A review of the WCRP Climate and Cryosphere project, GCOS and IGOS Theme on Cryosphere requirements for

Barry Goodison (Chair WCRP/ CliC) and
Vladimir Ryabinin (Joint Planning Staff for WCRP)

WCRP World Climate Research Programme

WMO of UNESCO ICSU

World Climate Research Programme (WCRP)
http://wcrp.wmo.int

Objectives

- To determine the predictability of climate
- To determine the effect of human activities on climate

GEWEX 1988 → SPARC 1992→ CLIVAR 1995 → CliC 2000 →

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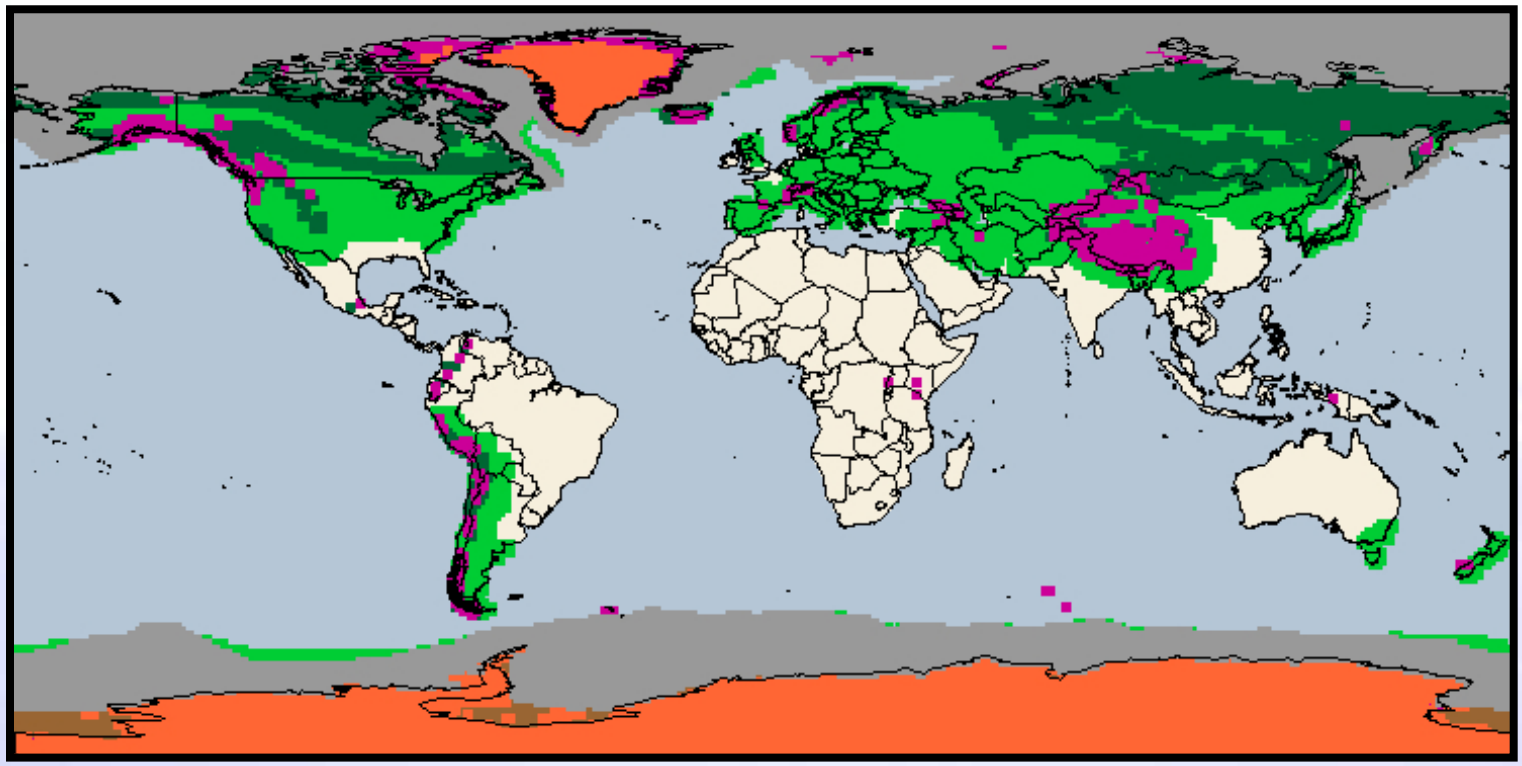
Global Cryosphere by Type



Glacier | Ice Sheets | Ice Shelves

Sea Ice | Permafrost | Snow Cover

• Foster D.J. and Davy R.D., 1988: Global snow depth climatology, USAF Environmental Technical Applications Center, Note TN-88/006, 49 pp.

