The Role of Ice Shelf - Ocean Interaction in the ECCO2 Data Synthesis

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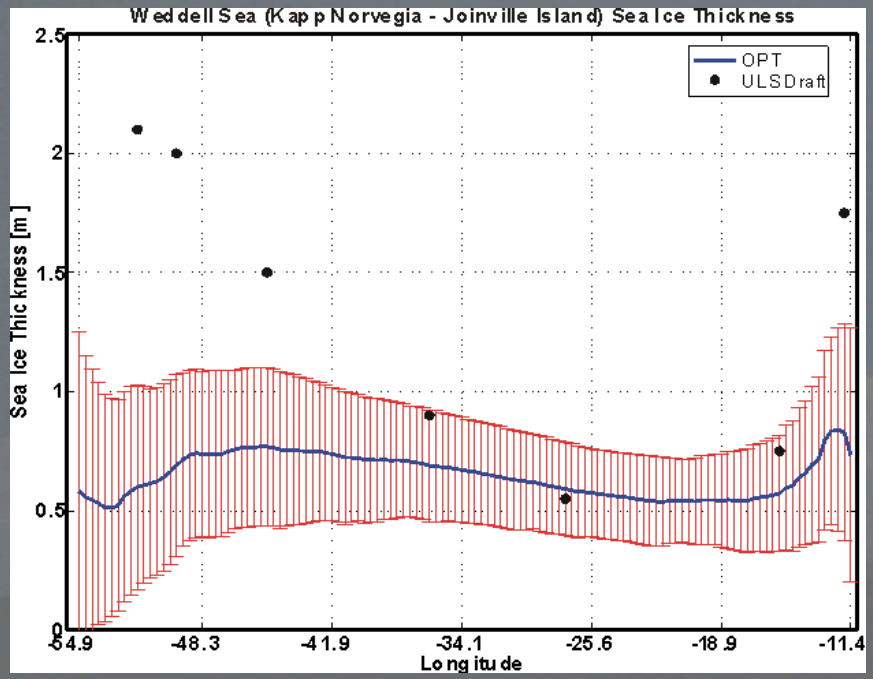
Outline

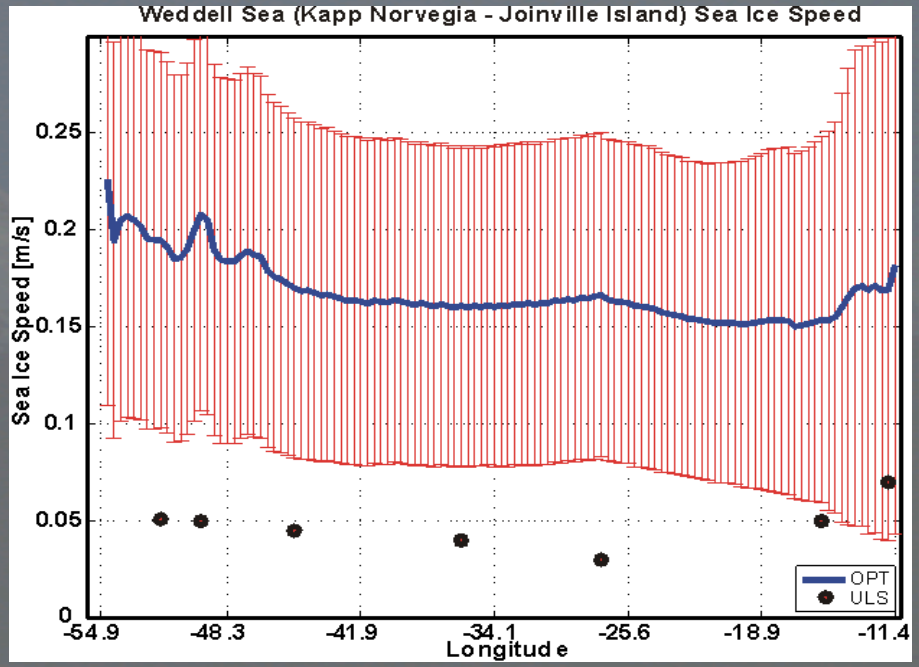
- Model Set up
- Results
- Outlook

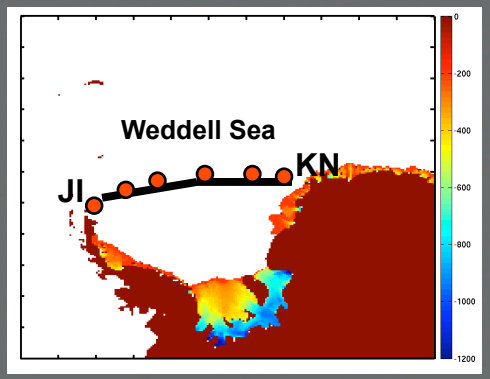
Sea Ice Thickness & Sea Ice Velocities (Cube 78)

Section: Kapp Norvegia (KN) - Joinville Island (JI)

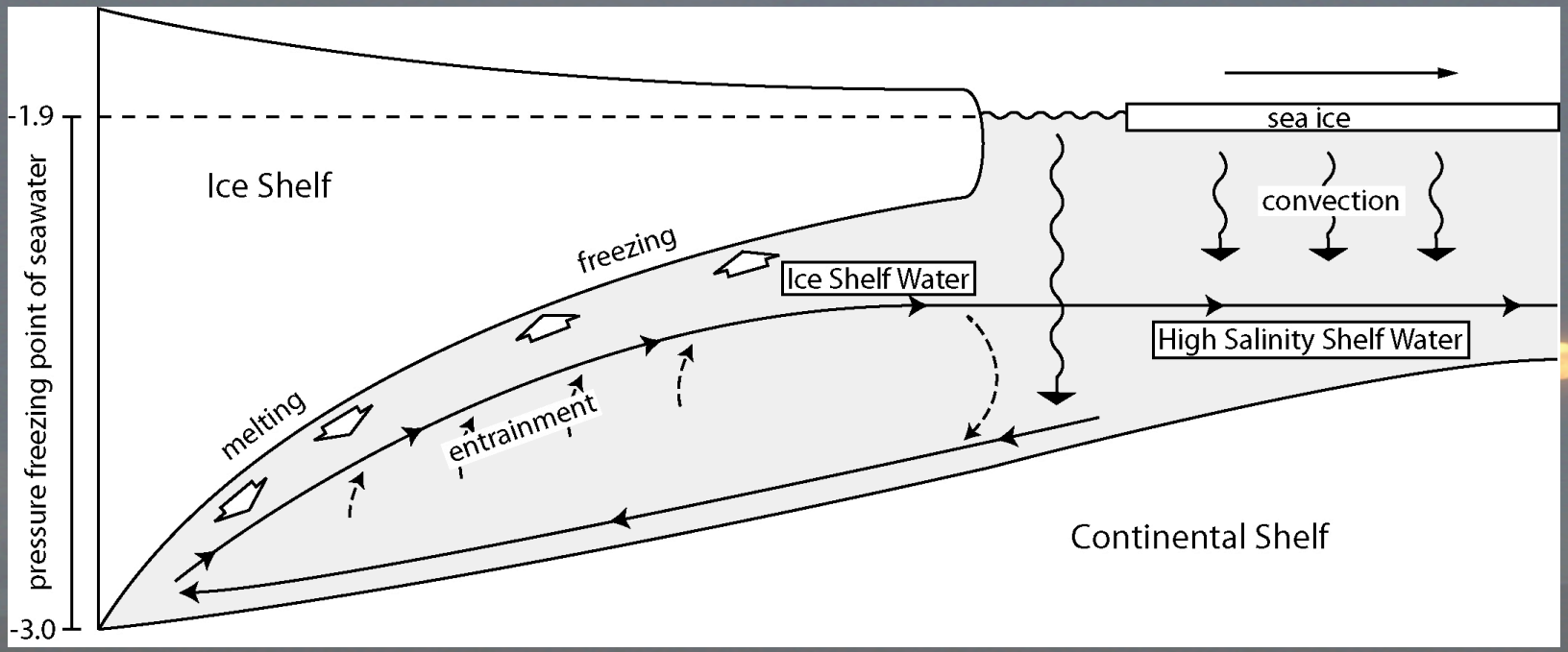
Model data vs AWI ULS data







Ice Shelf Ocean Interaction:



Combination of 2 Datasets:

BEDMAP:

- Ice Shelf Thickness
- Water Column Thickness

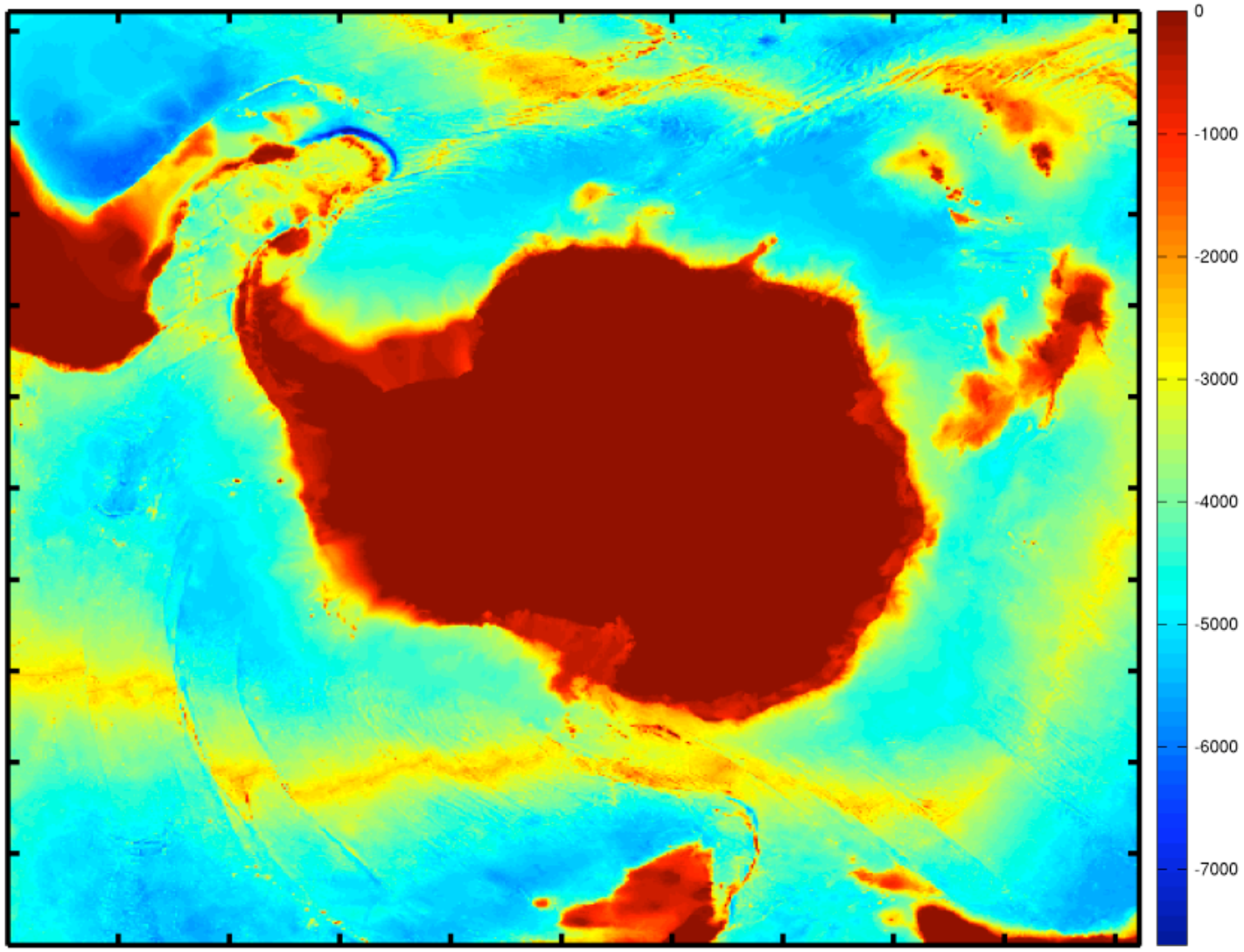
=> Ice Shelf Draft + Water Column Thickness =
Bathymetry beneath Ice Shelves

Bathymetry as in CS510:

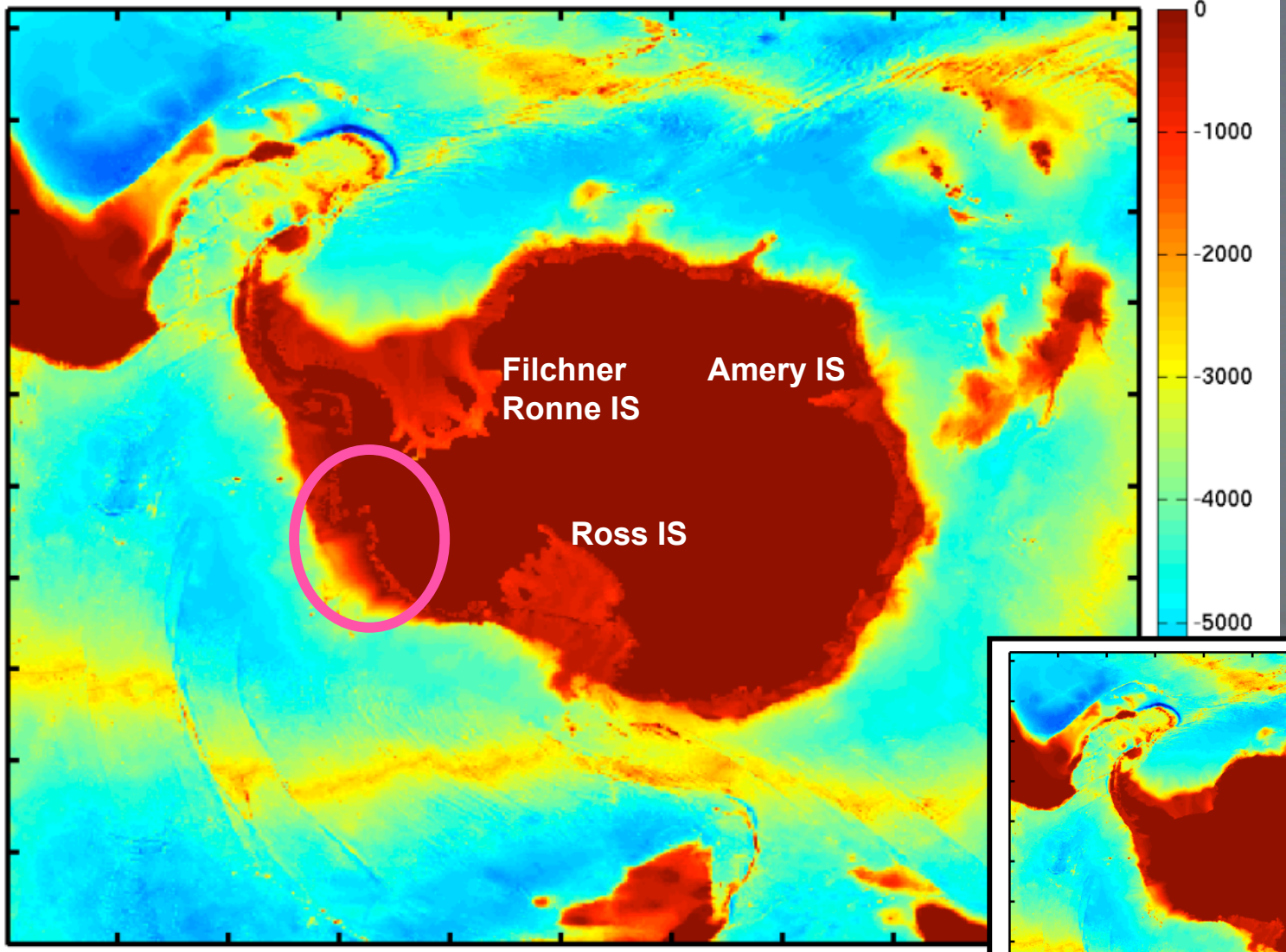
- Bathymetry South to Ice Shelf Edge

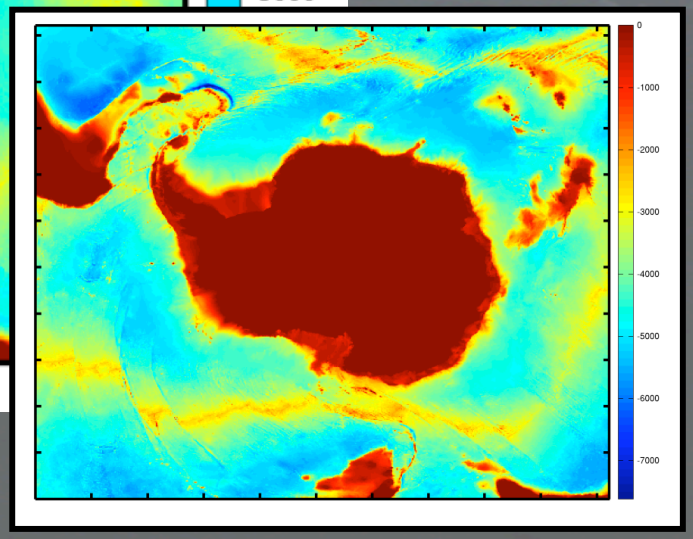
How good are the data sets?

- Ice Shelf reliable
- Bathymetry questionable in parts

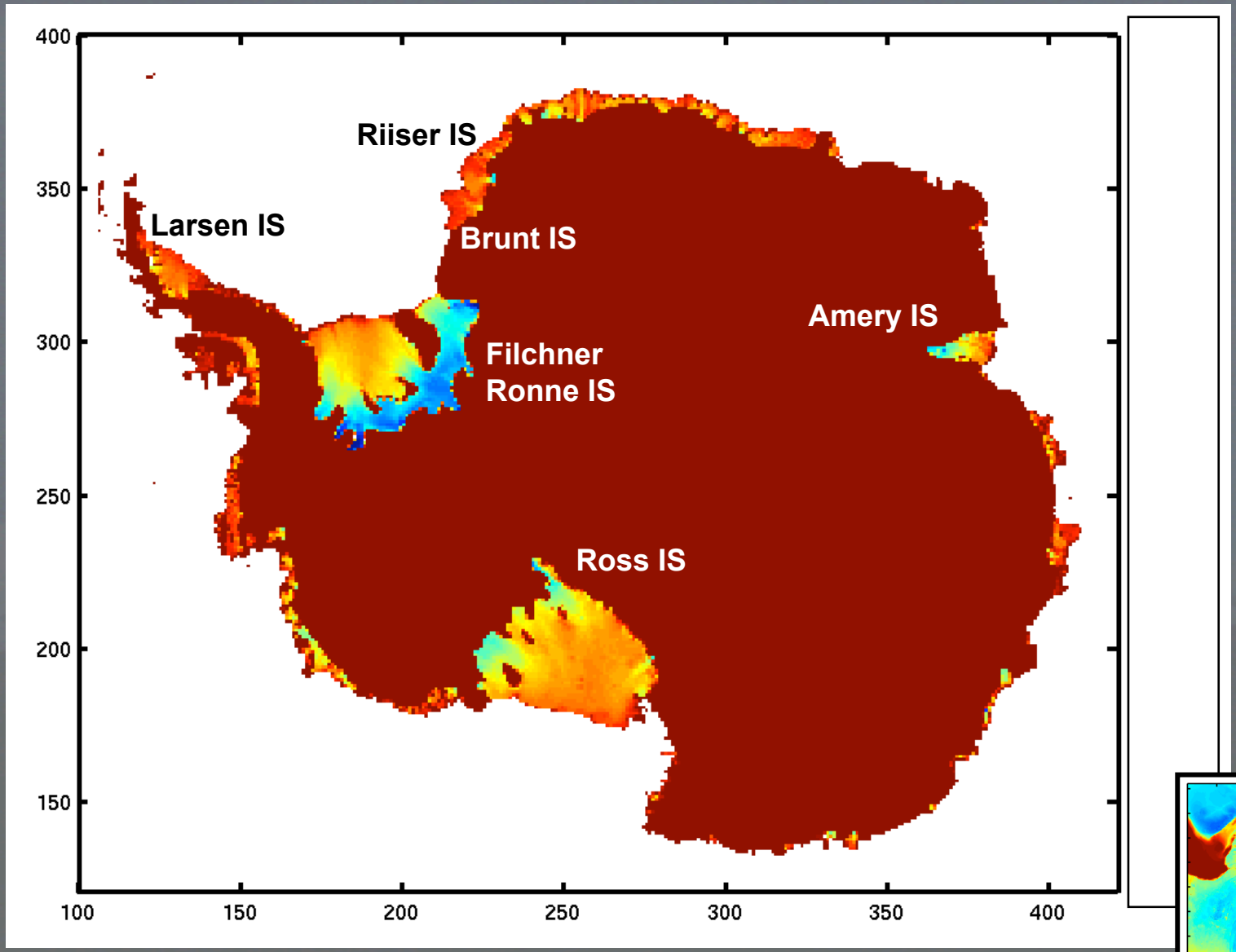


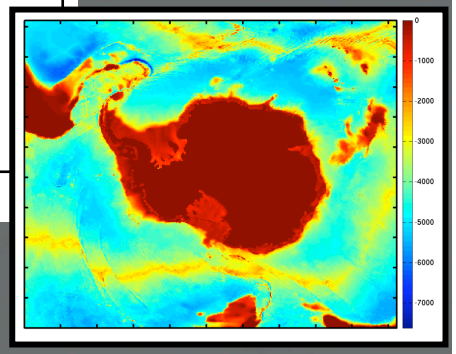
Face 6 as in CS510





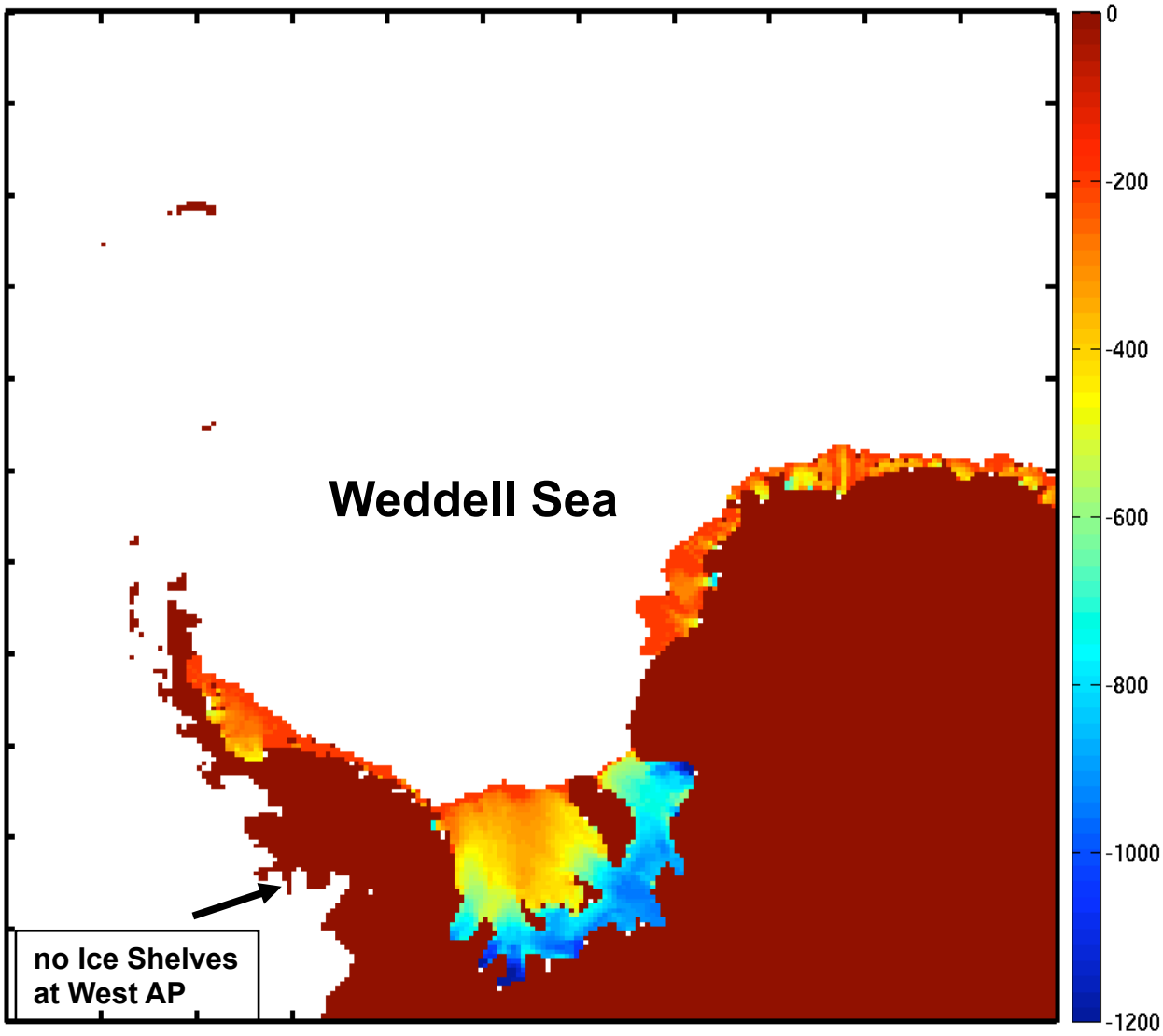
Face 6 with sub-ice shelf cavities





Ice Shelf Thickness

Test Case for Regional Domain from CS 510



Regional Domain:

- Weddell Sea
- 220 x 220 x 50
- Boundary conditions from Cube 78
- Monthly Ocean Values
  - T, S, u, v
- Daily Sea Ice Values
  - H, A, Sn, Sl, u, v
- Ice shelf pkg (Losch 2008)

RUNS:

- control
- ISOMIP (Grosfeld et al., 1997)
- BRIOS/Hellmer (Hellmer and Olbers, 1989)
- Down slope flow (J-M Campin, 1991.)

