



Regional Arctic System Model (RAS) project: progress to-date and future plans

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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

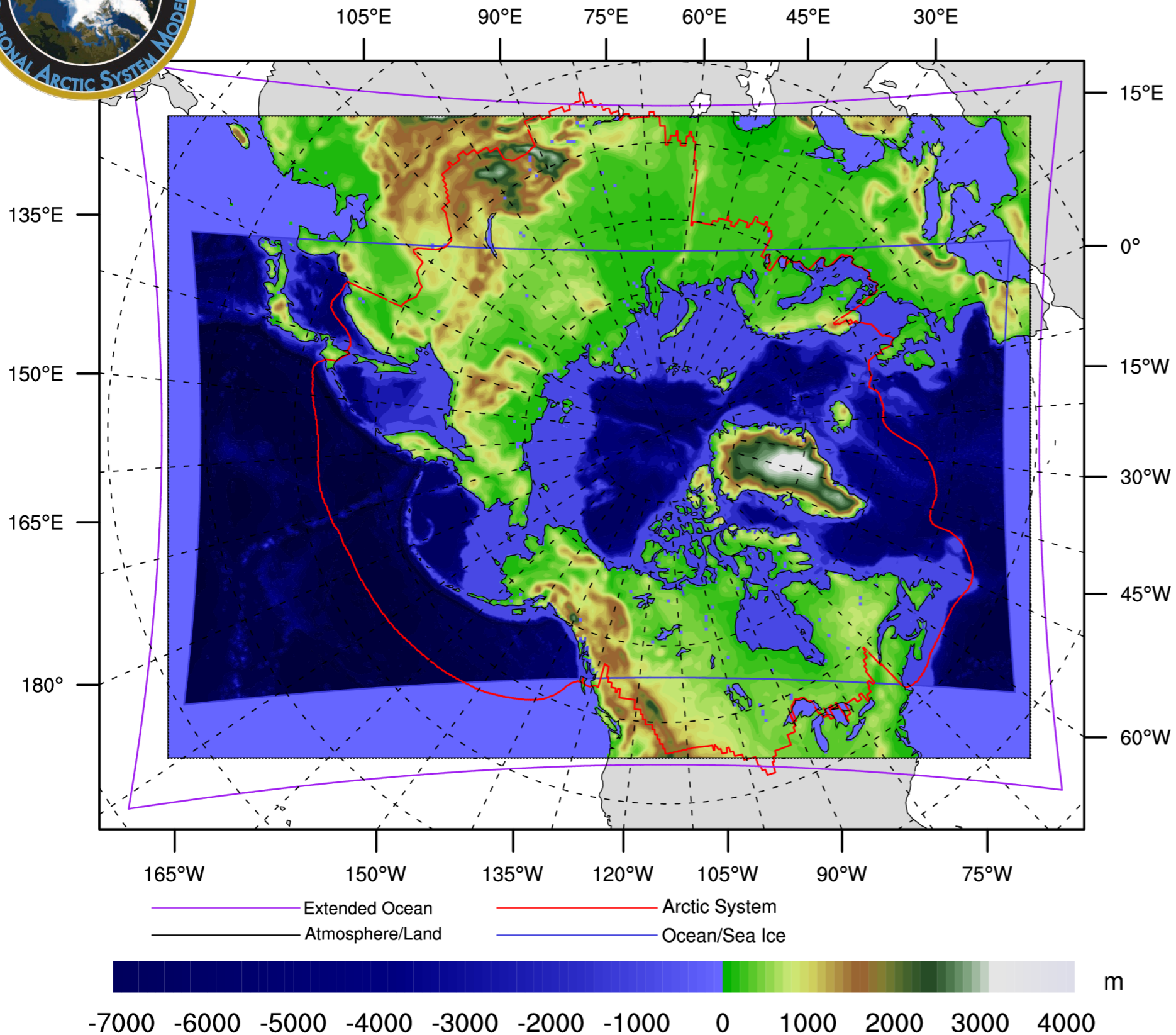


How can coupled regional system models be used to understand uncertainty, complexity and change?

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 both regional and global models to help quantify uncertainty.



RASM Domains for Coupling and Topography



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

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

RASM configuration

Component	Model/Code	Configuration
Atmosphere	WRF	50km, 35 levels, dt=2.5mins Lateral BCs from ERA-I & spectral nudging to wavenumber 1&2 in the upper half
Land Hydrology	VIC	50km, dt=20mins
Ocean	POP	9km, 45 levels, dt=8/8/4mins Restoring to monthly T/S climatology along closed lateral boundaries
Sea Ice	CICE	9km, 5cats, dt=20mins
Coupler	CPL7	20 min coupling

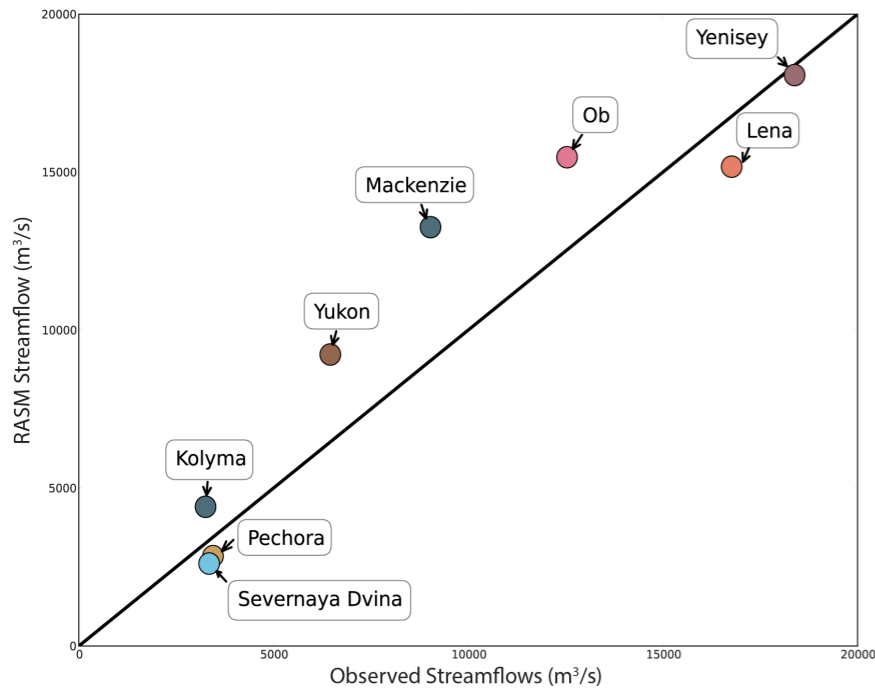
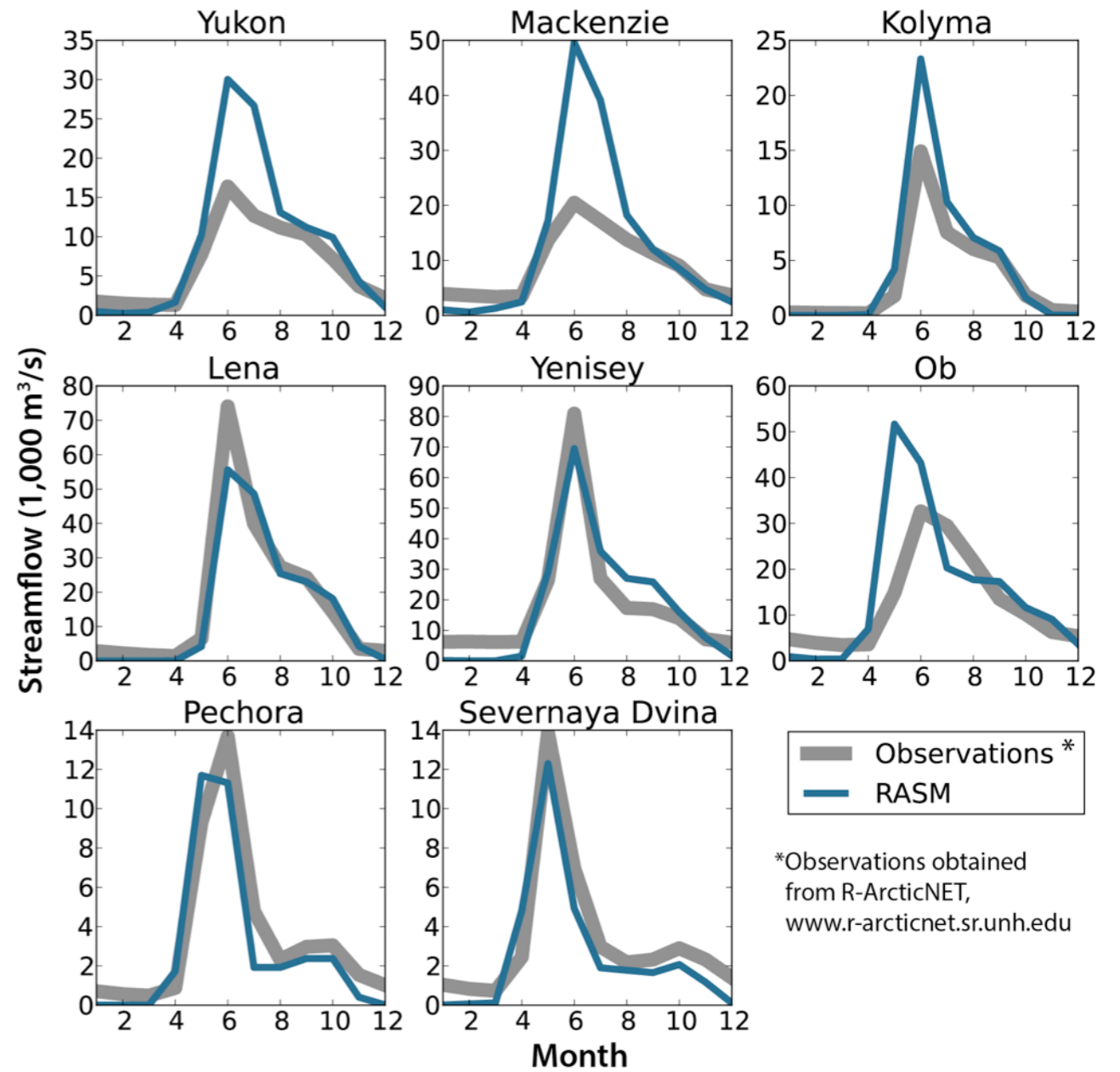
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- **Streamflow Routing**
- **Dynamic Vegetation – VIC + CLM** (same as WRF)
- **Dynamic Ice Sheet – Glimmer-CISM plus** (gridcell $\leq 5\text{km}$)
- **Glacier and Ice Caps (GIC)**
 - A new parameterization for evolving area and volume of GIC in VIC

