Regional Arctic System Model (RASM): Progress, Needs and Opportunities.

W. Maslowski[1] and the RASM Team (25+ researchers from 10 institutions)

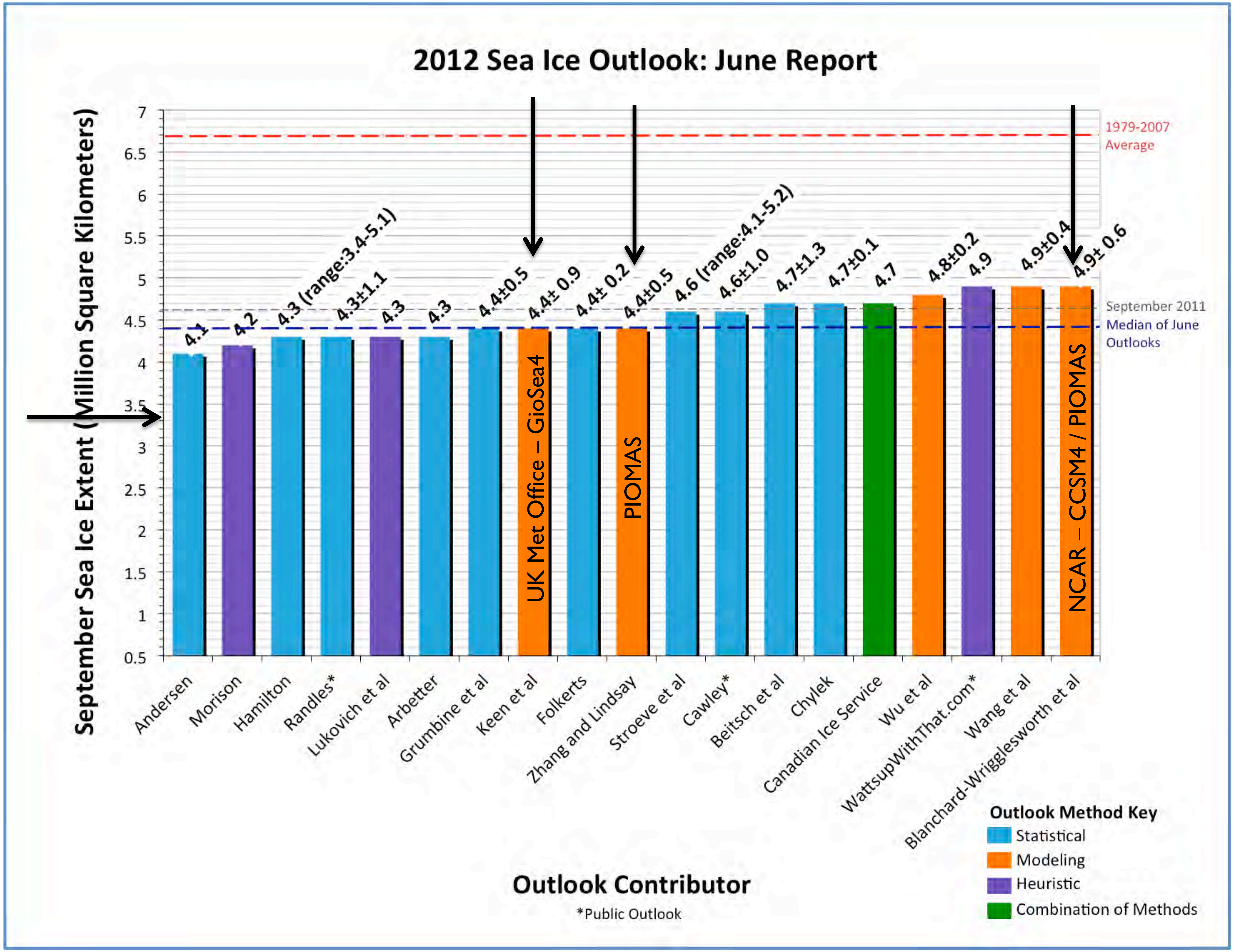
J. Clement Kinney[1], R. Osinski[9], A. Roberts[1], J. Cassano[2], A. Craig[1*], W. Gutowski[3], D. Lettenmaier[4], W. Lipscomb[5], B. Nijssen[4], W. Robertson[6], S. Tulaczyk[7], X. Zeng[8], A. Carolina Barbosa[6], M. Brunke[8], D. DiMaggio[1], A. DuVivier[2], B. Fisel[3], J. Fyke[5], J. Hamman[4], S. Hossainzadeh[7], M. Hughes[2], S. Knuth[2], T. Mills[1], J. Renteria[10]

