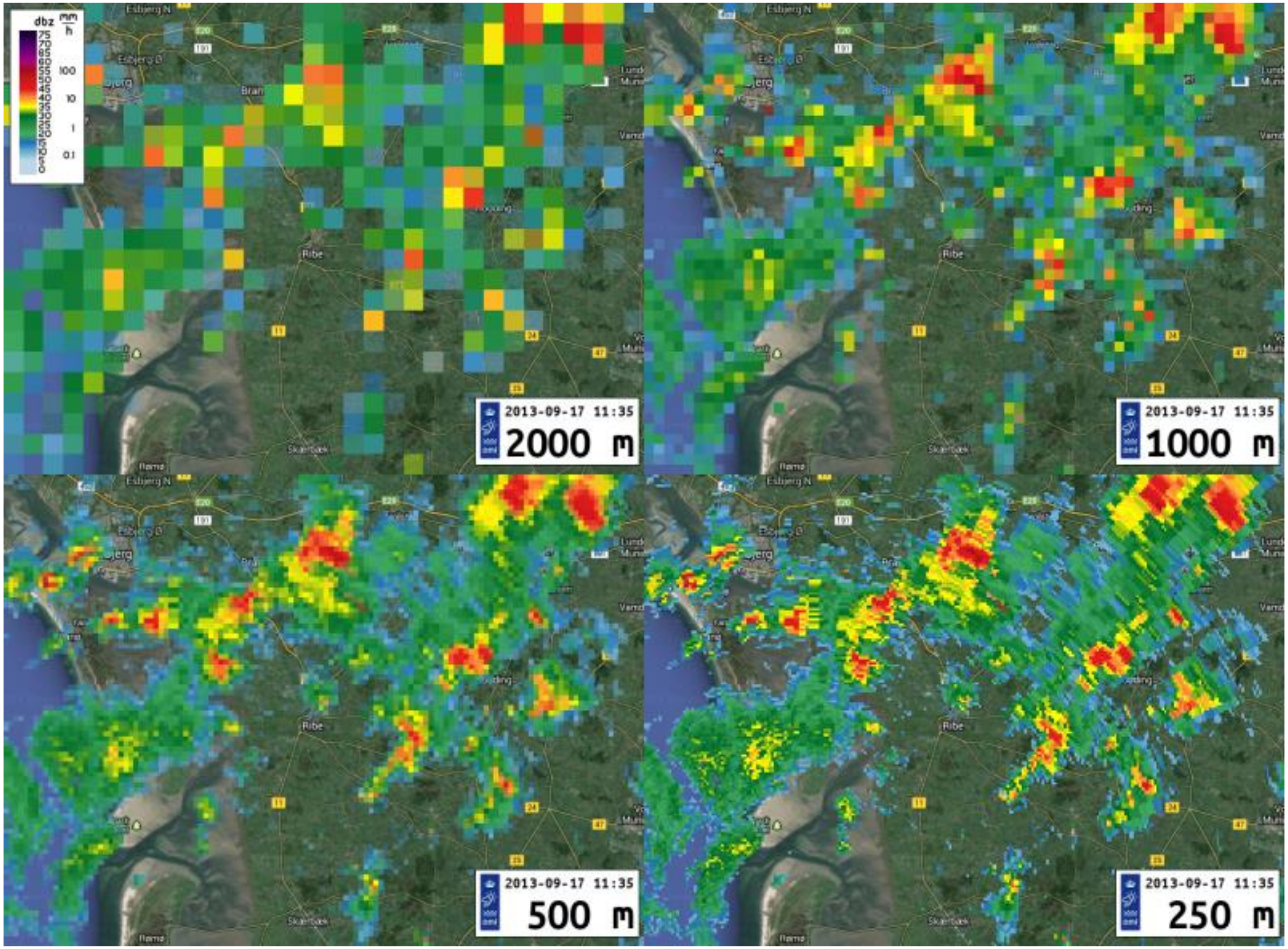
From short range forecasts to climate change projections of extreme events in the Baltic Sea region

Martin Stendel, Danish Climate Centre, DMI

- Short range forecast of the Copenhagen ”cloud burst” July 2, 2011
- Extreme value analysis of the flooding in Roskildefjord December 6/7, 2013
- Barents and Kara Sea ice retreat and cold European winters

Great Baltic Sea flood, November 13, 1872
Farm houses in Niendorf (near Lübeck) being torn away.
Privately owned, Fam. Muuß, Hotel Friedrichsruh.
Sea level 3.50 m above normal.

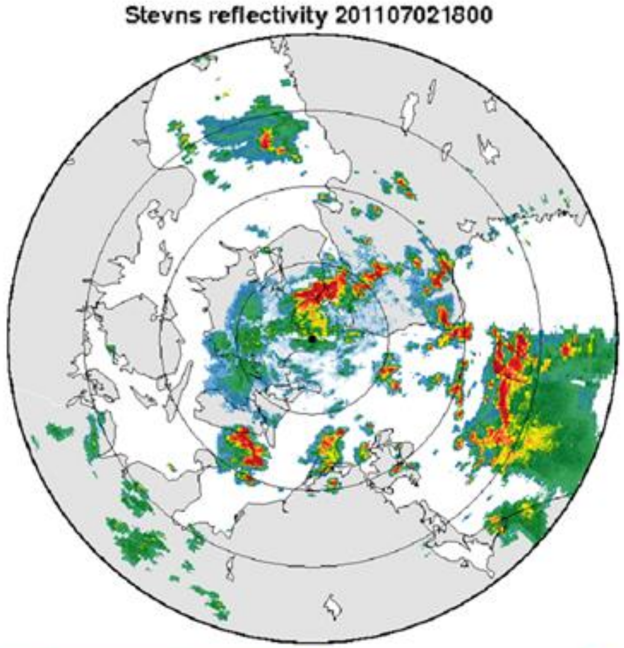
Size matters: radar precipitation at different resolutions