Ice Shelf Ocean Interaction

ISOMIP:

- heat flux proportional to temperature difference ice shelf base and sea water
- neglecting heat flux through ice
- all heat used for basal melting and freezing
- virtual salt flux computed with constant reference salinity

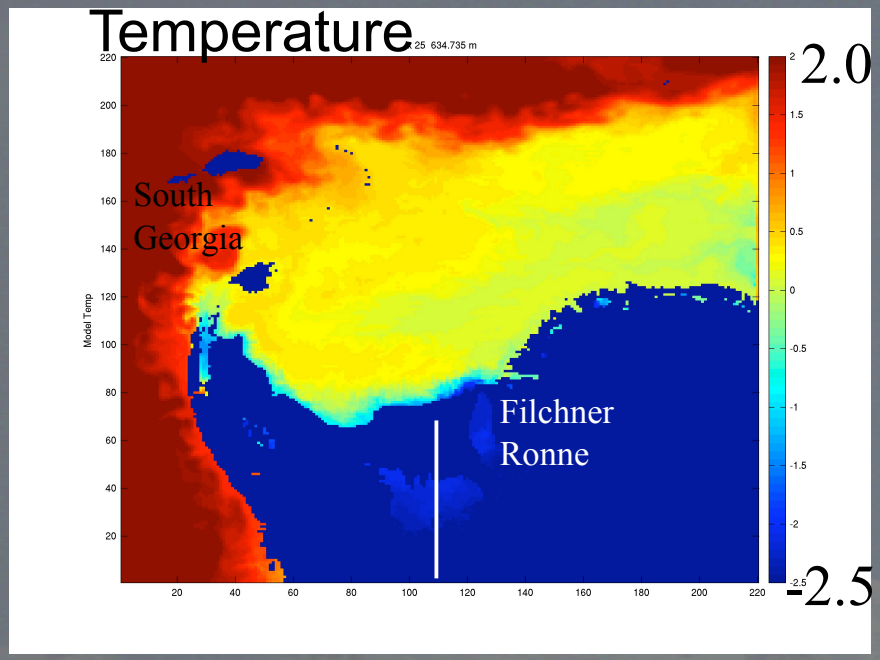
BRIOS/Hellmer: system of 3 equations

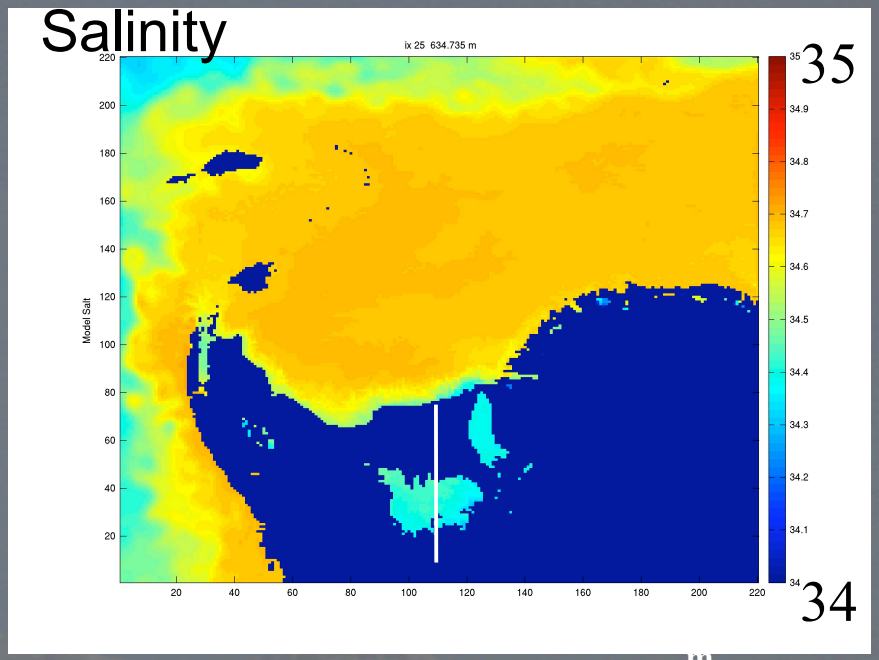
- heat flux, salt flux, and linear equation of freezing point temperature (Tf)
- heat flux through ice shelf considered
- constant surface temperature –20C
- virtual salt flux across ice shelf ocean interface equal to salt flux due to melting and freezing
- solved for temperature and salinity at ice shelf base

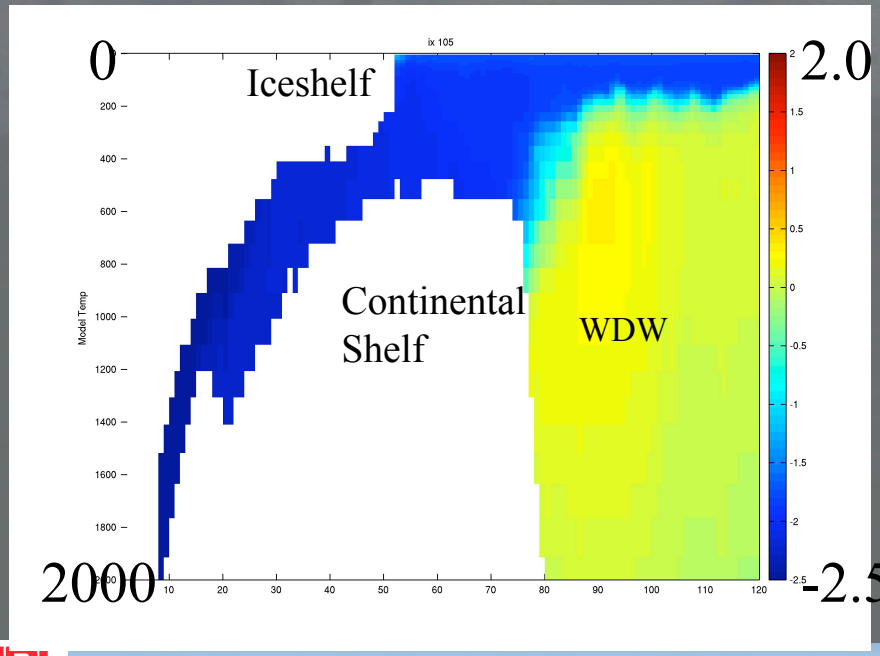
⇒ Smaller melt rates:
freshwater flux decreases salinity -> raises Tf -> less freezing at interface

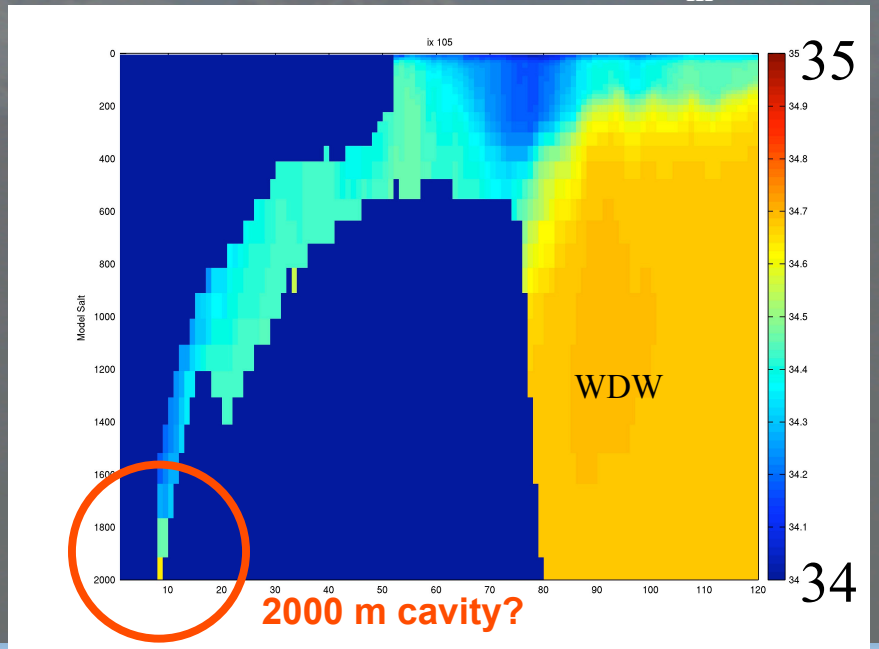
Constant turbulent exchange coefficients equal to a velocity of ~0.25 m/s