• Cogley, J.G., 2003: GGHYDRO – Global Hydrographic Data, Release 2.3, Trend Technical Note 2003-1, 11 pp.

CliC Themes

The Terrestrial Cryosphere and Hydroclimatology of Cold Regions

snow on land

What are the magnitudes, patterns and rates of change in terrestrial cryosphere regimes on seasonal to century timescales? What are the associated changes in the water cycle?

Outputs:

- **Daily/monthly hydrological and climate (eg water cycle) products for cold regions.**
- **Establishment of CliC 'Super Study Sites' for process studies and model validation.**
- **Advanced and validated remote sensing algorithms.**
- **Improved radiative transfer and surface process models for cryospheric regions.**
- **Enhanced information for water resource management.**
- **Estimation of carbon emissions from permafrost and frozen ground regions.**
- **Prediction of changes in the cryosphere that will have socio-economic impacts.**

Ice Masses and Sea Level - snow on ice sheets

The Marine Cryosphere and Climate - snow on sea ice

Global Predictions and/of the Cryosphere

Where the climate science has to deliver

Long-term prediction:

MRF -> Seasons -> Decades

Anthropogenic climate change (ACC):

Scenario based projections

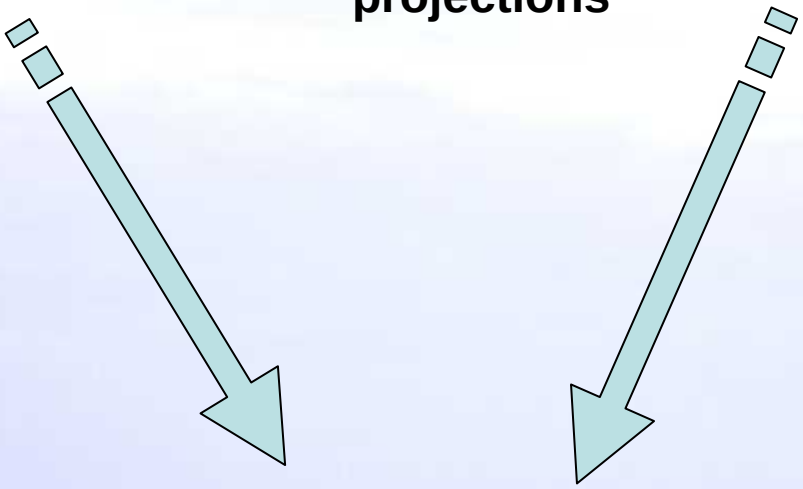
Impact assessment

Adaptation

Mitigation

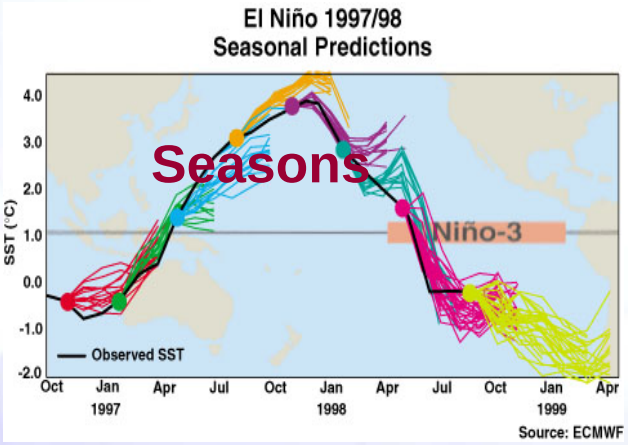
Nairobi WP

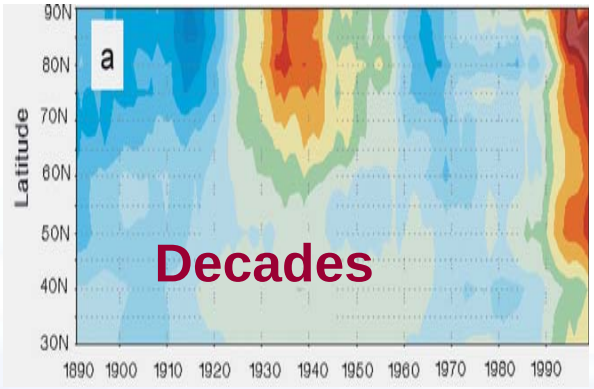
Post-Kyoto

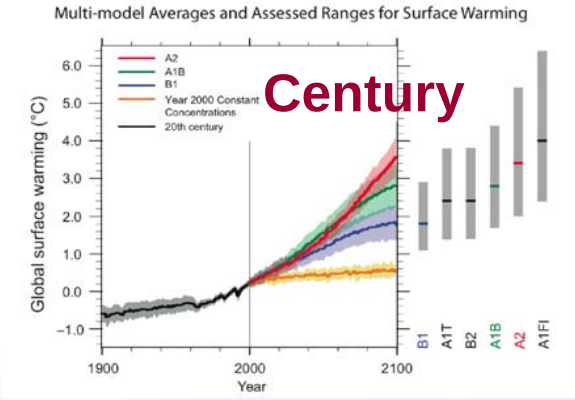


Applications, products: many,
e.g. climate system ReAnalysis, hydrological forecasts, etc.