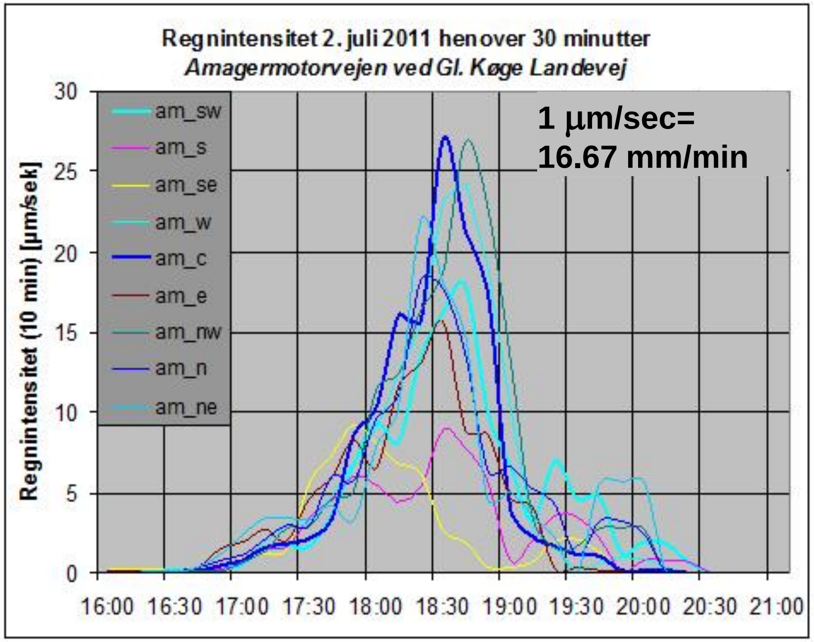


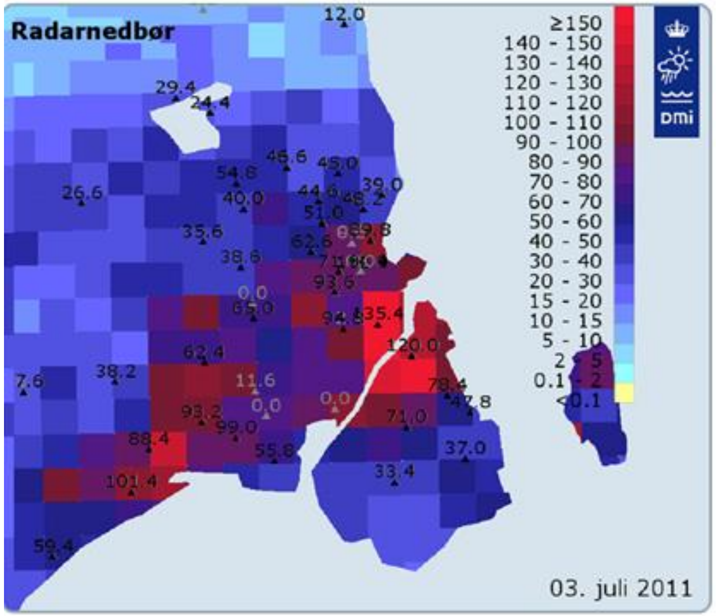
DMI custom-tailored products

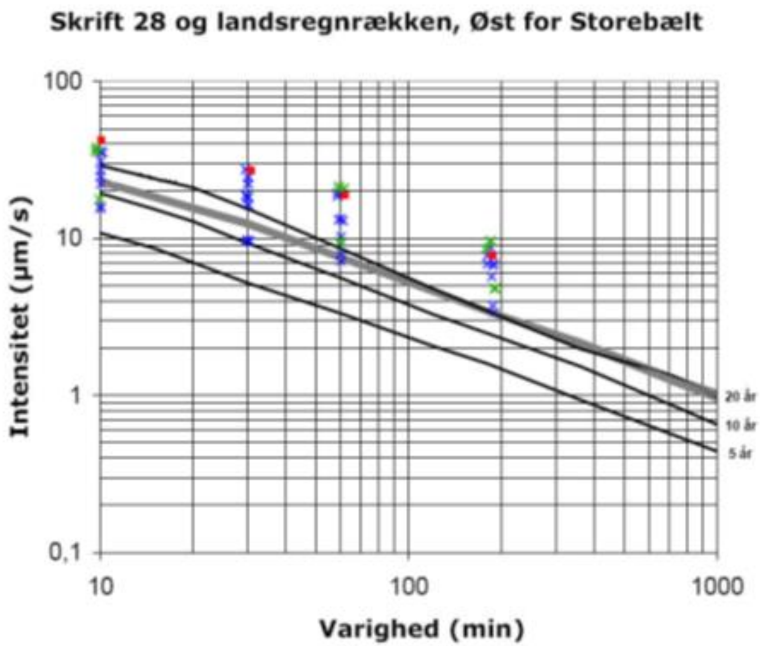
- Station data up to hourly resolution
- Gridded data up to 1x1km^2 horizontal resolution
- Radar ”nowcasting” up to 10 minutes temporal and 500 m vertical resolution

