WCRP
World Climate Research Programme

Climate Research, Monitoring, and Snow: yes and now

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SSO, JPS for WCRP

Beyond scope: huge societal value and impact of snow and its changes: local life support, transport, ecology, resources exploration and production, health, biodiversity, etc.

Outline

1. Relevant developments in WCRP and other programmes interested in snow research and data (the longest part)
2. Snow in changing climate
3. Snow and long-range prediction
4. Conclusions

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

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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
- Regional climate prediction
- Reprocessing leading to reanalysis (of climate system)

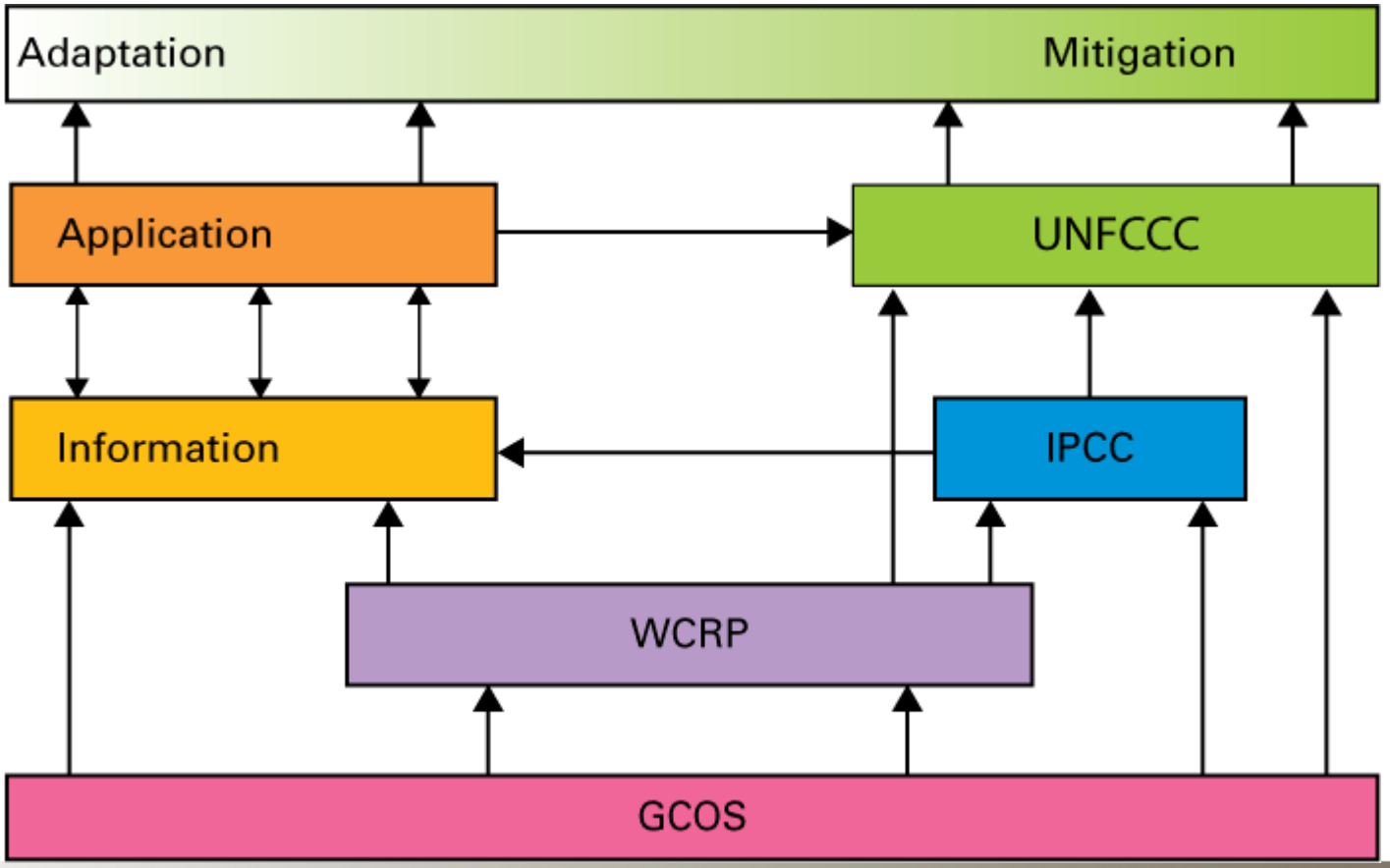
CHFP