The RASM Streamflow Model



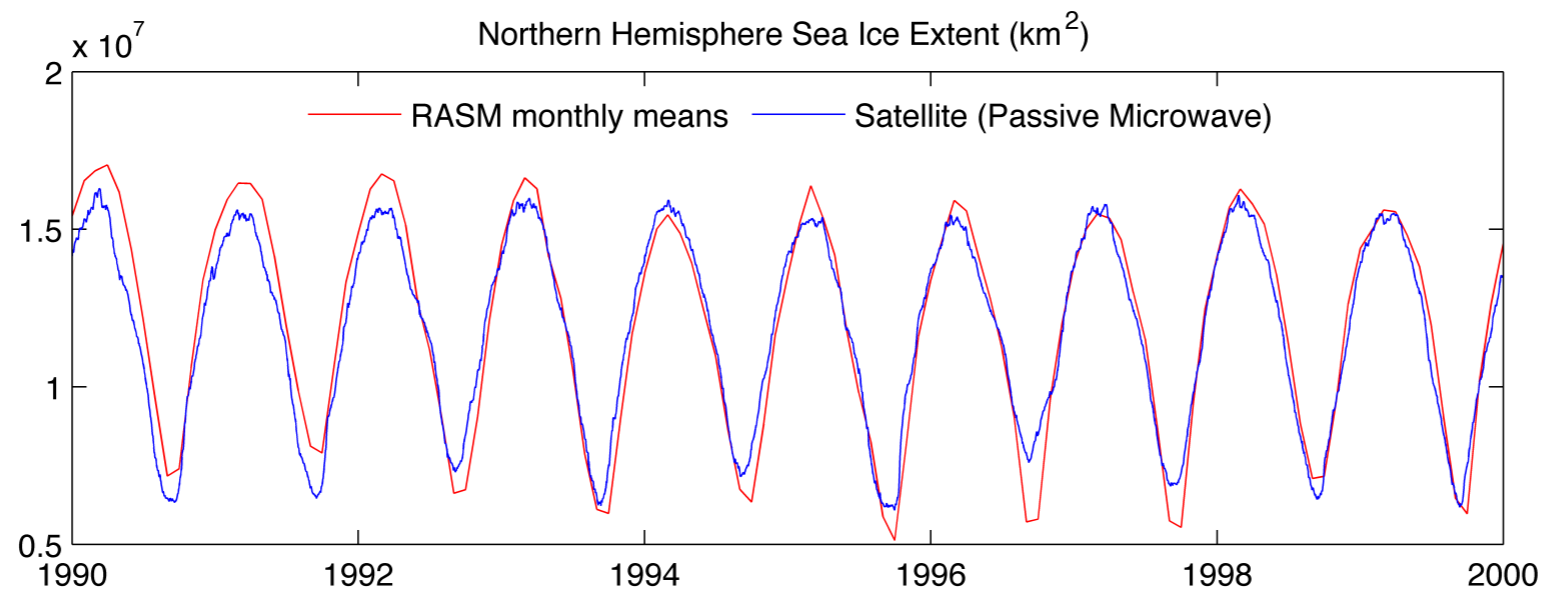
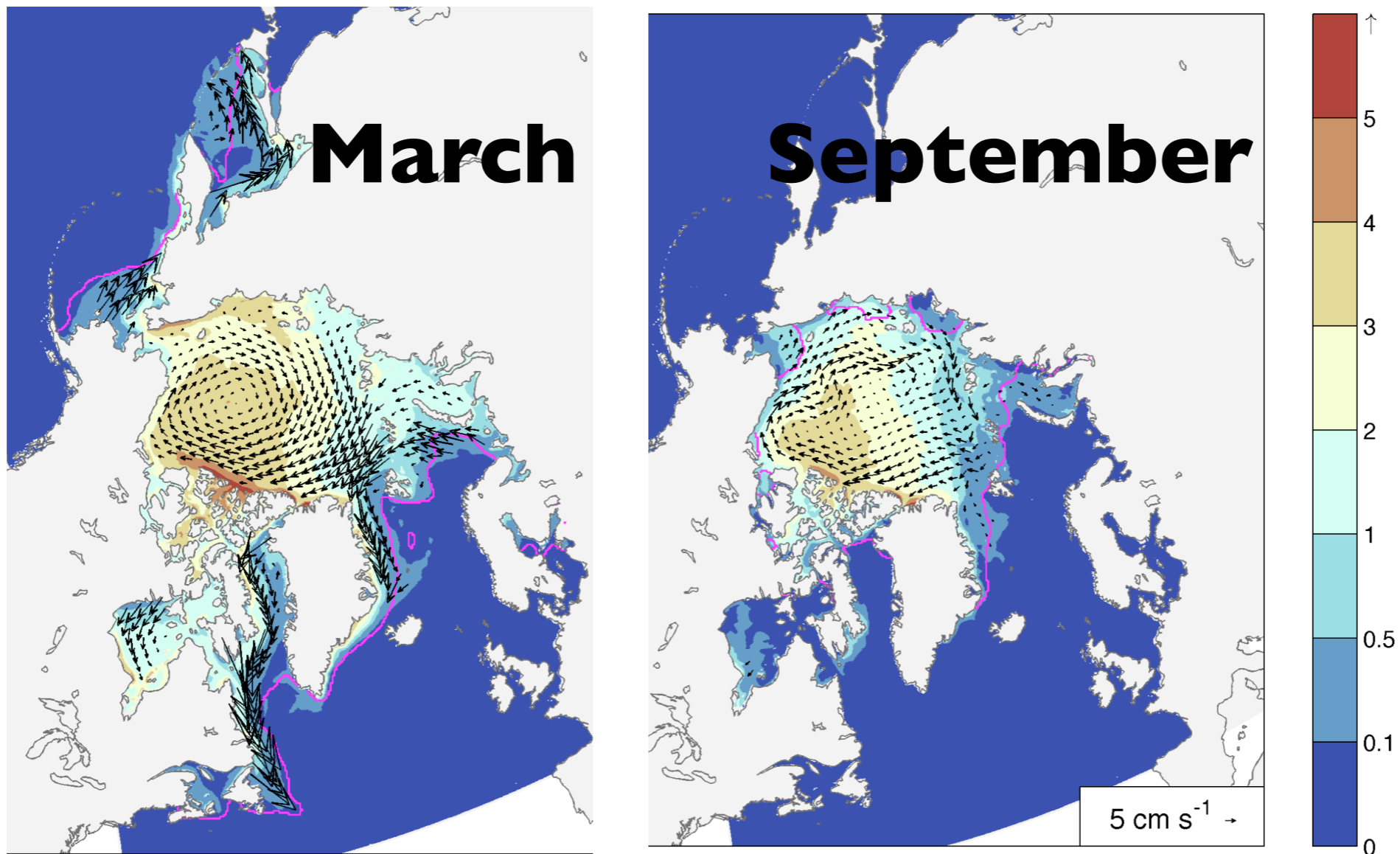
Mean Monthly Discharge



