Scientific Grand Challenges for Global Climate Research addressing Societies Needs

Martin Visbeck

Gino Cassassa, James Hurrell, Thomas Peter,
Theodore Shepherd, Kevin Trenberth and Howard Wheater

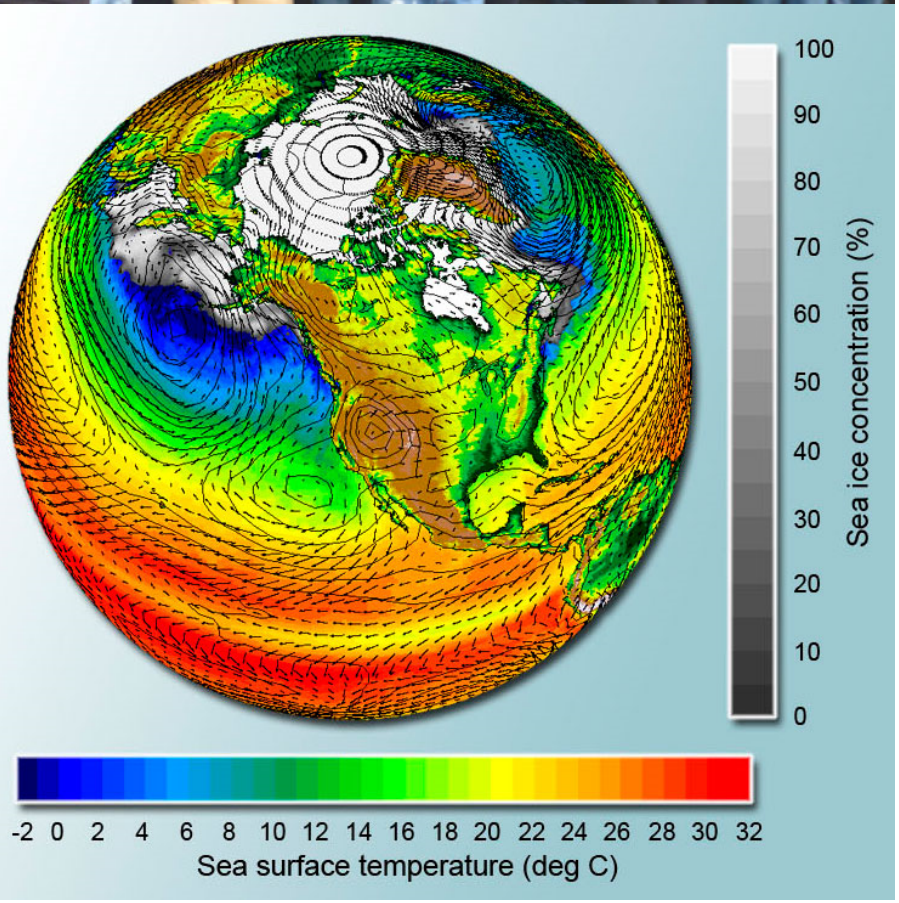
Outline

Brief History

Climate Information

Grand Challenges

Build Capacity



First World Climate Conference 1979:

- World Climate Programme
  "Climate and its role in society"

- World Climate Research Programme
  "Facilitate Global Climate Research"

- Provided context for the foundation in 1988 of the Intergovernmental Panel on Climate Change
  "Assess Climate Change Science Knowledge"

Brief History

Major WCRP projects have been successfully completed in the last decade.

The **Tropical Ocean and Global Atmosphere** (TOGA) project (1985–1994) established the physical basis for the understanding and prediction of El Niño temperature signals and associated changes in global climate. This led to a major breakthrough in operational seasonal climate forecasting.

The **World Ocean Circulation Experiment** (WOCE) (1982–2002), the biggest and most successful global ocean research programme to date, collected observations of the world's oceans of unprecedented quality and coverage and led to the development of important new ocean observing techniques and improved understanding of physical processes in the ocean.

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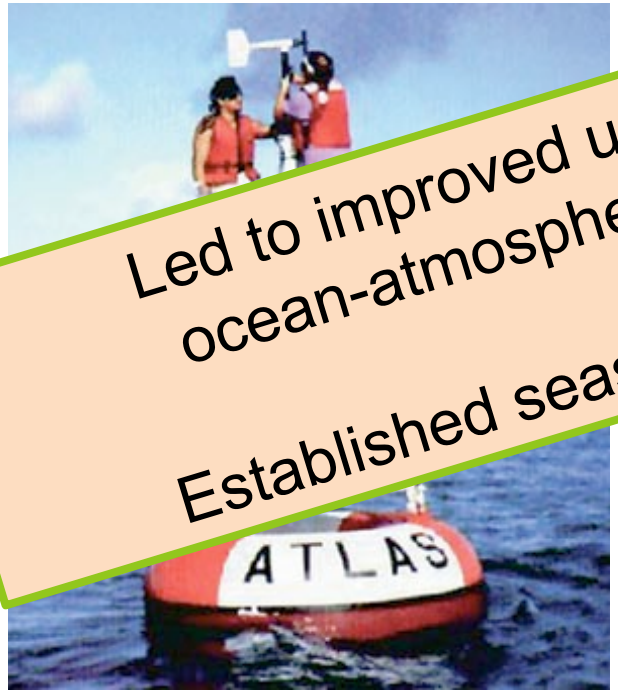
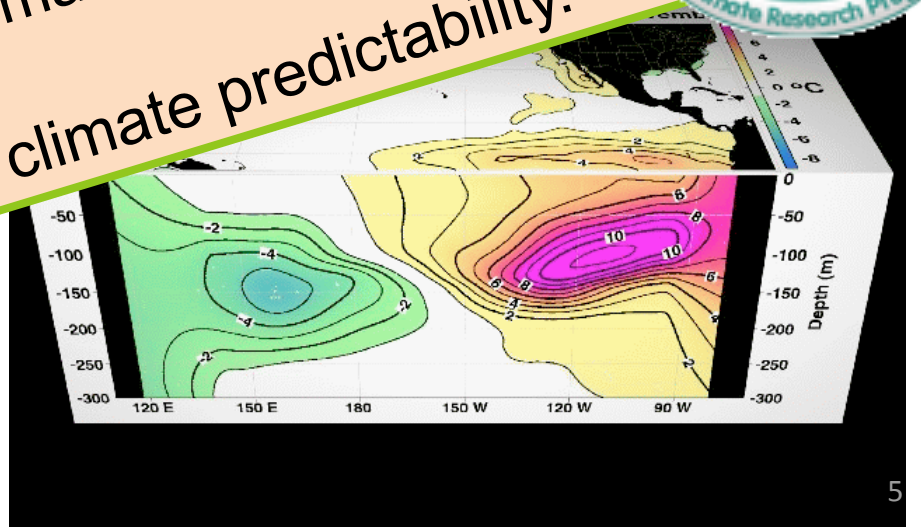
Led to improved understanding of tropical ocean-atmosphere climate interactions.

Established seasonal climate predictability.



