The Regional Arctic System Model

Overview and Coupled Streamflow Routing

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UNIVERSITY OF WASHINGTON

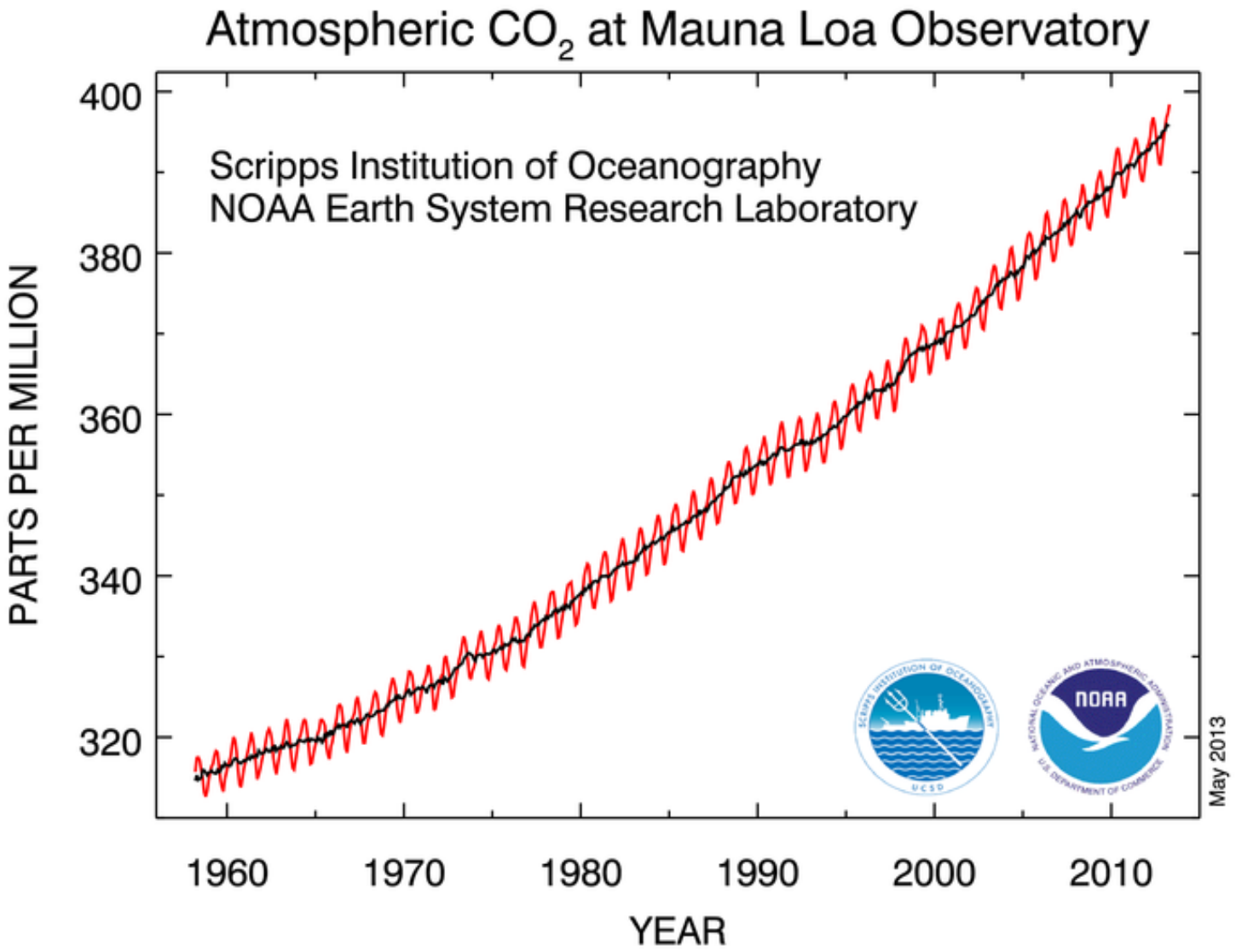
Department of Civil and Environmental Engineering

The New York Times

May 10, 2013

Heat-Trapping Gas Passes Milestone, Raising Fears

By JUSTIN GILLIS



The Economist

Climate change

The measure o

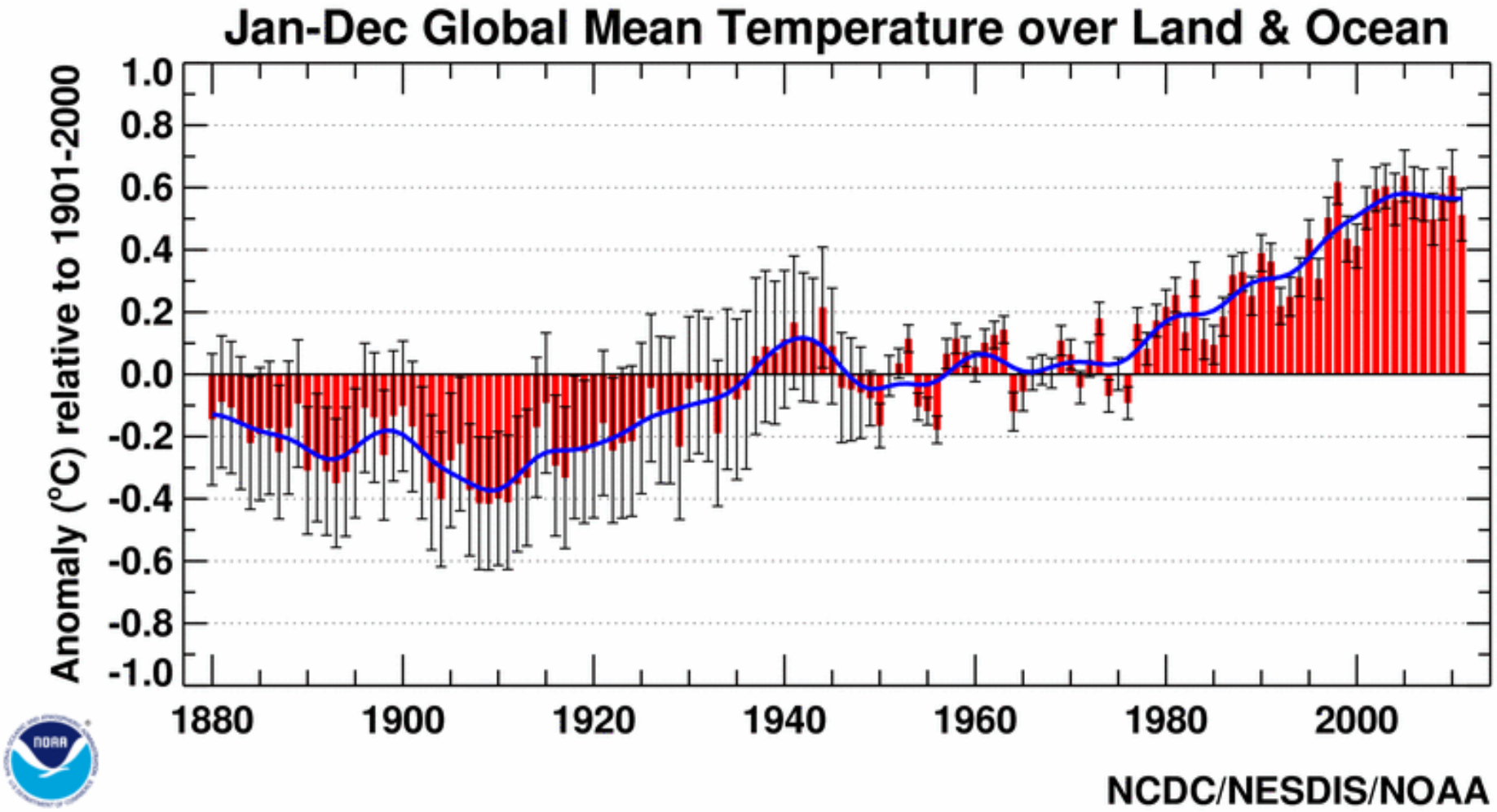
Carbon-dioxide concentrati

May 11th 2013 | From the print e

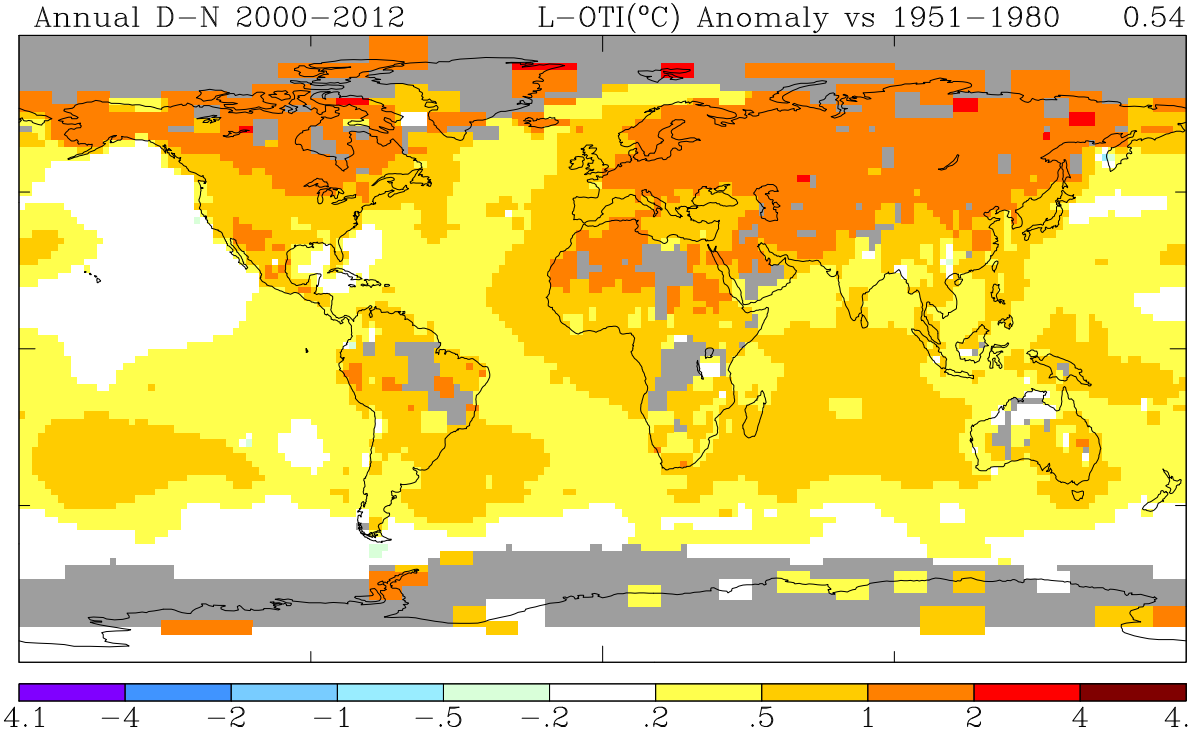
AT NOON on May 4th the carbo
Loa Observatory in Hawaii hit 4
and researchers at the observato
The last time such values prevail
jungles covered northern Canad

There have already been a few r
Ocean in May 2012, for example
CO_2 measurement (and has bee
concentrations of humanity. The
North America.

