



# Climate and Cryosphere Project

Konrad Steffen - Chair, Gino Casassa - Vice Chair  
Jenny Baesmann, Heidi Isaksen, CLIC Project Office, NPI, Norway  
Vladimir Ryabinin, WCRP Officer, Geneva



# CliC's Mission

## WCR-Project co-sponsored by SCAR and IASC

- To **assess and quantify the impacts** that climatic variability and change have on components of the cryosphere and the consequences of these impacts for the climate system.
- In addressing this aim, CliC also seeks to **determine the stability of the global cryosphere**.



# CLIC SSG-8 Meeting

## Innsbruck, 9-12 March, 2012



Host: Helmut Rott,  
Research Center for Climate and Cryosphere, University of Innsbruck

# CliC SSG



Konrad (Koni) Steffen, Chair, USA & CH, ice sheets  
off)

(7 SSG members rotating

Gino Casassa, Vice-Chair, Chile, mountain glaciers

Ayako Abe-Ouchi, Japan, GCMs, ice sheet dynamics

\*David Bromwich, USA, polar climatology

Sebastian Gerland, Norway, sea ice

Alexander Klepikov, Russia, polar ocean/climate modeling

\*Terry Prowse, Canada, freshwater ice

Annette Rinke, Germany, polar climate modeling, RCMs

Vladimir Romanovsky, USA, permafrost

Helmut Rott, Austria, remote sensing terrestrial ice & snow

\*Tony Worby, Australia, sea ice

Cunde Xiao, China, ice cores

## Working Groups

- **CASIWG:** CliC Arctic Sea-Ice Working Group . Chair Don Perovich, USA Steering Committee member Sebastian Gerland, Norway
- **ASPeCt:** Antarctic Sea Ice Processes & Climate (CliC-SCAR), Steve Ackley, Chair, USA. Tony Worby, Australia



# CliC SSG



Greg Flato (chair), Canada, **climate modeling**, cryosphere

Peter Lemke (Vice Chair), Germany, **modeling & prediction** sea ice and climate

Tetsuo Ohata (Vice Chair), Japan, cold climate processes, regional

Nolan Koc, Norway, paleo-oceanography, sea ice biology

Gerhard Krinner, France, **ice sheets modeling**

Alexander Klepikov, Russia, polar ocean/climate **modeling**

Rob Massom, Australia, remote sensing snow and ice

Annette Rinke, Germany, polar climate **modeling**, RCMs

Vladimir Romanovsky, USA, permafrost

Helmut Rott, Austria, remote sensing terrestrial ice & snow

Larry Hinzmann, USA, cold region and permafrost

Cunde Xiao, China, ice cores

Dorthe Dahl-Jensen, Denmark, **inverse modeling**, Ice core analyses, paleo-climate

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# International Project Office

**Project Office at the Norwegian Polar Institute, Tromsø, Norway**

Tordis Villinger resigned in October 2010

Daqing Yang resigned in December 2010

**Selection of Director and support staff for CLiC Office**

New Director of Project Office **Dr. Jenny Baeseman**, started April 1, 2012

**Heidi Isaksen**, assistant to Jenny was hired in June, 2012

Both positions are funded by NPI

**CLiC Website**

Has been revised, updated

Social media tools have been added to engage the “younger” generation





# CliC Project Themes

## *CliC's four theme areas:*

### Ice Masses and Sea Level (IMSL)

- *contribution of glaciers, ice caps and ice sheets to sea level rise*
- *how will ice shelves respond to changes in ocean and atmosphere*

### The Marine Cryosphere and Climate (MarC)

- *impacts and feedbacks of a reduction in sea ice cover*
- *nature of hemispheric differences between the two polar regions*

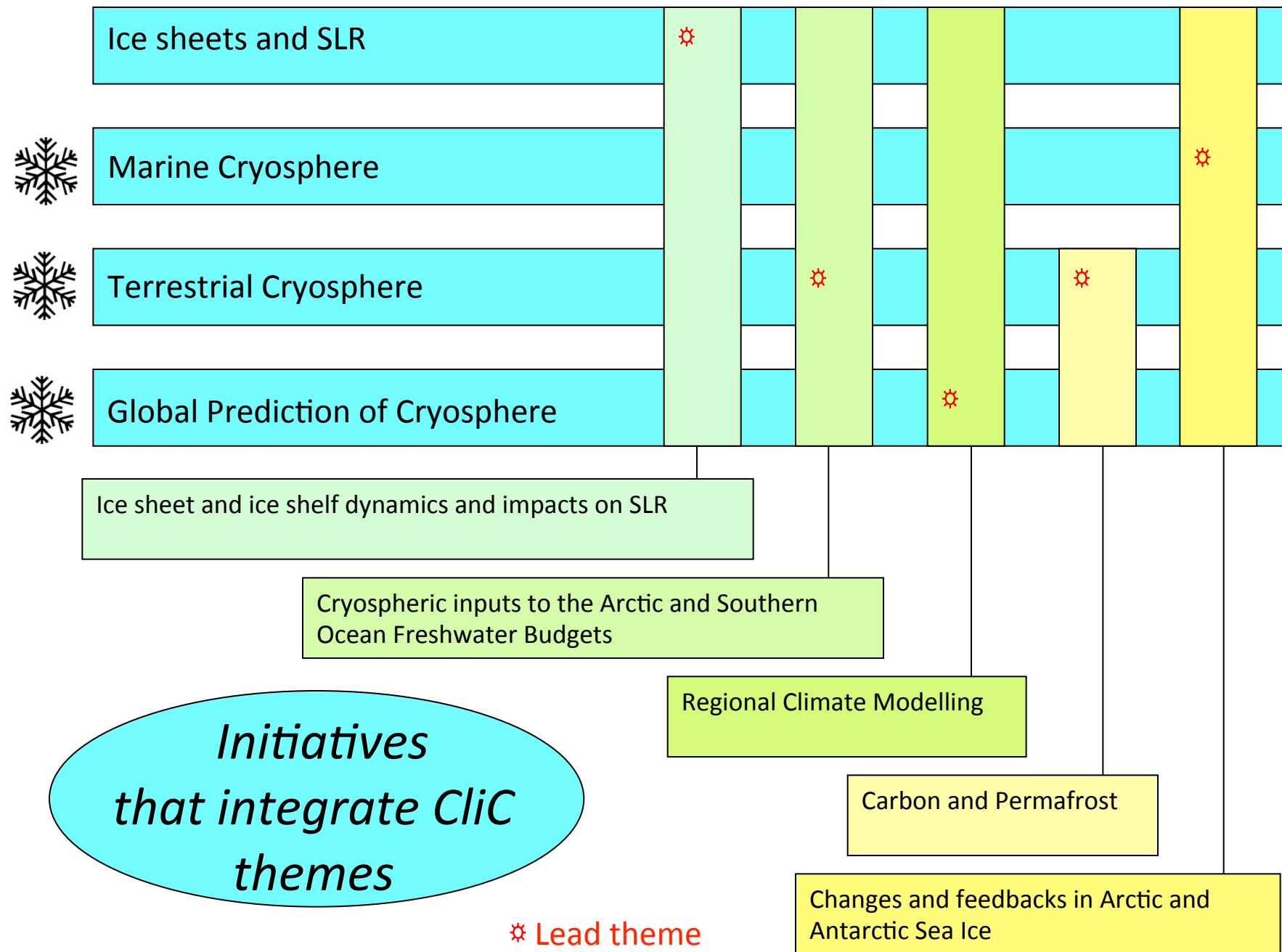
### Terrestrial Cryosphere and Hydroclimatology of Cold Regions (TCHM)

- *role of terrestrial processes in water, energy, carbon cycles of cold regions*
- *interactions and feedbacks between terrestrial and other elements of cryosphere/climate*

### Global Predictions and the Cryosphere (GPC)

- *impacts of changes on ocean and atmosphere circulation*
- *likelihood of abrupt climate changes*