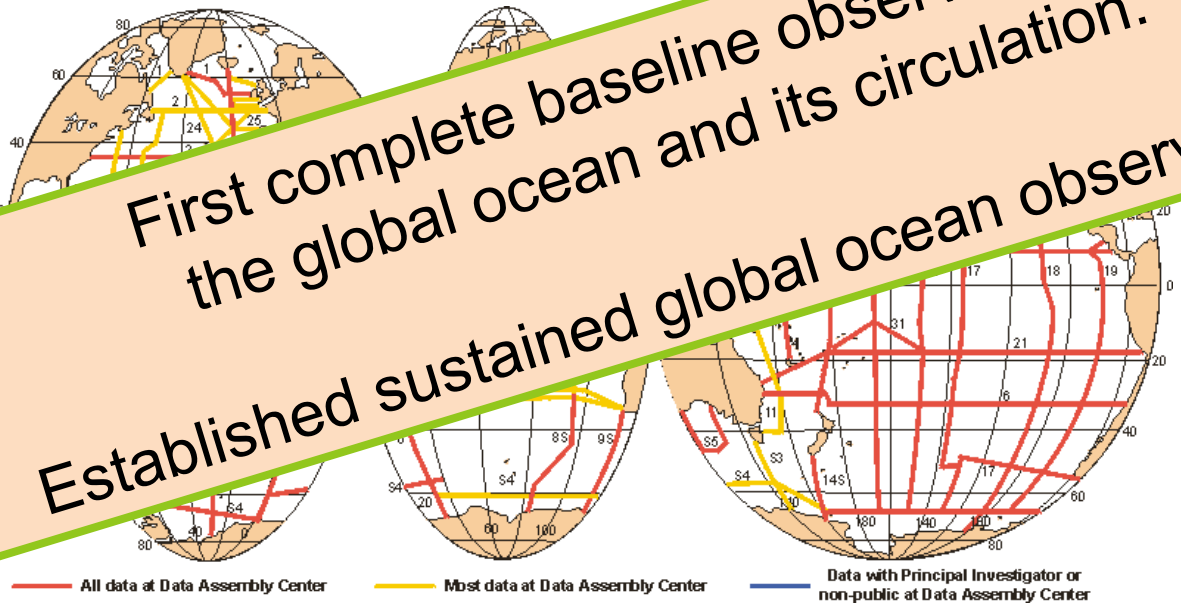


WOCE

Major WCRP projects have been successfully completed in

First complete baseline observation of the global ocean and its circulation.

Established sustained global ocean observations.



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World Meteorological Organization
Working together in weather, climate and water

Second World Climate Conference 1992

- Global Climate Observing System
  "Design, Implement and Sustain global Observations"

- UN Framework Convention on Climate Change
  "Develop Instruments for Mitigation and Adaptation to Global Climate Change "

UNFCCC

GCOS
Global Climate Observing System
Ensuring the Availability of Global Observations for Climate

ACSYS

Three major WCRP projects have been successfully completed in the last decade.

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ACSYS

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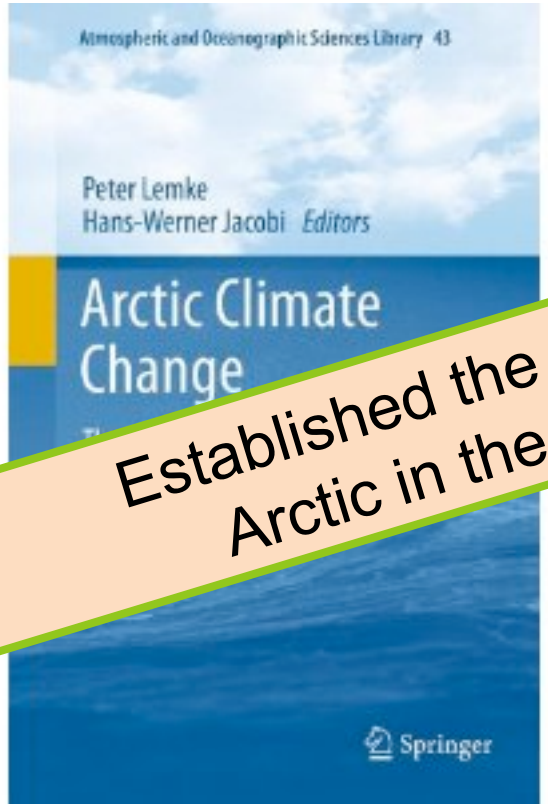
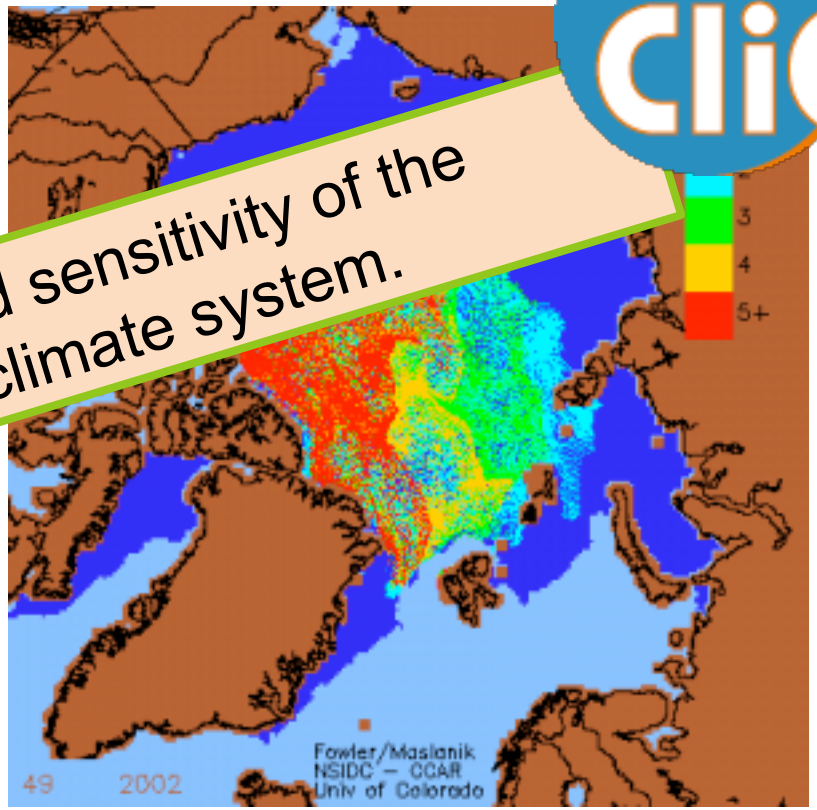


Established the role and sensitivity of the Arctic in the global climate system.