[1]NPS, [2]CU, [3]ISU, [4]UW, [5]LANL, [6]UTEP, [7]UCSC, [8]UA, [9]IOPAS, [10]DOD/HPCMP/PETTT, [*]contractor

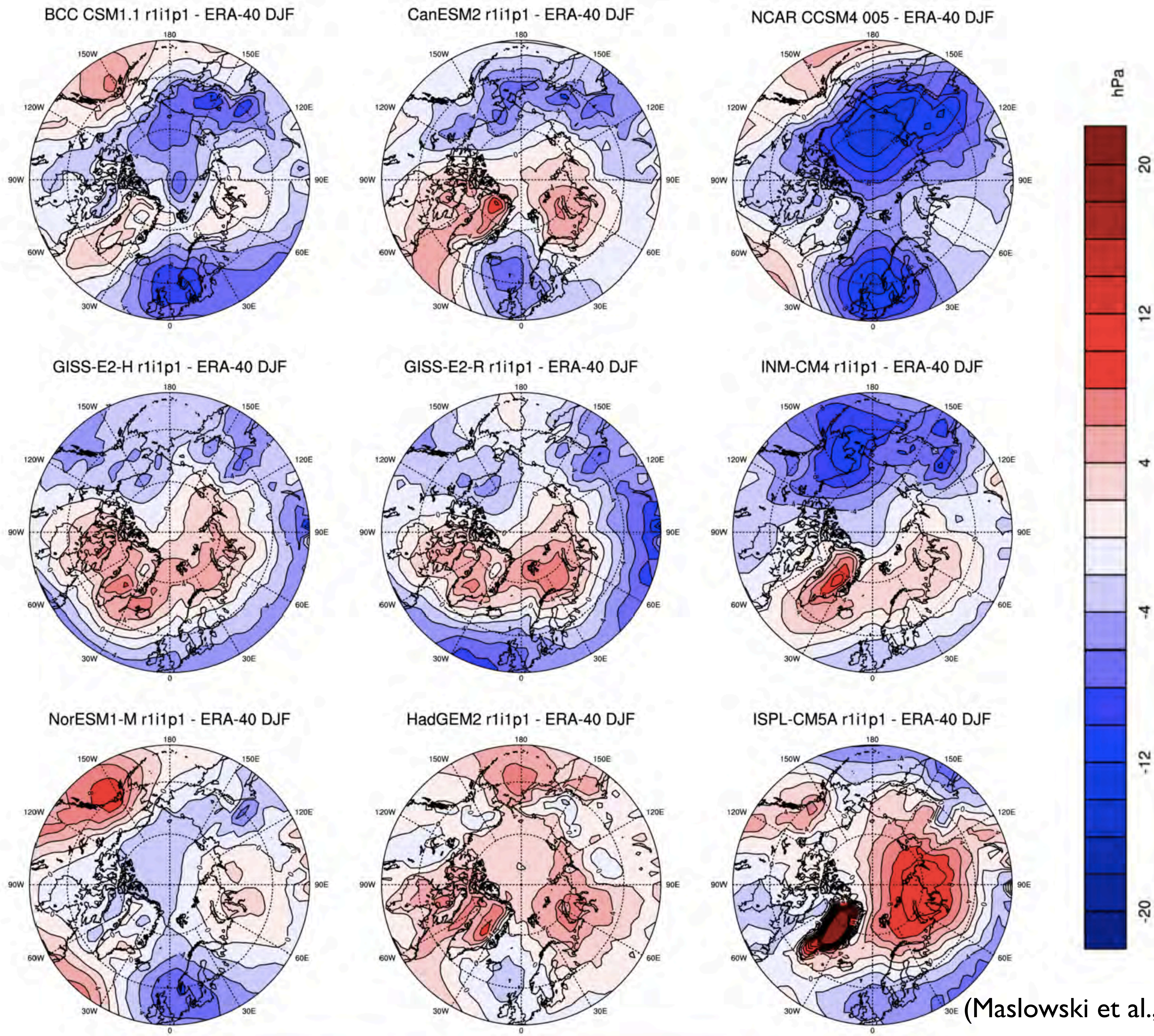
<http://www.oc.nps.edu/NAME/name.html>

Pacific Arctic Group Meeting, KOPRI, Incheon, South Korea, 17 October, 2013

3-month Outlook

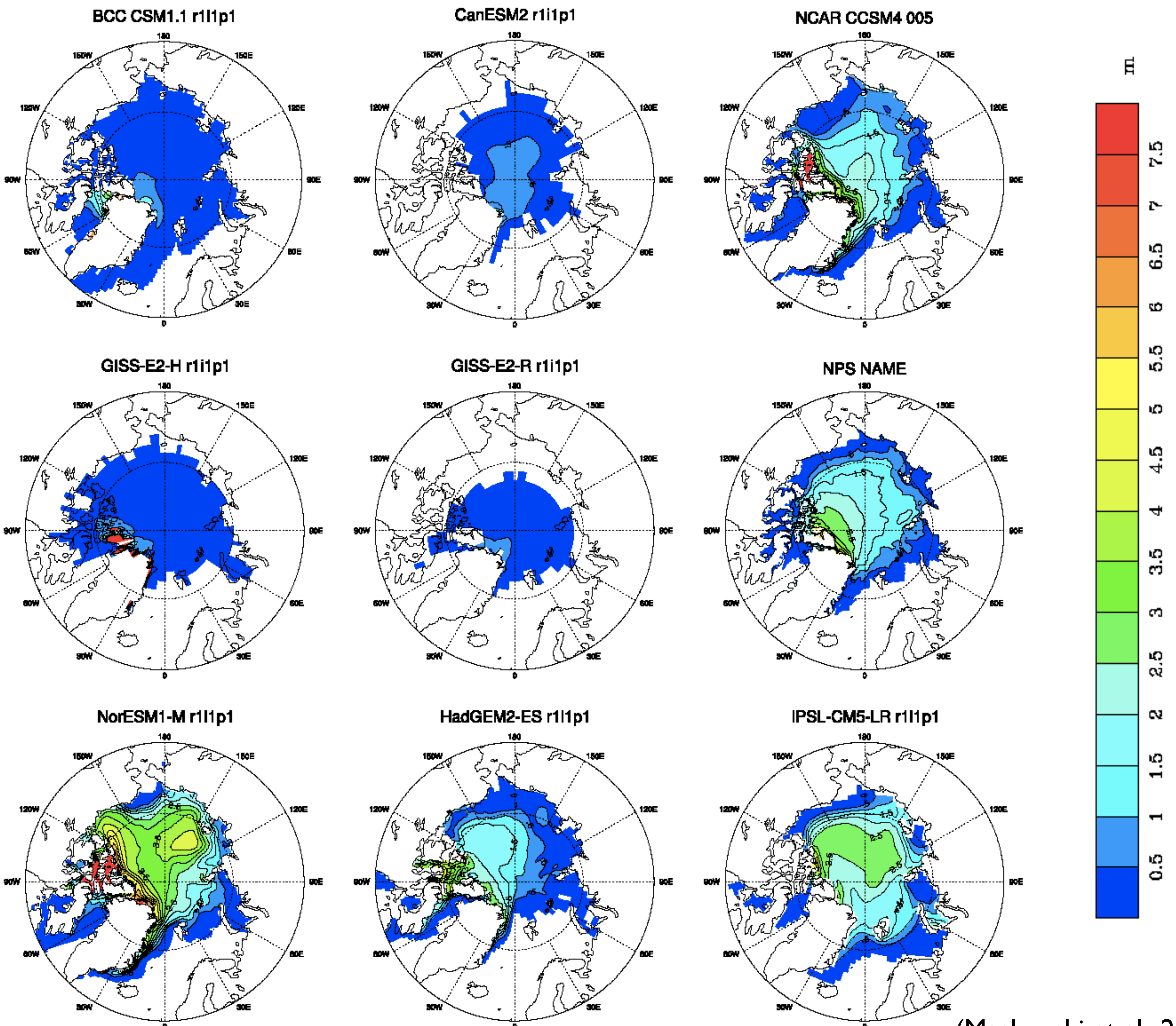


Differences in winter mean sea-level pressure averaged from 1979 to 2002 for nine CMIP5 global climate models versus ERA-40



(Maslowski et al., 2012)

September mean sea ice thickness (m) averaged over 2000–2004 from CMIP5 and NAME models.



(Maslowski et al., 2012)

MODEL LIMITATIONS AND BIASES

There are many arctic physical/climatic **processes** omitted from, or poorly represented in current-generation GC/ESMs, including:

- sea ice thickness distribution, deformation and export, fast ice, snow cover, melt ponds and surface albedo, permafrost,
- oceanic eddies, tides, surface/bottom mixed layer, buoyancy-driven coastal and boundary currents, fronts, cold halocline, upper ocean heat content, dense water plumes and convection,
- atmospheric modes of circulation, **clouds** and fronts,
- ice-sheets/ocean, fjord-shelf-basin, wave-ice and air–sea-ice interactions and coupling.

another person can possibly come up with a different list

How can an Arctic System Model be used to advance understanding and prediction of arctic climate change?

1. By resolving unresolved or under represented **processes** in individual system components.

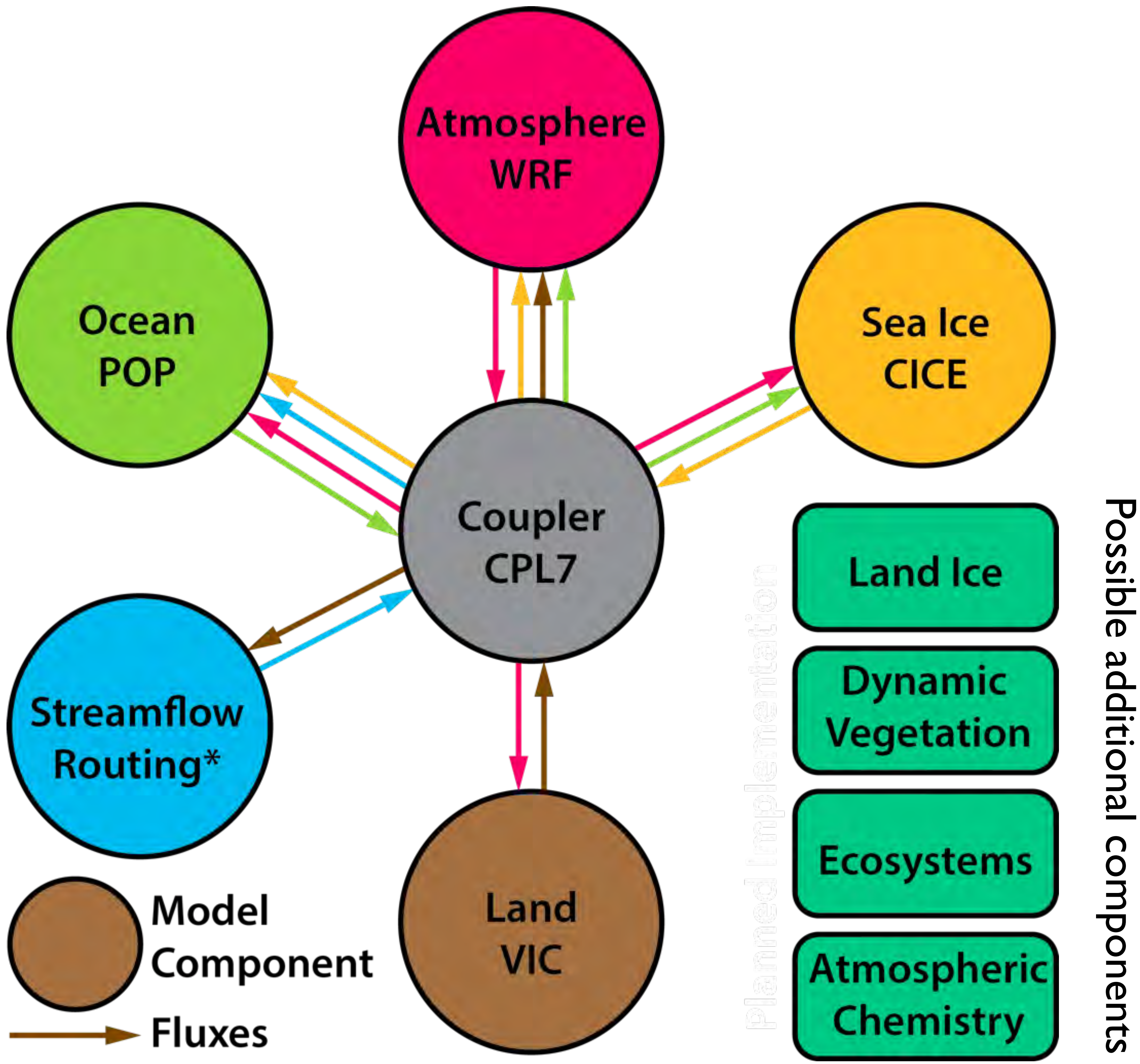
2. By addressing inadequacies along **coupling** channels between different system components