Weddell 220x220 January 1998

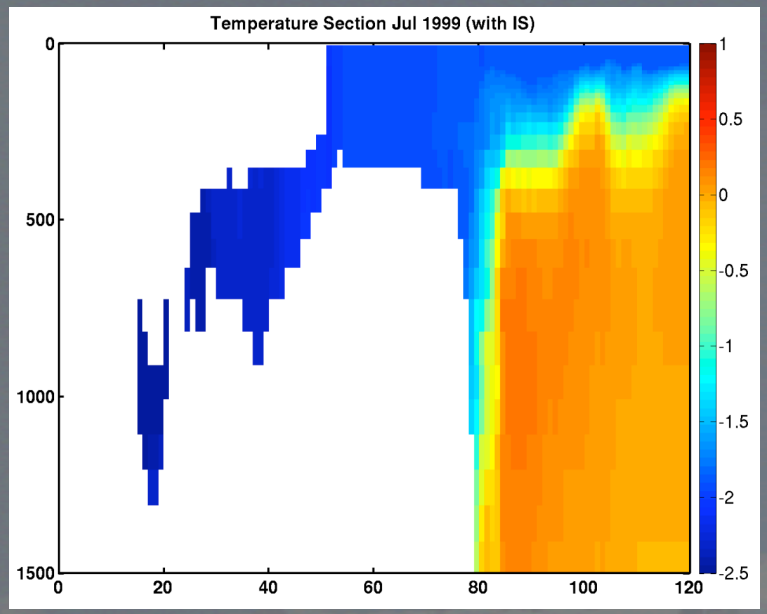


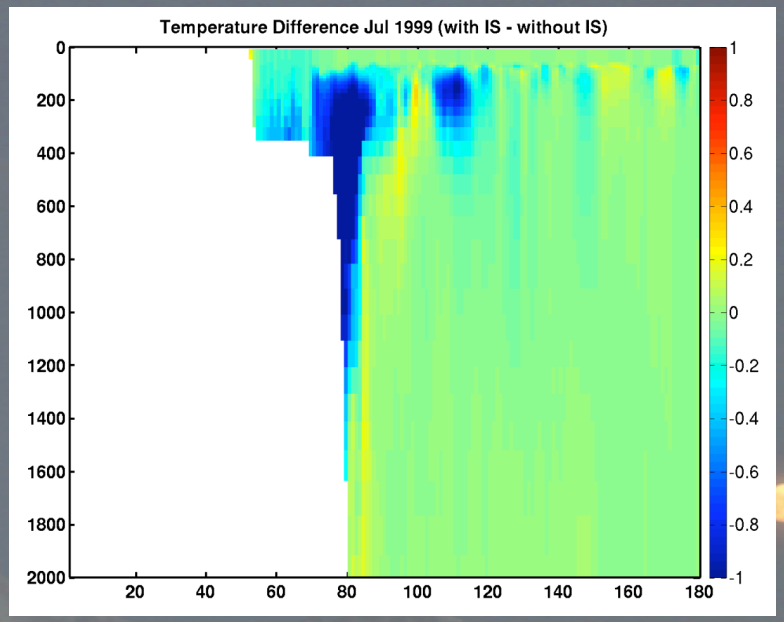


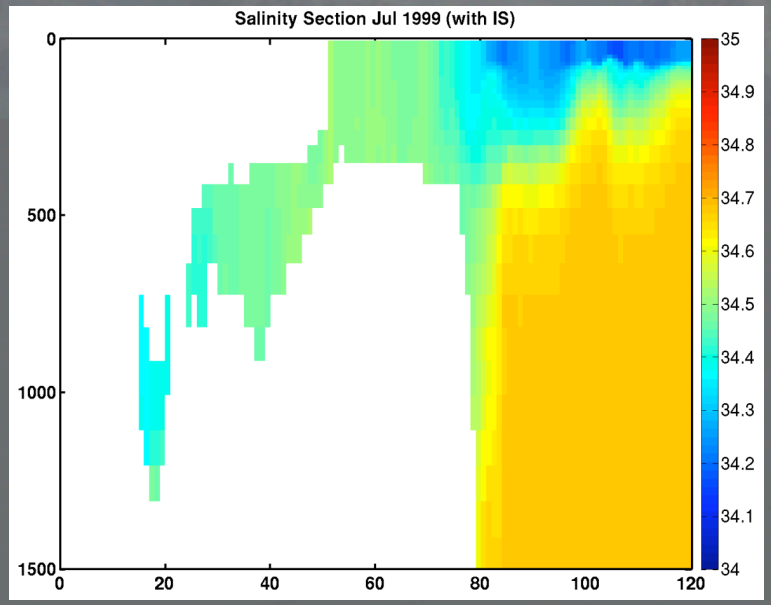


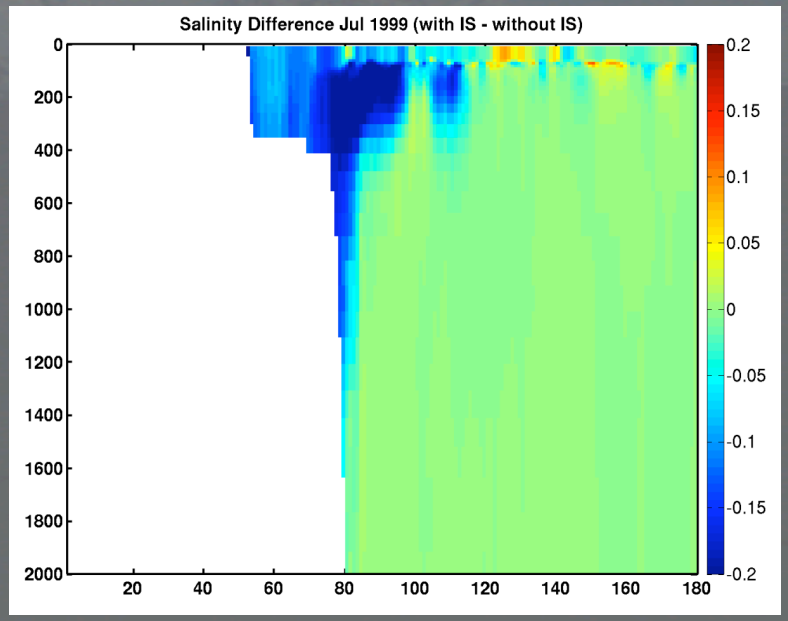


Hydrography

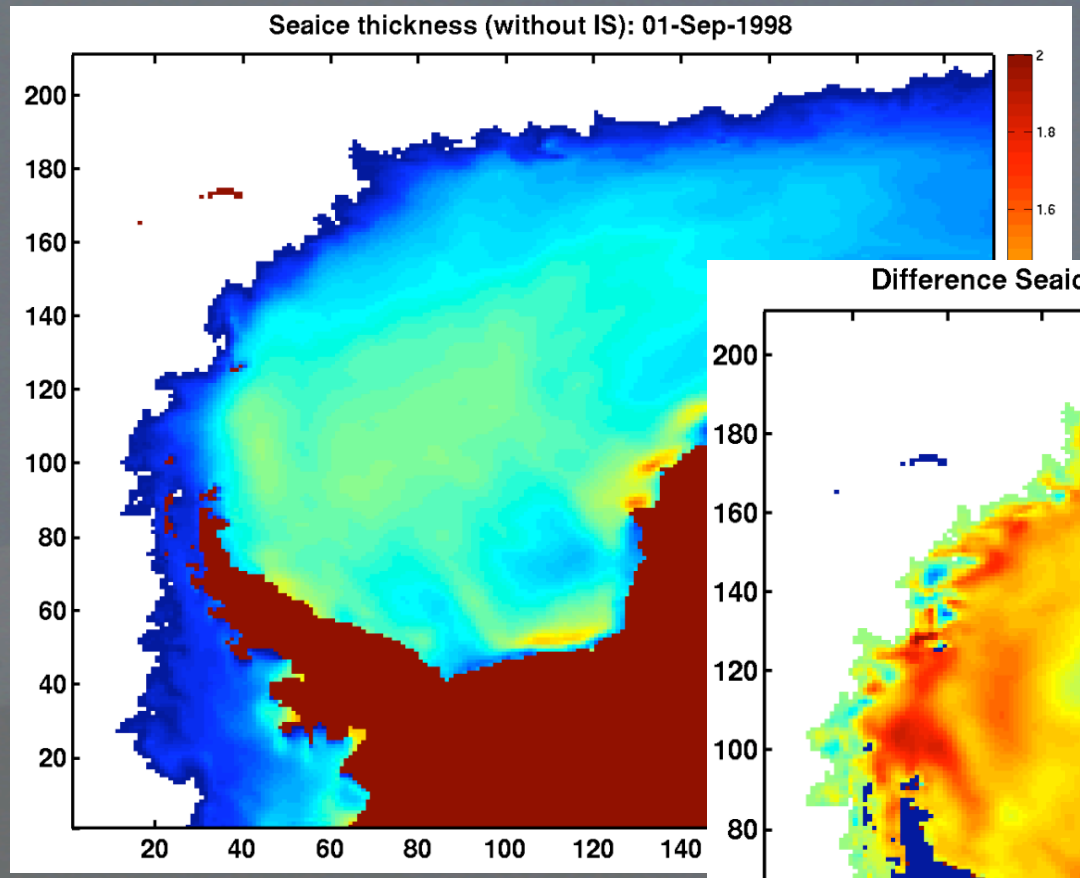


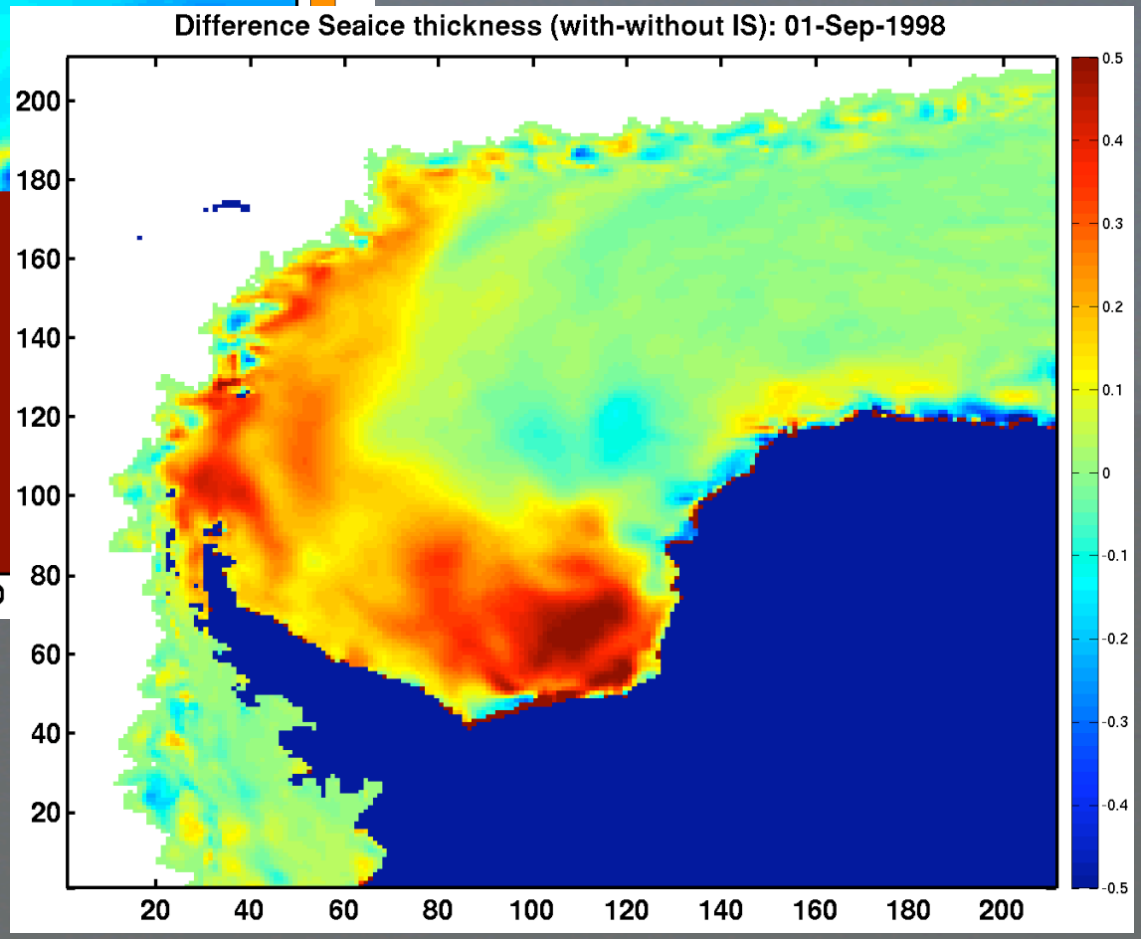


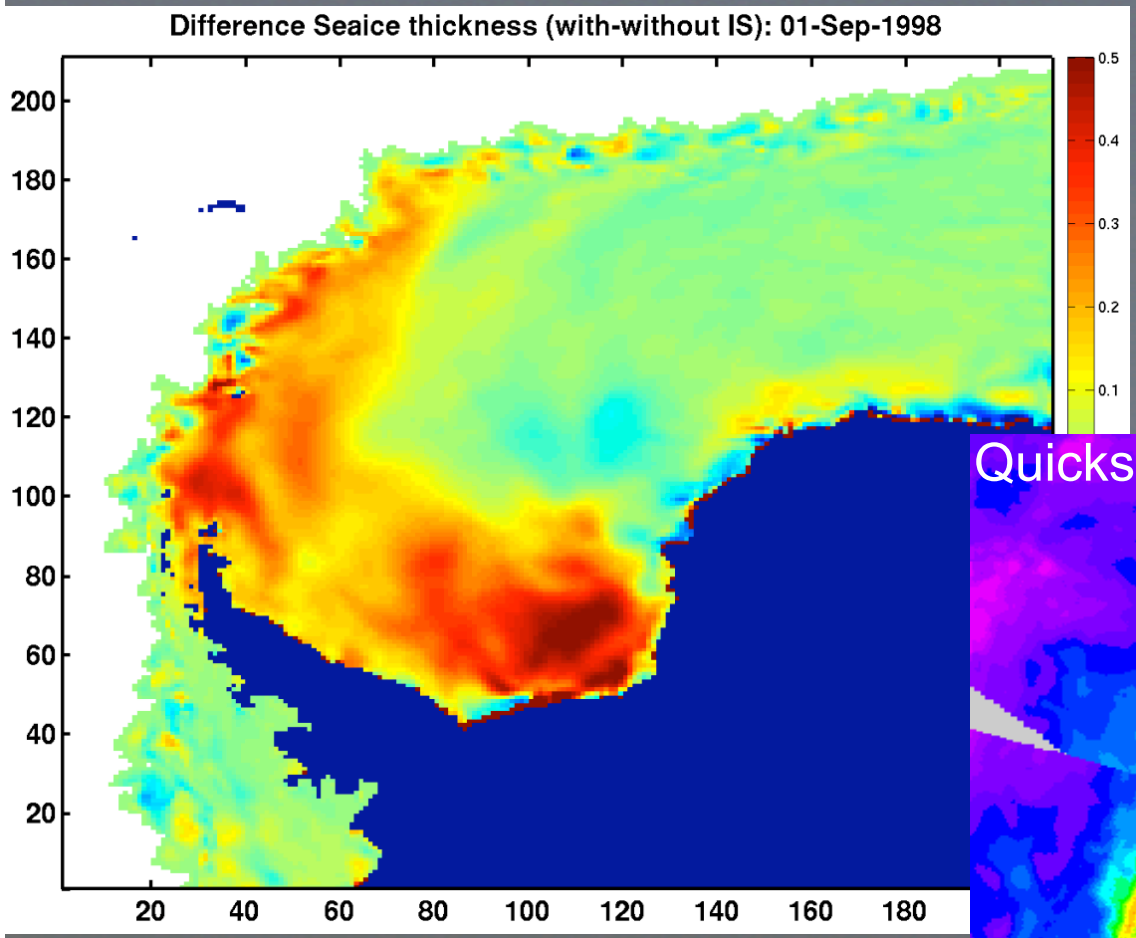


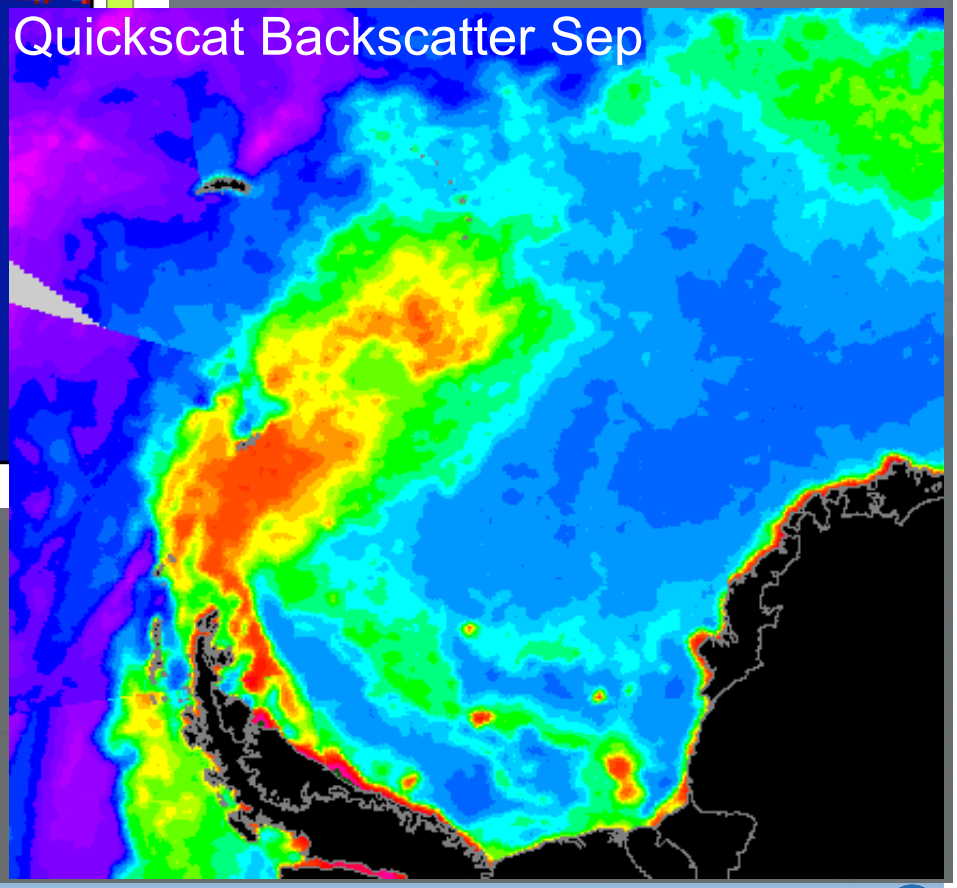


Sea Ice Thickness



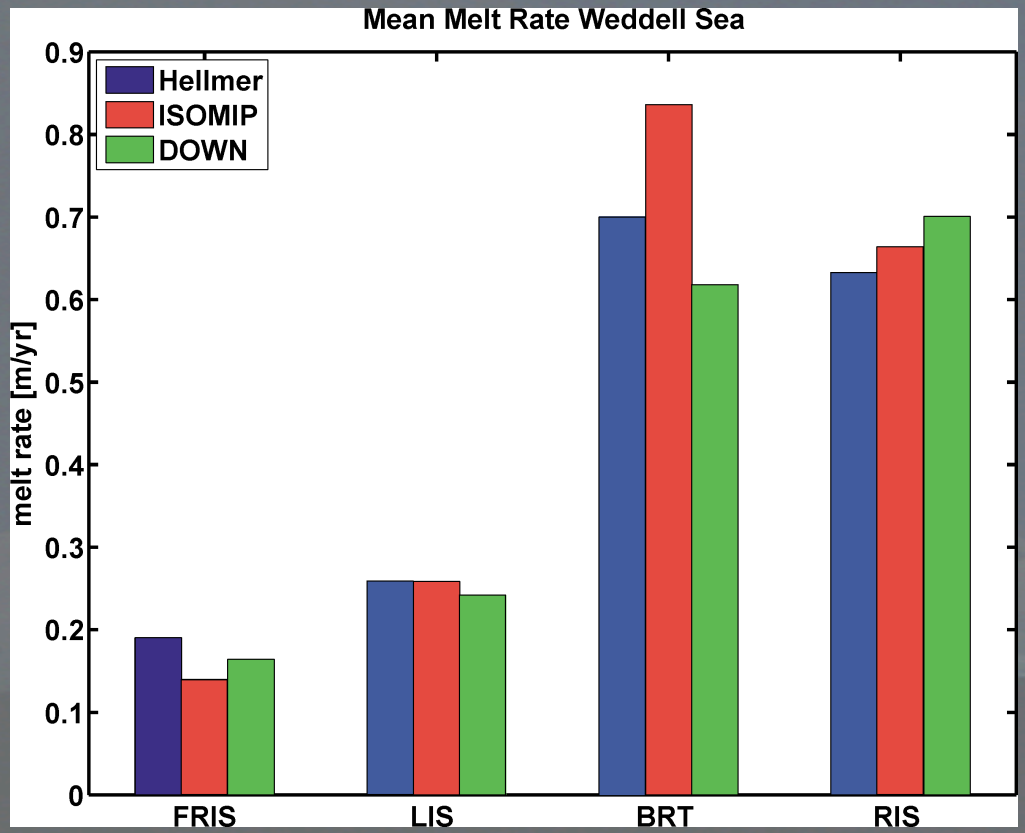


