Initial state
  - Lateral boundary conditions
- How sensitive is the event to changes in sea surface temperature, soil moisture content and surface heat fluxes?



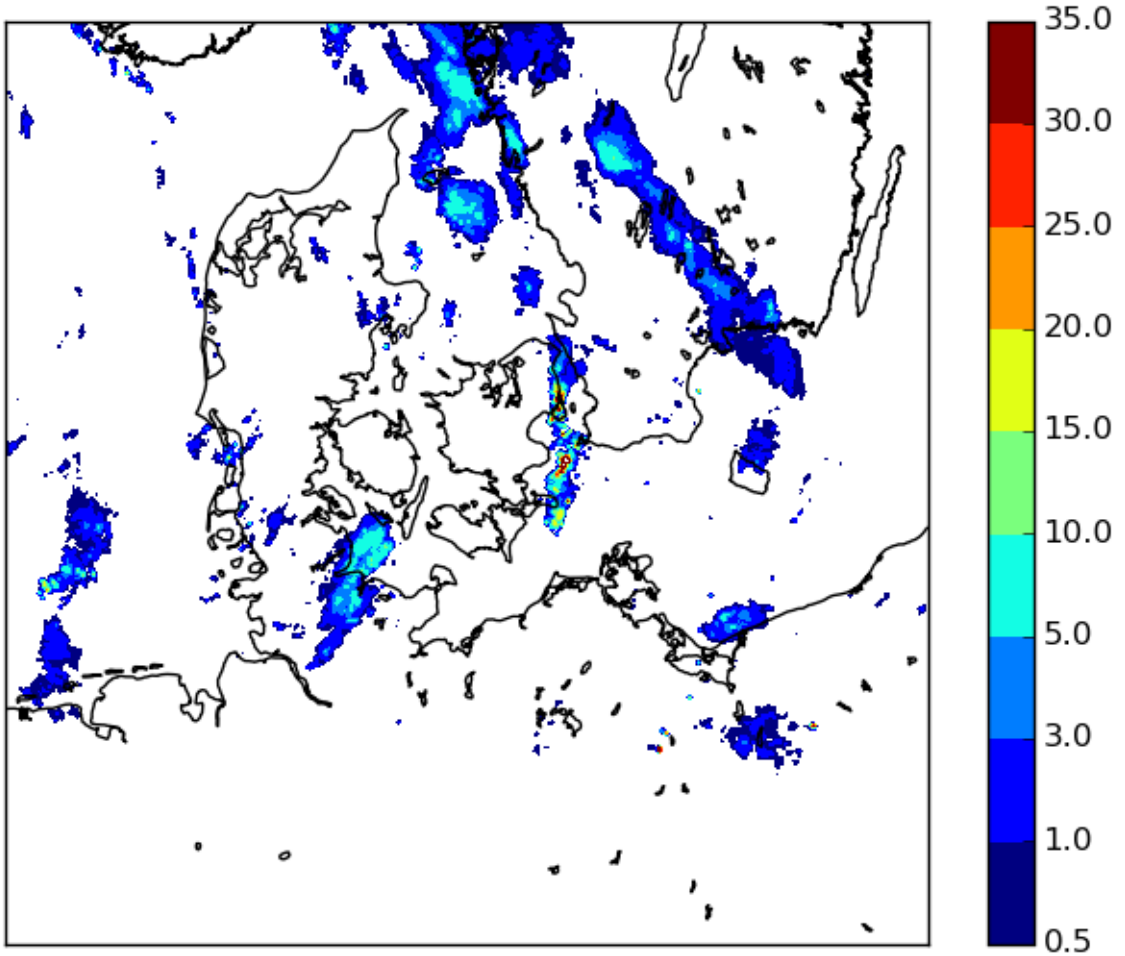
ECMWF Analysis, 20140831 06. 850 hPa Temperature and Wind



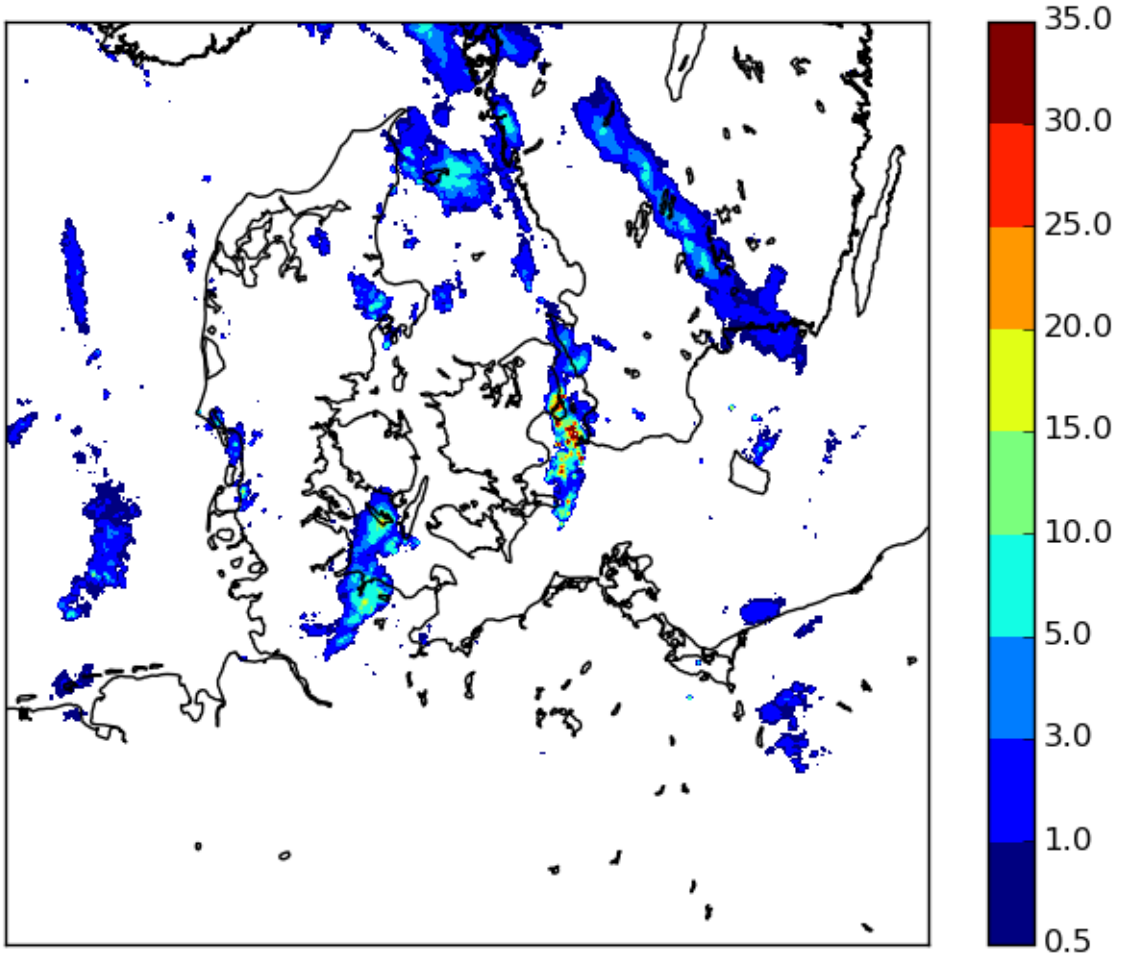
SST AROME (ECMWF)