Challenge in terms of time scales in climate prediction







Initial value problem. Applications on the rise.

Predominantly "physical" domain, upper ocean crucial, El Nino-based.

Hard: combines the challenges of the two previous scales. Predictability not yet there.

Scope: closer to Earth System, but mostly physics with deeper ocean
+ some BGC

Forcing by emissions. Initial conditions not so crucial.
IPCC AR4: "Climate change unequivocal."

Scope: Earth System including human dimensions.

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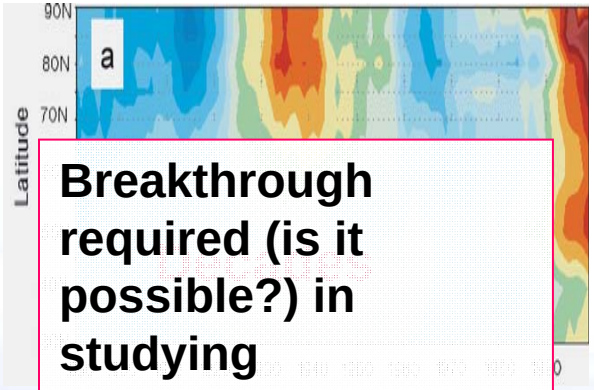
Challenge in terms of time scales in climate prediction

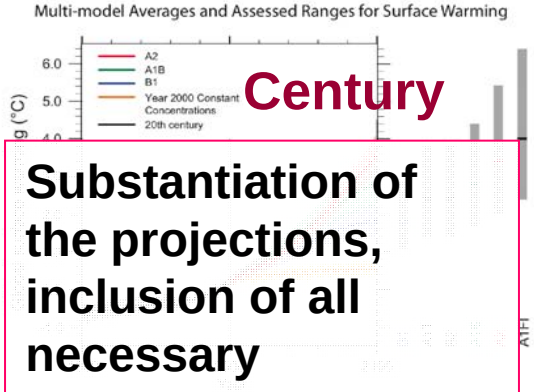
Seasons

Operationalisation, turning bits and pieces of knowledge and skill into a global system, creating quasi-operational environment similar to the one of NWP but going beyond the traditional meteorological domain, looking for more <u>sources of predictability</u>



Breakthrough required (is it possible?) in studying predictability on decadal scales and of regional modes of atmospheric circulation

Scope: closer to Earth System, but mostly physics with deeper ocean
+ some BGC



Century

Substantiation of the projections, inclusion of all necessary feedbacks, full carbon cycle, improvement of <u>representation of the water and energy balance</u> in climate models. Approach: global projections + <u>regional interpretation</u>