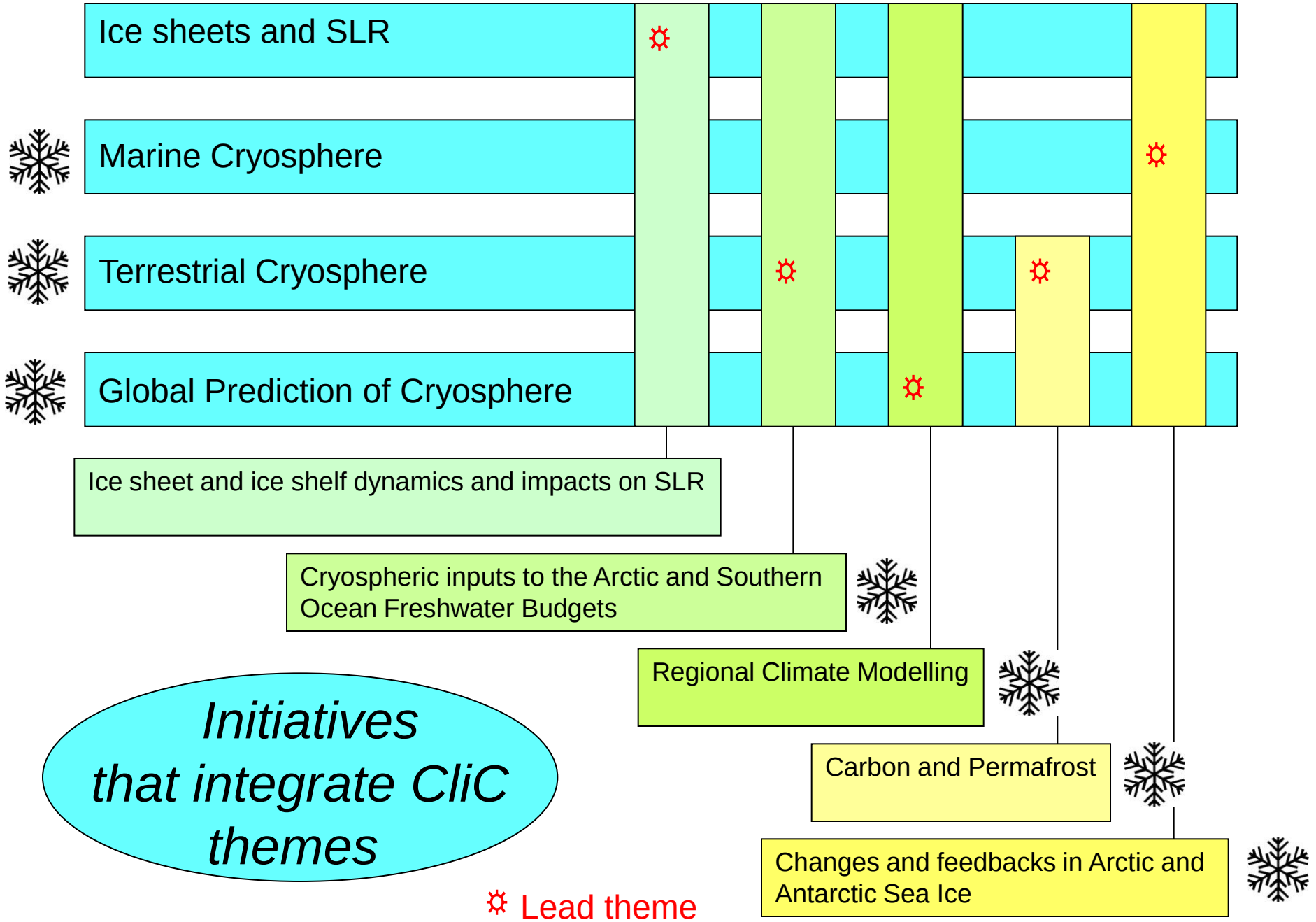
GLACE-2

ARCMIP
AOMIP
Coupled ARCMIP

CORDEX

Global Framework for Climate Services

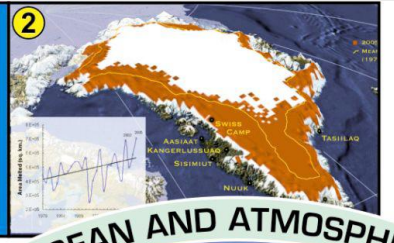


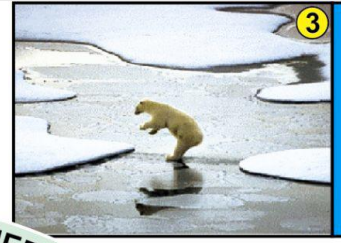

Ice sheets and SLR
Marine Cryosphere
Terrestrial Cryosphere
Global Prediction of Cryosphere
Ice sheet and ice shelf dynamics and impacts on SLR
Cryospheric inputs to the Arctic and Southern Ocean Freshwater Budgets
Regional Climate Modelling
Carbon and Permafrost
Changes and feedbacks in Arctic and Antarctic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

ICARP 2

SNOW COVER
Melting and retreating increases radiation absorption; a radiative feedback. Also large impacts on snow-based wildlife

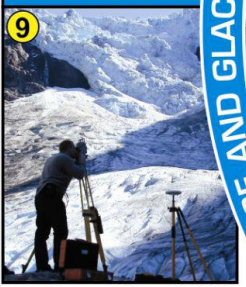
ICE SHEET
