Modeled Sensitivity of the Upper-Ocean Properties in the Nordic Seas to Wind Forcing

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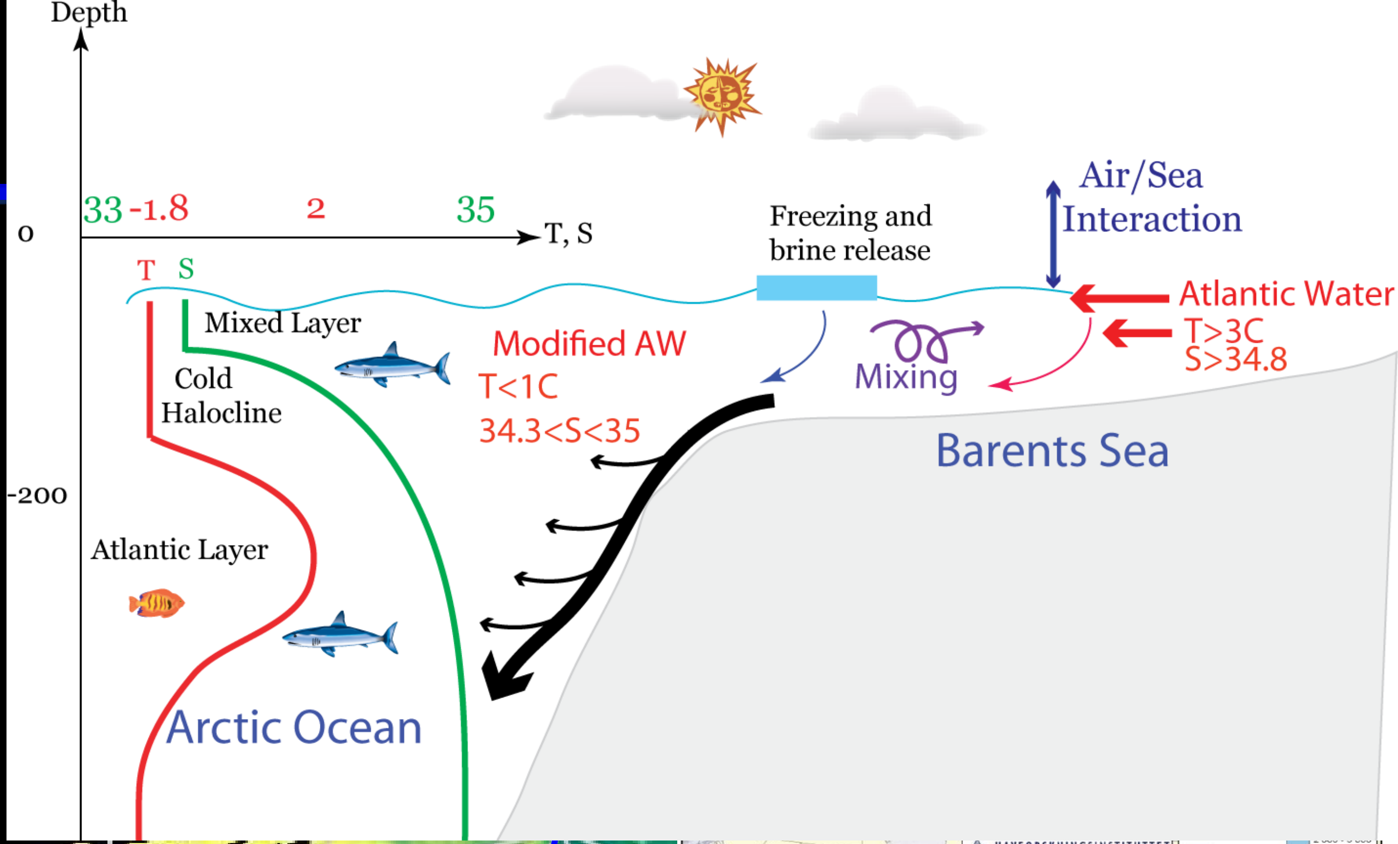

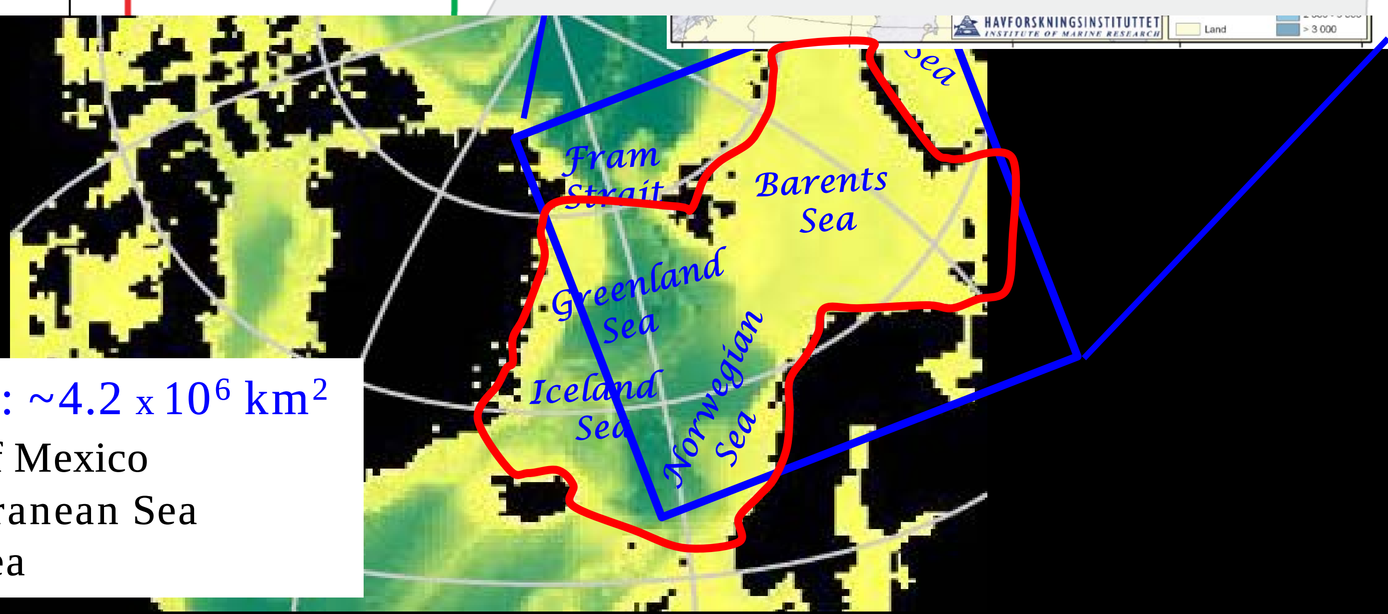

Area of the Nordic Seas: ~4.2 x 10^6 km^2

~**2.8** areas of the Gulf of Mexico

~**1.7** area of the Mediterranean Sea

~**11** areas of the Baltic Sea

Polar Lows off the coast of Norway and Russia on January 7 2009 from NOAA AVHRR

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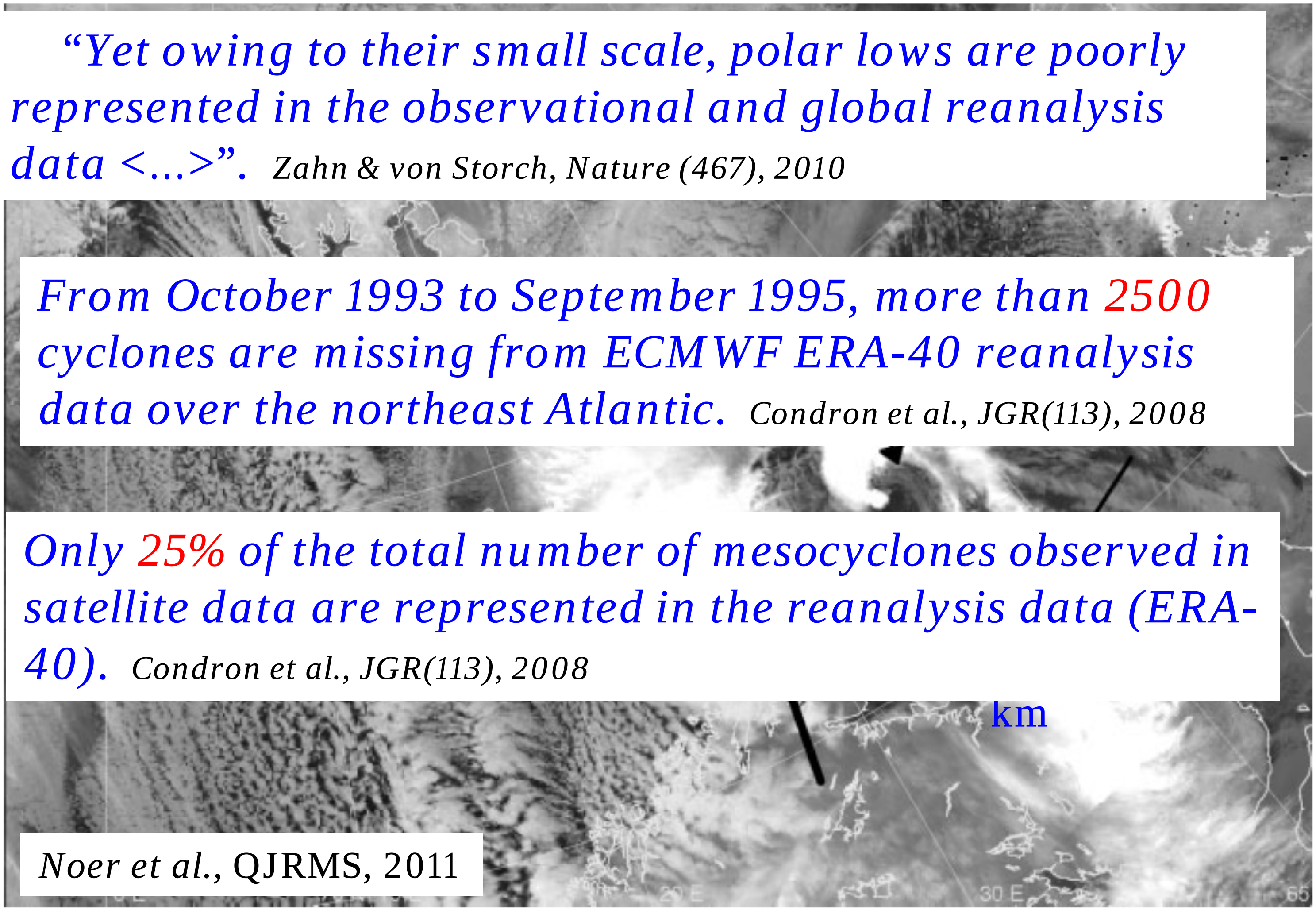
“Yet owing to their small scale, polar lows are poorly represented in the observational and global reanalysis data <…>”. *Zahn & von Storch, Nature (467), 2010*

From October 1993 to September 1995, more than 2500 cyclones are missing from ECMWF ERA-40 reanalysis data over the northeast Atlantic. *Condron et al., JGR(113), 2008*

Only 25% of the total number of mesocyclones observed in satellite data are represented in the reanalysis data (ERA-40). *Condron et al., JGR(113), 2008*