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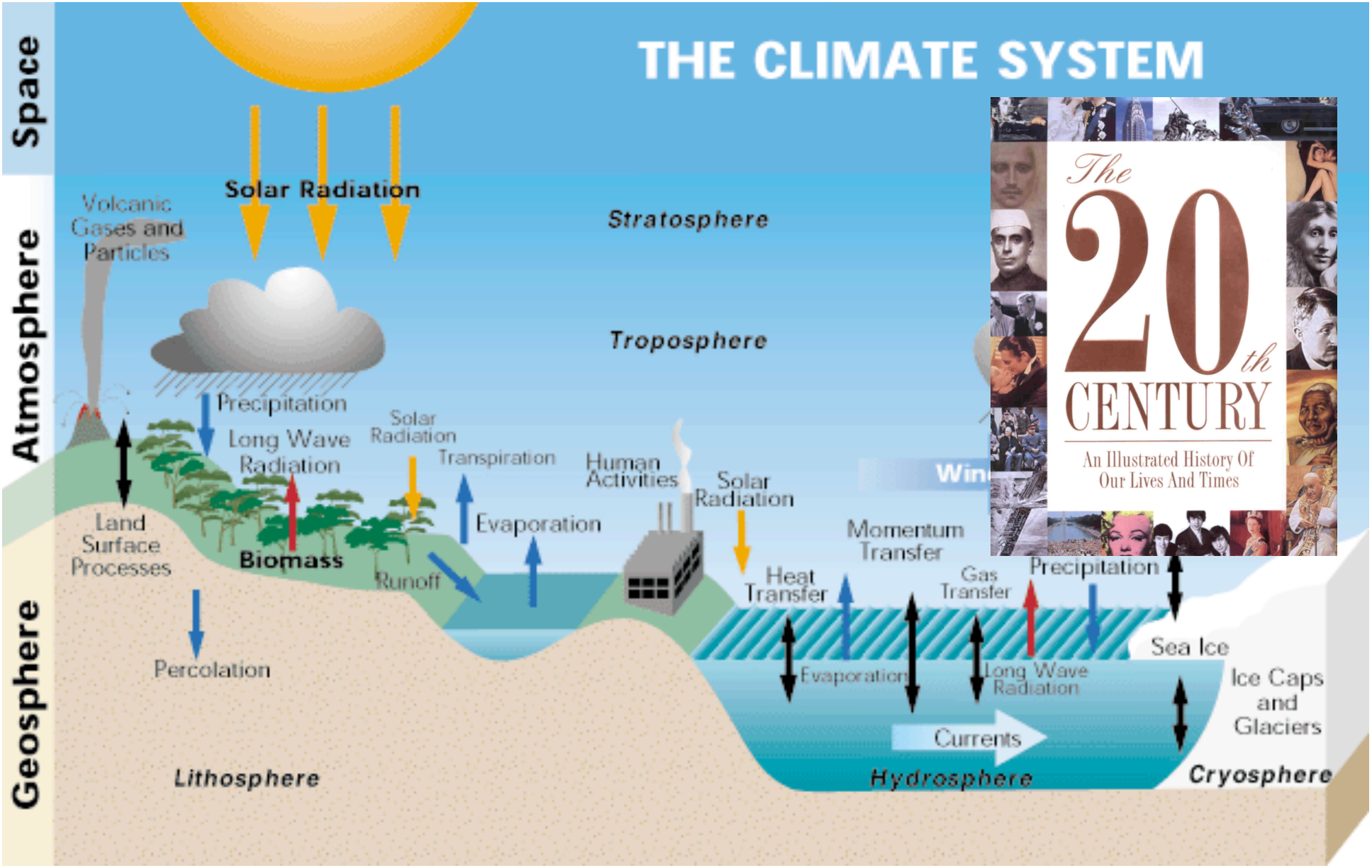
WCRP today

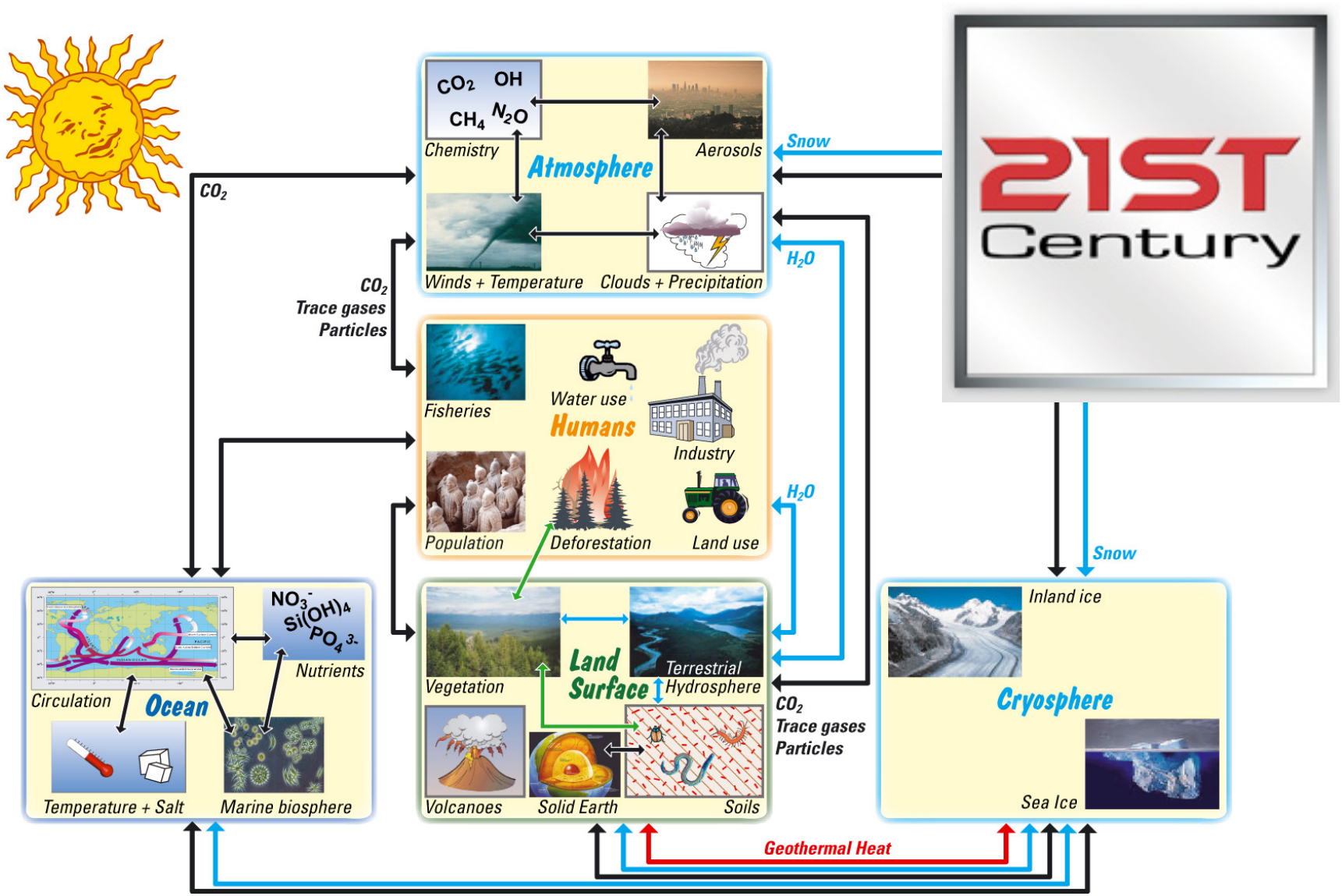
Today the WCRP consists of four major core projects:

- **Climate Variability and Predictability (CLIVAR)**
  since 1995
- **Global Energy and Water Cycle Experiment (GEWEX)**
  since 1979
- **Stratospheric Processes and their Role in Climate (SPARC)**
  since 1992
- **Climate and Cryosphere (CliC)**
  since 2000