Melting of large ice sheets contributes to sea level rise and freshwater flux with potential effects on thermohaline circulation and global climate





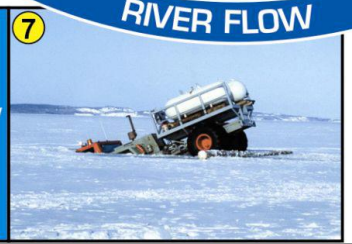
SEA ICE
Retreating sea ice contributes to increased radiative absorption and the loss of habitat for mammals such as polar bears and seals

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



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

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.

PERMAFROST
Thawing permafrost changes geomorphic/ geochemical processes and fluxes. Impact example: changes to flow systems and aquatic ecology

Chapters under national review

SWIPA

Predictions using WCRP CMIP3

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

Arctic System Reanalysis

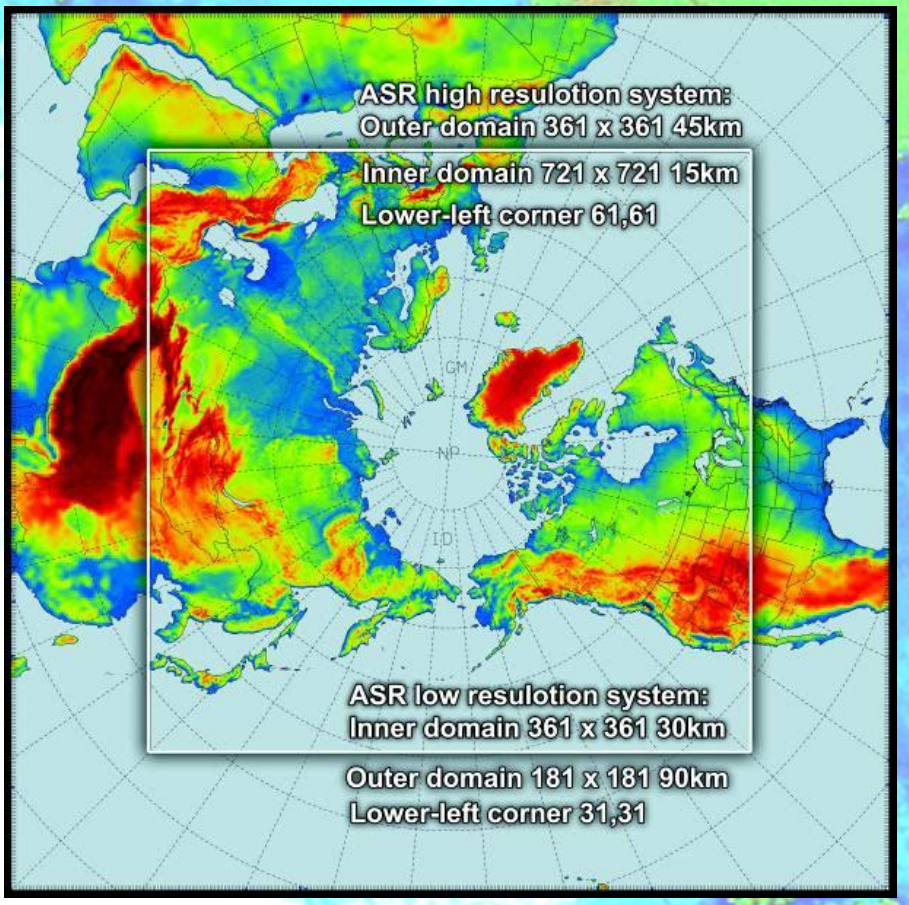
- Regional Reanalysis of the Arctic Atmosphere/Ocean/Land System