Noer et al., QJRMS, 2011

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km

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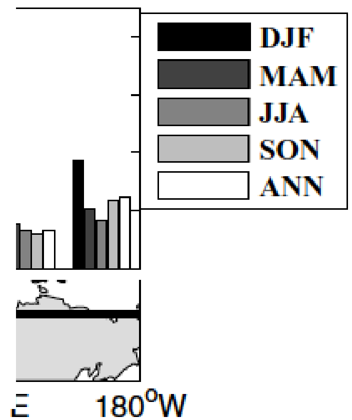
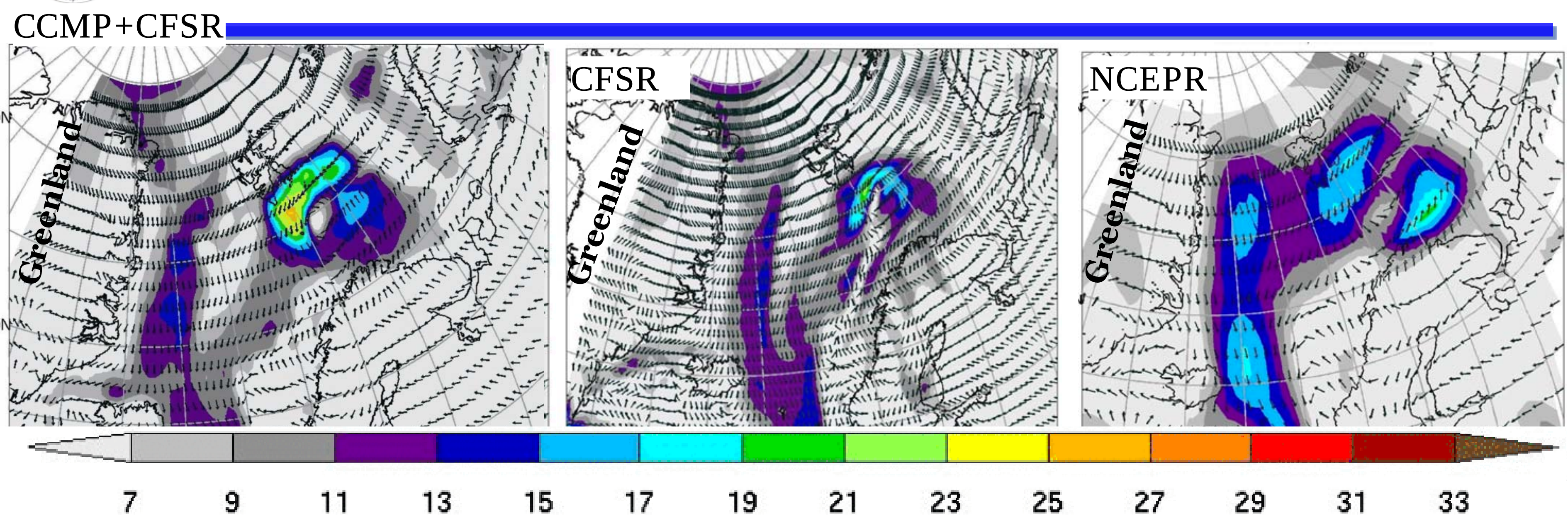


DJF:	9	5	5	6	1	26	12	8	9	4	3	12
MAM:	7	6	8	8	1	18	10	10	11	7	6	7
JJA:	8	3	5	7	0	14	12	12	14	11	6	7
SON:	8	5	8	11	0	21	10	9	10	7	4	8
ANN:	8	5	7	8	0	20	11	10	11	7	5	9

Sorteberg & Walsh, 2008

Surface Winds, March 5, 2006



Cross-Calibrated Multi-Platform Ocean Surface Wind Components (CCMP)

- Period covered: July 1, 1987 – 2011; **0.25**° resolution, 6hr fields
- The data set combines data derived from several scatterometer satellites
- Satellite data are assimilated into the ECMWF Operational Analysis fields

NCEP Climate Forecast System Reanalysis (CFSR)

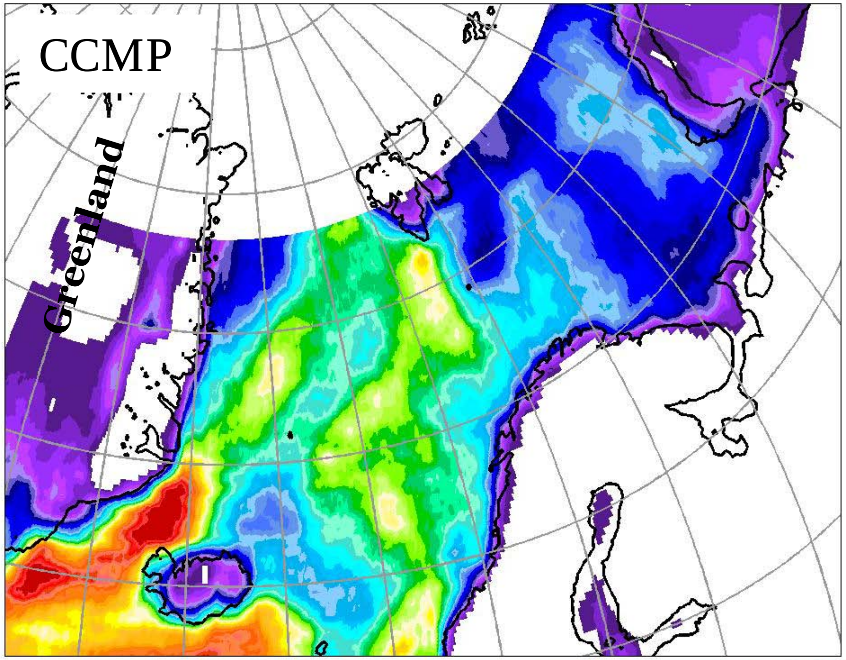
- Period covered: 1979 – March 2011; ~**0.31**° resolution, 1hr fields
- Assimilation: all available conventional and satellite observations
- Updated assimilation and forecast system (from NCEPR 2)
- Covers atmosphere, ocean, sea ice, and land
- Anticipated to supersede the older NCEPR products both in scope and quality

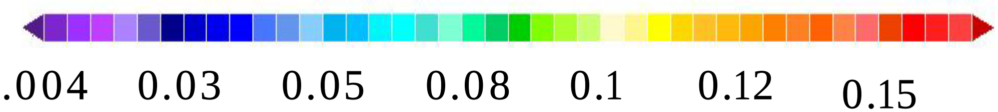
National Center for Environmental Prediction Reanalysis 2 (NCEPR)

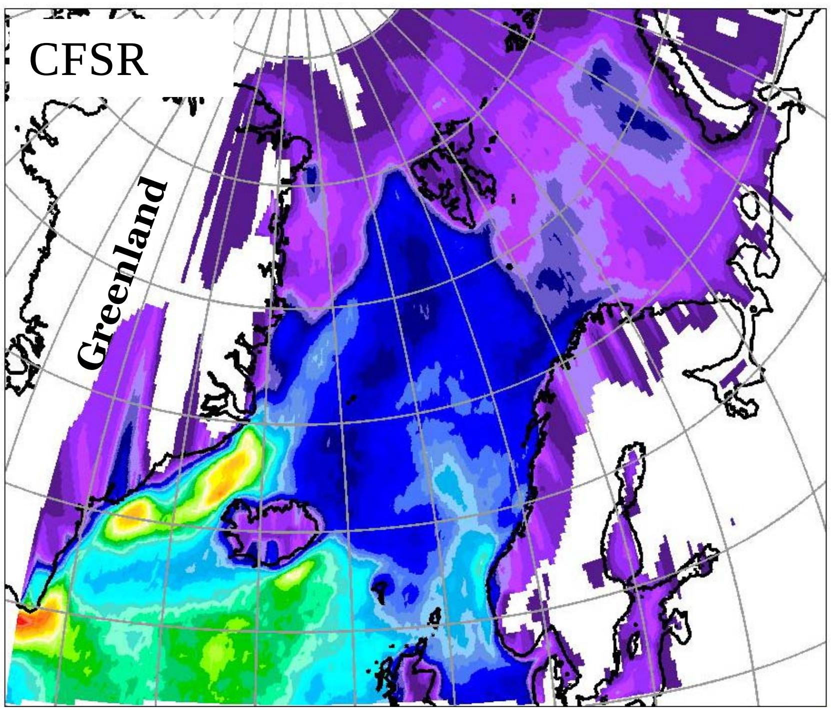
- Period covered: 1891 – present;
- Assimilated observations: surface pressure, SST and sea ice distribution, scatterometer winds (since 2002)
- Products include 3- and 6-hourly data on ~**1.9 x 1.9**° global grid, monthly, daily averages

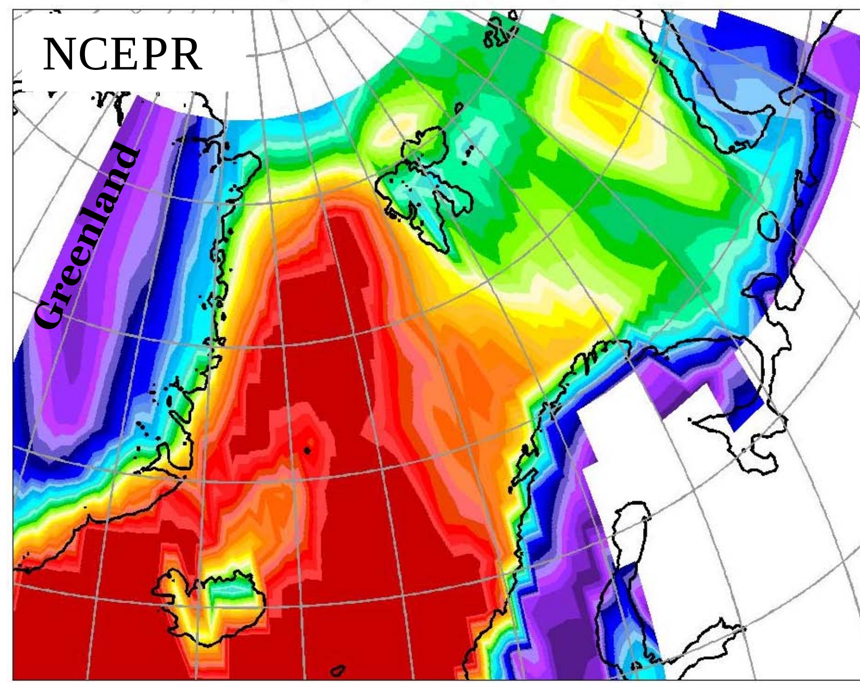
The primary source of forcing parameters in many Arctic Ocean model experiments