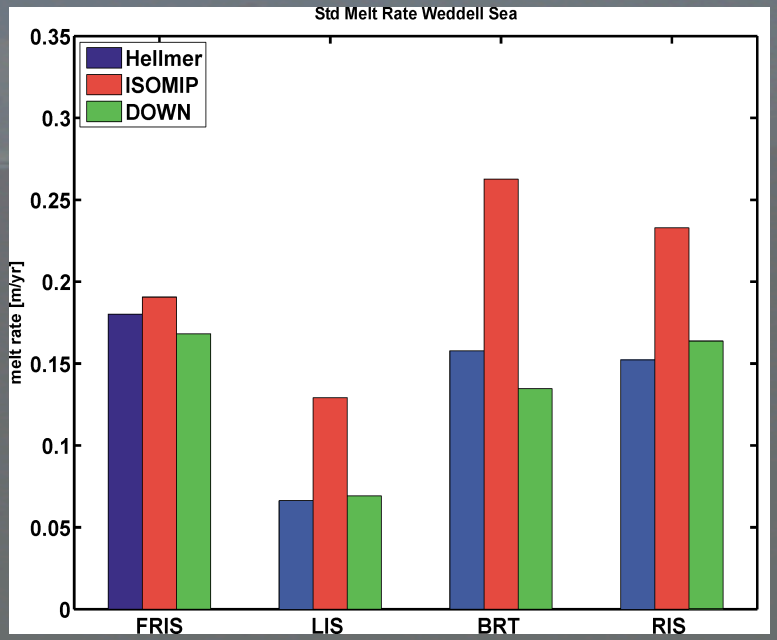




Red-ish – multi year ice
Blue-ish – first year ice

Weddell Sea Mean Ice Shelf Melt Rates (1992-1999)

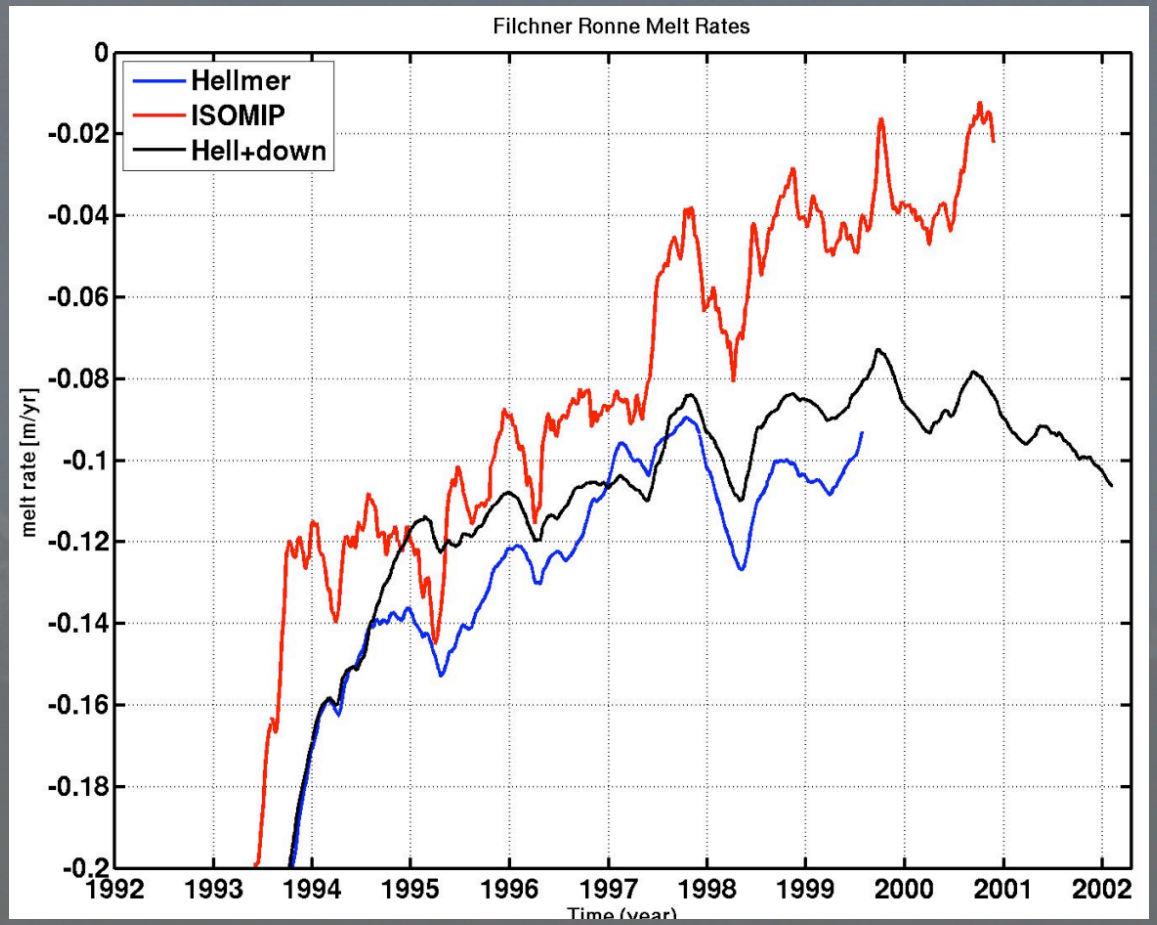




Standard deviation

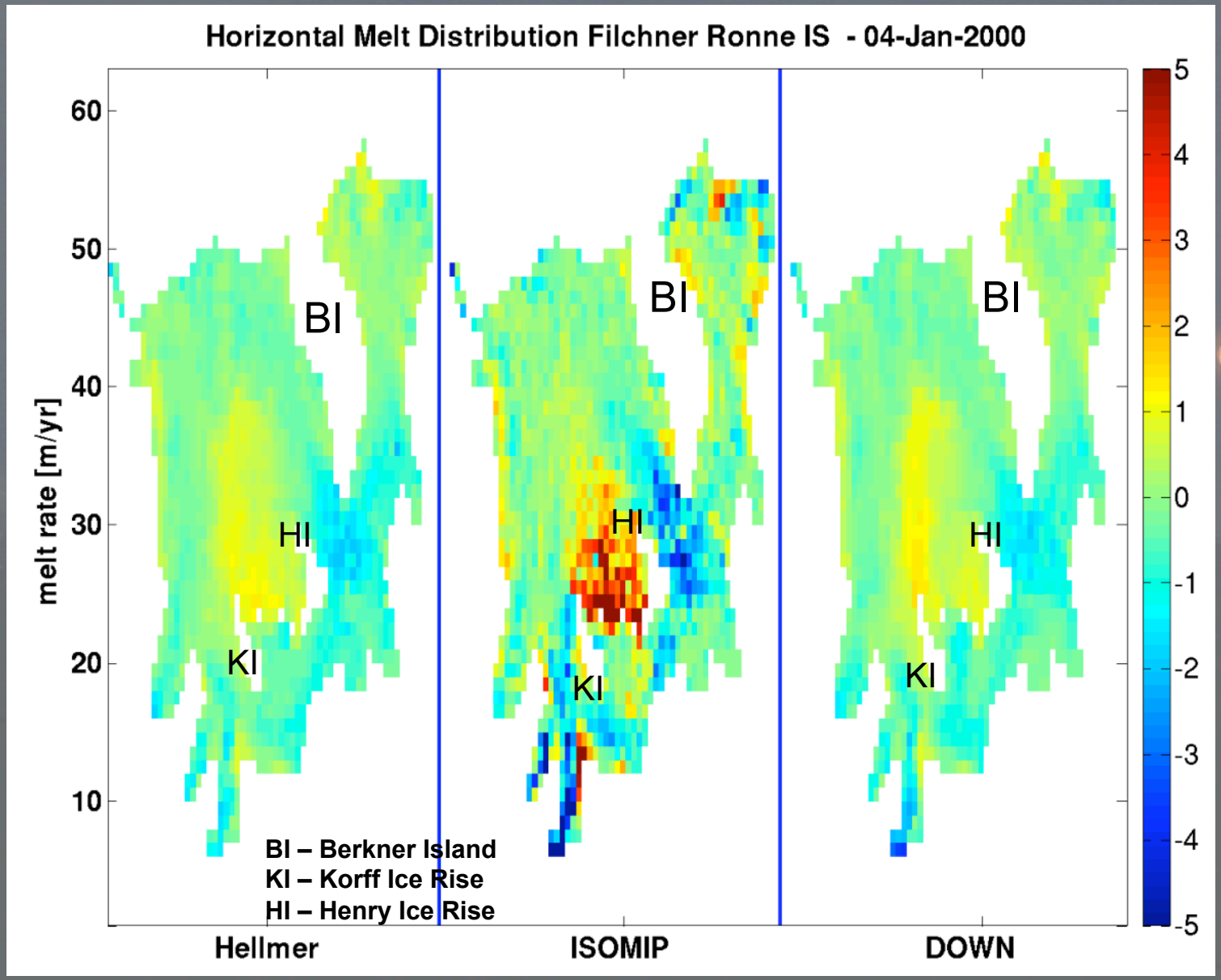
- Substantially smaller than e.g. BRIOS (**Beckmann et al., 1999, Schodlok et al., 2002, Timmermann et al., 2002**)
- LIS in good agreement with estimates (**E Rignot, 2008**)