The concentration of CO_2 peaks

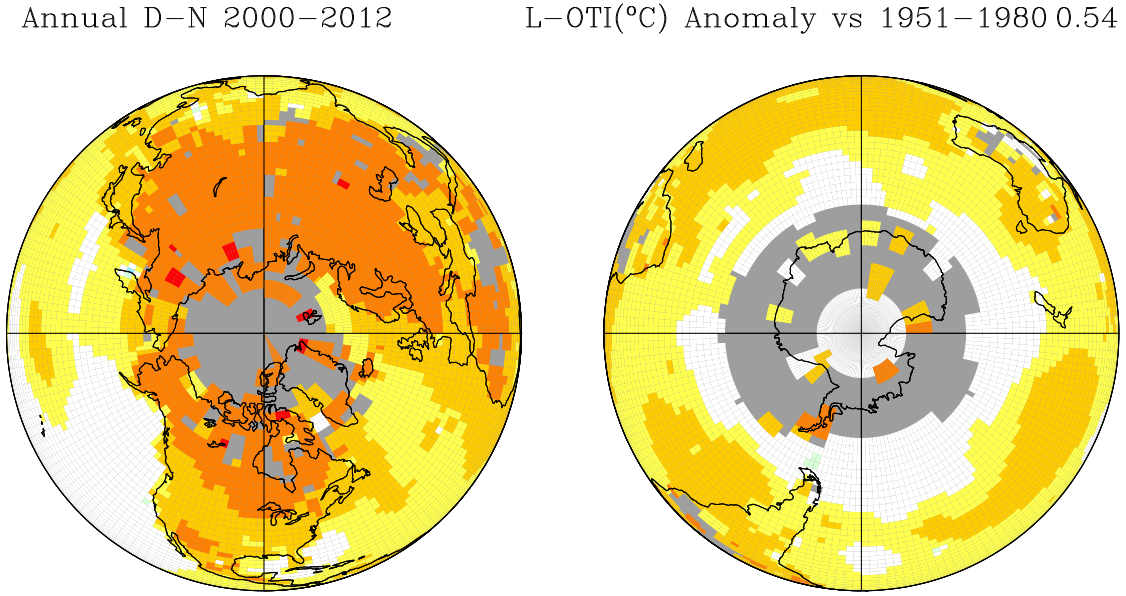


Credit: Global Surface Temperature Anomalies – NOAA, NCDC - http://www.ncdc.noaa.gov/cmb-faq/anomalies.php

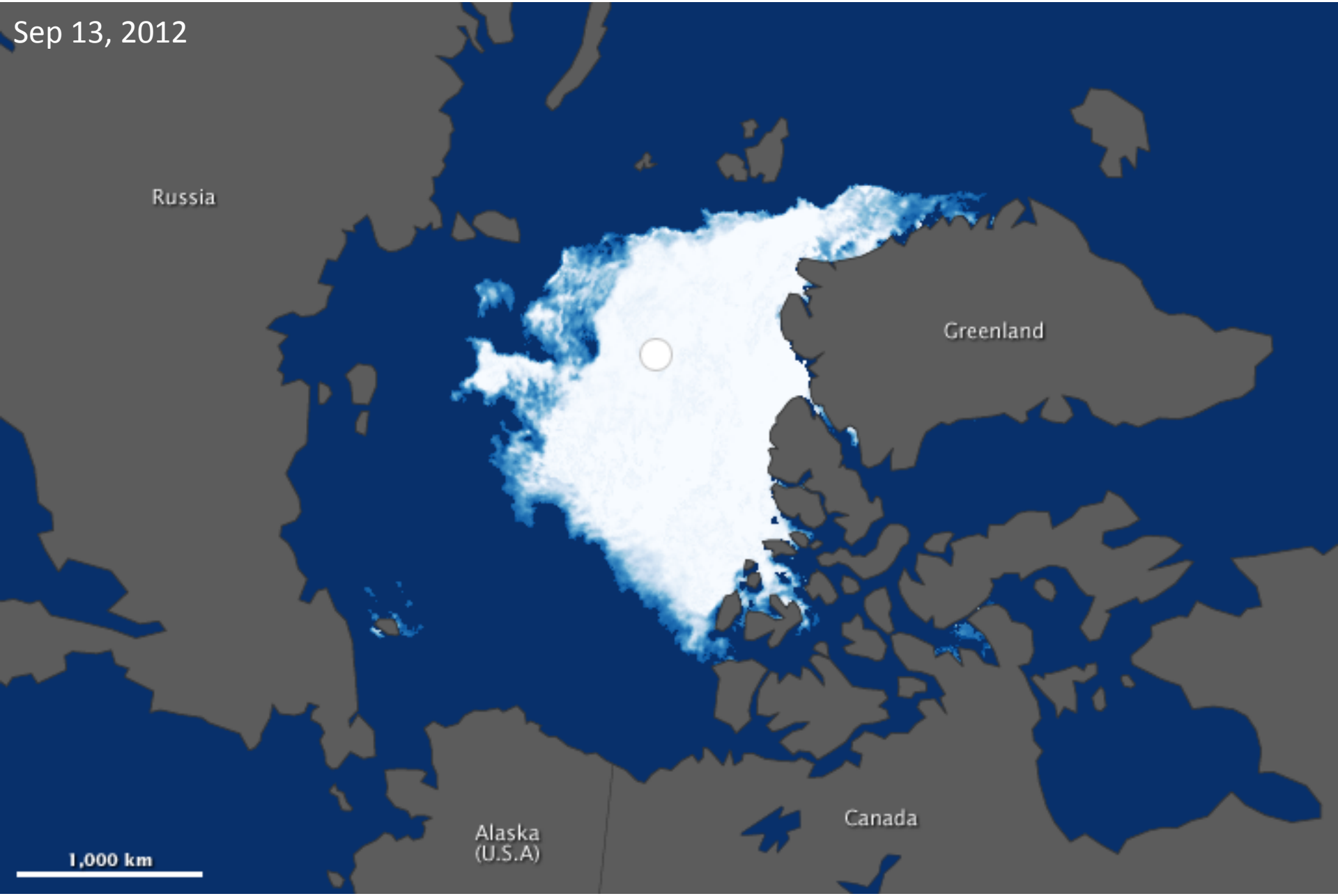


Temperature anomaly

2000-2012 versus 1951-1980

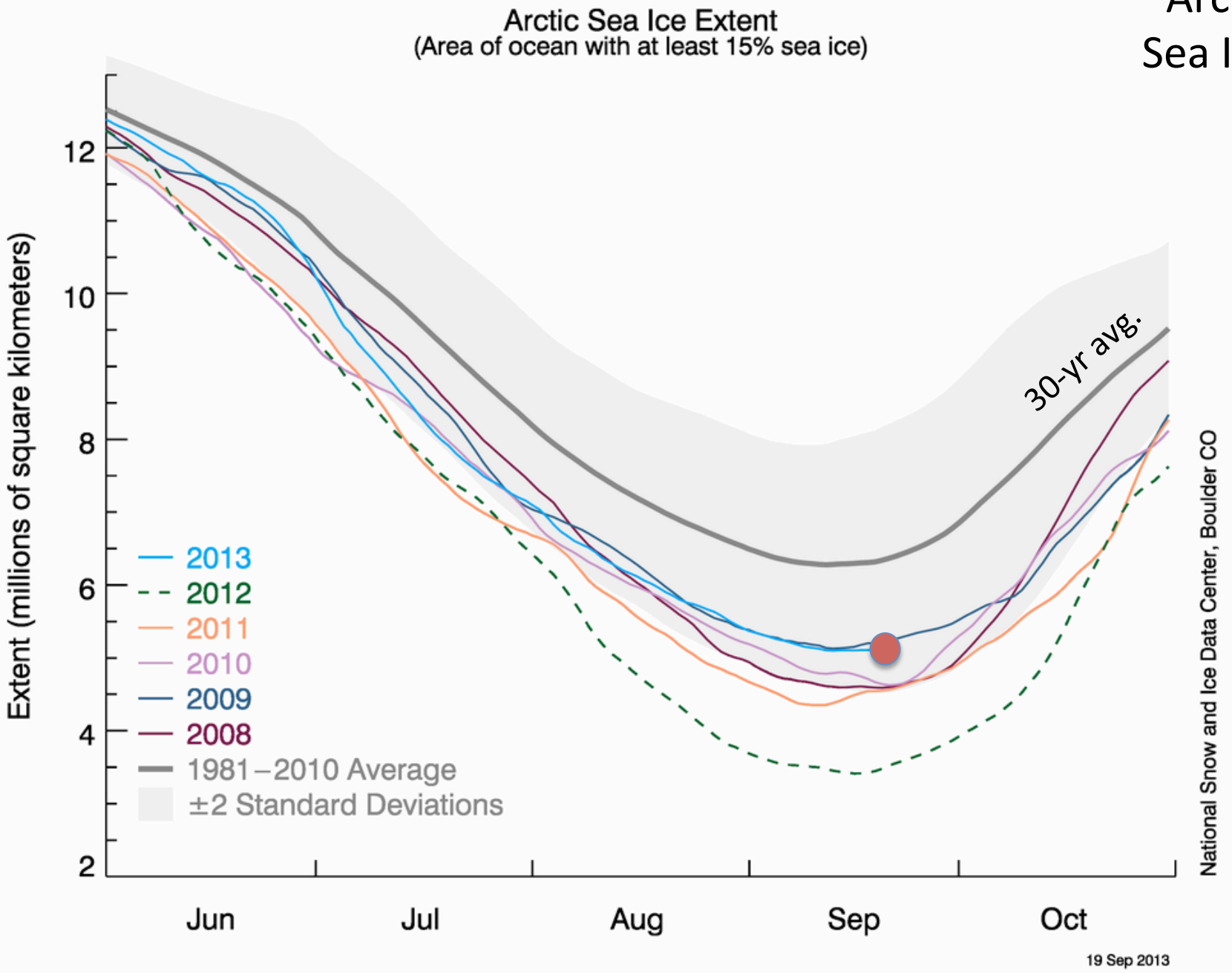


Credit: GISS Surface Temperature Analysis– GISS, http://data.giss.nasa.gov/gistemp/maps/