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

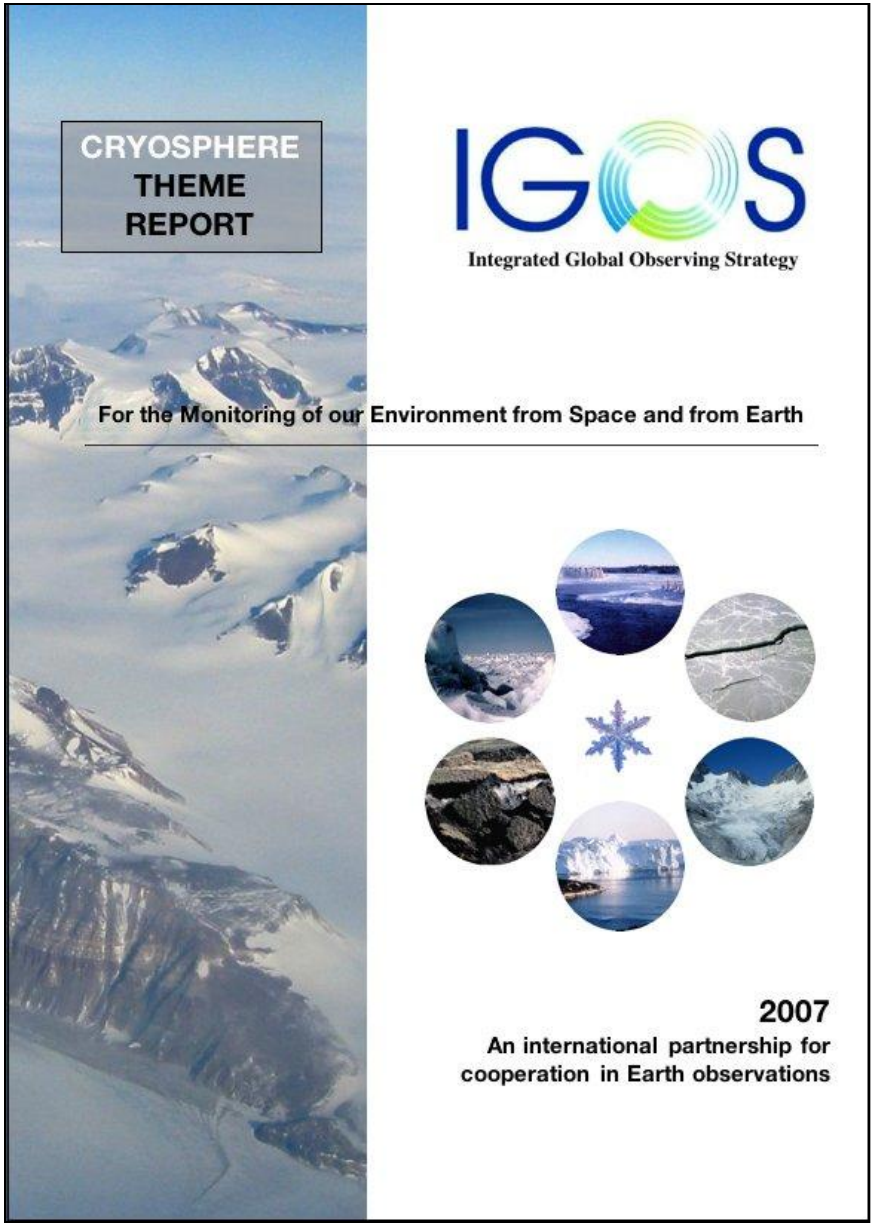
- Time – 2000 to 2010

- Satellite Radiance Assimilation

- Supported by NSF as an IPY Project



Courtesy: Dave Bromwich



The Report

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

http://igos-cryosphere.org

Global Cryosphere Watch-a WMO Initiative

- ***A legacy of IPY***
- ***A component of WIGOS***
- ***A legacy of WCRP/CliC in the area of observations***
- ***A contribution to GCOS & GEOSS***

- Scoping document accepted by WMO Executive Council in June 2009.
- Recommended initial actions :
  - **Develop/refine observing standards**, both with WMO CIMO (Commission on Instruments and Methods of Observation) and with GCOS
  - **Initiate a CryoNet** as part of CryOS implementation (IGOS/GEO)
  - **Develop pilot projects:**
    - **for each cryosphere component**;
    - with research groups and World Data Centres (e.g., NSIDC, **ESA's "Glob" projects**)
    - …
  - …
- The Council requested the preparation of a **GCW implementation strategy** for consideration by the WMO Congress in 2011.

Open for review: 2010 Update of the GCOS Implementation Plan in support of the UNFCCC

Solid precipitation and snow are dealt with in the Terrestrial Domain

- **Action T13:** Strengthen and maintain existing snow-cover, snowfall observing sites; ensure that sites exchange snow data internationally, and establish global monitoring of that data on the GTS; recover historical data.