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

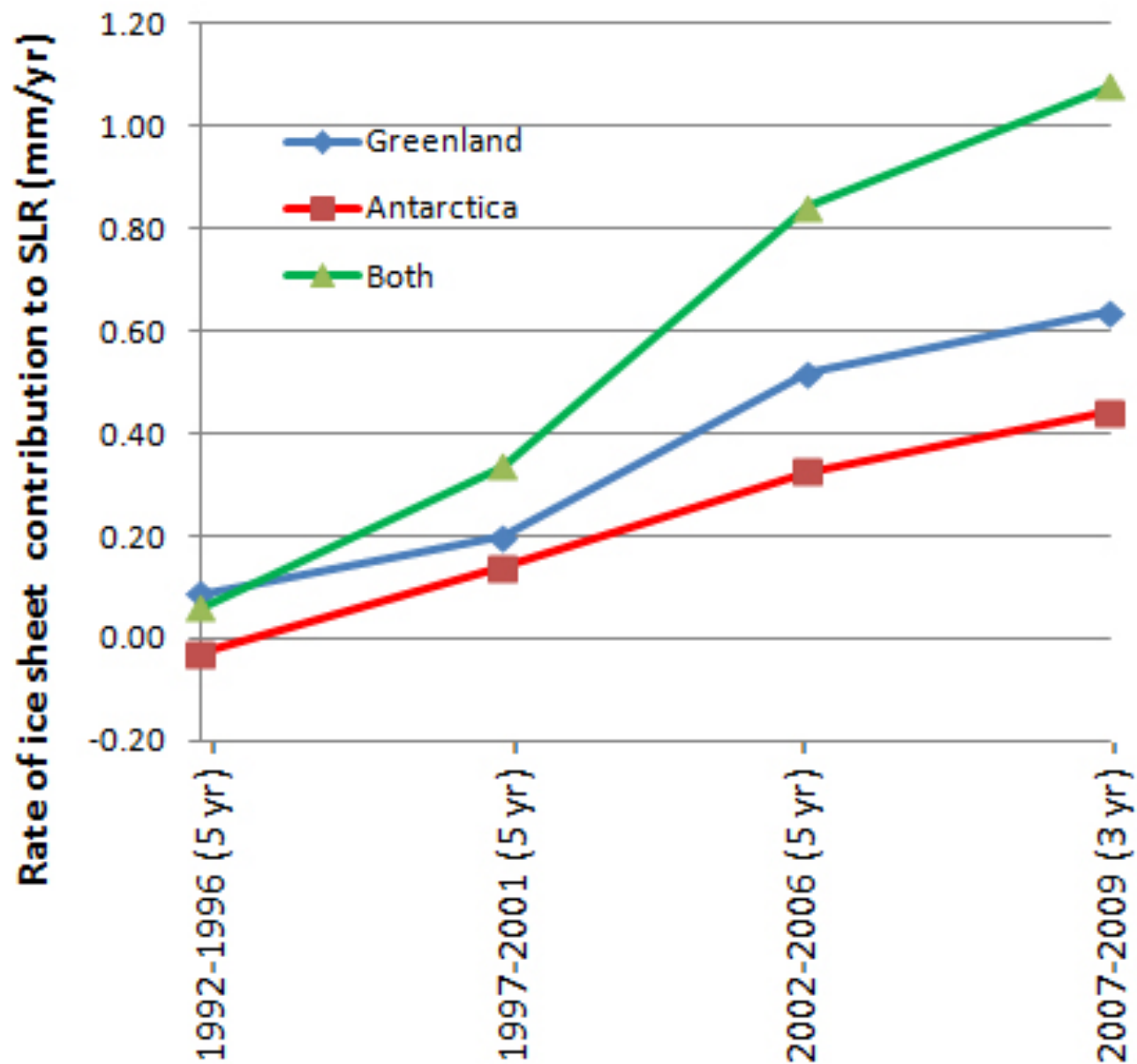
## Activities & Accomplishments

- Workshop on regional SLR – Paris, Feb. 2011.
- Workshop on ice sheet stability and dynamic ice sheet modelling, planned Boulder 2011/12 → 2013 delayed (Waleed Abdalati)
- Ice shelf modelling and ocean interaction – regional model, 2012/13
- Proposed workshop on south-American glaciers and Antarctic Peninsula, NH spring 2013, Calafate, Argentina



***A focused effort on developing ice sheet models, with specific emphasis on the role of ice sheet dynamics on the rate of the sea-level rise.***

# Rate of Sea level Rise (mm/yr)

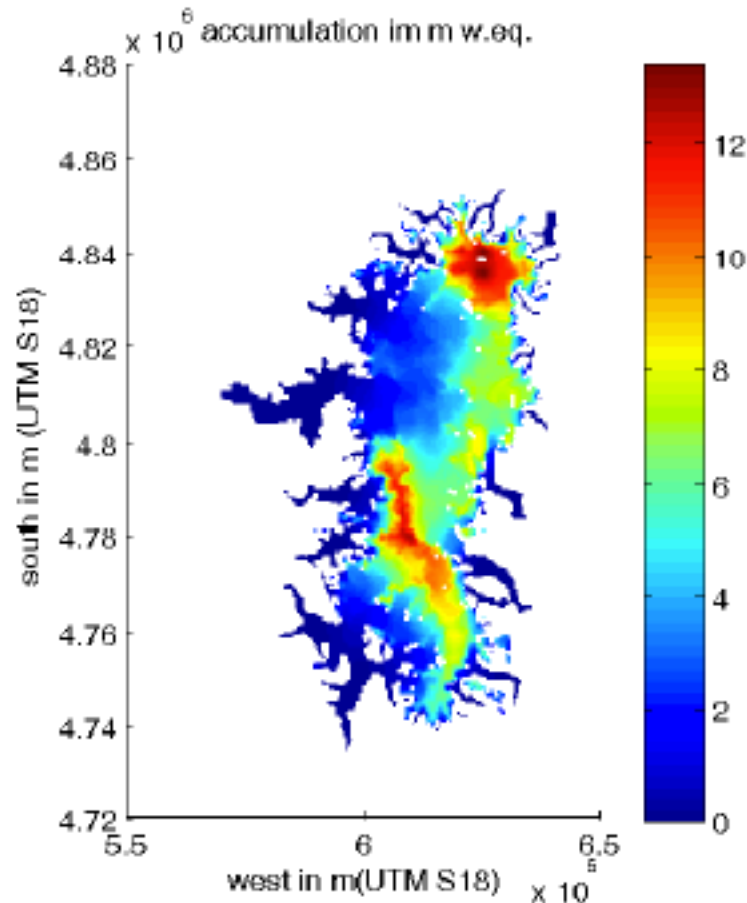




# Patagonia Ice Cap: Reanalysis downscaling

Validation of Meteorological Data

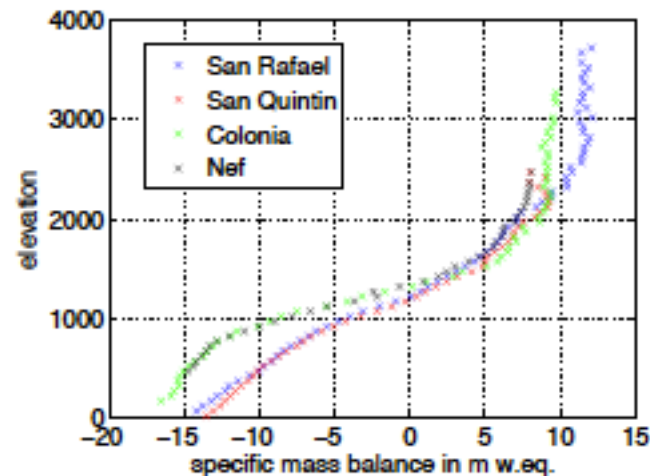
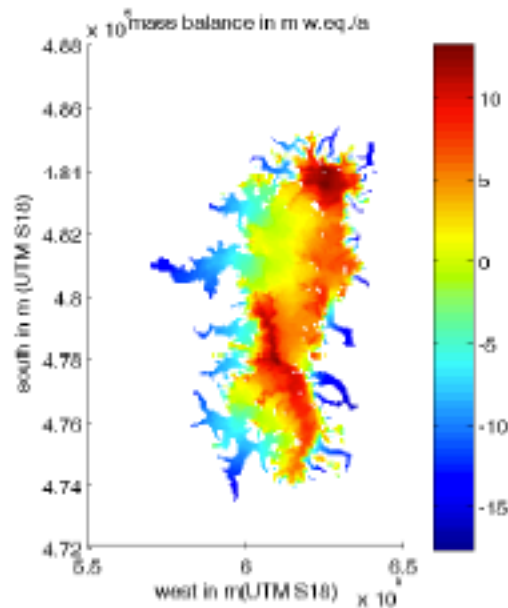
## Yearly accumulation 2005-2010 northern icefield



# Patagonia Ice Cap: Reanalysis downscaling

Results of the surface mass balance model

## Specific mass balance 2005-2010 northern icefield



# Patagonia Ice Cap: Reanalysis downscaling

Results of the surface mass balance model

## Summary

- There are large ice masses in Patagonia with high mass turnover and a high sensitivity to climate change
- First attempt to physically downscale Reanalysis/GCM data on the Patagonia Icefields with qualitatively good results
- Mass balance model can reproduce observed geodetic mass balances in the past

### Outlook:

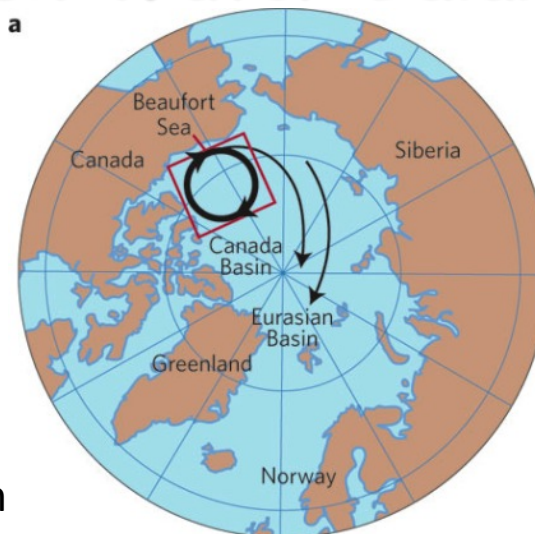
- Correct temperature and precipitation biases in WRF
- Calculate into the future