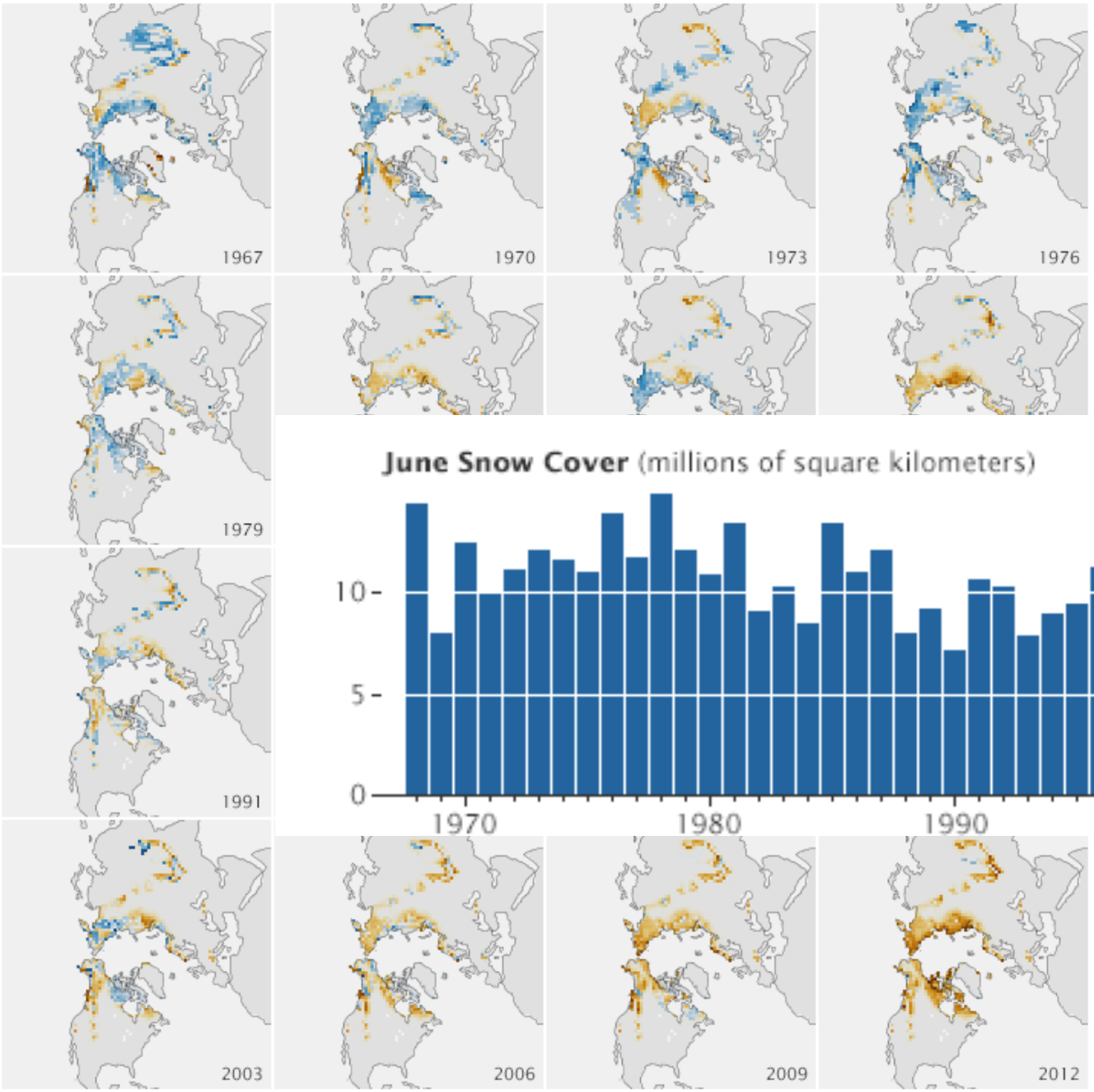


Credit: NASA Earth Observatory images by Jesse Allen, using data from the Advanced Microwave Scanning Radiometer 2 (AMSR-2) and the Scanning Multichannel Microwave Radiometer (SMMR) http://earthobservatory.nasa.gov/IOTD/view.php?id=80821

Arctic Sea Ice



Arctic Snow Cover Extent



compared to the 1971–2000 mean

Credit: Image by Robert Simmon, using data from the Rutgers University Global Snow Lab. http://visibleearth.nasa.gov/view.php?id=80102

Greening of the Arctic

past 30 years

Credit: NASA's Goddard Space Flight Center Scientific Visualization Studio. Data from: Xu, L., and Coauthors, 2013: Temperature and vegetation seasonality diminishment over northern lands. *Nature Clim. Change*, 10.1038/nclimate1836

http://www.nasa.gov/topics/earth/features/growth-shift.html

Why do we want to develop a regional Arctic system model?

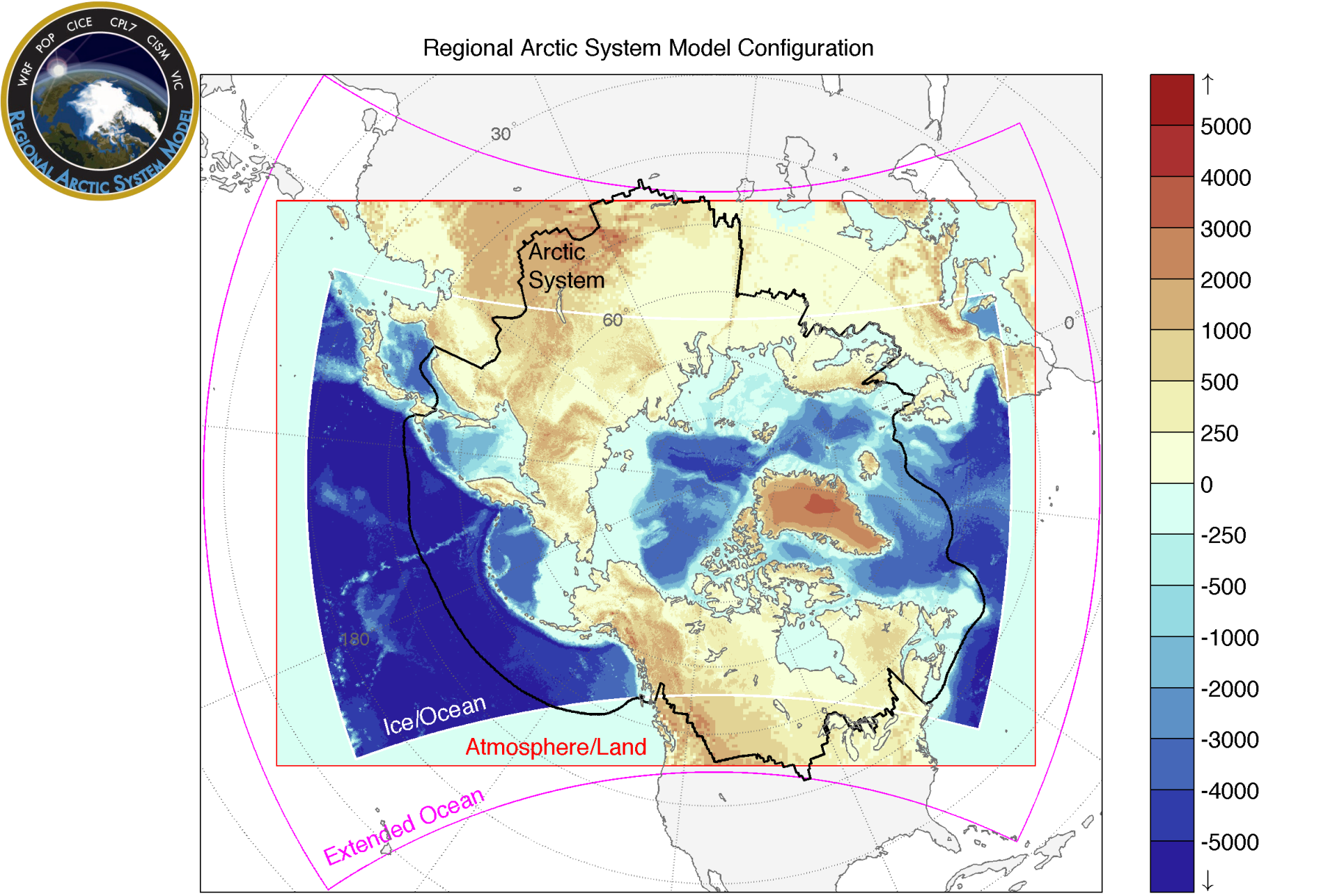
- Observed rapid changes in Arctic climate system
  - Sea ice decline
  - Greenland ice sheet
  - Temperature
- There are large errors in global climate system model simulations of the Arctic
- Arctic change has global consequences
  - Global energy balance
  - Sea level rise
  - Thermohaline circulation

Science Objectives

- Gain improved understanding of coupled Arctic climate system processes responsible for Arctic climate change

