# WORLD CLIMATE RESEARCH PROGRAMME

*Name*
*WCRP*
*Date*
*Location*

WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

# WCRP's mission….

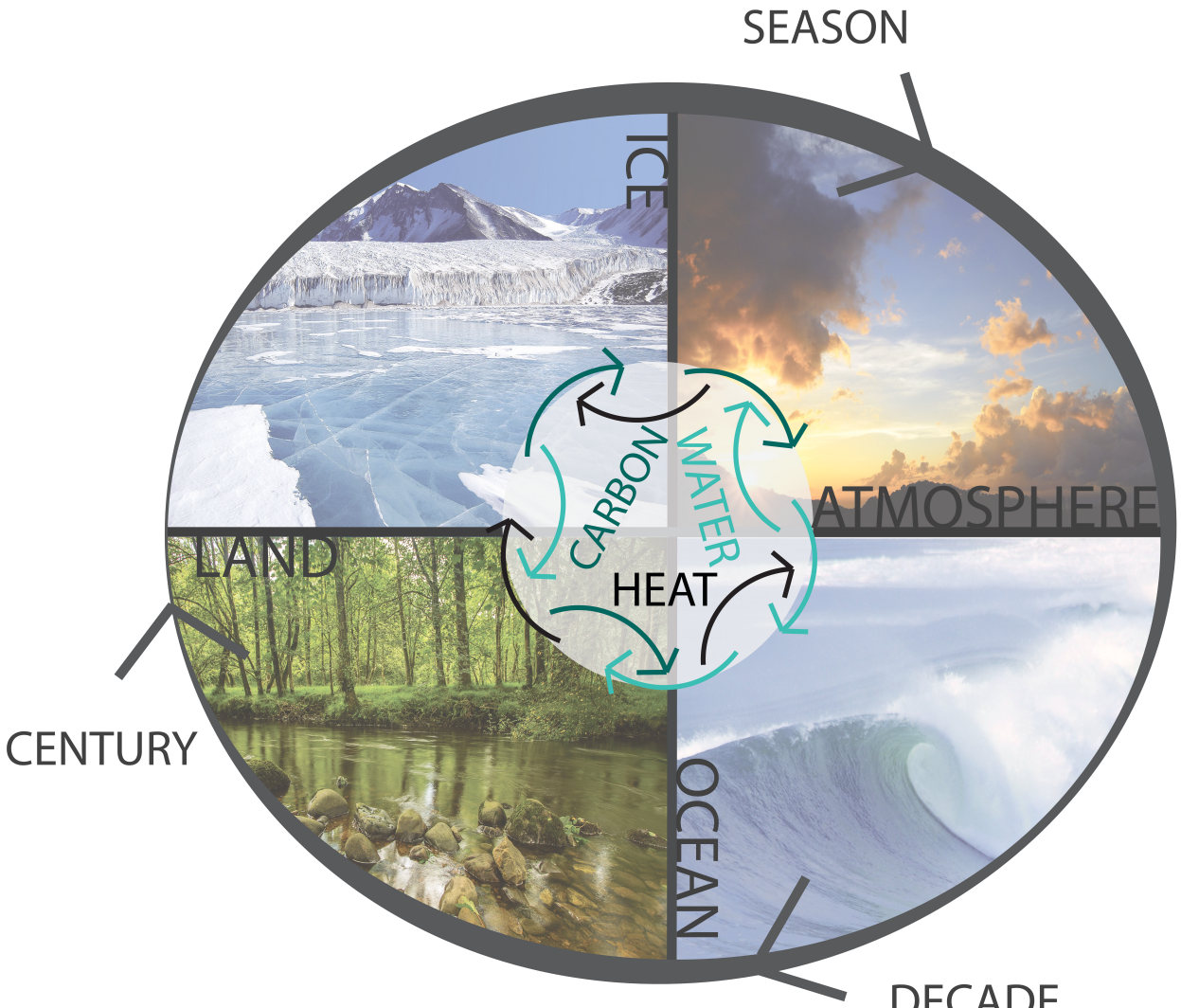
… is to facilitate analysis and prediction of Earth system variability and change for use in an increasing range of practical applications of direct relevance, benefit and value to society.