Filchner Ronne Ice Shelf Melt Time Series

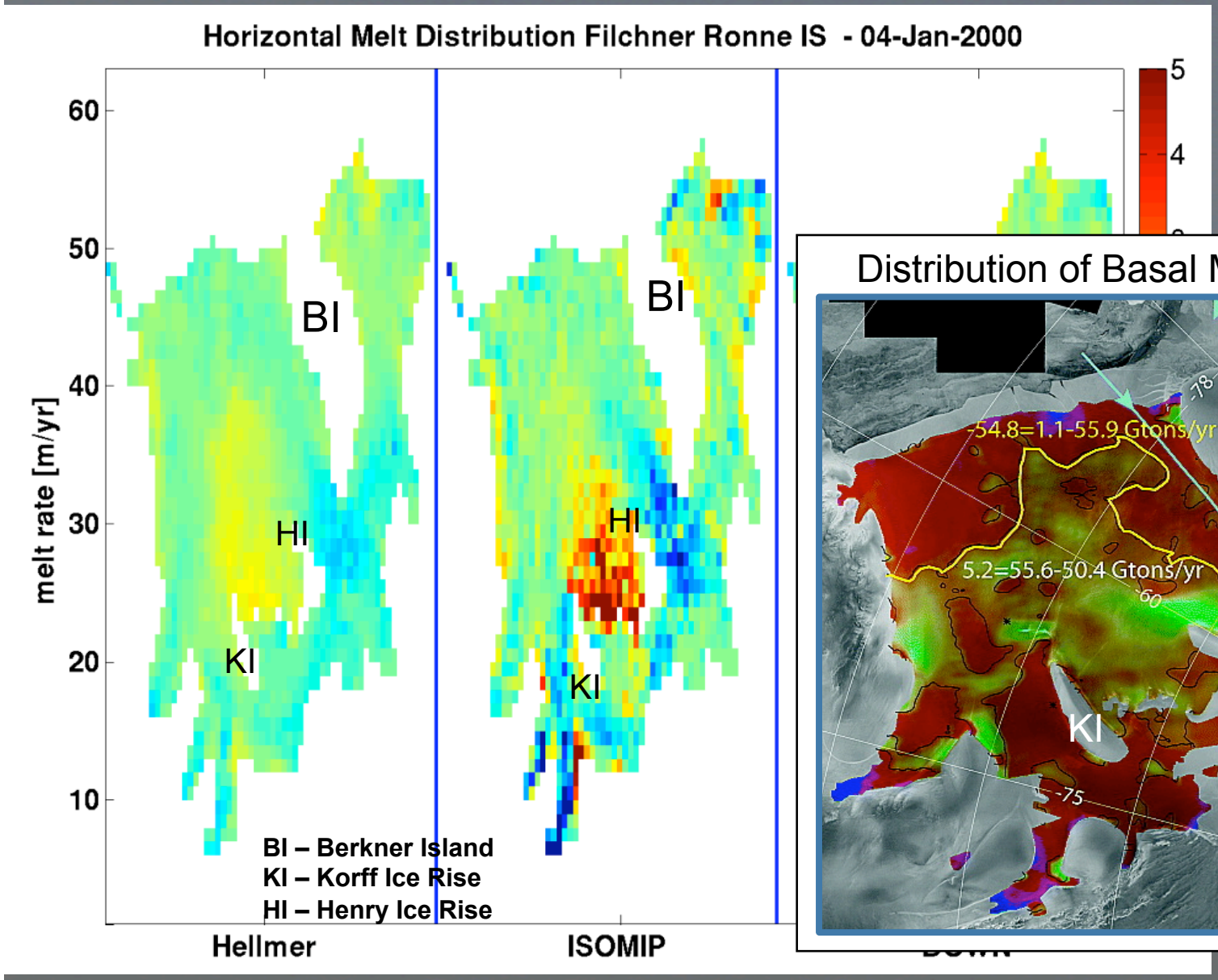


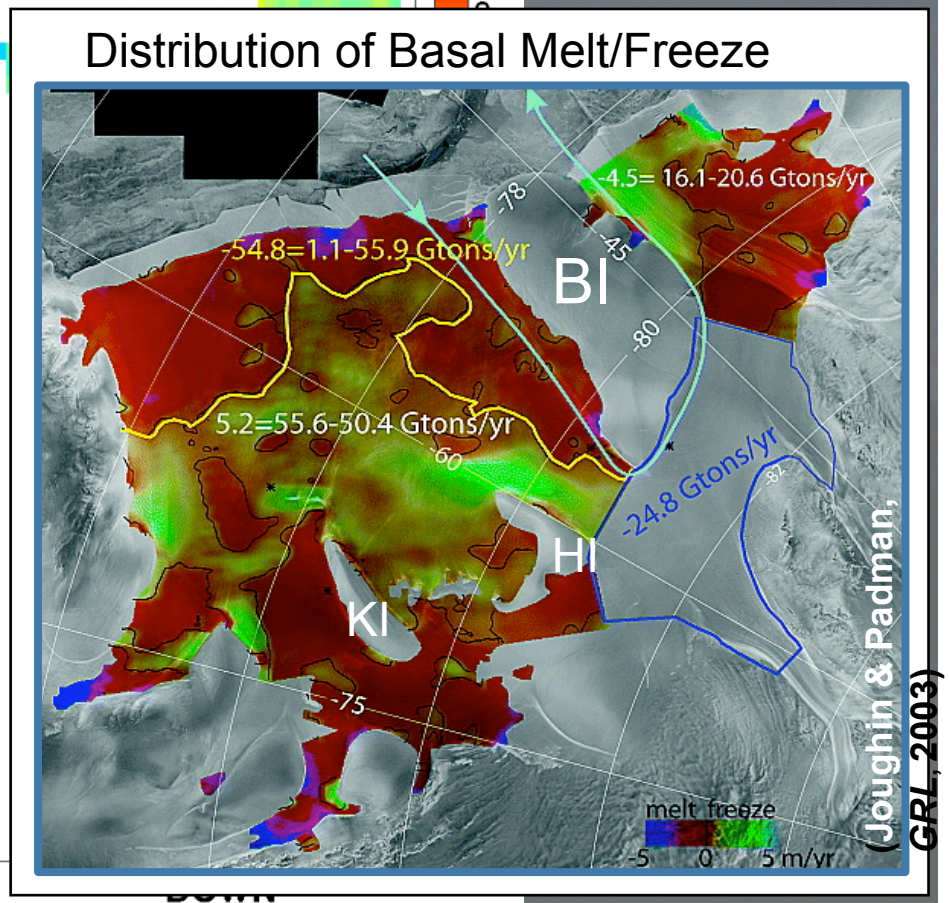
Trend:
ISOMIP: 0.017 m/yr
Hellmer: 0.012 m/yr

Filchner Ronne Horizontal Melt Distribution



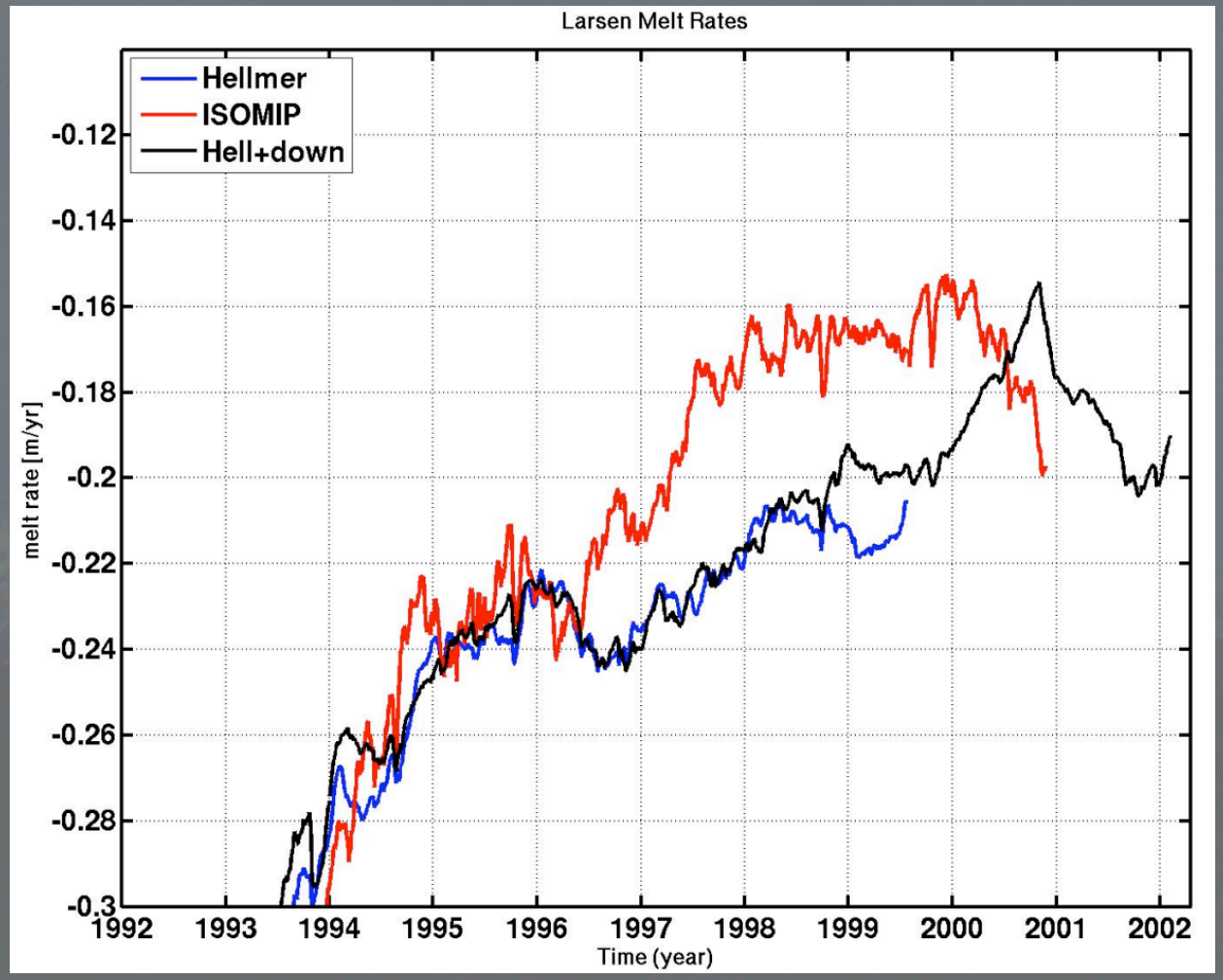
Filchner Ronne Horizontal Melt Distribution



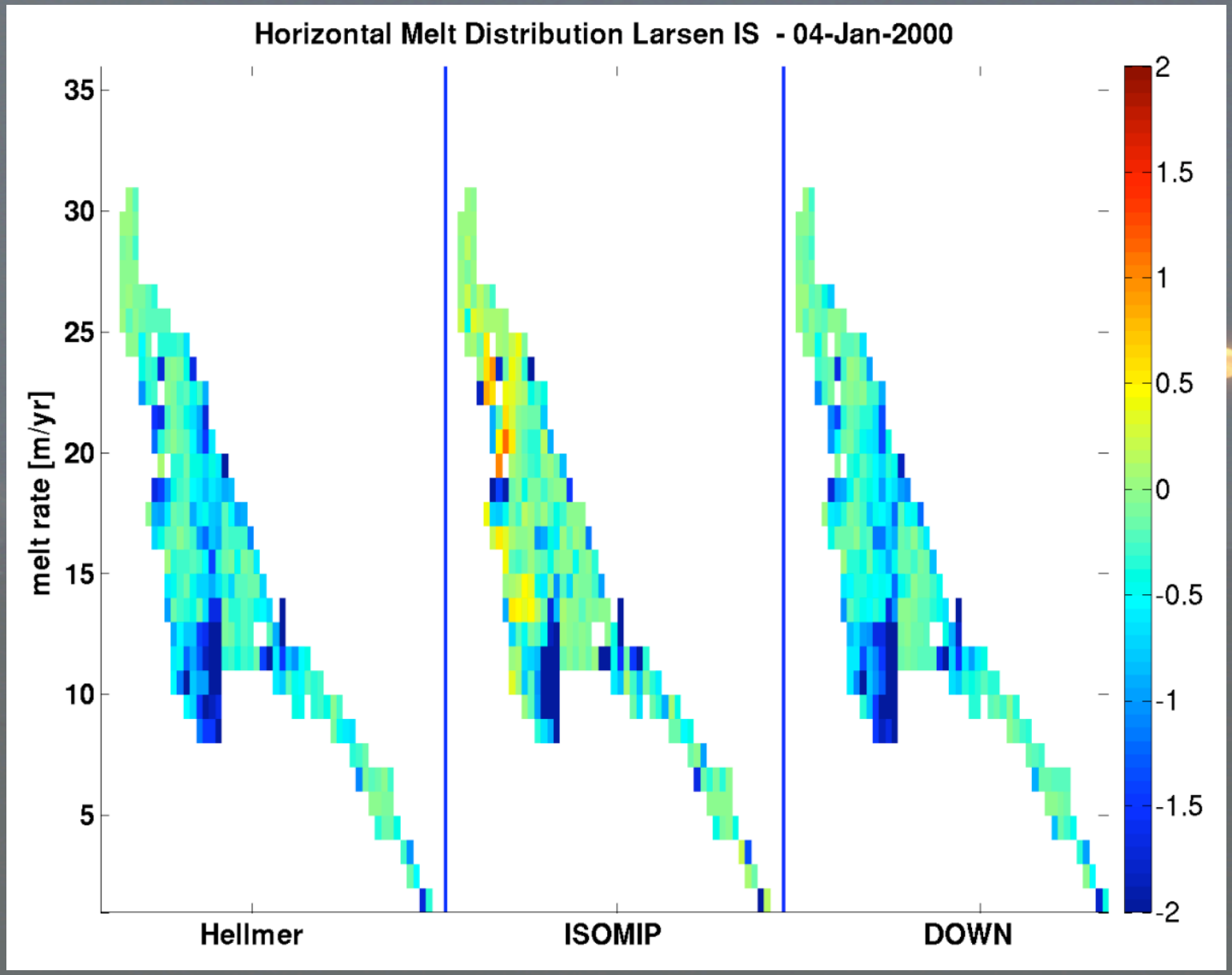


(Joughin & Padman, GRL, 2003)