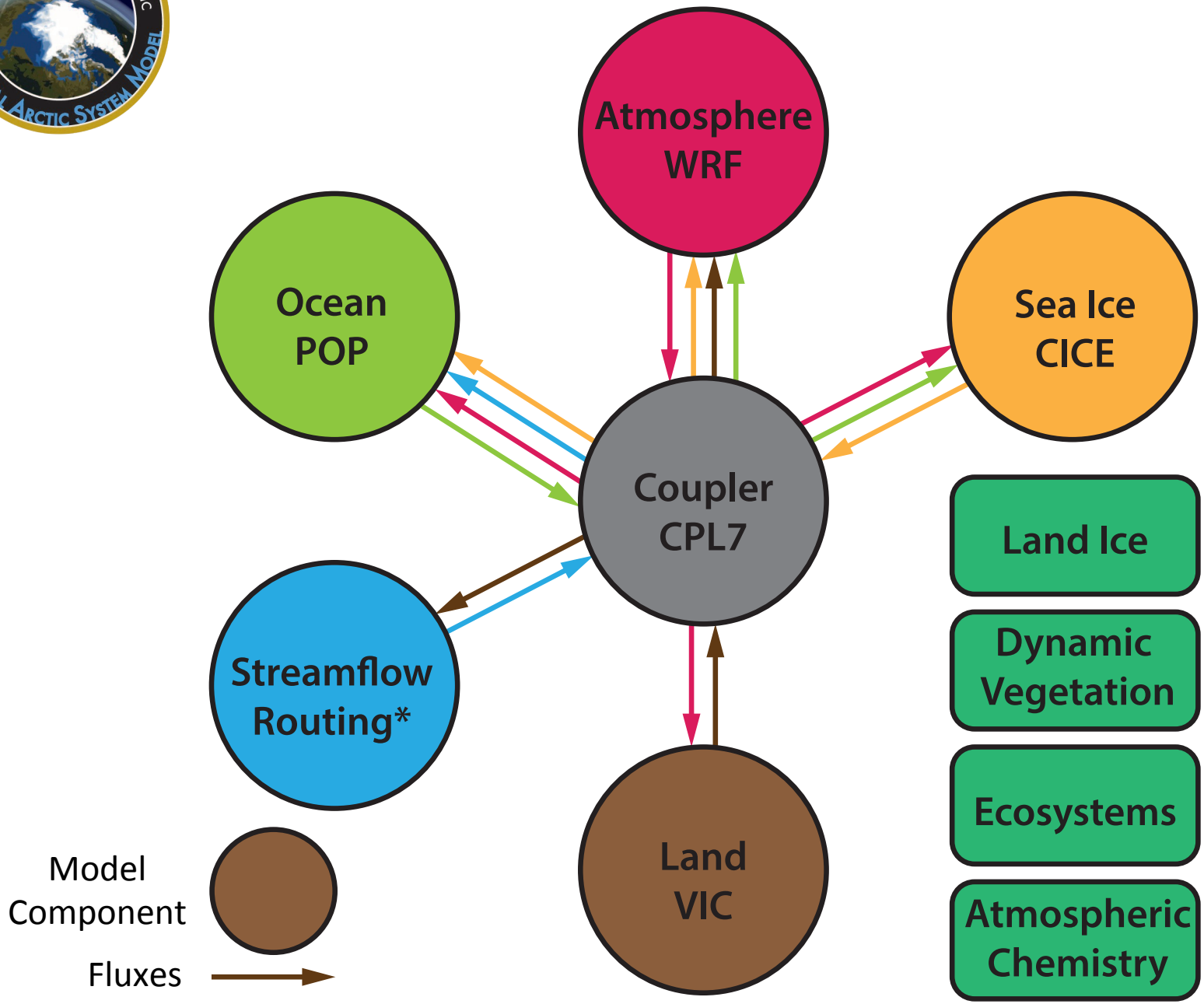
- Improve predictions of Arctic climate change by simulating features not resolved in global models

- Identify limitations and physical and numerical requirements of global climate system model simulations of Arctic



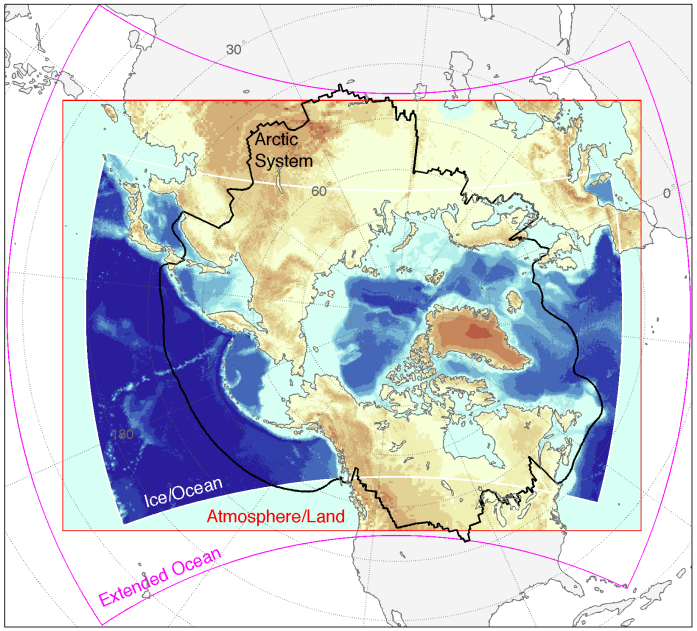
The Regional Arctic System Model (RASM) is a high-resolution Earth System model that covers the Arctic drainage basin and is developed to better understand polar climate variability, system inter-connectivity and improve and understand constraints on decadal predictions in high northern latitudes.

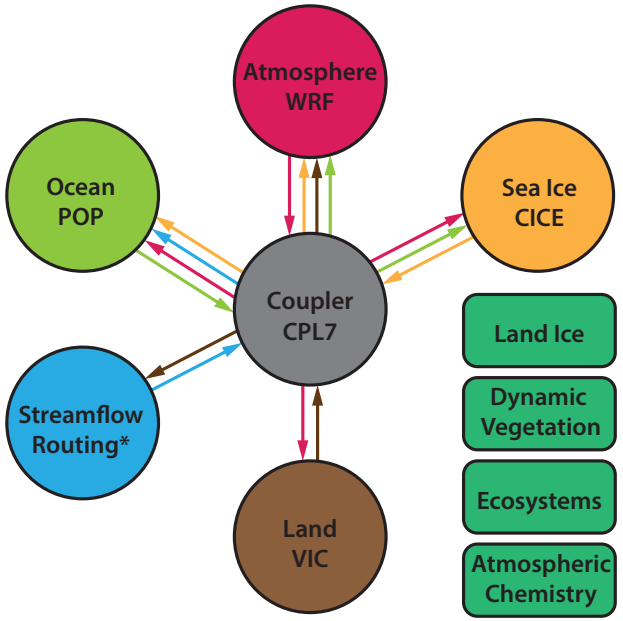
RASM Configuration



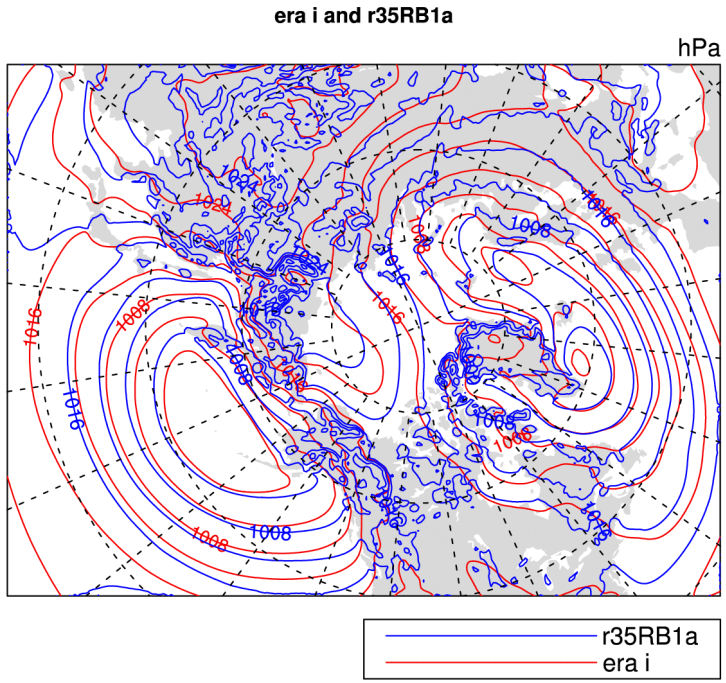
Model implementation

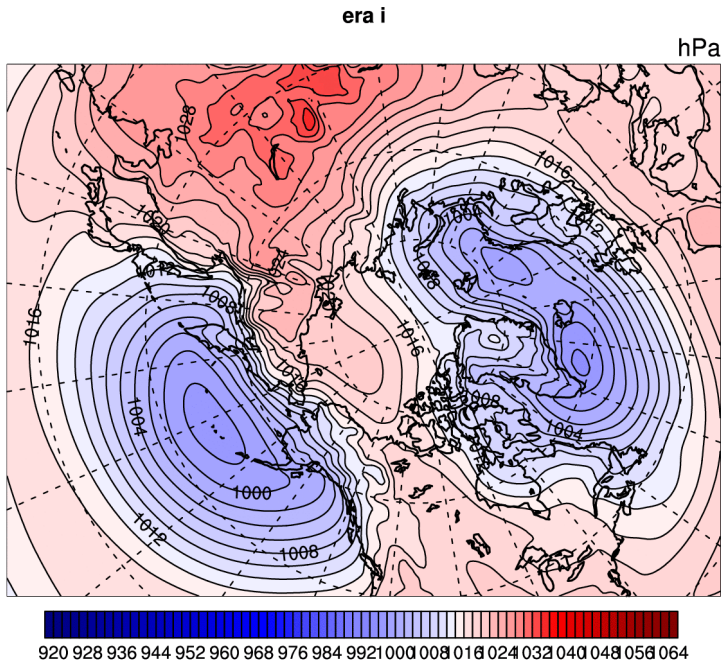
Component	Model/Code	Configuration
Atmosphere	WRF	50km, 35 levels, dt=2.5 minutes
Land Hydrology	VIC	50km, dt=20 minutes
Ocean	POP	9km, 45 levels, dt=8/8/4 minutes
Sea Ice	CICE	9km, 5 thickness categories, dt=20 minutes
Coupler	CPL	20 minute coupling timestep





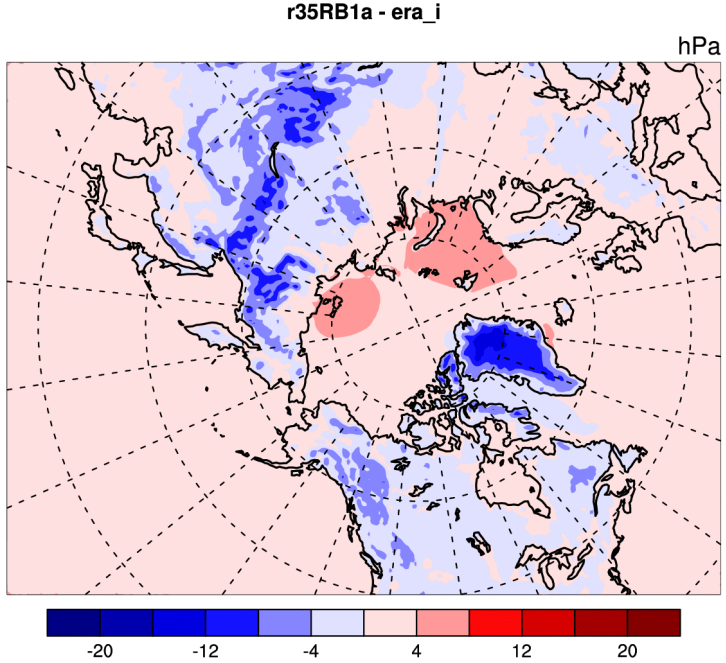
1989-2007-DJF Sea Level Pressure: era i and r35RB1a