3. By exploring space-dependent **sensitivities** in the parameter space

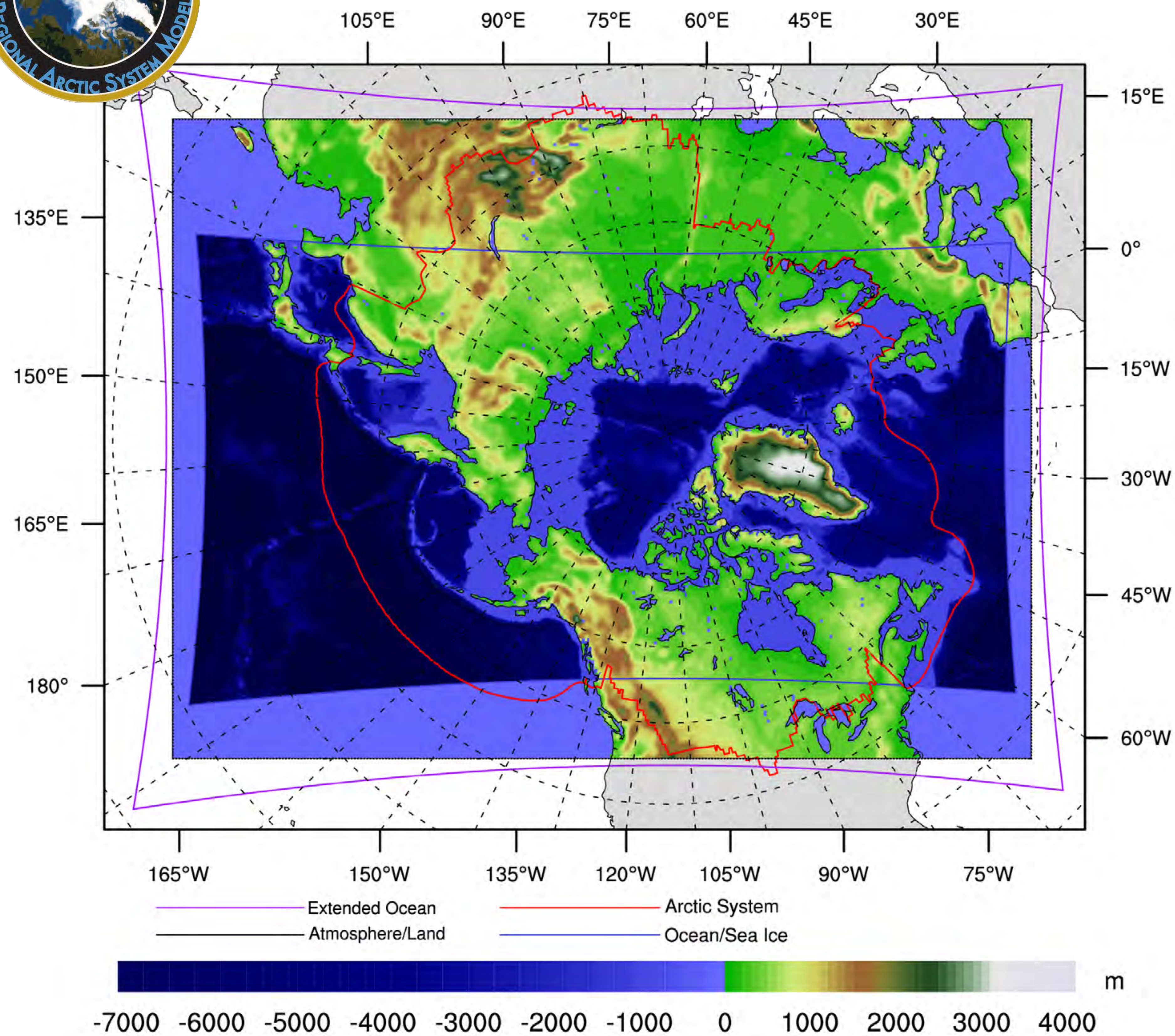
4. Through a **hierarchical modeling** approach using regional and global models to help quantify uncertainty.

Maslowski et al. 2012

RASM wiring diagram



RASM Domains for Coupling and Topography

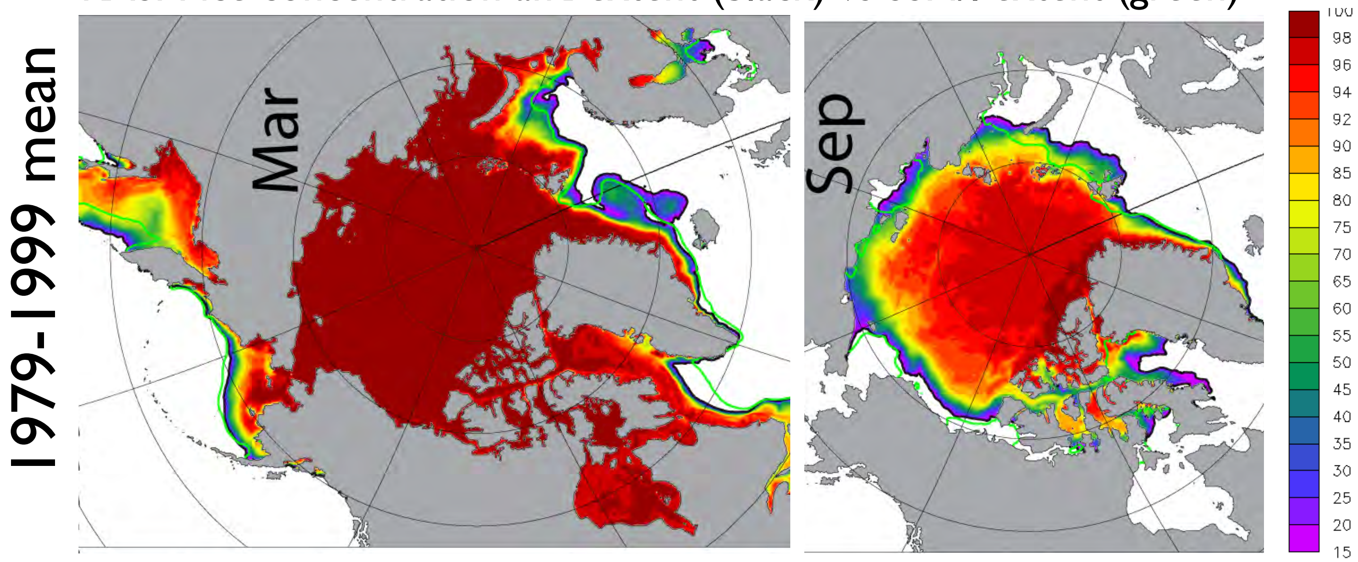


Pan-Arctic region include:
- all sea ice covered ocean in the NH
- Arctic river drainage
- inter-ocean exchange and transport
- large-scale weather patterns (AO, PDO)
- WRF and VIC model domains (50-km) cover the entire colored region
- POP and CICE domains (9-km) cover the inner colored region