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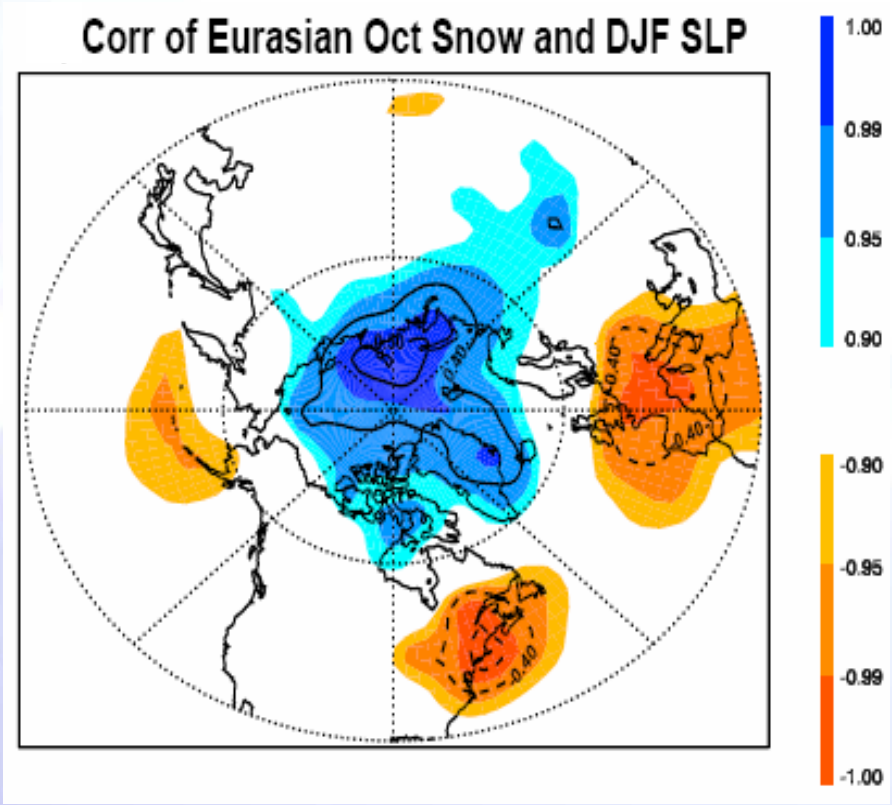
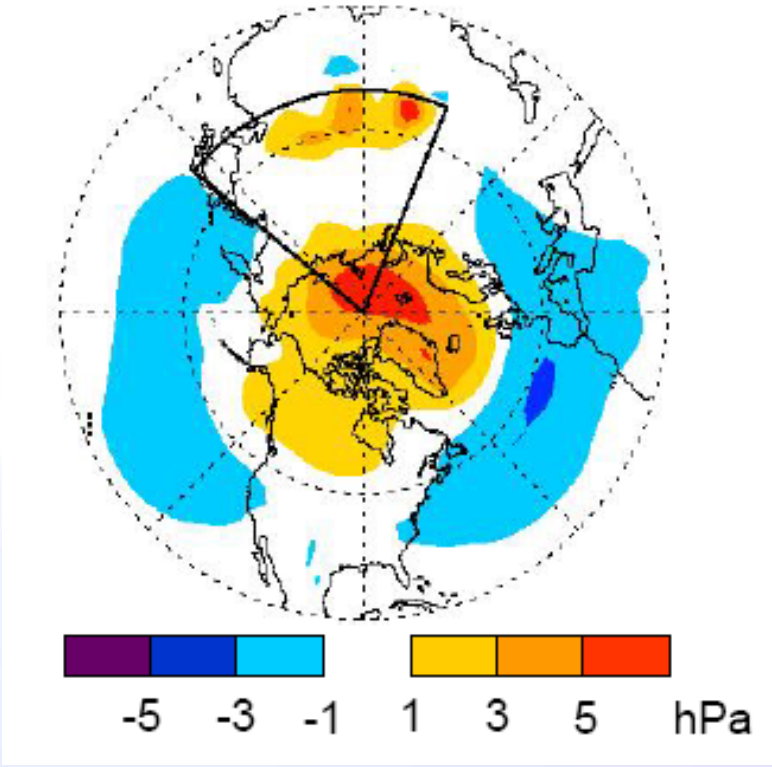
Snow and predictability (1)