# cliC Initiative 2: Cryospheric Inputs to Arctic and Southern Ocean Fresh Water Balance

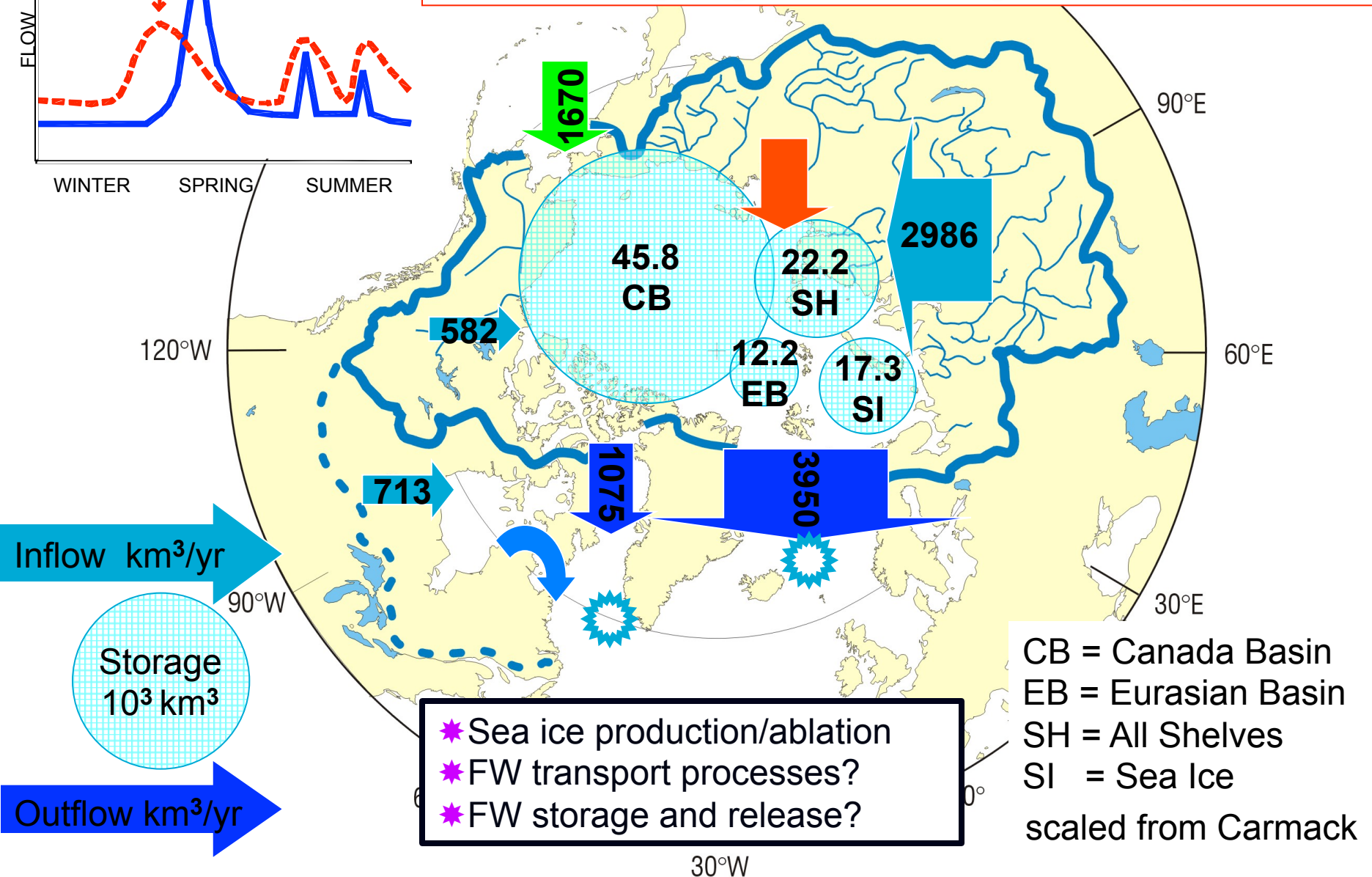
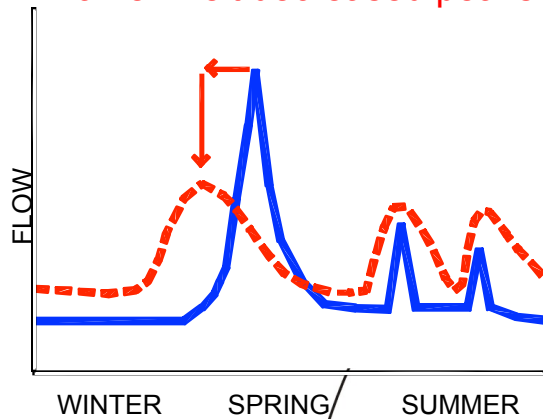
## Activities & Accomplishments

- cliC-sponsored workshop on Cryospheric Controls on the Arctic Freshwater Budget
- Workshop on Changing Lake and River Ice in the High Northern Latitudes
- Participation in Nuuk public conference “Greenland climate – ice dynamics and fresh water”



# Do we need to know the seasonality of FW inputs (as dominated by the cryospheric components)?

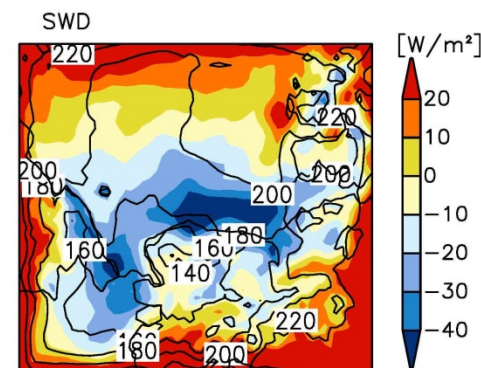
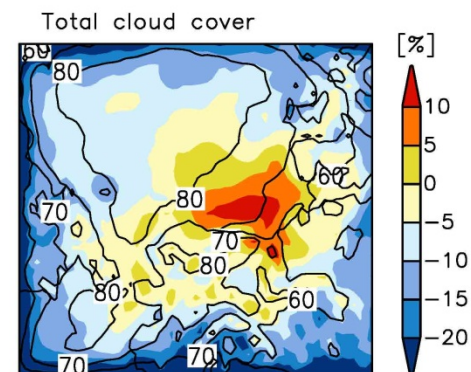
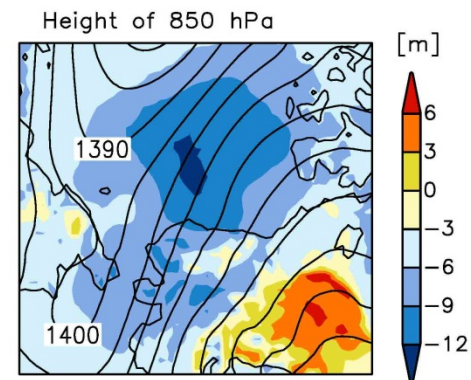
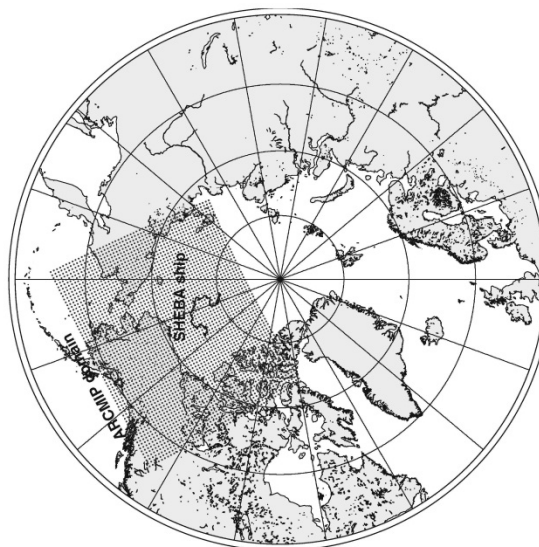
Earlier melt/decreased peaks



# CliC Initiative 3: Regional Climate Modelling

## Activities & Accomplishments

- CliC-cosponsored workshop on “Prediction of Cryosphere”
- Workshop: 21st Century Challenges in Regional-scale Climate Modelling, Lund, Swede.
- Involvement in a second ARCMIP experiment (for a pan-Arctic integration domain)



***A more focused analysis of model intercomparison results aimed specifically at understanding and attributing model biases and shortcomings related to cryosphere***



# COREX (Coordinated Regional climate Downscaling Experiment)

## Polar regions – Participants:

### **Arctic**

Group: University of Colorado - Cassano; Model: WRF, RACM

Group: University of Trier - Heinemann; Model: COSMO

Group: SMHI - Koenigk; Model: RCA, RCAO

Group: Canadian Centre for Climate Modeling & Analysis, University of Victoria - Scinocca;  
Model: CanRCM4