The Climate System

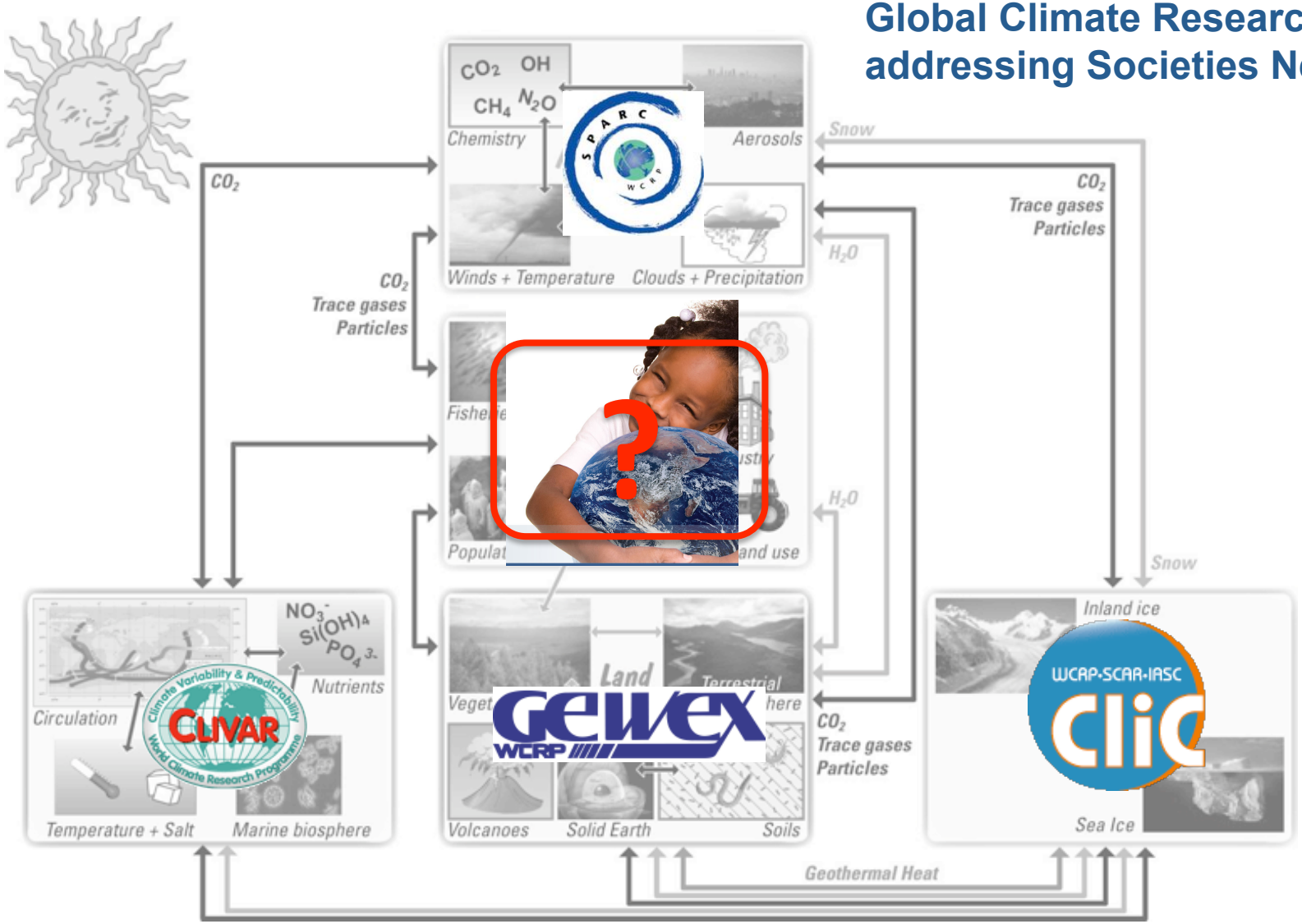


The Earth System



WCRP – Human Dimension

Global Climate Research addressing Societies Needs



Human Dimension

MDGs

GOAL 1	Eradicate extreme hunger and poverty
GOAL 2	Achieve universal primary education
GOAL 3	Promote gender equality
GOALS 4,5,6	Reduce child mortality, improve maternal health and combat HIV, malaria and other diseases
GOAL 7	Ensure environmental sustainability
GOAL 8	Develop a global partnership for development

Millennium Development Goals

Vigorous adaptation actions on the basis of:

- climate scenarios and economic impact assessments;
- financial needs assessments;
- capacity building and risk management strategies;
- integration of adaptation actions into sectoral and national planning;
- the development of risk management and risk reduction strategies; including insurance, and disaster reduction strategies;
- support to design of policies that are appropriate for a world of uncertainty, change and surprise. and participation.

Human Dimension

In order to mitigate the most vere
lopment-related im
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be ado

Vis

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sectoral and national planning;
• the development of risk management and risk reduction strategies; including insurance, and disaster reduction strategies;
• support to design of policies that are appropriate for a world of uncertainty, change and surprise. and participation.

Mainstreaming climate (change) adaptation and mitigation through greater focus on **local adaptive capacity and community engagement.**

What is the role of WCRP?

Third World Climate Conference 2009

- Global Framework for Climate Services
  "Provide timely climate information on global and regional scales to all people"

Provide reliable, well documented, science based, authoritative and easily used climate information and develop the most effective approaches to climate adaptation and mitigation strategies.

Develop sustained, nationally and regionally-based interactions with users in different societal and economic sectors.

Elements of Climate Service

World Meteorological Organization
Working together in weather, climate and water

WCC-3

The **Global Climate Observing System** and all its components and associated activities; and provision of free and unrestricted exchange and access to climate data;

The **World Climate Research Programme**, underpinned by adequate computing resources and increased interaction with other global climate relevant research initiatives.

Climate services information systems taking advantage of enhanced existing national and international climate service arrangements in the delivery of products, including sector-oriented information to support adaptation activities;

Climate user interface mechanisms focussed on building linkages and integrating information, at all levels, between the providers and users of climate services; and

Efficient and enduring **capacity building** through education, training, and strengthened outreach and communication.