- **Who:** National Meteorological and Hydrological Services and research agencies, in cooperation with WMO and WCRP, with advice from TOPC and AOPC and GTN-H.

- **Action T14:** Obtain integrated analyses of snow cover over both hemispheres.
- **Who:** Space agencies and research agencies in cooperation with CliC, with advice from TOPC, AOPC and IACS

ECV: Snow Cover

Deadline for Review: 31 Jan 2010

IPY
2007
2008

IPY Sub-Committee on Observations has developed a draft roadmap towards IPY observing systems legacy.

Main observing initiatives contributing to the creation of an IPY Legacy:

- Sustaining Arctic Observing Networks (SAON),
- Integrated Arctic Ocean Observing System (iAOOS), and Arctic-HYCOS as parts of SAON,
- Pan-Antarctic Observing System (PAntOS),
- Southern Ocean Observing System (SOOS) as part of PAntOS,
- The Global Cryosphere Watch (GCW),
- Polar Satellite Constellation (PSC),
- Polar Regional Climate Outlook Forum (PCOF)

International Polar Decade is considered

WMO
OMM

Snow Role in Climate System

A very sophisticated picture:

- Multiple feedbacks and impacts (through albedo, roughness, insulation of surface and at the same time active chemical interaction, permeability for water, impacts on hydrology hence on the Arctic Ocean, vegetation hence on carbon balance, etc.)…

- Some relatively new results – role of BC

  O (Forcing by BC over N. Eurasia) = O (Forcing by GHG)