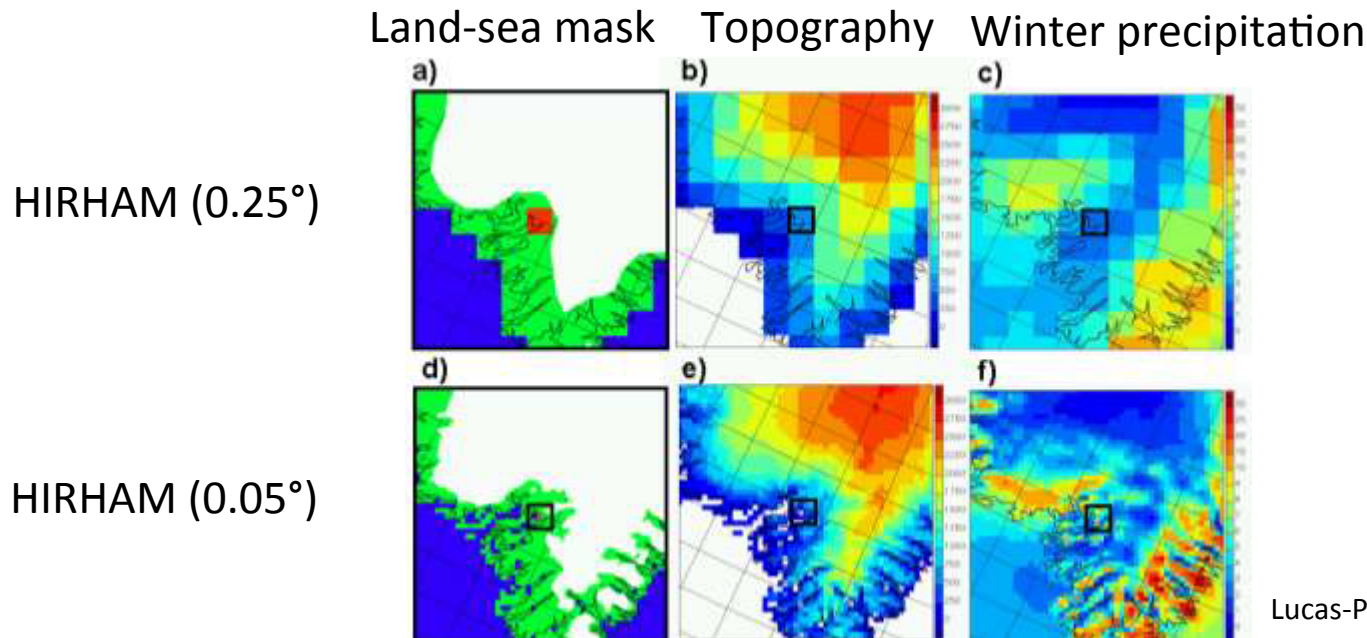
Group: Alfred Wegner Institute - Rinke/Dethloff; Model: HIRHAM, HIRHAM-NAOSIM

### **Antarctic**

Group: New Mexico Tech - Reusch; Model: PolarWRF

# Very high resolution RCM simulation over Greenland

HIRHAM at  $0.05^\circ$  ( $\sim 5$  km) and  $0.25^\circ$  ( $\sim 28$  km) resolution,  
driven by ERA-Interim, 1989-2009

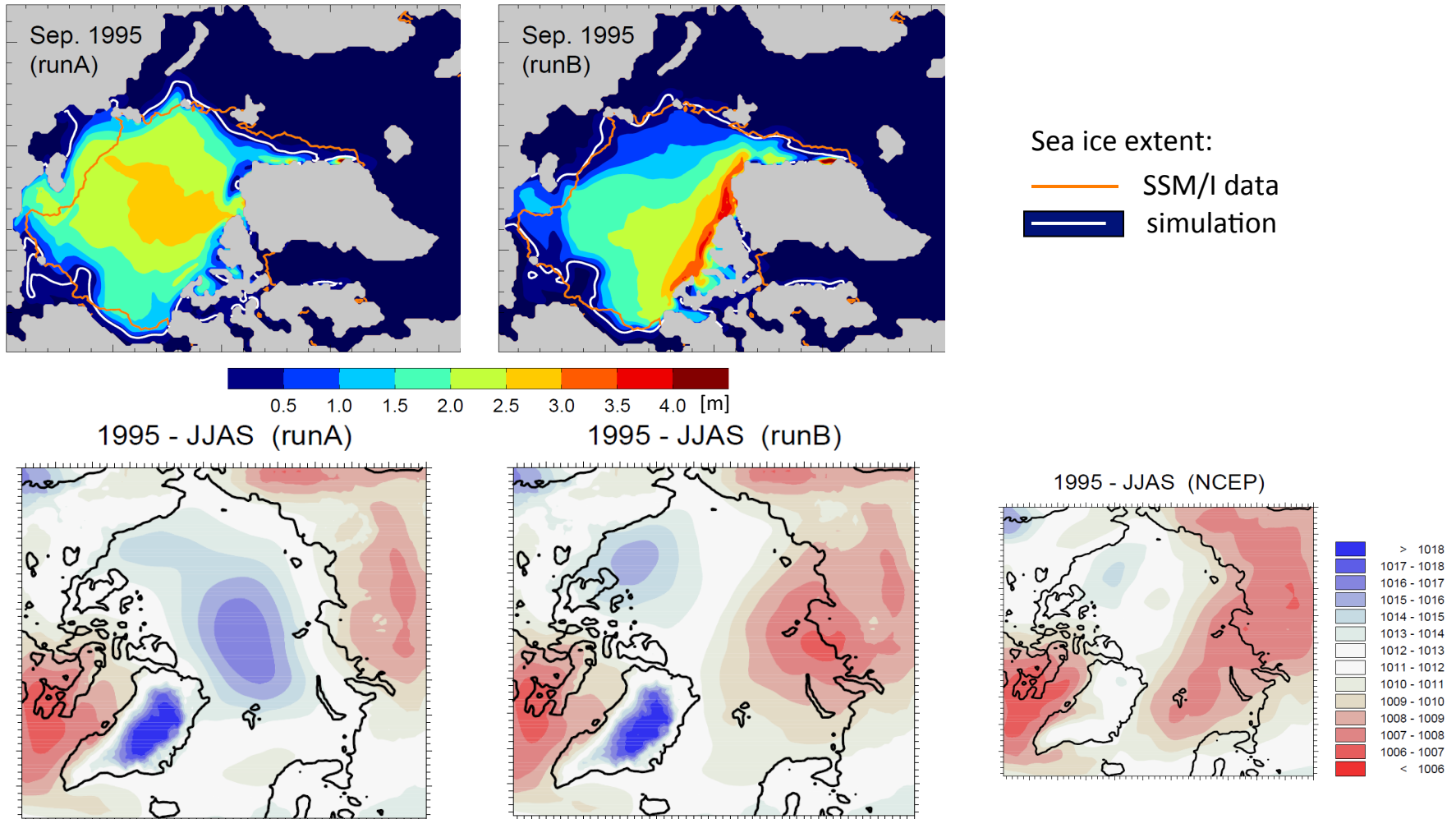


- detailed temperature and precipitation fields → adequate forcing fields for ice sheet models, particularly for their improved simulation of the processes occurring at the steep margins of the ice sheet
- used to force ice-sheet models in ice2sea

# Coupled atmo-ice-ocean RCM simulation over Arctic

HIRHAM-NAOSIM at  $0.5^\circ$  (atmosphere),  $0.25^\circ$  (ocean) resolution ,  
driven by NCEP, 1948-2008,  
ensemble of 7 simulations (different initial ice/ocean state)

Sea ice extent/thickness and mean sea level pressure [hPa], [summer 1995](#)



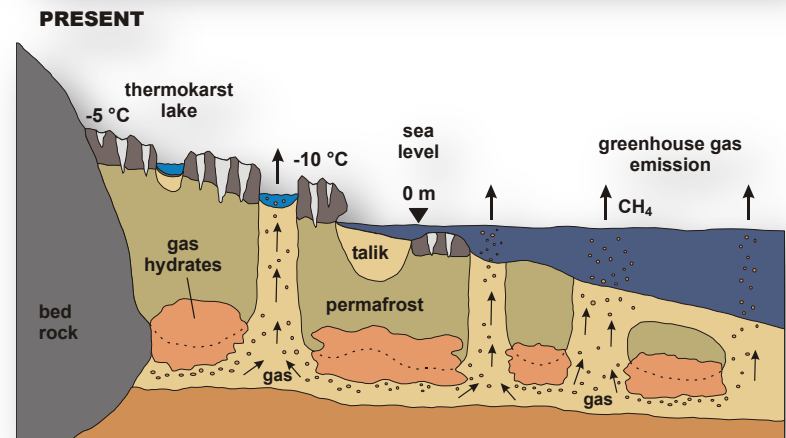
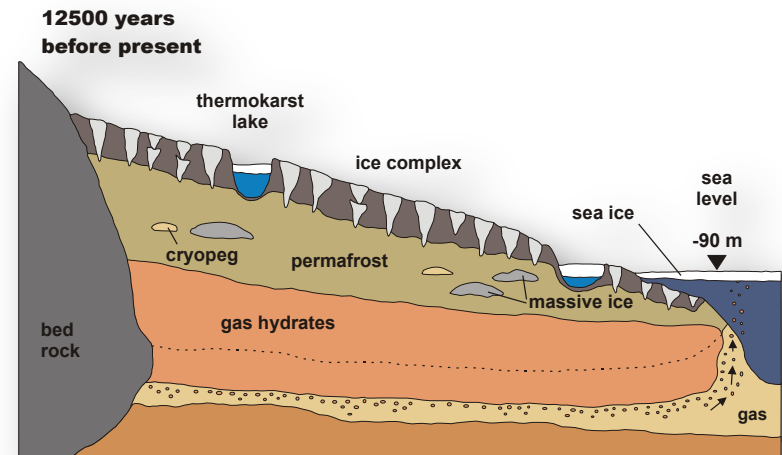