Courtesy Bart Nijssen and Joe Hamman



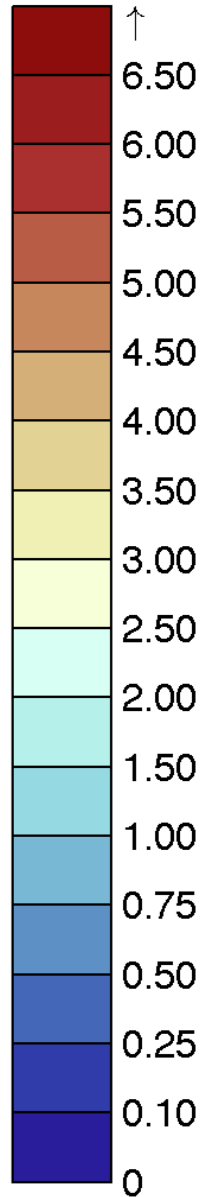
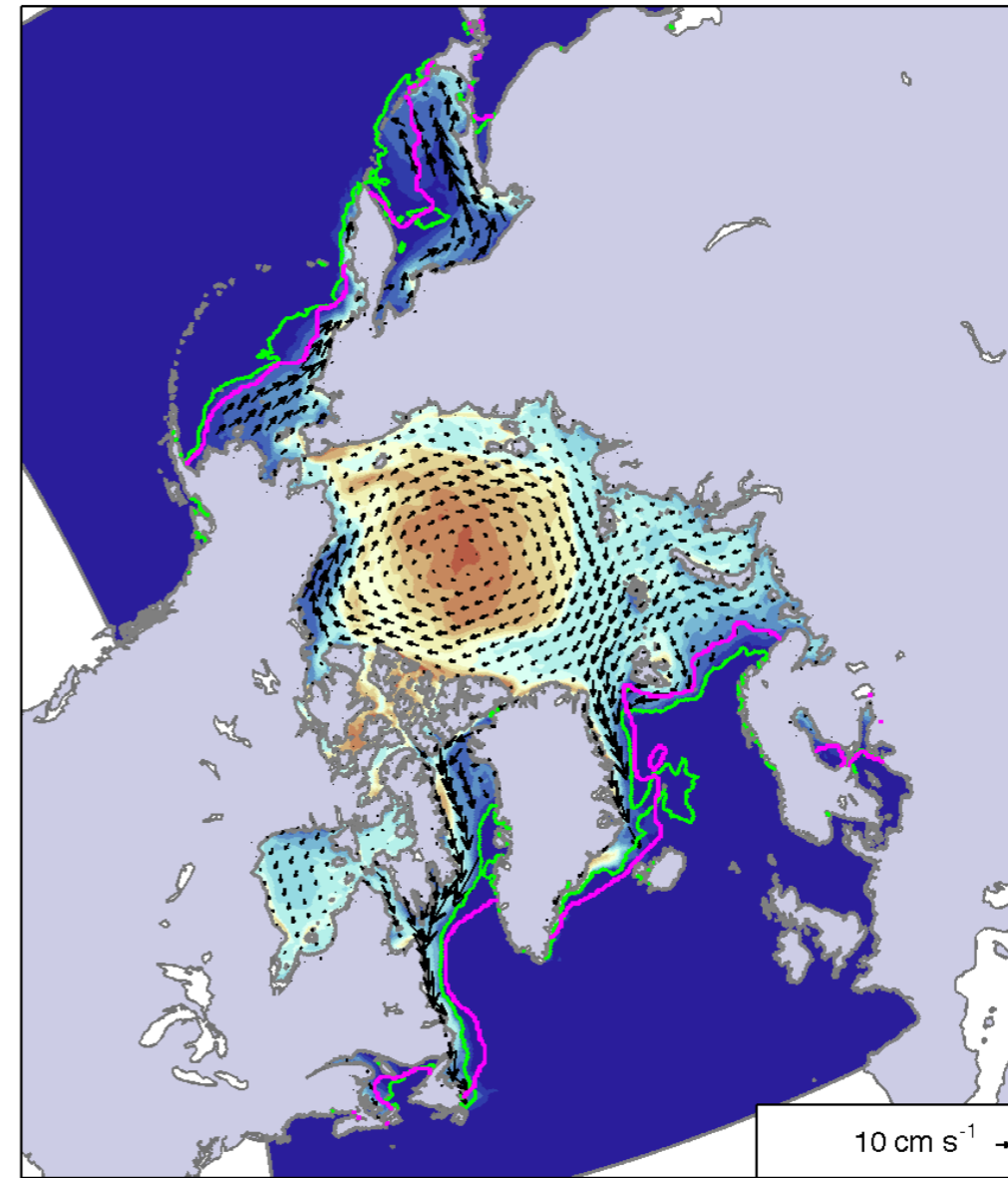
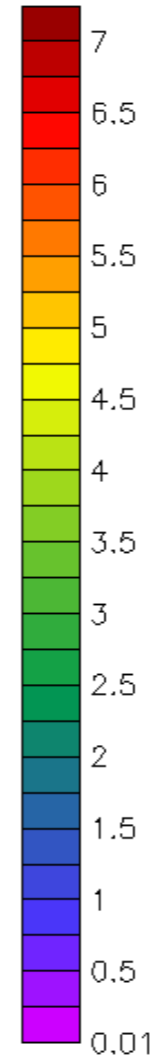
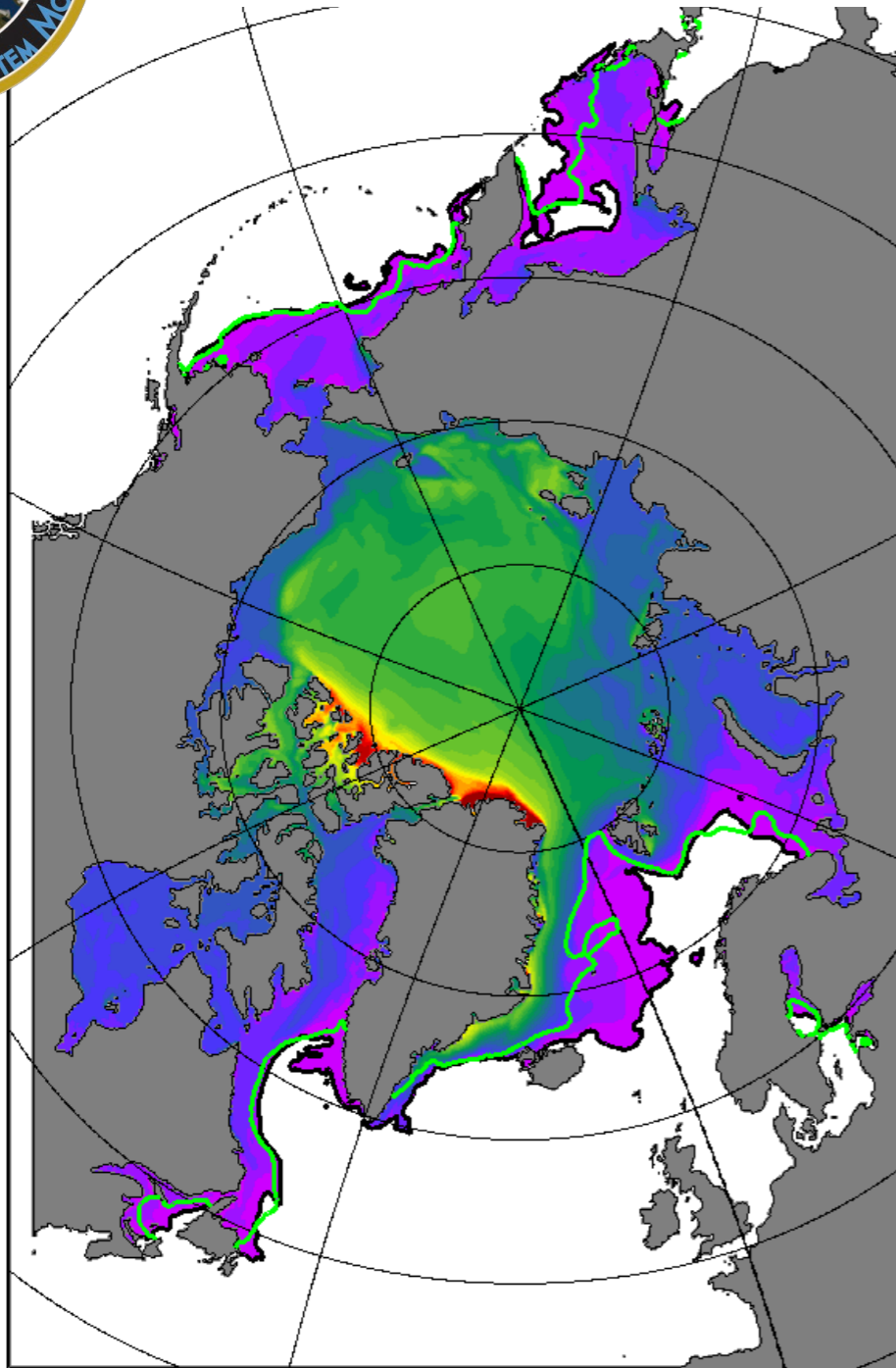
RASM sea ice - mean (1990-1997)





Sea ice thickness for March 1998

Mar-1998 r28RB1g sea ice velocity and thickness with observed extent

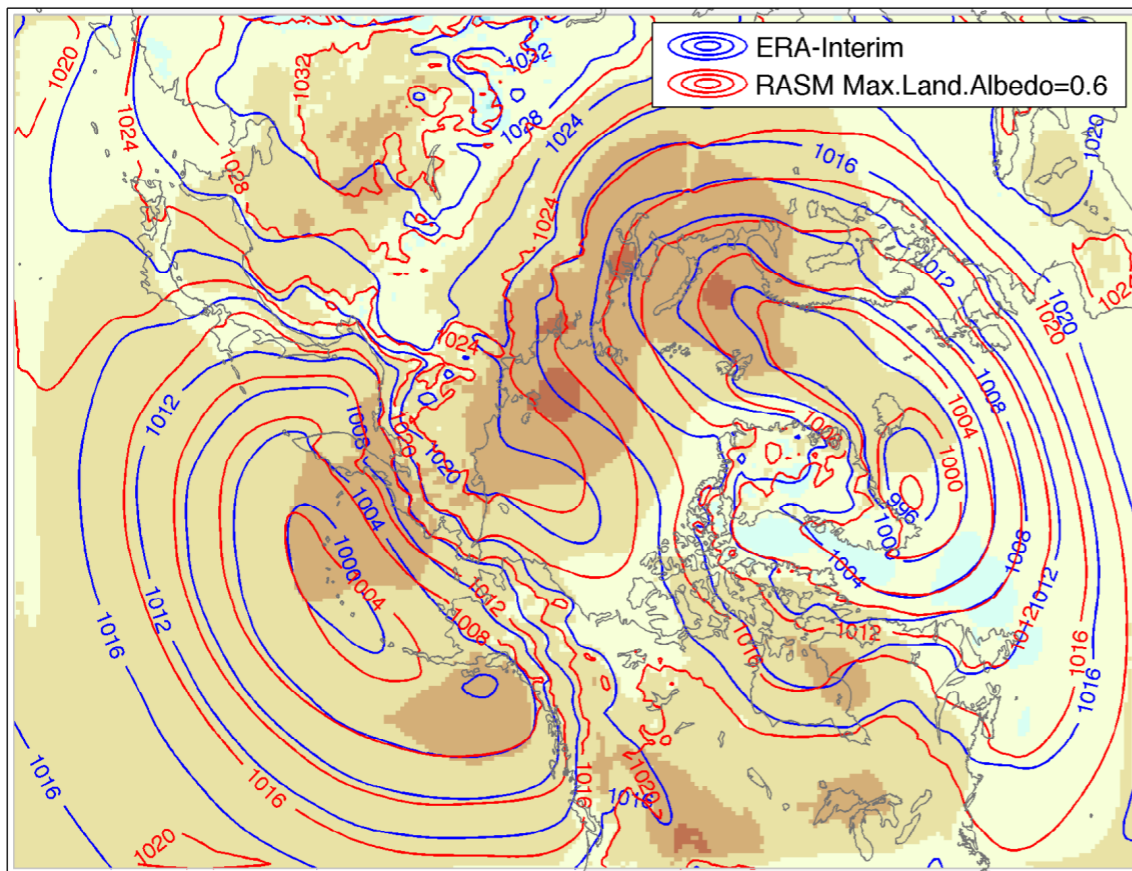


From H-compset forced with CORE2 (left) and the fully coupled case r28RB1b (right)