Structure of Climate Service

World Meteorological Organization
Working together in weather, climate and water

WCC · 3

Global Climate Observing System

World Climate Research Programme

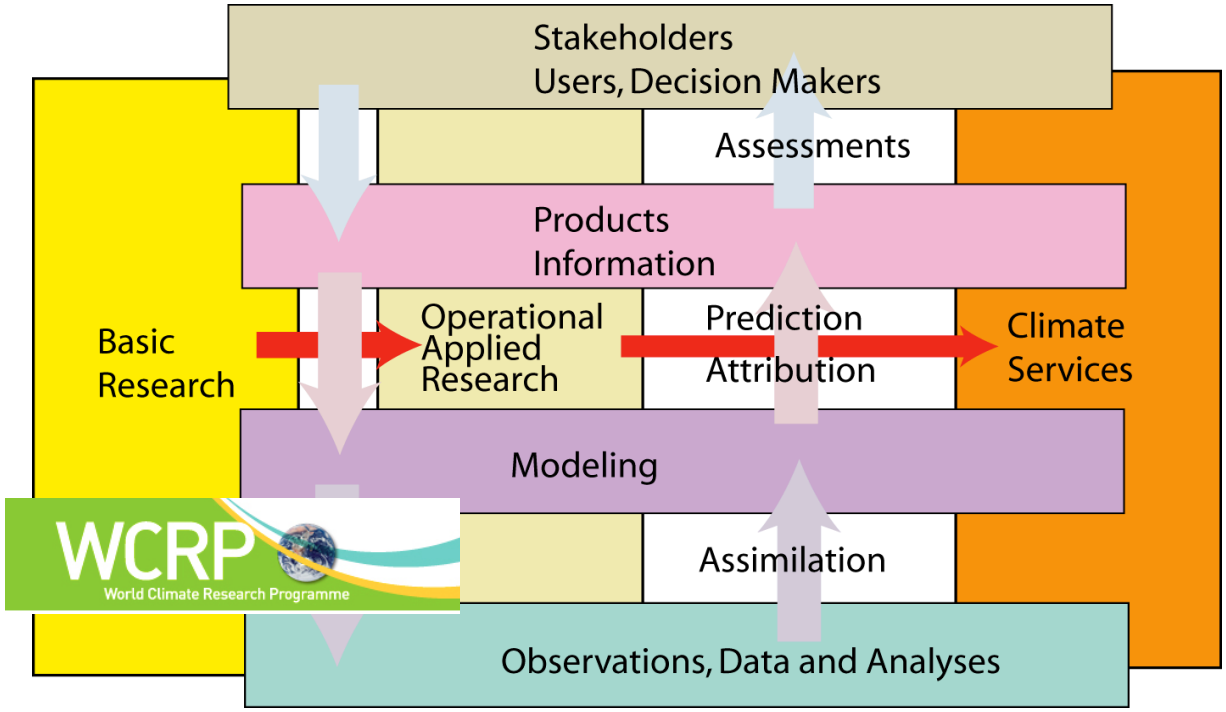
Climate services information systems

Climate user interface mechanisms

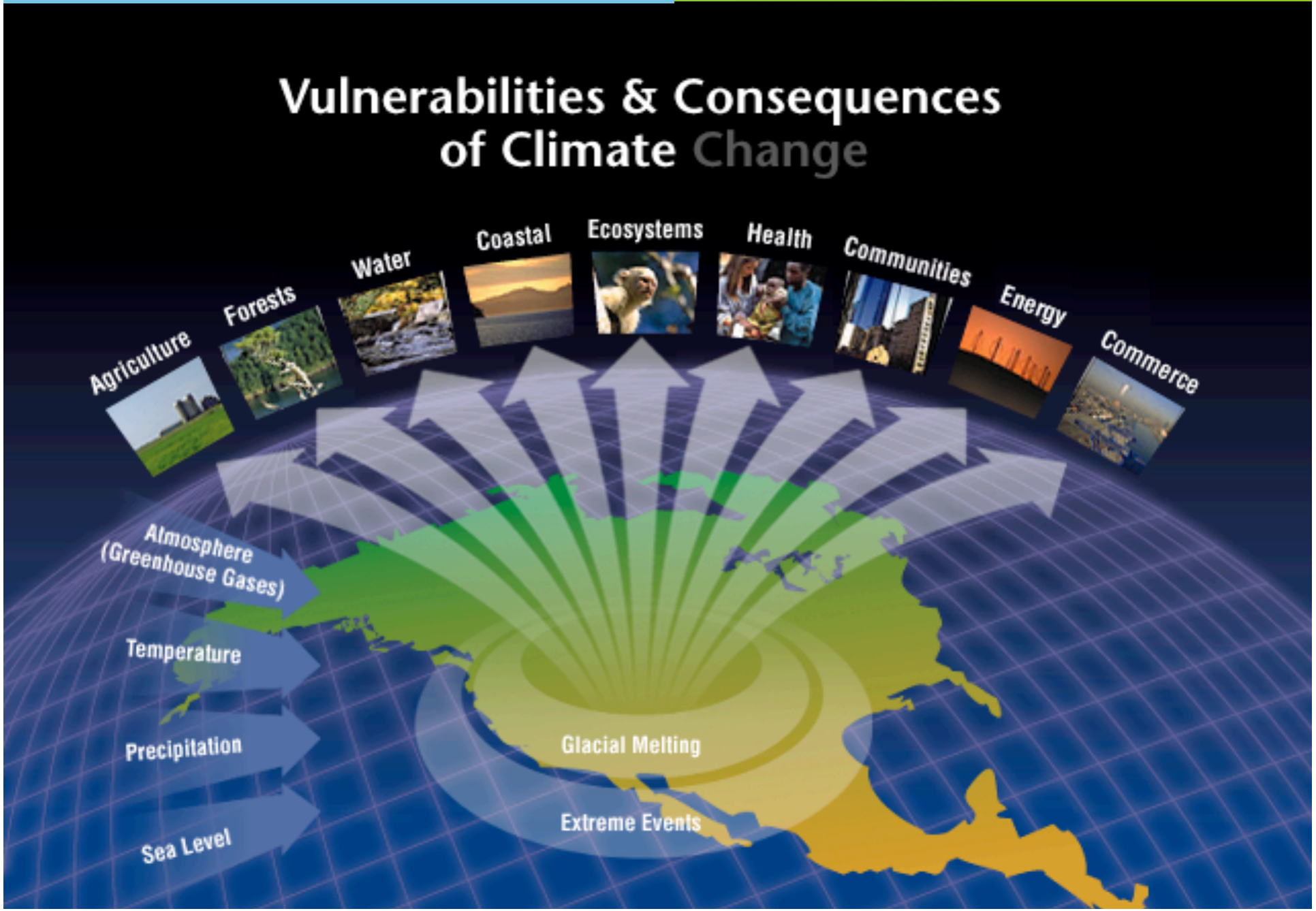
Enduring capacity building

"Build a climate information system and climate service (IPCC is not it)"

Kevin Trenberth



Societal Benefit Areas



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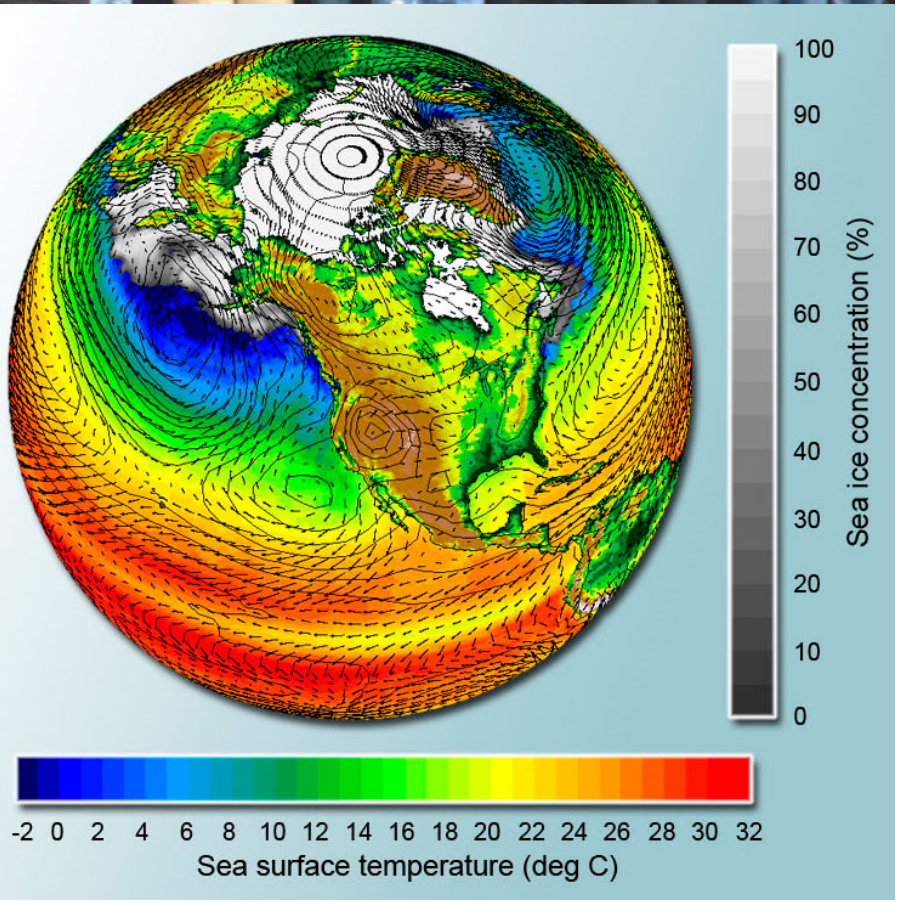
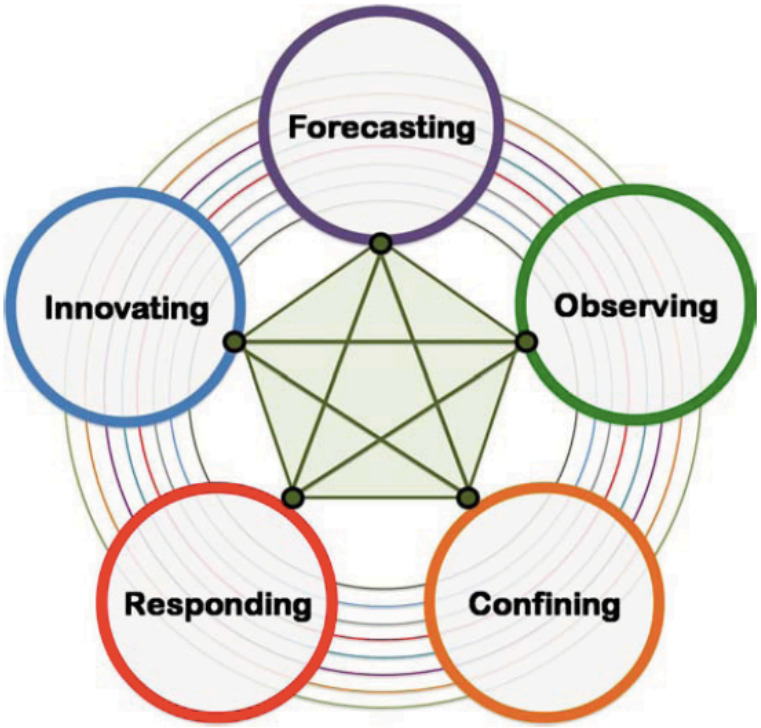