*The two overarching objectives of WCRP are:*

to determine the predictability of climate

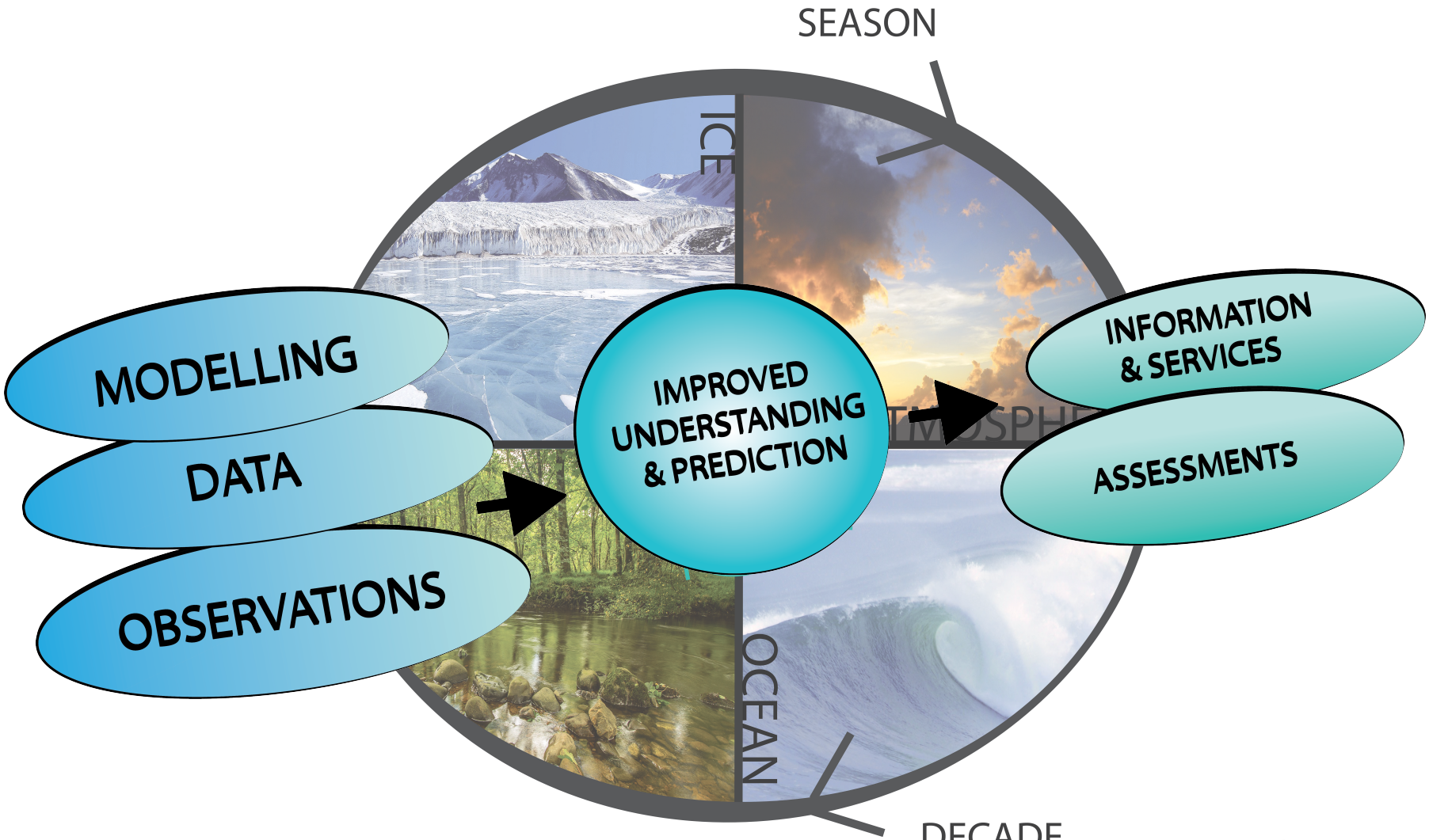
to determine the effect of human activities on climate

# Role of WCRP




WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

# Role of WCRP




WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

# WCRP Structure

**JOINT SCIENTIFIC COMMITTEE (JSC)**

**WCRP MODELLING ADVISORY COUNCIL (WMAC)**

**WCRP DATA ADVISORY COUNCIL (WDAC)**

**JOINT PLANNING STAFF (JPS)**

**WORKING GROUPS ON:**

- COUPLED MODELLING (WGCM)
- NUMERICAL EXPERIMENTATION (WGNE)
- SUBSEASONAL TO INTERDECADAL PREDICTION (WGSIP)
- REGIONAL CLIMATE (WGRC)

| CRYOSPHERE-CLIMATE | OCEAN-ATMOSPHERE | LAND-ATMOSPHERE | TROPOSPHERE-STRATOSPHERE | REGIONAL CLIMATE DOWNSCALING |
|---|---|---|---|---|
| CliC | CLIVAR | GEWEX | SPARC Stratosphere-troposphere Processes And their Role in Climate | WCRP CORDEX |