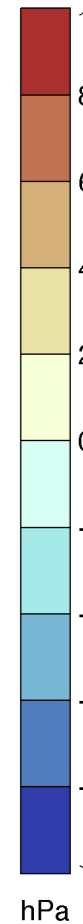
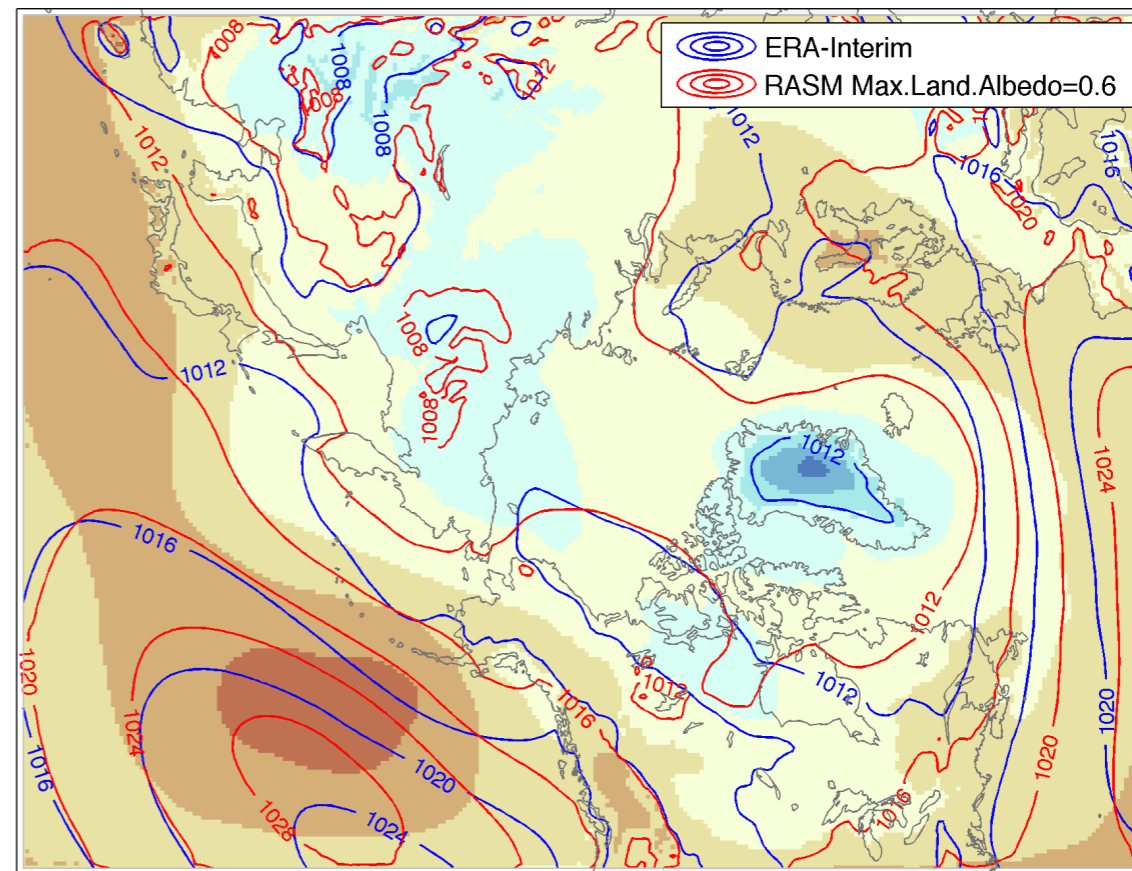


MSLP RASM/WRF and ERA-I

DJF PMSL and difference from ERA-Interim 1990-2000



JJA PMSL and difference from ERA-Interim 1990-2000





RASM H-compset forced with CORE2 vs SSM/I