Exceedence Probability of U>17 m/s during winter season, 2005-2007







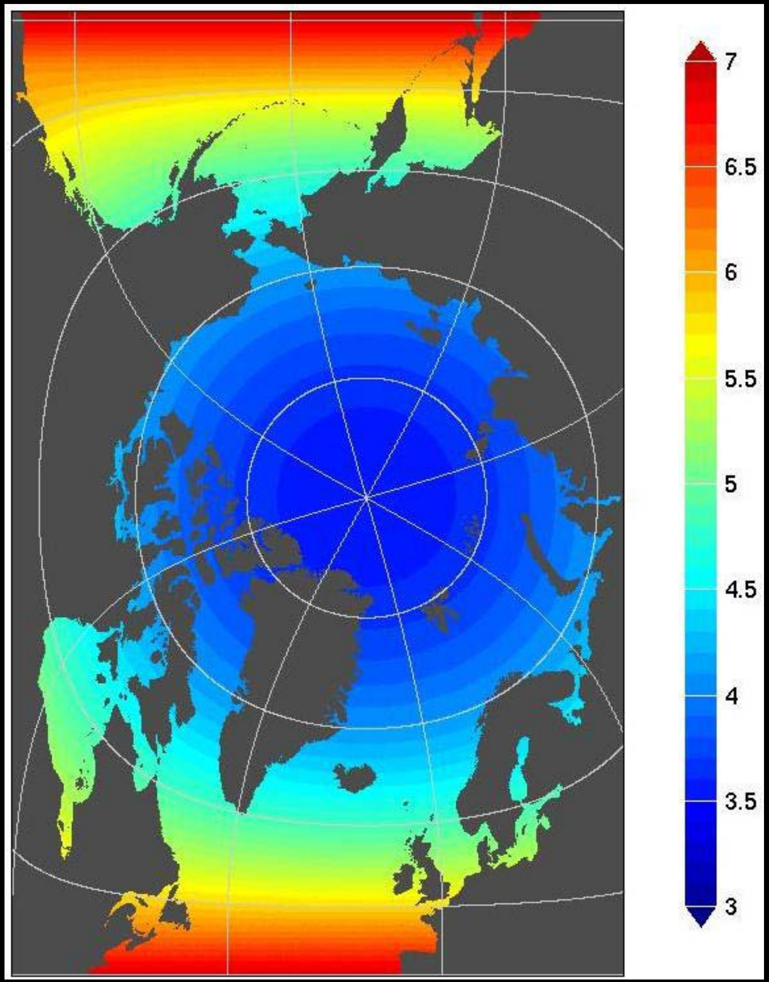


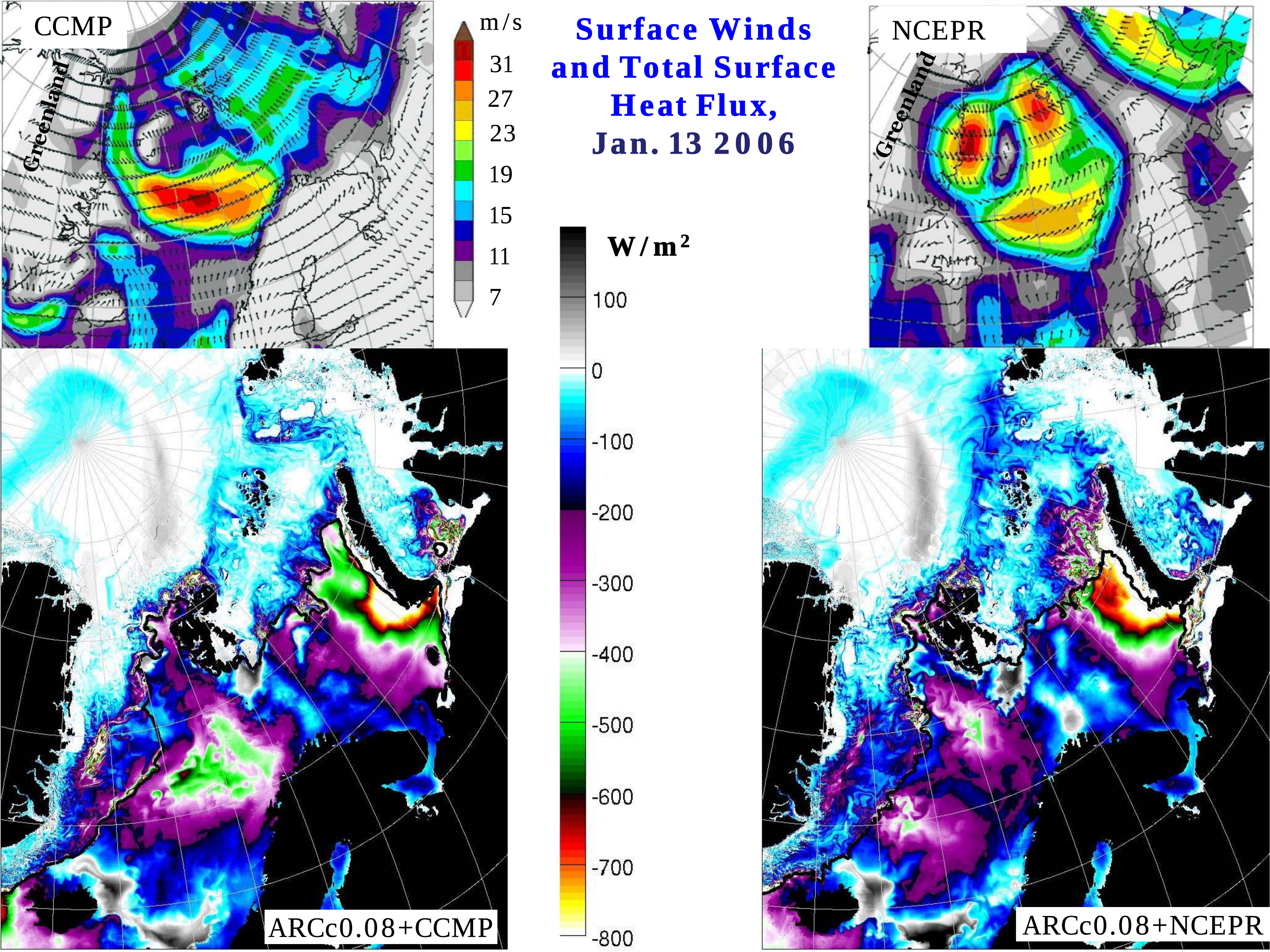
Model Experiments with CFSR, NCEPR, and CCMP Winds

0.08° HYCOM/CICE Modeling System of the Arctic Ocean

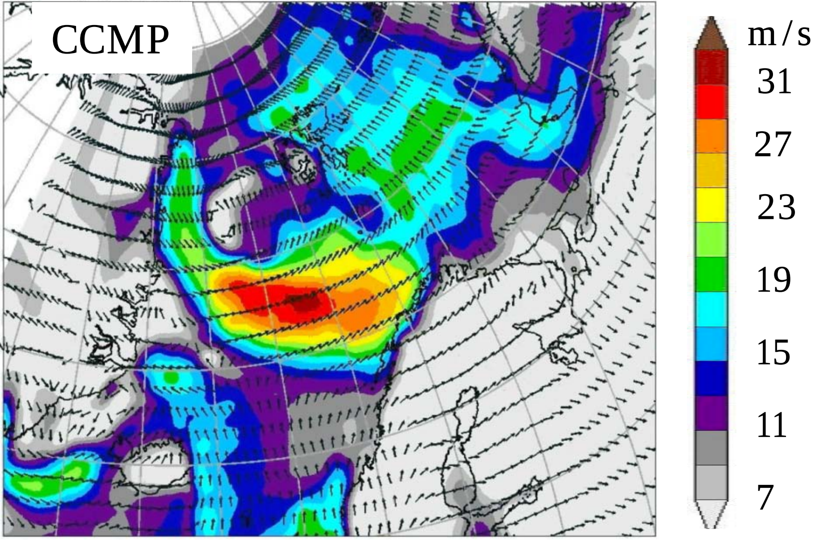
- ARCc0.08: Coupled HYbrid Coordinate Ocean Model and Los Alamos Sea Ice Model (CICE 4.0)
- 32 vertical ocean levels
- Atlantic and Pacific Boundaries at ~39° N
  - Closed (no-ice) in CICE
  - Nested into 1/12° Global HYCOM
- Initialized from Sept. 2005
- Run from Oct. 2005 – April 2006 with
  - CFSR winds
  - NCEPR winds
  - CCMP + CFSR (north of 78.375N) winds

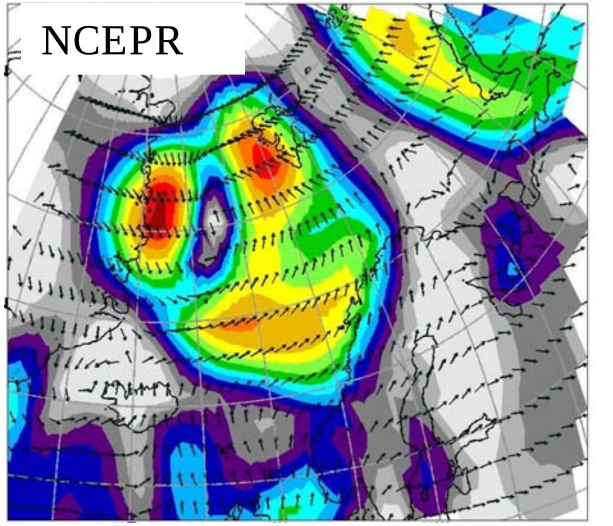
Model Domain and Grid Resolution (km)

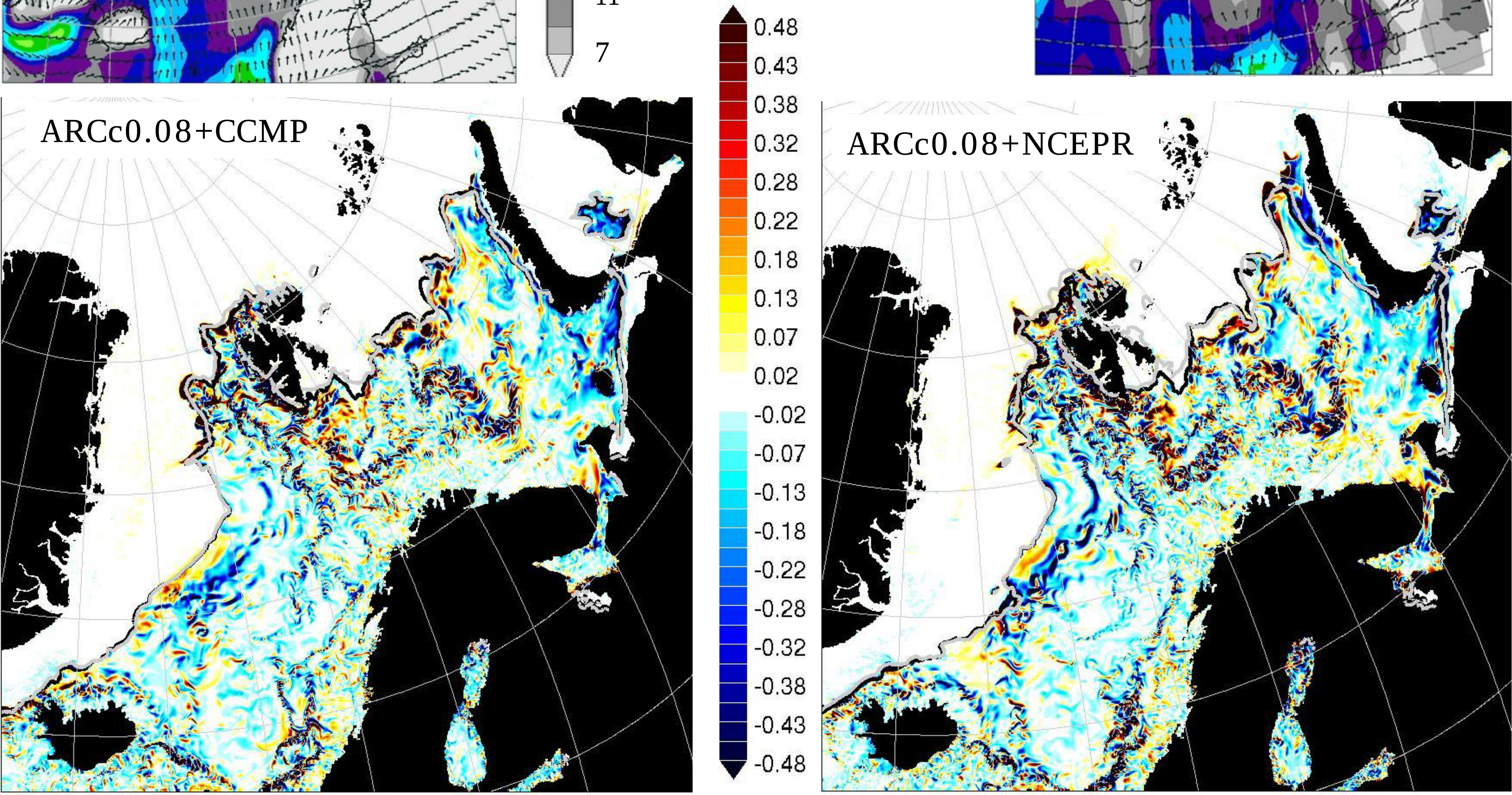



Surface Winds
and Total Surface
Heat Flux,
Jan. 13 2006
CCMP
Greenland
m/s
31
27
23
19
15
11
7
NCEPR
Greenland
W/m²
100
0
-100
-200
-300
-400
-500
-600
-700
-800
ARCc0.08+CCMP
ARCc0.08+NCEPR

