WCRP
World Climate Research Programme

WCRP Perspectives in Polar Research, and a little more

Vladimir Ryabinin
SSO, JPS for WCRP

WCRP Science Conference 2011

Scientific Knowledge for Climate Adaptation, Mitigation and Risk Management

- Motivation: inputs to next IPCC AR5, progress on implementing COPES, 30th WCRP anniversary
- Structure: symposia on cross-cutting themes/topics, i.e. CMIP5 results, reanalysis, decadal predictions, regional climate change, earth system data assimilation, etc…
- Venue: most likely USA, proposals being reviewed
- Attendance: expected around 1500 participants
- Time: March – May 2011.

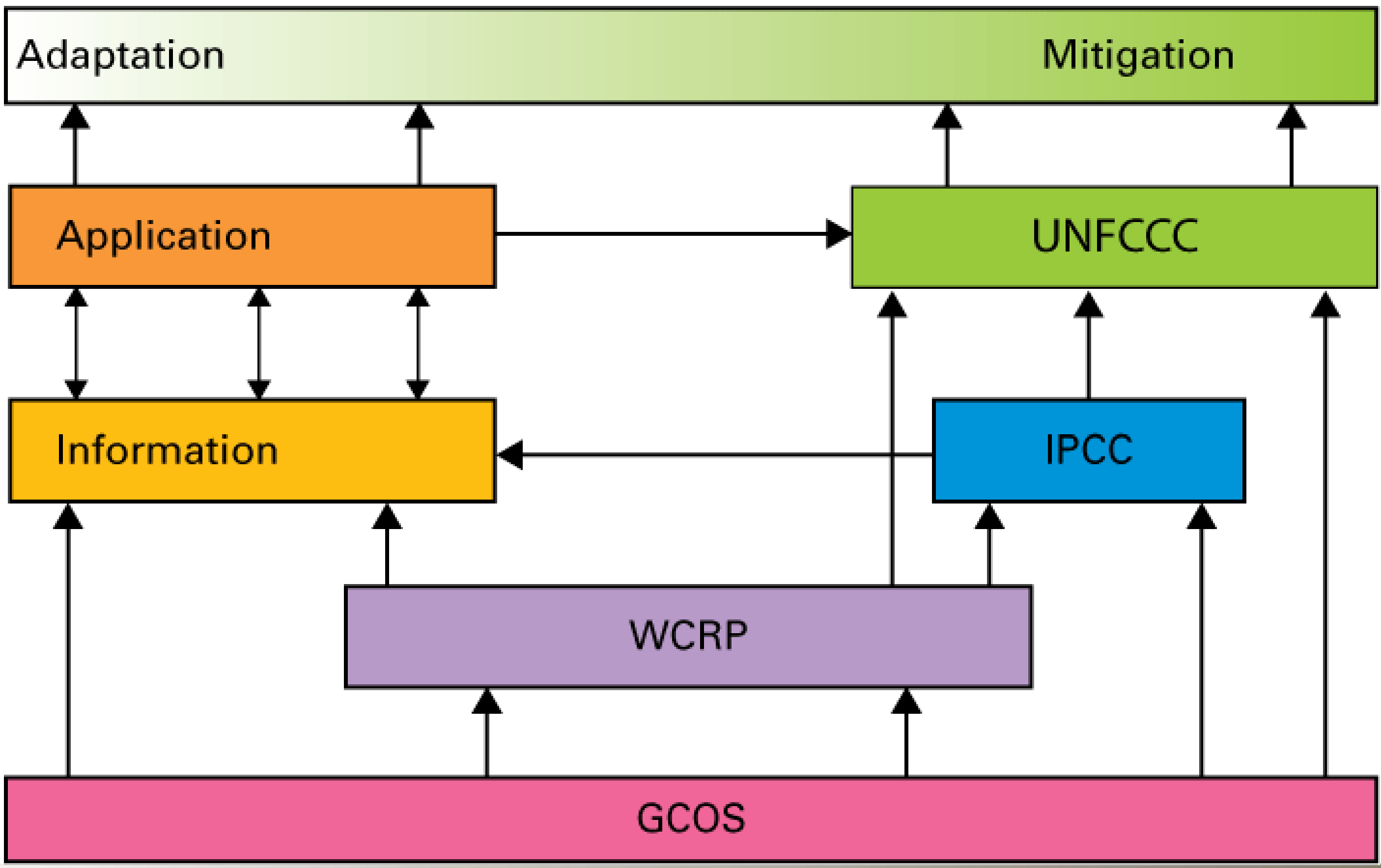
Intermediate & Long-Term Planning

- 2010-2015: WCRP focuses on implementing the Strategic Framework COPES (Coordinated Observation and Prediction of the Earth System) through the work of core projects and pan-WCRP initiatives
- post-2013(15): to align closer to the scientific requirements of the time and effectively interface with the users of climate products, a new WCRP structure is likely to be needed

Activities in support of WCRP Key Deliverables

- Decadal Variability, Predictability and Prediction
- Sea-Level Variability and Change
- Climate Extremes
- Atmospheric Chemistry and Climate
- Centennial Climate Change Projections
- Seasonal Climate Prediction
- Monsoons and Climate
- Polar Activities
- Seamless prediction system
- Reprocessing leading to reanalyses

Global Framework for Climate Services



Long-Term Predictions

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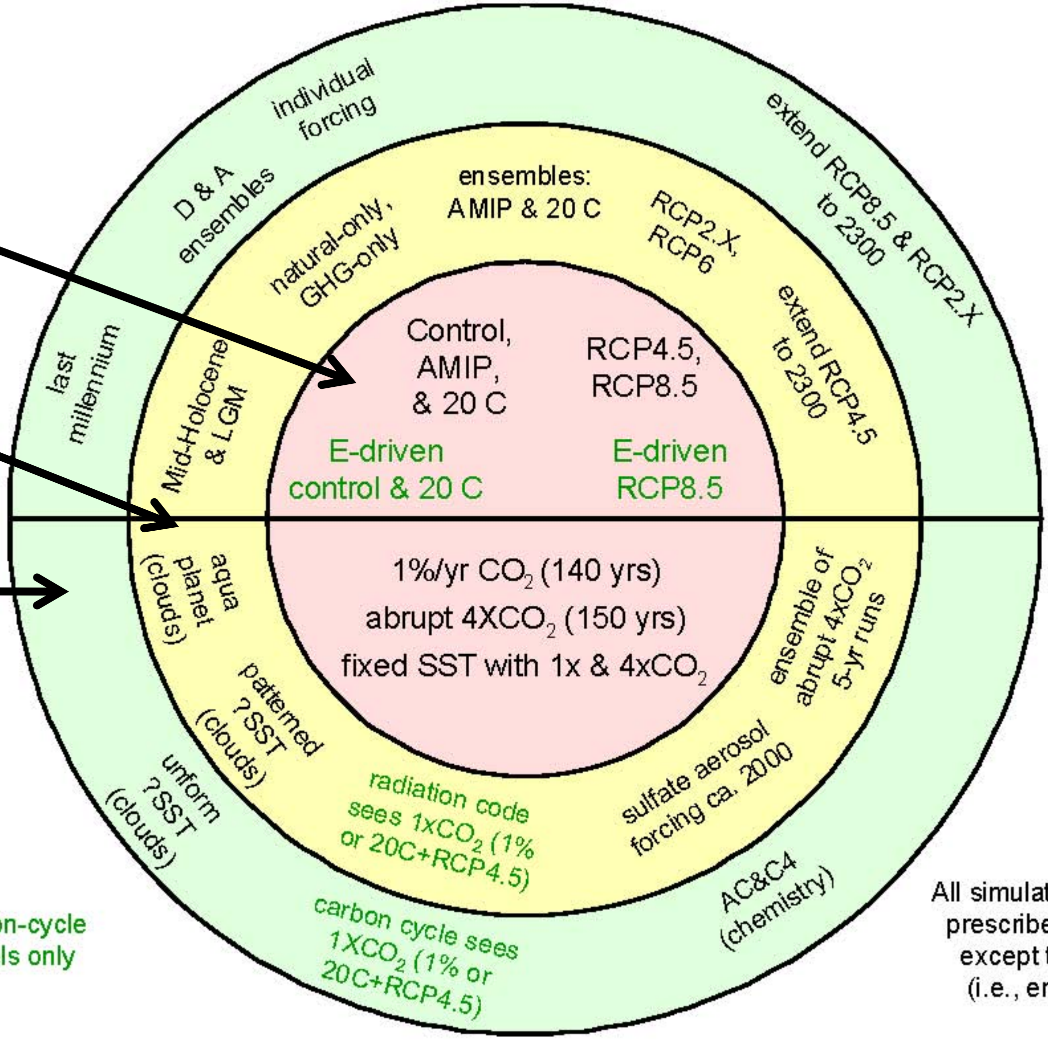
**WCRP
WGCM
CMIP5**