# CliC Initiative 4: Carbon and Permafrost



## Activities & Accomplishments

- CAPER (CARbon and PERmafrost): new joint WCRP-CliC and IGBP-AIMES initiative
- CliC-sponsored 1-day planning workshop for development of CAPER, in conjunction with AIMES and Carbon Pools in Permafrost meeting
- Through CAPER – develop and international coordination role for CliC in data exchange, and observation and modelling efforts



***A focused effort on improving the representation of permafrost and high-latitude land surface, including wetlands, in climate models, with specific emphasis on their role in the global carbon cycle.***

# Working Group on Quantity of Permafrost C pools

## Background and Objectives:

In recent years it has become evident that pools of soil organic carbon (SOC) in periglacial terrain are significantly larger than what has previously been recognized in global estimates of SOC pools. Linking the Northern Circumpolar Soil Carbon Database (NCSCD, 3530 pedons) to a circum-arctic soil map, Tarnocai et al. (2009) estimated SOC stocks in the northern permafrost region to be 1024 Pg for the upper three meters (with Histosols contributing 278 Pg and Cryosols 634 Pg), with an additional 241 Pg stored in deep deltaic deposits and 407 Pg in Yedoma. Estimates of deep cryoturbated soil (1–3 m depth) as well as deep Yedoma and deltaic deposits (>3 m) are identified as particularly uncertain. Based on several different sources, McGuire et al. (2009) consider a likely range of 1400–1850 Pg C for the combined arctic SOC pool in non-peatland soils, peatlands, deep alluvial sediments and Yedoma.

Some of the main challenges that were identified during the Permafrost RCN workshop in Seattle include: an updated and spatially distributed estimate of deep SOC storage (1–3 m), characterizing and quantifying uncertainties in current estimates of SOC storage, developing typical SOC distribution depth profiles for different soil classes and the development of more high-resolution inventories of SOC storage, partitioning and remobilization potential.

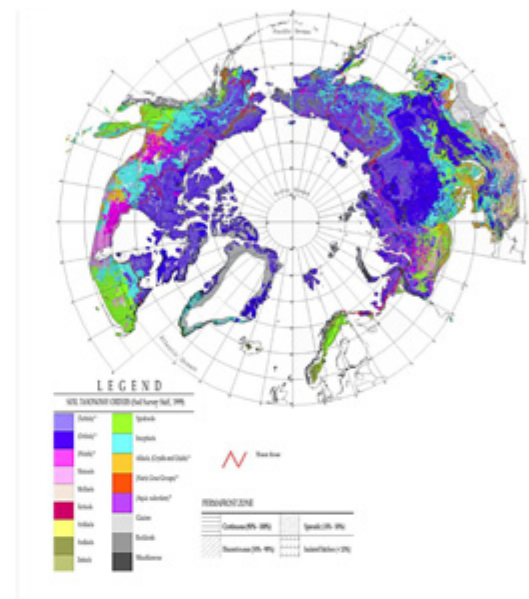
## Citations:

McGuire, A. D., L. G. Anderson, T. R. Christensen, S. Dallimore, L. Guo, D. J. Hayes, M. Heimann, T. D. Lorenson, R. W. Macdonald and N. Roulet (2009). "Sensitivity of the carbon cycle in the Arctic to climate change." *Ecological Monographs* **79**(4): 523-555.

Tarnocai, C., et al. (2009). "Soil organic carbon pools in the northern circumpolar permafrost region." *Global Biogeochemical Cycles* 23.

For more details on this working group send an email to [Gustaf Hugelius](mailto:Gustaf.Hugelius)

back to [activities](#)



Distribution of soils in the northern circumpolar permafrost region based on the NCSCD (Tarnocai et al., unpublished data, 2007). Source: Tarnocai et al. 2009



Cryoturbated soil, Cherskii, Russia (photo by Gustaf Hugelius)