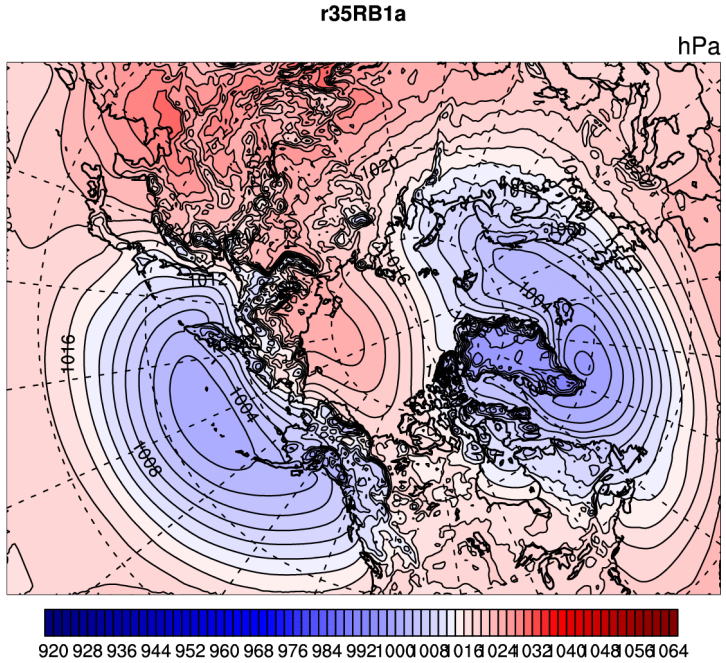




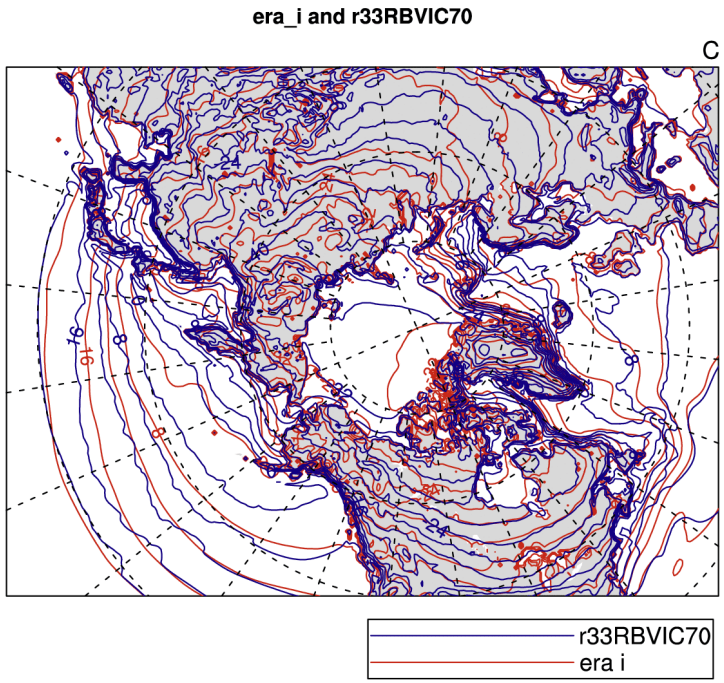
RASM

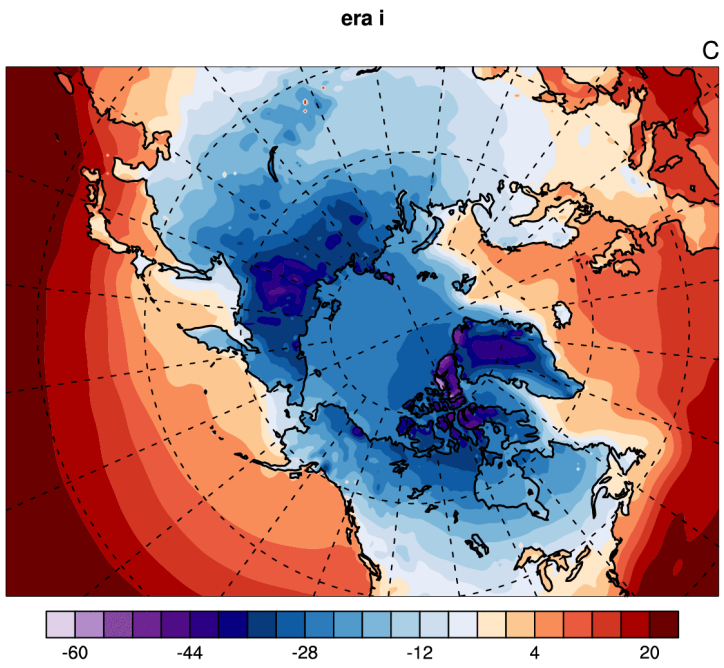
DJF SLP

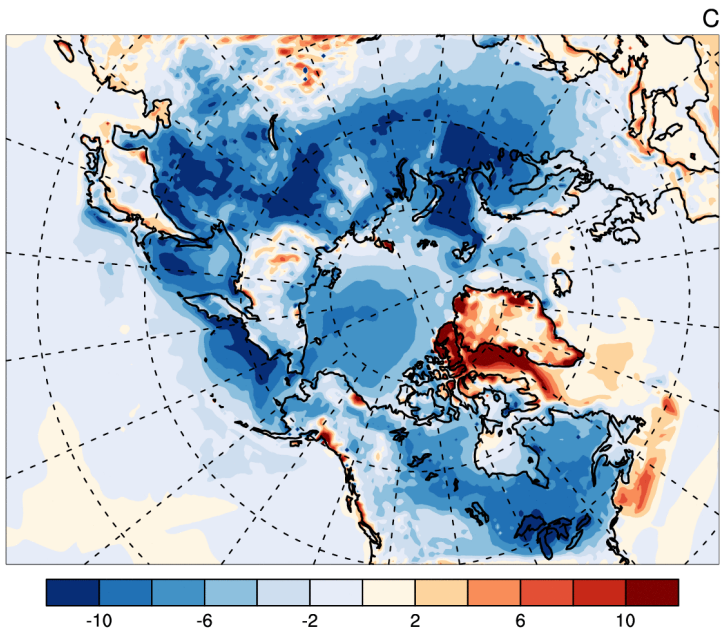


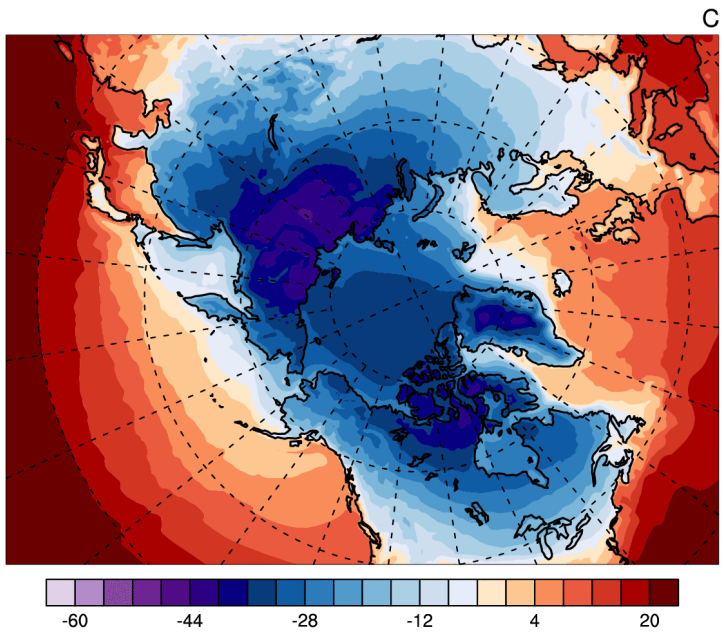


1989-1999-DJF Temperature at surface: era i and r33RBVIC70





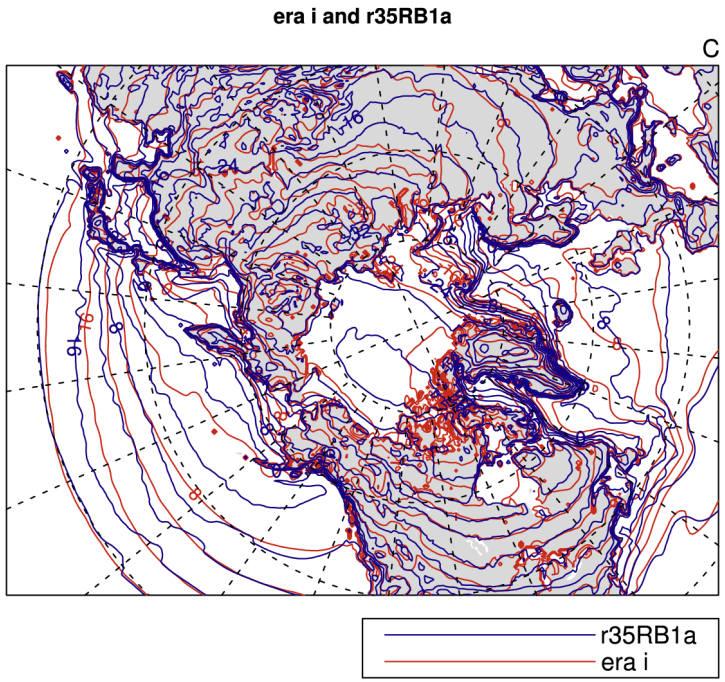


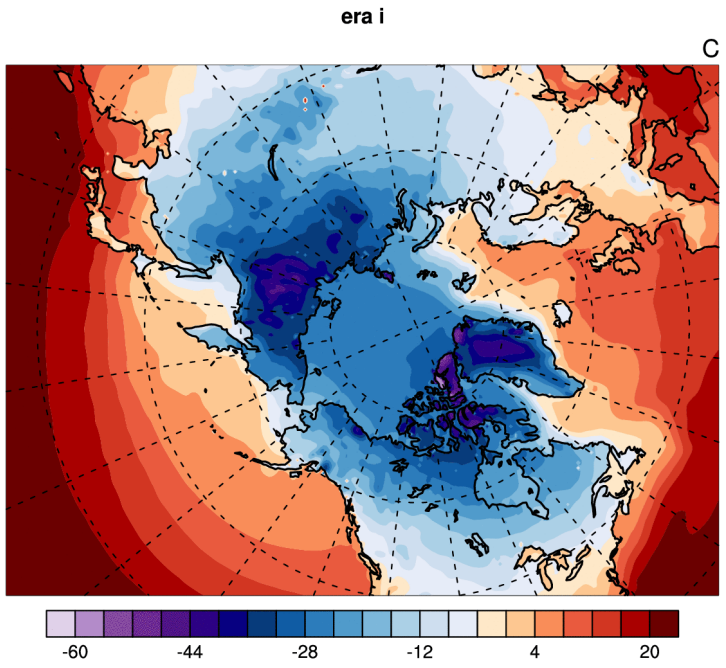


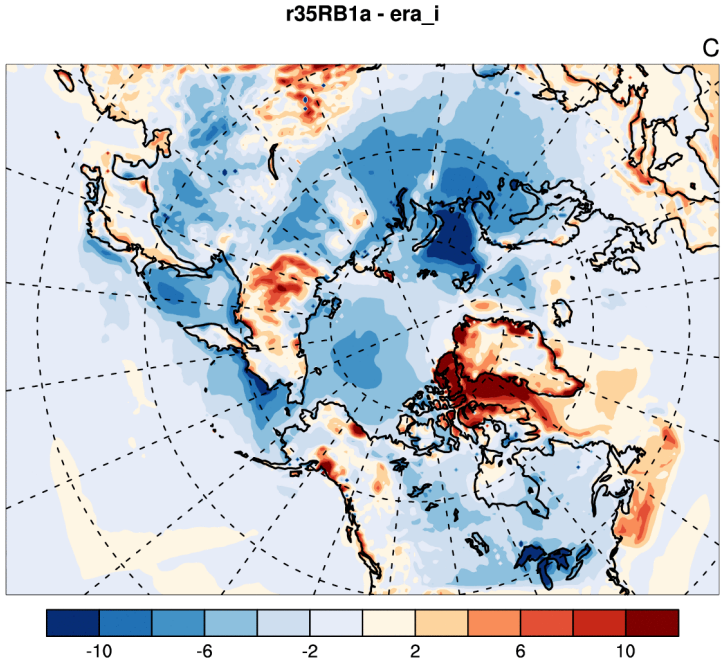
RASM ~6 months ago