Example: ”Cloud burst” in Copenhagen, July 2, 2011











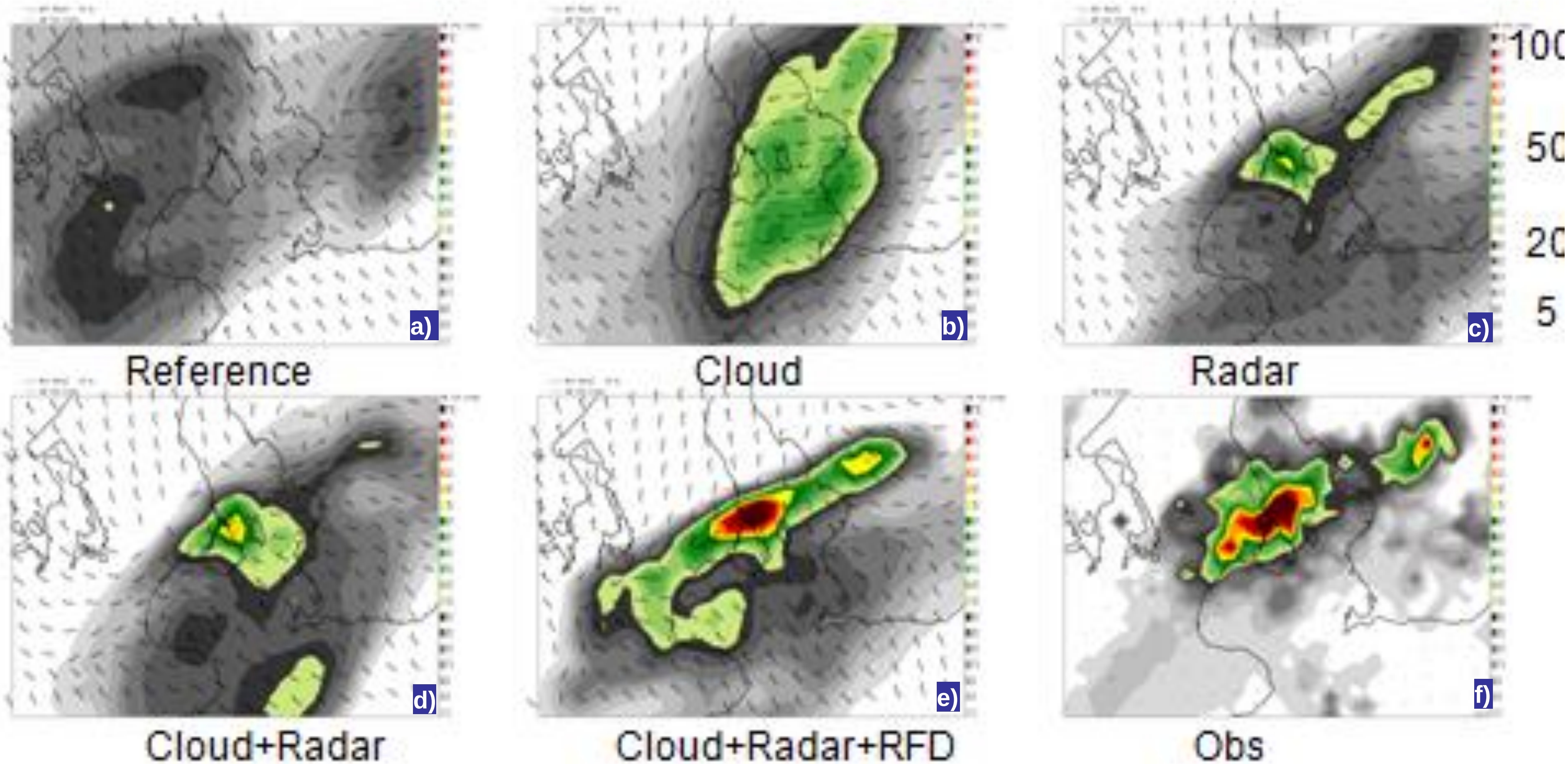




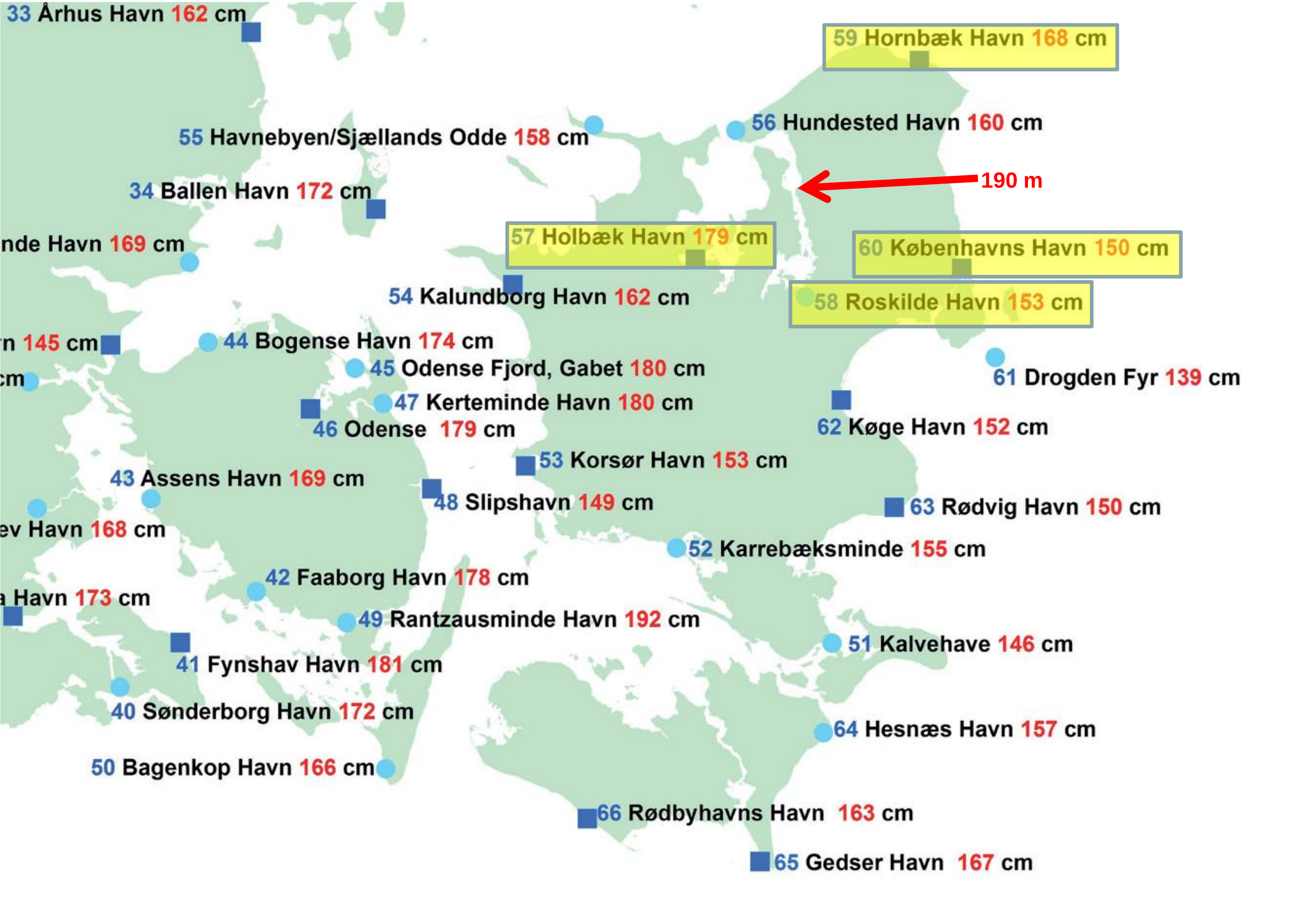


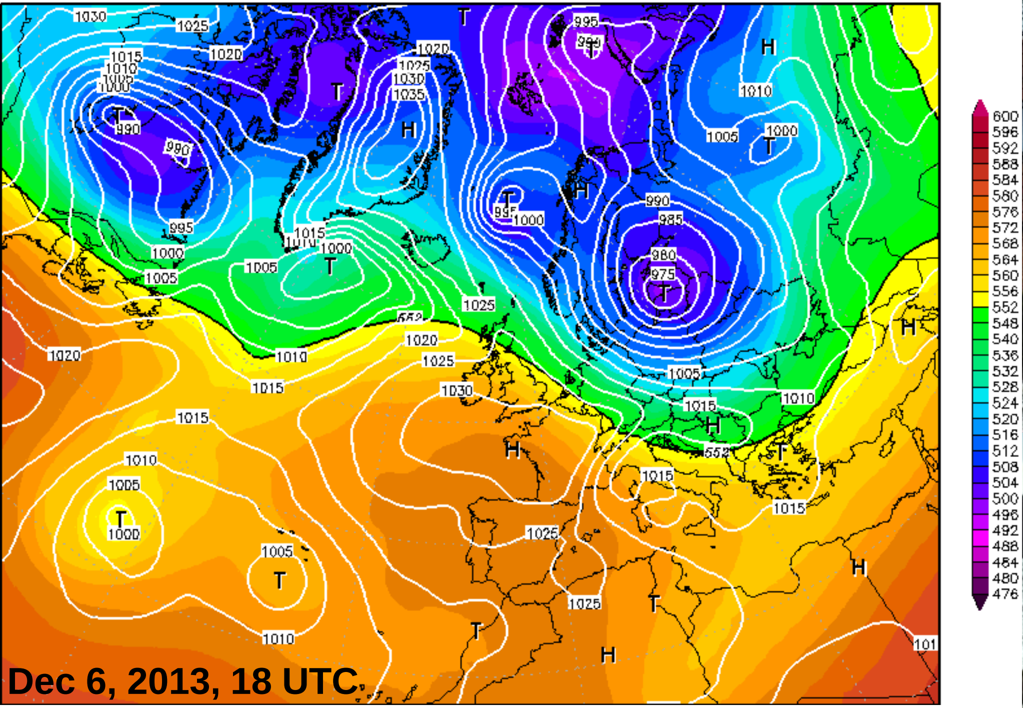
Two hour forecasts of the cloudburst event in Copenhagen, 2 July 2011

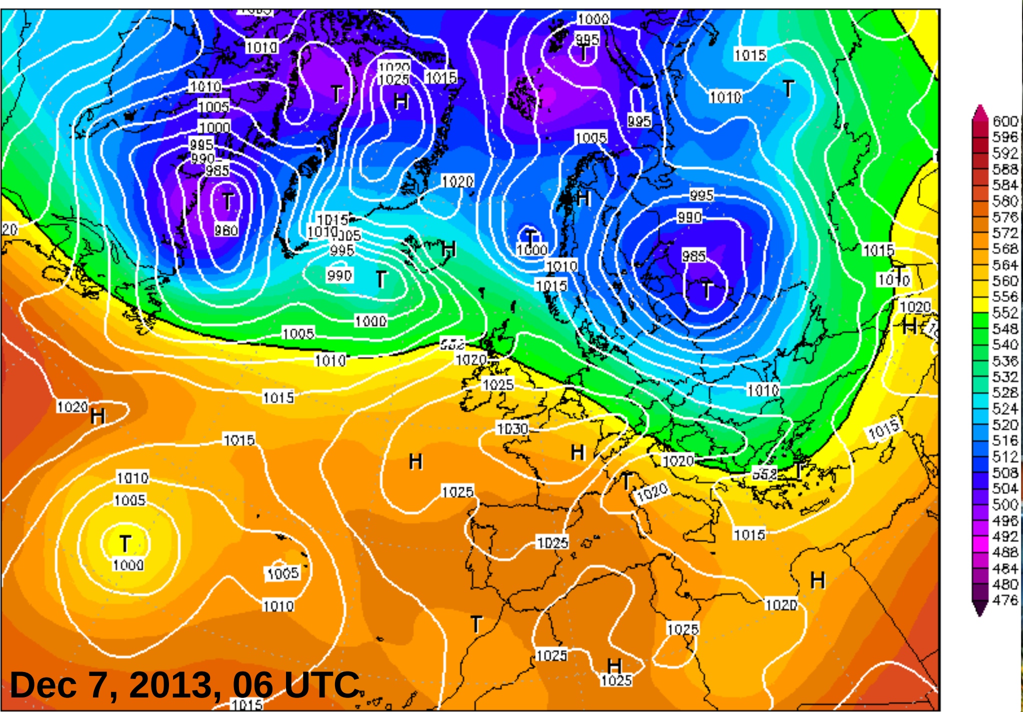
a) Standard weather forecast without additional data
b) Forecast with assimilation of cloud data
c) Forecast with assimilation of radar data
d) Forecast with assimilation of cloud and radar data
e) Forecast using model plus clouds plus short range radar forecast
f) Observed