Core

Tier 1

Tier 2

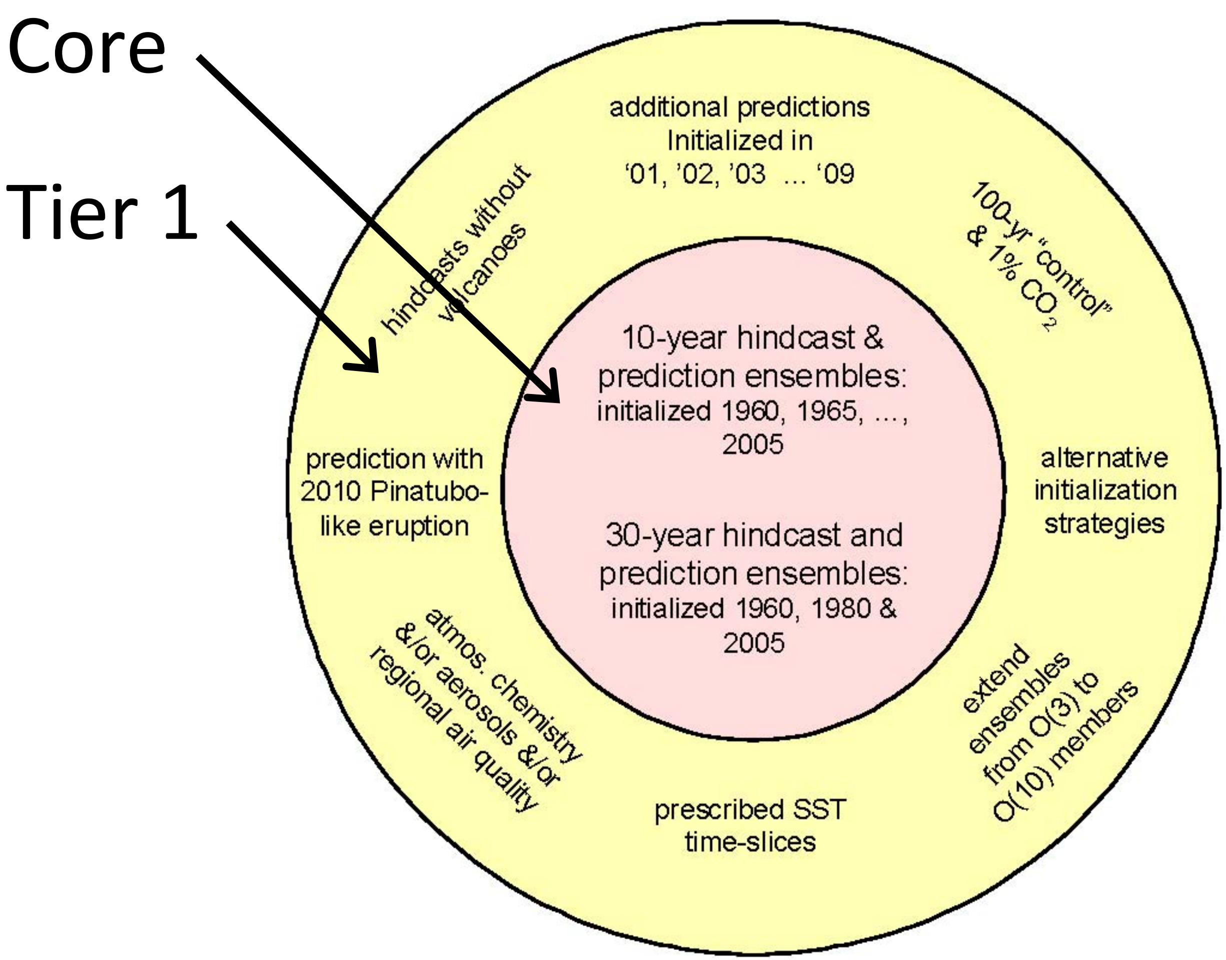


Coupled carbon-cycle climate models only

All simulations are forced by prescribed concentrations except those "E-driven" (i.e., emission-driven).

Decadal Predictions

WCRP
WGCM
CMIP5



Seasonal Predictions

Experiment Protocol

WCRP
WGSIP
CHFP

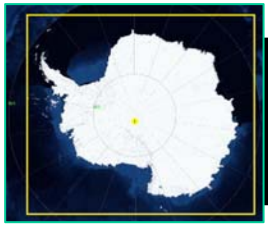
- Best Possible Observationally Based Initialization of all the Components of Climate System
  - Role for each of core WCRP projects
  - Key: No future information after initialization
- Seven Month Lead Ensemble (10 member) Fully Interactive Predictions of the Climate System
  - Predictions Initialized Four Times per Year for Each Year 1979-
  - Some Groups Extend to Decadal (JSC crosscut)
- Agreed upon output (variables, frequency, …)
- International Multi-Institution Participation
- Diagnostic sub-projects
  - will involve extensive interactions among WCRP project panels

Regional Predictions

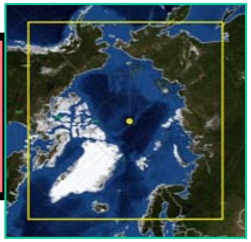
WCRP
WGSIP
CORDEX

Model Evaluation Framework

Climate Projection Framework



Multiple regions including polar
50 km grid spacing or better



ERA-Interim BC
1989-2007

RCP4.5, RCP8.5

Multiple AOGCMs

Regional Analysis
Regional Databanks

Polar climate predictability

- Pan-WCRP workshop "Seasonal, Decadal, and Centennial Predictability of Polar Climate"
- Dates: 25-29 October 2010
- Venue: Scandinavia,
  TBD with IGFA rep for Norway.

- We wish to review feedbacks / teleconnections / processes / interactions / modes of variability in the climate / earth systems and asynchronous relations between various components of these systems that have a polar or mid-latitude manifestation and are essential for secular, decadal and seasonal scale climate prediction.

Polar climate predictability

Topics :

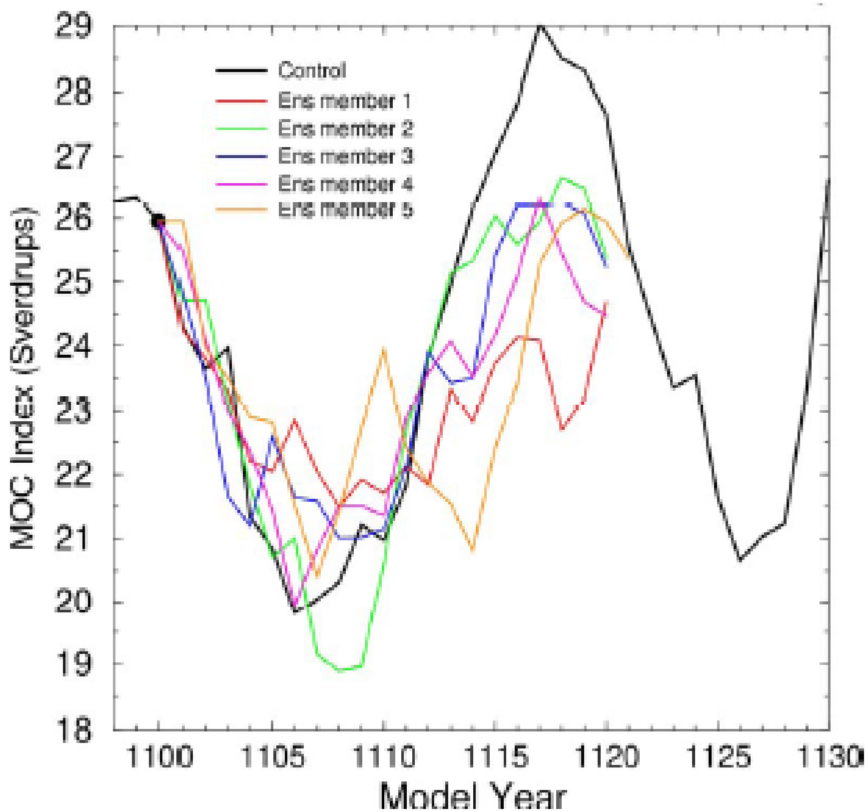
- Atmospheric effects of sea-ice changes and vice versa
- Ice sheets and ice shelves effects on ocean circulation, other cryospheric effects
- Major processes in and predictability of the polar oceans
- Land surface effects such as ones of snow cover, soil moisture, etc.
- Northern river run-off effects and freshwater balance
- Sudden stratospheric warmings
- Effects of atmospheric constituents, e.g. O3, GHG, aerosols, BC, CH4
- Volcanic effects
- Solar cycle effects
- QBO effects
- ENSO effects and teleconnections with lower latitudes
- Large-scale modes of climate variability (AMO, PDO, AO/NAO, SAM) and long-living anomalies in the ocean heat content and its transport
- Dynamic effects – planetary and gravity waves, polar night jet, etc.

Stratosphere and Polar Climate

- Sudden stratospheric warmings and coolings
- Other dynamic effects
- Effects of stratospheric ozone hole and expected ozone layer recovery
- Predictability of the polar vortex
- CCMVal or WMO/UNEP Assessment 2010
- DYNVAR
- Etc.

- To what extent is decadal variability predictable?

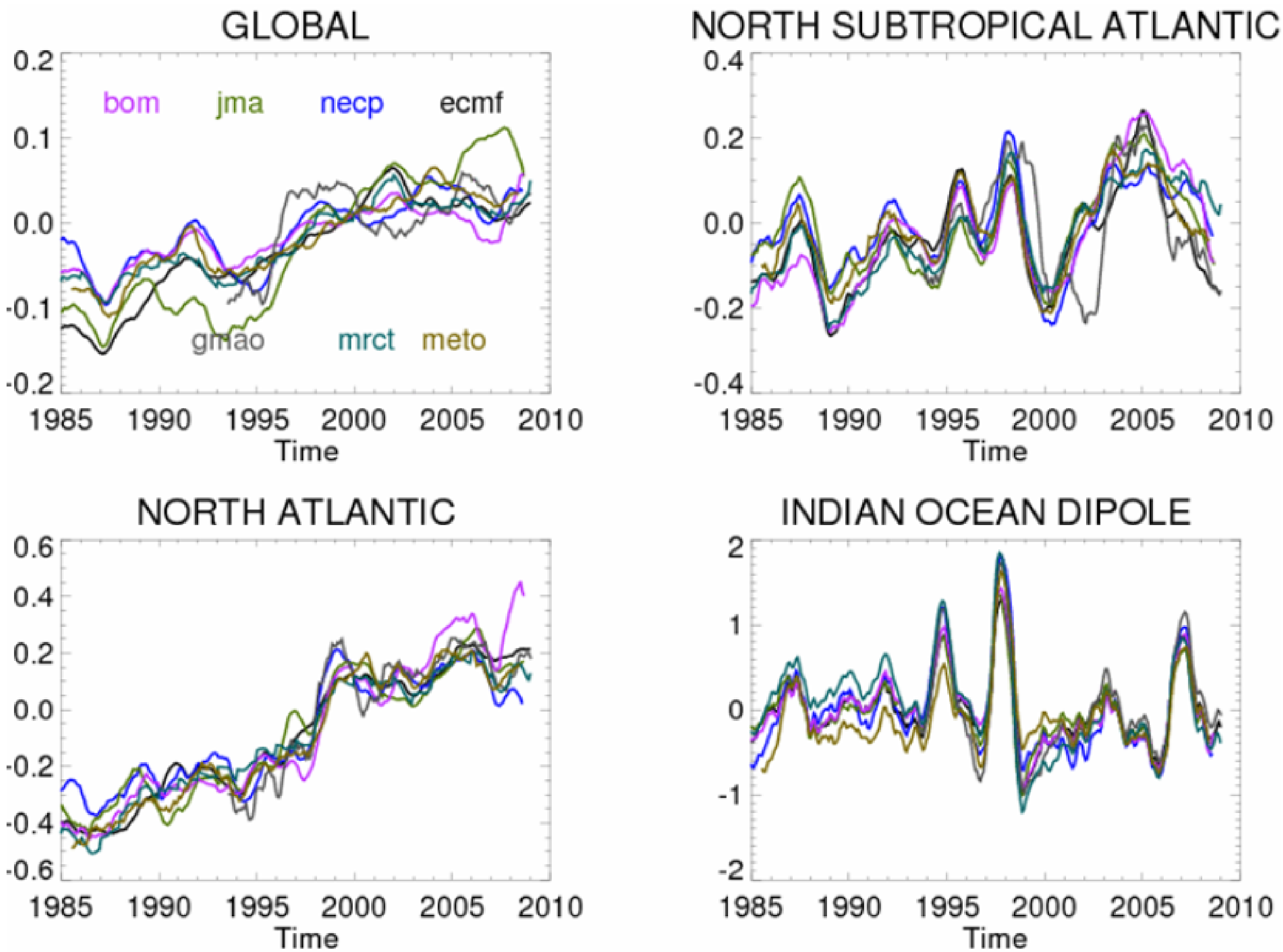
Phenomena: Idealized Predictability Experiments