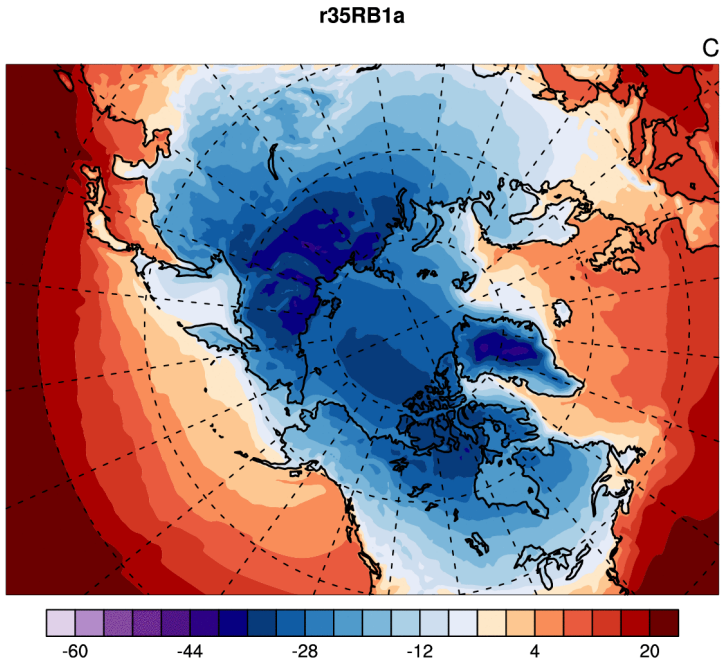
DJF Tsfc

1989-2007-DJF Temperature at surface: era i and r35RB1a







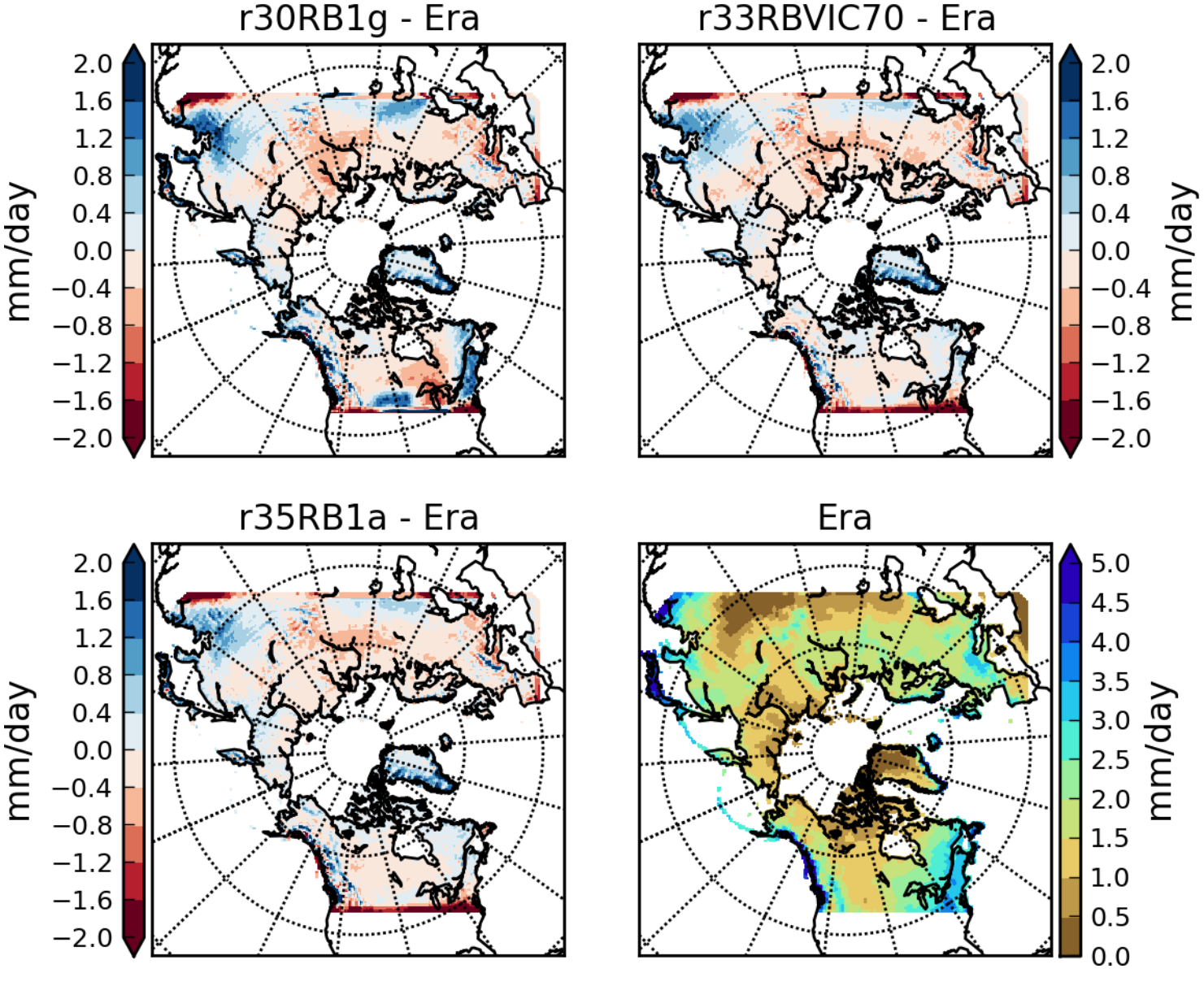


RASM

DJF Tsfc

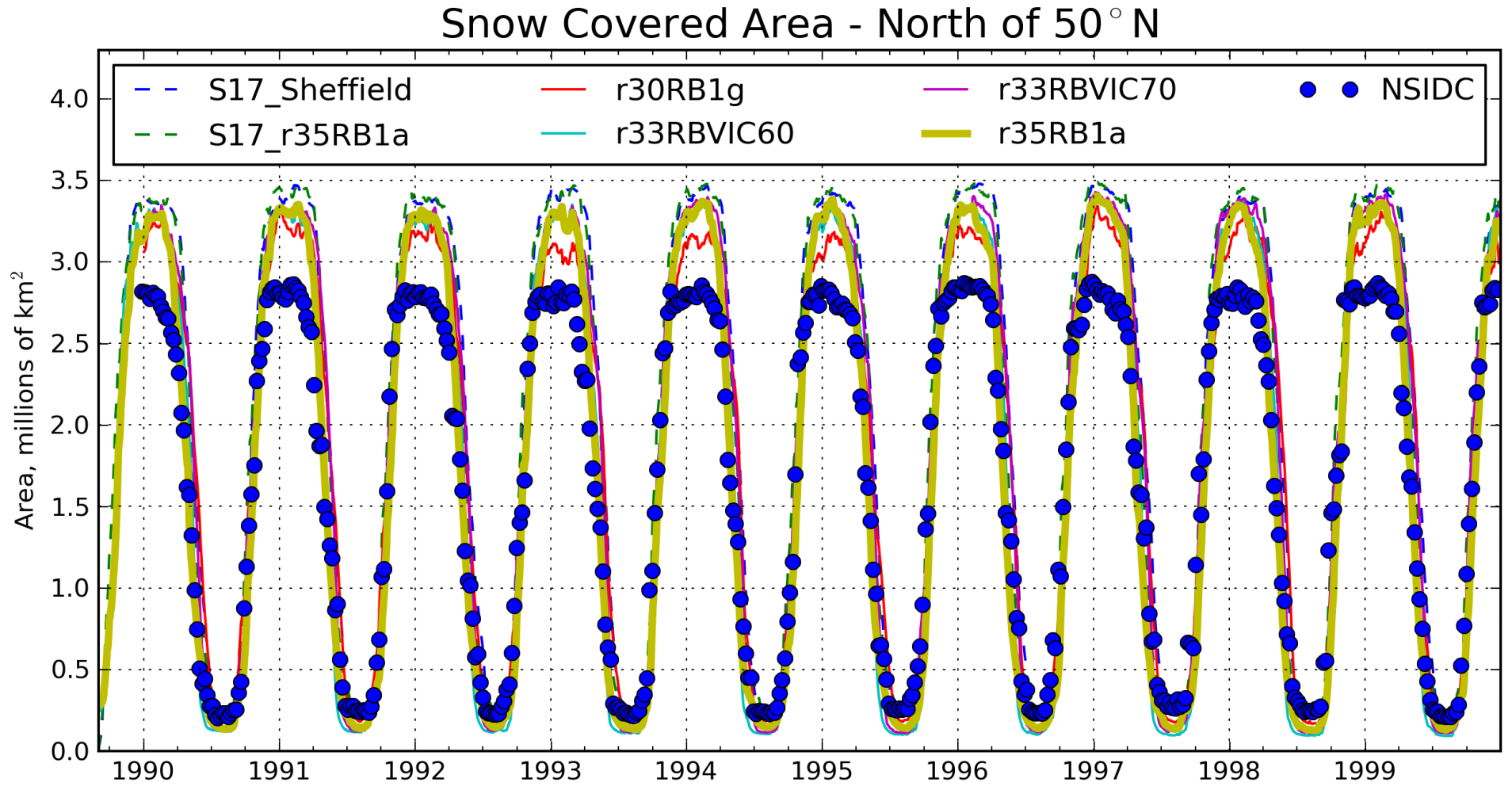
Precipitation

1990-1999-Decadal-Anomaly



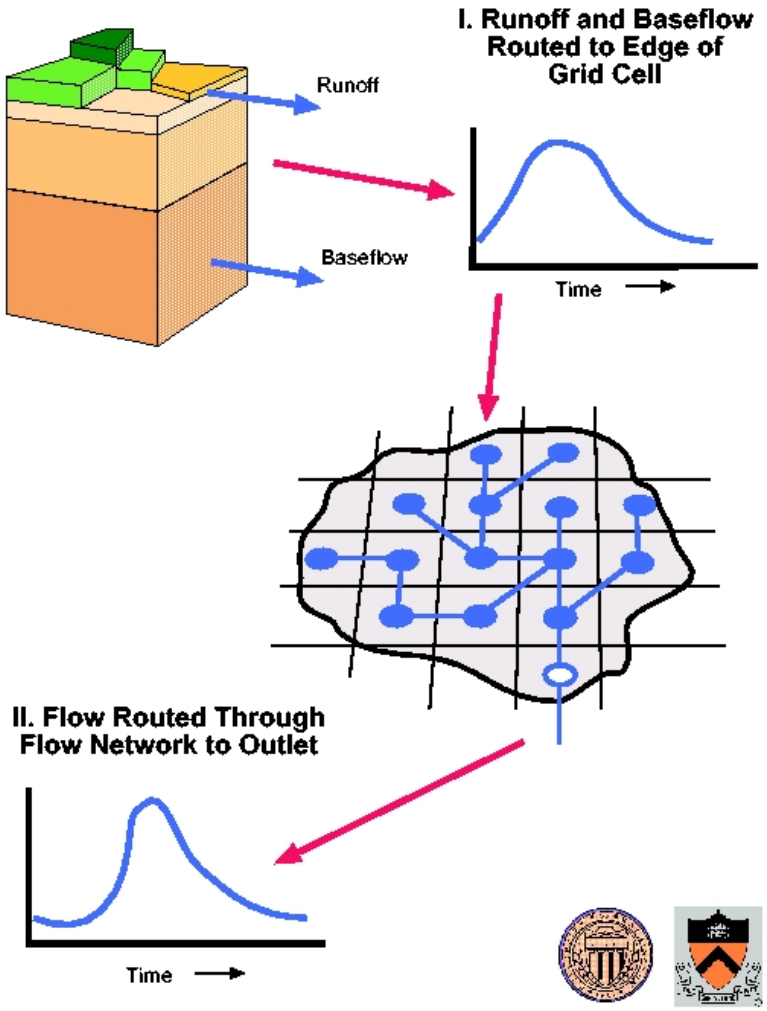
Precipitation
1990-1999
Mean

Snow extent Comparison with NSIDC

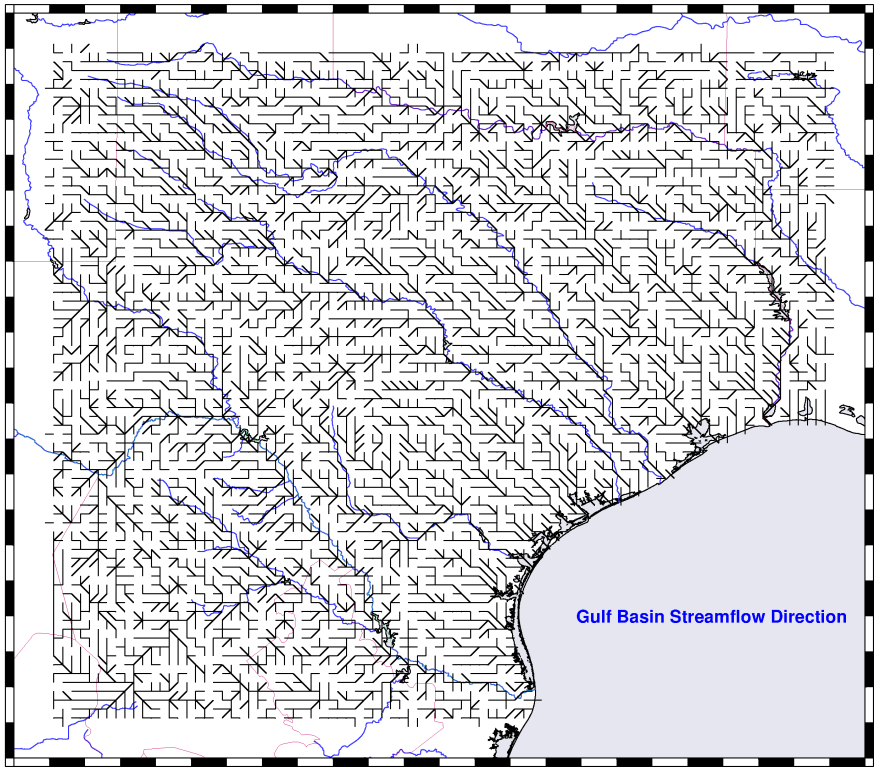


River routing

VIC offline river network routing model