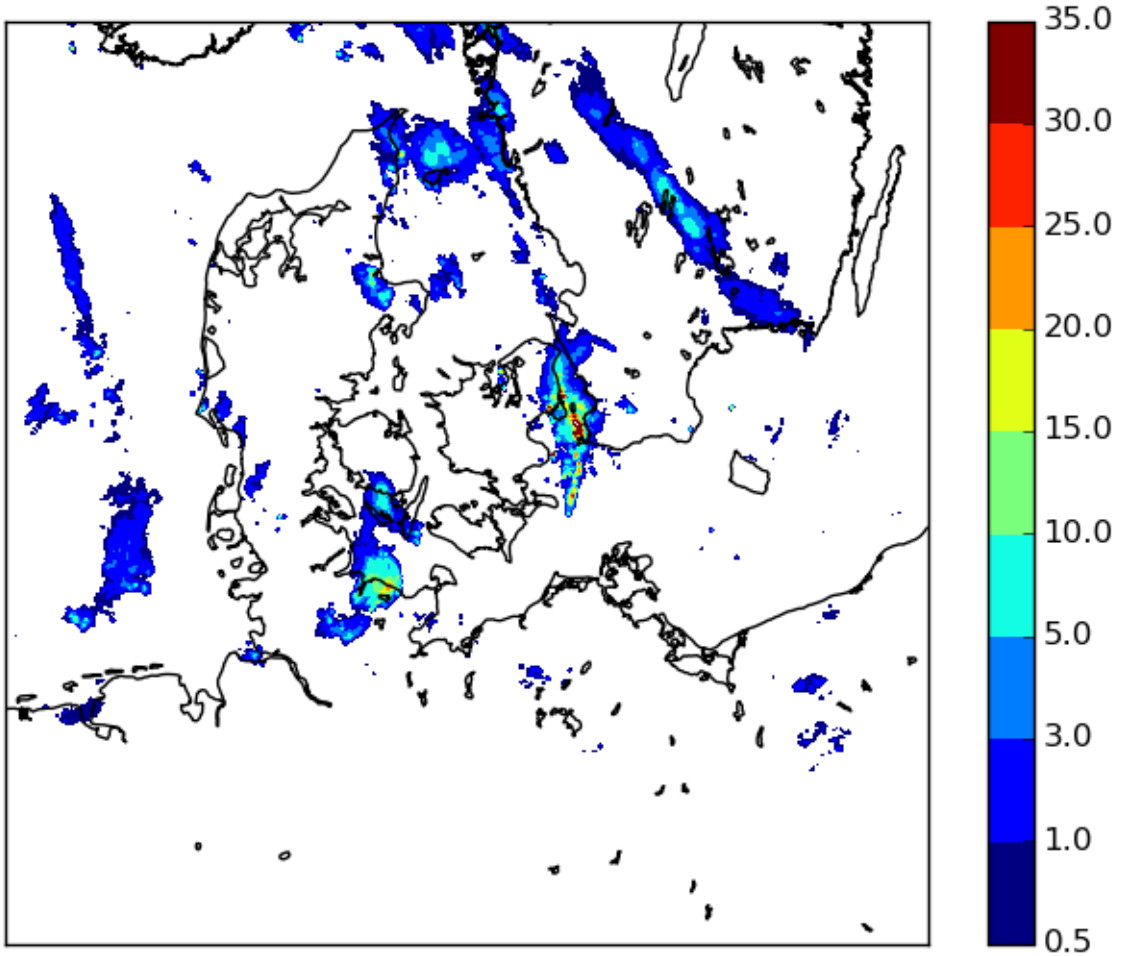
Radar sequence (mm/h), 01 Z



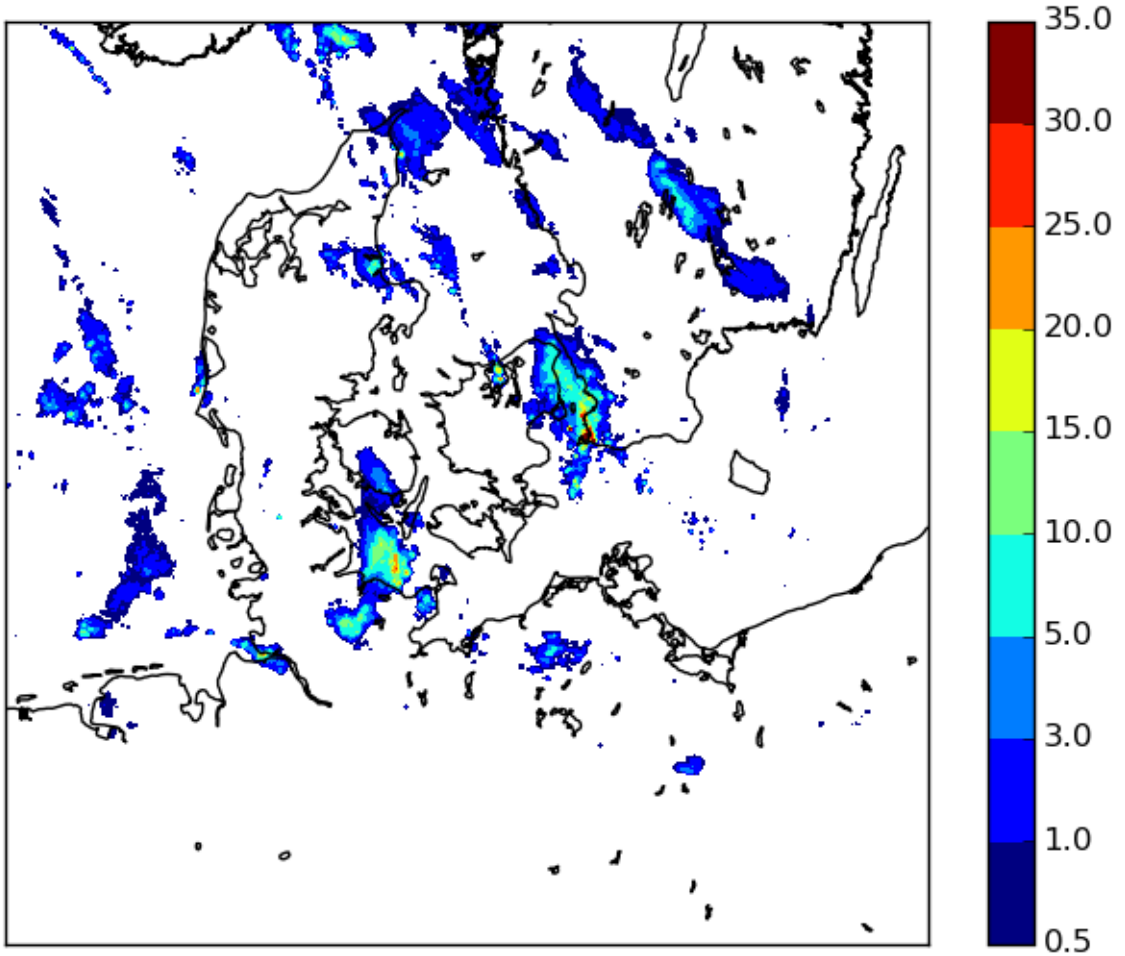
Radar sequence (mm/h), 02 Z



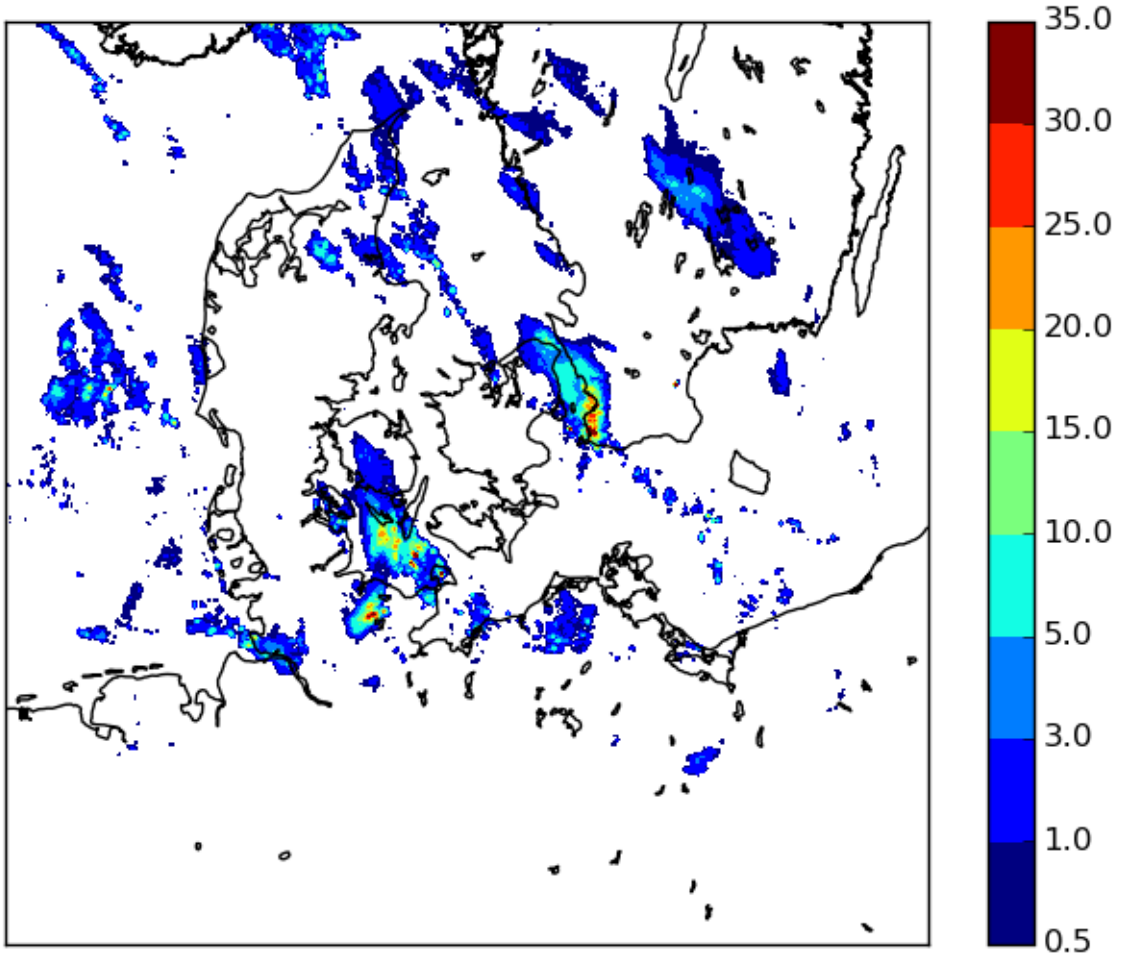
Radar sequence (mm/h), 03 Z



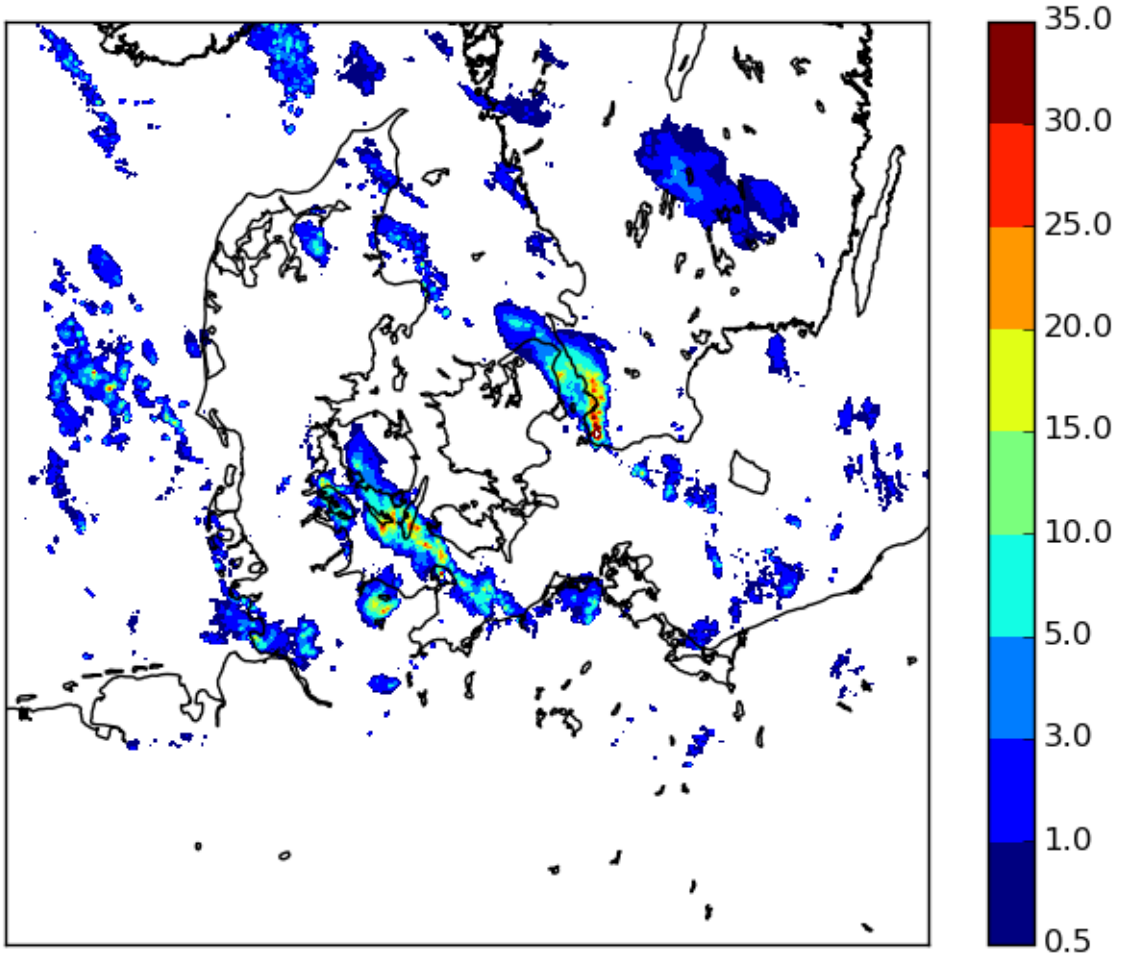
Radar sequence (mm/h), 04 Z



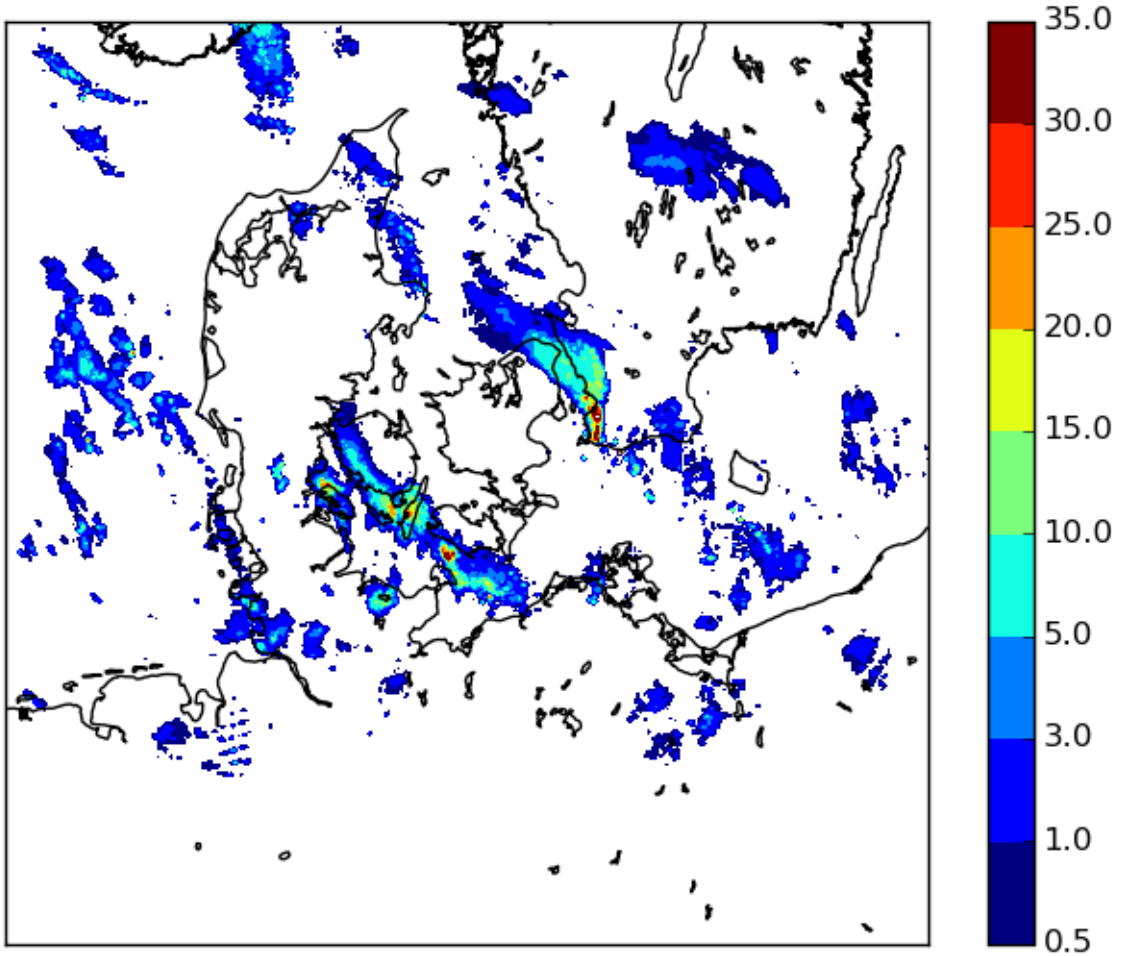
Radar sequence (mm/h), 05 Z



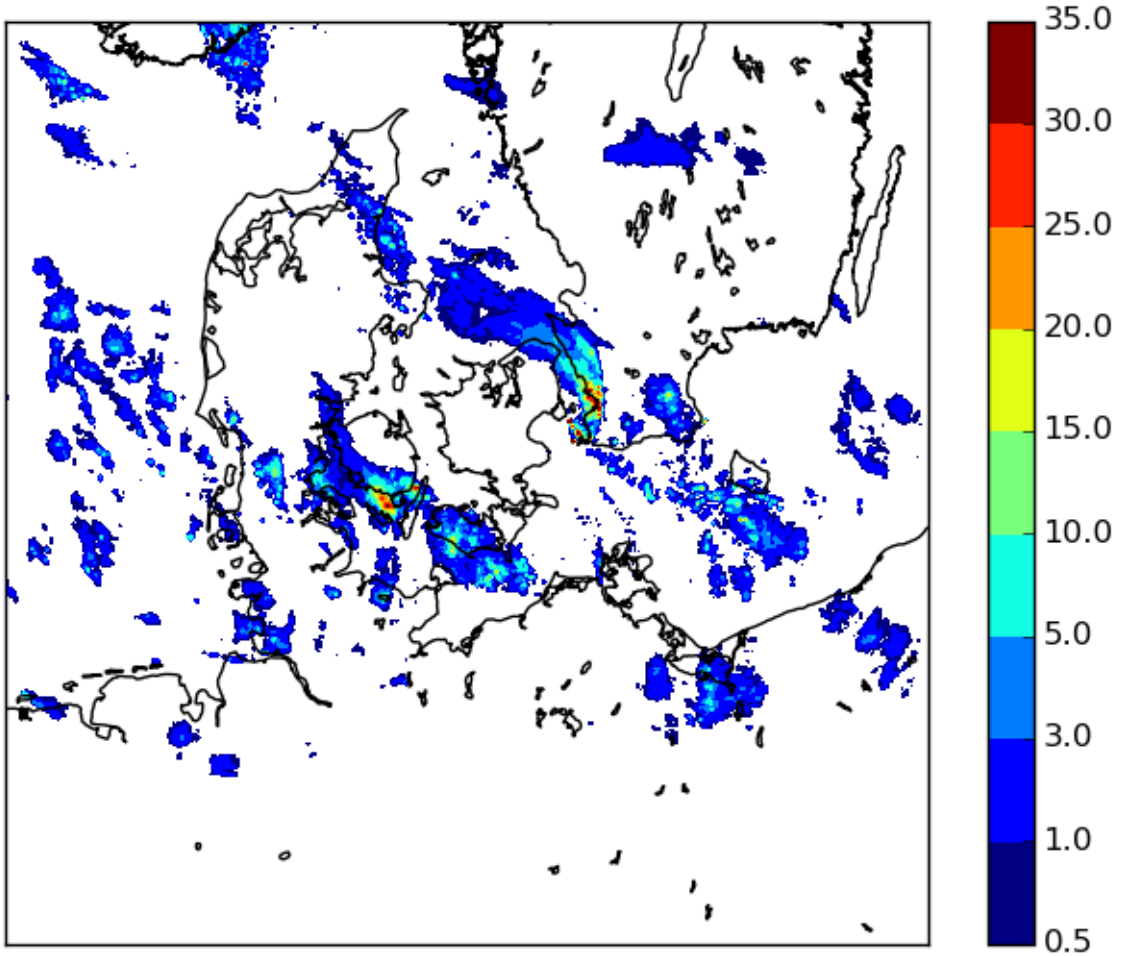
Radar sequence (mm/h), 06 Z



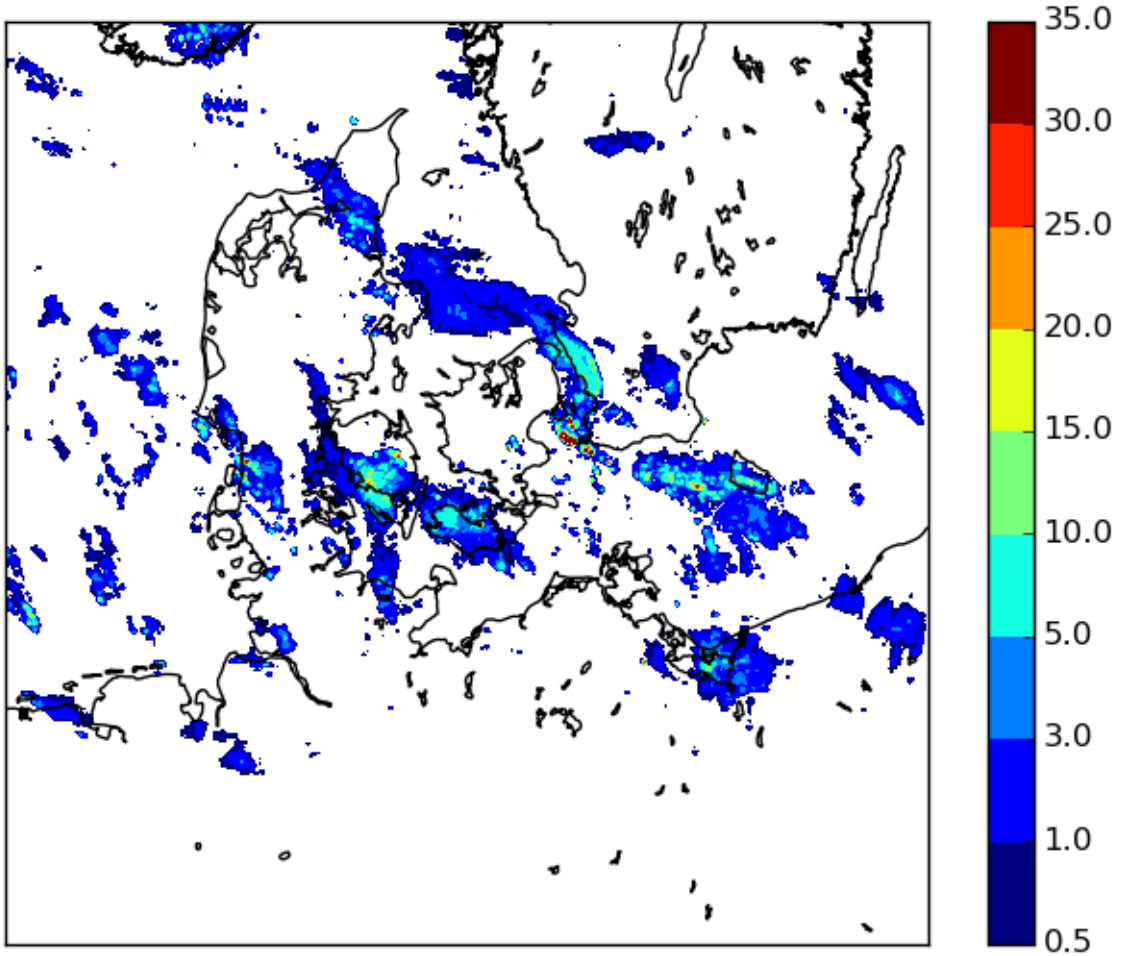