Earth System Science for Global Sustainability

The Grand Challenges

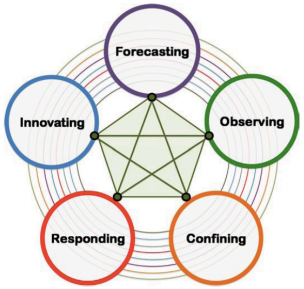
ISSC
international social science council

ICSU
International Council for Science



Earth System Science for Global Sustainability

The Grand Challenges



- Forecasting — Improve the usefulness of forecasts of future environmental conditions and their consequences for people.
- Observing—Develop, enhance and integrate the observation systems needed to manage global and regional environmental change.
- Confining—Determine how to anticipate, recognize, avoid and manage disruptive global environmental change.
- Responding—Determine what institutional, economic and behavioural changes can enable effective steps toward global sustainability.
- Innovating—Encourage innovation (coupled with sound mechanisms for evaluation) in developing technological, policy and social responses to achieve global sustainability.

Framing Challenges

"Measuring what we must manage"

Jacqueline McGlade

European Environment Agency

Framing Challenges

Heide Hackmann

"Can science save us:
How can we better anticipate
the consequences of change?"

Framing Challenges

META QUESTIONS

ICSU
International Council for Science

Karen O'Brien

"How to improve and apply science-based analyses and models to anticipate potential consequences of human actions on the environment and society.
And what are the limits to such approaches?"

Framing Challenges

IPCC
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Susan Solomon

"Understanding how temperatures are increasing around the world, how ice is melting at the poles, and how rain is decreasing in key regions are among the critical issues attracting the attention of the public, scientists, and policymakers worldwide."

WCRP - Objectives

The overarching objectives of the WCRP are:

- **to determine the predictability of climate**
- **to determine the effect of human activities on climate**

"for use in an increasing range of practical applications of direct relevance, benefit and value to society"

Develop and evolve WCRP Grand Challenges around several criteria:

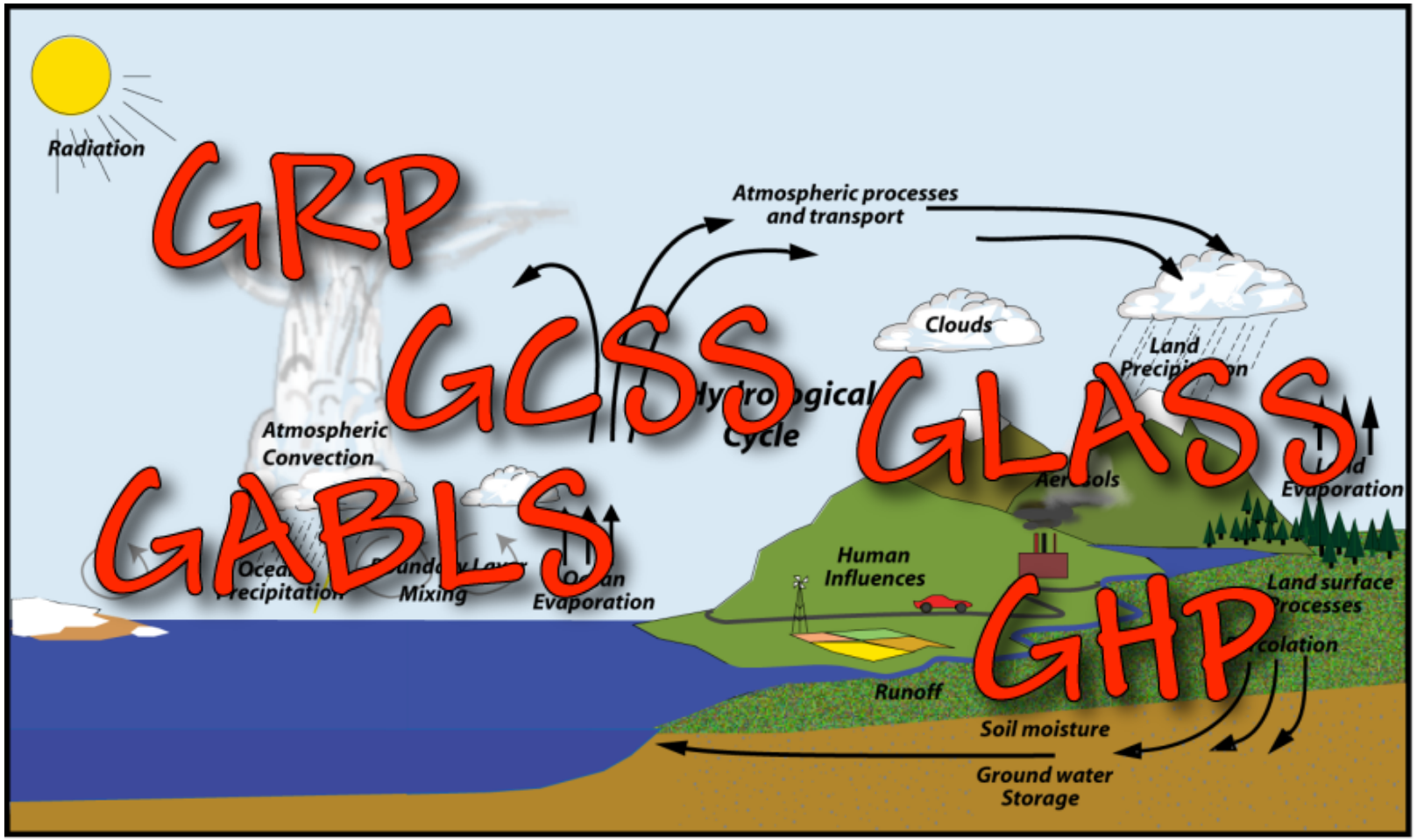
- scientific importance
- opportunity to make considerable progress
- benefit from international coordination
- relevant for societal issues

Need a champion, interest of funders and the scientific capacity to address them.