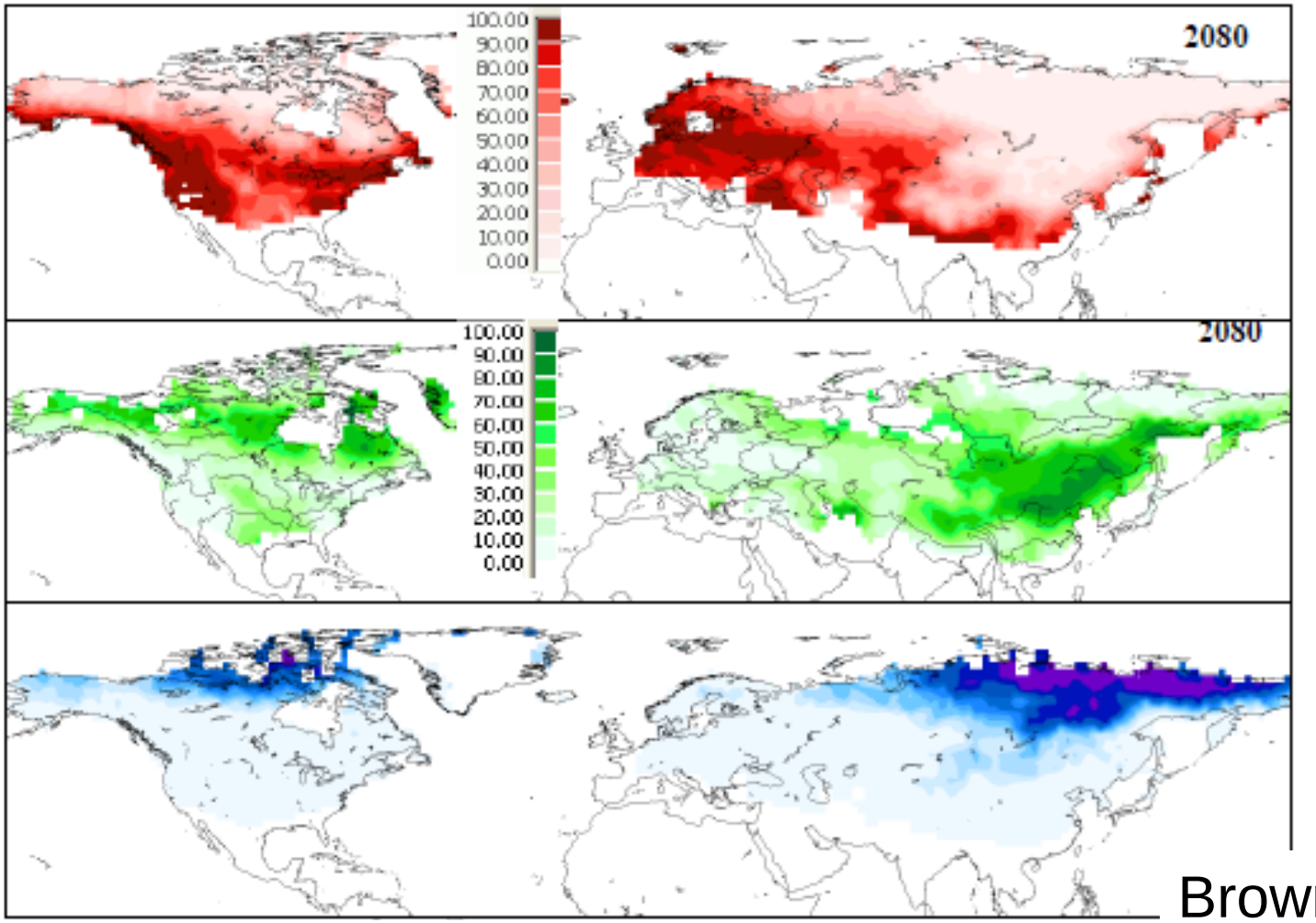
  BC changes in ppbs <–> snow albedo change by %s

Snow Trends

A non-uniform picture:

- Snow cover largely decreasing
- SWE and Depth –
  various trends, including tendencies of increase in NE and decreases over Canada
- Duration, onset, snow-off – various trends, mostly negative
- Cold season precipitation –
  largely increasing trends with regional dependence
- Snow properties, stratigraphy –
  signs of increased bottom layer hardness and moisture
- Rain on snow, mid-winter thaw – dangerous events