Perturbed ensemble members evolve coherently for two decades

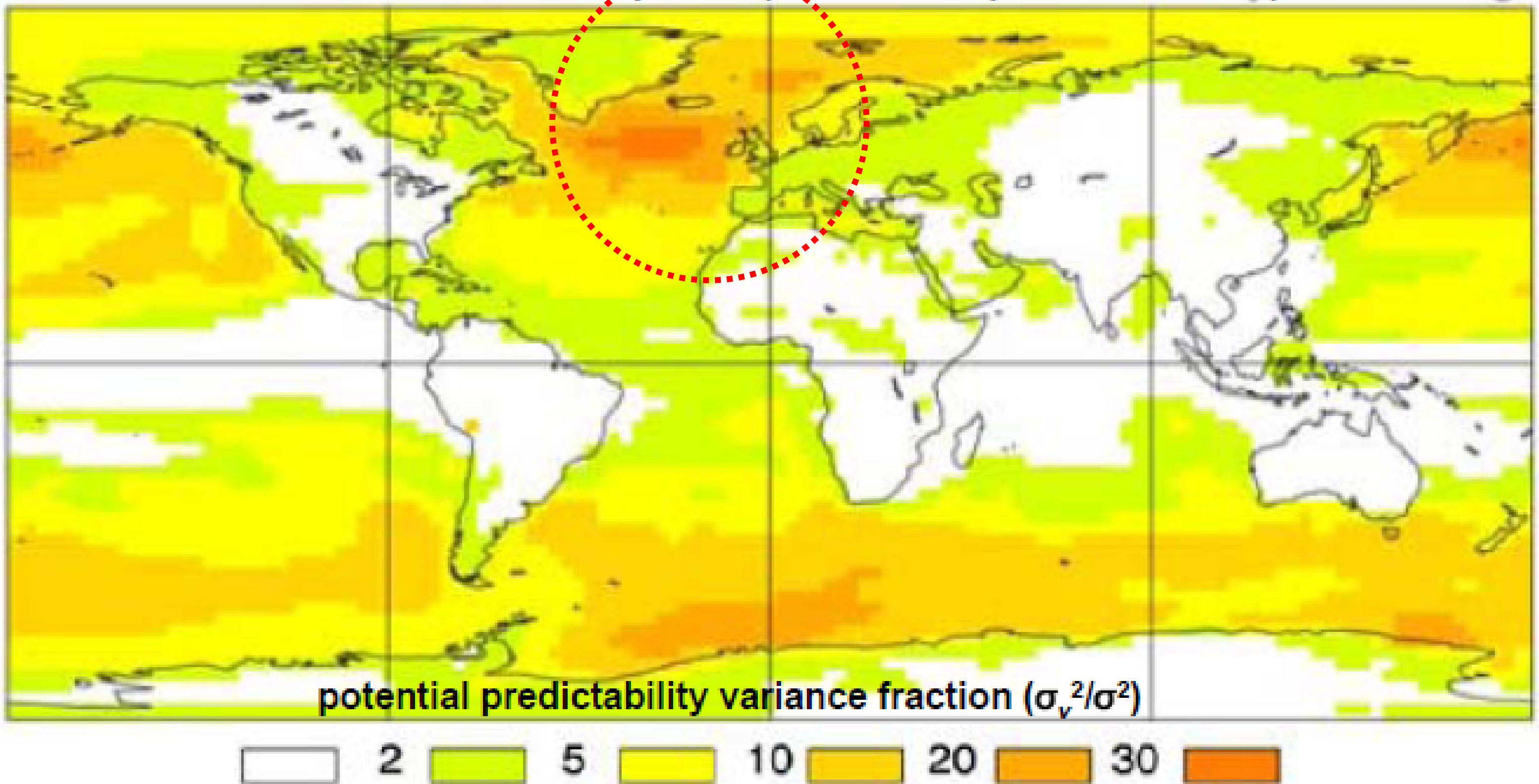
Courtesy Tom Delworth in Hurrell et al. (2009)

Ocean ReAnalyses

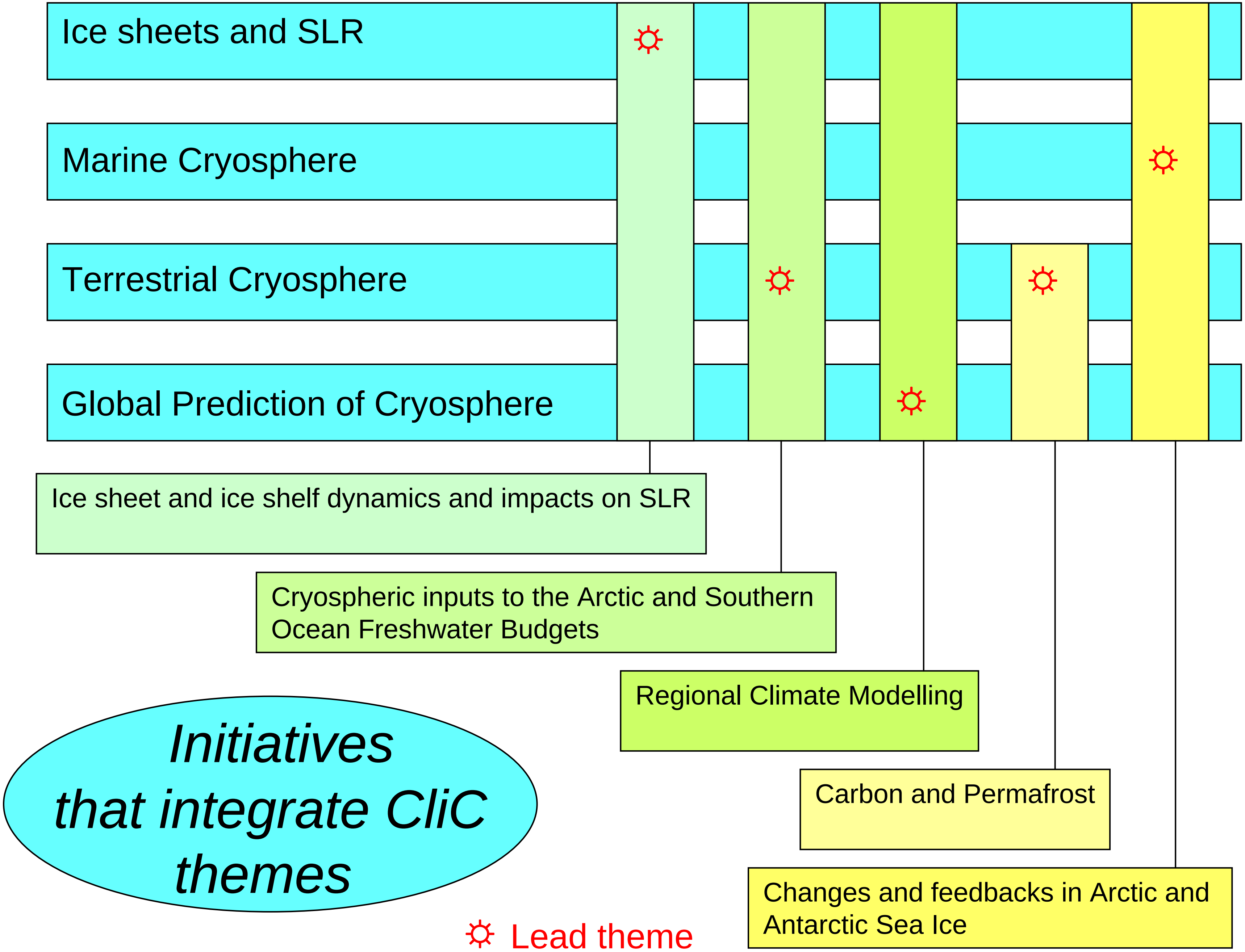


Potential Predictability in Surface Temperature

IPCC AR4 Models (8900 yrs Control) 10 yr means



Boer and Lambert (2008)


Ice sheets and SLR
Marine Cryosphere
Terrestrial Cryosphere
Global Prediction of Cryosphere
Ice sheet and ice shelf dynamics and impacts on SLR
Cryospheric inputs to the Arctic and Southern Ocean Freshwater Budgets
Regional Climate Modelling
Carbon and Permafrost
Changes and feedbacks in Arctic and Antarctic Sea Ice
Initiatives that integrate CliC themes
☼ Lead theme

1 CliC Initiative 1: Improved understanding of ice sheet and shelf dynamics and impacts on SLR

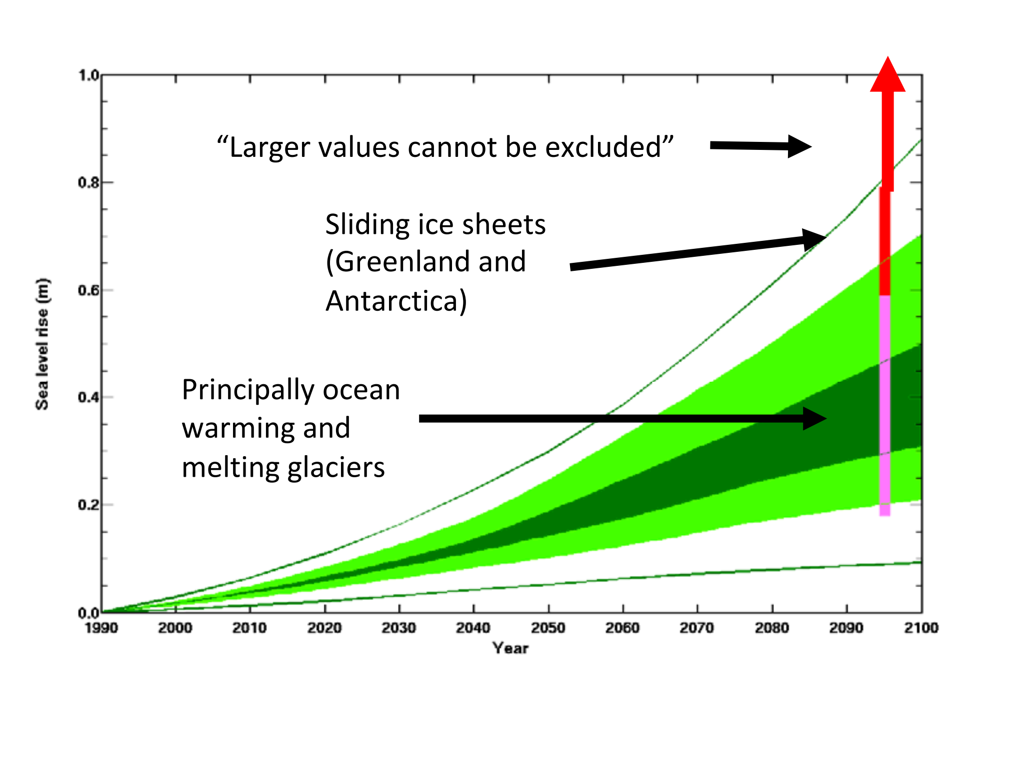
NEED IS DRIVEN BY:

Future sea level predictions are uncertain because of uncertainties in the contributions of Greenland and Antarctica

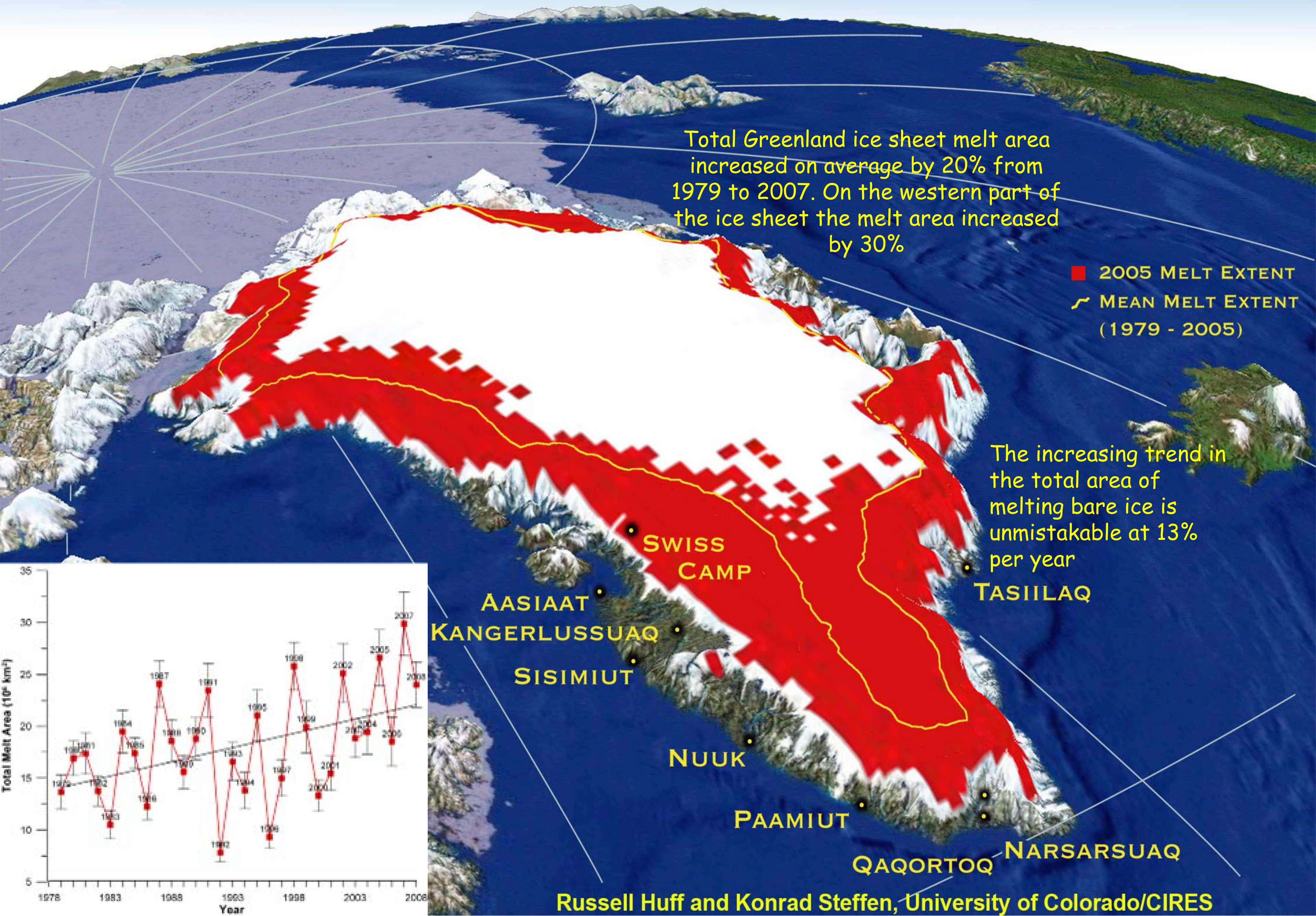
IPCC models do not include ice sheet dynamics

Current language in the IPCC AR4 is conservative (0.28 – 0.58 m SLR by 2100)

A recent study suggests a range of 0.4 – 1.4 m by 2100 (Rahmsdorf, 2007)



Greenland 2005 Melt Extent



Russell Huff and Konrad Steffen, University of Colorado/CIRES

ICARP 2


SNOW COVER
Melting and retreating increases radiation absorption; a radiative feedback. Also large impacts on snow-based wildlife
ICE SHEET
Melting of large ice sheets contributes to sea level rise and freshwater flux with potential effects on thermohaline circulation and global climate
SEA ICE
Retreating sea ice contributes to increased radiative absorption and the loss of habitat for mammals such as polar bears and seals
TRACE GASES
With enhanced surface ponding as permafrost degrades, methane production increases. With wetland drying, CO_2 emissions increase as organic materials oxidize. Both processes can be significant climate feedbacks.
GLACIERS/ICE CAPS
Retreating glaciers initially increase runoff but lower flows eventually result as ice masses diminish. Impact example: reduced fish habitat and water supply
PERMAFROST
Thawing permafrost changes geomorphic/ geochemical processes and fluxes. Impact example: changes to flow systems and aquatic ecology
RIVER ICE
Changes in magnitude/ timing of snowmelt runoff and river-ice processes modify ice-jam flooding with related positive (e.g., aquatic recharge) and negative (infrastructure damage) impacts
LAKE ICE
Shrinking ice cover produces numerous ecological impacts generally leading to greater productivity but can also affect surface transport
RIVER FLOW
Increasing precipitation plus melting snow & ice increases arctic river flow although summer flows may decrease with enhanced evaporation. Changes in freshwater flux may affect thermohaline circulation and global climate
OCEAN AND ATMOSPHERE
SEA ICE
PERMAFROST
RIVER FLOW
SNOW, ICE AND GLACIERS
RADIATIVE FEEDBACKS
Reductions in snow and ice coverage leads to lower reflection and increased surface absorption (warming), thereby producing a major feedback to global climate
SEA LEVEL RISE
THERMOHALINE CIRCULATION
FRESHWATER OUTFLOW
METHANE
CO_2
1
2
3
4
5
6
7
8
9

2

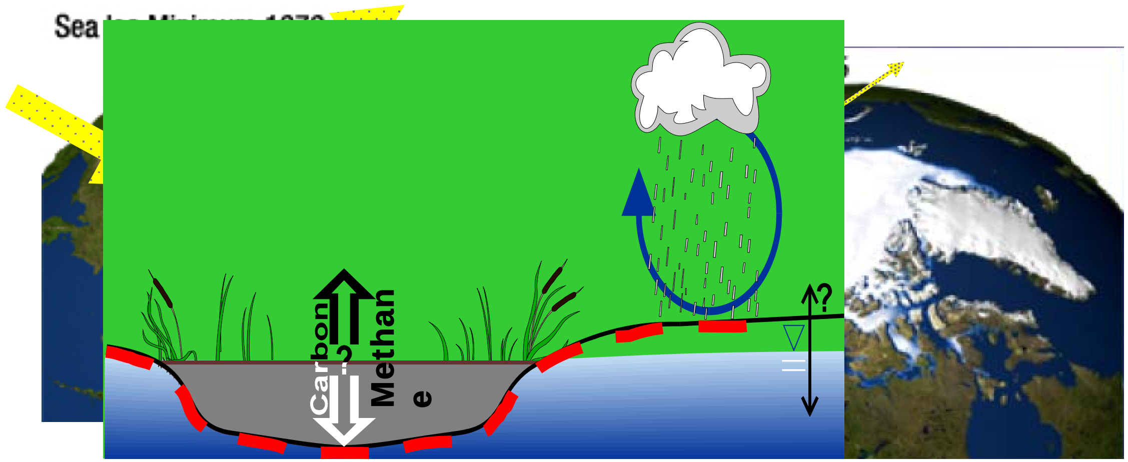
CliC Initiative 2: Cryospheric inputs to Arctic and Southern Ocean Fresh Water Balance

NEED DRIVEN BY

Terrestrial supply of freshwater to the Arctic Ocean affects:

Salinity/sea-ice production and hence radiative feedbacks

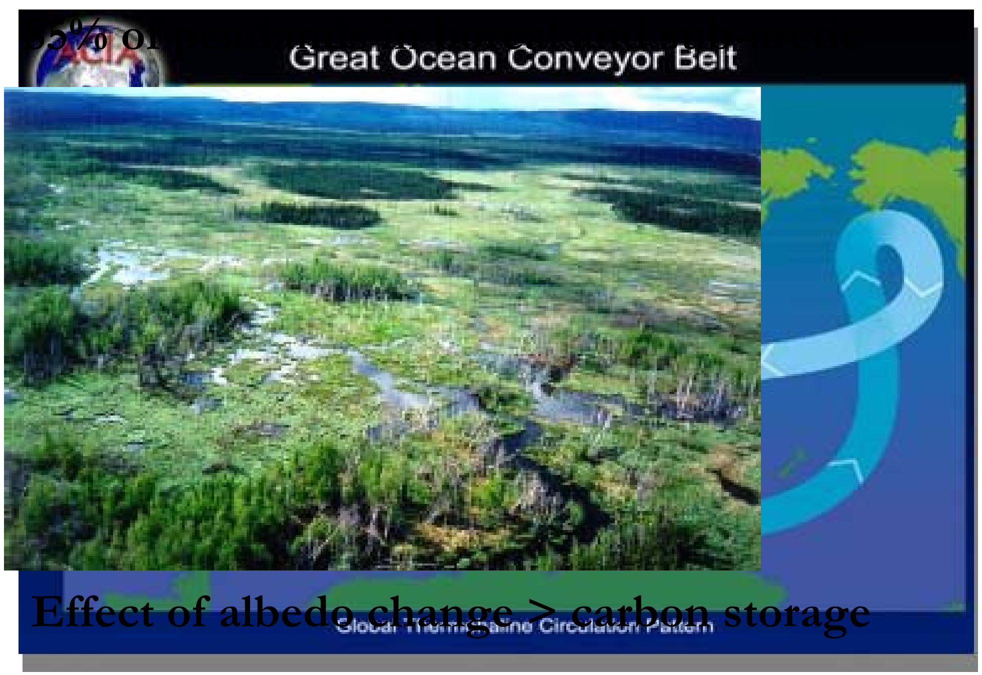
Intensity of thermohaline circulation



Additionally, terrestrial water budget impacts:

Source/sink relationships of major organic stores (e.g., peatlands)

Soil moisture/vegetation succession that can affect radiative feedbacks



4 CliC Initiative 4: Carbon and Permafrost

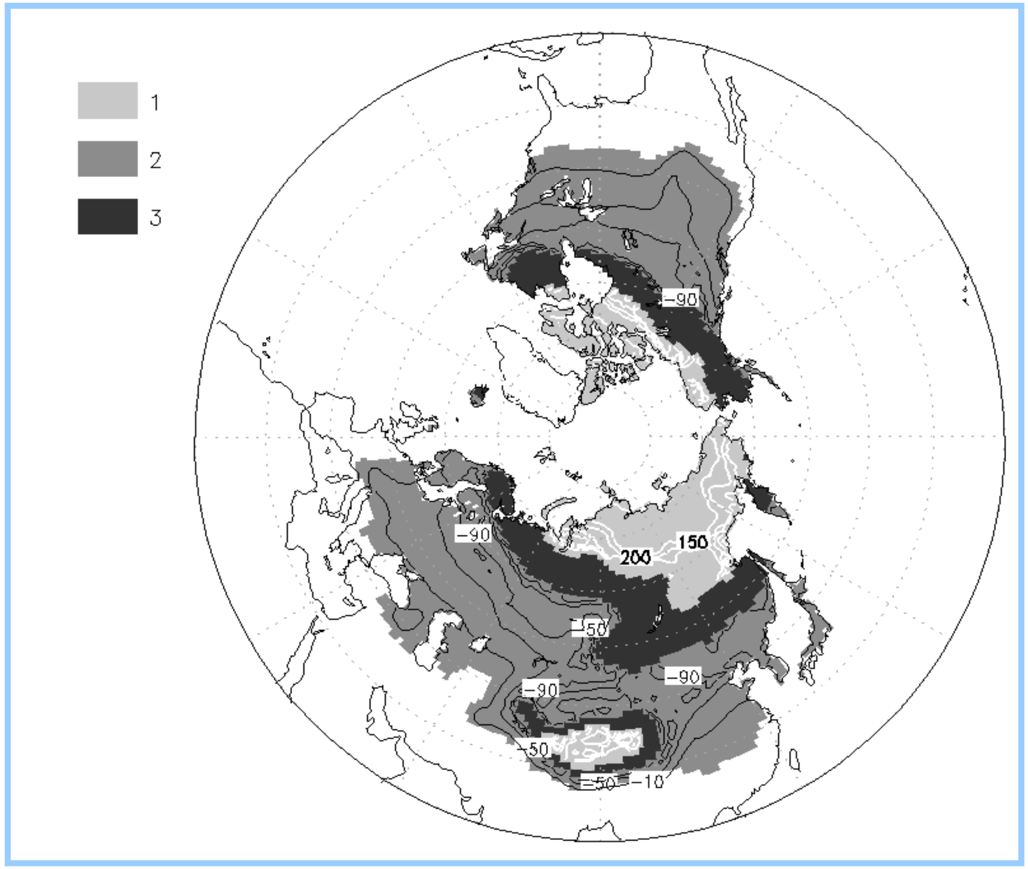
NEED DRIVEN BY

Major uncertainties in permafrost related to cryosphere

1 – regions of seasonal thawing retained by the end of 21st Century

2 – regions of seasonal freezing by the end of 21st Century

3 – regions where seasonal thawing is replaced by seasonal freezing in upper 3 m layer



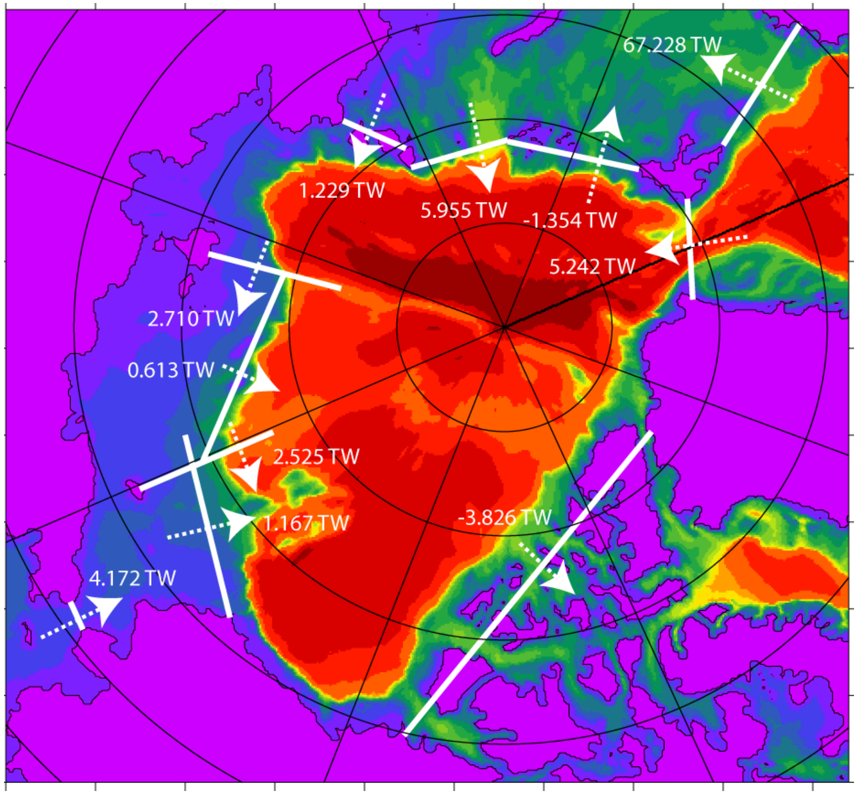
Pavlova et al., 2007

3 CliC Initiative 3: Regional Climate Modelling

NEED DRIVEN BY

Key modelling challenges
- Inflow of Pacific/Atlantic water into Arctic ocean
- Bering Strait (60 miles)
- Outflow/inflow through Fram Strait

10km or higher horizontal resolution is needed if we agree that such details are important for realistic modeling of sea ice conditions, variability, and effects on atmosphere - ocean exchanges



Maslowski and Kinney, 2009 (in revision)

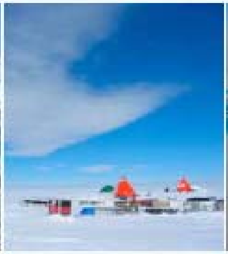
SWIPA

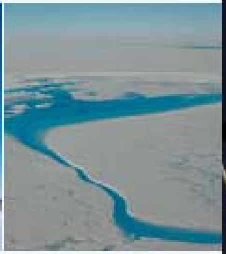
SWIPA Products

December 2009:
A first report on "The Greenland Ice Sheet in a Changing Climate" and two short films are being prepared under the Arctic Council as contributions to the 15th Conference of Parties (COP15) under the United Nations Framework Convention on Climate Change (UNFCCC), to be held in Copenhagen, Denmark.

Spring 2011:
The final SWIPA reports will be presented to the Arctic Council in 2011 and will serve as an Arctic contribution to the Fifth Assessment Report of the UN Intergovernmental Panel on Climate Change (UNIPCC), scheduled for completion in 2013/2014.

SWIPA reports will be subject to a thorough scientific peer review, as well as a national review by Arctic countries, prior to publication.





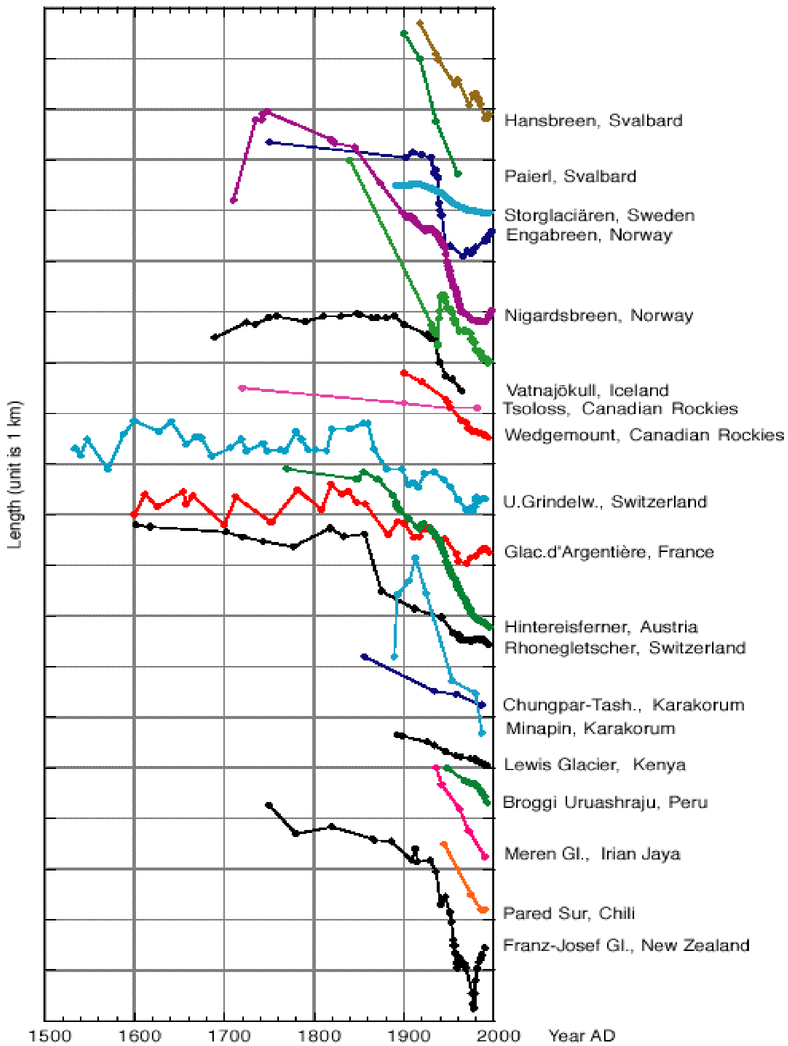
Organization of SWIPA Work

Overall coordination of the project is conducted by the SWIPA Integration Team (IT), composed of authors and representatives of the sponsoring organizations:

- Arctic Monitoring and Assessment Programme (AMAP)
- International Arctic Science Committee (IASC)
- World Climate Research Programme Climate and Cryosphere Project (WCRP/CliC)
- International Polar Year (IPY) International Programme Office.
- International Arctic Social Sciences Association (IASSA)

The AMAP Secretariat serves as the secretariat for SWIPA, convening meetings and organizing the overall activities. The SWIPA implementation plan, draft list of contents and timetable are available from the SWIPA website at www.amap.no/swipa

Glaciers



Massive effort aimed at terrestrial cryosphere prediction (in order to assess cryospheric sources of freshwater):
CMIP6(?) – HR downscaling – WGMS data for major glaciers – multinational effort of interpreting the climate predictions in terms of changes in glaciers.
Calibrated input can be used for SLR projection.
(- at the stage of idea only)

+ Permafrost

+ Snow + solid precipitation

5 CliC Initiative 5: Climate feedbacks from changes in Arctic and Antarctic sea ice

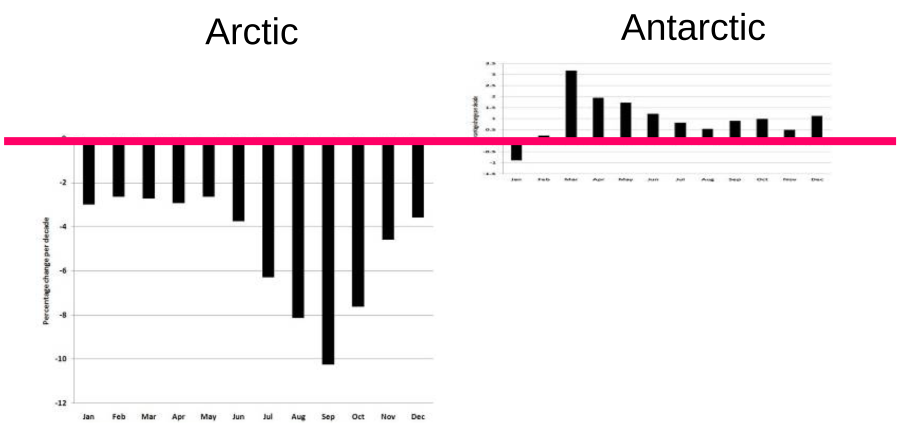
NEED IS DRIVEN BY

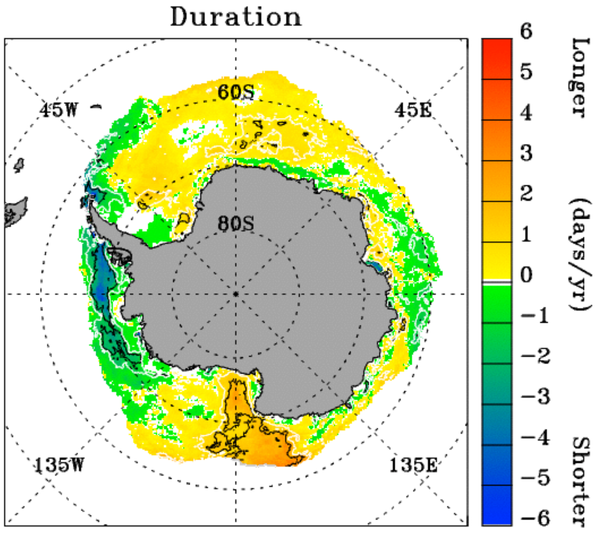
Hemispheric mismatch in sea ice extent in Arctic v. Antarctic

Inability of models to correctly predict the observed response in either hemisphere

Importance of albedo-feedback to climate processes

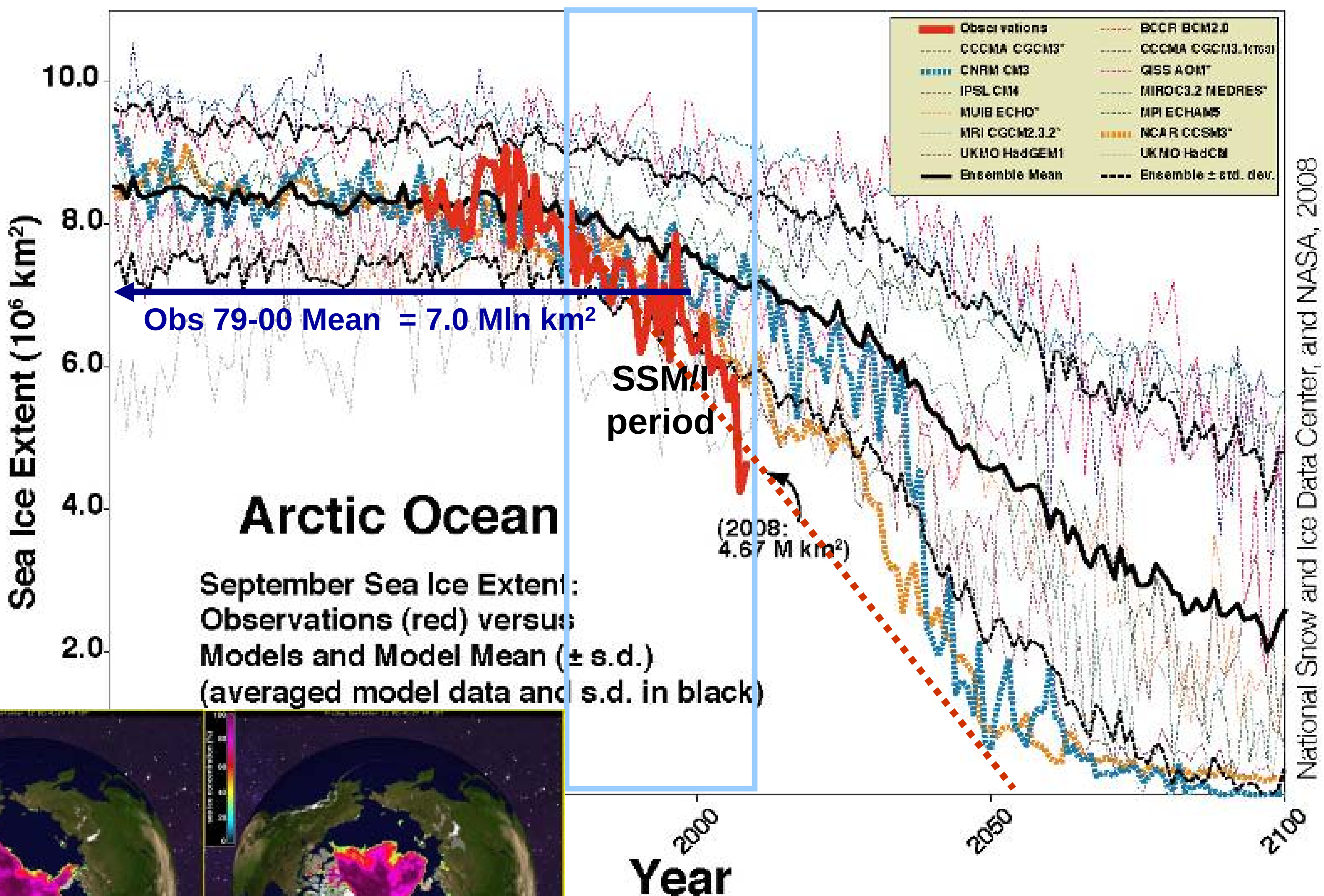
Need to coordinate in situ, remote sensing and modelling studies