Surface Winds and SST Change Jan. 13 2006



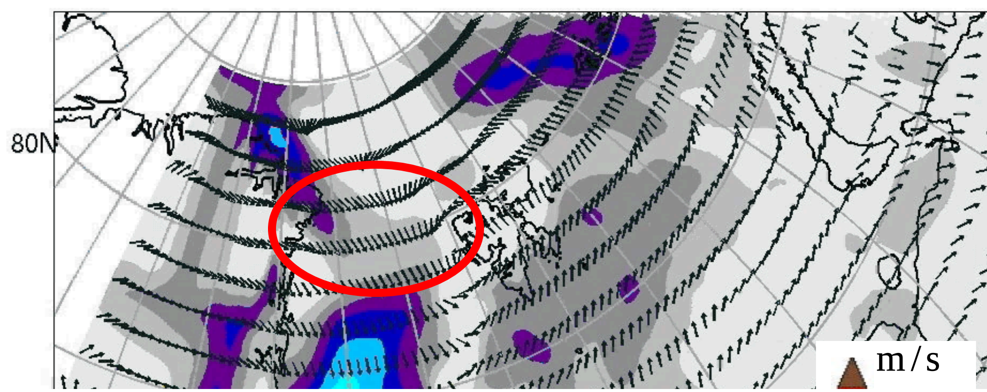


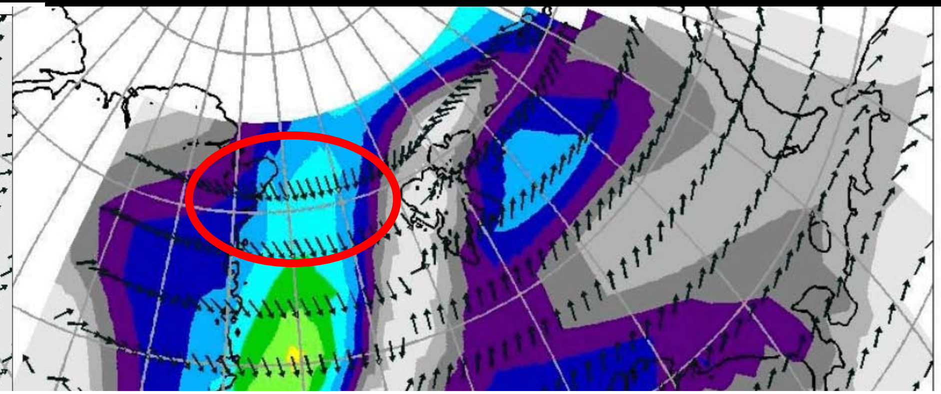


Wind Impact on Fluxes through Fram Strait

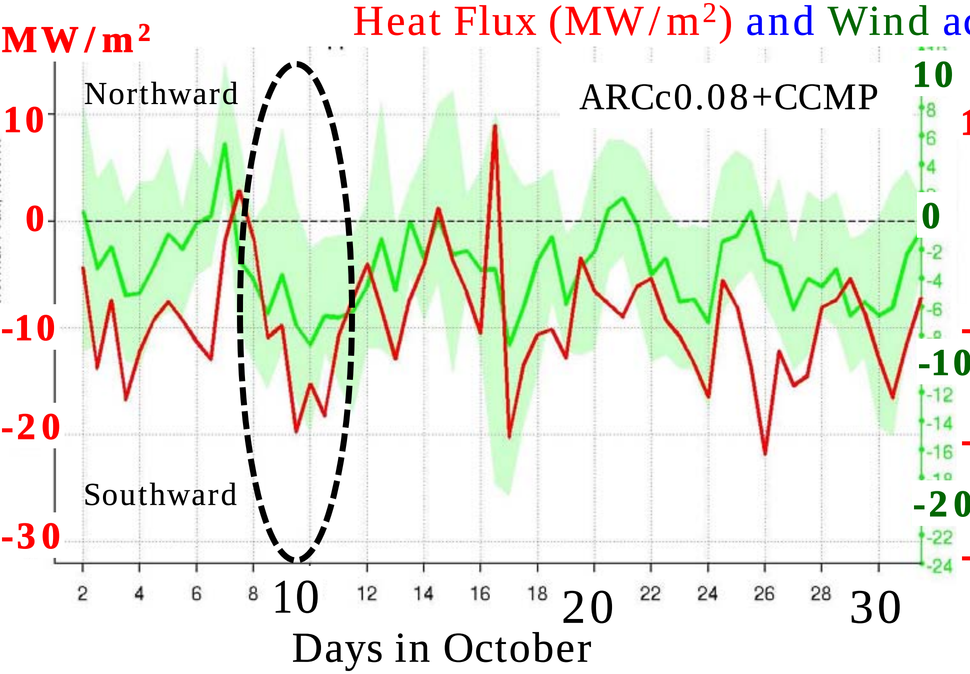
CCMP, Oct. 10 2005 0:00 UTC

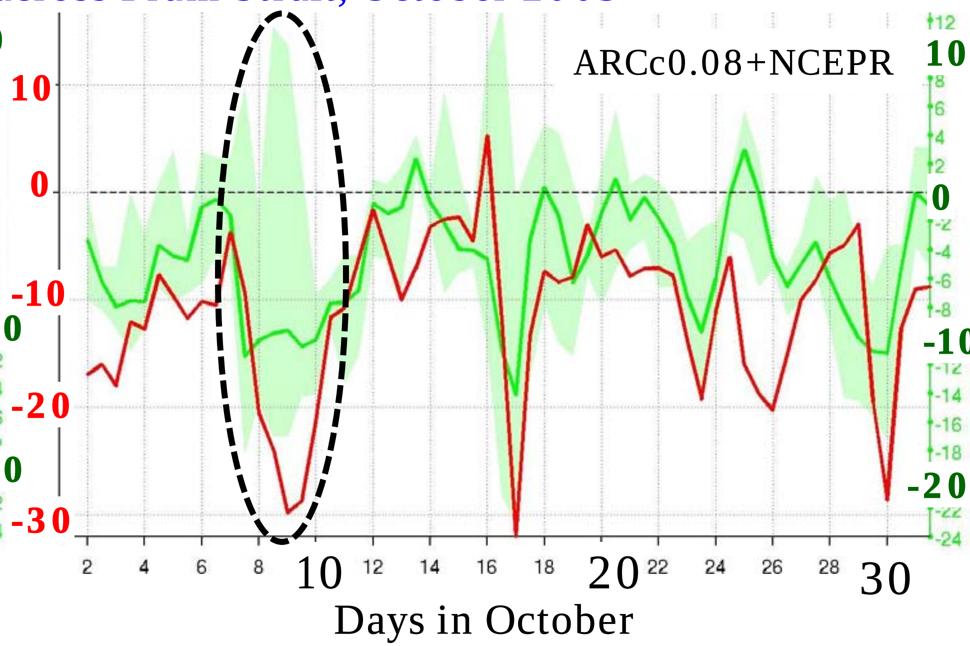
NCEPR, Oct. 10 2005 0:00 UTC



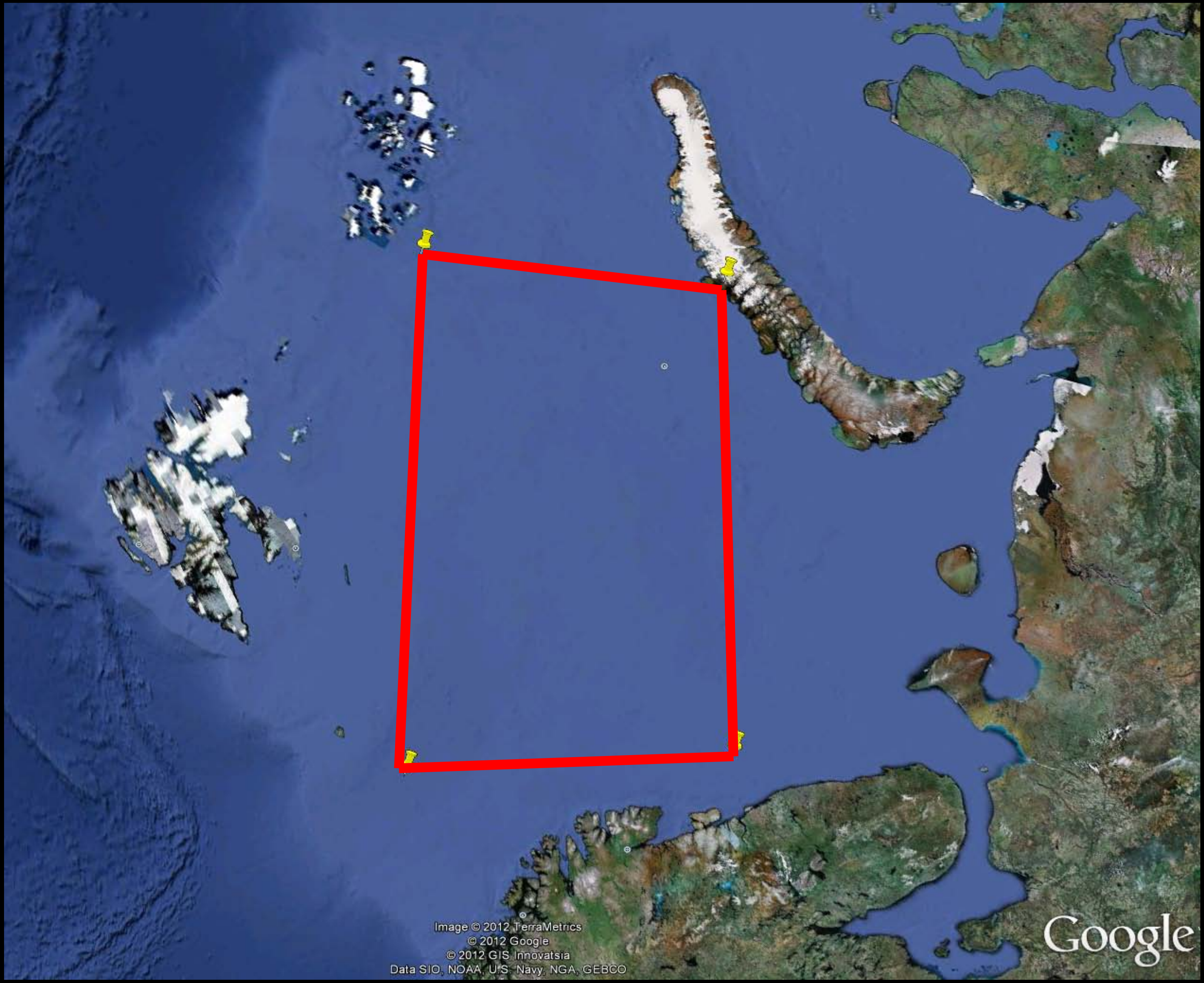


Heat Flux (MW/m²) and Wind across Fram Strait, October 2005