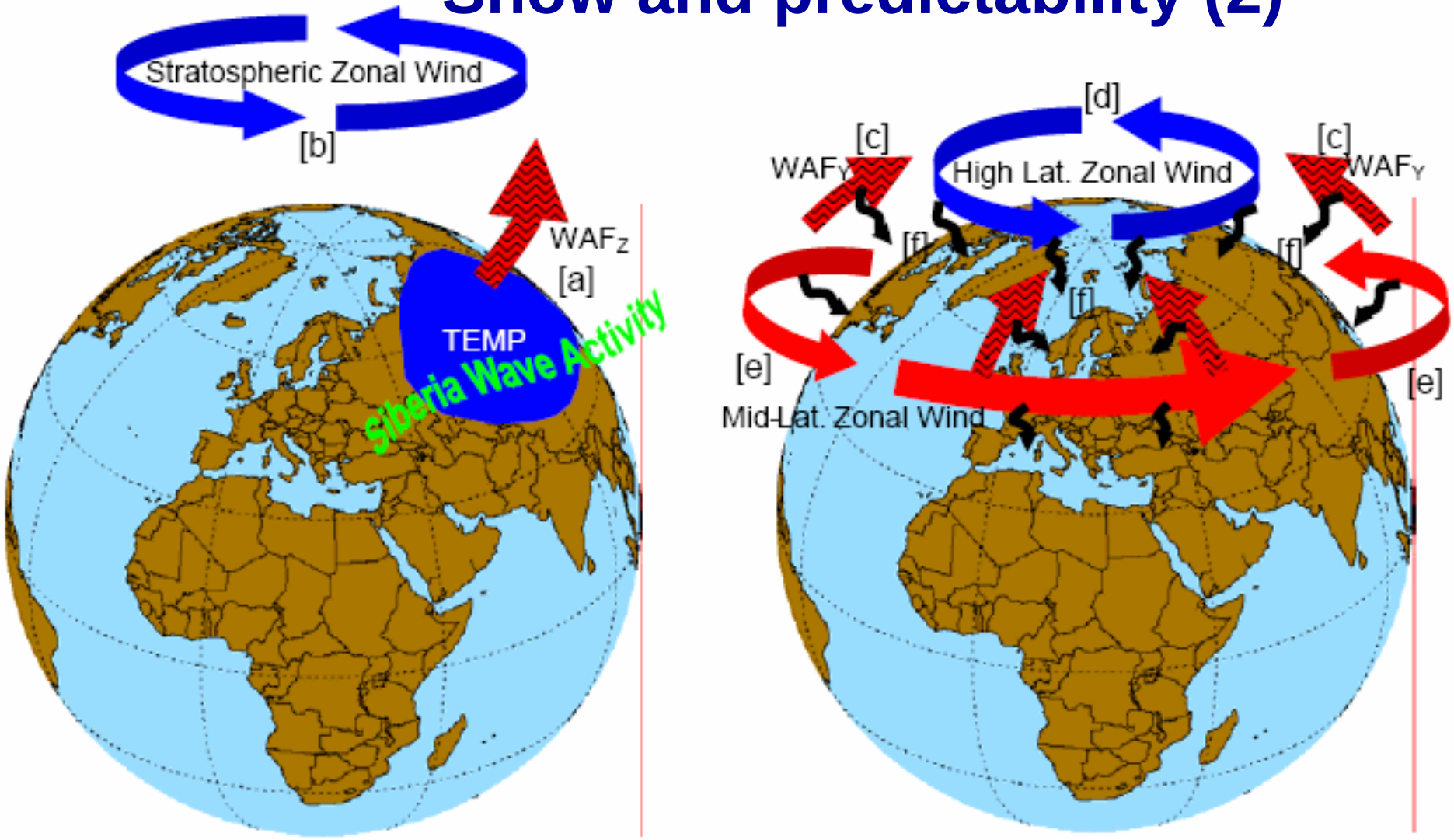


October snow cover anomalies correlated with winter sea level pressure, for 1972-2003.
Cohen and Saito (2003)



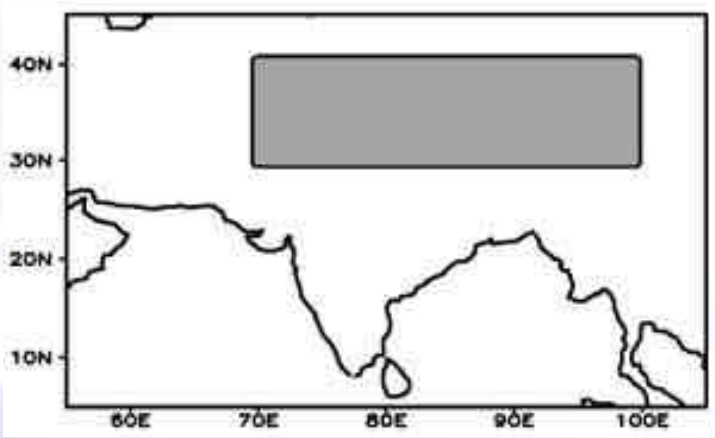
Modeled climate response to the Siberia snow forcing: winter sea level pressure.
Gong et al. (2003a)