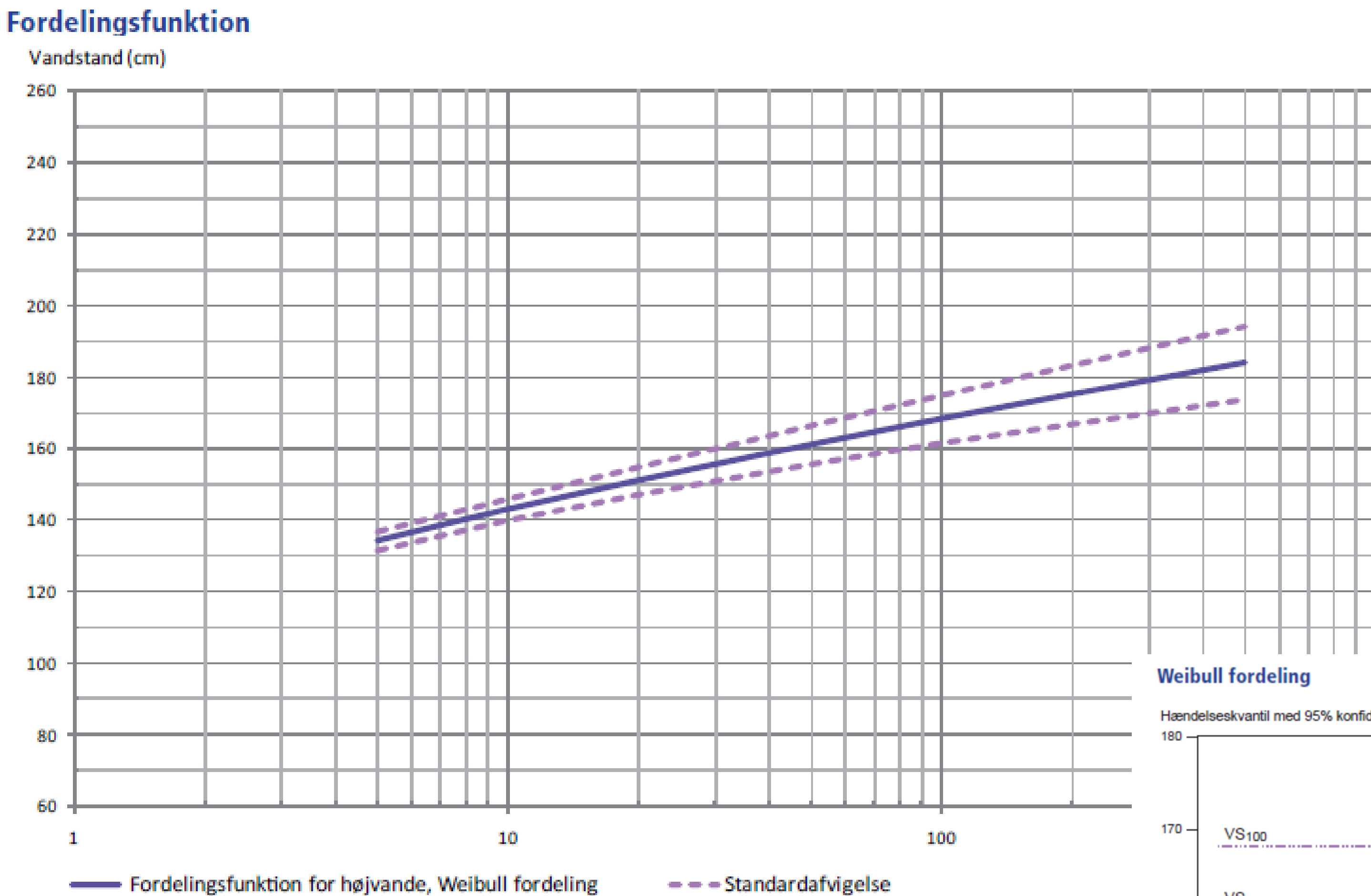


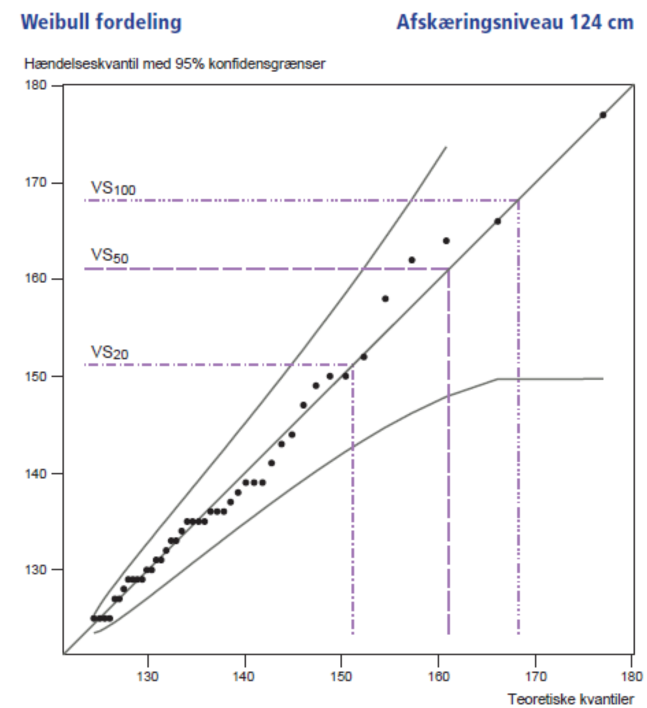
Extreme flooding in Roskildefjord and Holbækfjord, December 6/7, 2013
Cooperation of DMI and Kystdirektoratet (Coast Administration)