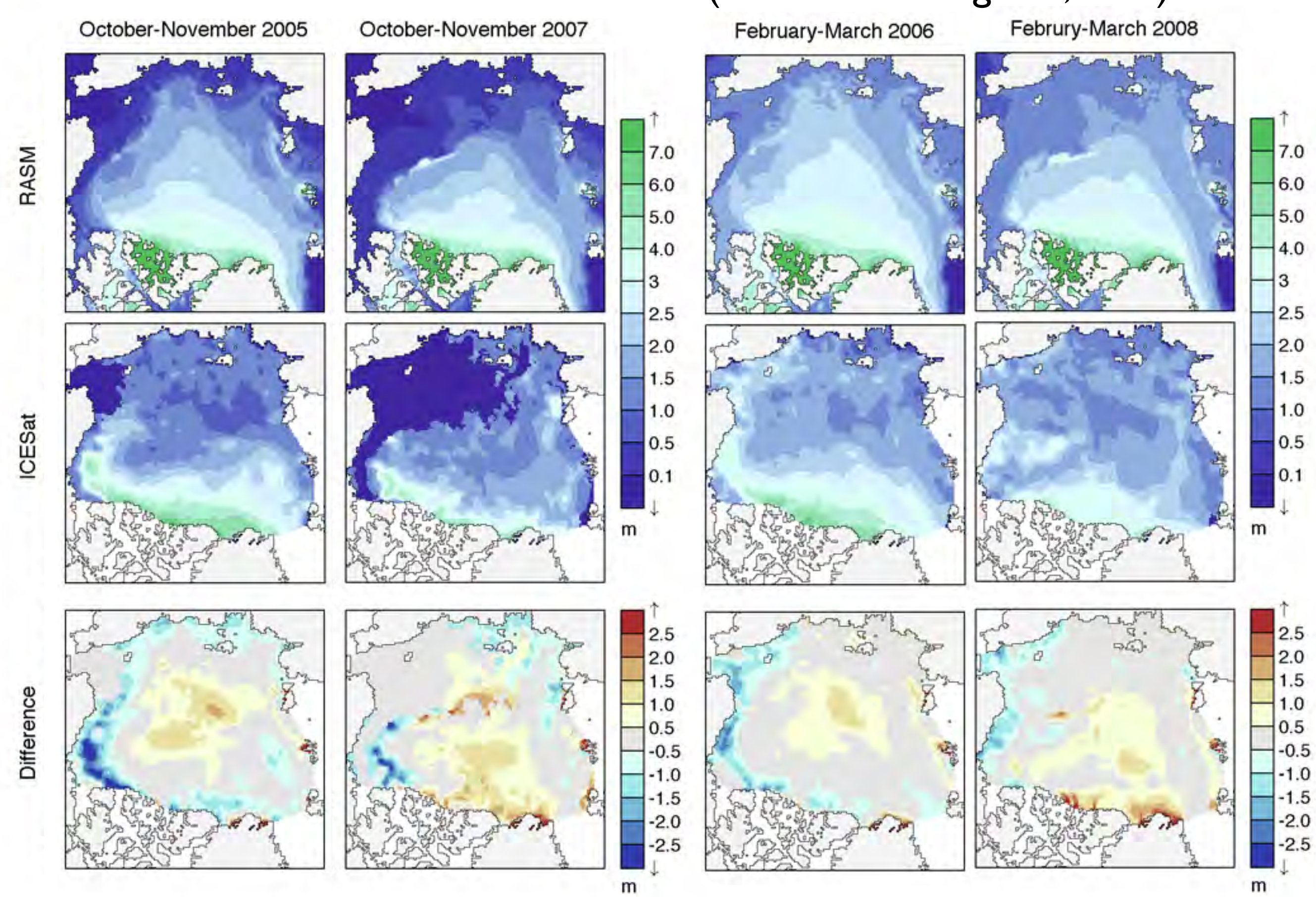
The Arctic System domain (red line) after Roberts et al. (2010).

RASM-H sea ice analyses with observations

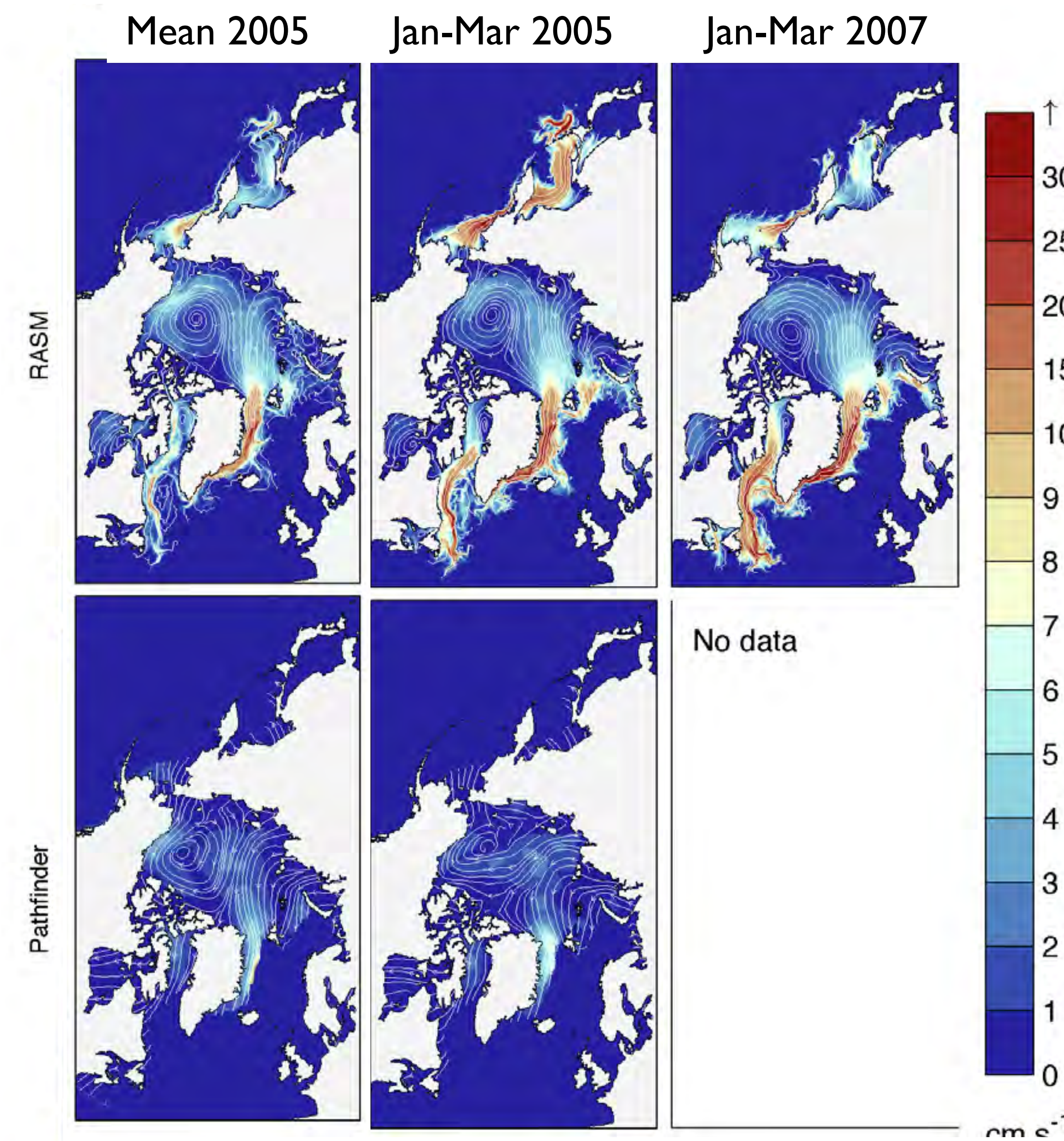
RASM ice concentration and extent (black) vs SSM/I extent (green)



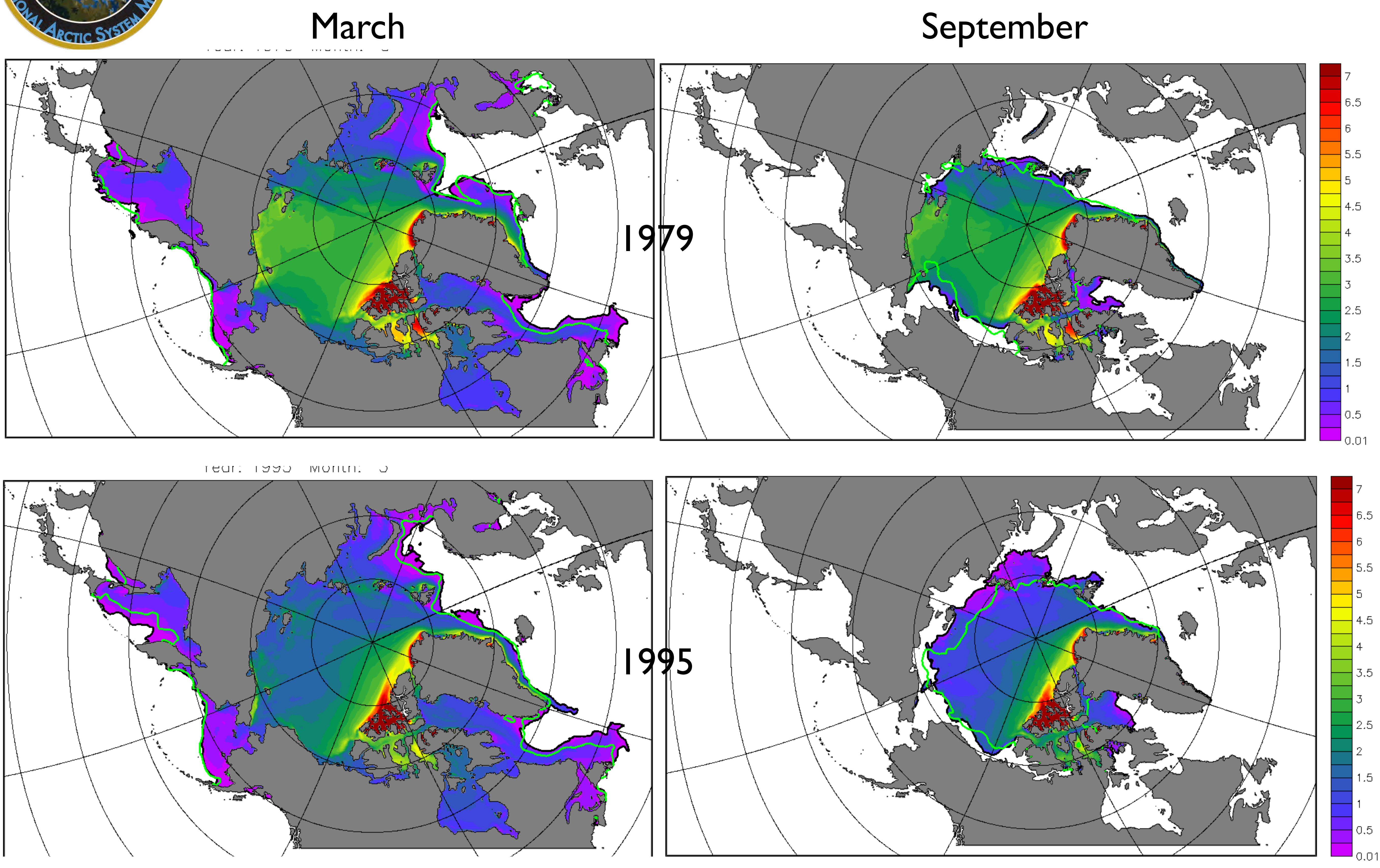
RASM sea ice thickness vs IceSat (Kwok & Cunnigham,2008)