Example routing network

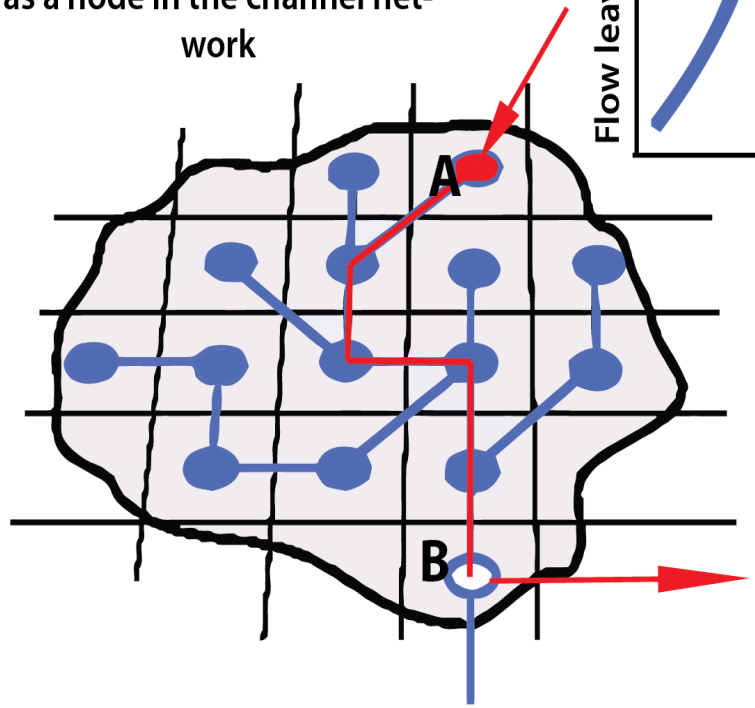


In essence a source-to-sink routing model with a pathway dependent travel time. However, the travel time from each location is time-invariant.

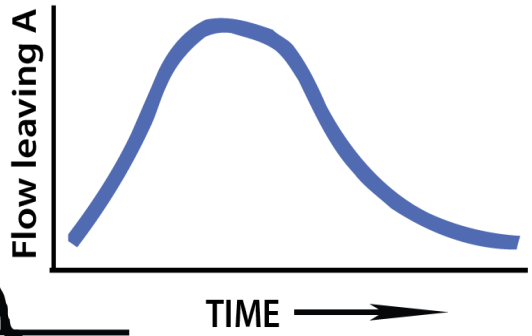
Coupled streamflow routing

Development of Impulse Response Fuctions

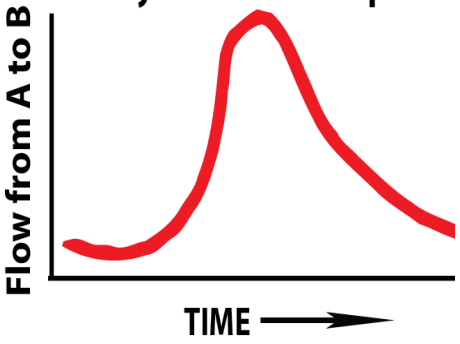
I. Each grid cell is represented as a node in the channel net-work