Dec 6, 2013, 18 UTC


Dec 7, 2013, 06 UTC



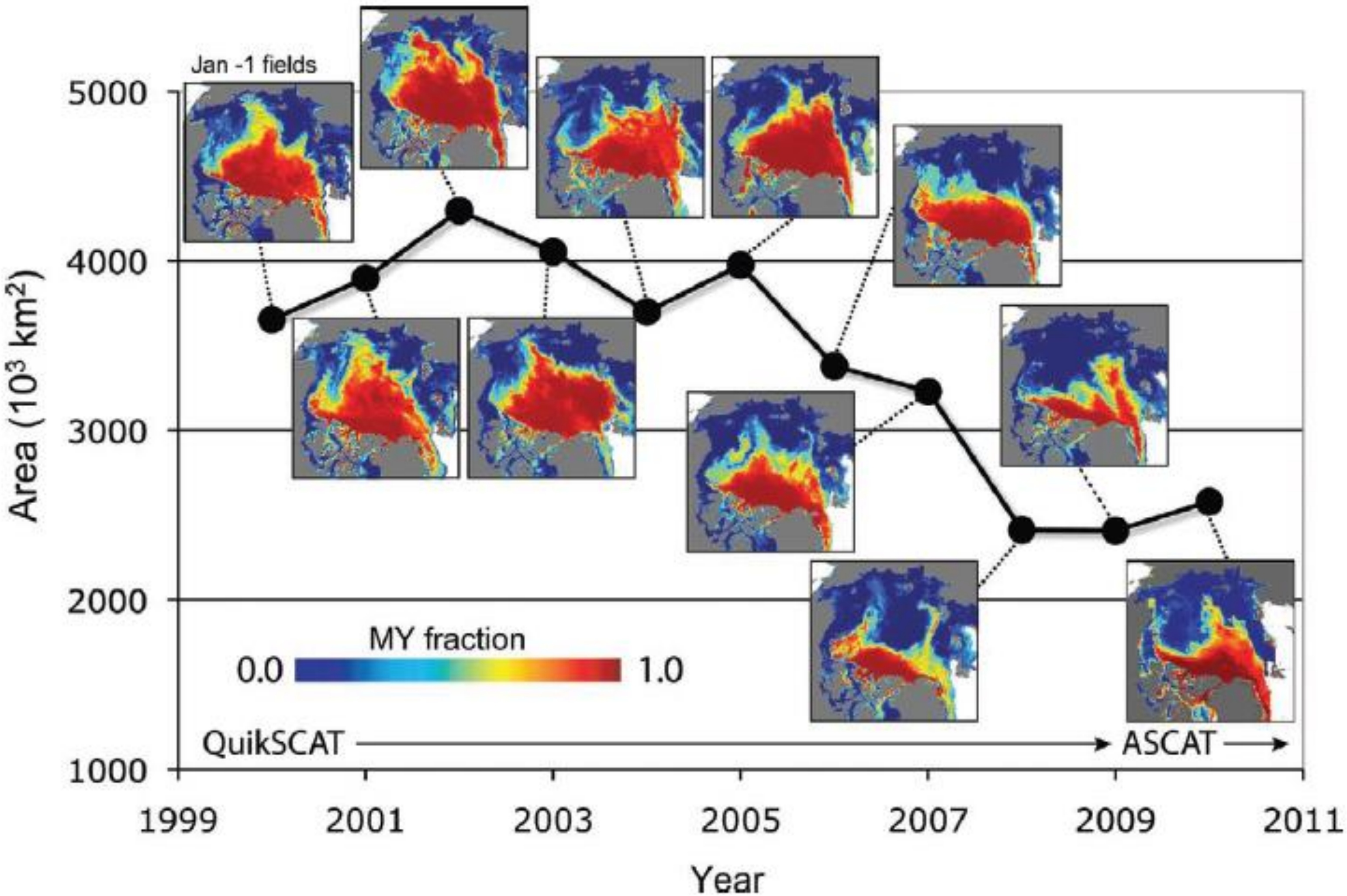


Example: Hornbæk (123 years of data)
December 6, 2013: 1.96 m
Old record: January 1, 1922: 1.73 m
100 year return value: 1.69 m

500-1000 year return values in Holbæk, Roskilde
(from shorter time series)

Recent decline of Arctic sea ice

Satellite-based Arctic Ocean multiyear ice (MYI) coverage on Jan. 1

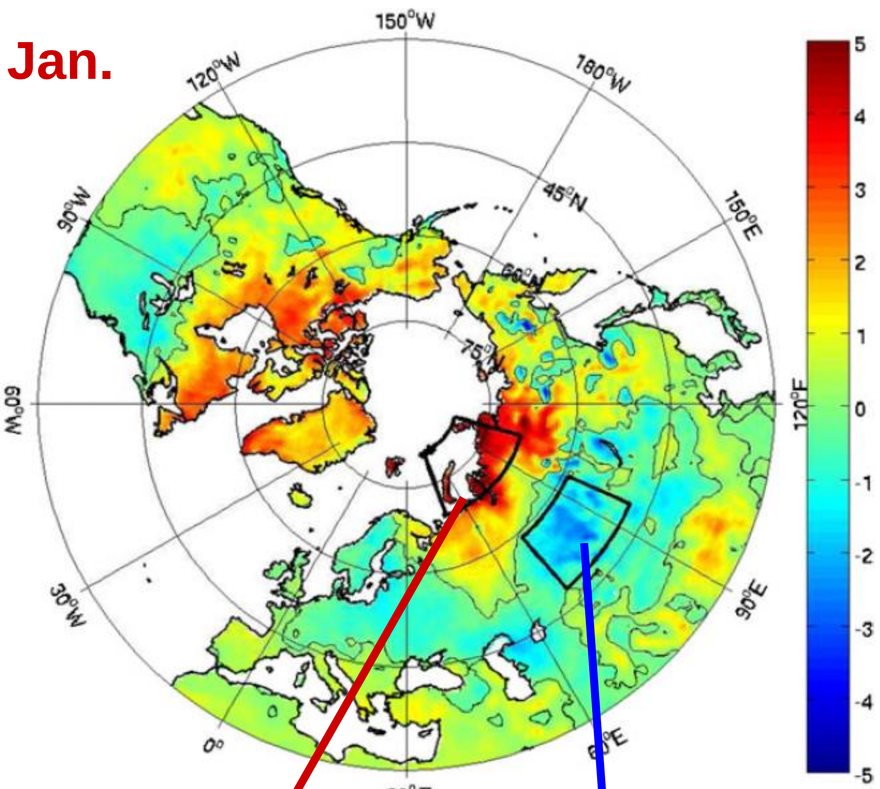


Polyakov et al. BAMS 2012

Recent cooling over Eurasia

Temperature trends
ERA Interim 1989-2009

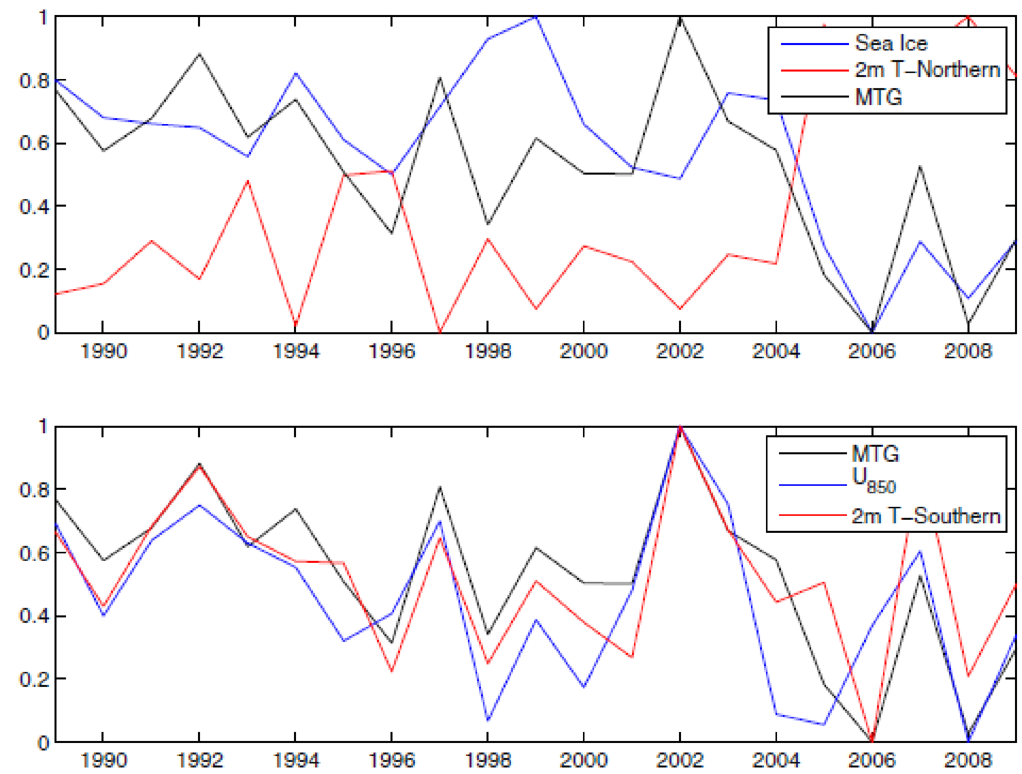
Jan.