Snow Projections



CMIP3 SWE

Decreases

No Changes

Increases

Brown, Motte, 2009

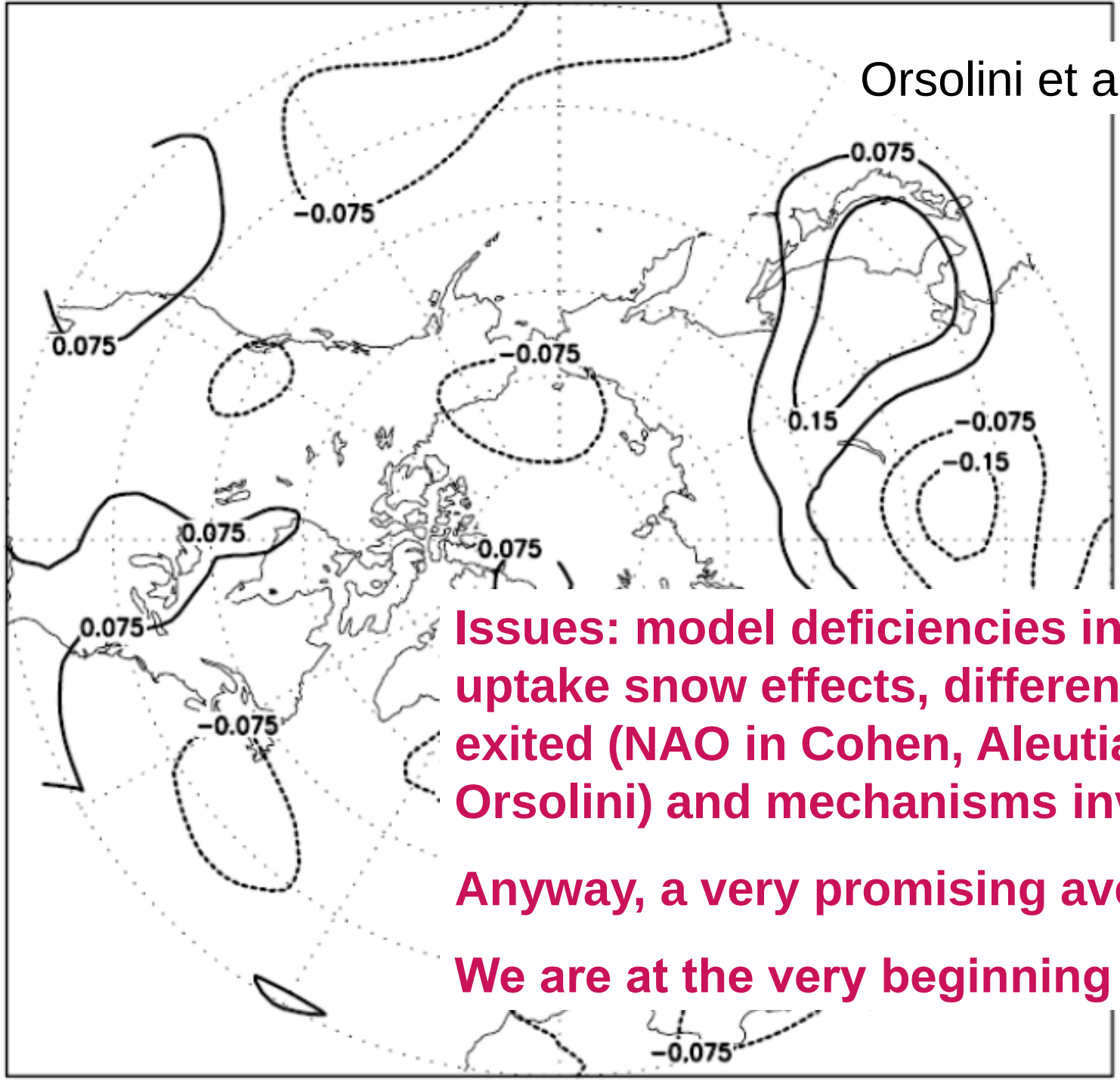
Snow and River Runoff

Snow Melt -> up to ¾ annual transport in high-latitude rivers

Arctic:
likely changes towards more uniform runoff throughout a year, with a multitude of attendant changes, likely increased (up to 50% runoff to the Arctic ocean

Alps:
Higher snow line (by 900 m by 2071-2100).
more or less robust conclusion: spring melt, higher peaks on runoff (tendency for flooding) but less annula volume – water shortage (Bavay et al., 2009)

Orsolini et al., 2008



Issues: model deficiencies in how their uptake snow effects, different modes exited (NAO in Cohen, Aleutian Low in Orsolini) and mechanisms involved