March

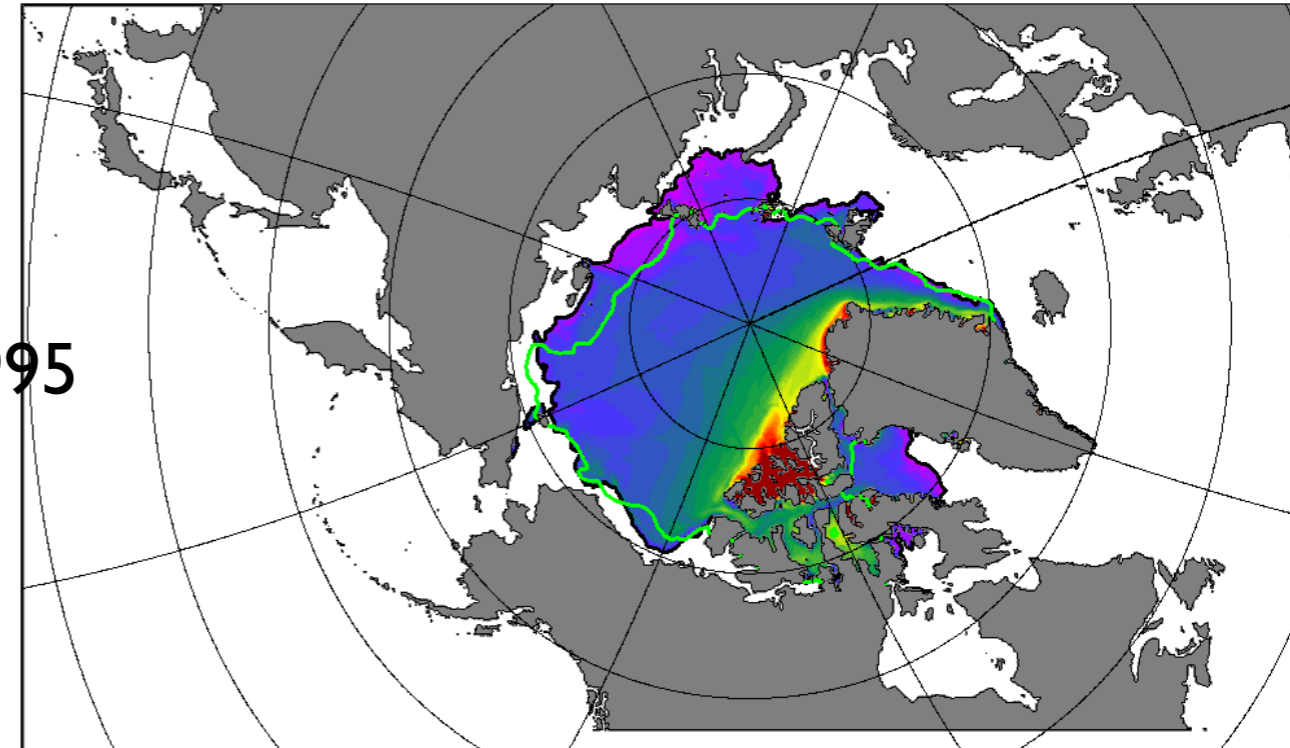
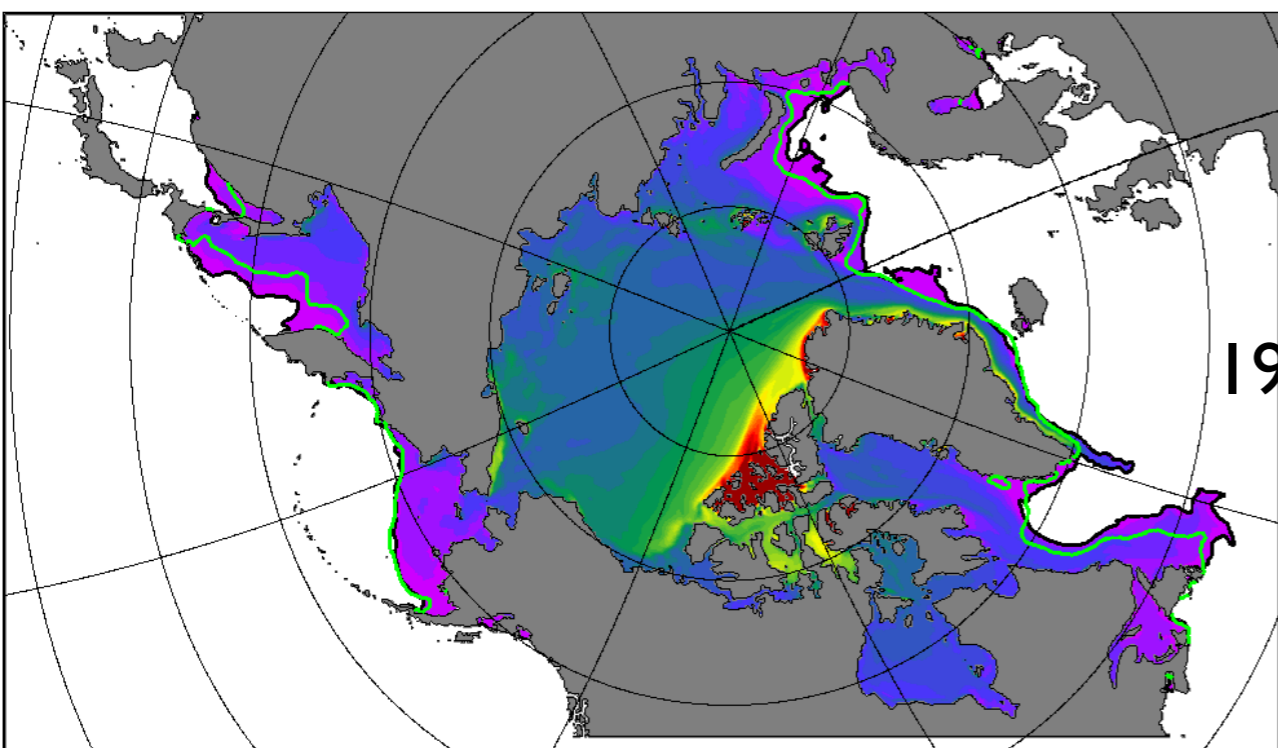
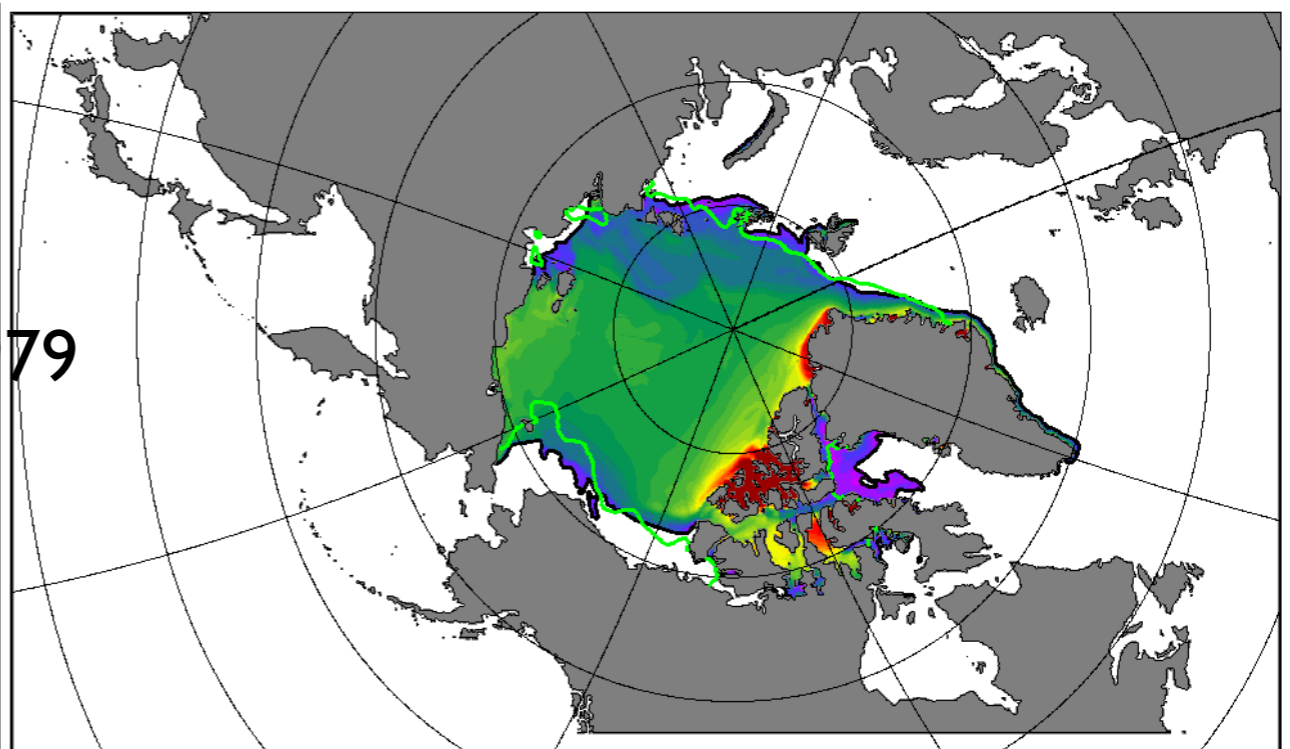
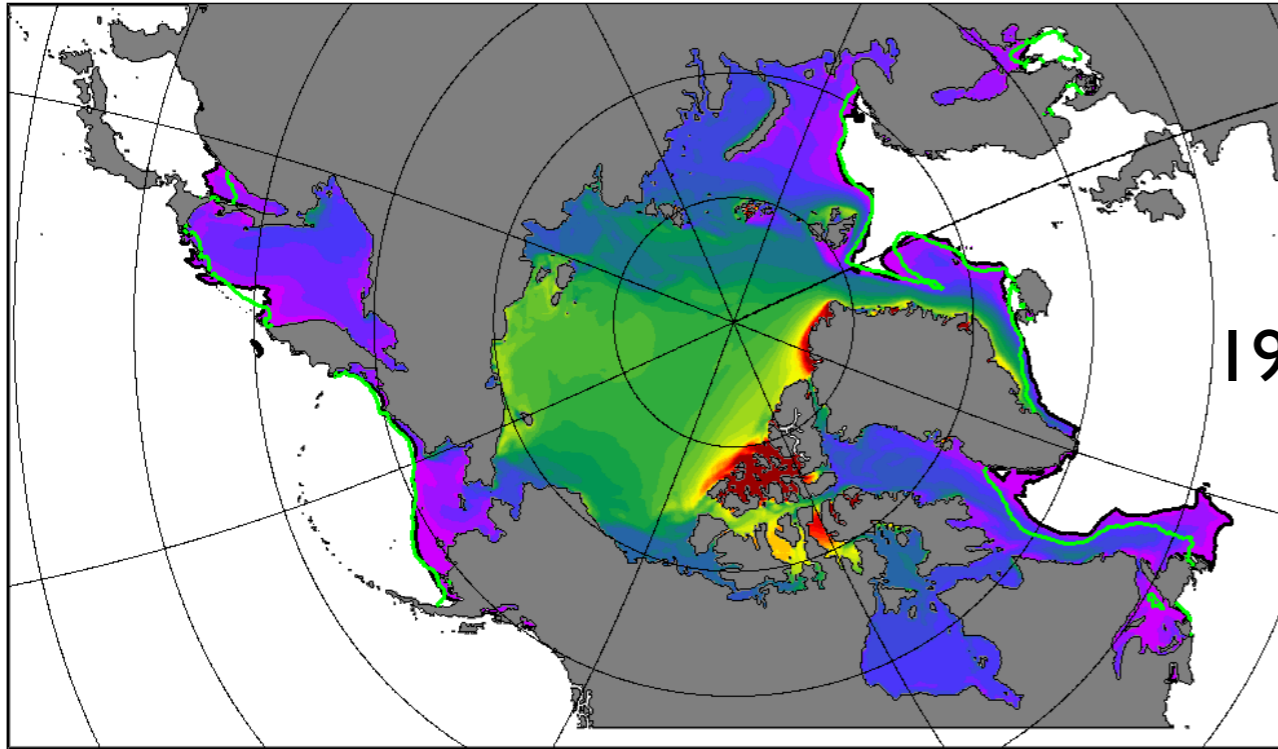
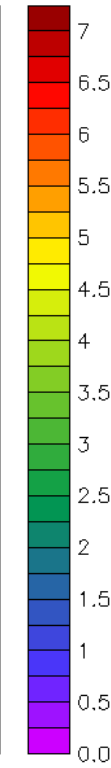
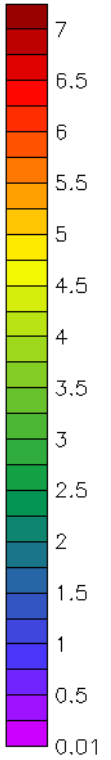
September