RASM / Pathfinder sea ice streamlines and speed

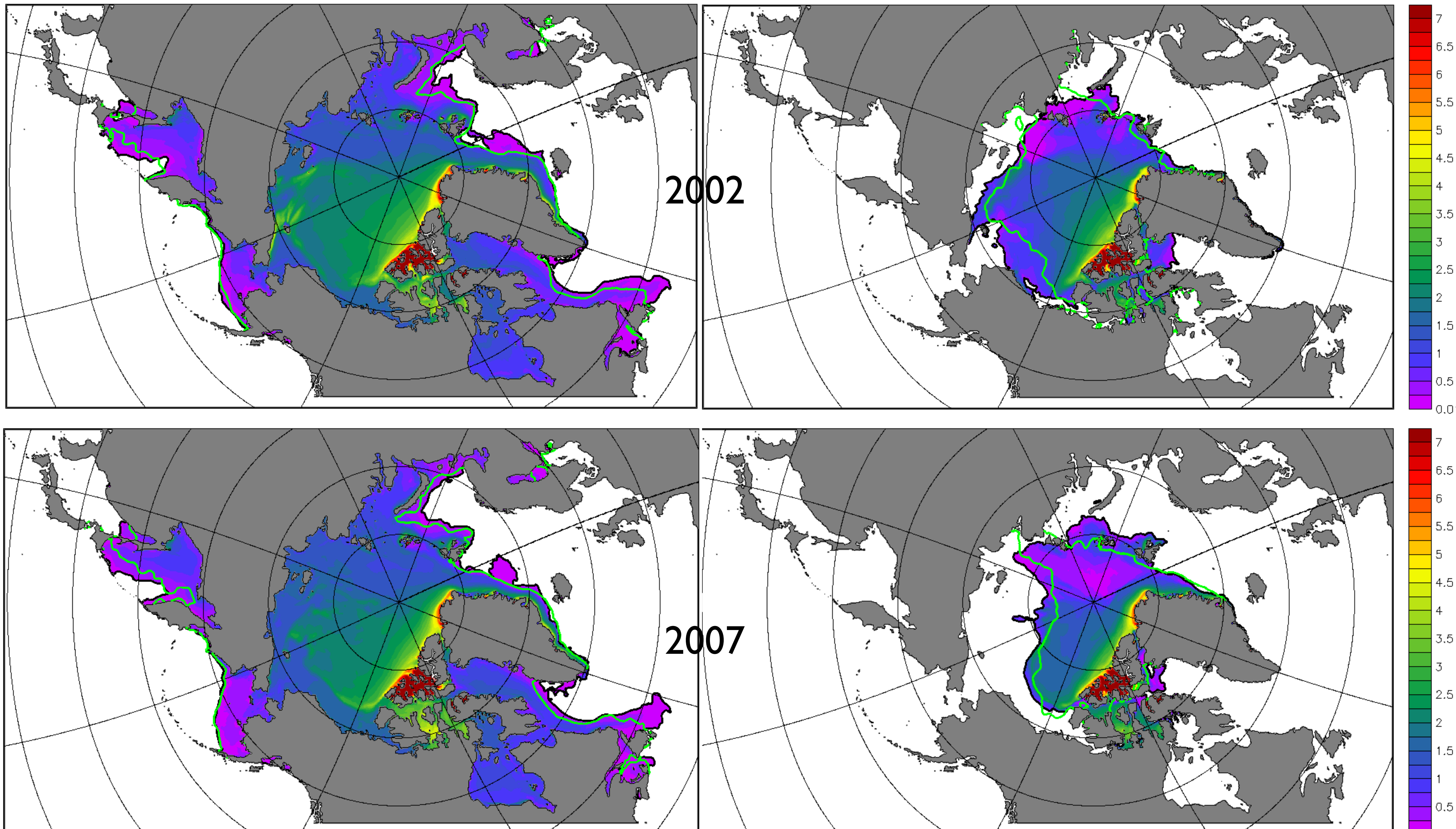


RASM H-compset forced with CORE2 vs SSM/I

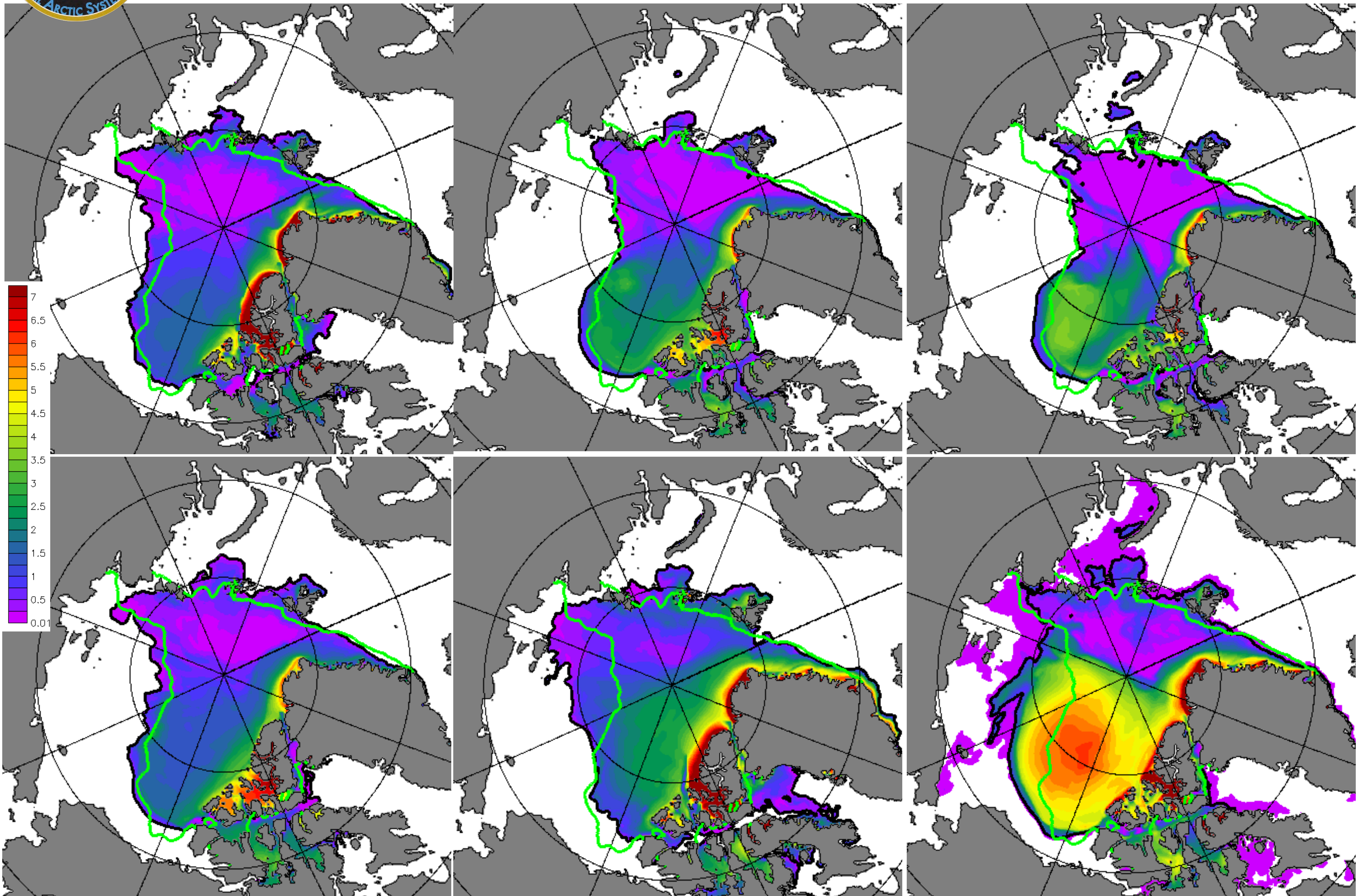