Anyway, a very promising avenue

We are at the very beginning here…

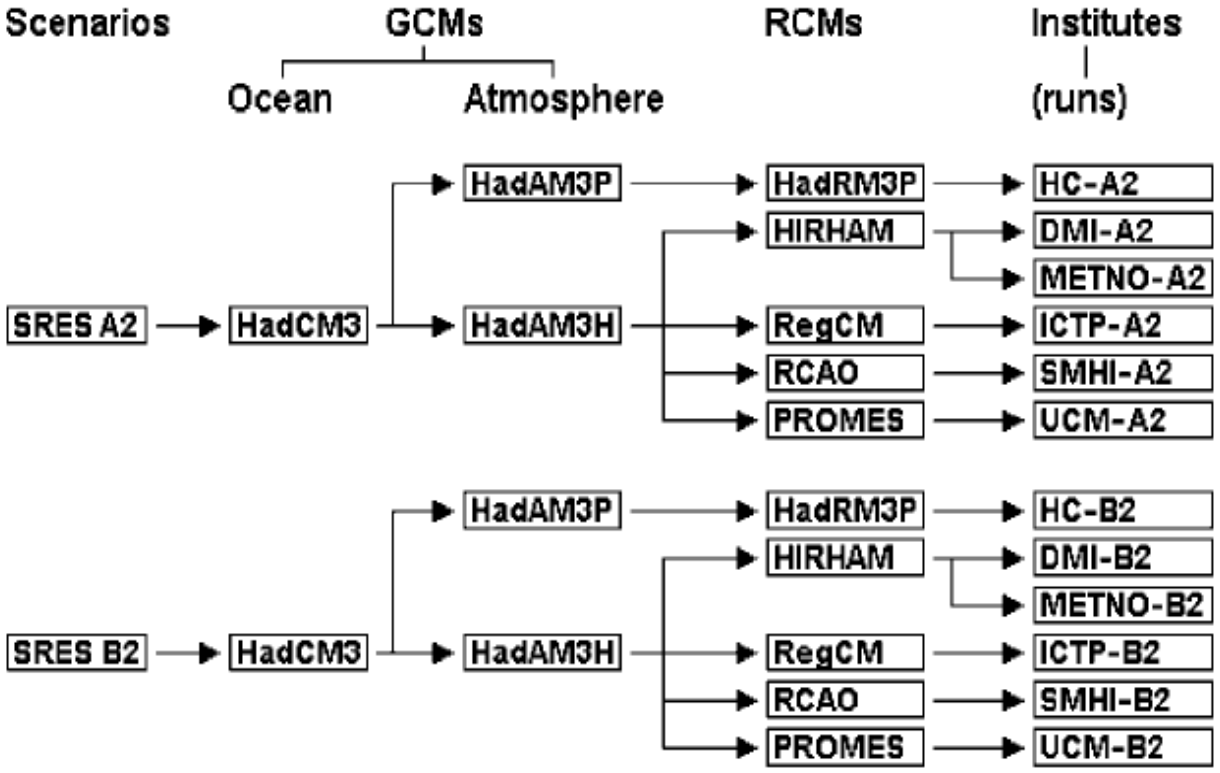
Snow Modelling

- Different types of surface – tiles, fractional snow cower
- Multi scales
- Blowing snow model, sublimation (+ combined effect)
- Need for multi-layered snow models
- Comprehensive radiation code with ray tracing, exposure
- Comprehensive model for albedo (highly time, BC and history dependent)
- Vegetation, various heights, plant bending
- Hydrology incorporated

SNOWMIP2, IP3, other campaigns

Atmospheric Modelling for Snow

- A variety of biases in dynamics and physics:
  (too zonal flow, multiple issues in surface layer especially with the inversion, no blowing snow, etc., etc.
- Too simple snow and snowfall modules/schemes
- Weak calibration
- Downscaling – multiple issues



(Bavay et al., 2009)

(Unsure) conclusions/proposals

- Comment on GCOS IP (before 31 Jan 2010)!
- Develop and promote integrated snow cover datasets, it is GlobSnow
- Only combined analysis of information will work for climate (re-) analysis (eg precipitation, snow and hydrology), in-situ and remote sensing
- Climate services and adaptation will require more snow characteristics, eg crust
- In situ snow observations host of problems overlooked, no measures of uncertainty, no adequate metadata on observing system development and impact of automation, weak standardisation
- Multi-variate snow DAS – priority for R&D
- Propose GTN-S (Snow)?