**GRAND CHALLENGES**

- CLOUDS, CIRCULATION AND CLIMATE SENSITIVITY
- NEAR-TERM CLIMATE PREDICTION
- REGIONAL SEA-LEVEL CHANGE AND COASTAL IMPACTS
- MELTING ICE AND GLOBAL CONSEQUENCES
- CARBON FEEDBACKS IN THE CLIMATE SYSTEM
- WATER FOR THE FOOD BASKETS OF THE WORLD
- UNDERSTANDING AND PREDICTING WEATHER AND CLIMATE EXTREMES

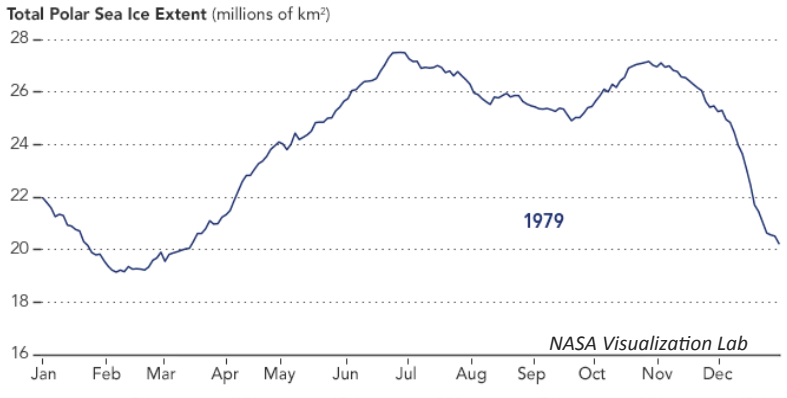
WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

# CliC
*Climate and Cryosphere*

Understanding the changing cryosphere and its climate connections

*Overarching research needs guiding CliC activities:*

- Improved understanding and quantification of the **role of the cryosphere in the global climate system**, its variability and change
- Improved utilization of **cryospheric observations** as indicators of global and regional climate change
- Improved understanding of the physical, chemical and other **processes** that govern behavior of the cryosphere, and the **representation of these processes in Earth System Models**
- Improved ability to make **quantitative predictions and projections** of the cryosphere in a changing climate




WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

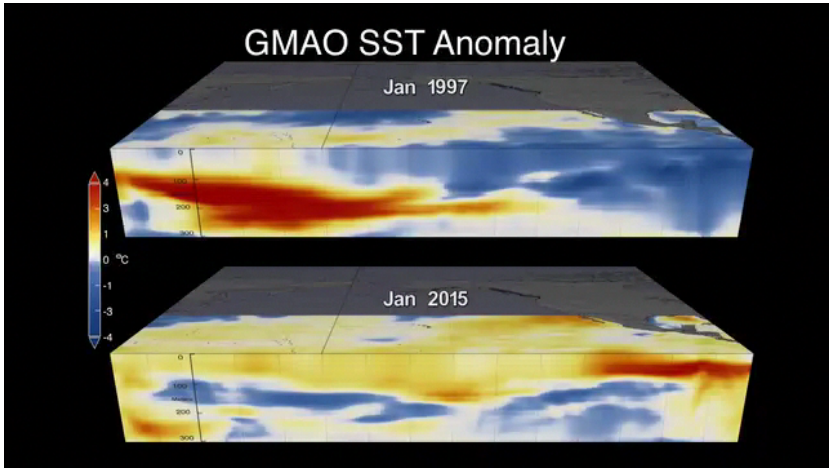
# CLIVAR

*Climate and Ocean: Variability, Predictability and Change*

Understanding the dynamics, the interaction and the predictability of the coupled ocean-atmosphere system

**Long term objectives:**

- Identify ocean and coupled **climate processes** that are critical for global and regional climate variability and change
- Identify temporal and spatial scales of **climate predictability**
- Quantify constrains on **climate sensitivity**, air-sea exchange and Earth's energy budget / ocean heat content
- Quantify **regional impacts** of climate change in **sea level, cryosphere and water cycle**
- Quantify past/present/future **ocean role in heat and $CO_2$ uptake** and links between **climate and ocean ecosystems**