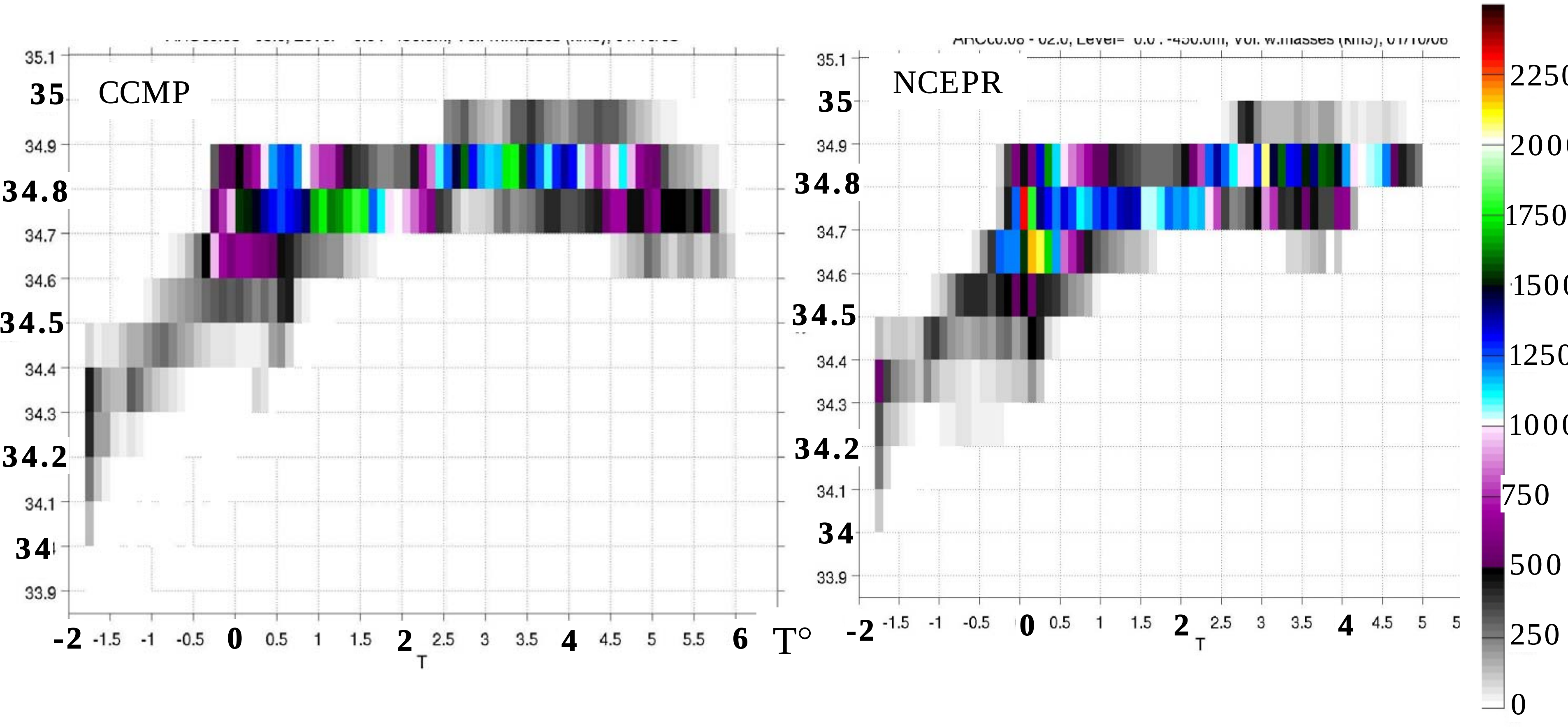




Water Mass Transformation in a Control Volume in the Barents Sea

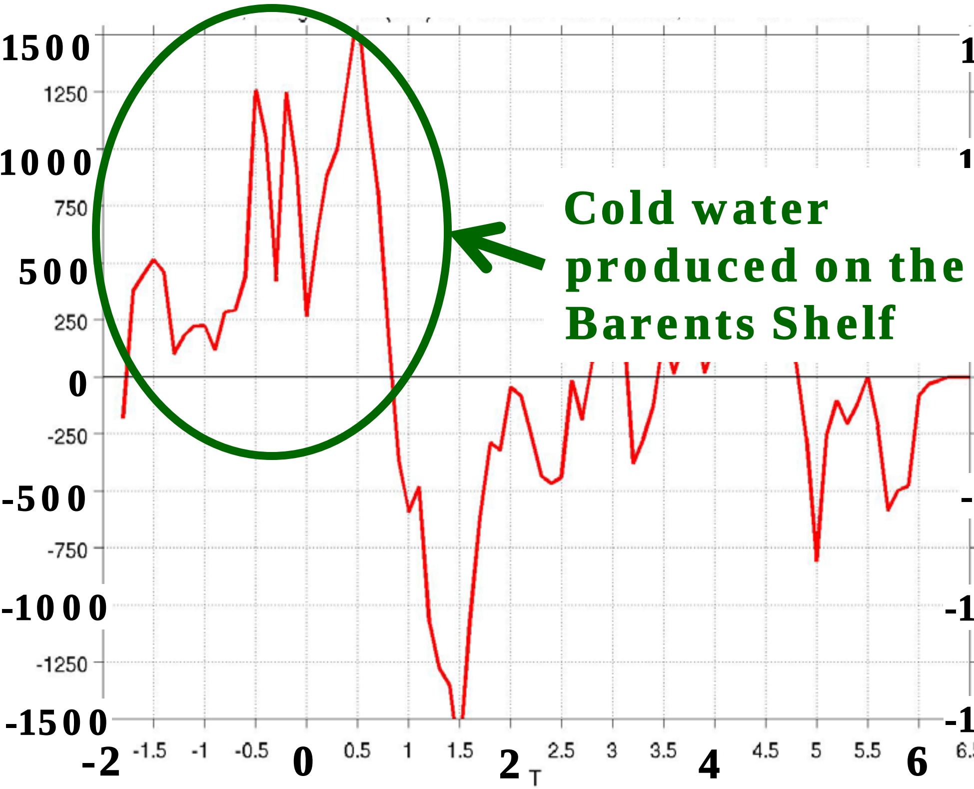


Volume (km^3) of Water Masses, 10 January 2006



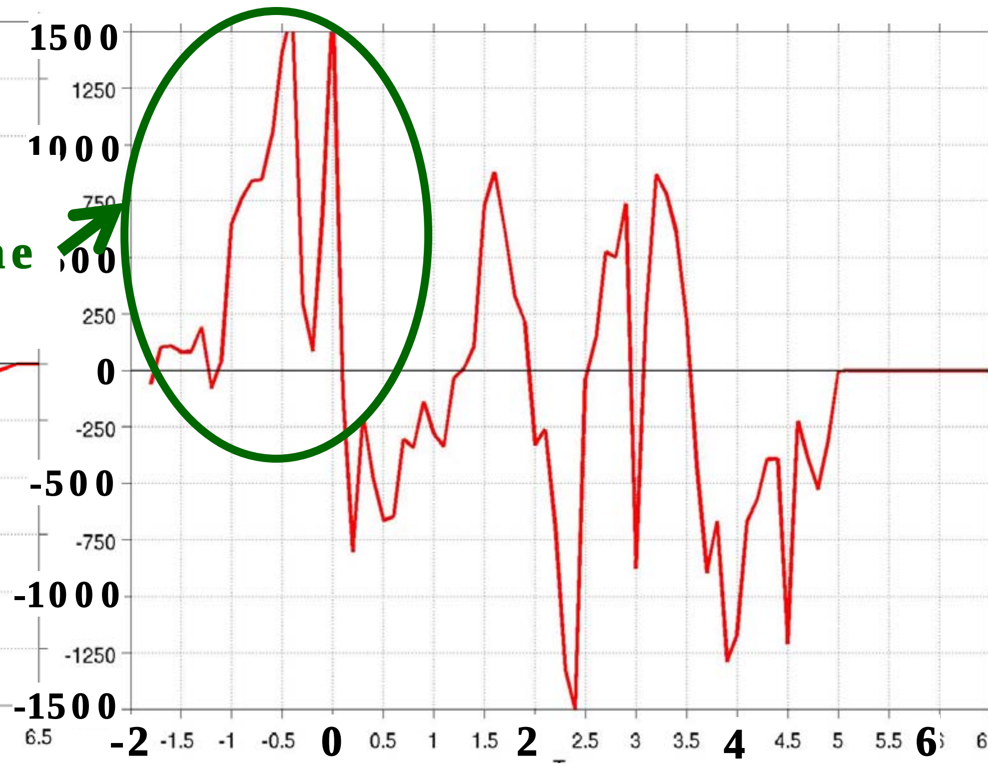
Net Volume Change of Water Masses Binned in T Groups

ARCc0.08+CCMP



Cold water produced on the Barents Shelf

ARCc0.08+NCEPR



Closing Remarks

(1) Winds in the CCMP, NCEPR, & CFSR are different :