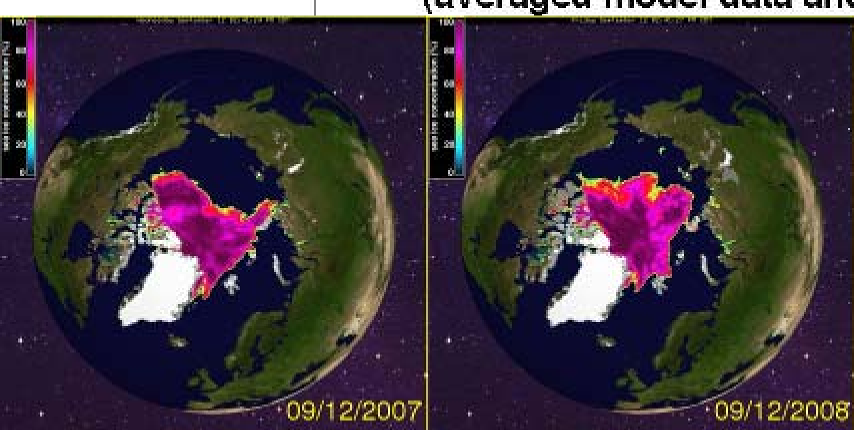




Courtesy: John Turner

Observed Rate of Loss Faster Than GCM Predicted





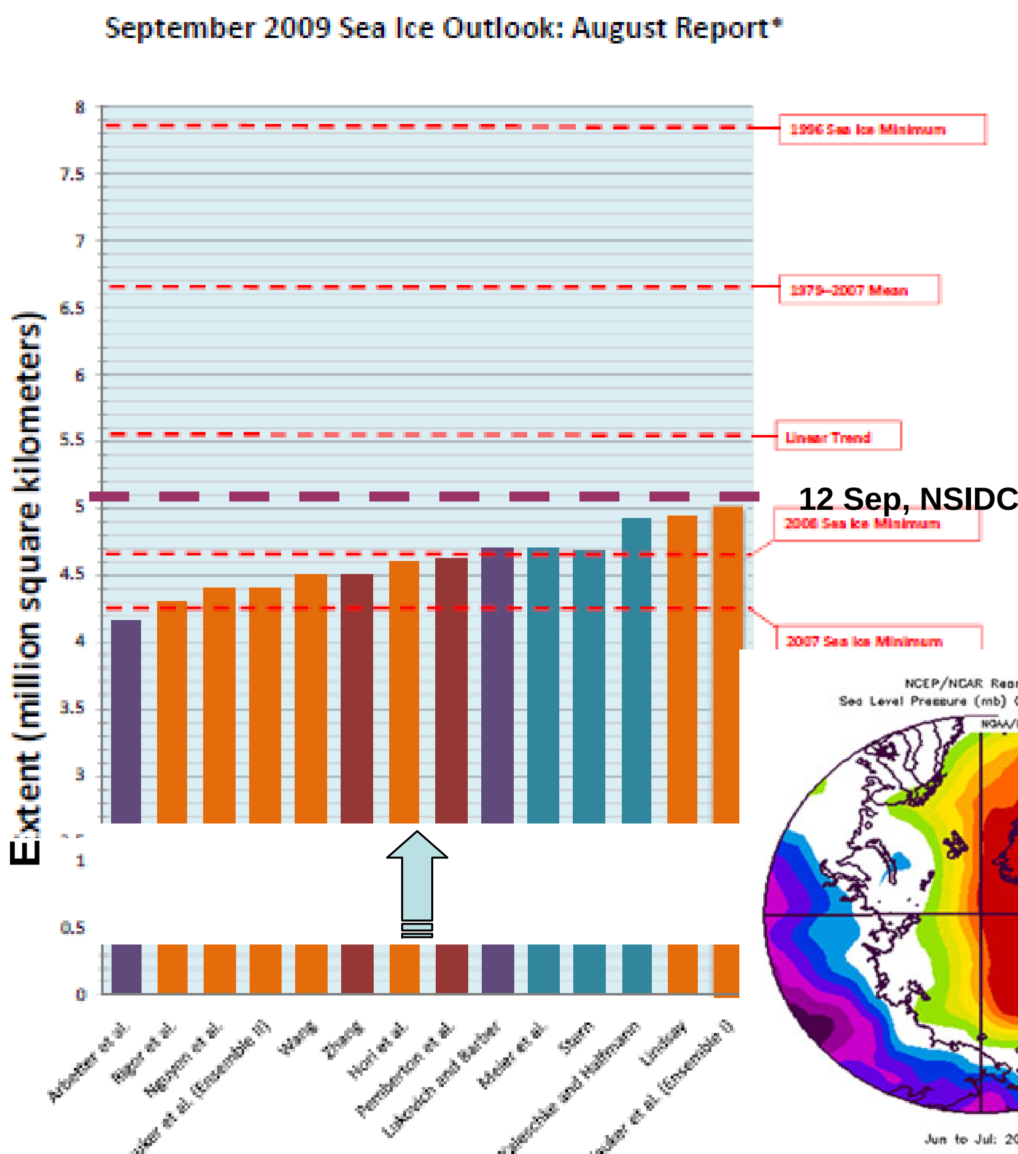
Adapted from Stroeve et al., 2007

Sea-ice research and prediction

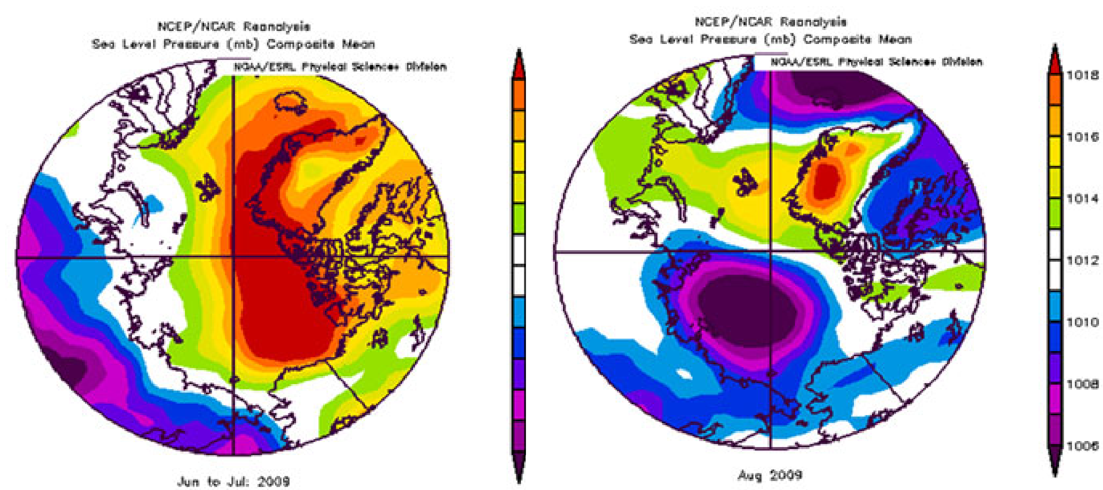
Major problems

- Extremely weak confidence in sea-ice predictions for the Arctic, which can be traced to the still poor representation of ice (rheology, brine processes, drift, heat flux) in climate models and as well low confidence in the model ability of adequately representing heat influx to the Arctic Ocean and influence of the atmosphere and freshwater run-off from continents.
- Intercomparison of climate datasets and algorithms is not conclusive leading to significant differences in sea-ice climate products on sea-ice offered to users.
- Poor representation of ice and melt ponds in satellite retrieval algorithms to generate atmospheric initial conditions for numerical weather prediction (NWP).

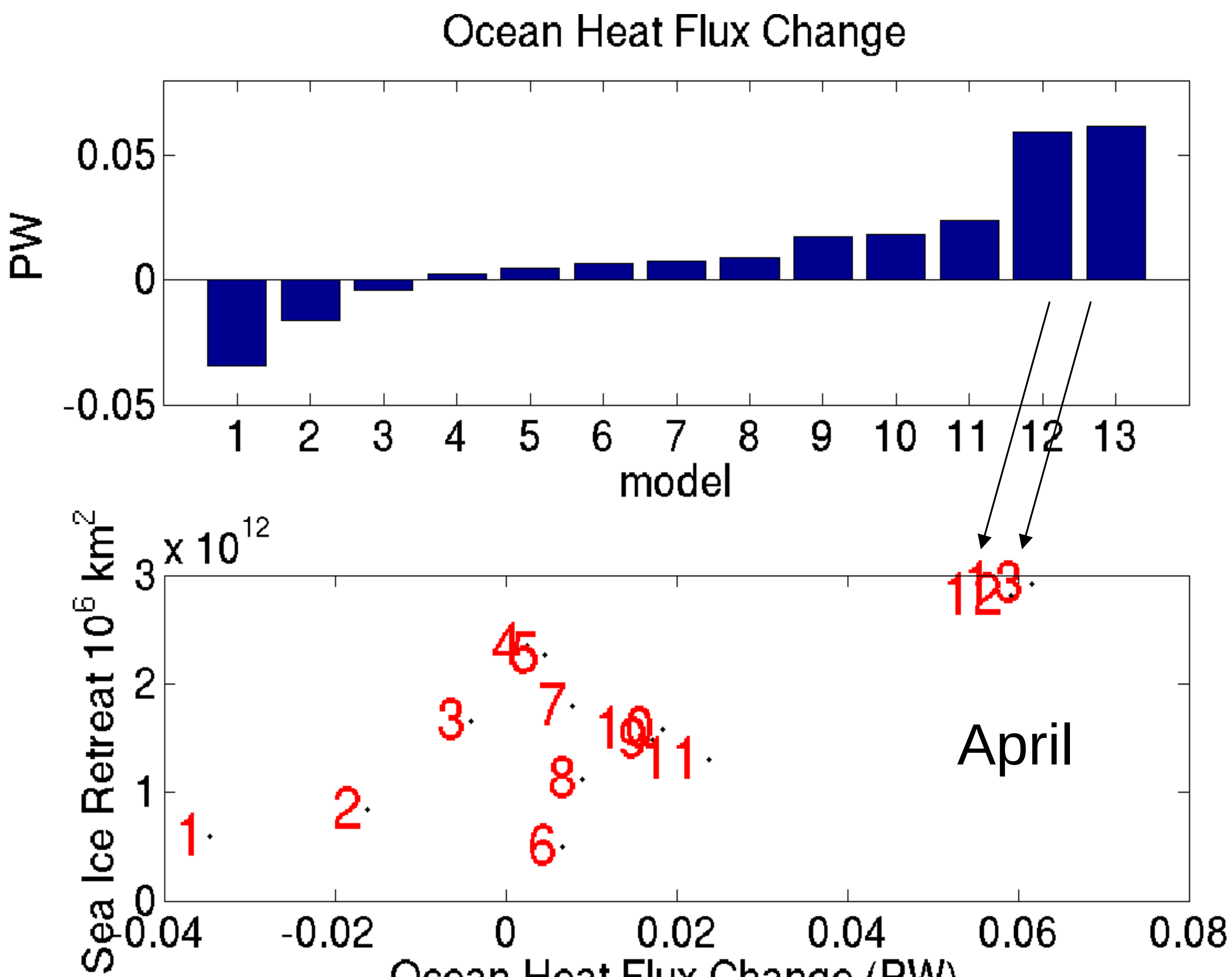
SEARCH Sea-Ice Outlook



Consistent underestimate of sea-ice extent in the predictions made in August 2009 for September 2009 shows the important role of background meteorological and oceanographic predictions

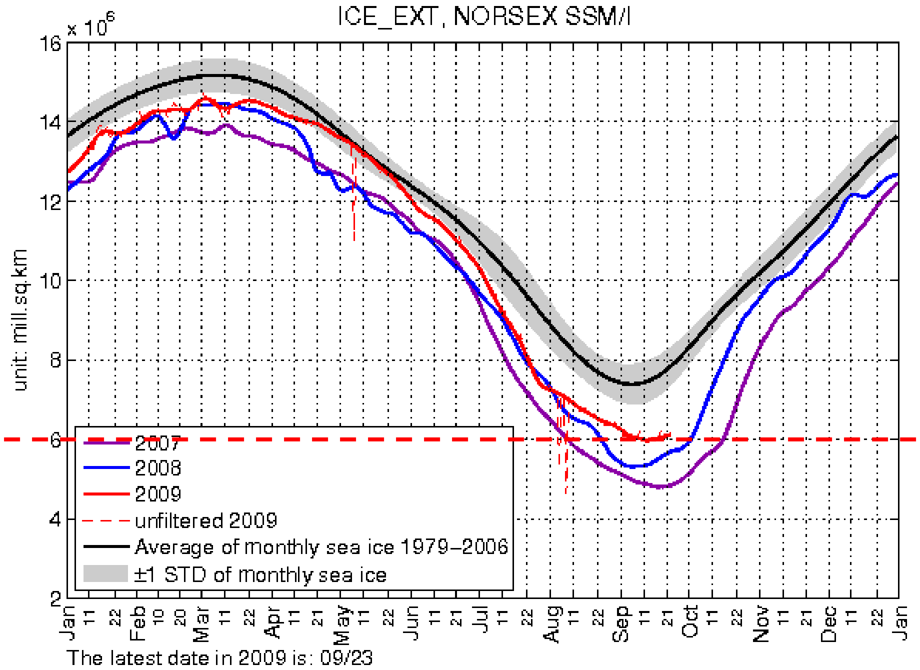


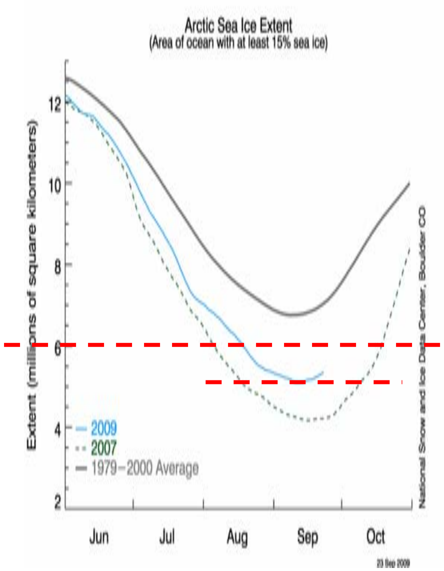
WCRP CMIP3: simulated ice extent at mid 21st century relative to 1980-2000