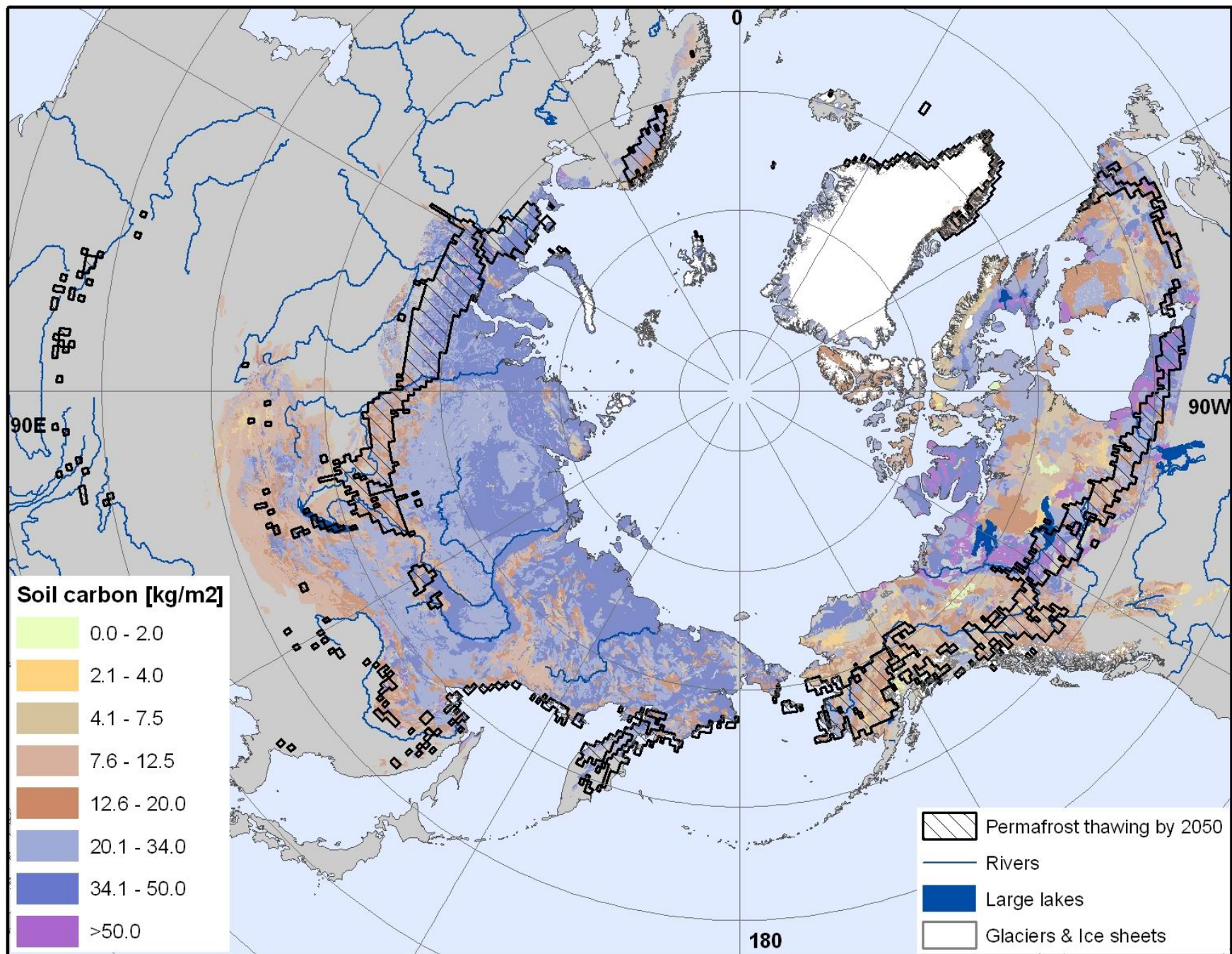
# Global Carbon Pools

Global Vegetation C	650 Pg
Global Soil C (1m)	1500 Pg
Atmosphere	777 Pg

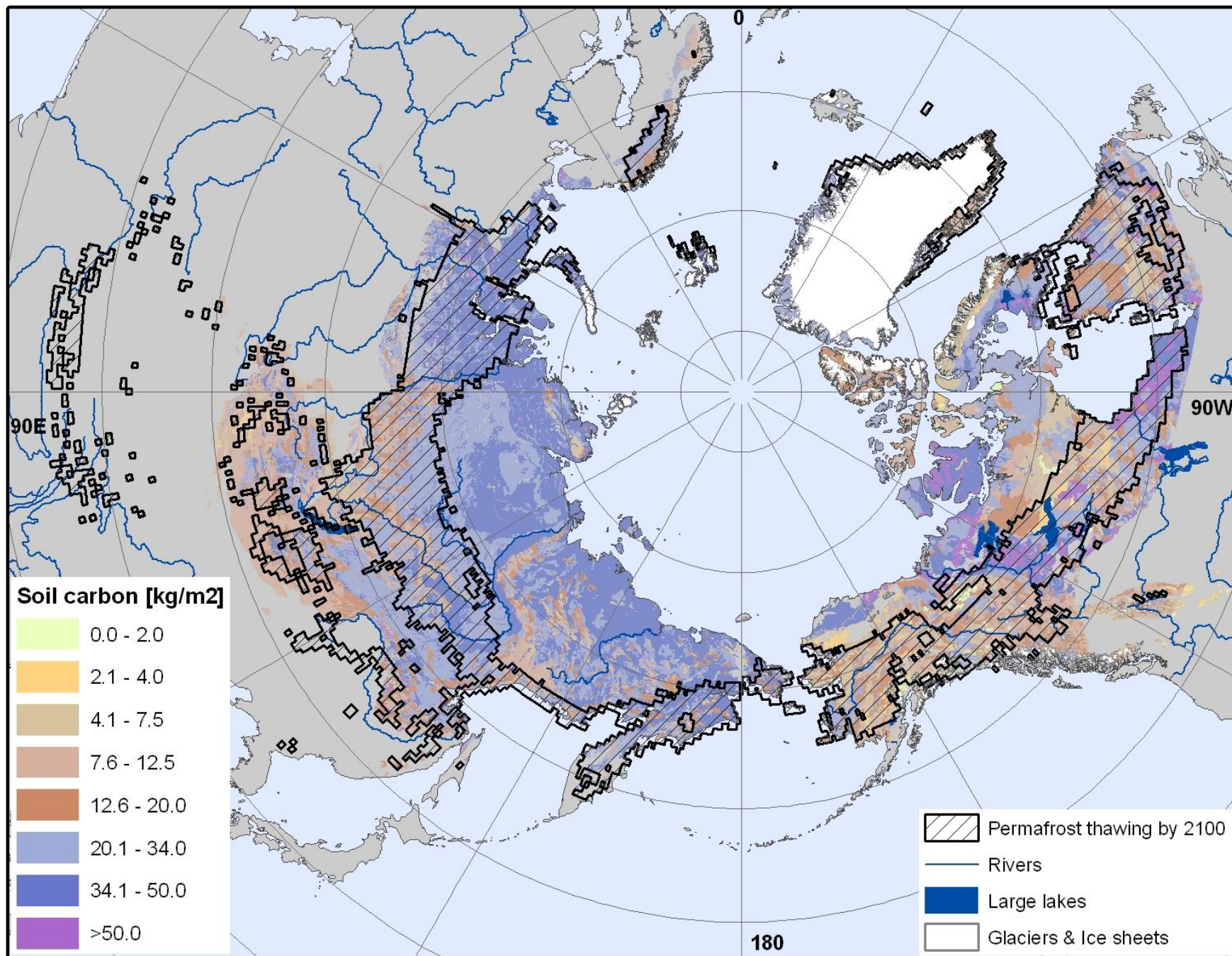
## Permafrost Zone Soil C

Peatlands (several m)	277 Pg
Mineral Soil (3m)	747 Pg
Siberian Deep C (~25m)	407 Pg
____ Alluvial Deep C (~25m) _____	241 Pg
1672 Pg	











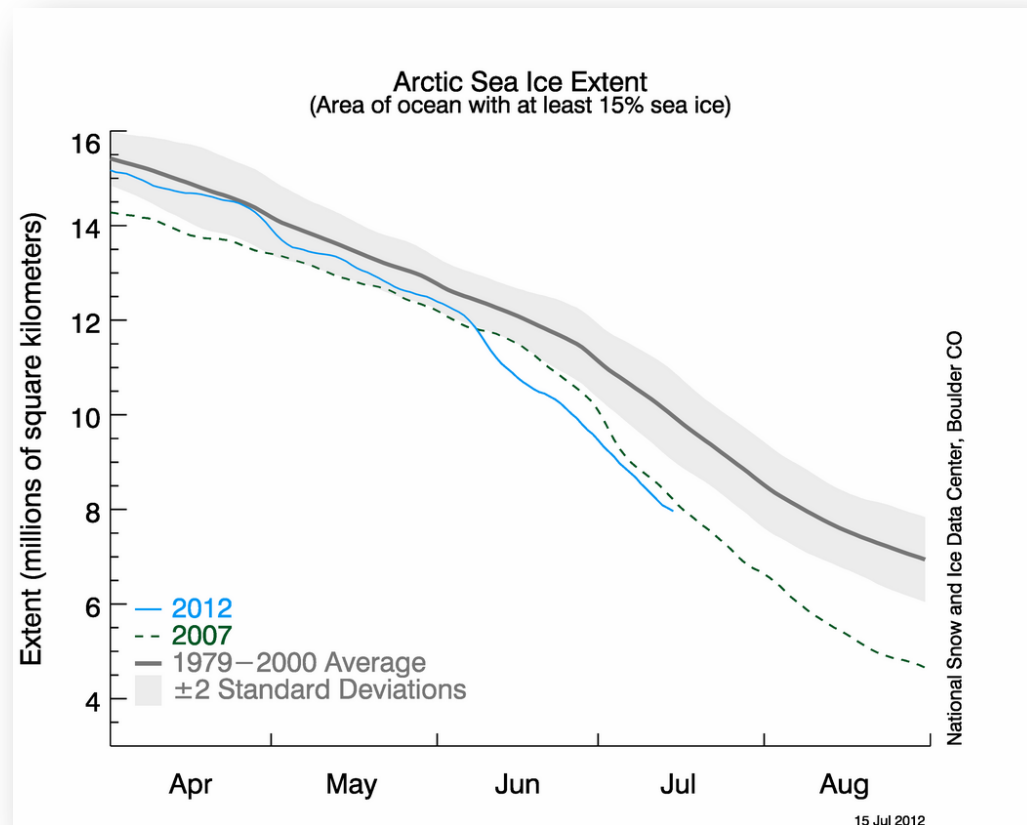
## Permafrost thawing on gentle slope



# CliC Initiative 5: Climate Feedbacks from Changes in Arctic and Antarctic Sea ice

## Activities & Accomplishments

- Established a CliC Arctic sea ice panel within the Marine Cryosphere program
- CliC-sponsored workshop on Arctic surface-based sea ice observations
- CliC-sponsored workshop on satellite algorithm inter-comparison, March 2011.
- Sea Ice Working Group Meetings, 2012

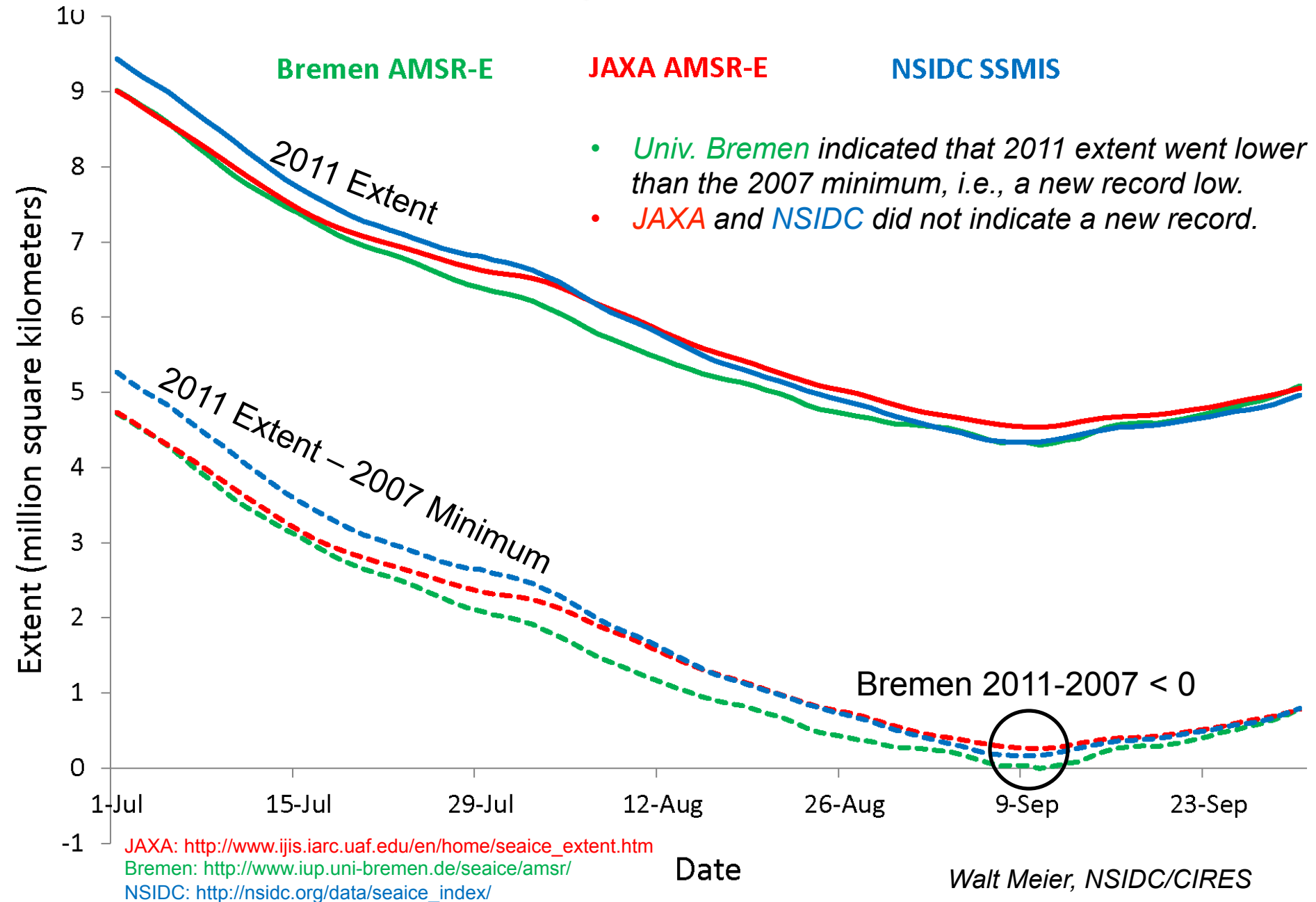


***A coordinated focus on seasonal, interannual and longer-term predictions and projections of polar climate and the role of cryosphere in climate predictability.***