RASM H-compset forced with CORE2 vs SSM/I

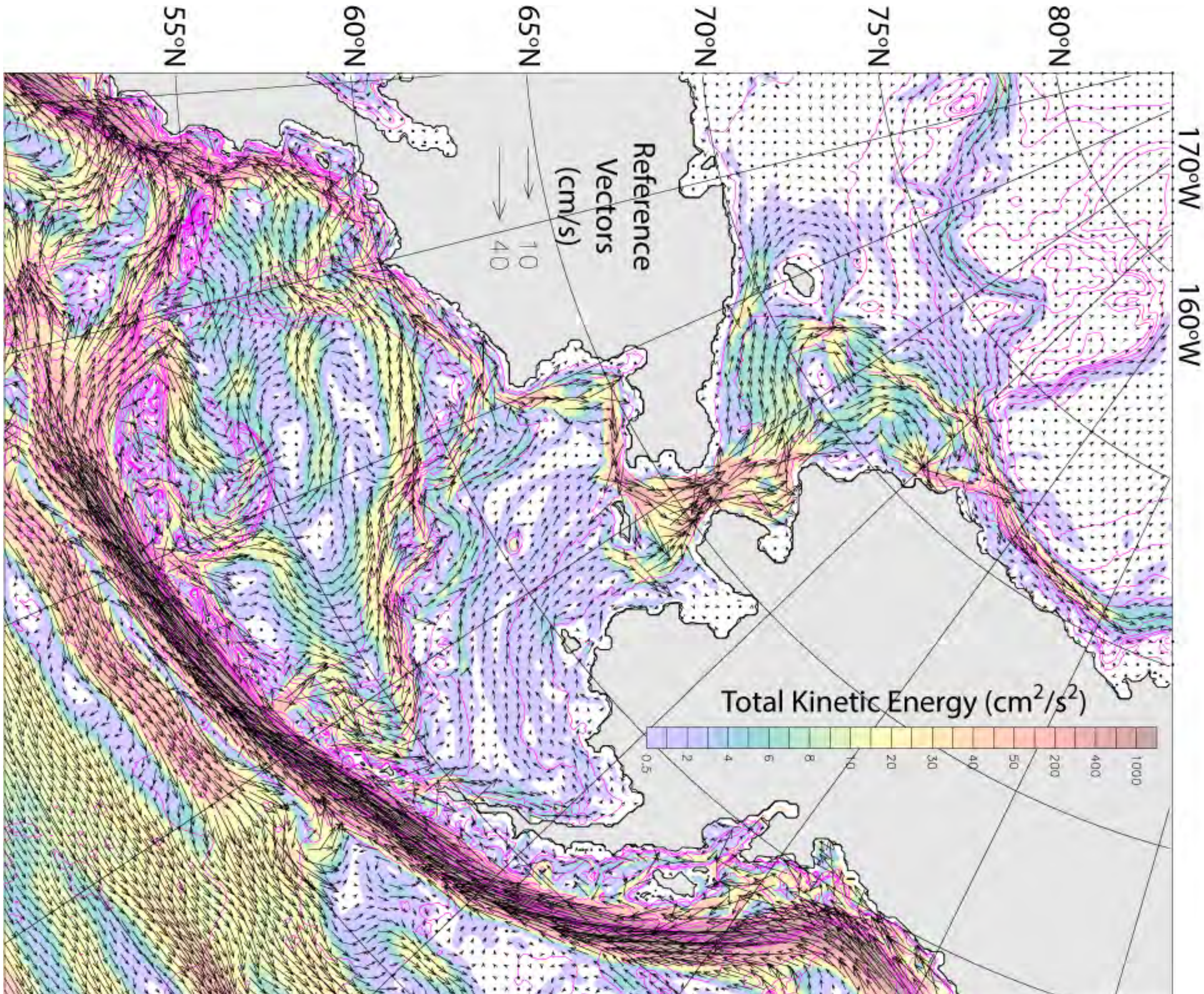
March September



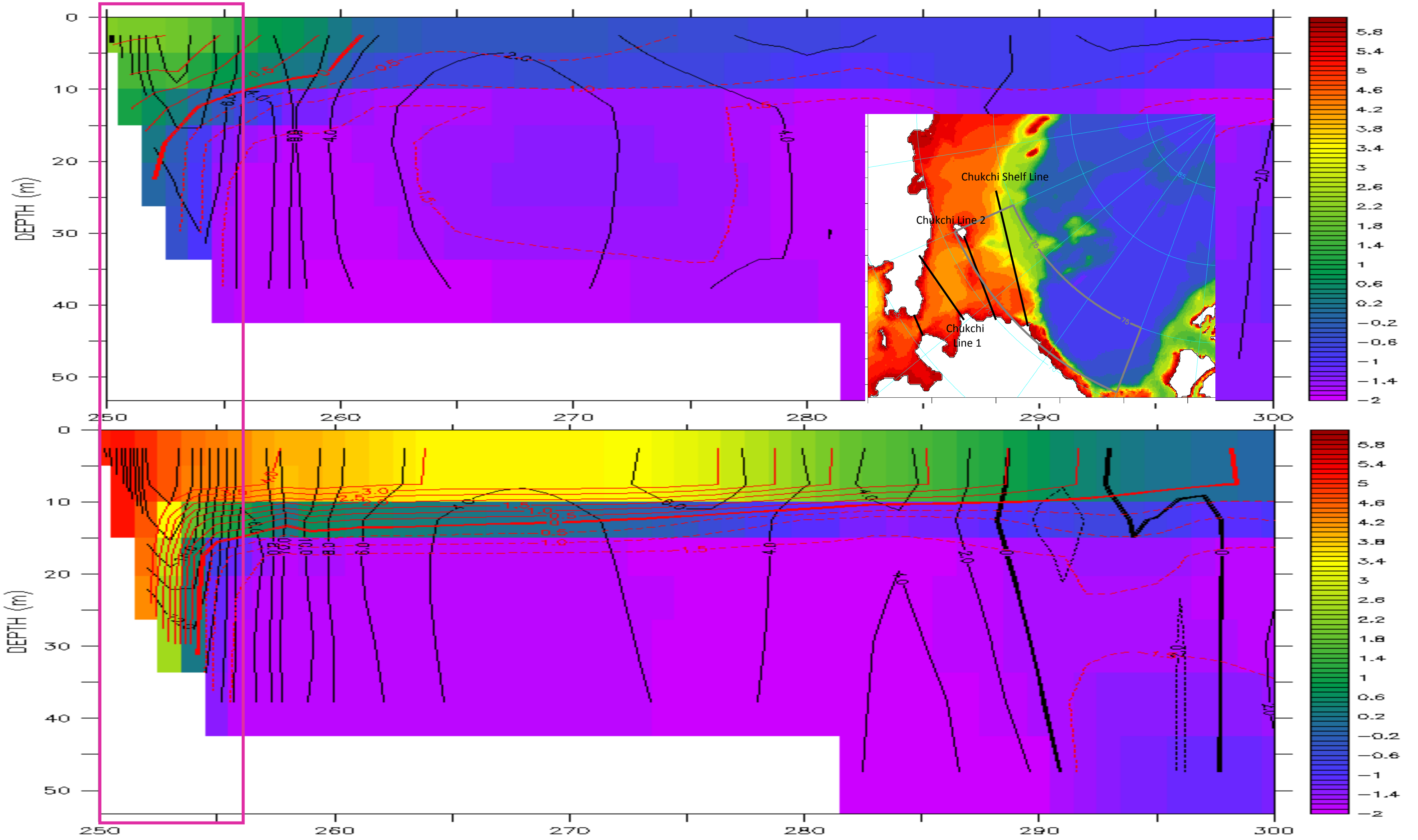
RASM paramter sensitivity results: Sep 2007