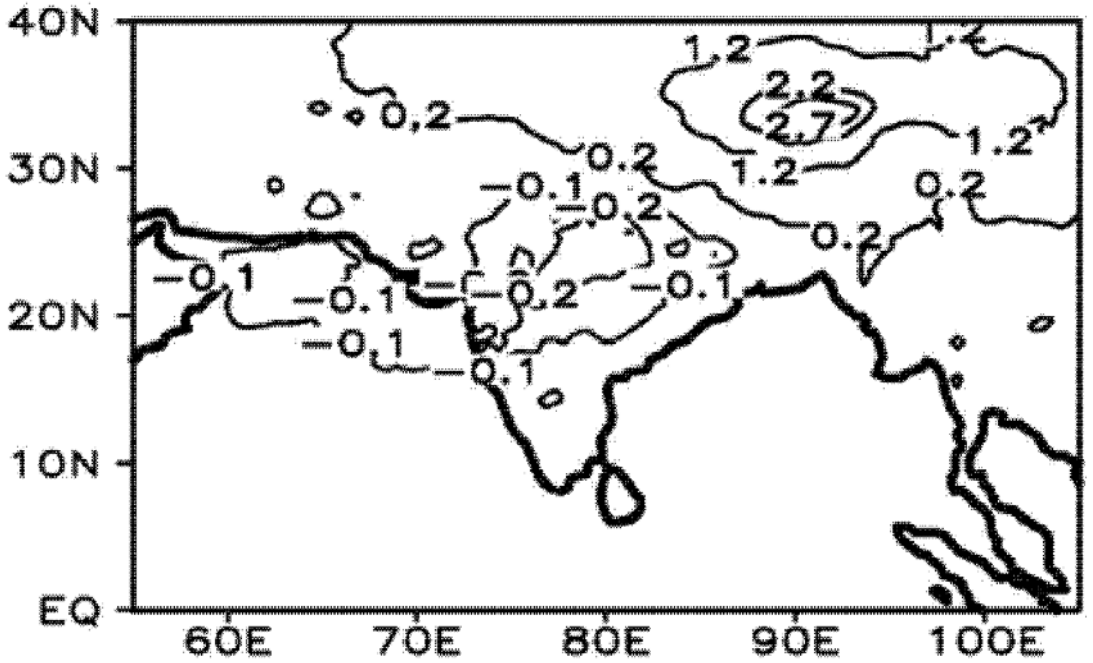
Snow and predictability (2)



Modeled remote teleconnection pathway in response to positive snow forcing over Siberia. Gong et al. (2005)

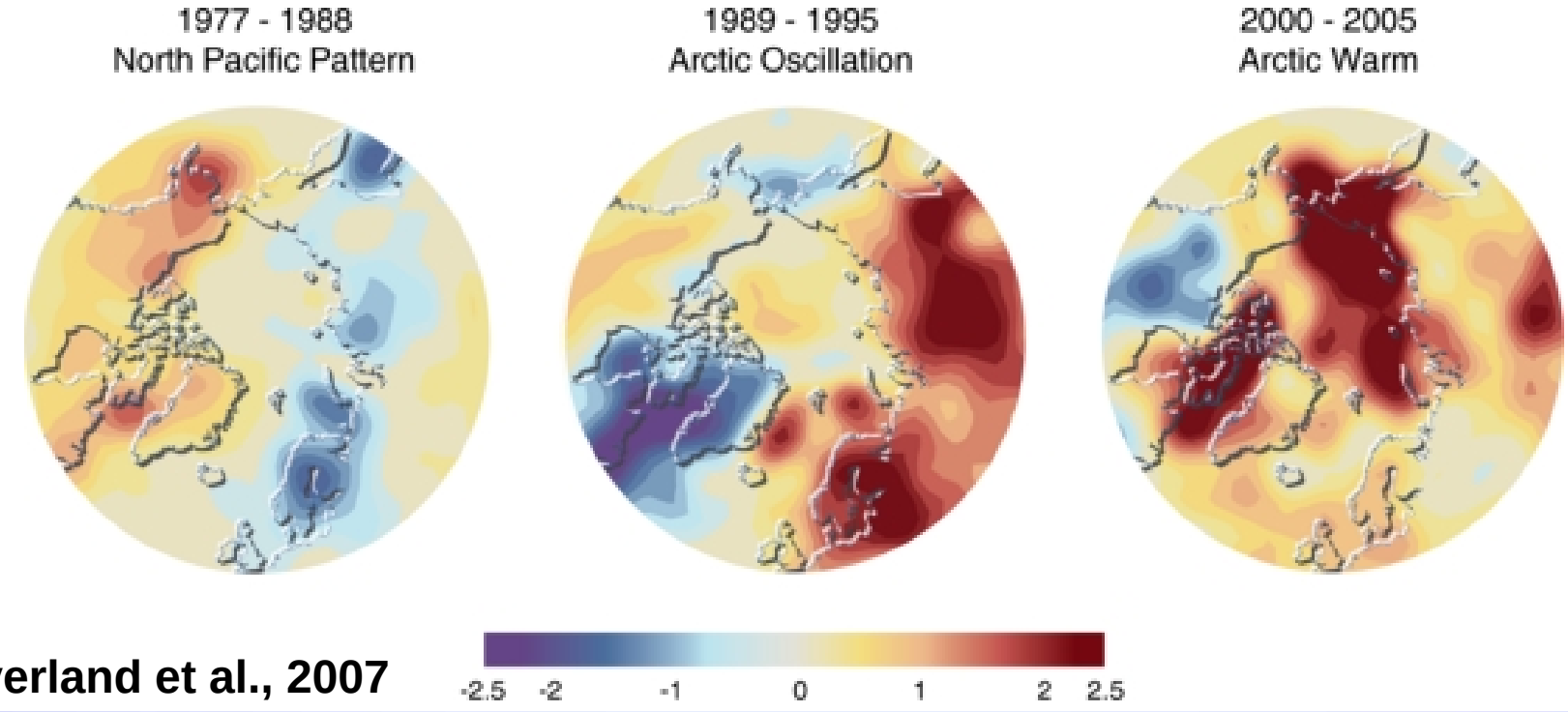
Snow and predictability (3): Indian monsoon