Year: 1979 Month: 3

1979

Year: 1995 Month: 3

1995

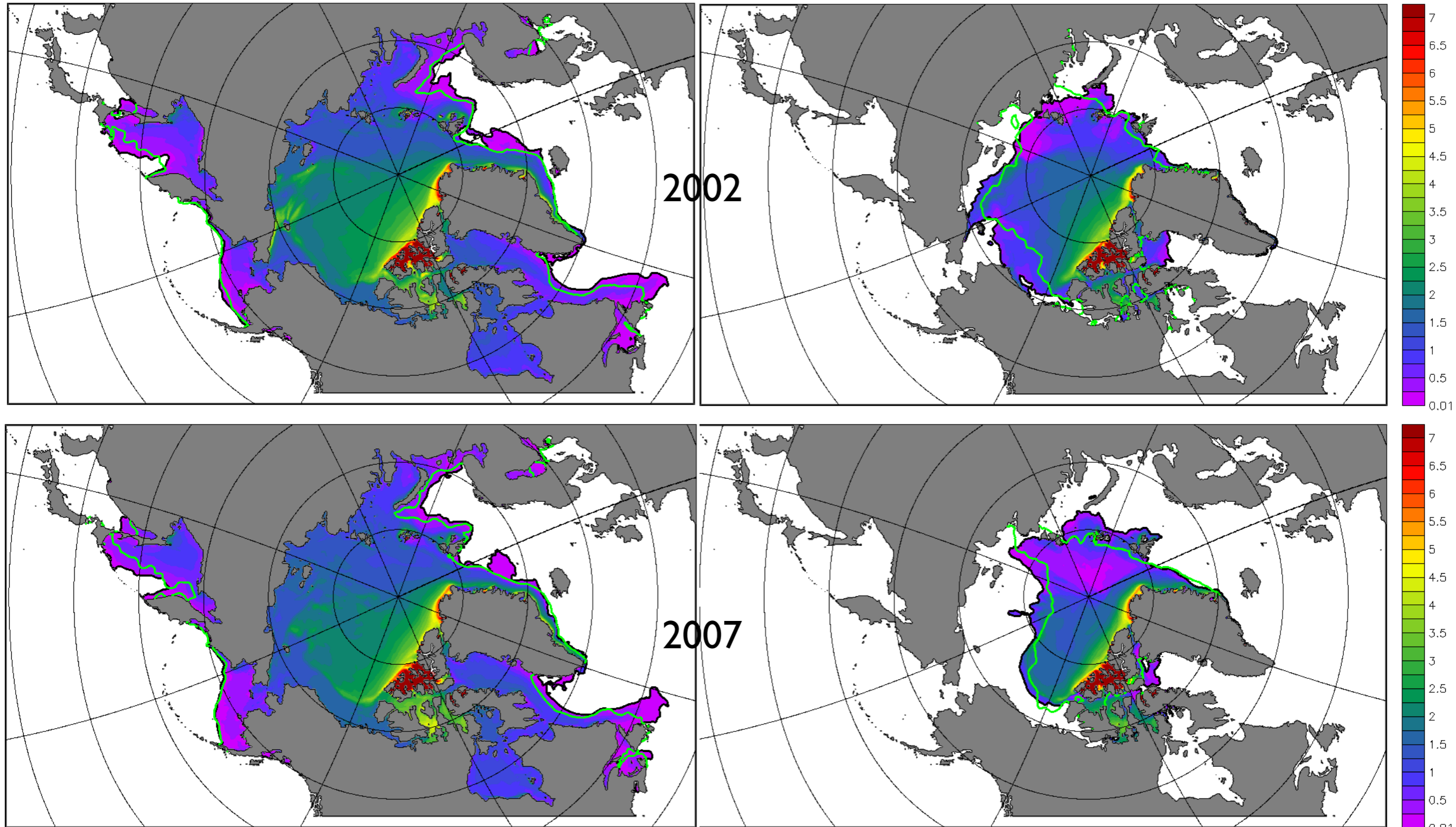


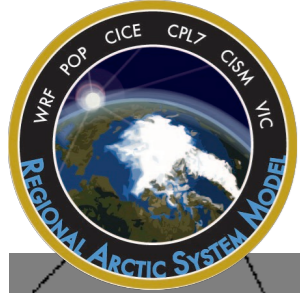


RASM H-compset forced with CORE2 vs SSM/I

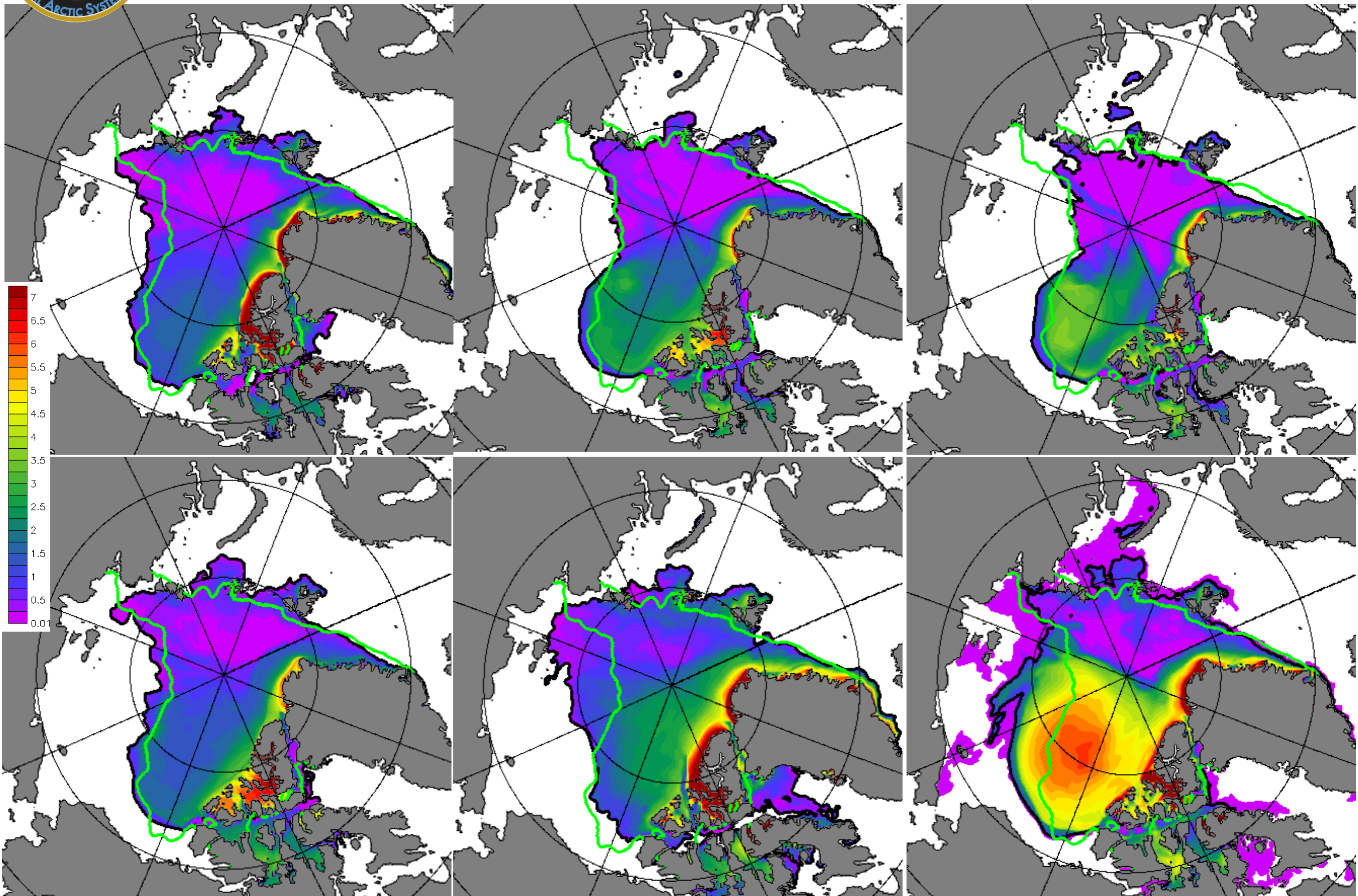
March

September



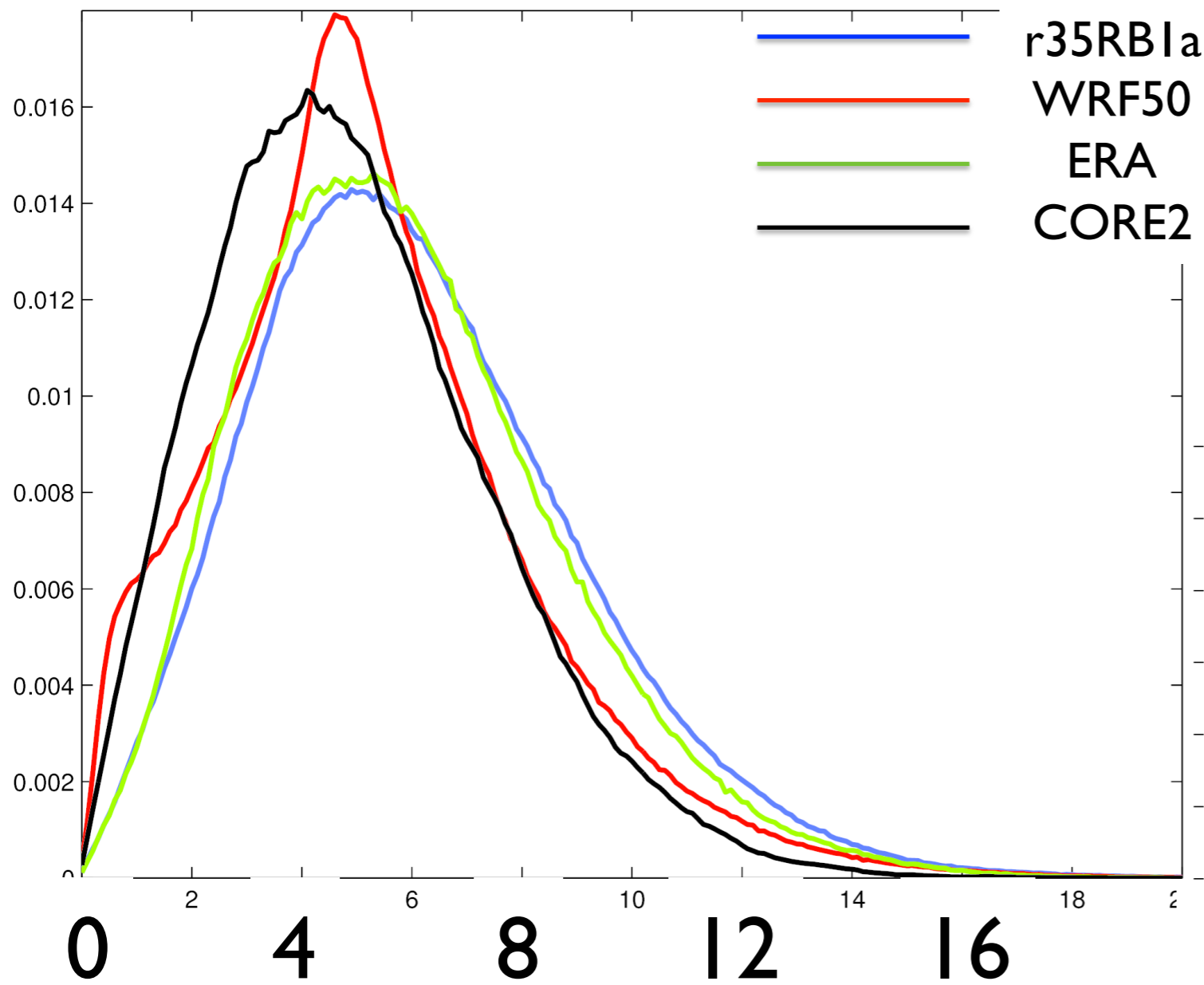


RASM H-compset sensitivity results: Sep 2007

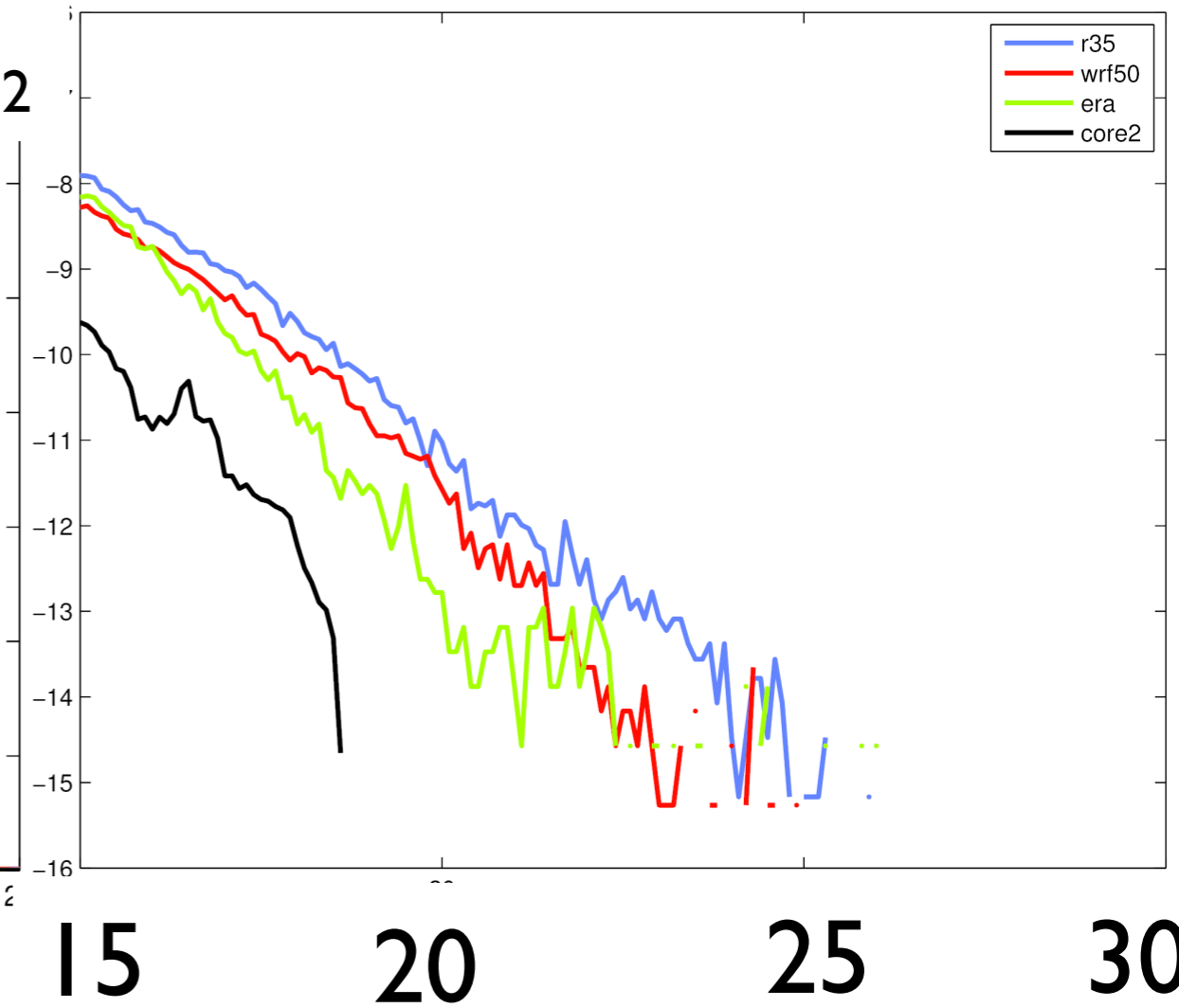


Wind speed PDFs for North Pole water and sea ice grid points

Low wind speeds



High wind speeds (on semi-log axes)