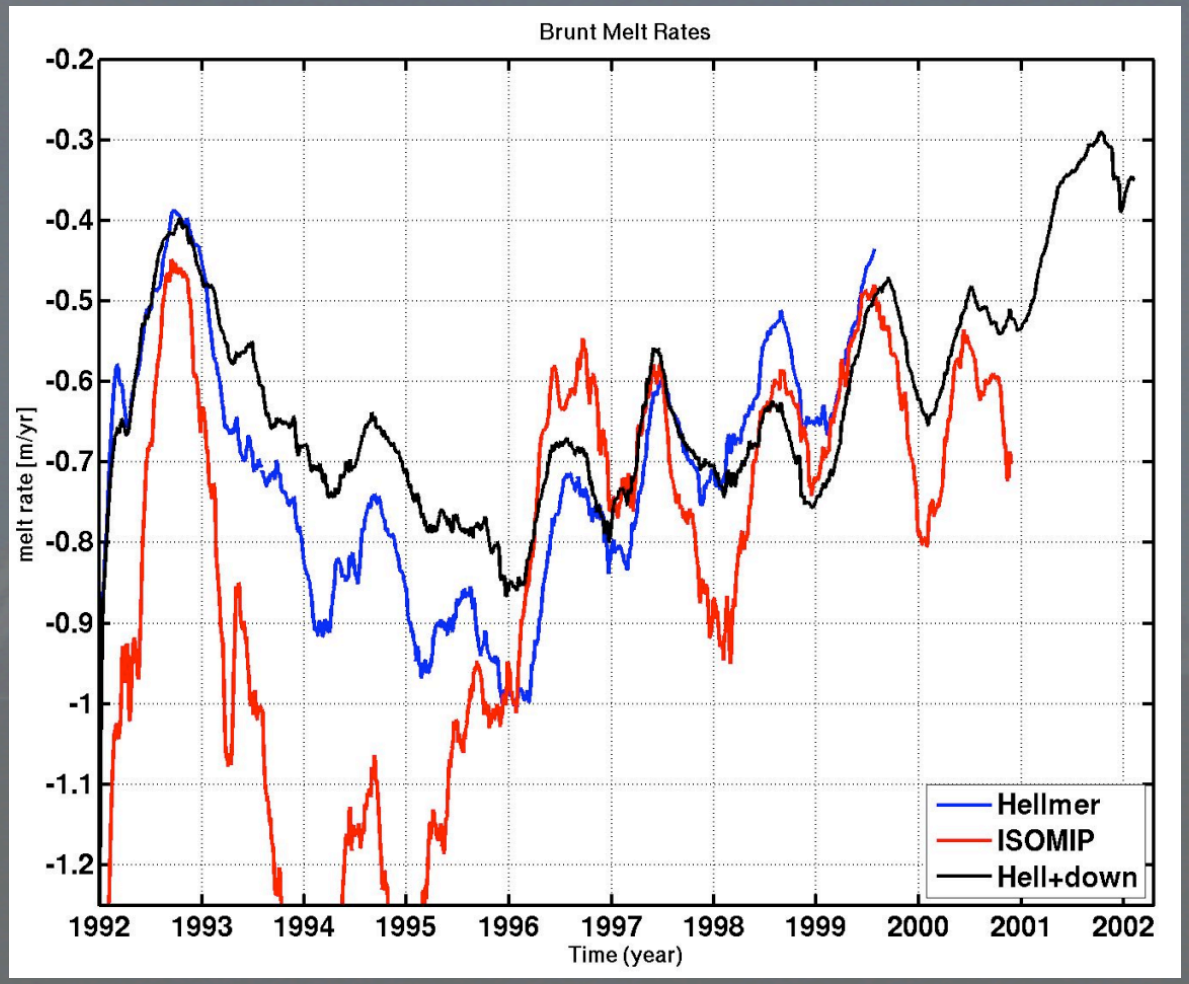
Larsen Ice Shelf Melt Rate Time Series



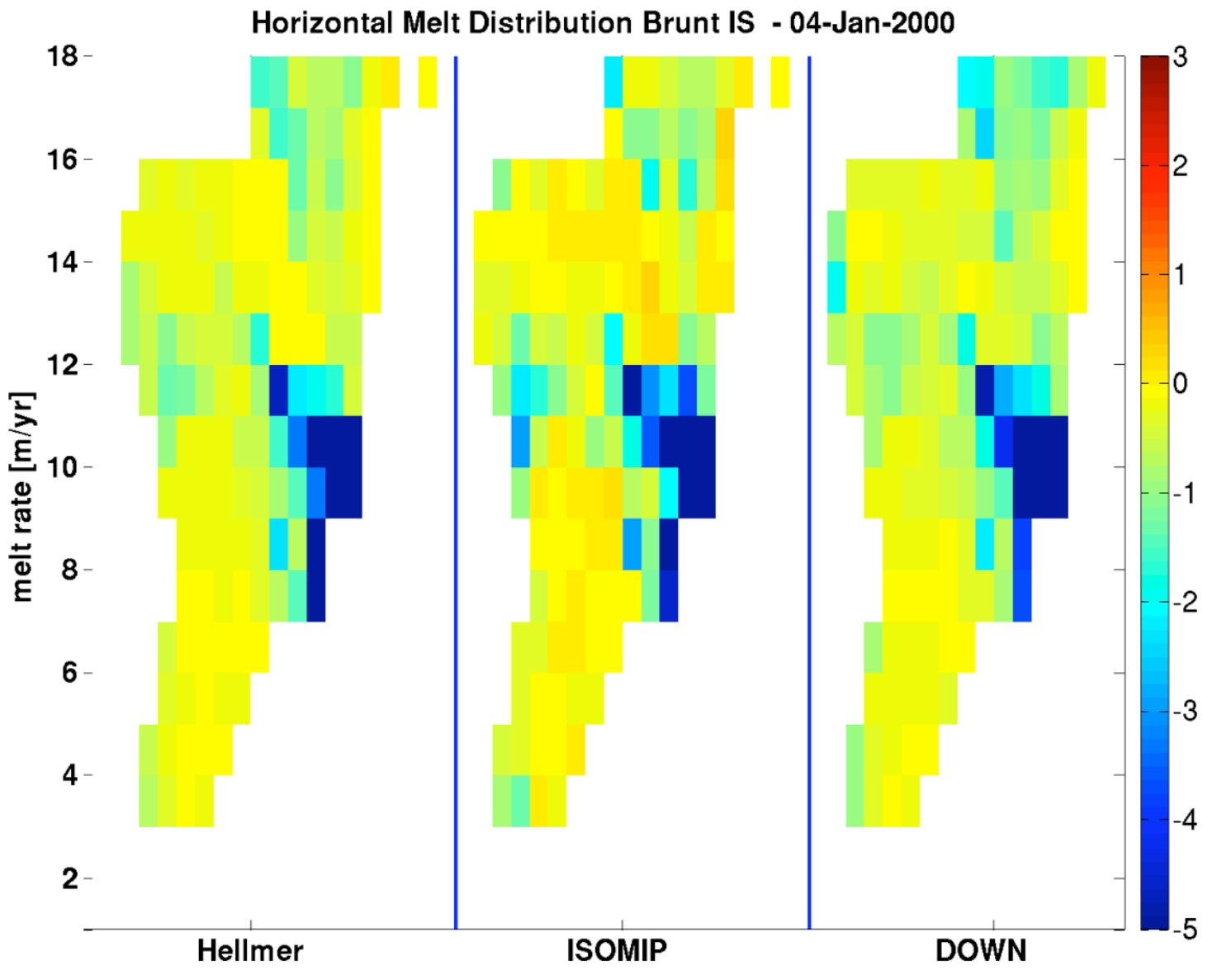
Larsen Horizontal Melt Distribution



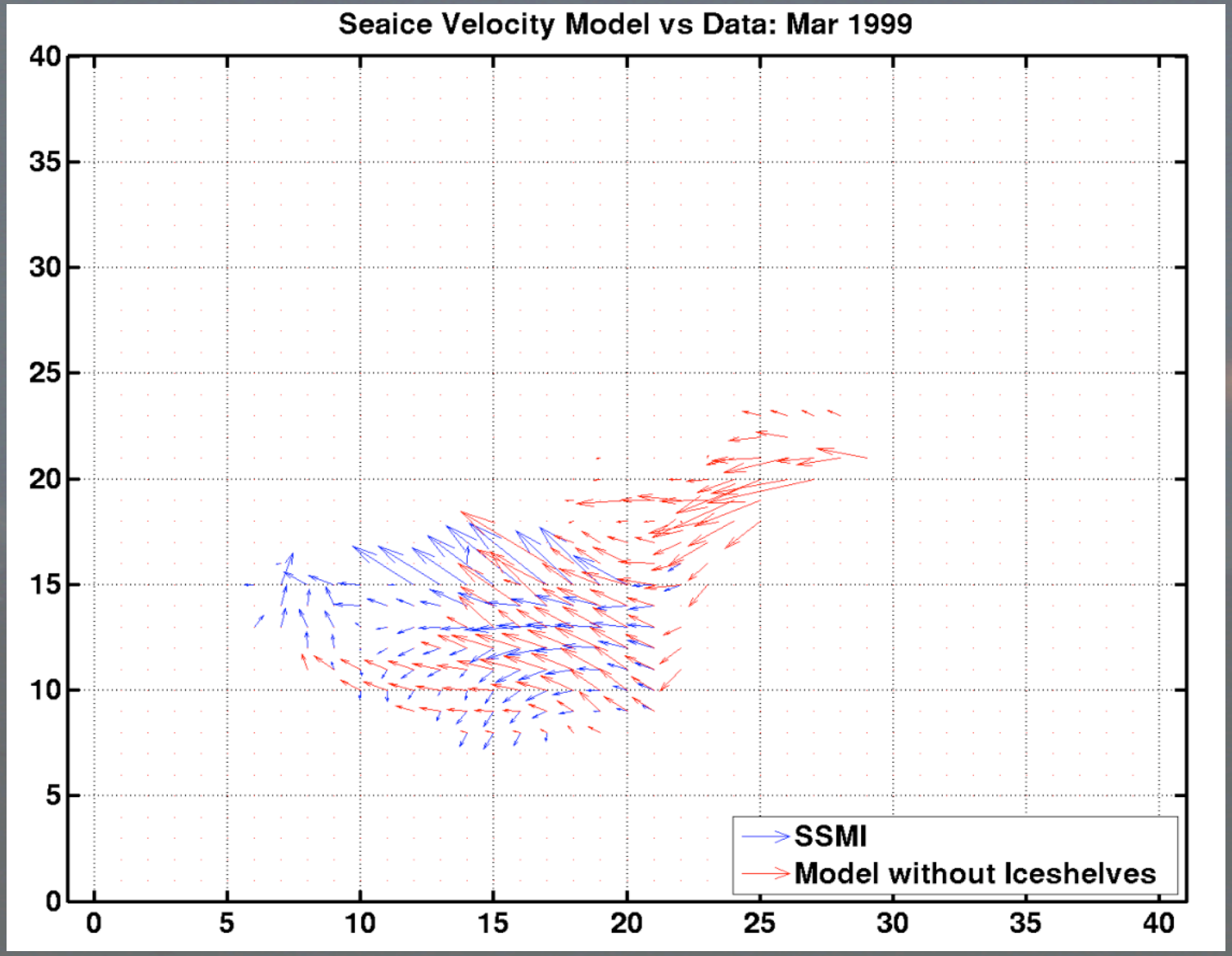
Brunt Ice Shelf Melt Rate Time Series



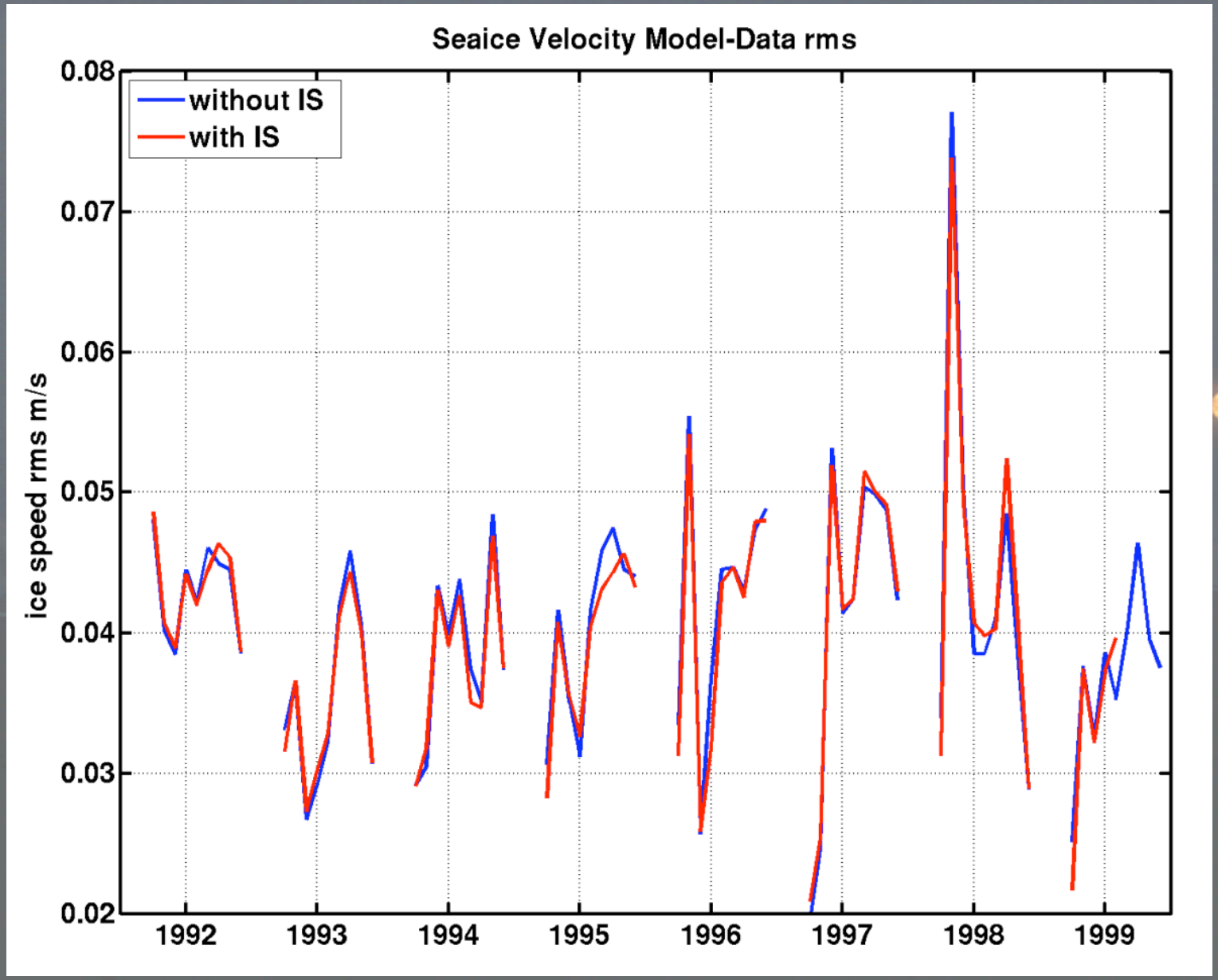
Brunt Horizontal Melt Distribution



Model – Data comparison



sea ice velocities from SSM/I data on 1° grid (R. Kwok)