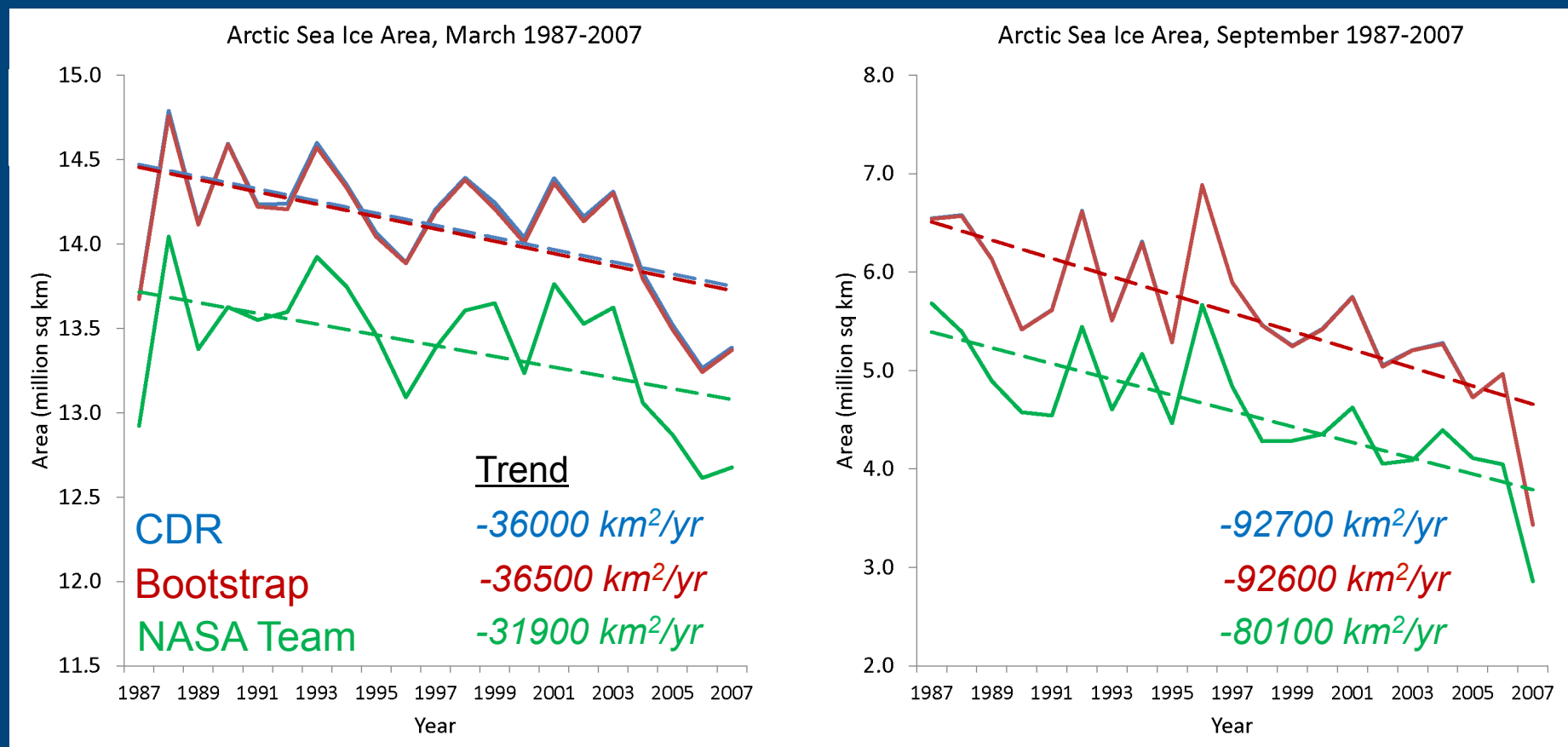




# 2011 Extend and Comparison with 2007 Record Low

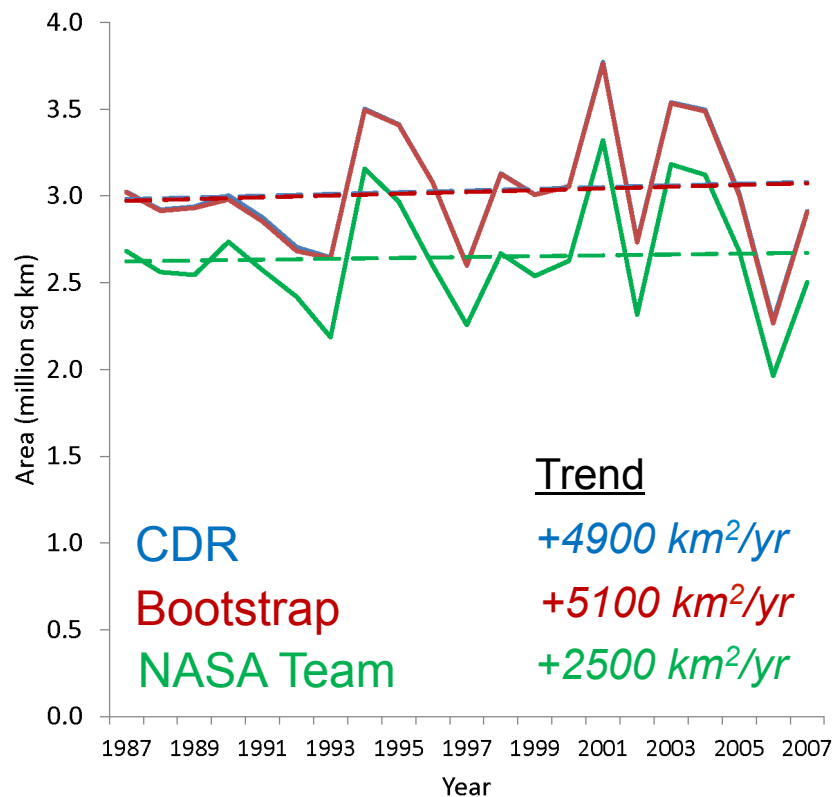


# 1987-2007 Arctic monthly sea ice area

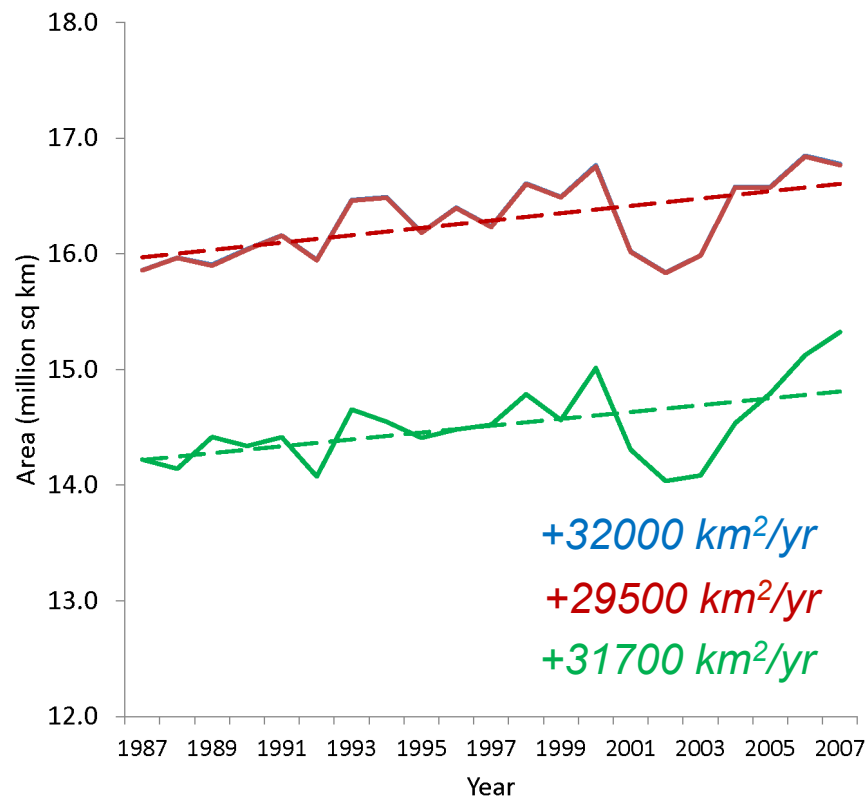


# 1987-2007 Antarctic monthly sea ice area

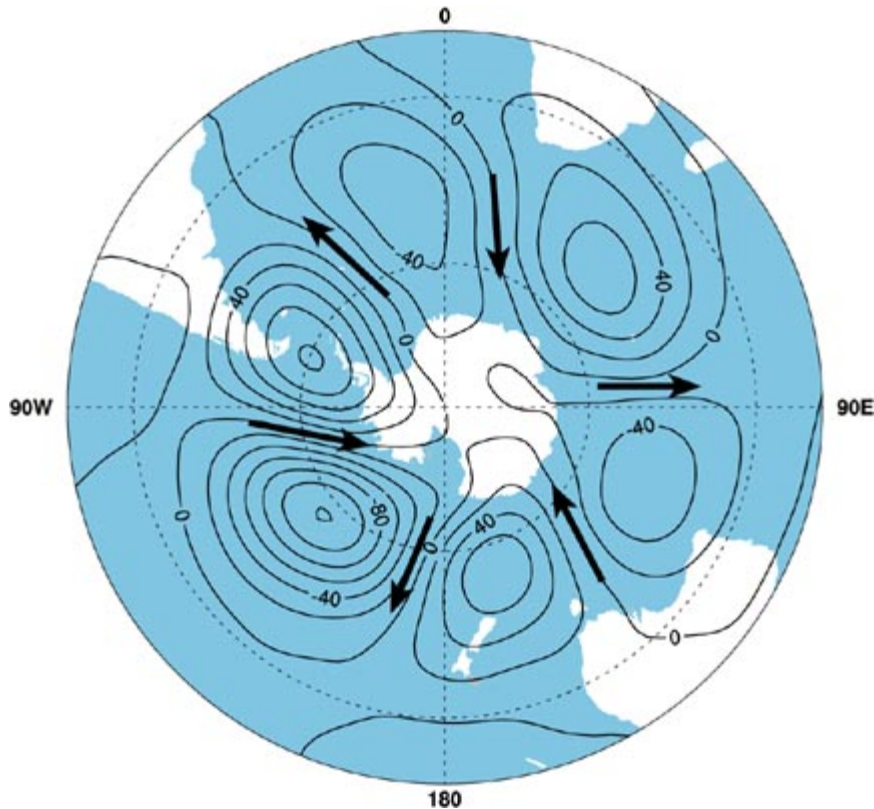
Antarctic Sea Ice Area, March 1987-2007



Antarctic Sea Ice Area, September 1987-2007



# Influence of Zonal Wave Three of the Circulation

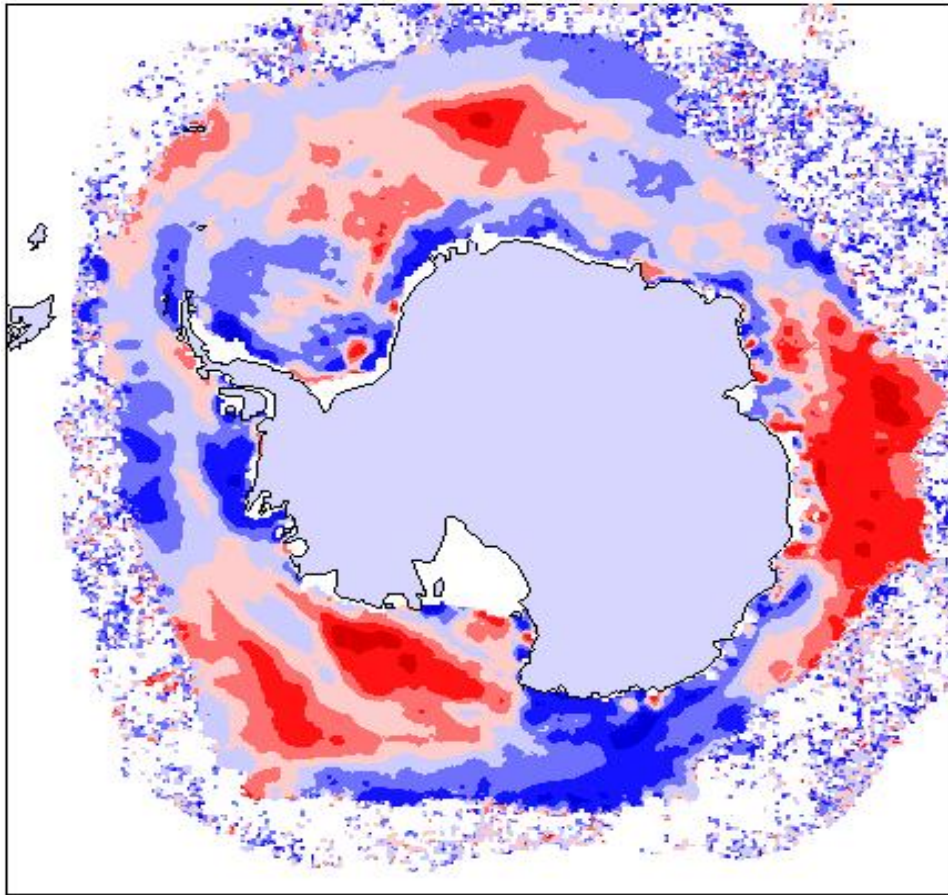


- Preferred regions of equatorward and poleward flow. Equatorward flow would bring colder air and poleward flow, warmer.
- Has the potential to influence the Antarctic sea-ice region by influencing the meridional transport of heat in the atmosphere and ocean.

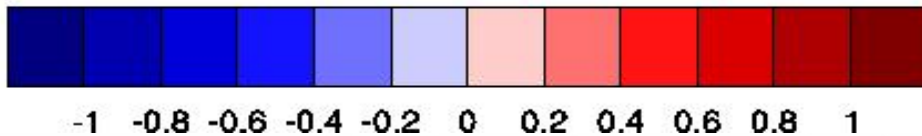
*Raphael, 2004*



# Correlation of ZW3 Index and Sea-Ice Concentration



- Wave 3 pattern of correlation of up to 0.6.
- Positive ZW3 index is associated with larger SIC in Ross Sea, Eastern Weddell Sea and in Eastern Antarctica.
- Positive ZW3 index is associated with smaller SIC in Bellingshausen and Amundsen Seas and around the Antarctic peninsula.
- SIC – sea ice concentration



# Long-Term Objectives

**Cryosphere in A changing climate:**

**A Grand Challenge of Climate Science (Kattsiv et al.)**

- Enabling prediction of the Arctic climate system;
- Enabling prediction of the Antarctic climate system;
- Enabling prediction of terrestrial cryosphere; and
- Enabling improved assessment of the past, current and future sea-level variability and change.





# Priorities and Challenges

1. Global sea level: Response of ice sheets and glaciers to climate variability, including ice sheet processes and dynamic modeling ([Koni Steffen](#), [Gino Casassa](#), [Helmut Rott](#), & new members)
2. Polar Climate Predictability (as part of a WCRP initiative based on the outcomes of the Toronto Workshop, WCRP: SPARC+CLiC ([Annette Rinke](#)))
3. Cryospheric inputs to the Arctic and Southern Ocean freshwater budgets ([Tbt](#))
4. The role of carbon and permafrost in the climate system (CAPER, WCRP/CLiC & IGBP/AIMES) ([Vladimir Romanovsky](#))
5. Sea-ice: observations, modelling and data products, endorsements of a community sea-ice concentration and ice extent product ([Walt Meier](#), [Marilyn Raphael](#))
6. Changes in mountain cryosphere and water resources, via regional activities (Asia – CLiC, South America) ([Helmut Rott](#), [Gino Casassa](#))