5.9 K/dec

-3.2 K/dec

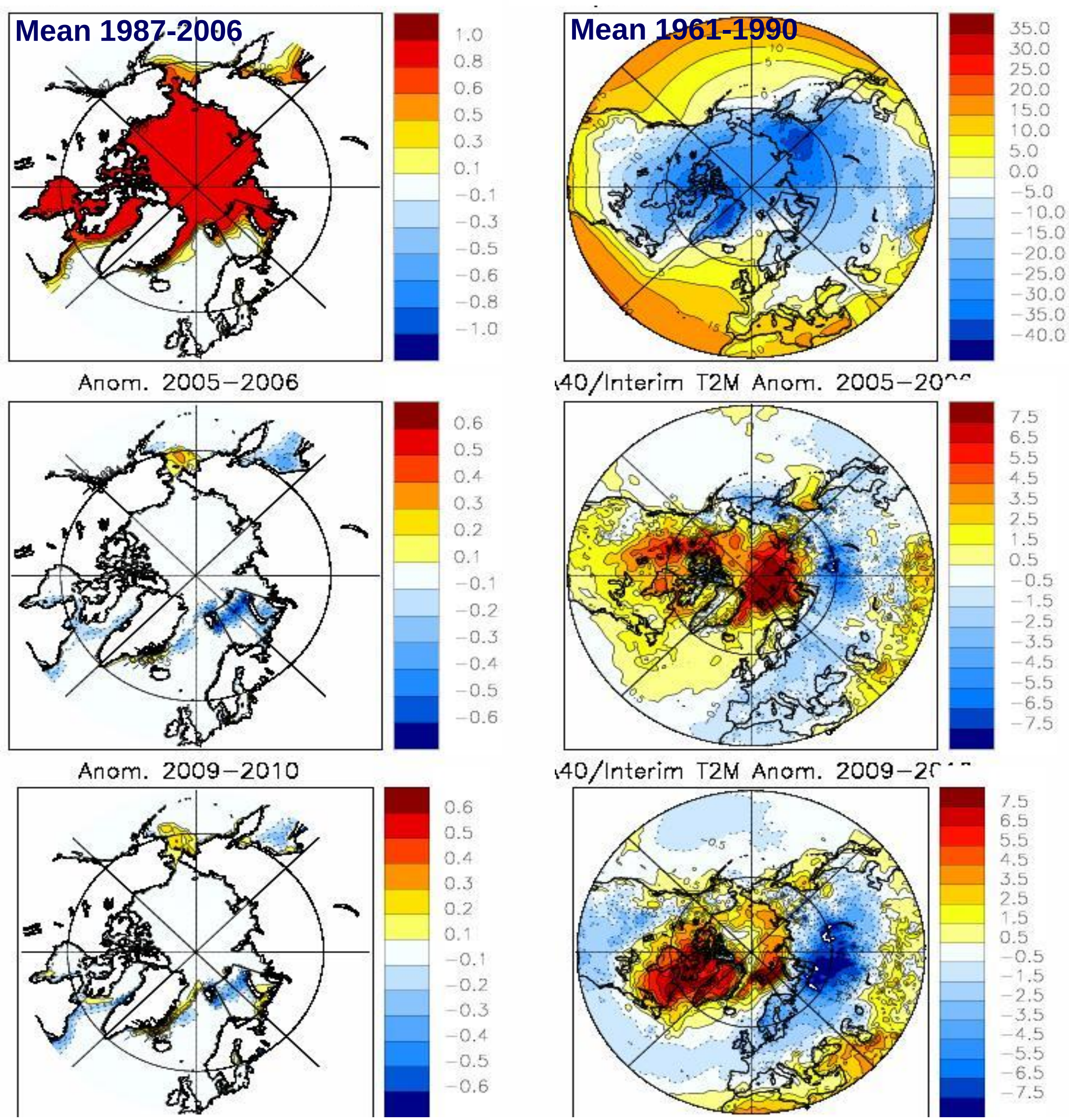
ERA Interim time series: SIC, T2m (N+S), meridional temp. gradient (MTG), U_{850}



Outten and Esau Clim. Change 2012

Recent cold European winters coincide with abnormally reduced sea ice concentration in the Barents-Kara Sea