Time-Mean Ocean Circulation in the Pacific-Arctic

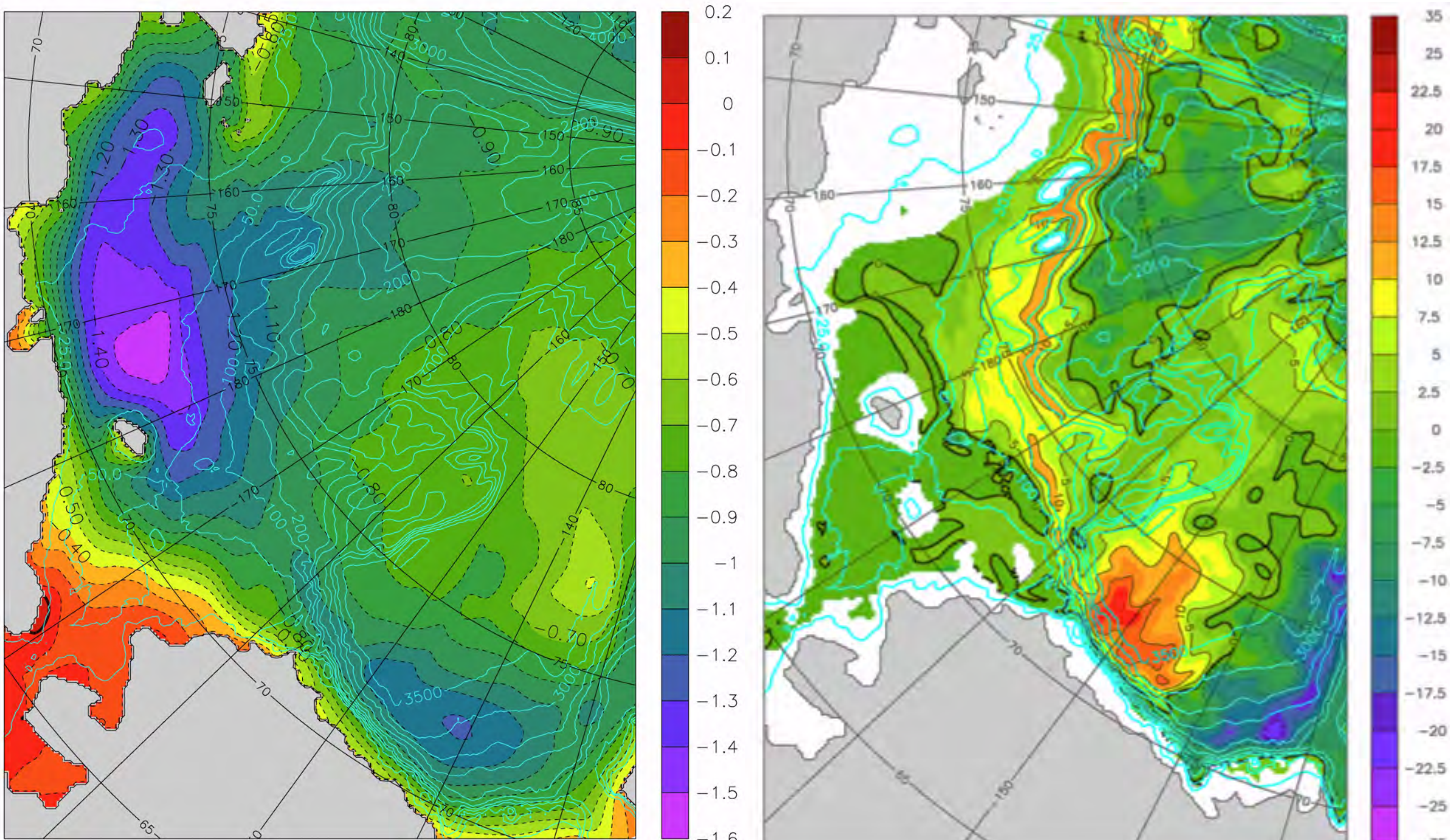


The importance of coastal currents: Alaska Coastal Current



~67% of all oceanic heat from the Chukchi Sea is transported by the Alaska Coastal Current within 30-50 km along the coast

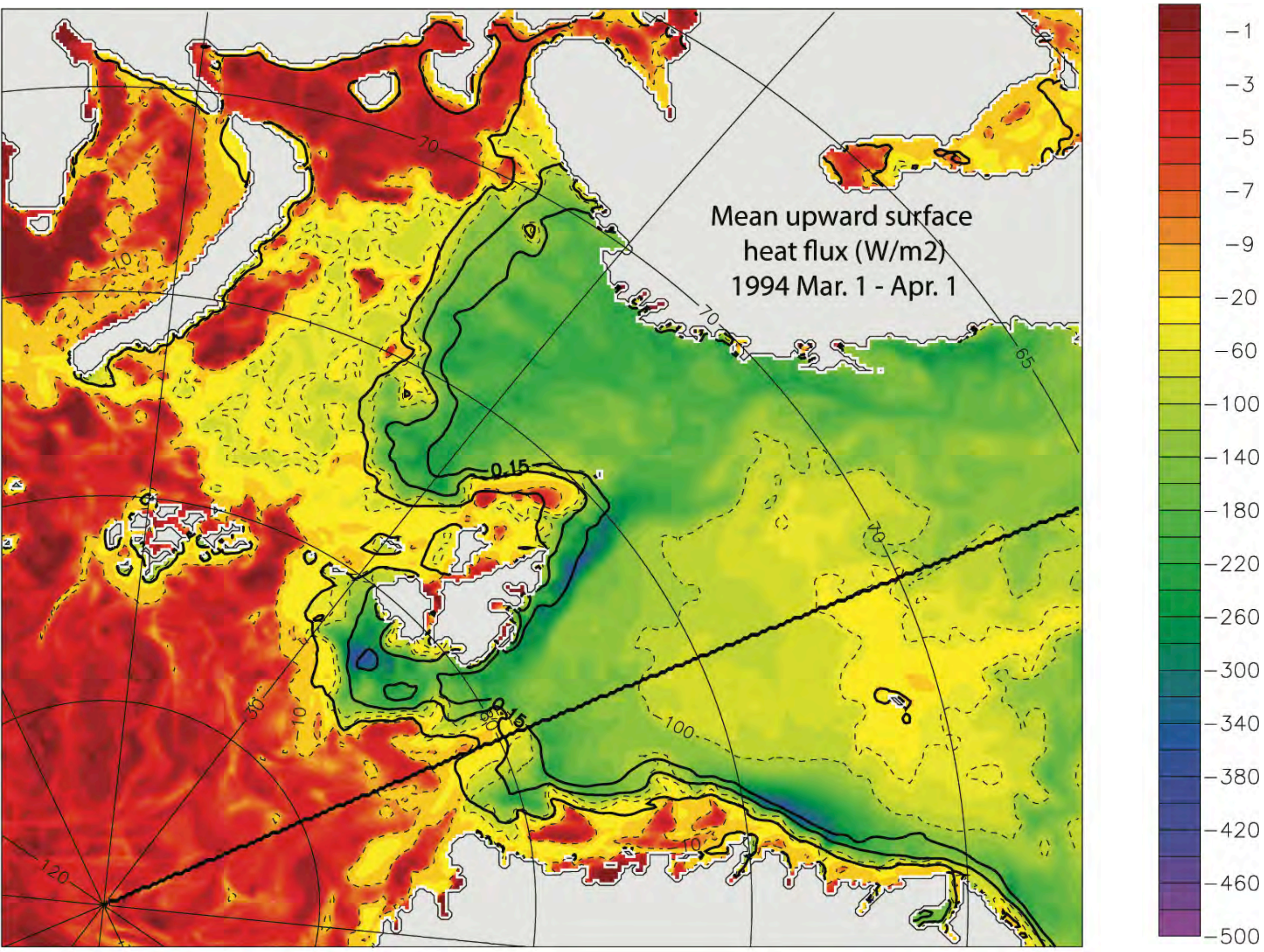
Modeled changes in (a) heat content (TJ) at depth 33-120 m and (b) sea ice thickness (m) between the mean of 1979-1998 and the mean of 1999-2004.