El Nino comparison 1997 vs. 2015, NASA Visualization Lab

WMO IOC ICSU WCRP World Climate Research Programme

# GEWEX

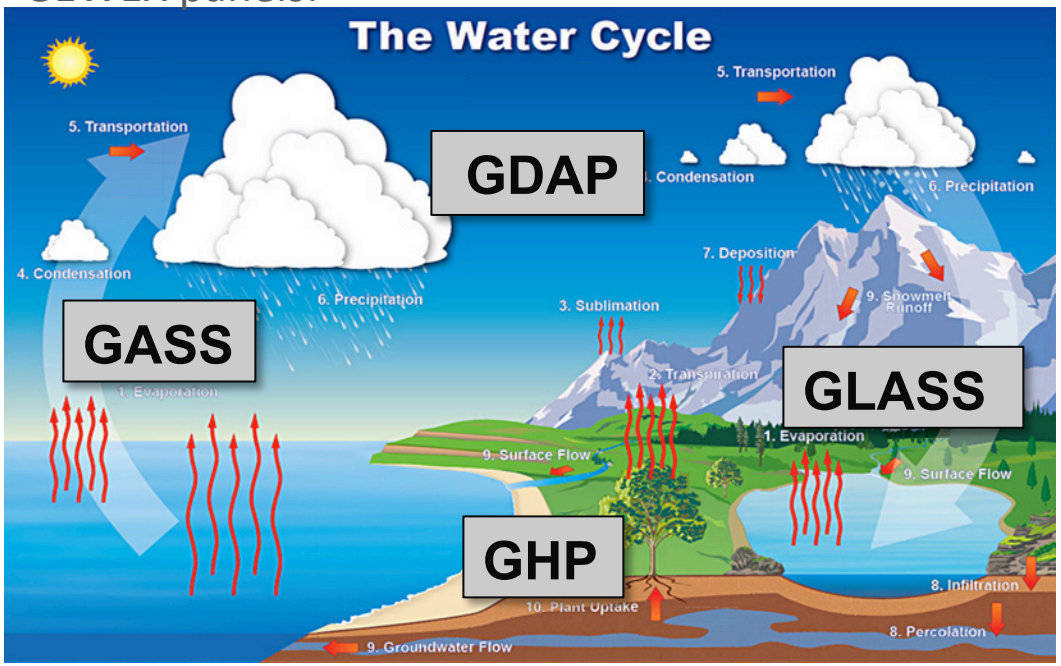
*Global Energy and Water cycle EXchanges project*

Understanding Earth's water cycle and energy fluxes at the surface and in the atmosphere

*GEWEX science questions:*

- Observations and predictions of **precipitation**
- Global **water resources** systems (land use and hydrology)
- Changes in **extremes** (esp. droughts, flood, heat waves)
- **Water and energy** cycles and processes

GEWEX panels:




Gobal Land/Atmosphere System Study (GLASS), Global Atmospheric System Studies (GASS), GEWEX Hydroclimatology Panel (GHP), GEWEX Data And Assesments Panel (GDAP). Modified from NASA Earth Observatory.

WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

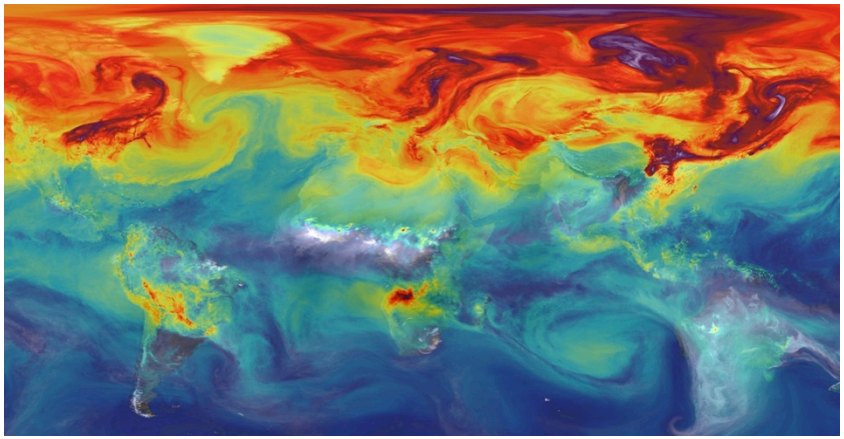
# SPARC

*Stratosphere-troposphere Processes And their Role in Climate*

Coordinating international efforts to bring knowledge of the atmosphere to bear on issues regarding climate variability and prediction