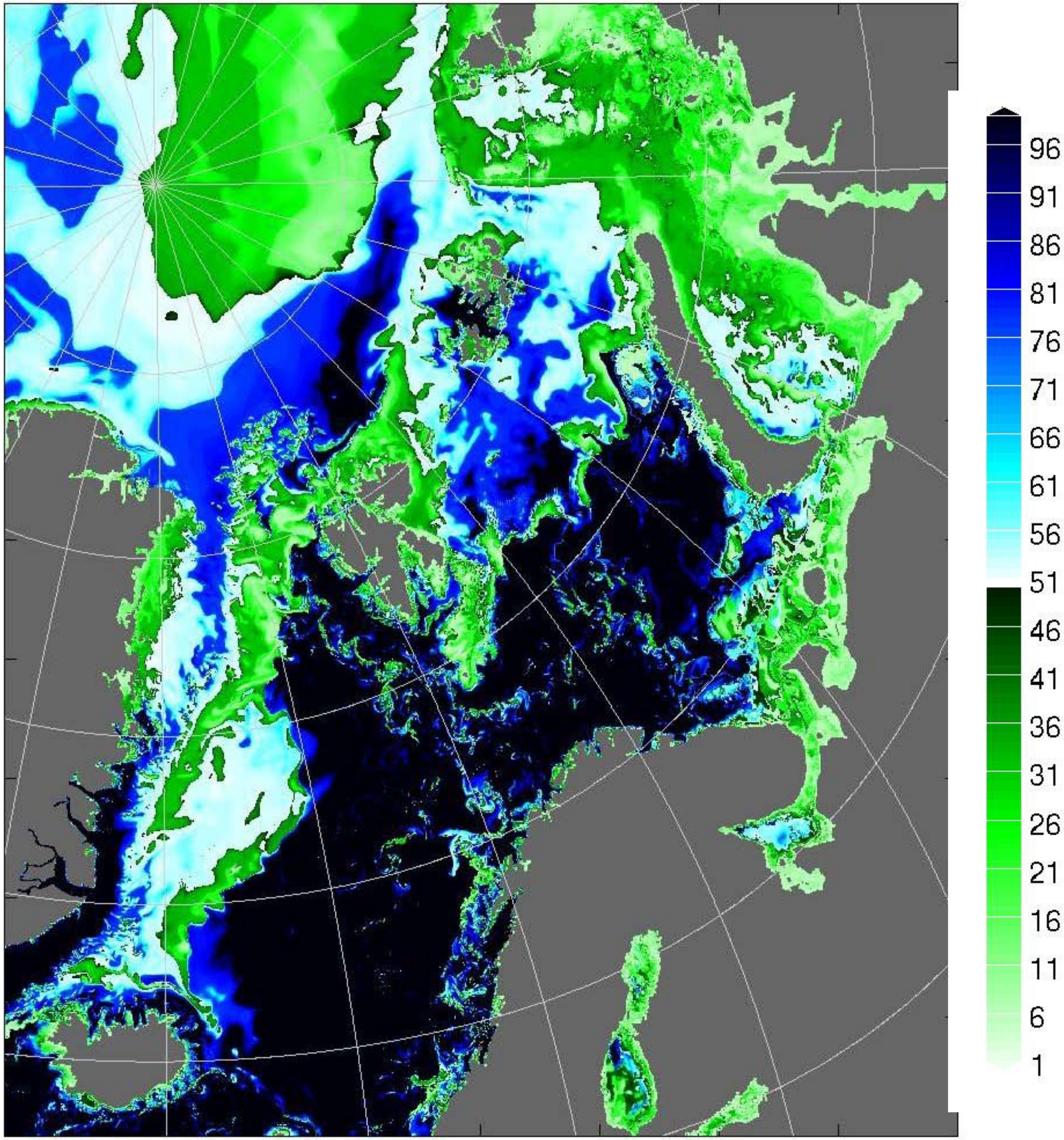
- Location, size, and timing of storms
- On average, the NCEP winds have higher speeds compared to the CCMP & CFSR winds
- In storms, the CCMP winds have higher peak values than both the NCEP & CFSR winds
- CFSR winds have lower winds in the storms than the other wind products
- Meso-scale cyclones are not resolved in the NCEPR data

(2) Oceanic response of the Nordic Seas to the winds is different:

- In the storms, surface heat fluxes differ by ~2 times due to differences in the wind fields
- Winds have obvious impact on Arctic – Nordic Seas exchange
- Numerical experiments with different winds predict different processes of water mass formation in the region

(3) Are meso-scale cyclones represented in the CCMP (other scatterometer wind prodcuts)?

Mixed Layer Depth (m) in ARCc0.08



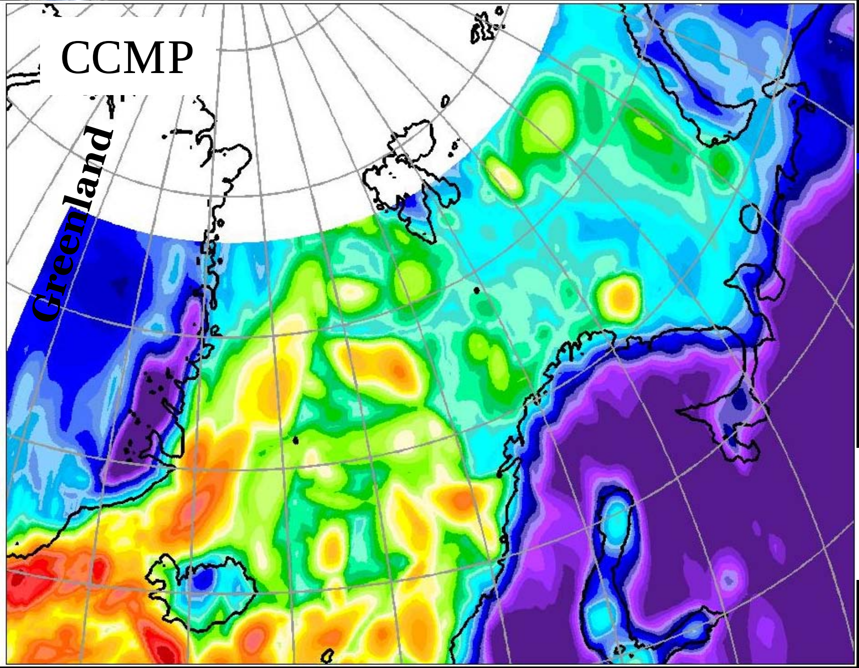
Defined as the average of the depths where:

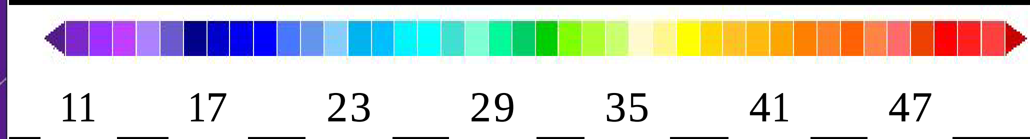
$d\rho/dz > 0.001\ kg/m^4$

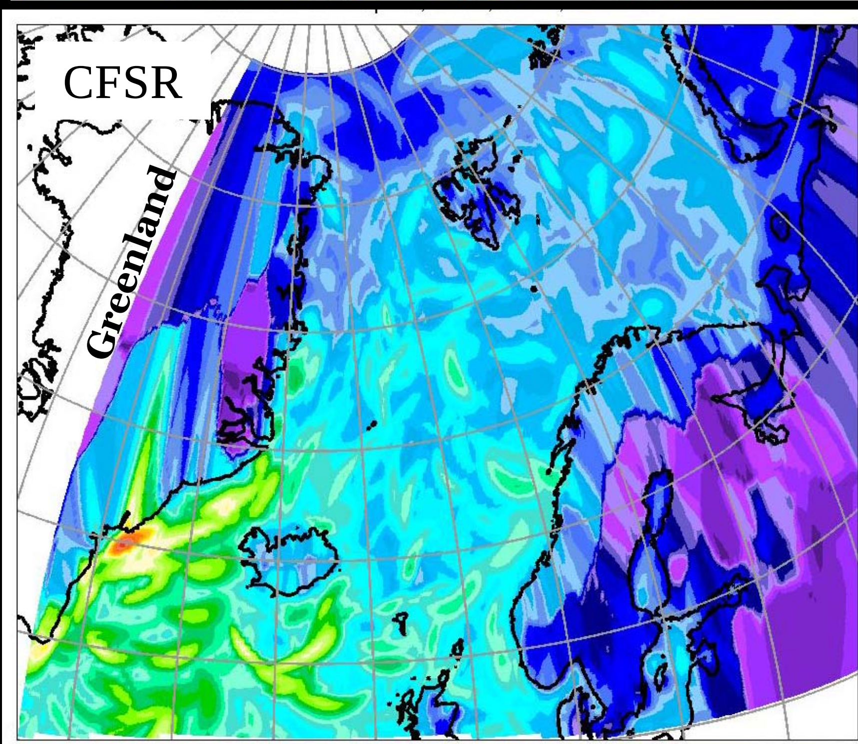
$(\rho(z)-\rho_0)>0.01$

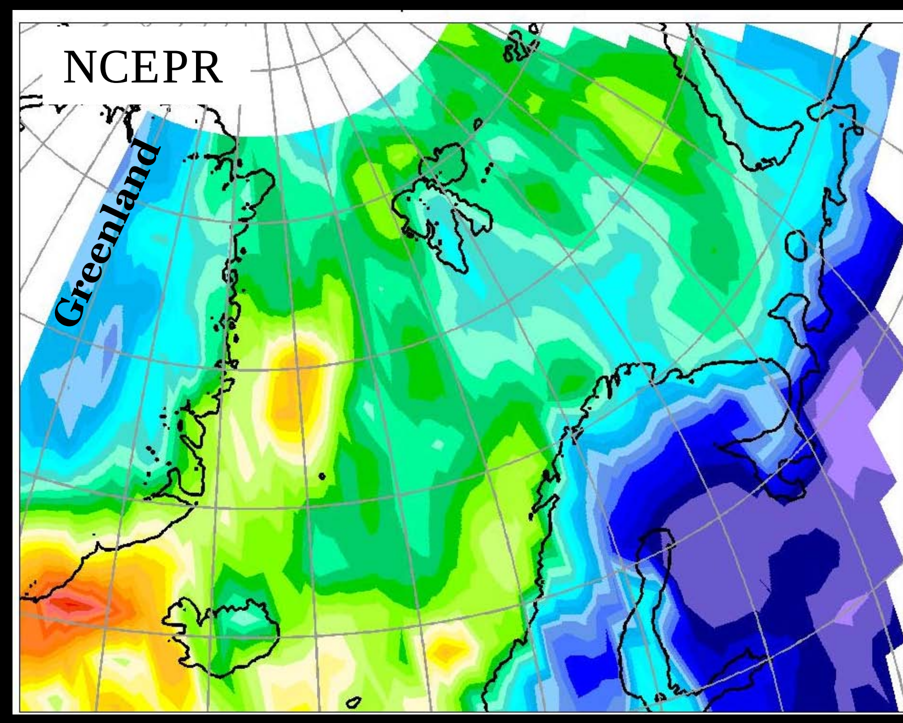
Estimated ΔT in the mixed layer of 100 m depth over 6 hours of Q_{tot}=-1000 W/m^2 is -0.05° C