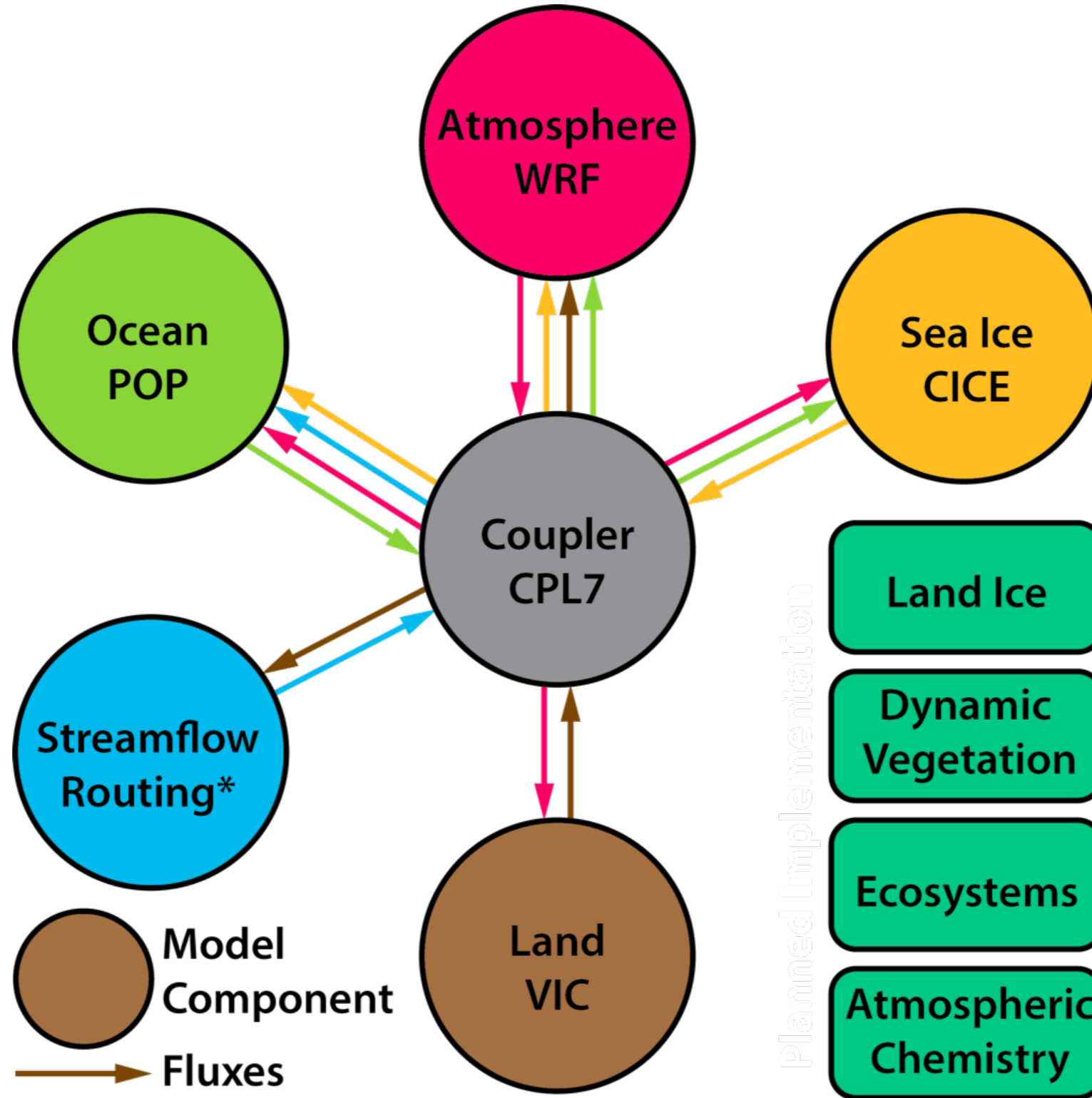


Future Plans

- 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° (~2.3 km) POP / CICE**
- 5. Addition of new components:**
 - ecosystem / marine BGC**
 - tidewater fjords with ice-sheet/ocean interactions**



RASM wiring diagram

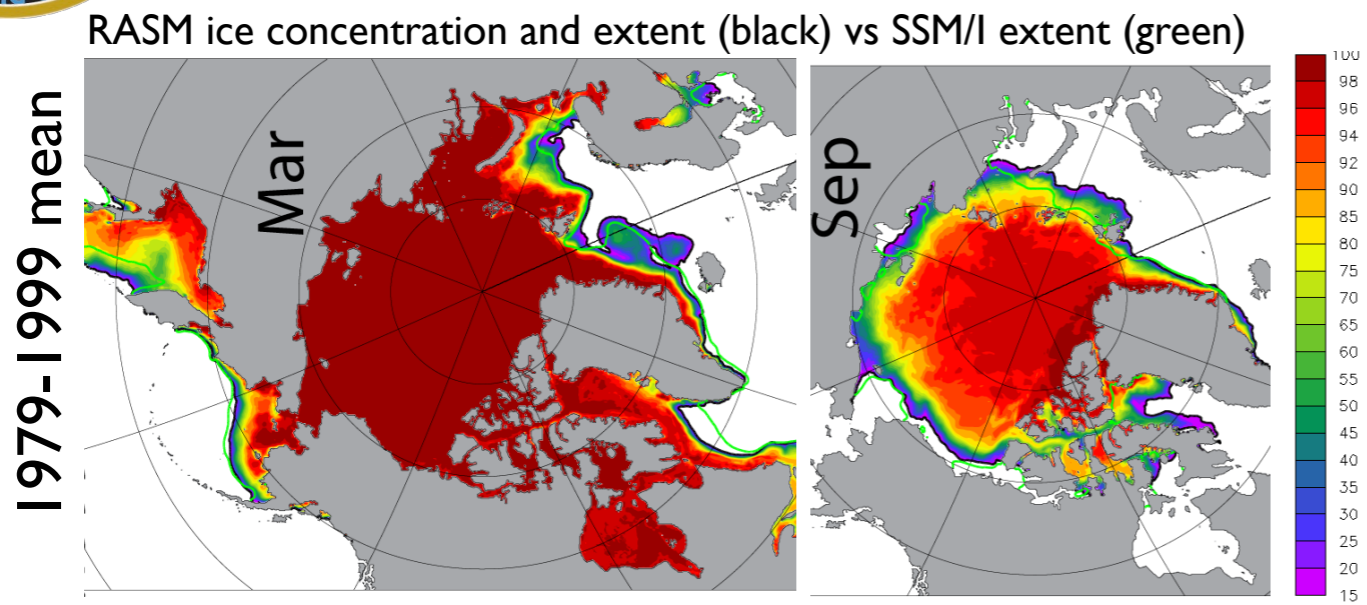




Thank You!