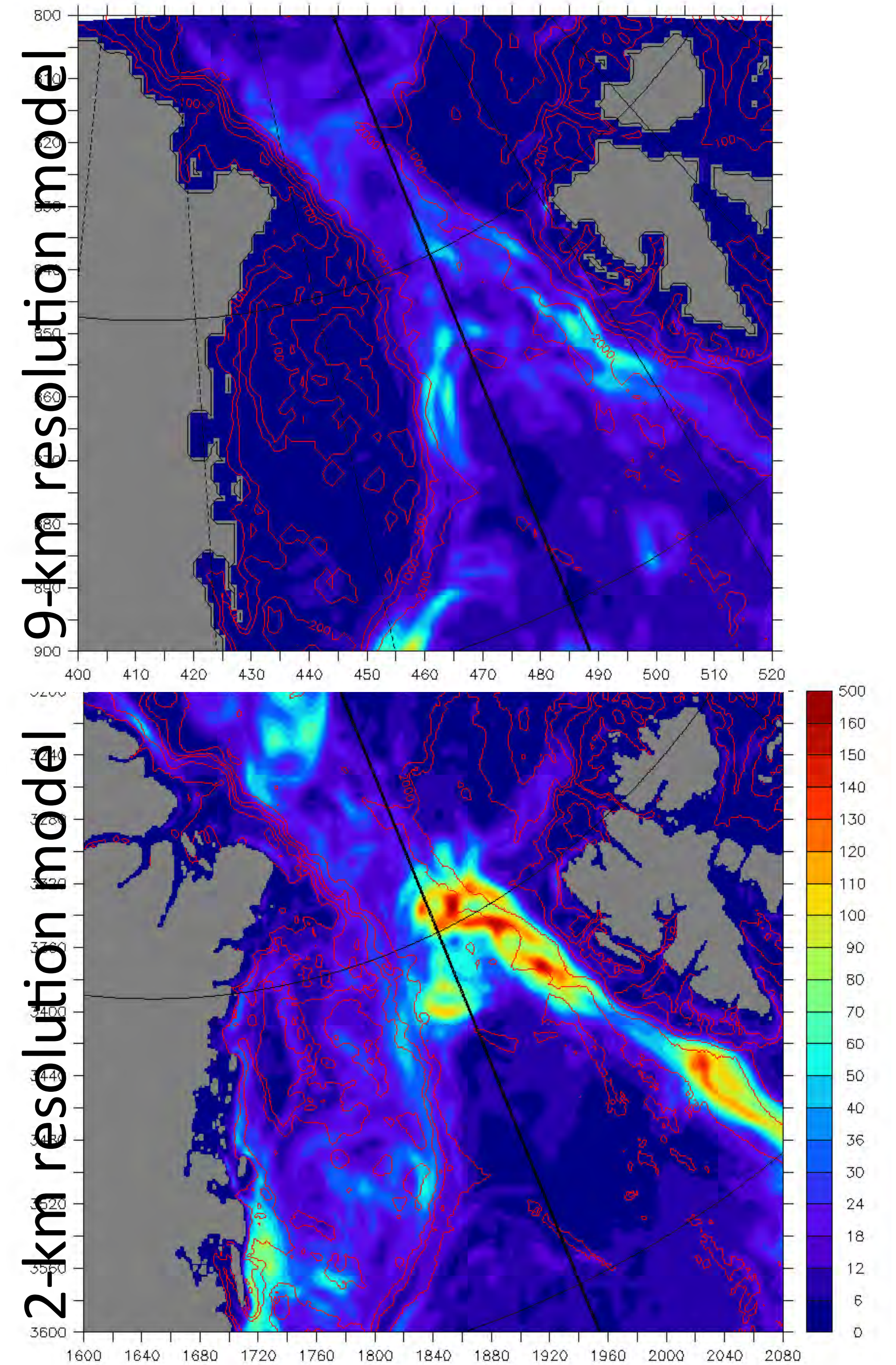


Increasing heat content due to local insulation, advection of warm water from shelves, anticyclonic eddies, slope upwelling or advection

(Maslowski et al, 2013)

RASM monthly mean upward sfc heat flux – 3/93 and mean EKE (cm^2/s^2; 0-223 m) – Fram Strait

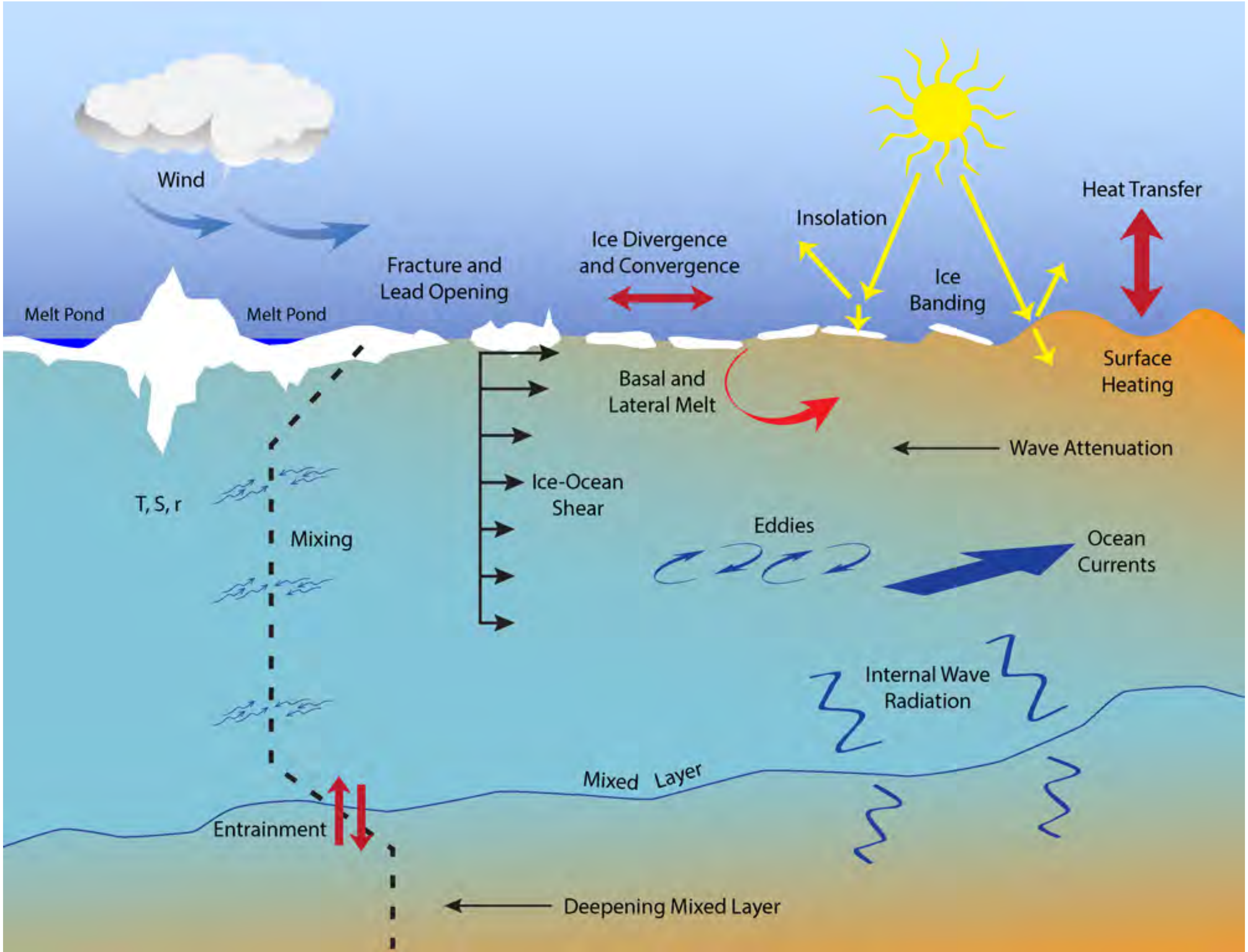




	obs	NAME	CCSM3
Fram Strait Vol Heat Flux (N)	6.8 Sv 36 TW	6.9 Sv 45 TW	2.0 Sv 17 TW
FJL – NZ Vol. Heat Flux (net)	NA Near zero	2.6 Sv 2.2 TW	4.35 Sv 31 TW

- Surface monthly-mean heat fluxes in excess of 350 W/m^2 along the marginal ice zone

Atmosphere, sea ice, and upper ocean processes in the MIZ



ONR/DRI MIZ Science Plan

Future RASM Plans

1. Parameter space sensitivity studies in fully coupled RASM
2. Alternative BCs for WRF
    - NCEP/CFSR - underway
    - 21st century global climate model scenarios (e.g. CESM)
3. Ensemble generation in RASM
4. Higher resolution RASM component model configurations
    - 25 & 10-km WRF / VIC
    - 1/48^{o} (~2.3 km) POP / CICE
5. Addition of new components:
    - ecosystem / marine BGC
    - tidewater fjords with ice-sheet/ocean interactions
    - wave model component
    - atmospheric chemistry

PAR-relevant RASM Advancements: 5-yr Outlook

- Eddy and tide-resolving ocean/ice models (1-2km)
- Atmosphere model with improved clouds
- Consistent across components initial conditions
- Ensemble prediction based on:
    a. Perturbed initial state
    b. Variable parameter space
    c. Variable atmospheric boundary conditions
    d. Multi-model

Other Arctic System Modeling / Prediction Related Needs

- Validation Data (e.g. sea ice thickness/concentration and motion/deformation, upper ocean (0-150m) hydrography, snow distribution, cloud microphysics, air-sea fluxes, runoff)
- Process studies (e.g. subsurface heat content and entrainment into the surface mixed layer, seasonal pycnocline, sea ice deformation, marginal ice zone (MIZ), ice-wave interaction, air-sea fluxes, cloud microphysics)
- Continuous core support

Thank You!