Radar sequence (mm/h), 07 Z



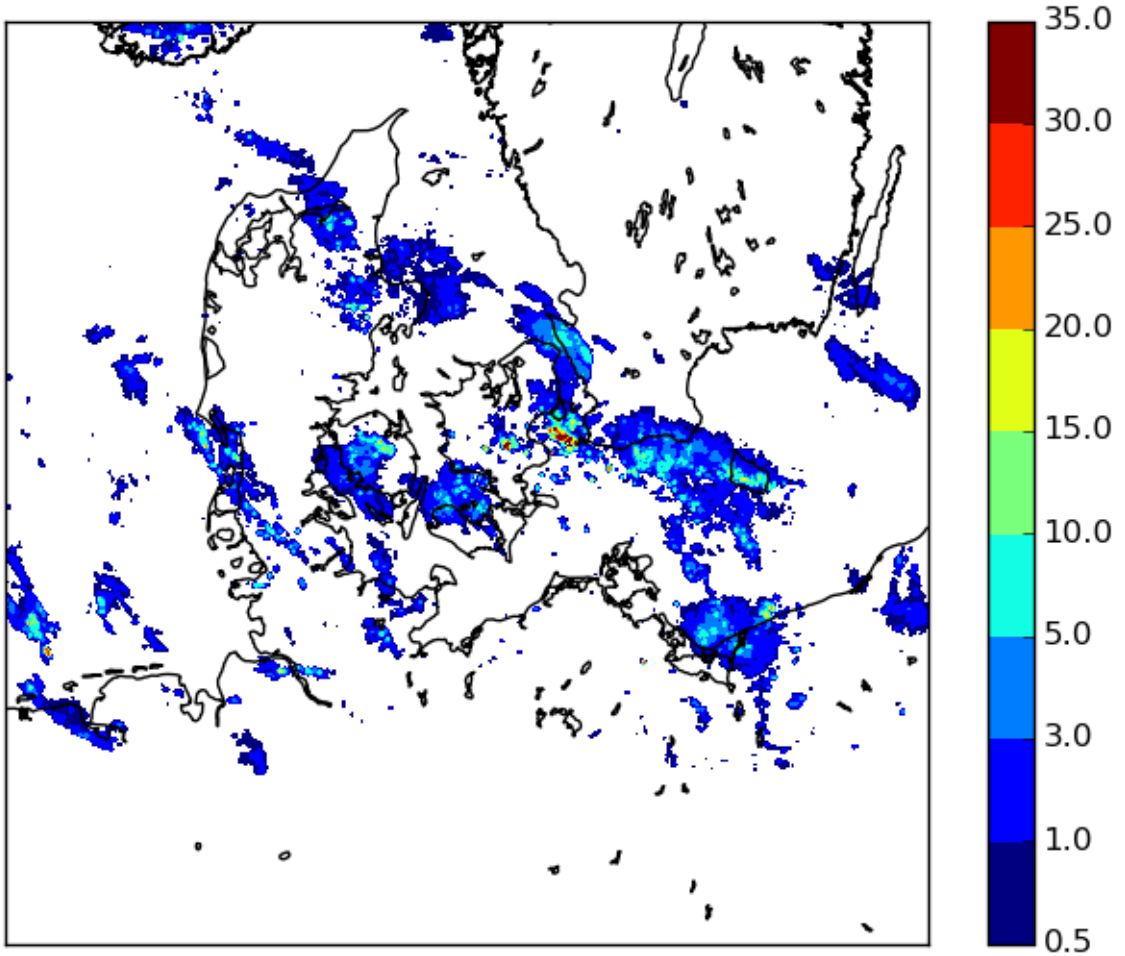
Radar sequence (mm/h), 08 Z



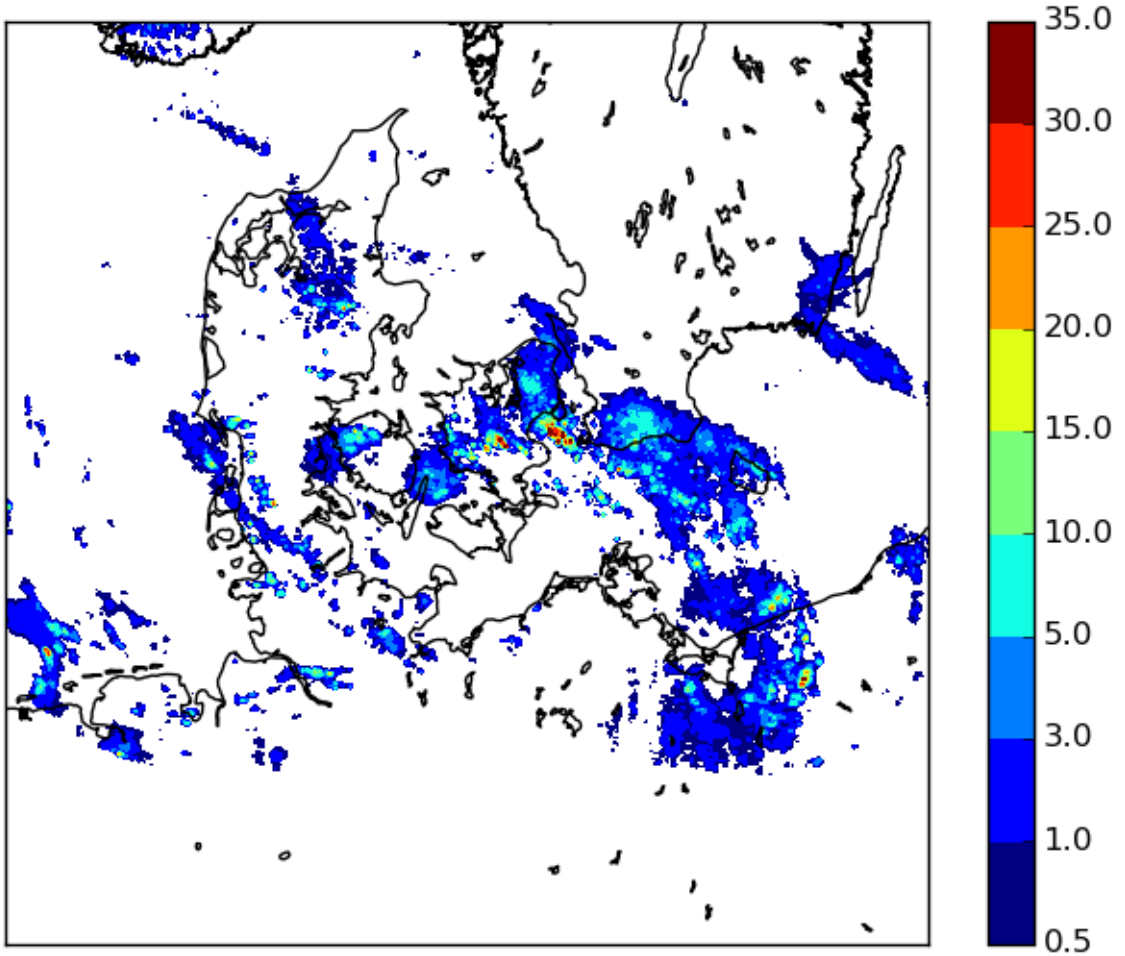
Radar sequence (mm/h), 09 Z



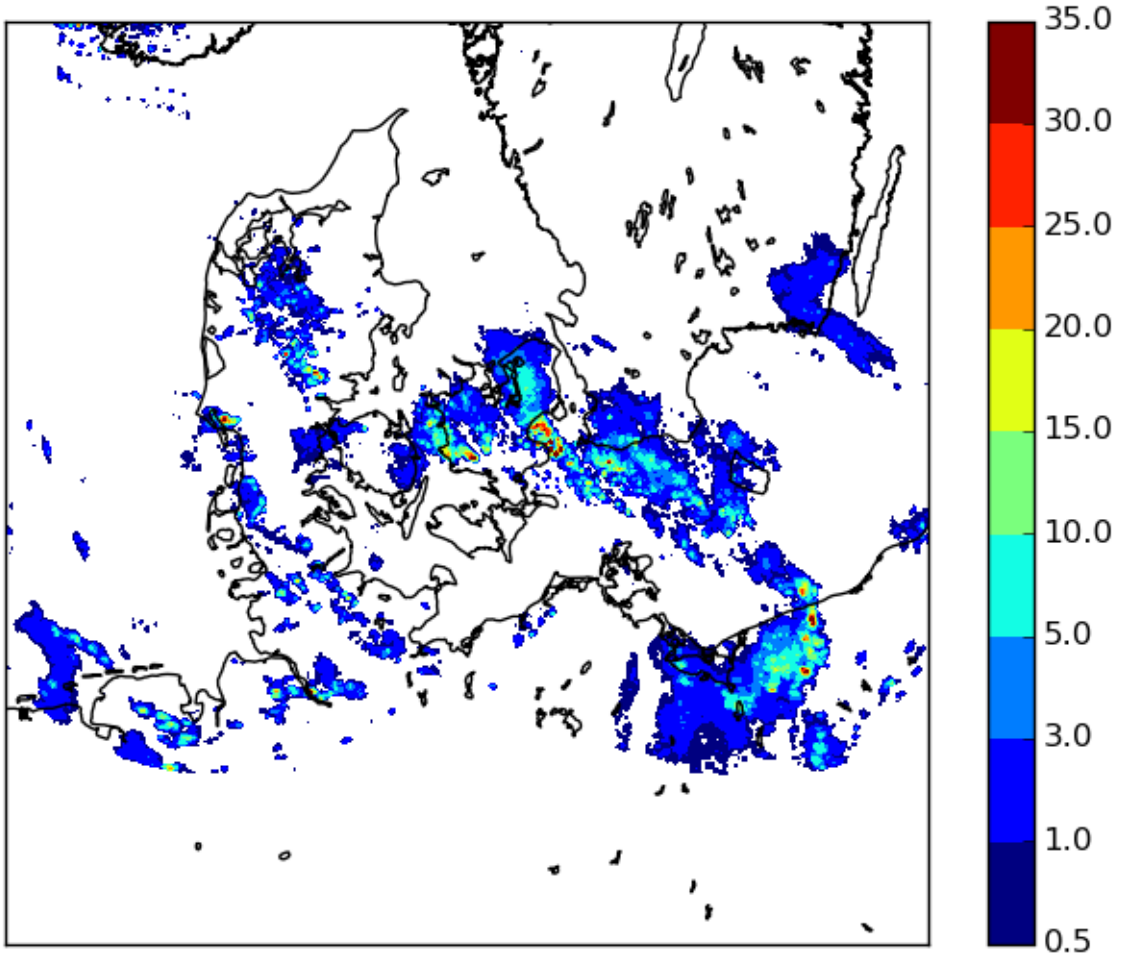
Radar sequence (mm/h), 10 Z



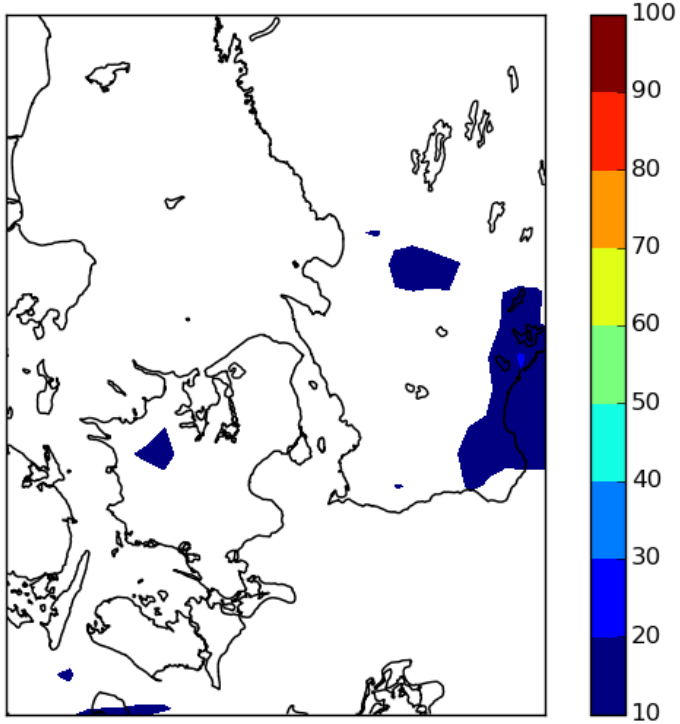
Radar sequence (mm/h), 11 Z



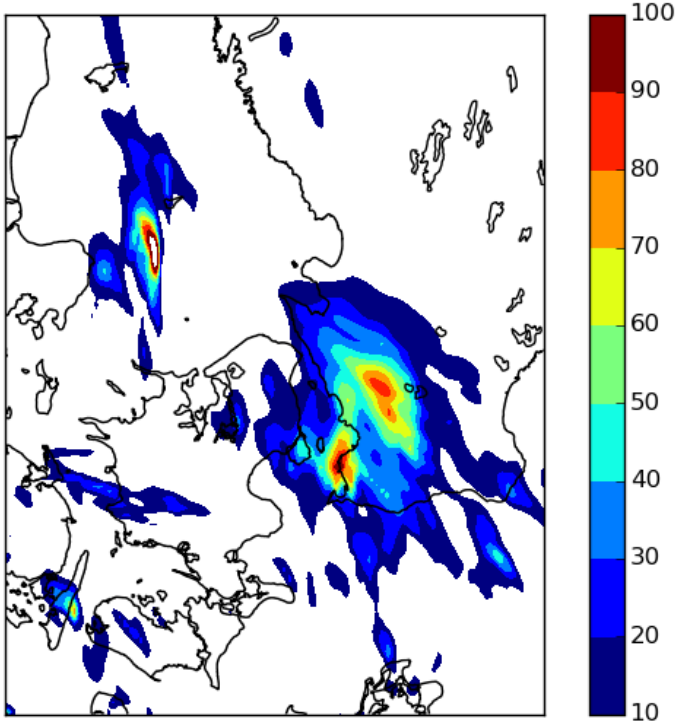
Radar sequence (mm/h), 12 Z



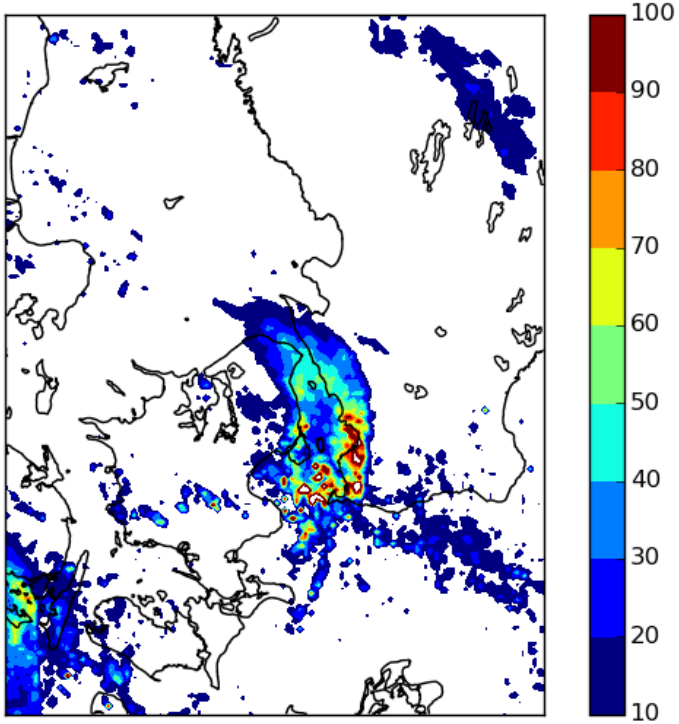
12 hour accumulated precipitation.