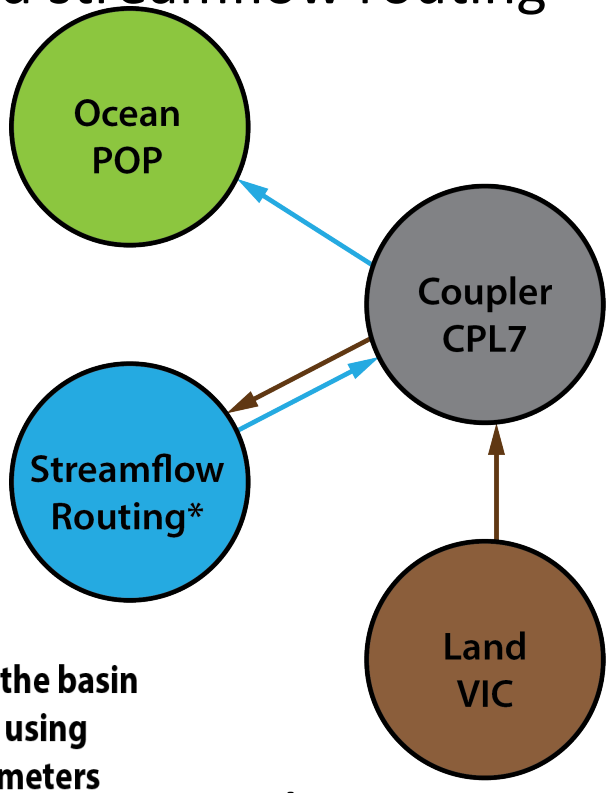


II. Flow is routed to the edge of each grid cell using a unit hydrograph

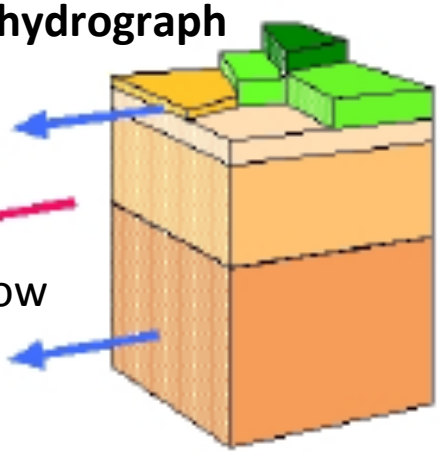


III. Flow from each grid cell in the basin is routed through network using velocity and diffusion parameters

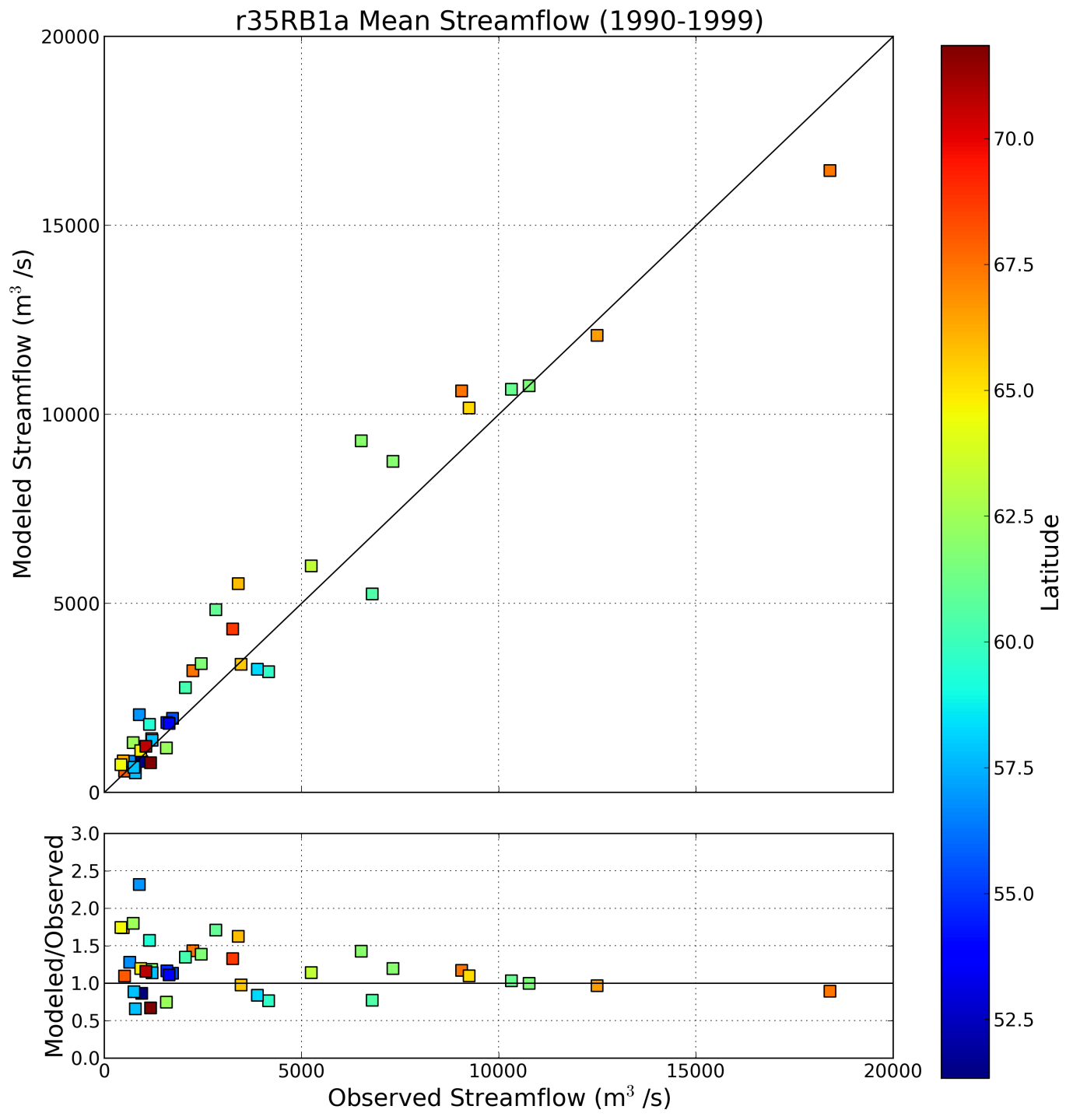




VIC Fluxes are convolved with unit hydrograph

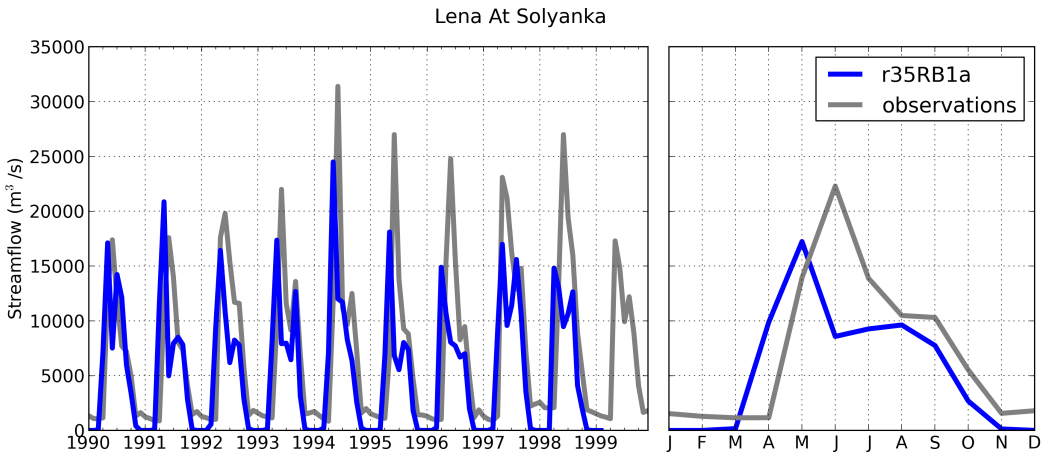


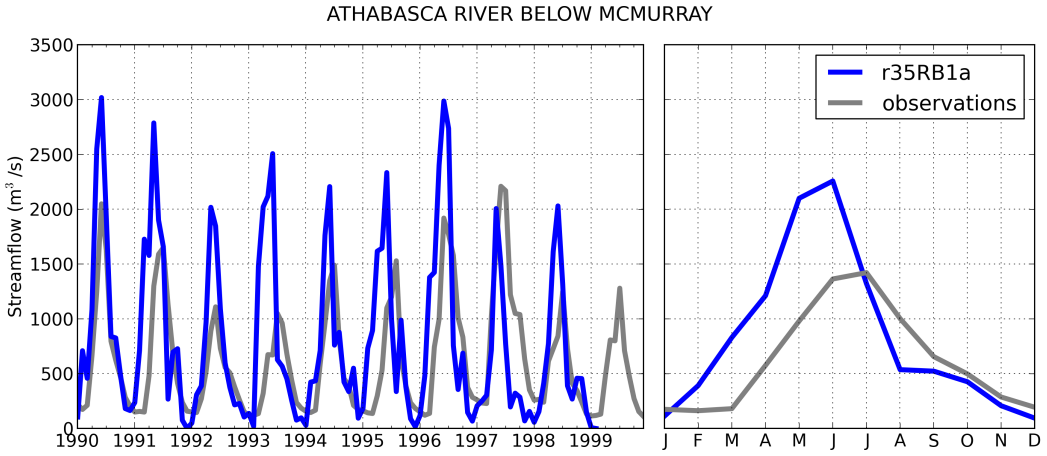
Streamflow

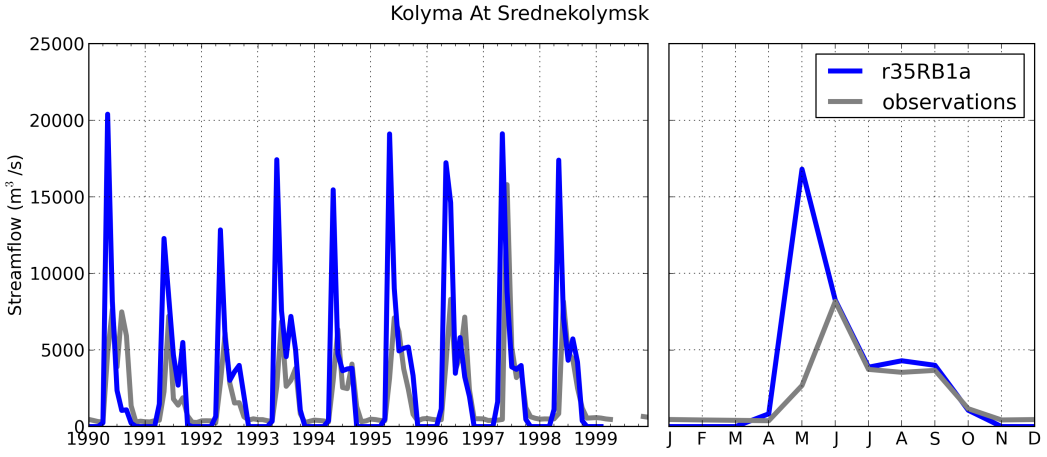


Mean Streamflow Comparison to R-Arctic Net

Monthly Streamflows







Distribution of Permafrost in the Northern Hemisphere

Modified from Collett et al. (2009)

Ongoing development work

Upgrade VIC to latest version

Ongoing development work

Credit: Terry Callaghan, EU-Interact/Sergey Kirpotin, Tomsk State University
http://www.nasa.gov/topics/earth/features/growth-shift.html

Ongoing development work

Credit: NASA Earth Observatory
Photograph by Michael Studinger
http://earthobservatory.nasa.gov/IOTD/view.php?id=81035

Closing remarks

AFRL DSRC
SUPERCOMPUTING RESOURCE CENTER

1056 cores: 2 year/day
data volume: 1 Tb/year

EarthCube

1. University of Washington
2. Naval Postgraduate School
3. University of Colorado
4. NCAR
5. Iowa State University
6. Polish Oceanographic Institute
7. Los Alamos National Lab
8. University of Arizona

Acknowledgements

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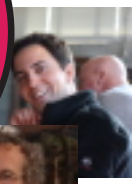
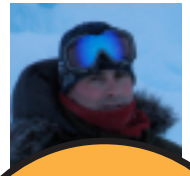
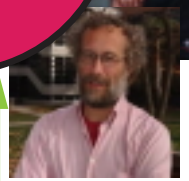
Bill Lipscomb[7]
Michael Brunke[8]
Xubin Zeng[8]

Atmosphere WRF
Ocean POP
Sea Ice CICE
Coupler CPL7
Streamflow Routing*
Land VIC
Land Ice
Dynamic Vegetation
Ecosystems
Atmospheric Chemistry