Exemplary Grand Challenges

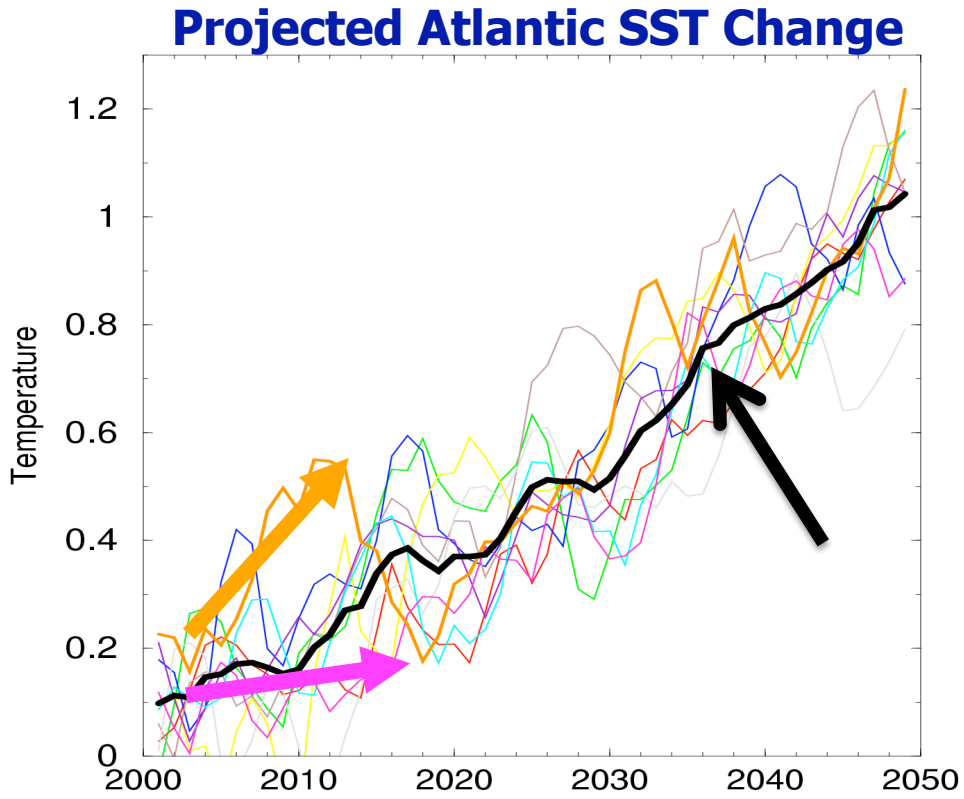
- The global and regional water cycle
- Decadal climate predictability
- Atmospheric chemistry and jet stream dynamics
- Polar climate predictability
- Monsoon variability and change
- Dynamics of ocean upwelling system
- Droughts
- Ice sheet dynamics
- Predictability of extreme events
- Climate Engineering

The global and regional water cycle



Decadal climate predictability

- Clear evidence of decadal variability in ocean and atmosphere, but to what extent is it predictable?
- What are the sources of predictability and the processes that give rise to decadal variability?



Decadal Variations:

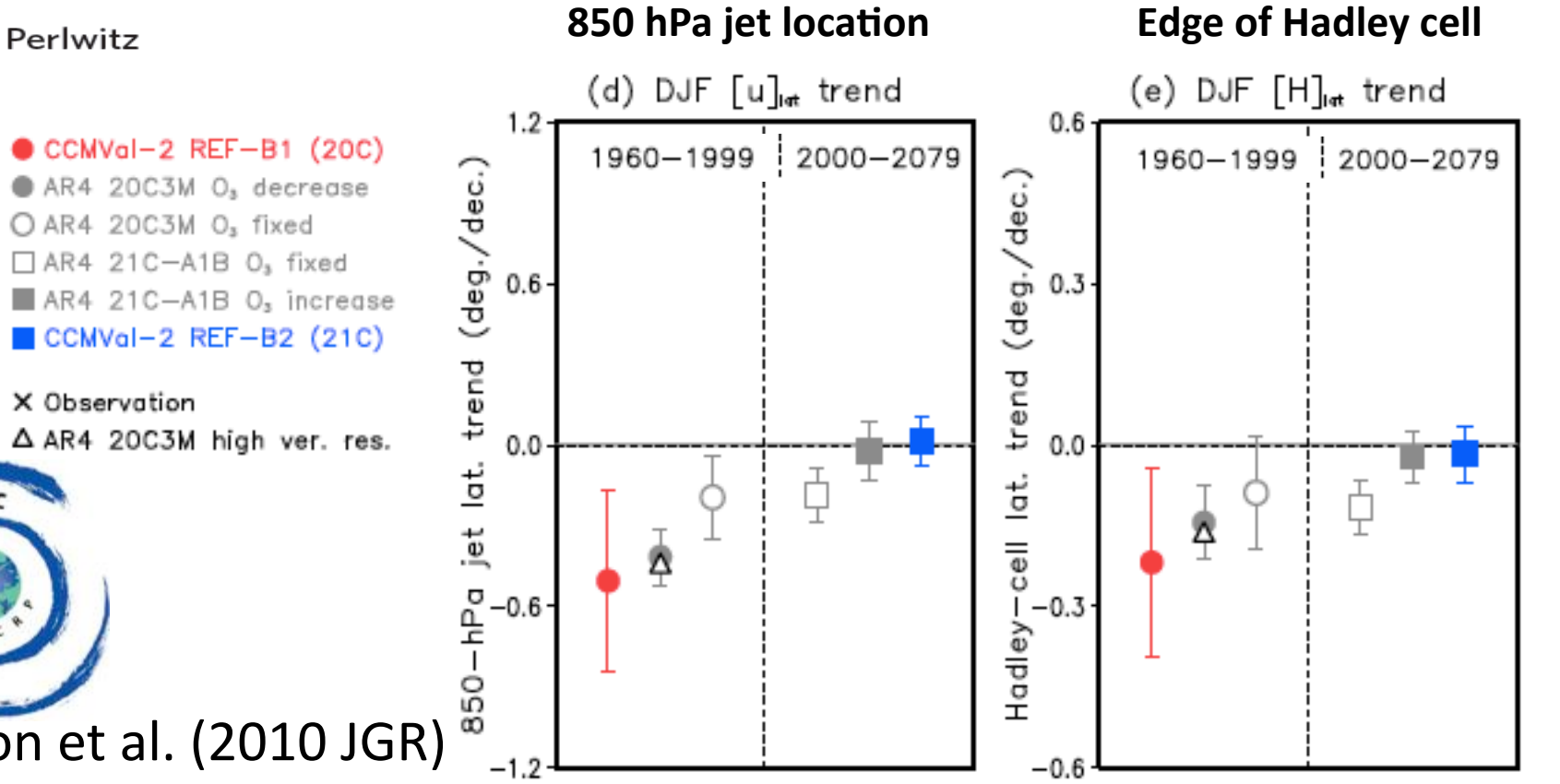
- ✓ **Forced by External Processes**
- ✓ **Generated by Internal Processes**
- ✓ **Interactions of Forced and Natural Variability**

Atmospheric chemistry and jet stream dynamics

Tug of war on the jet stream

Recovery of the ozone hole and increasing greenhouse-gas concentrations have opposite effects on the jet stream. New model experiments indicate that they will cancel each other out over coming decades, leaving storm tracks at a stand still.

Judith Perlwitz



Son et al. (2010 JGR)

Polar climate predictability

WCRP Workshop on Polar Predictability on Seasonal to Multi-Decadal Timescales (workshop Bergen, October 2010)

Progress in polar predictability will require crossing disciplinary boundaries to understand feedbacks between the troposphere and the stratosphere, ocean, land, and sea ice.