*Themes:*

- **Atmospheric Dynamics and Predictability**
  climate variability, near-term climate predictions, stratosphere-troposphere interactions
- **Chemistry and Climate**
  coupling of climate-dynamical-radiative processes, gas emissions
- **Long-term records for Climate Understanding**
  construction, analysis, and interpretation of long-term climate records



Global CO2 fluxes. Nasa Earth Observatory

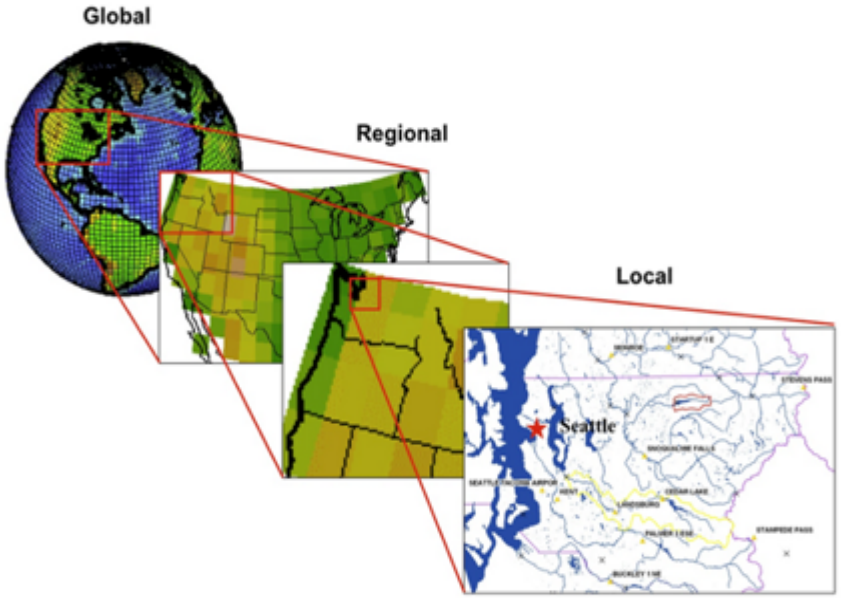
# CORDEX

*COordinated Regional climate Downscaling Experiment*

Advancing the science and application of regional climate downscaling, for improved regional climate information

*CORDEX scientific challenges:*

- **Added value** of downscaling, scales, bias and uncertainties, user-oriented metrics
- Understanding and simulating **human elements**, e.g. land use, urban development, climate and coastal cities
- Coordination of regional **coupled modeling**
- Precipitation, e.g. convective systems, monsoon
- Local wind systems