Seaice Velocity Model-Data rms
without IS
with IS
ice speed rms m/s
0.08
0.07
0.06
0.05
0.04
0.03
0.02
1992
1993
1994
1995
1996
1997
1998
1999

Summary

- working Ice Shelf – Ocean Interaction Package
- smaller melt rates than previous estimates
- trend in the Filchner Ronne melt rates
- major differences in T and S at Shelf Break

Outlook

- IceSat/Glas data set for ice shelf thickness
- compatible version downslope and iceshelf package
- parameter optimization for Weddell Sea domain
- global ECCO2 run with ice shelf package implemented

Wish List

- to represent mixing at slope front/shelf break and velocity dependent cavity processes

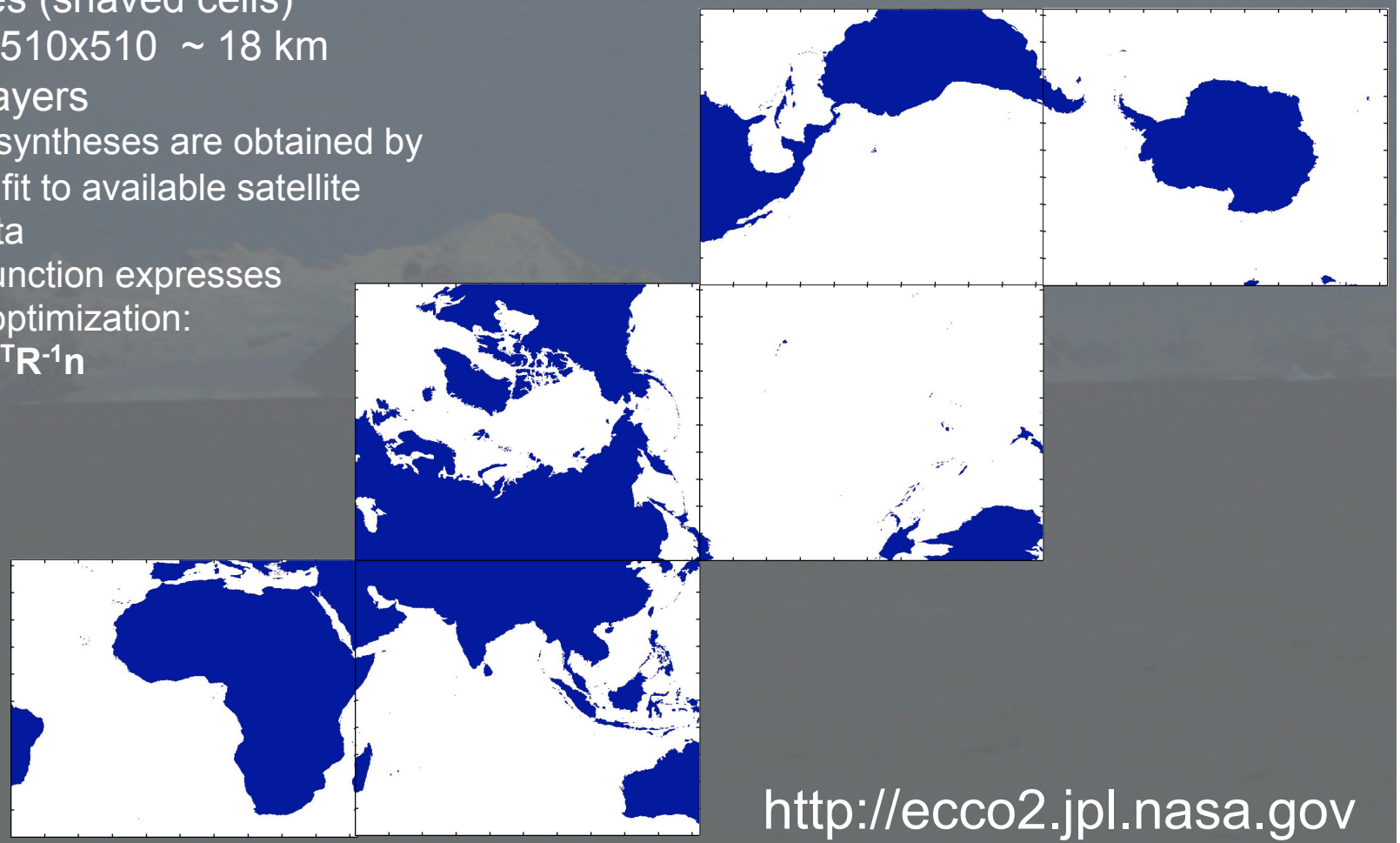
tide package in MITgcm

Estimating the Circulation and Climate of the Ocean, Phase II: High Resolution Global-Ocean and Sea-Ice Data Synthesis

Model Set up:

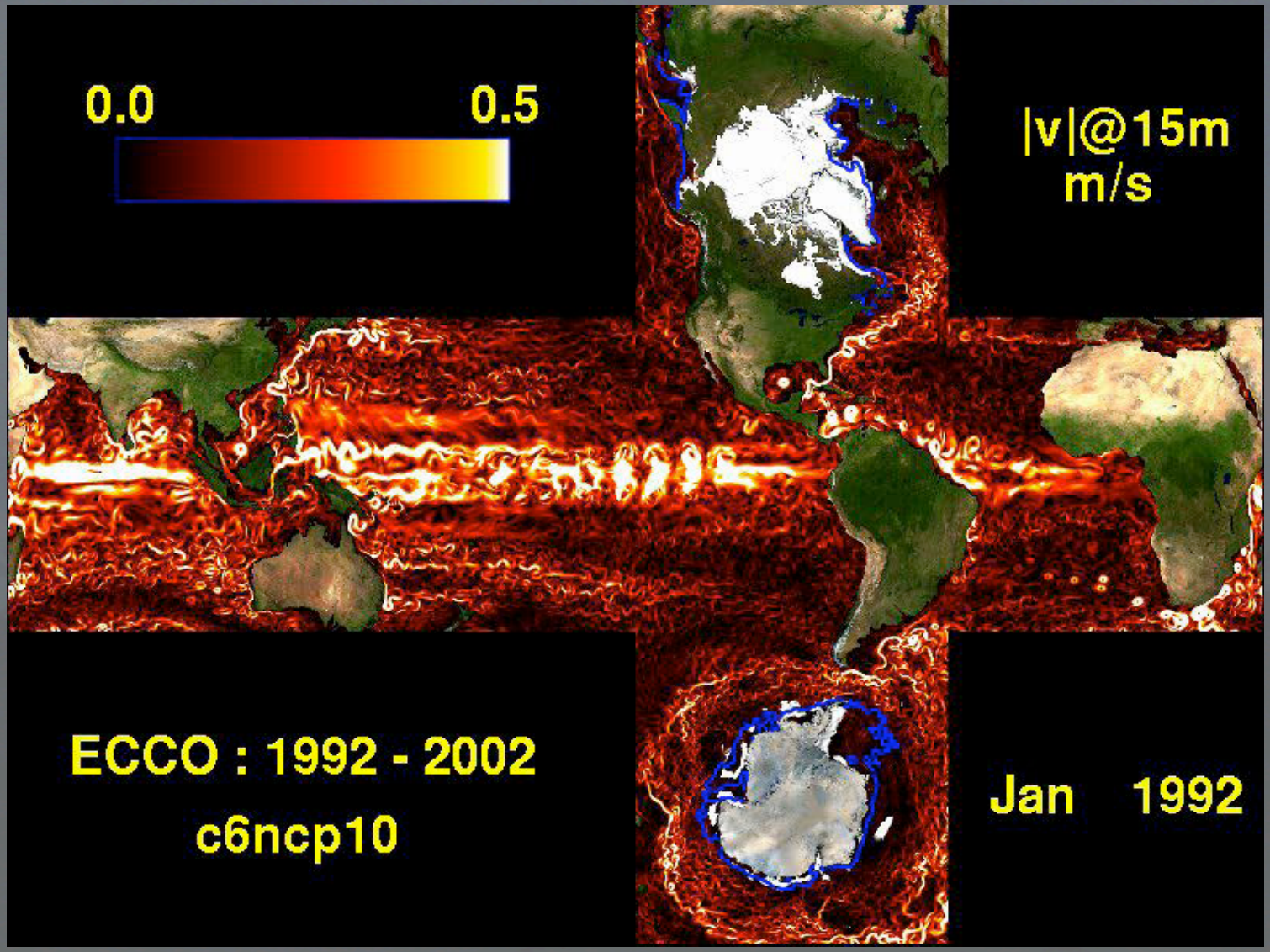
- Ocean model MITgcm
- z-coordinates (shaved cells)
- 6 `Faces` à 510x510 ~ 18 km
- 50 vertical layers
- ECCO2 data syntheses are obtained by least squares fit to available satellite and in-situ data
- An objective function expresses the extent of optimization:

$$J = u^T Q^{-1} u + n^T R^{-1} n$$



http://ecco2.jpl.nasa.gov

Early Model Results: Velocities at 15 m



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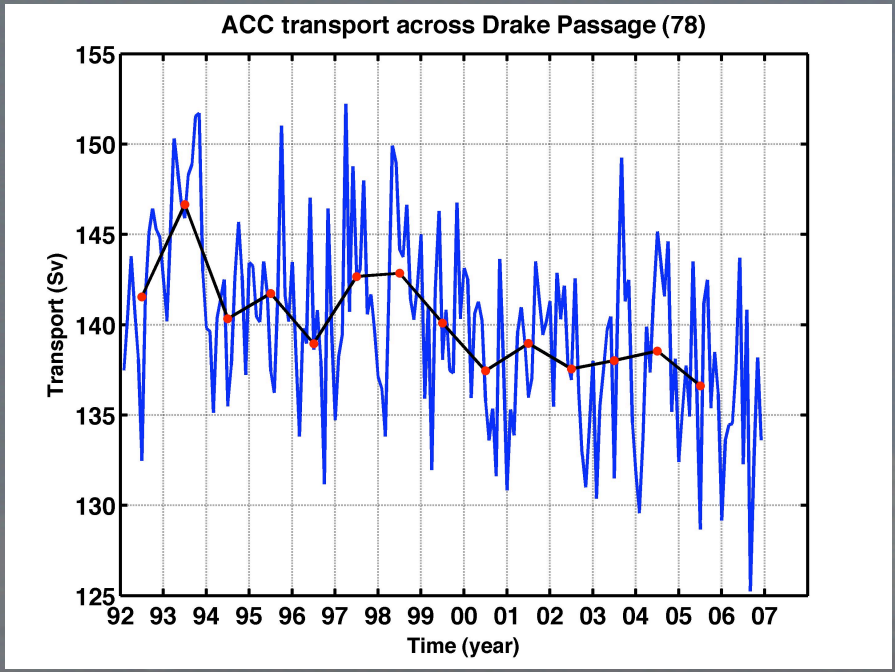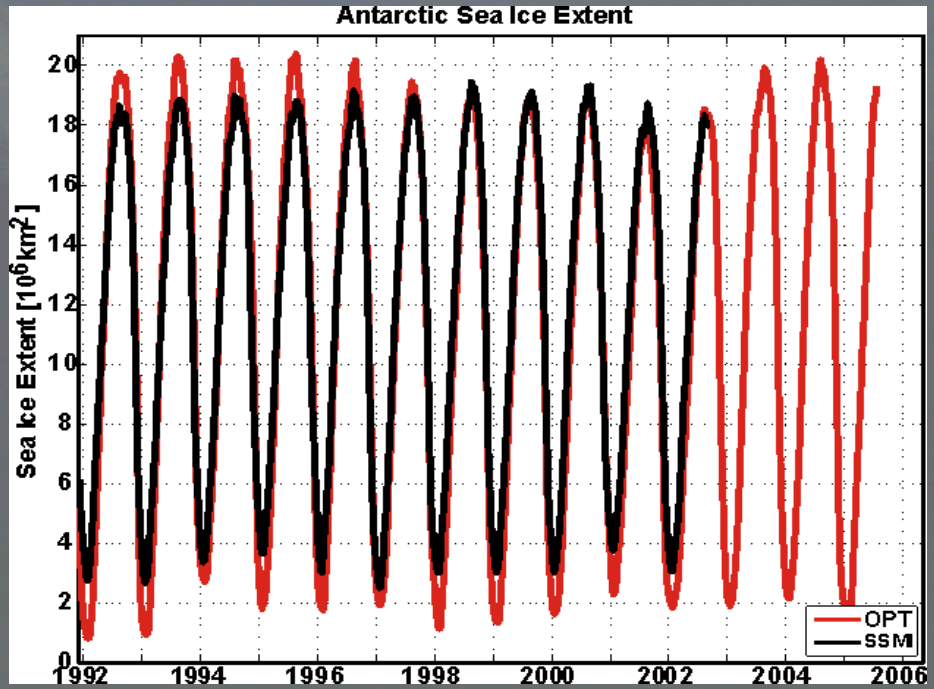
Latest Optimized Solution (Cube 78)