ECMWF, 00 Z +
12 h acc



Operational
AROME, 00 Z +
12 h acc

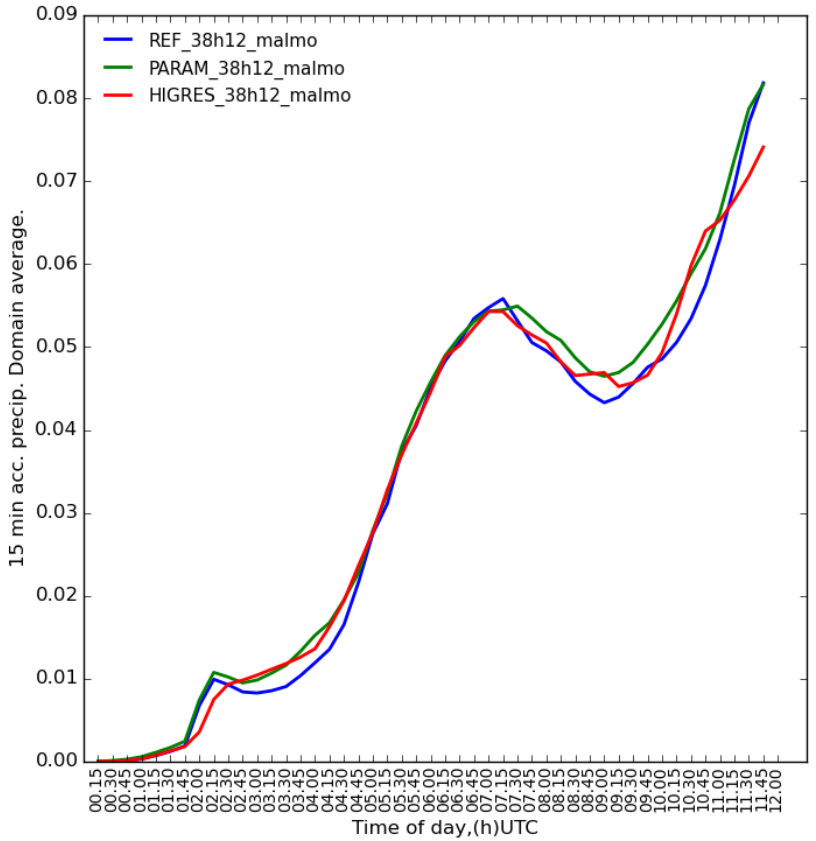


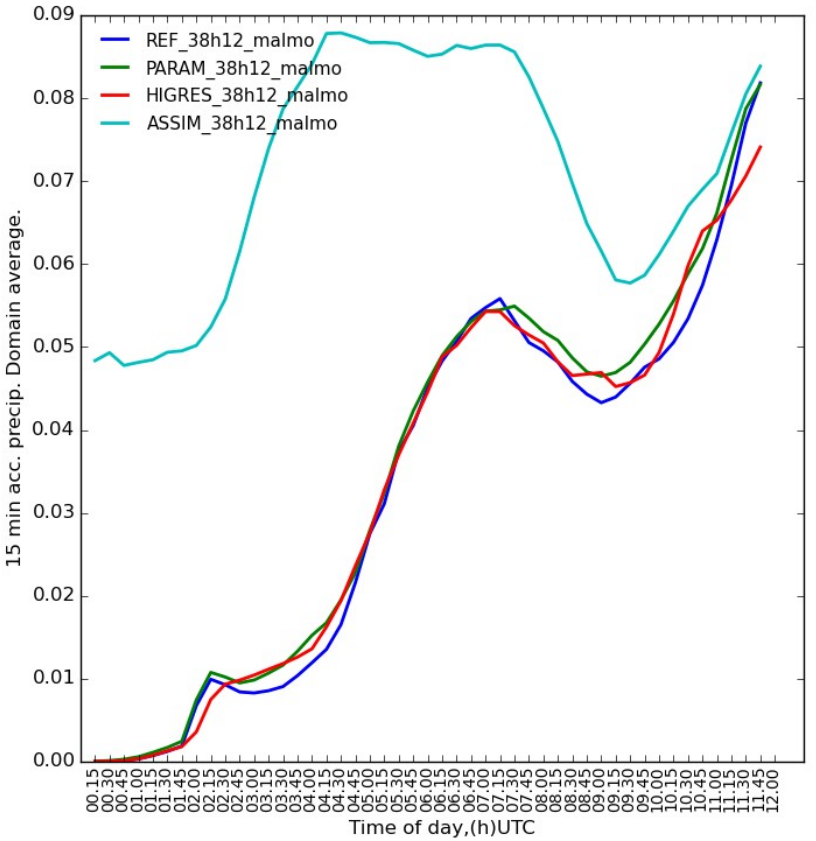
Radar, 12 h acc

Experimental setup

- 2.5 km resolution
  (1.3 km resolution)
- “Cold start” - ECMWF
  (Surface DA optimal
  interpolation)
- Explicit deep convection
  (Parameterized deep
  convection)

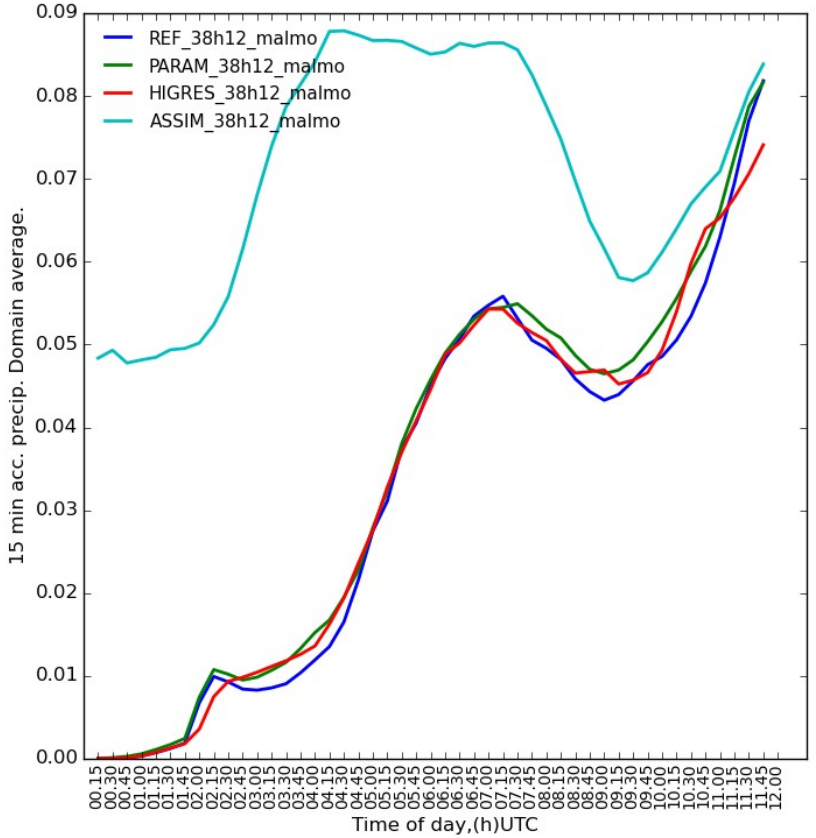
Domain averaged 15 min acc. Precipitation. Impact of surface data assimilation.

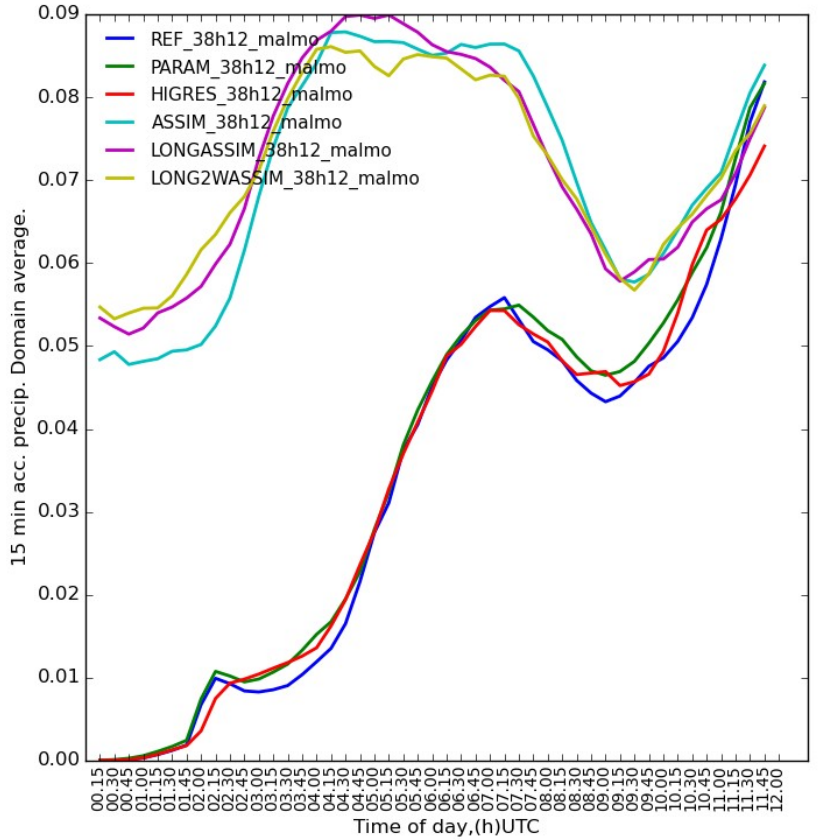




Internally generated surface fields are needed to get the correct initial onset!
For nowcasting in meso-scale models, surface data assimilation is essential!

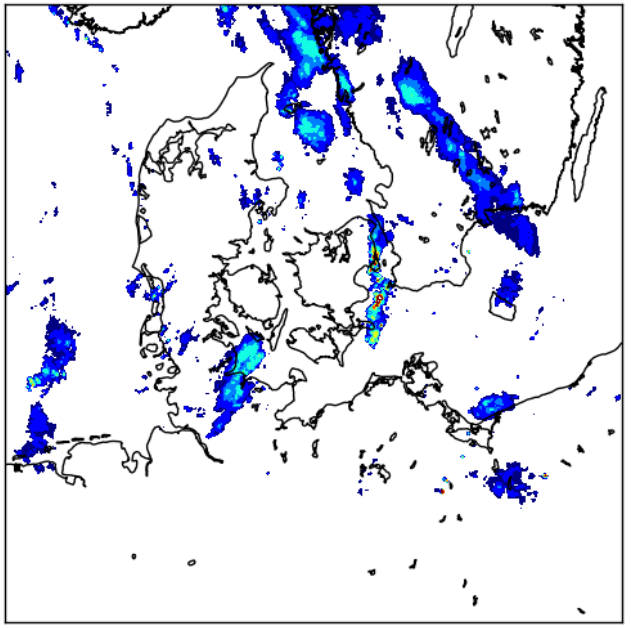
Domain averaged 15 min acc. Precipitation.
How long surface “spin-up”, 1 day, 1 week, 2 weeks?

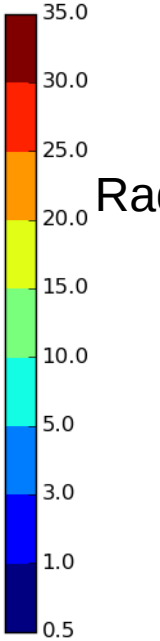




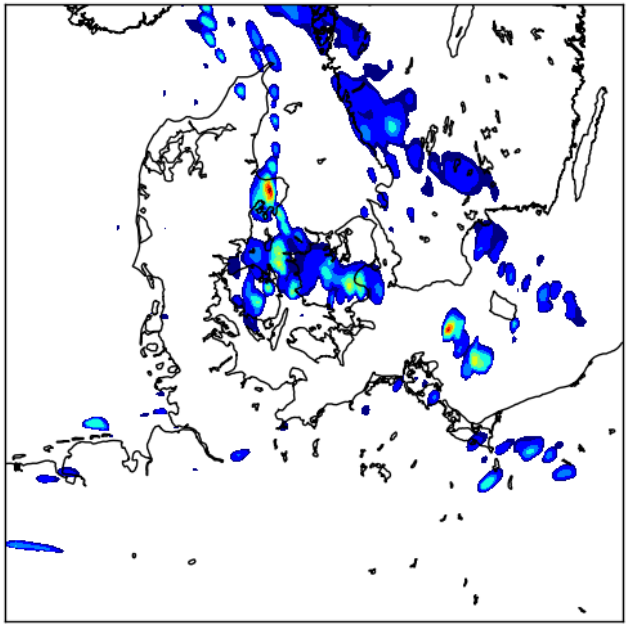
Initial amounts increase slightly with longer spin-up, otherwise small impact on domain average.

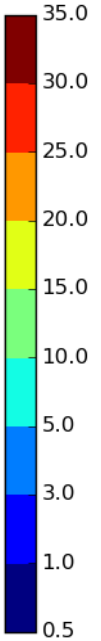
1 hour acc. precip at 01 Z
Impact of length of surface spin-up