(C. Bitz, in press)

Comparison of Arctic Ice Extent
NERSC (Arctic ROOS) vs NSIDC Sep 23 09





Arctic System Reanalysis

- Regional Reanalysis of the Arctic Atmosphere/Ocean/Land System

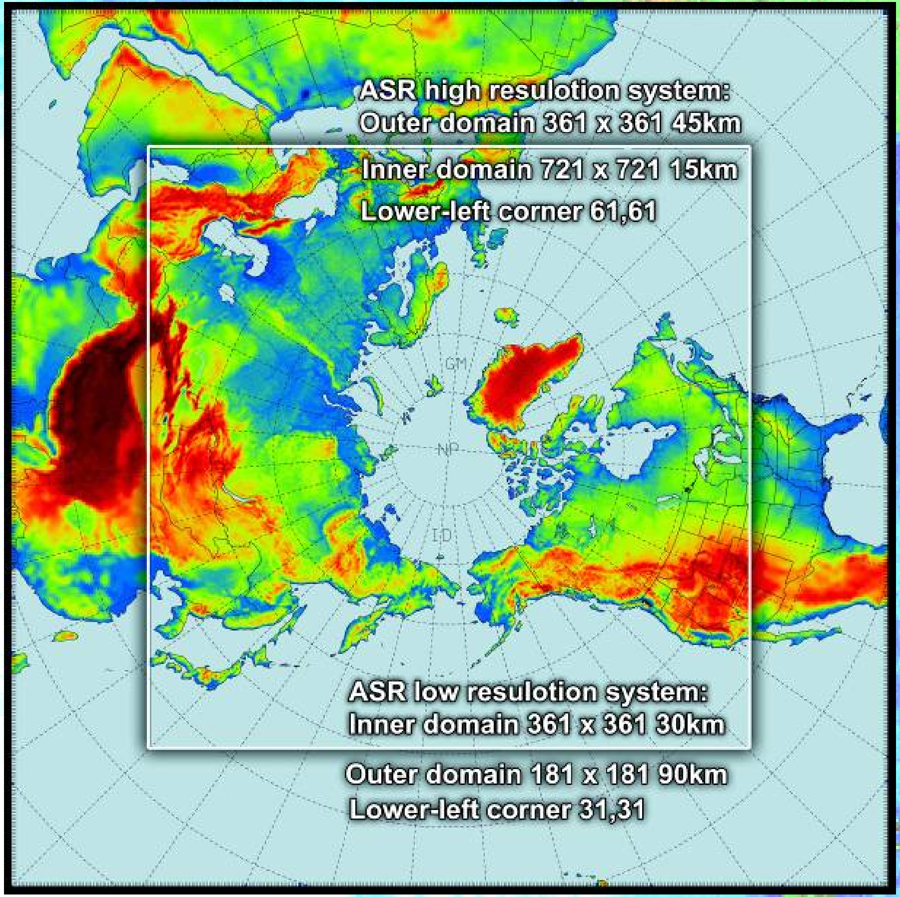
- High Resolution in Time (3 hours) and Space (15 km, 71 levels) – will consider 10 km resolution

- Time – 2000 to 2010

- Satellite Radiance Assimilation

- May Extend Grid to Cover All of the Continental U.S.

- Supported by NSF as an IPY Project



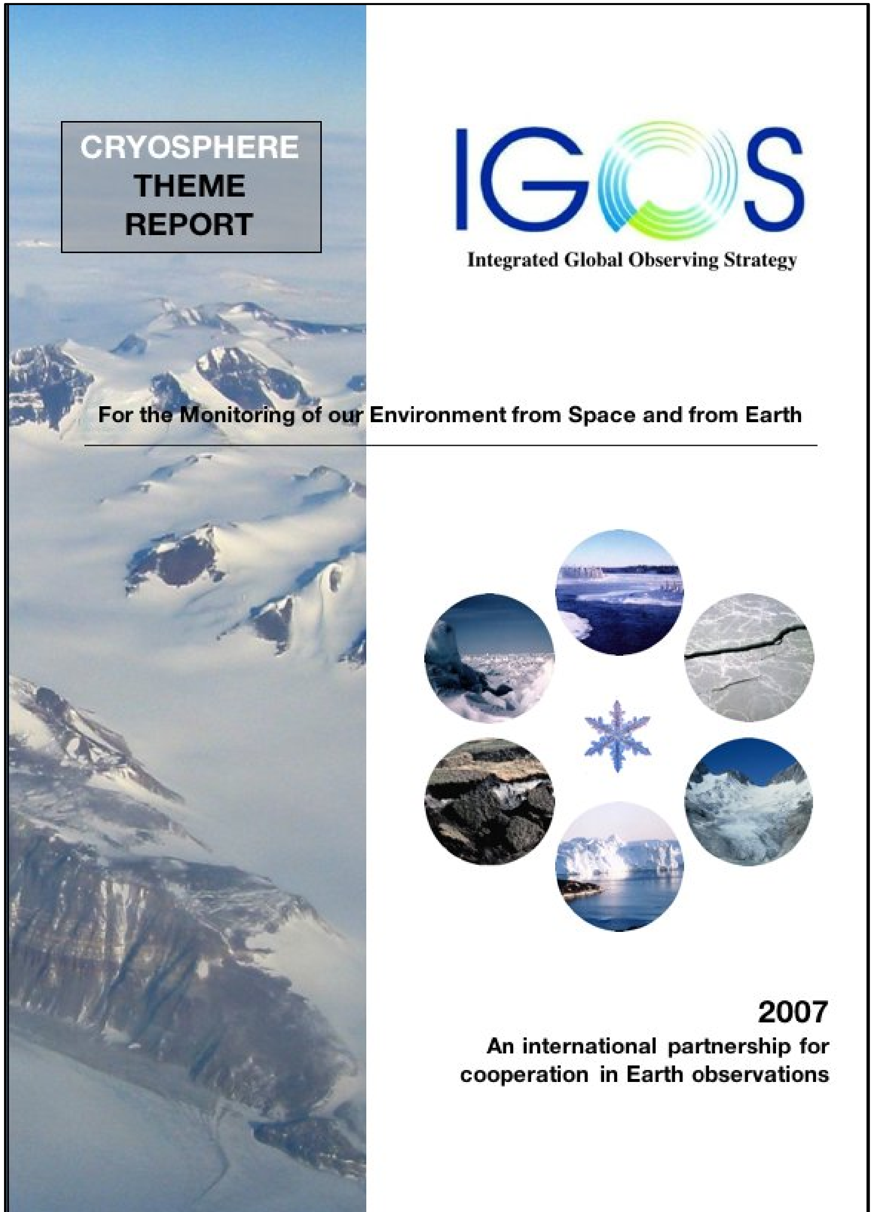
Courtesy: Dave Bromwich

CLIPS in Polar Regions

There is a need for consistent, useful, operational climate information, products and services for high latitudes:

Rapid change is affecting traditional way of life, health and safety; threatens land-based, freshwater and marine species

Industry including land and marine transportation, mining, oil and gas exploration and energy production must consider climate variability and change in planning and operations



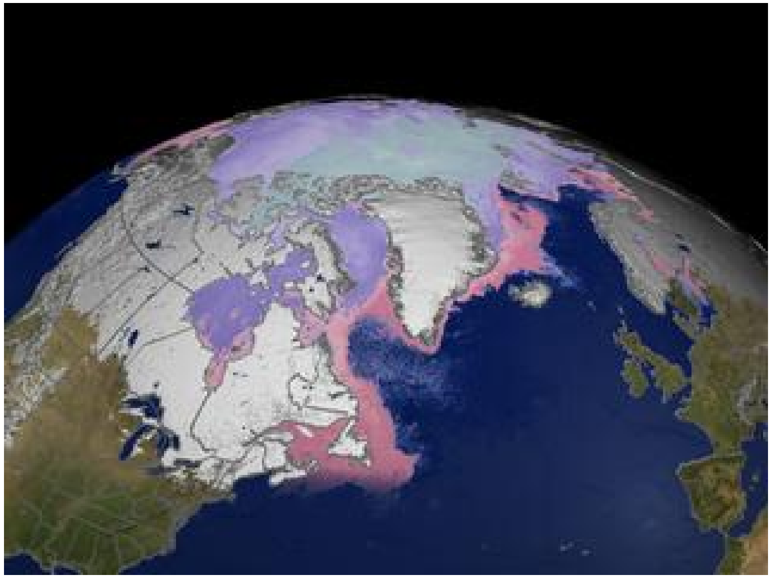
http://igos-cryosphere.org

The Report

Update?

Contributions from ~80 people in 17 countries throughout the development phase.

Global Cryosphere Watch-
A WMO Initiative



*"The 15th WMO Congress (May 2007) welcomed the proposal of Canada that WMO will create a **Global Cryosphere Watch** which would be an important component of the **IPY legacy**. Congress requested the WMO Inter-commission Task Group on IPY to establish an ad-hoc expert group to explore the possibility of creation of such global system and prepare recommendations for its development."*

A Component of the WMO Integrated Global Observing System

A Legacy of WCRP/CliC in the area of observations

WCRP-SCAR-IASC CliC

CliC: Post 2013

- Cryospheric module in Earth System Model (including atmosphere/ ocean/ vegetation etc.)
- Cryospheric and polar reanalyses (reprocessed gridded data sets with error bars)
- Cryospheric factors of seasonal, decadal, centennial prediction
- Improved understanding of dynamics and thermodynamics of ice sheets (internal structure)
- Continue to have focus groups on topics of particular interest
- Establishment of Global Cryosphere Watch (GCW)
- Continuing development of cryospheric observations
- International Polar Decade

International Polar Decade

Developments in

- studies of real predictability (ocean reanalysis),
- observations of polar regions,
- polar and cryospheric reanalyses,
- modelling and data assimilation, and
- etc.,

could be integrated in an IPD and result in significant progress in polar climate prediction at a variety of scales – ooportunity not to be missed!

For WCRP this could be the main motivation for an IPD.

Need to start planning now.

WCRP has to be represented on the planning bodies, lack of such did not help IPY.

Satellite products:

Need to try to change the way the whole system works

- ~10% (?) of satellite data assimilated and used
- one sensor – one product

Massive reprocessing of records using most updated algorithms (proposed by GEWEX) is starting.

The time is approaching for a climate system reanalysis more and multi-variate data assimilation

– e.g. melt ponds would be a very big value in the domain of cryosphere.