6. Global snow cover, past observed changes and variability, prediction for the future ([proposed new priority](#))

Cryosphere Grand Challenge: 1,2,4,5



# Potential Gaps

**Sea level rise of ice sheets triggered by ocean interaction** (50% of ice loss in Greenland, larger in Antarctica)

- Need better collaboration with ocean community in polar regions, both hemispheres → Ice/Ocean Initiative
- Regional sea level rise emerging issue

**Dynamic response of ice sheets in a warming climate**

- SCAR-IASC-WCRP/CliC collaboration on ISMASS
- Proposal for WS-support to ICSU, submitted in December 2011

**Global Snow Cover – combine observations and modeling**

- Albedo feedback
- Water resources
- Regional trends and variability

ISMASS – Antarctic ice sheet mass balance and sea level



# Capacity Building South America

## CliC sponsored 4 workshops in 2011



Meeting Latin American Snow and Ice Working Group  
14-18 November 2011, , Mérida, Venezuela

# South America 2011 Activities

## 1. USA-Chile Glacier Mass Balance Workshop , 23-25 August 2011, Valdivia, Chile

CECs  
CENTRO  
DE ESTUDIOS  
CIENTÍFICOS



**Monday, October 3, 2011**

University at Albany Department of Atmospheric and Environmental Sciences, Assistant Professor Mathias Vuille, has received a \$990K grant from the US State Department's Bureau of Western Hemisphere Affairs, to study the impacts of climate change and glacier retreat in Colombia, Ecuador, Peru and Chile.

## 2. UNESCO IHP – Ministry of Foreign Affairs Chile Melting of Snow and Glaciers: Science, Technology and Politics to Face the Challenges of the Andean Region in the Context of Climate Change, Santiago, Chile, 13-15 September 2011



Ministry of the Flemish Community  
Science and Innovation Administration



UNESCO-PHI willing to consider an ice-water centre in the Andes  
G.Casassa gave a key talk



# South America 2011 Activities

## 3. **Regional Meeting Strategic Initiative on the Impacts of Climate Change, Adaptation and Development in the Mountain Regions Santiago, Chile, FAO, 25 – 28 October 2011**



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS



*G.Casassa et al. presented a background paper*

## 4. **10th Meeting Latin American Snow and Ice Working Group UNESCO IHP 14-18 November 2011, , Mérida, Venezuela**



# Name Branding



ETH-Zürich and EPLF-Lausanne Faculty Chair: Climate and Cryosphere

# Climate and Cryosphere