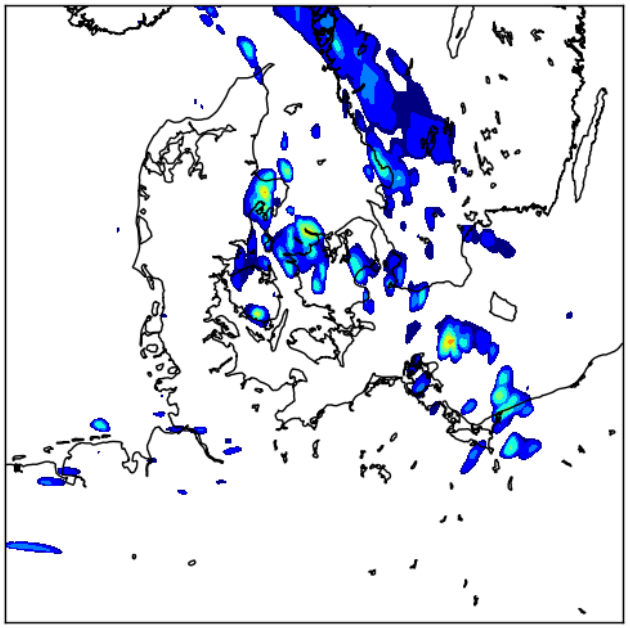


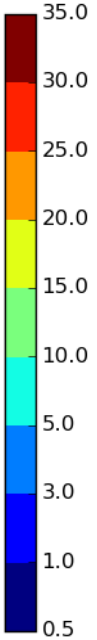
Radar



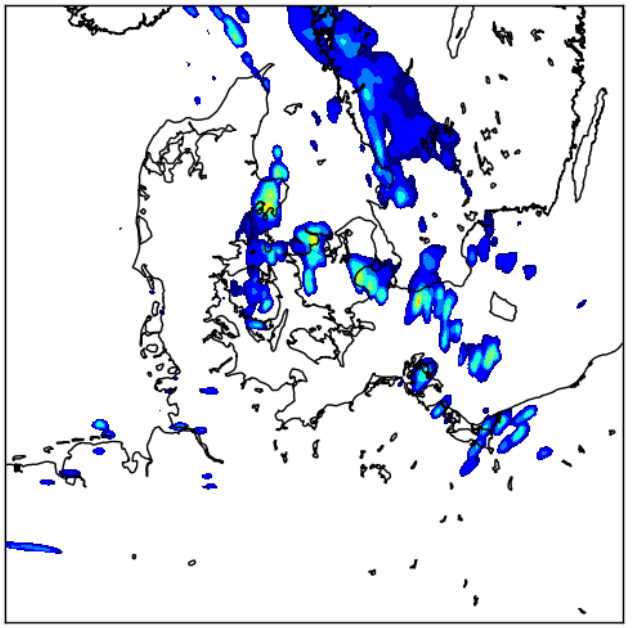


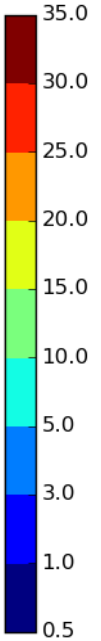
1 day





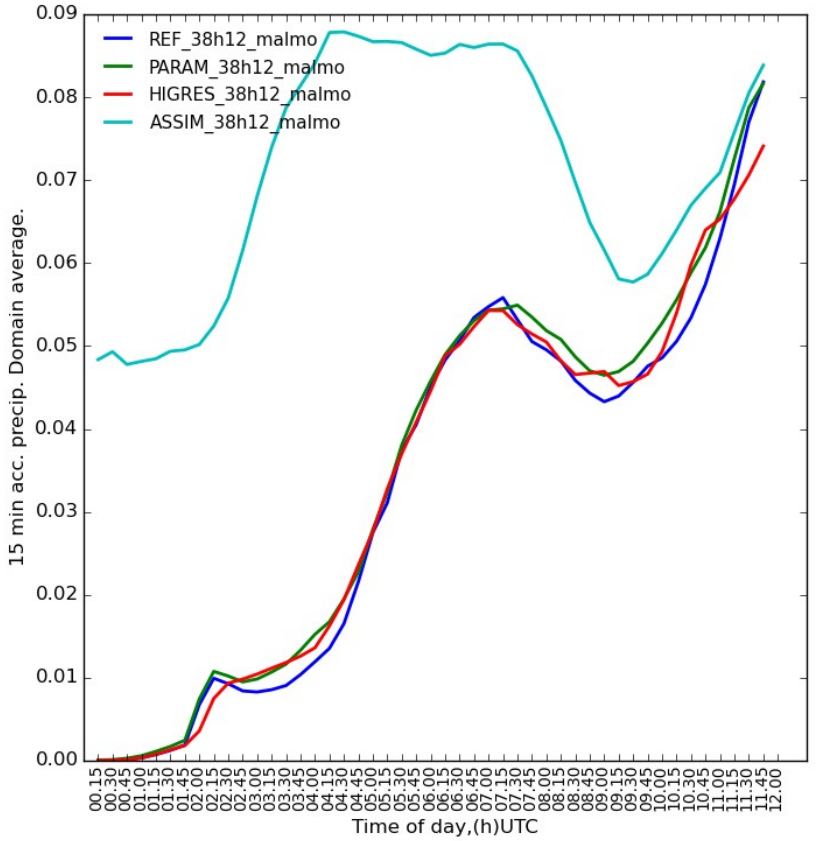
1 week

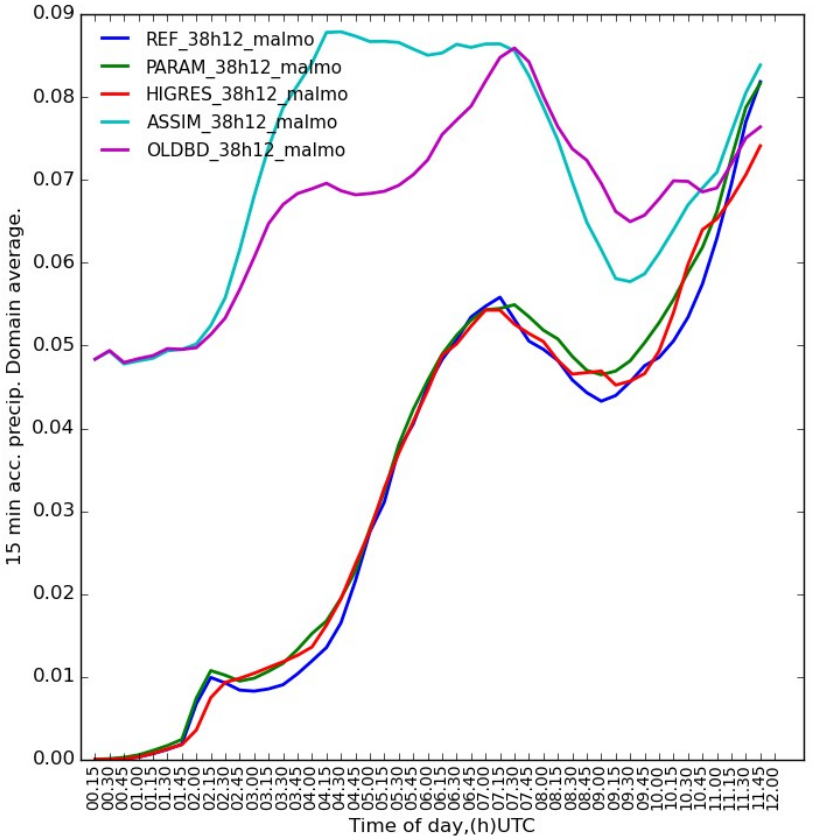




2 weeks

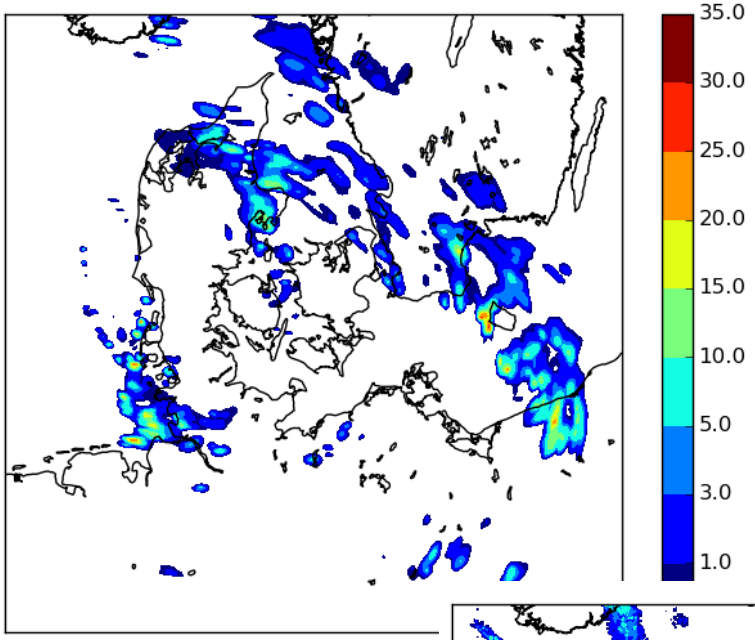
Domain averaged 15 min acc. Precipitation.
Impact of 12 hour old lateral boundary conditions



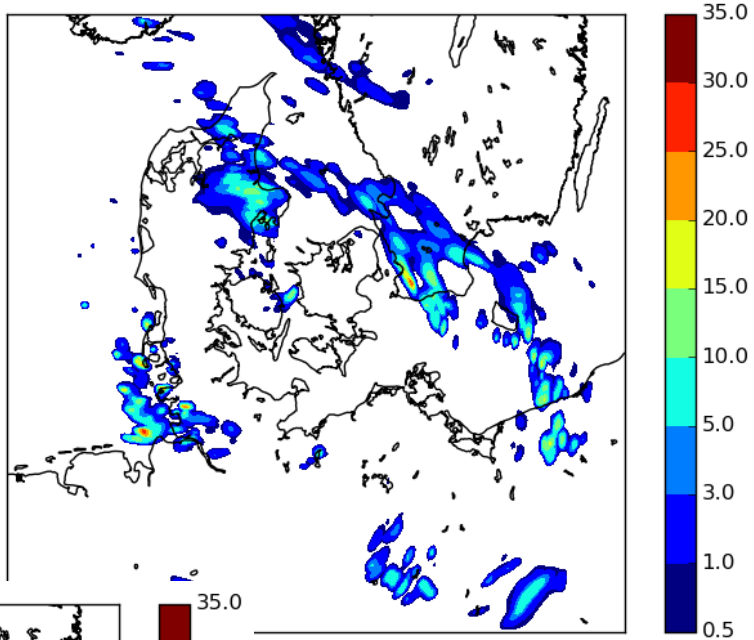


Initial amount of precipitation identical, slower onset.

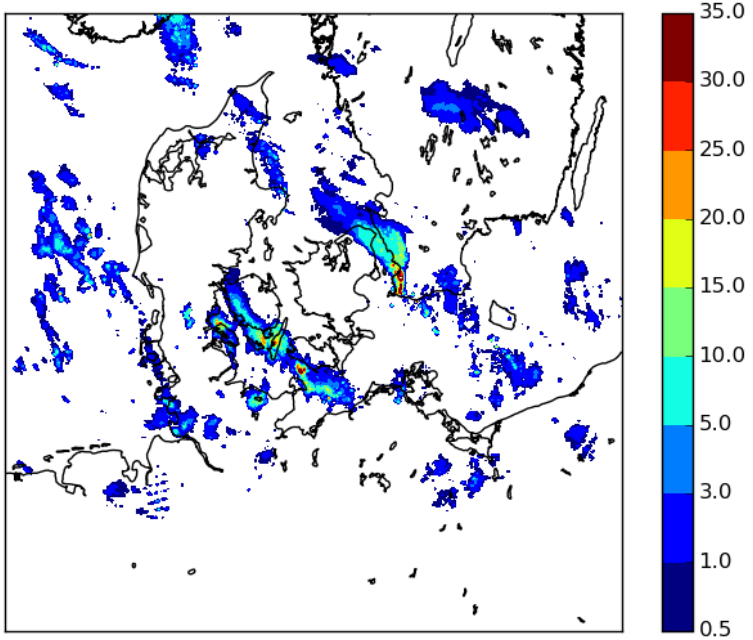
1 h acc precip, at 07 UTC.
Impact of 12 hour old later bc's



6 h old BC's

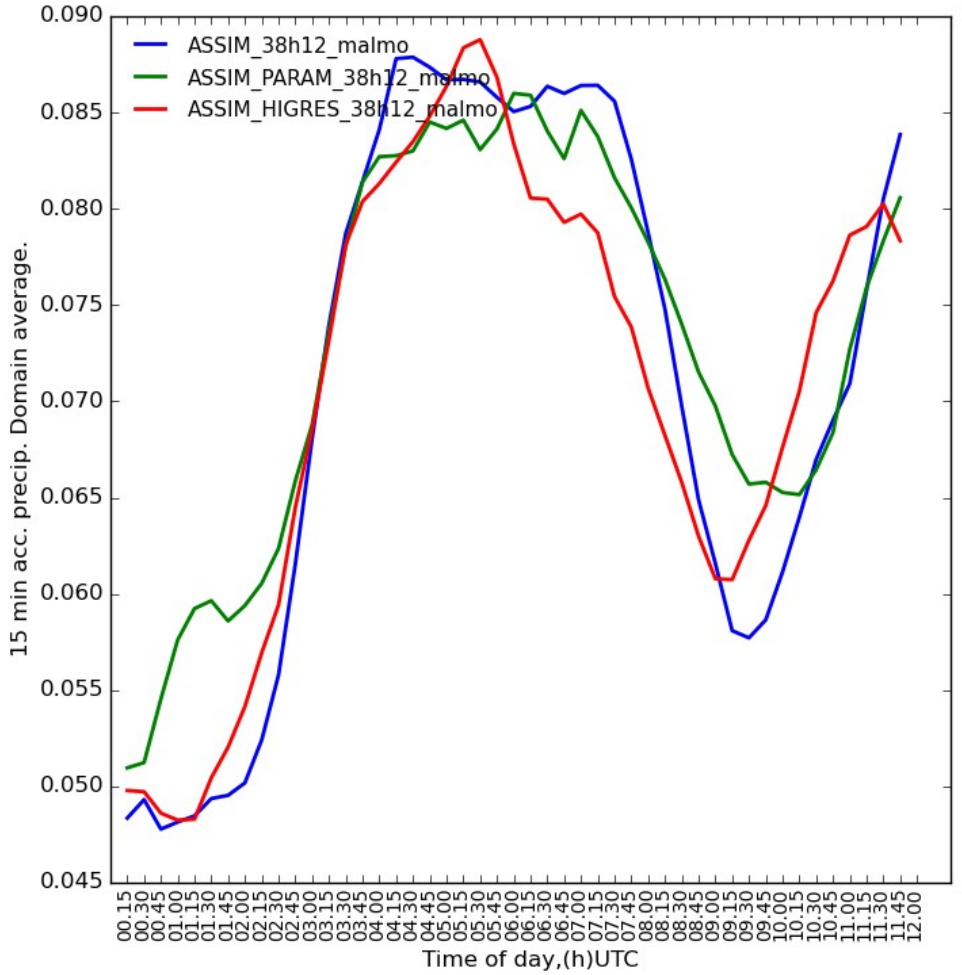


12 h old BC's



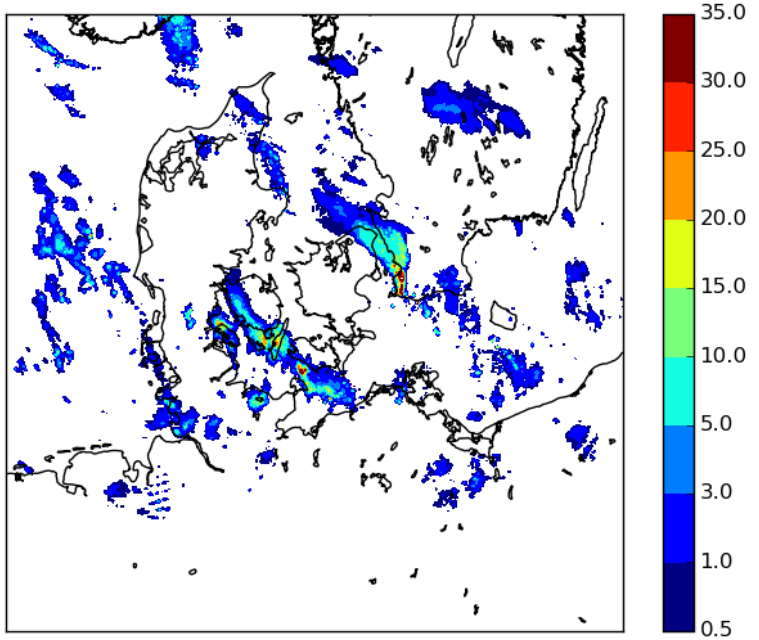
Radar

Domain averaged 15 min acc. Precipitation.
Impact of high resolution and parameterized conv.

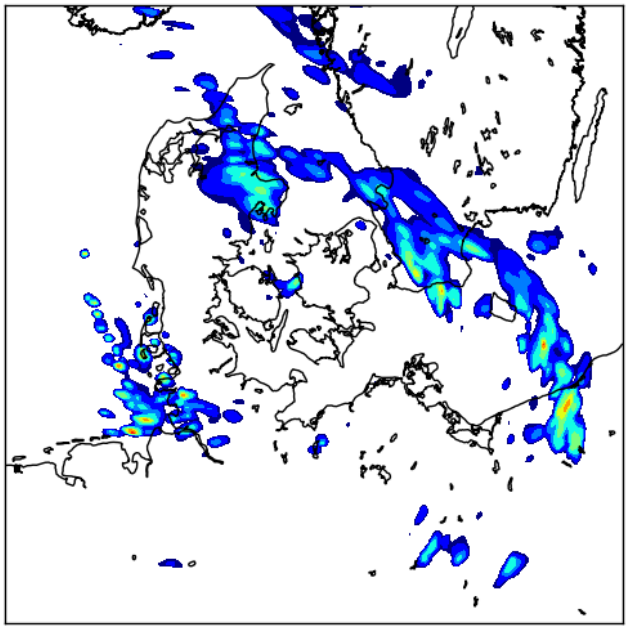


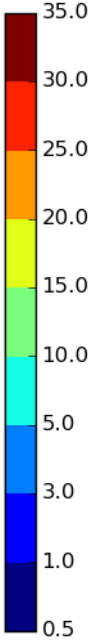
Not much impact on average, some differences in the details.