Sea Ice Concentration | **Surface Air Temperature (°C)**



Mean

Anomaly DJF 2005-2006

Anomaly DJF 2009-2010

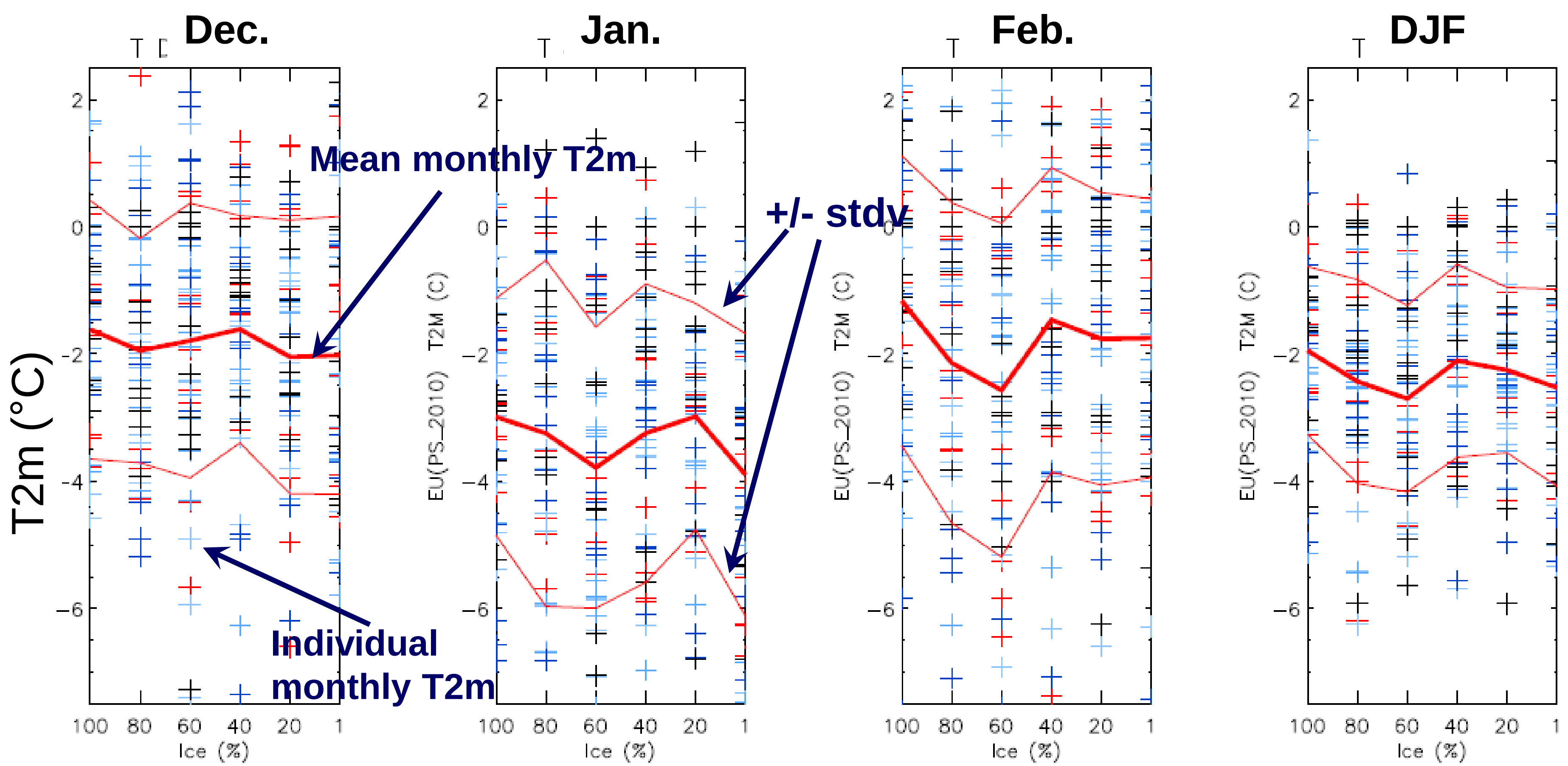
dmi

Arctic sea ice reduction and extreme cold winters in Europe: revisited

- **Experiment setup as in Petoukhov and Semenov (PS2010).**
- EC-Earth atmosphere-only, T159 L31
- **6 experiments** of 50 years AMIP-type runs:
  - forced with the same prescribed SSTs but different SICs;
- Climatological run (**100%**):
  - SSTs from AMIP (obs) for year 2005 – 2006 (a cold European winter);
  - SICs from climatological mean over period 1987-2006;
- 5 reduced SIC runs (**80%, 60%, 40%, 20% and 1%**)
  - Same SSTs as in 100%;
  - SICs as in 100% everywhere except in the Barents and Kara (B-K) Sea sector (30°E - 80°E, 65°N - 80°N)
  - SICs in B-K Sea are set to 80%, 60%, 40%, 20% and 1% of November to April climatology

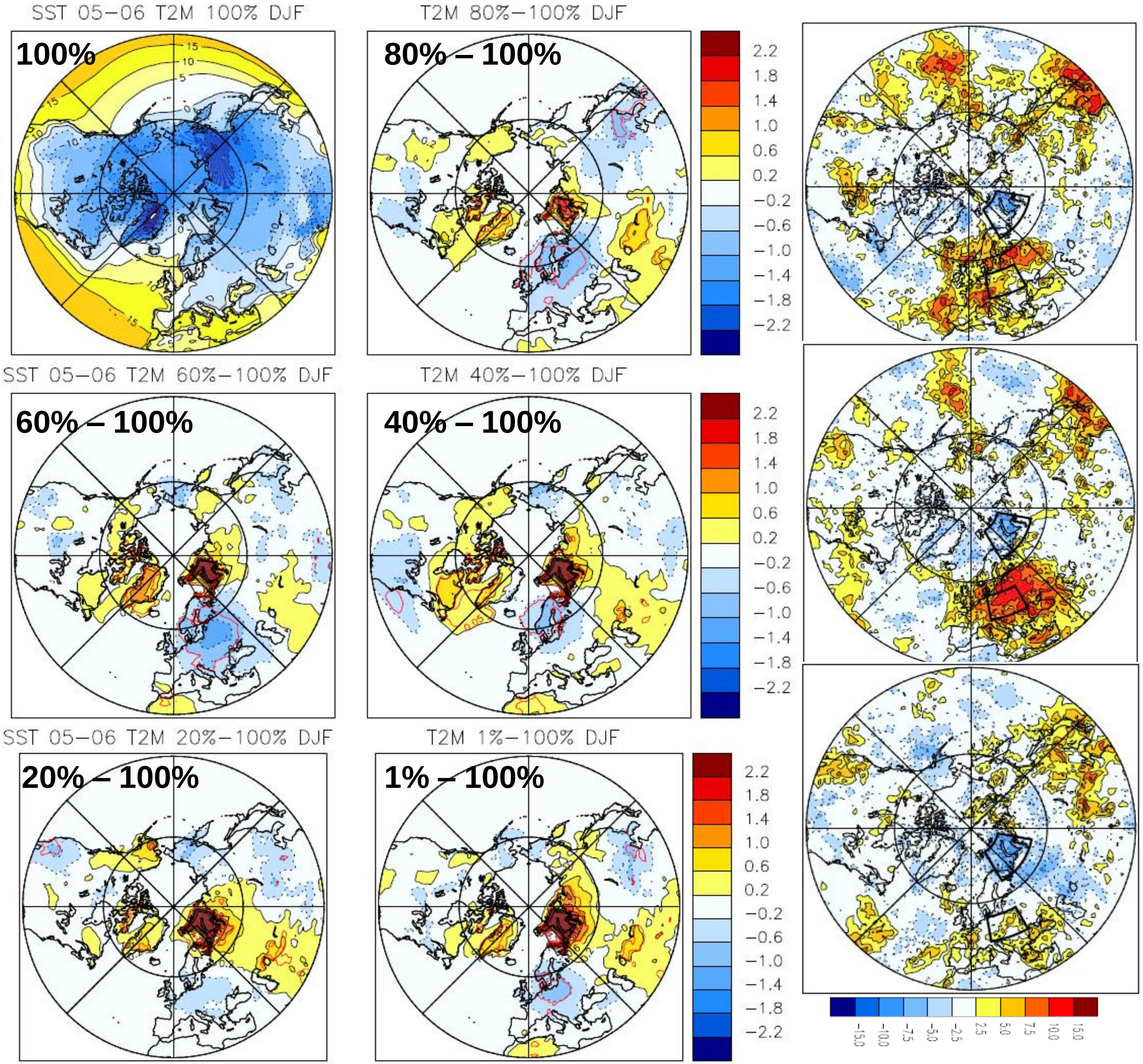
"Cold" Case

T2m Response in Central Europe (10°E-30°E, 45°N-55°N)



B-K SIC with respect to climatology (%)

“Cold” Case



Left: Mean T2m DJF differences wrt 100%
Right: Change in probability (T<1.5σ)

Confirms main results of PS2010 with another model at much higher resolution.
Reduction of B-K SIC can result in increased probability of cold European winter months.
We do not see the nonlinear response of PS2010 to the B-K sea ice reduction

Does B-K sea ice reduction always mean cold winters?