Maximum Wind Speed winter 2005-2007

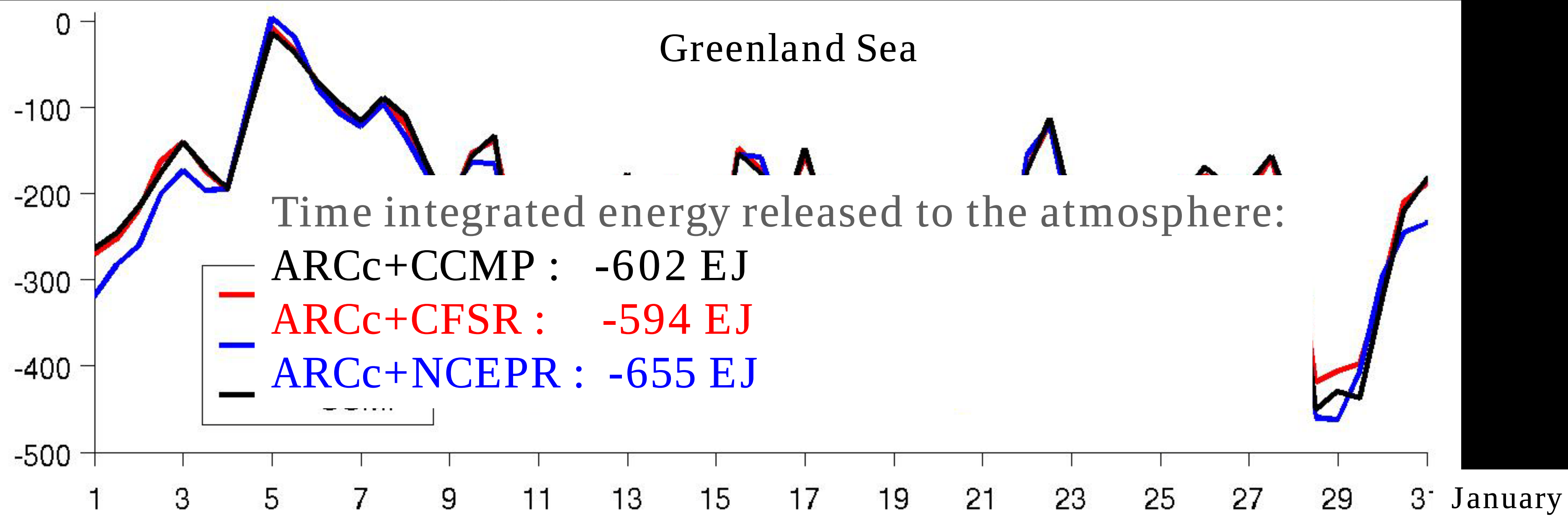


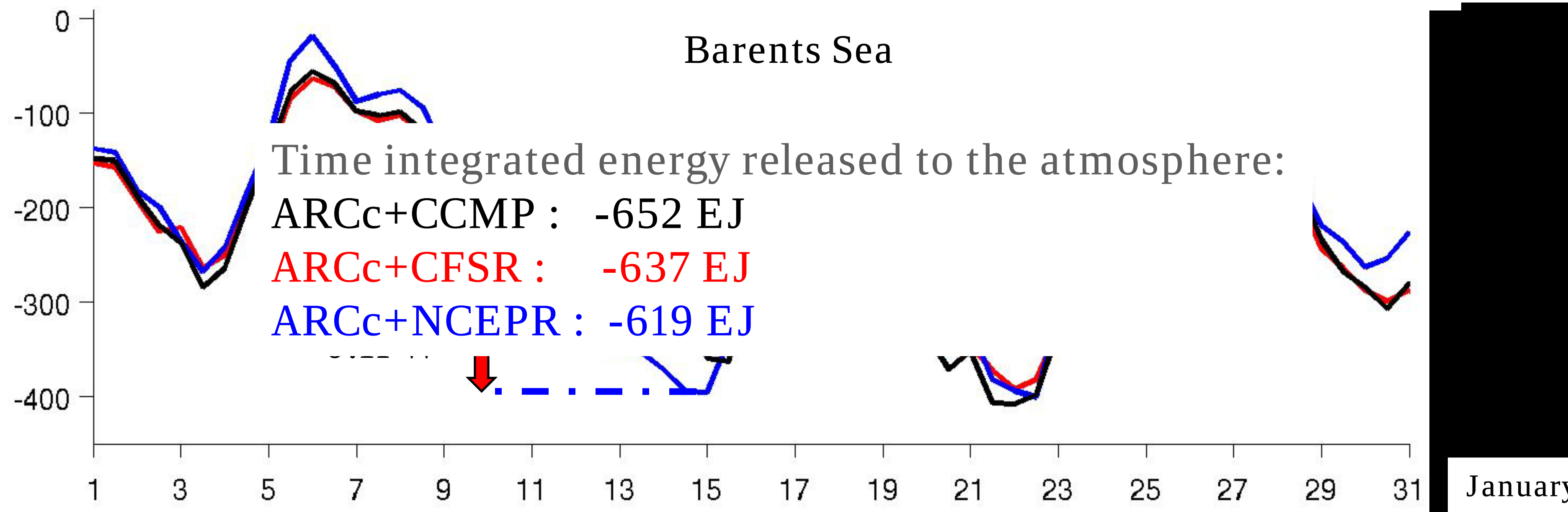




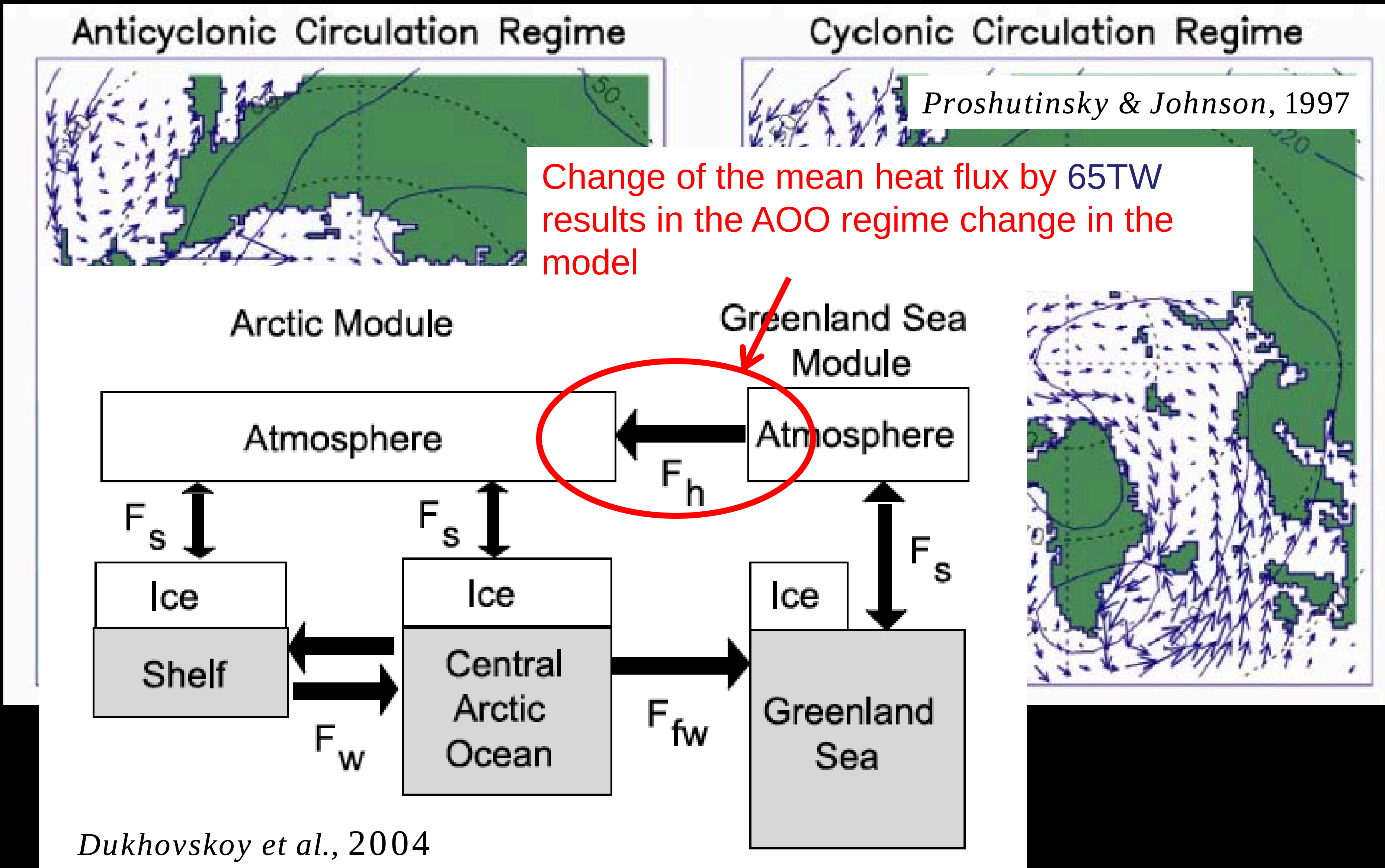


Area-Integrated Heat Flux (TW), January 2006

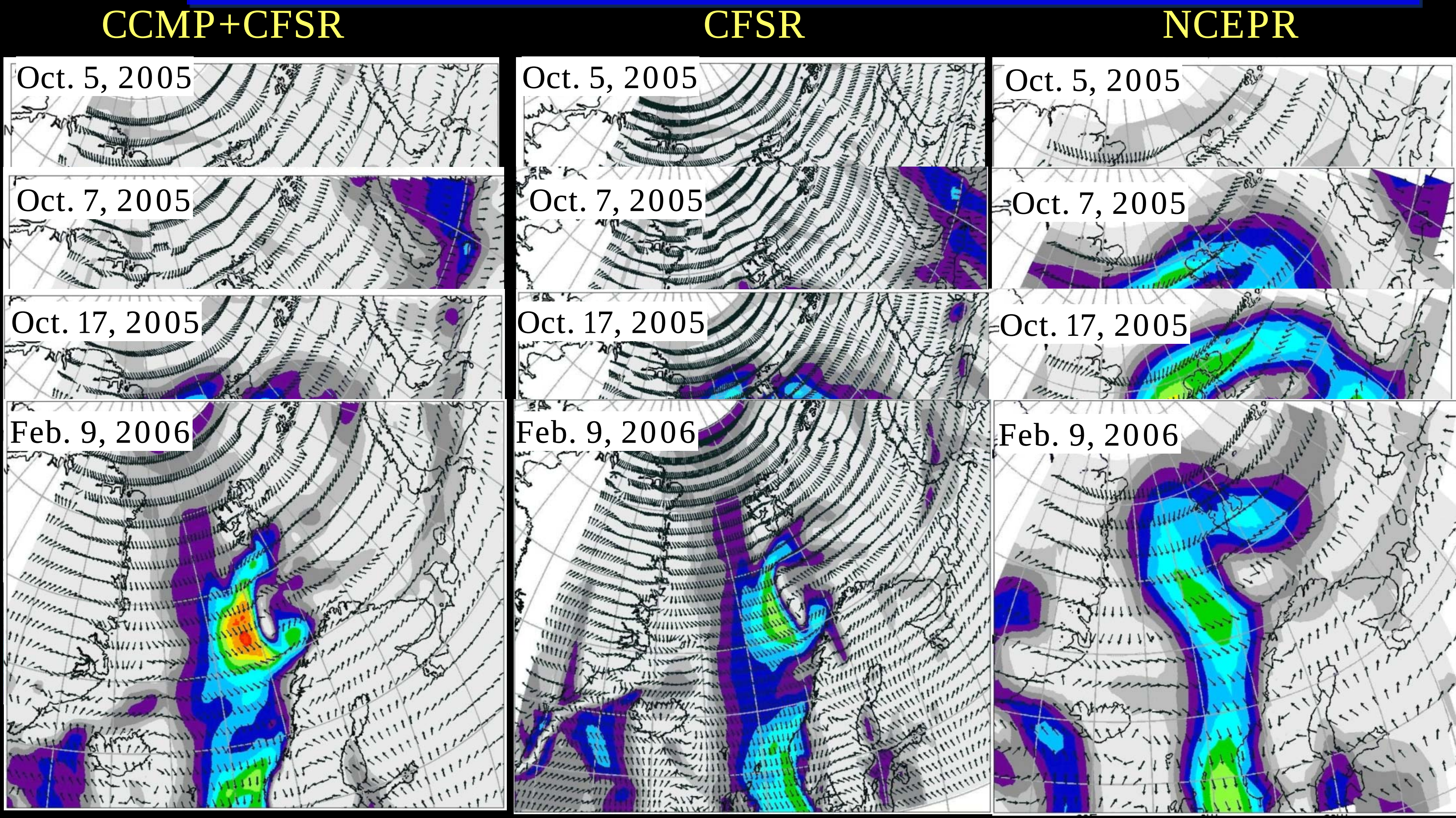




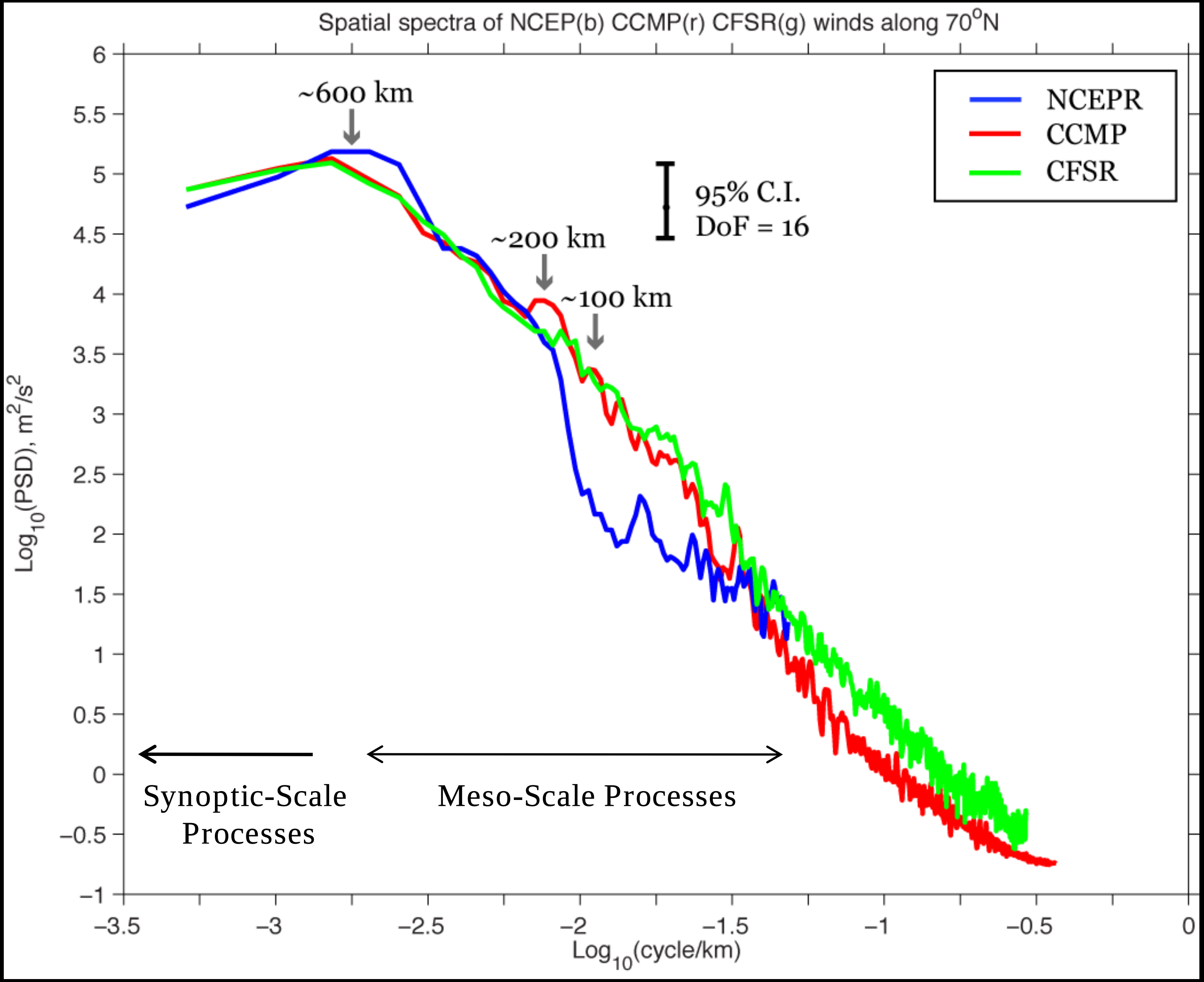
Arctic Ocean Oscillation



Representation of Storms in the Wind Products