1 h acc precip, at 07 UTC.
Impact of high-res, param deep conv

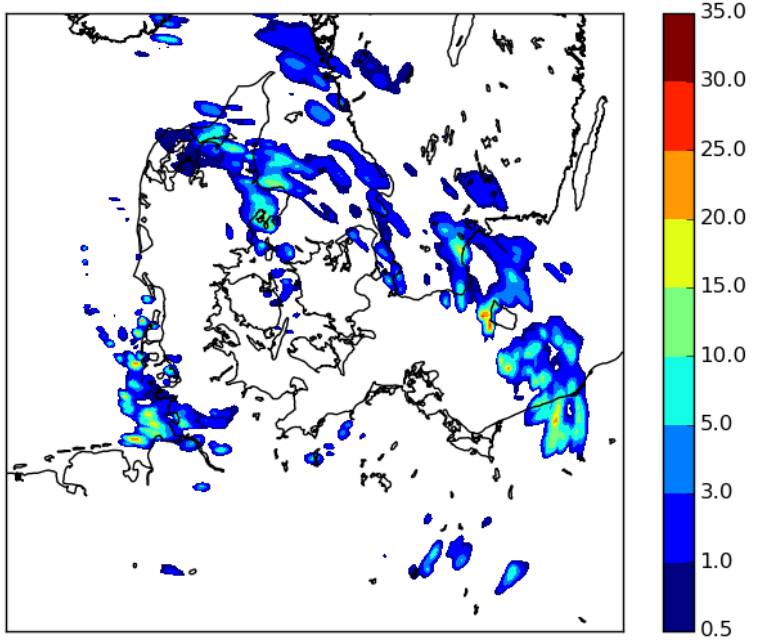


Radar

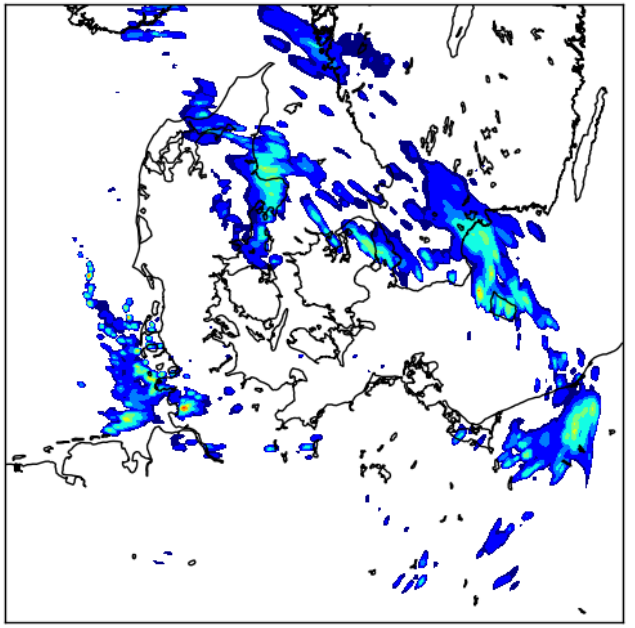


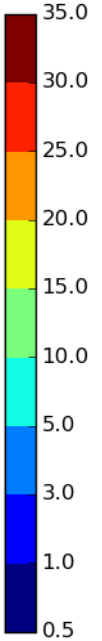


Explicit
Conv
2.5 km



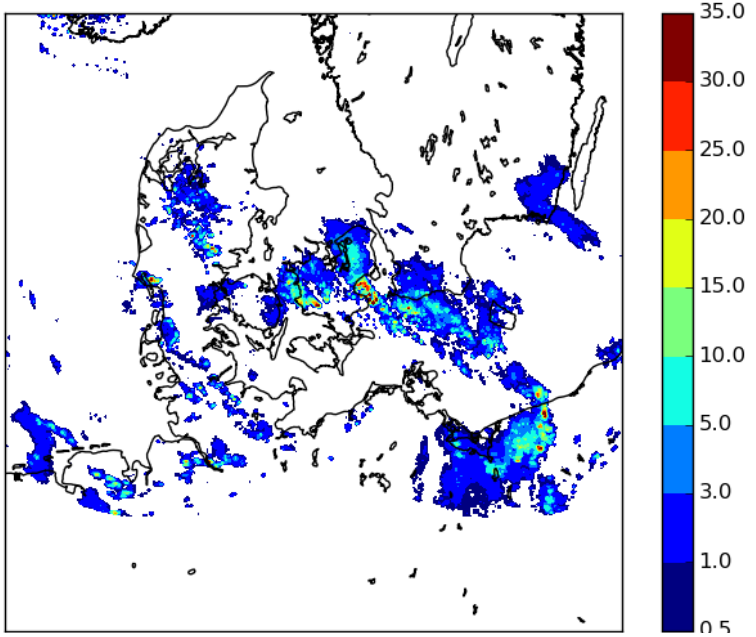
Param
Conv.
2.5 km



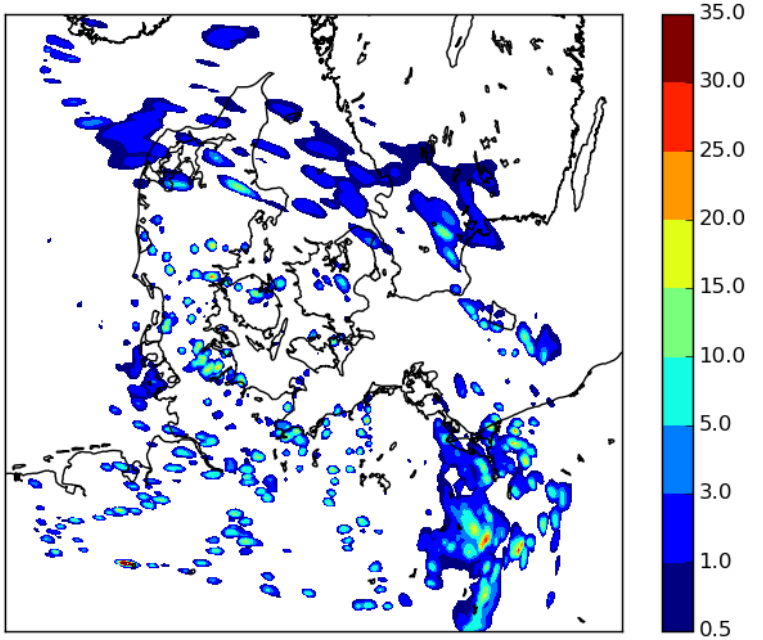


Explicit
Conv
1.3 km

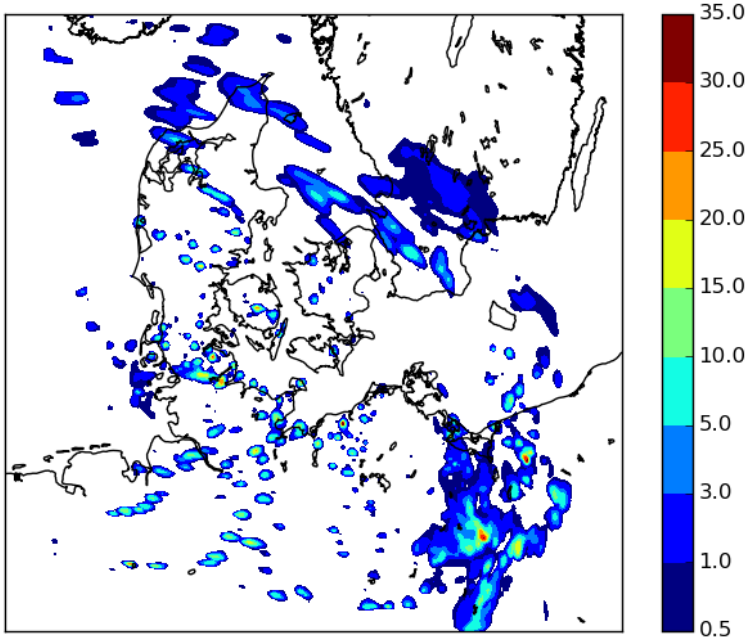
1 h acc precip, at 12 UTC.
Impact of high-res, param deep conv



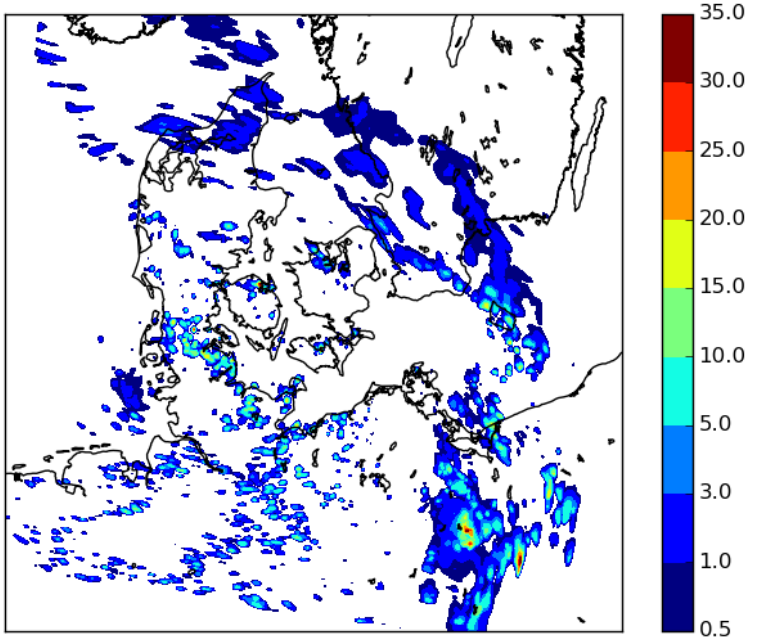
Radar



Explicit
Conv
2.5 km

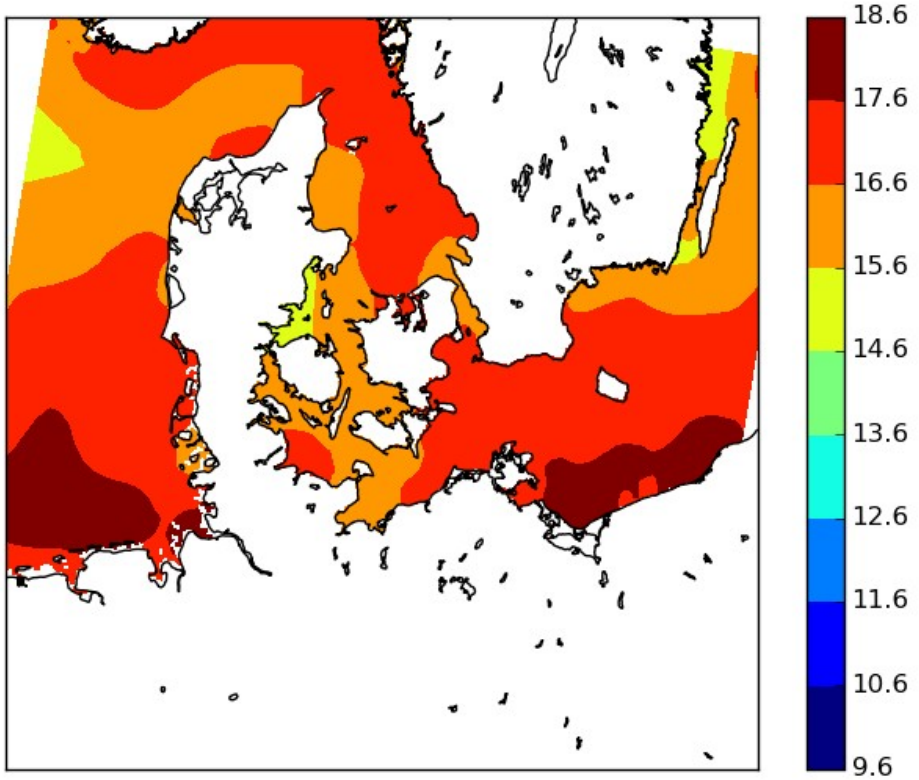


Param
Conv.
2.5 km



Explicit
Conv
1.3 km

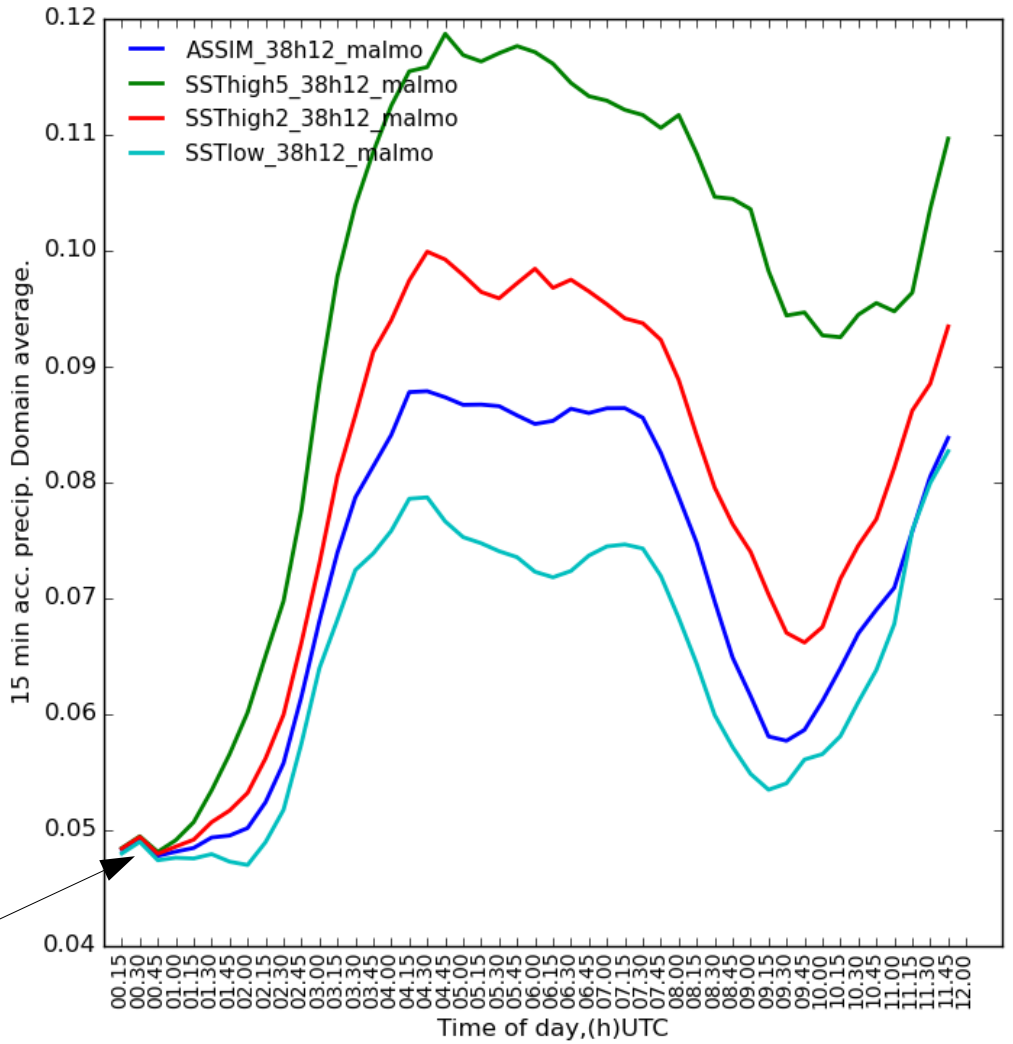
Sensitivity of the event to increased sea surface temperature (SST).