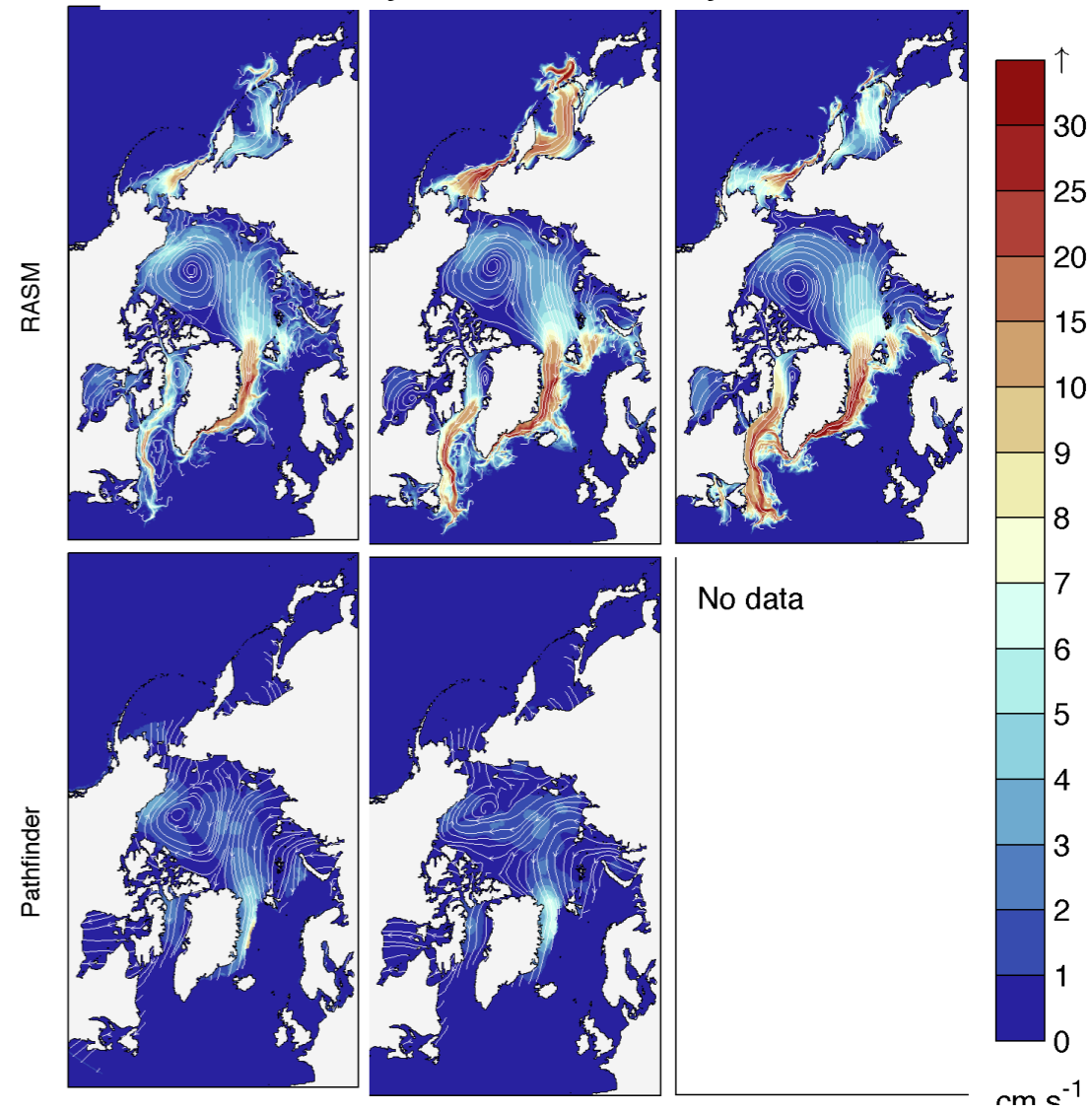


RASM-H sea ice analyses with observations

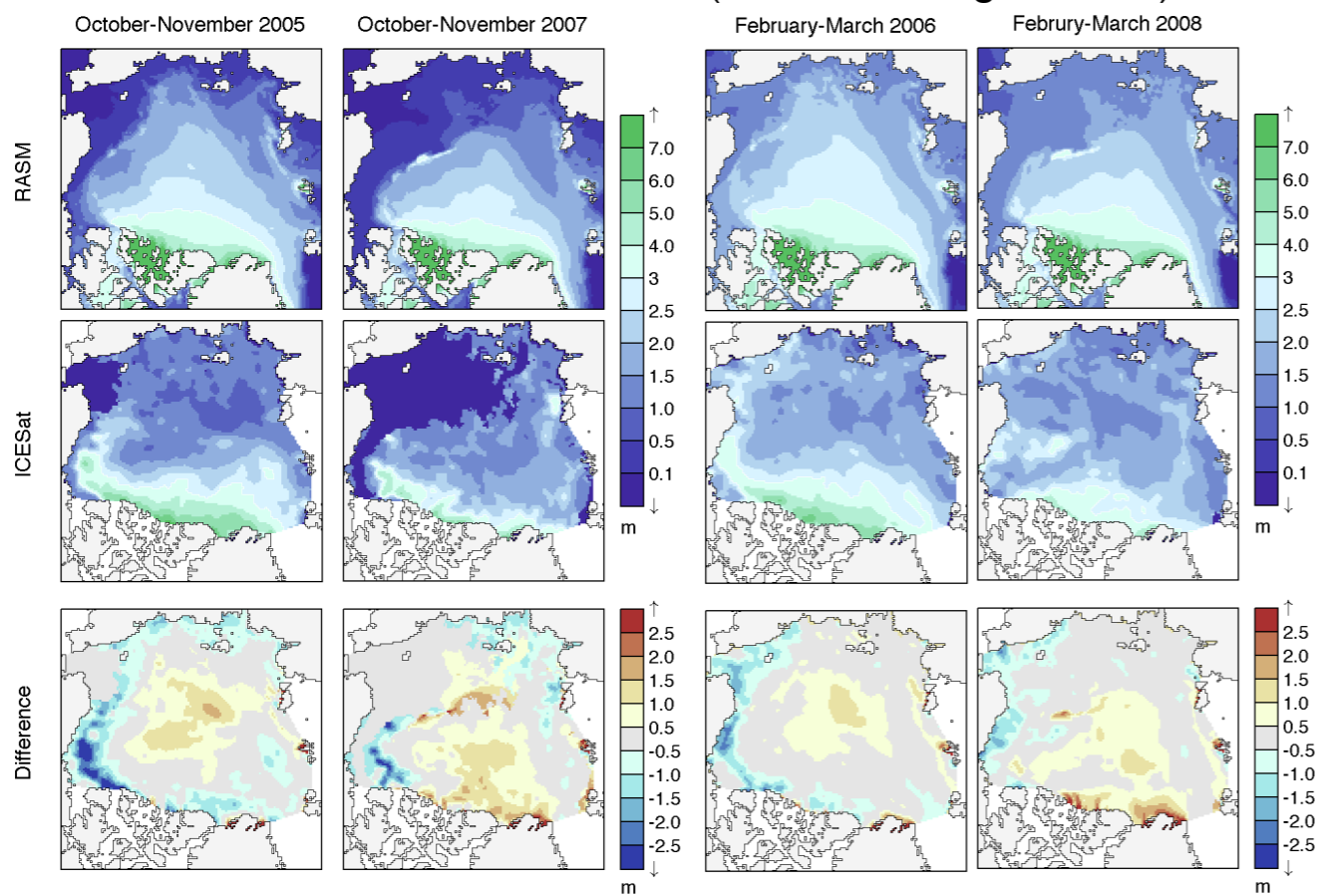


RASM / Pathfinder sea ice streamlines and speed

Mean 2005 Jan-Mar 2005 Jan-Mar 2007



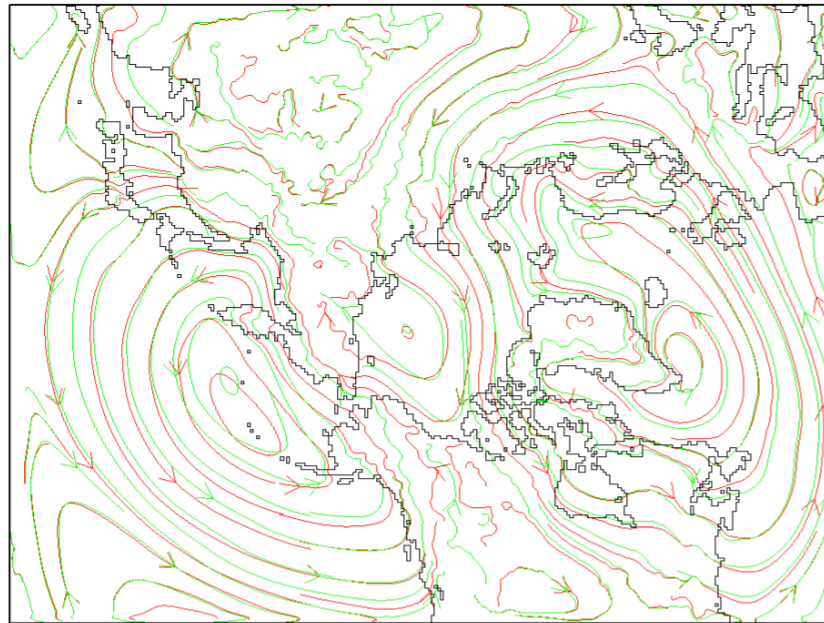
RASM sea ice thickness vs IceSat (Kwok & Cunningham, 2008)



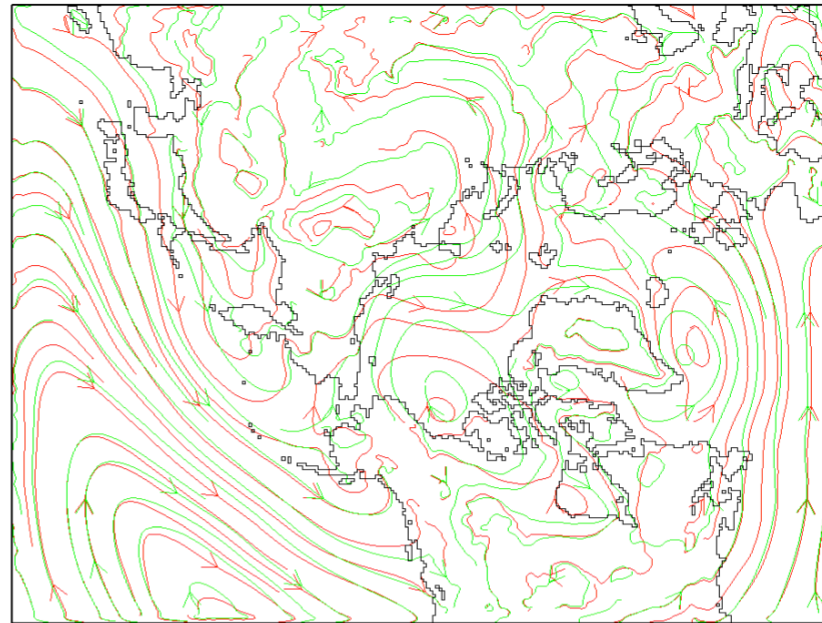
Introduction to ensemble generation in RASM

RASM geostrophic surface wind streamlines 2000-2009

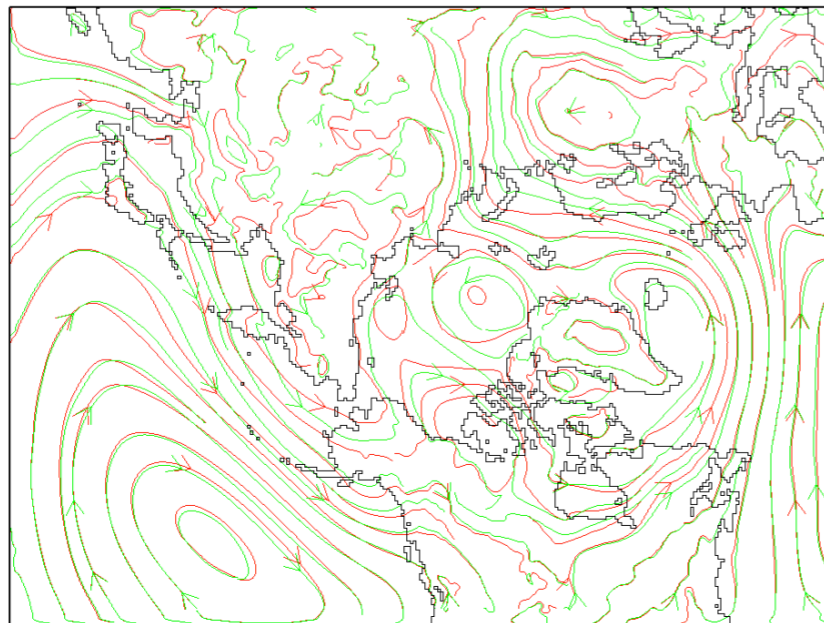
January-March



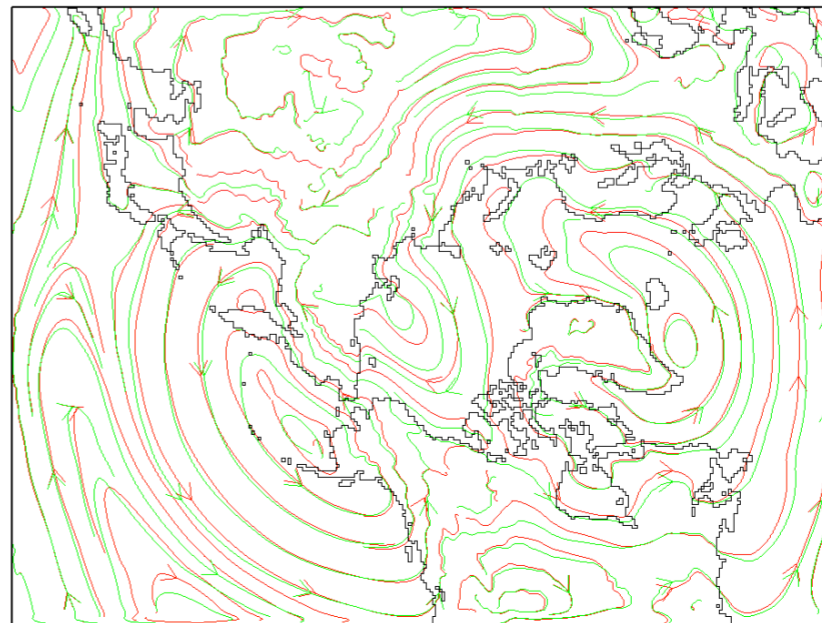
April-June



July-September



October-December



— r35RB1a — r35RB1c

Introduction to ensemble generation in RASM, compared to stand-alone POP/CICE

RASM domain-wide sea ice statistics 1989-2010