Spatial Power Spectra of Winds along 70° N



Polar Lows off the coast of Norway and Russia on January 7 2009 from NOAA AVHHR

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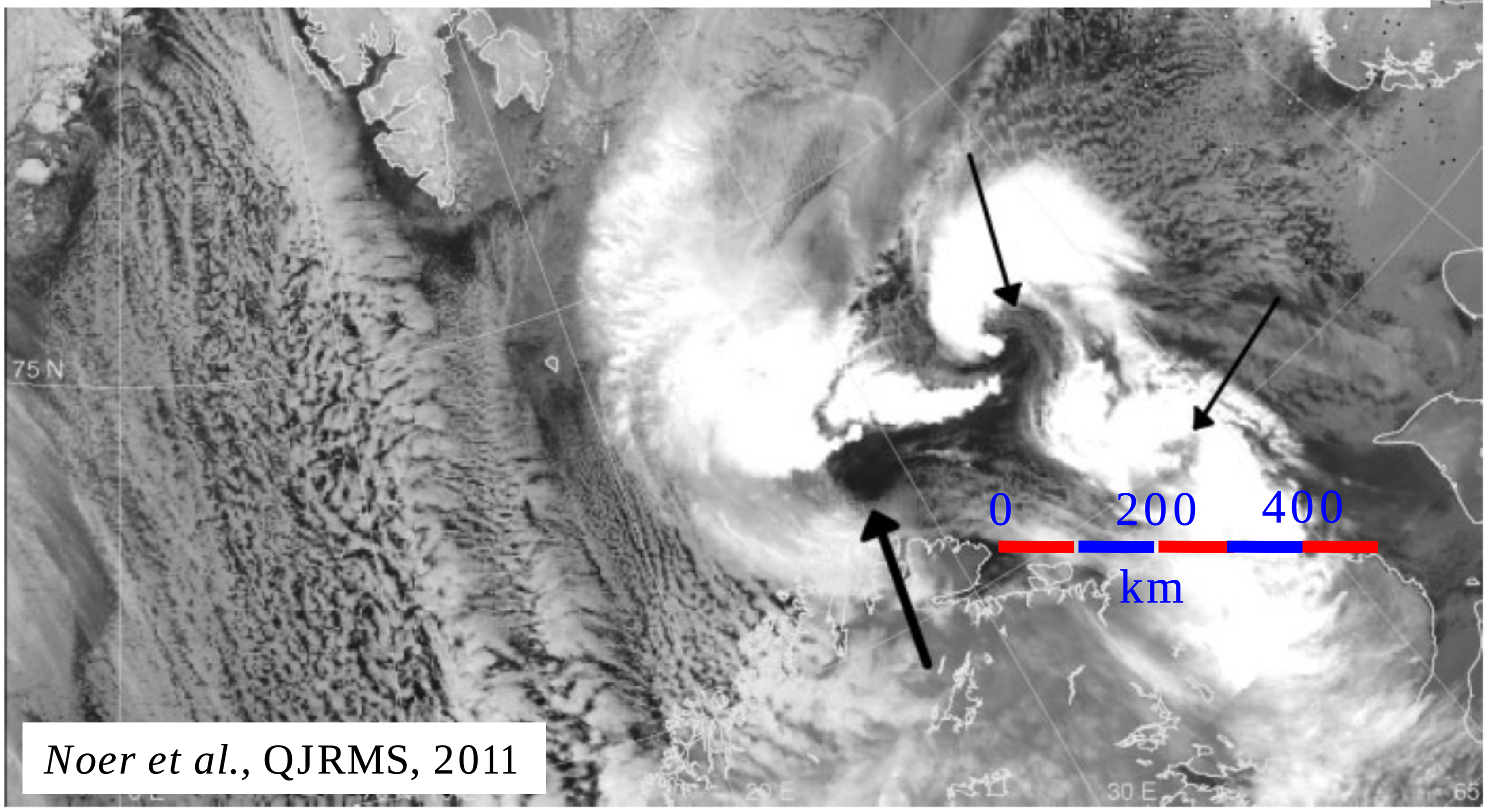

Noer et al., QJRMS, 2011

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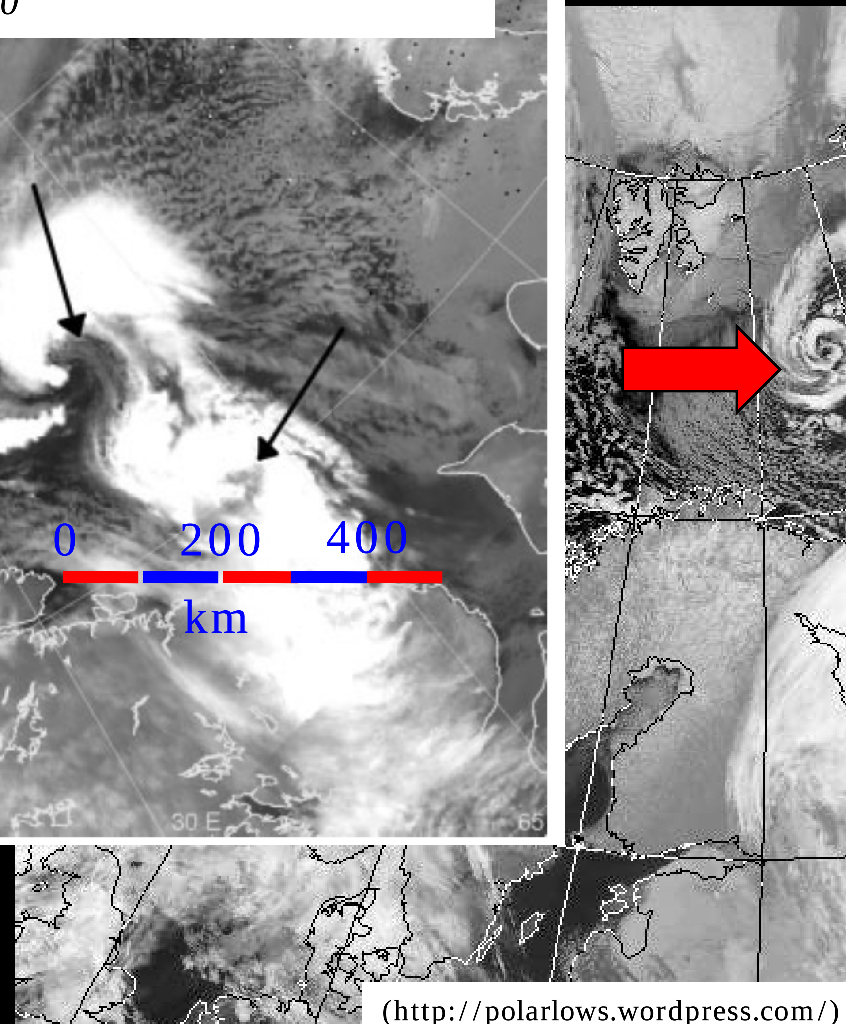

(http://polarlows.wordpress.com/)