- Reference
- SST – 2 degrees K
- SST + 2 degrees K
- SST + 5 degrees K

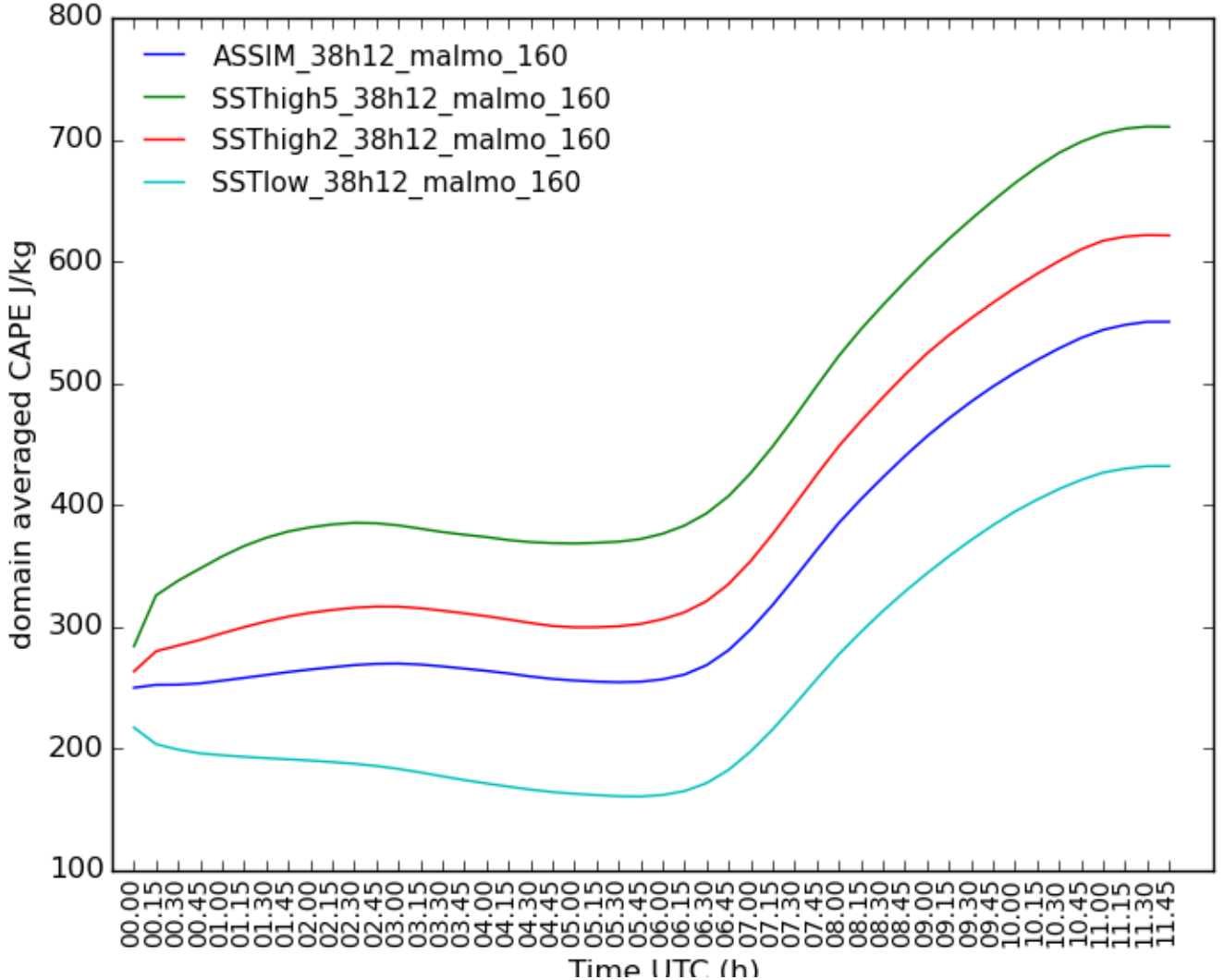
- SST comes from ECMWF at initial time and remains constant throughout the simulation.

Domain averaged 15 min acc. precipitation. Impact of modified SST



Same initial Precipitation

CAPE


ASSIM_38h12_malmo_160
SSThigh5_38h12_malmo_160
SSThigh2_38h12_malmo_160
SSTlow_38h12_malmo_160
domain averaged CAPE J/kg
800
700
600
500
400
300
200
100
00.00
00.15
00.30
00.45
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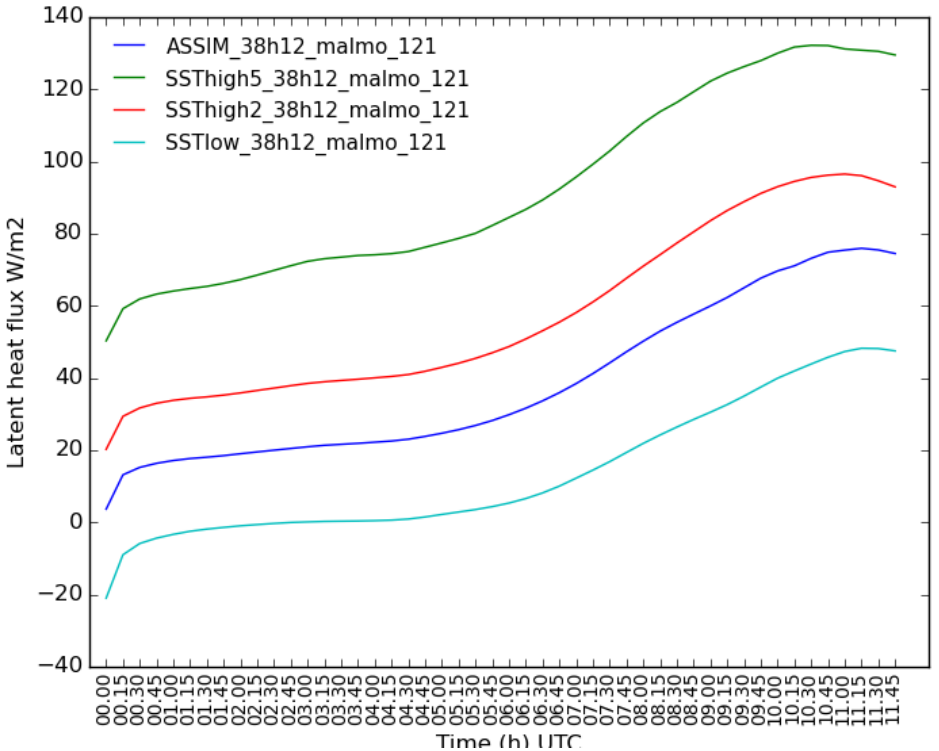
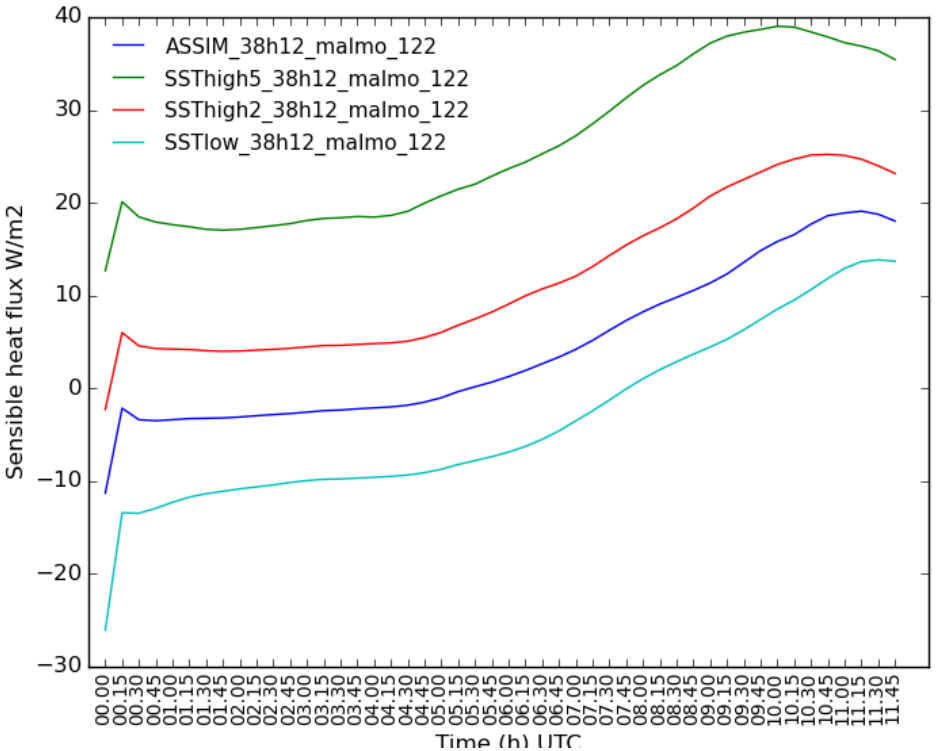
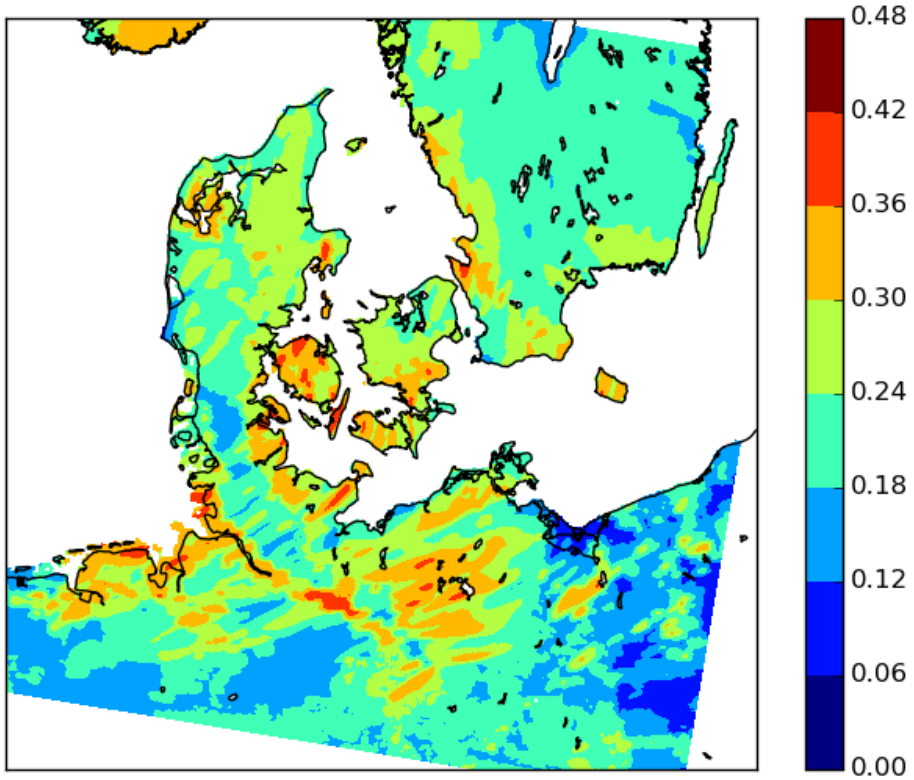
10.30
10.45
11.00
11.15
11.30
11.45
Time UTC (h)

Heat-Fluxes (latent/sensible)