- The nature of these feedbacks appears to be somewhat different in the two hemispheres, leading to somewhat different "big questions":

  - **Arctic: How rapidly will the Arctic warm in the future?**
  - **Antarctic: How will the ocean, carbon uptake, and the West Antarctic ice shelf respond to circulation changes?**

- Examples of possible research foci:

  - **Seasonal predictability and seasonality of longterm changes**
  - **Forced and unforced components of decadal predictability**
  - **Initial state estimates**
  - **Extent of potential predictability**

Droughts

WCRP Workshop on Drought Predictability and Prediction in a Changing Climate Barcelona, March 2011

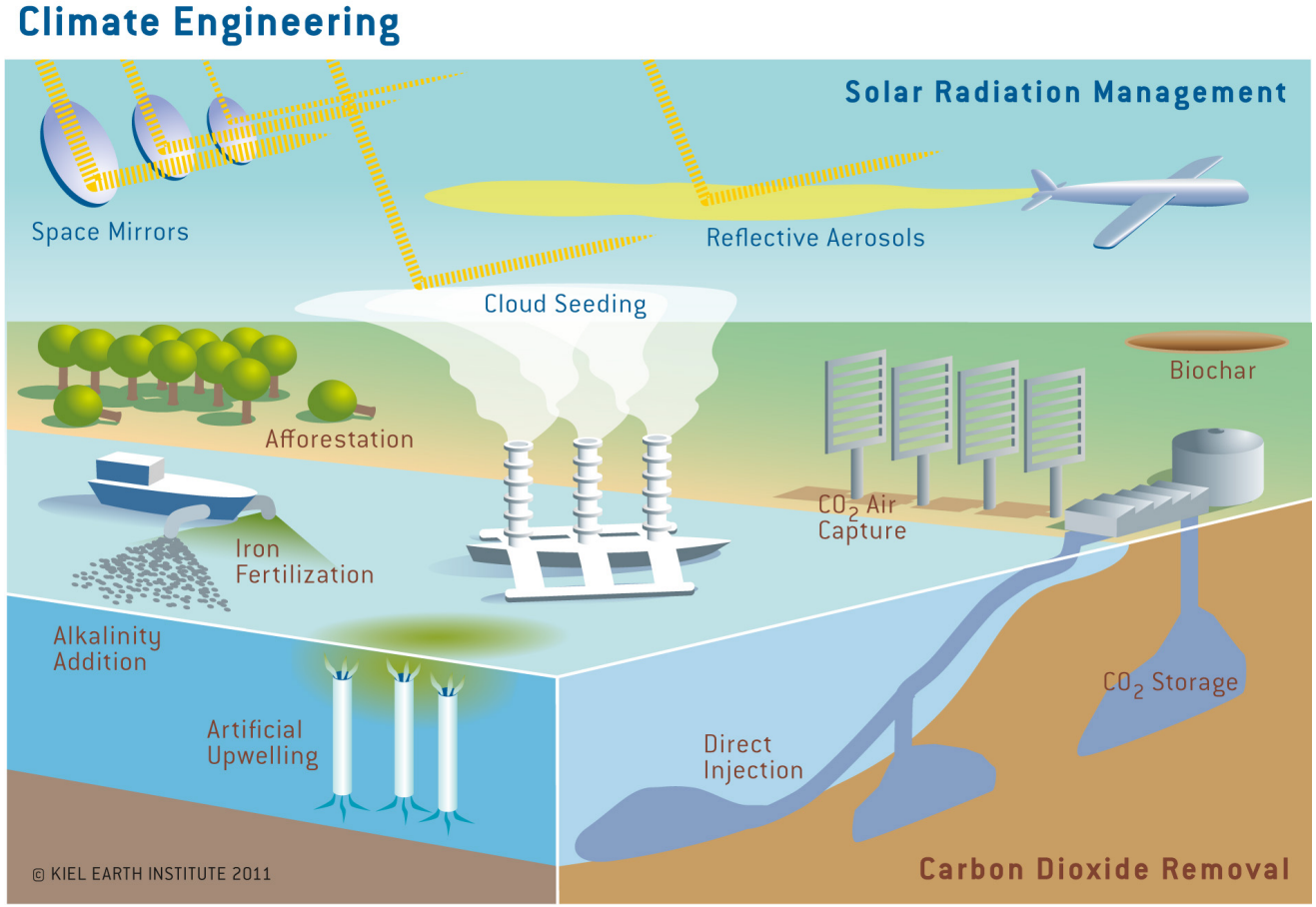
Three Major Recommendations:

1. **Drought Catalogue**
   Summarizing key drivers of global drought events.

2. **Case Studies**
   Focusing on large-scale and regional issues in areas where drought is a key issue.

3. **Develop Drought Early Warning System**

Climate Engineering

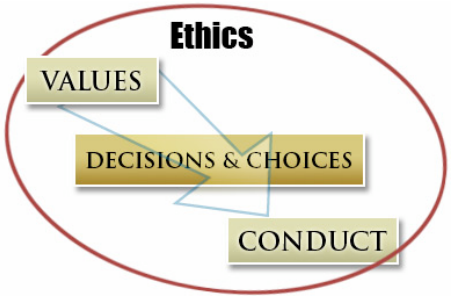


Feasible?

Beneficial?

Justifiable?

Manageable?



To what extent one can ***rely on modelling studies?***
How could viable strategies be tested in practice?

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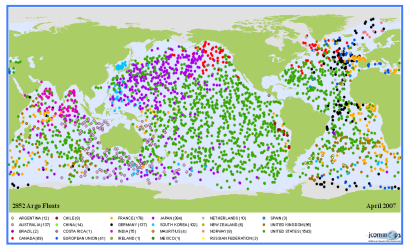
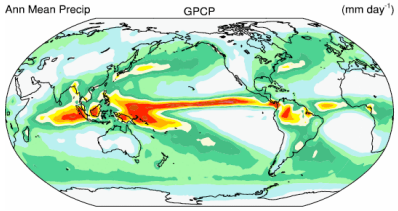
- Predictability of extreme events
- Climate Engineering

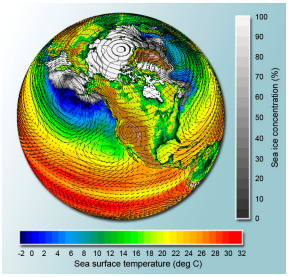
Build Capacity

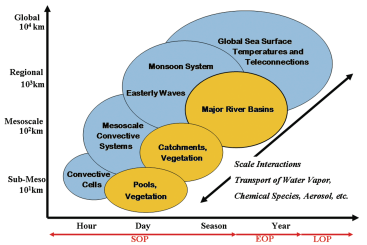
In order to make progress on any of the Grand Challenges the global community needs adequate scientific capacity:

- Improved & sustained global observations.
- More realistic global and regional climate (earth system) models & computing power.
- Reanalysis, assessments and predictions.
- Increased and enduring education in the developed and developing world.









Opportunities

- Public support because of **awareness and real impact of climate change**
  - User-driven needs imply that we do not have to be our own advocates.
  - Focus on regional climate change (rather than global mean surface temperature) puts emphasis on some fundamental processes.
- Improvements in computing power.
- New observational data sets (e.g. subsurface ocean observations, soil moisture, sea-ice thickness).

Challenges

- **Funding** to help coordinate international activities in the face of constrained budgets.
- **Observations**: loss, discontinuation, postponement.
- Fighting the perception that "**climate science is done**".
- Continuing to **improve** (not just add to) the **models**.
- Empowering developing countries.
- Engaging the next generation of scientists.

You can provide input!

WCRP World Climate Research Programme

WCRP OPEN SCIENCE CONFERENCE

CLIMATE RESEARCH IN SERVICE TO SOCIETY

Monday:	**The Climate System Components and their Interactions**
Tuesday:	**Observation and Analysis of the Climate System**
Wednesday:	**Assessing and Improving Model and Predictive Capabilities**
Thursday:	**Climate Synthesis and Assessments**
Friday:	**Translating Scientific Understanding into Climate Information for Decision Makers**

24–28 October 2011, Denver, Colorado, USA

conference2011.wcrp-climate.org