Shekhar & Dash, 2005

Snow and changing circulation modes

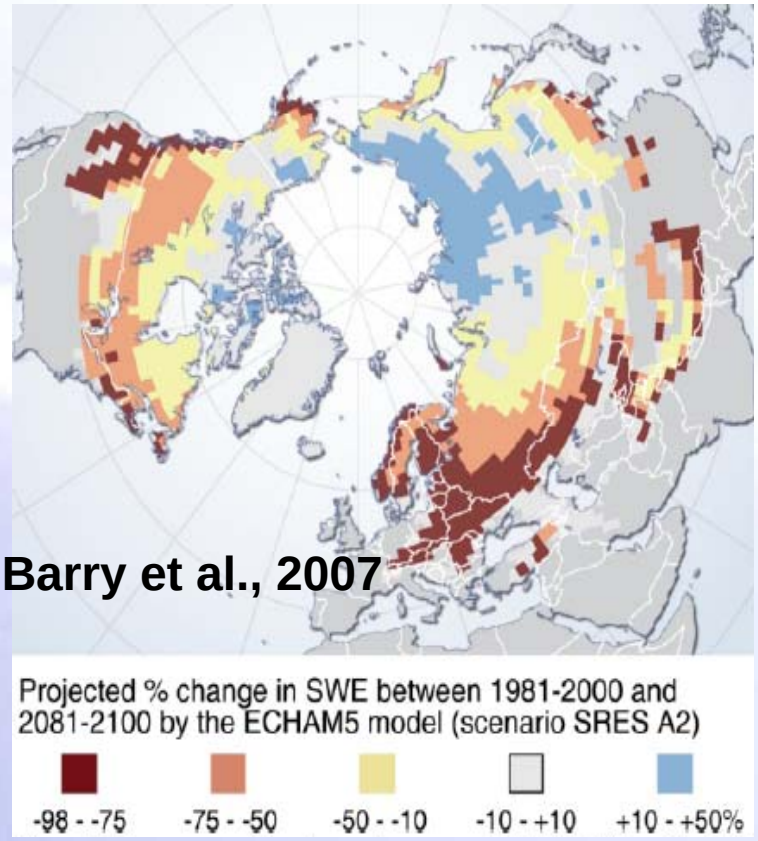


Overland et al., 2007

Snow-albedo feedback: 0.9 Wt/m², mostly due to spring melt, regionally 3 Wt/m² comparable to 4.4 Wt/m² due to GHG

Most important SCA but changes in snow albedo also crucial, snowmelt information required

Snow on land in the 21st century



Barry et al., 2007

Needs: cover, mass (SWE)

+ roughness, albedo, t°K

Model validation crucial

Operational <u>global</u> forecasting systems resolutions

Canada	**2010**	**25 km/L80 (now 35km)**
ECMWF	**2009**	**16 km/L91 (25km)**
Germany	**2009**	**20 km/L60 (40km)**
Japan	**2007**	**20 km/L60**
UK	**2009**	**25 km/L90 (40km)**
USA	**2010**	**25 km/L90 (~35km)**

(Similar plans for few other Centres)

(WGNE's 'Overview of plans at NWP Centres with Global Forecasting Systems, Jan 2008')

The Goal of GCOS is to provide continuous, reliable, comprehensive data & information on the state of the global climate system

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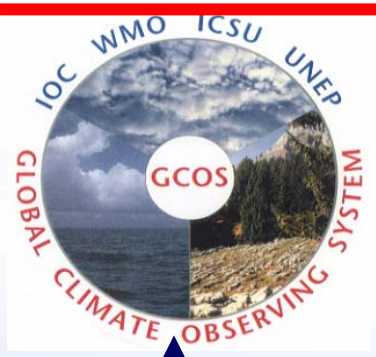
http? -> google „GCOS“