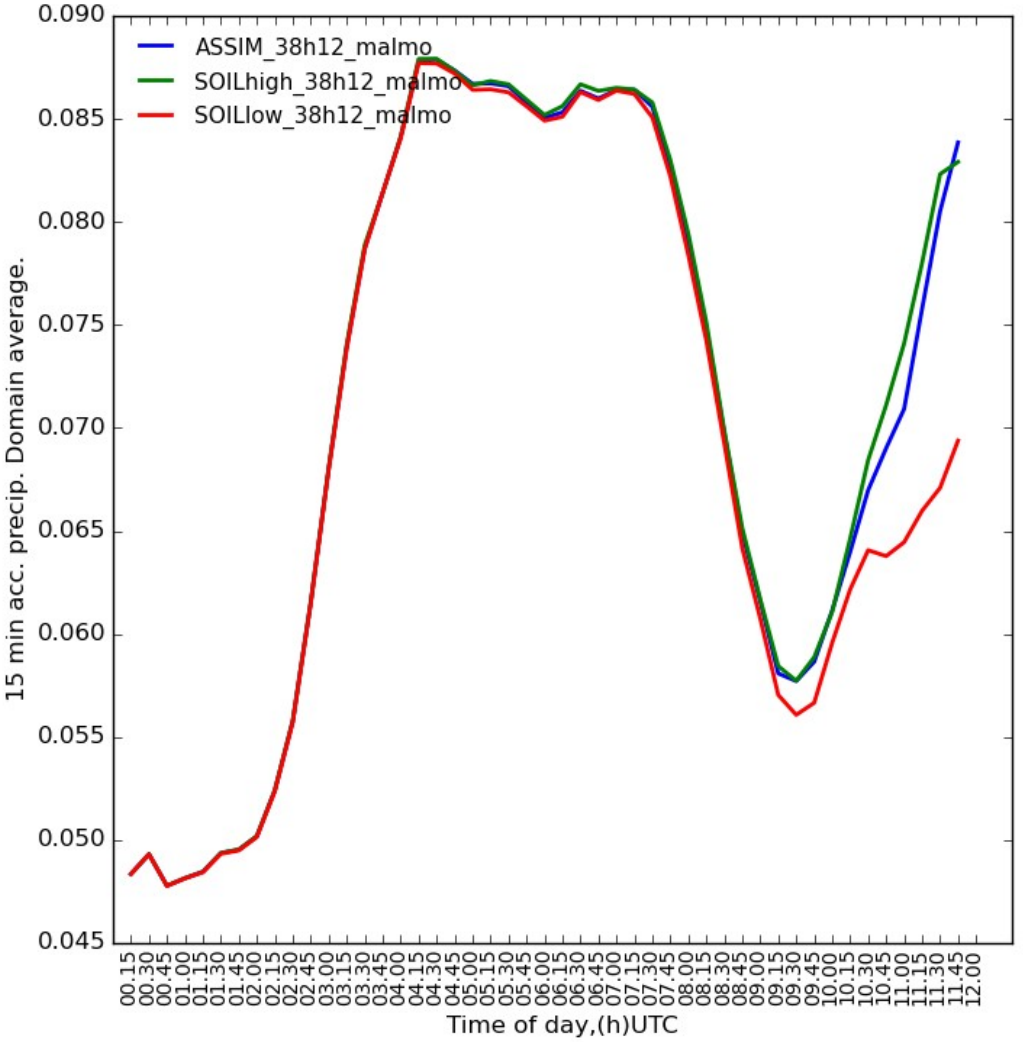


Sensitivity of the event to increased soil moisture

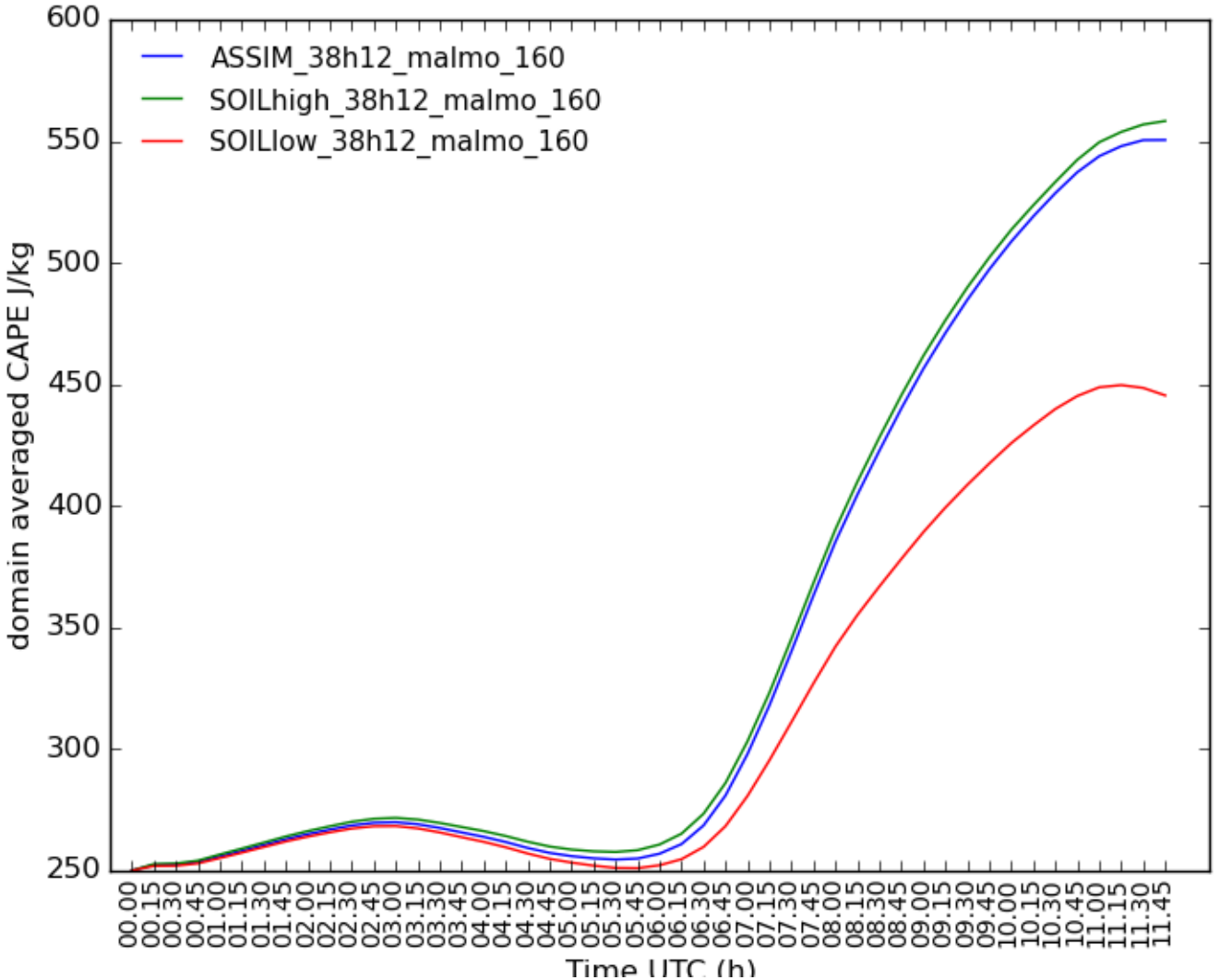


- Reference
- Soil-moisture * 0.5
- Soil-moisture * 1.5

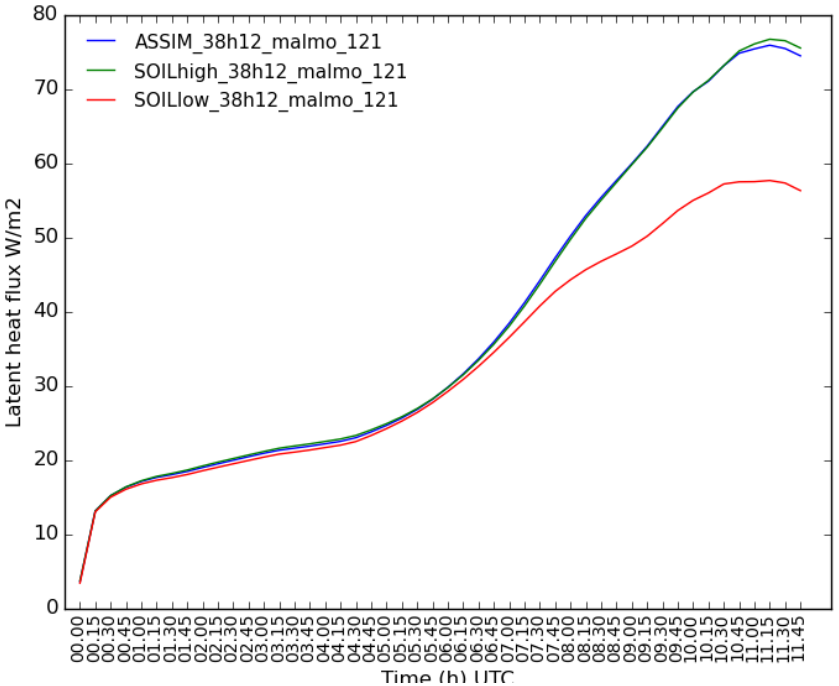
Domain averaged 15 min acc. precipitation. Impact of modified Soil Moisture

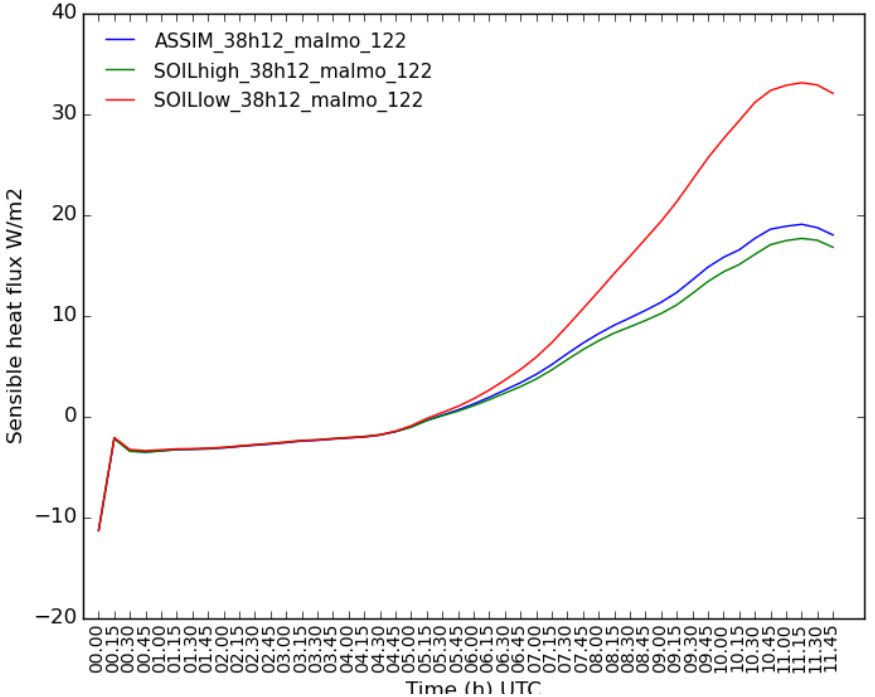


CAPE


ASSIM_38h12_malmo_160
SOILhigh_38h12_malmo_160
SOILlow_38h12_malmo_160
domain averaged CAPE J/kg
600
550
500
450
400
350
300
250
Time UTC (h)

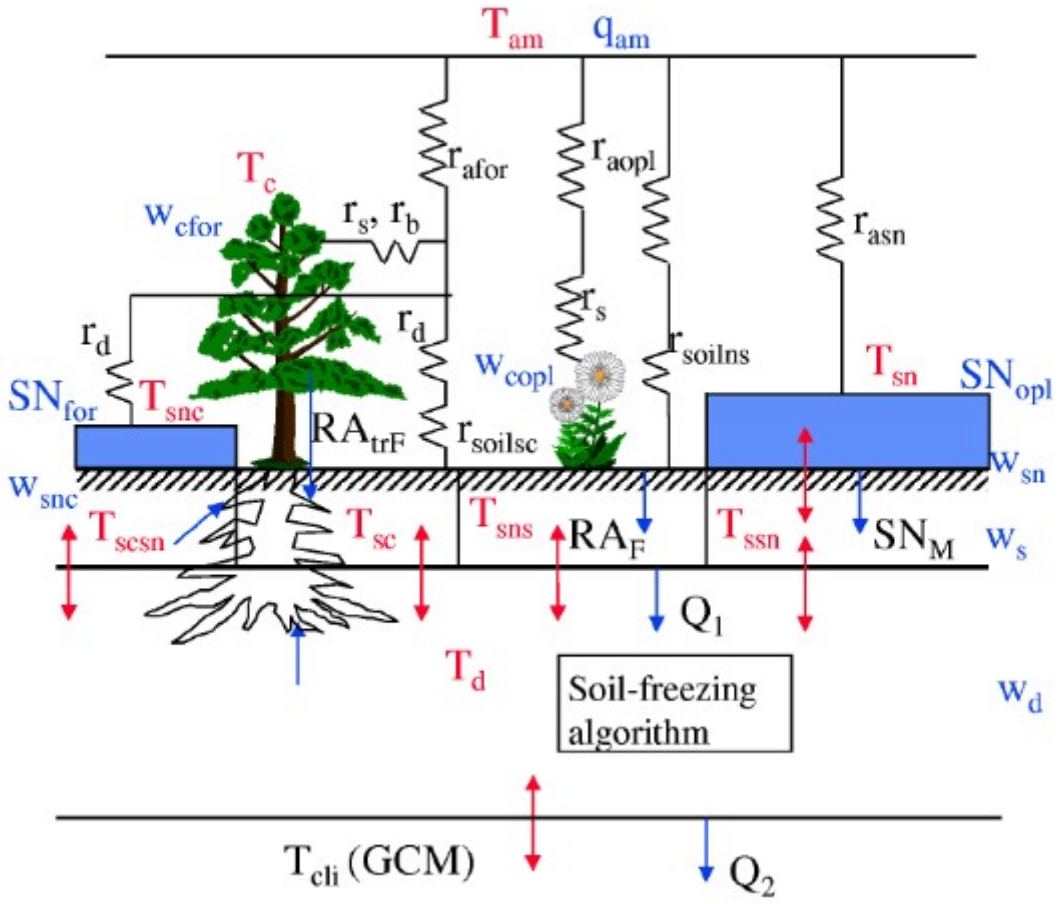
Heat fluxes (latent/sensible)



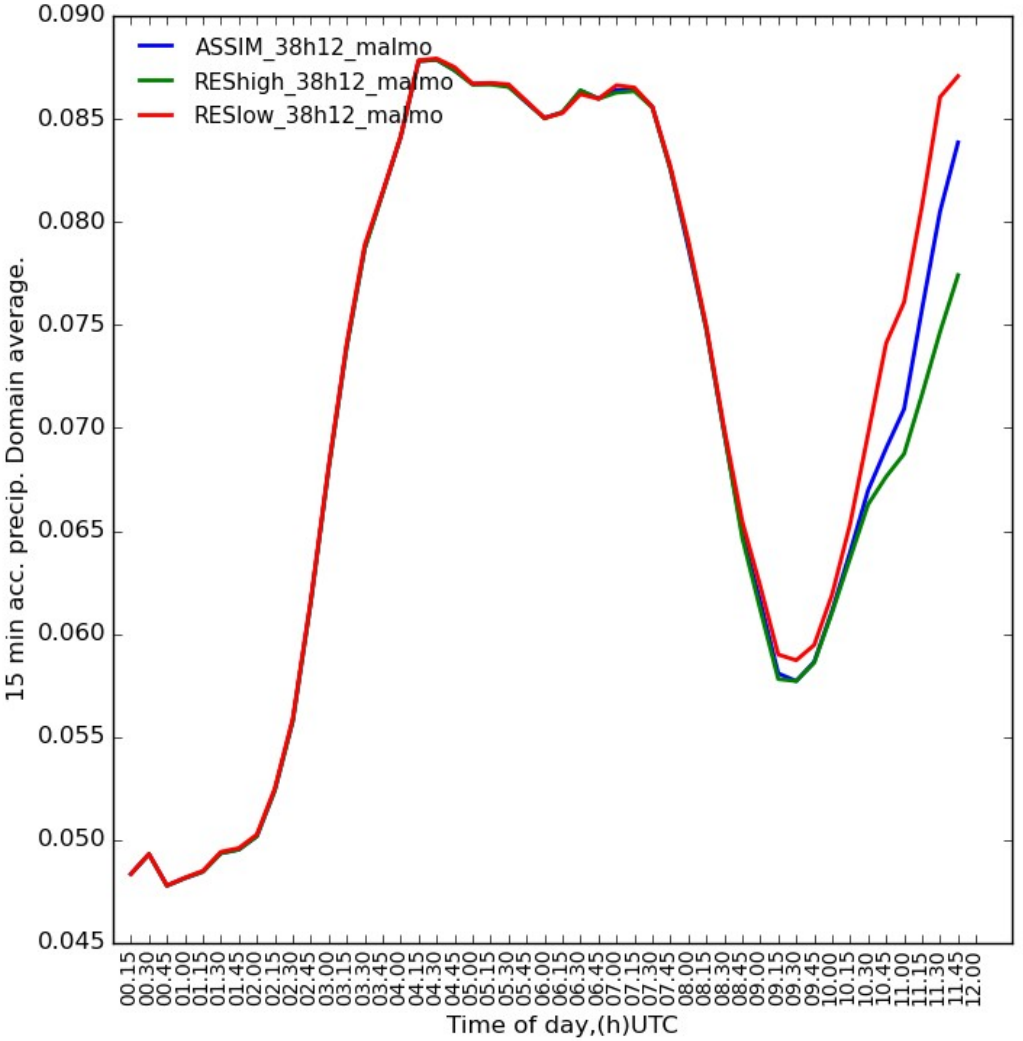


Drying of soil yields larger sensible heat values compared with reference.

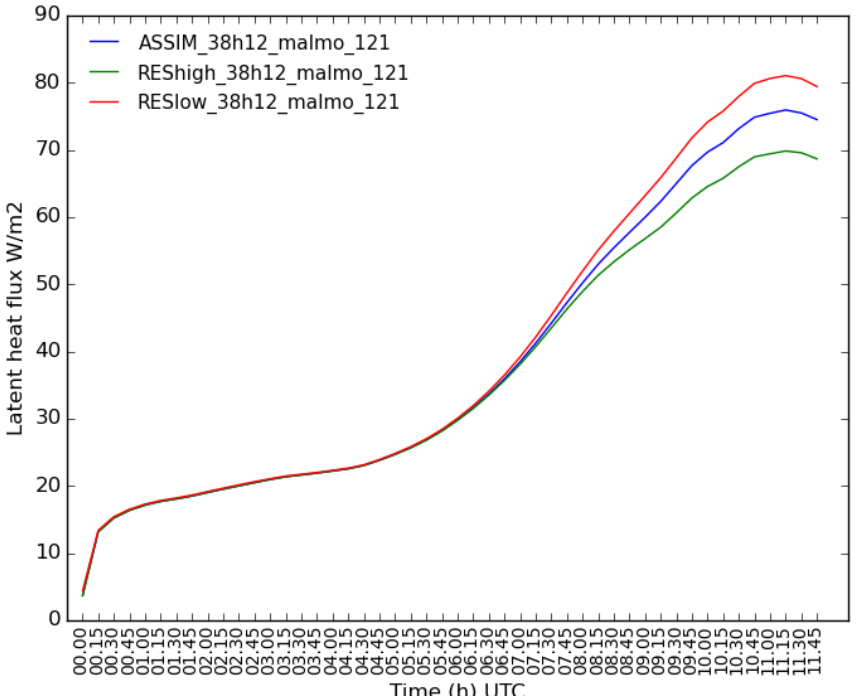
Sensitivity of the event to increased/reduced transpiration

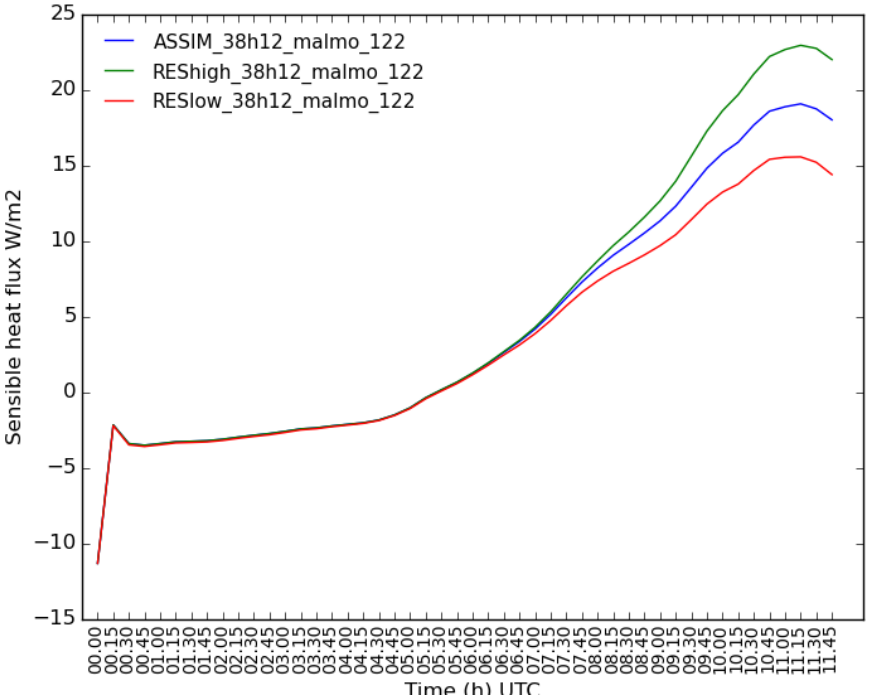


Domain averaged 15 min acc. precipitation. Impact of modified transporation



Heat-fluxes


ASSIM_38h12_malmo_121
REShigh_38h12_malmo_121
RESlow_38h12_malmo_121
Latent heat flux W/m2
Time (h) UTC


ASSIM_38h12_malmo_122
REShigh_38h12_malmo_122
RESlow_38h12_malmo_122
Sensible heat flux W/m2
Time (h) UTC

Summary and conclusions

- Two regimes:
  - First, synoptically driven convection (embedded within a front), that got an energy boost from the relatively warm sea. Thus sensitive to synoptic setup, but insesitive to land surface model, and small sensitivity to horizontal resolution and model physics.

    -> Makes it interesting for EPS
  - Later in the day open cell convection, strongly coupled to the land surface model, stronger sensitivity to horizontal resolution and model physics.

    -> Here we have a chance to improve our prediction by improved surface atmosphere coupligng, improved surface DA, higher resolution and improved physics.

HarmonEPS – AROME memebers