“Warm” Case

- **A warm winter year 1989-1990 for Europe**
  - **Experiment setup same as cold case except SSTs are from 1989-1990 (a warm year)**
  - 6 AMIP-type experiments with
    - the climatological B-K SIC (100%), and
    - 5 reduced SIC runs (80%, 60%, 40%, 20% and 1%).
    - Summary: In contrast to the cold case, under the warm winter condition, the sea ice reductions in the B-K sector lead to a general **increase** of winter temperature, and more extreme warm months in Europe. The only difference is that SSTs are taken from different years

Arctic SIC reduction and European cold winters in the future

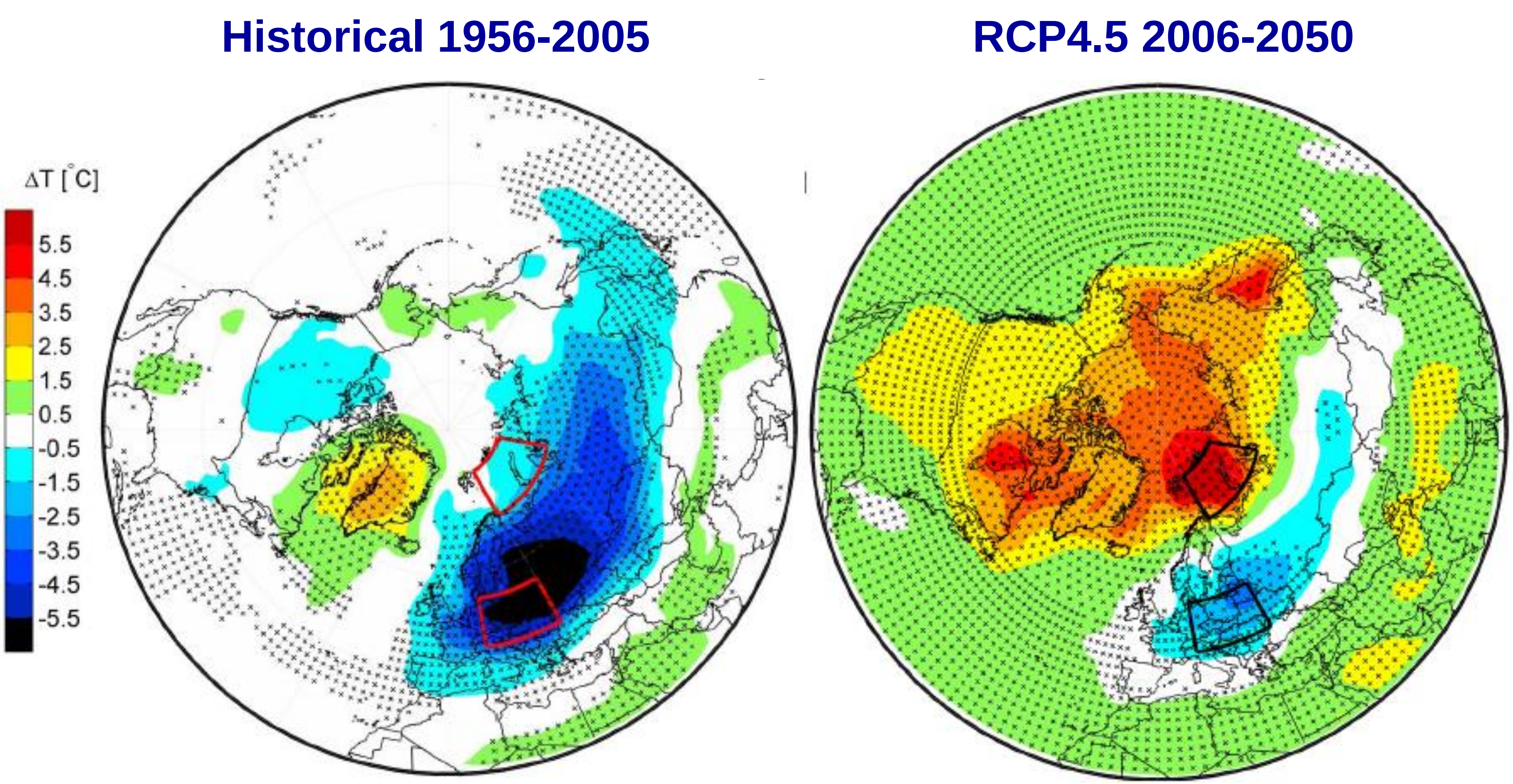
- Under certain conditions, SIC reduction in the B-K Sea may result in significant decrease of winter temperature in Europe
- North Atlantic SSTs not relevant; B-K Sea only relevant in "cold" mode – but then it is a sensitive factor
- Is this relationship between B-K sea ice reduction and the occurrence of European cold winters generic to climate system? Can we expect more cold winters as Arctic sea ice decline continues?

  – Investigate 13 CMIP5 model simulations
  – Focus on the occurrence of 'cold winters' in the in the future (defined as monthly mean T2m below average for the respective model climatological monthly mean temperature for the period 1971-2000)

DMI

European cold winters in CMIP5

Composite T2m anomalies for European cold Januaries



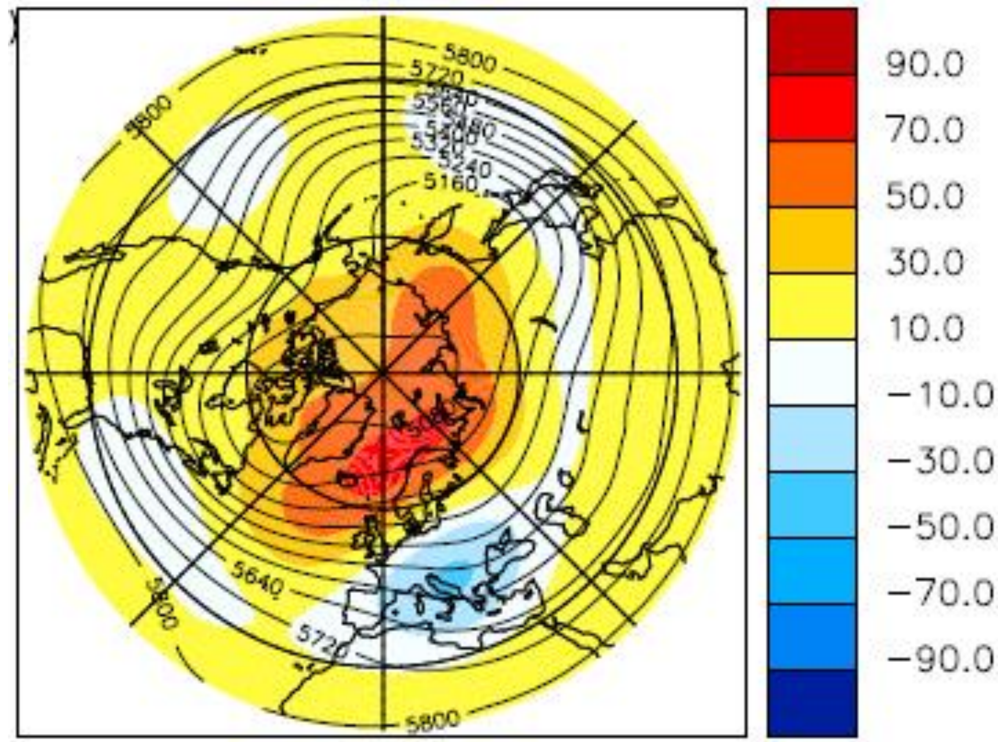
13 model ensemble

Yang & Christensen (2012)

European cold winters in CMIP5

Composite Z 500 hPa for European cold Januaries

RCP4.5 2006-2050



13 model ensemble

Yang & Christensen (2012)

Summary

- Under certain conditions, the SIC reduction in the B-K Sea may result in significant decrease of winter temperature in Europe

⇒ B-K SIC is a sensitive factor for European winter temperature when the global SST pattern is in the right condition

- Connection between European cold winters and B-K Sea SIC reduction also simulated in CMIP5 models
- Consistent circulation patterns associated in most CMIP5 models, similar to that in the idealized EC-Earth experiments.

⇒ **The recent cold winters in Europe are not in conflict with the global warming trend**