WCRP/GEWEX
BSRN

WMO
WWW
Global
Observing
System
(GOS)
Atmosphere

WMO
Global
Atmospheric
Watch
(GAW)
Atmospheric
Chemistry

IOC/
UNESCO
Global
Ocean
Observing
System
(GOOS)
Ocean

FAO
Global
Terrestrial
Observing
System
(GTOS)
Land

WMO
World
Hydrological
Cycle
Observing
System
(WHYCOS)
Land/Water

Other

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GCOS in general

44 GCOS ECVs (atmospheric, oceanic, terrestrial) + integrated analysis products, moving with WCRP to a climate RA

Snow: snow cover extent (km2) and duration, snow depth (cm)

Emerging ECV: soil moisture

GCOS Climate Monitoring Principles: 10+10

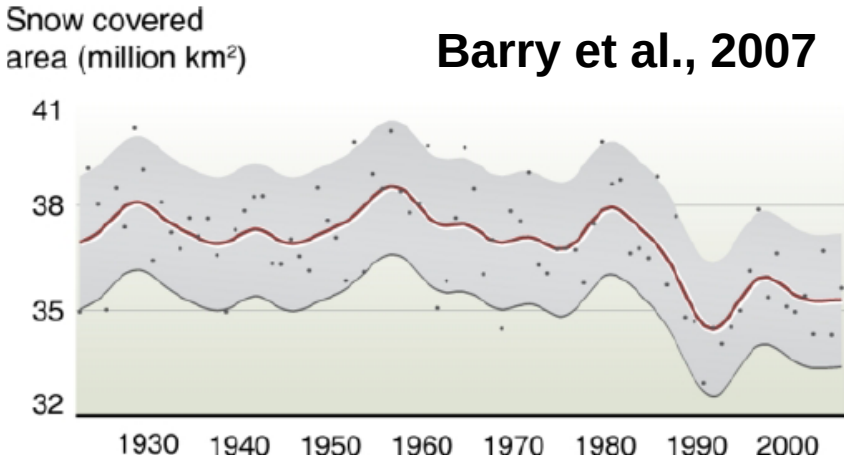
GIP: GCOS Implementation Plan ("Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC", GCOS-92, October 2004)

Satellite Supplement to GIP ("Systematic Observation Requirements for Satellite-based Products for Climate - Supplemental details to the satellite-based component of the GCOS Implementation Plan", GCOS-107, September 2006) + CEOS Response to it

GCOS Reg. Workshop Programme and 10 Reg. Action Plans
130 National Focal Points

GCOS/WCRP Observation Requirements in the WMO/CEOS Database

GCOS and snow



Barry et al., 2007

Main in situ data source:
WMO GSN (Global Surface Network)

Issues:
Synoptic and national networks have significant gaps and are ALL contracting.
Southern Hemisphere not monitored operationally for extent and duration.

Missing issue (?): snow on ice

Action T10: Strengthen and maintain existing snow-cover, snowfall observing sites and recover historical data.

Action T11: Obtain integrated analyses of snow cover over both hemispheres.
Who: Space Agencies through CliC and IGOS–P Cryosphere

Action T12: For snow cover and snow water equivalent, establish standards and protocols, design an optimum procedure and designate International Data Centre responsibilities.

Cryosphere Theme

http://igos-cryosphere.org

Goals:

To create a framework for improved coordination of cryospheric observations conducted by research, long-term scientific monitoring, and operational programmes;

To achieve better availability and accessibility of data and information needed for both operational services and research;

To strengthen national and international institutional structures responsible for cryospheric observations;

To increase resources for ensuring the transition of research-based cryosphere observing projects to sustained observations.

The Cryosphere Theme was approved at IGOSP-14, Paris, May 2007

The Report

Preface
Foreword
Executive Summary
1. The Cryosphere Theme
2. Applications of Cryospheric Data
3. **Terrestrial Snow**
4. Sea Ice
5. Lake and River Ice
6. Ice Sheets
7. Glaciers and Ice Caps
8. Surface Temperature and Albedo
9. Permafrost and Seasonally Frozen Ground
10. Solid Precipitation
11. An Integrated and Coordinated Observing System
12. Implementation

App. A. References
App. B. Observational Capabilities and Requirements
App. C. Satellite Missions in Support of the Theme
App. D. Acronyms
App. E. Contributors

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Implementation

Phases:

1: 2007-2009, IPY. CliC IPY project "The State and Fate of the Cryosphere" (cluster lead).

2: 2010-2015. Preserve the legacy of the IPY observing and data and information management system; expand system to the global cryosphere; realize plans or concepts for space observing systems for the cryosphere.

3: After 2015. Implement (hopefully) previously recommended space missions that fill key observational gaps, as well as routine in situ observations of such essential parameters as solid precipitation and/or snow water equivalent.

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WMO Initiative: Global Cryosphere Watch