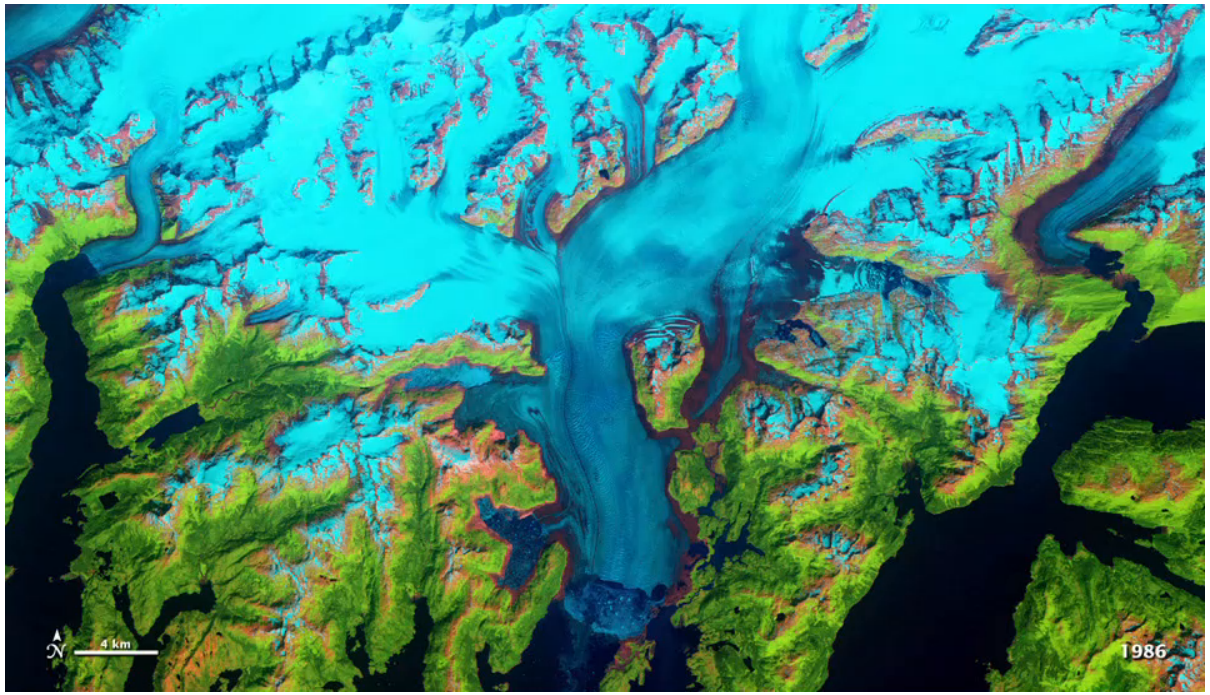



Model downscaling. NCAR dr. Andrew Wood

# Grand challenges


WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

# Melting Ice

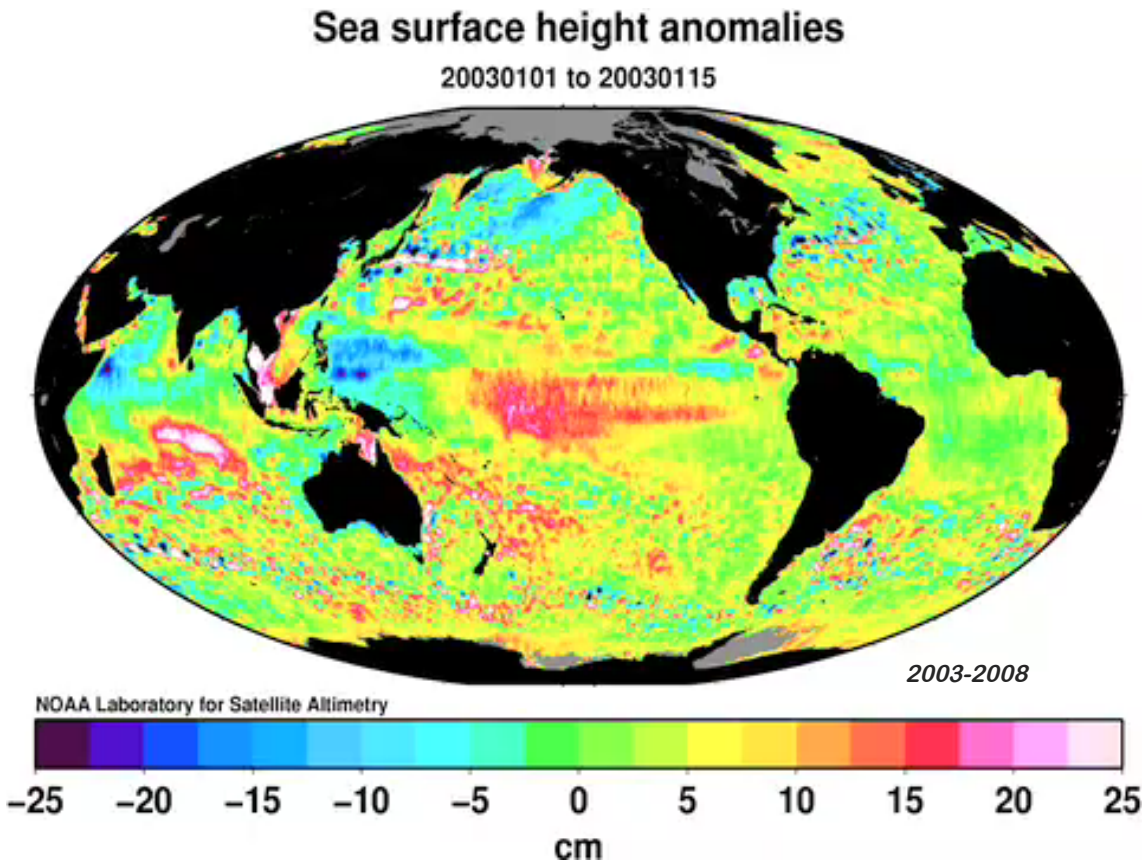



Columbia Glacier, Alaska
Snow and ice are seen as bright blue, while vegetation appears green and bedrock brown. Gray stripes on the glacier surface represent rocky debris. NASA visualization Lab

How will melting ice respond to, and feedback on, climate change and what will the impacts be on:

*- Permafrost and the global carbon cycle*
*- Ice sheets*
*- Glaciers*
*- Rising sea level*
*- Sea ice and snow interaction*

# Regional Sea Level Change

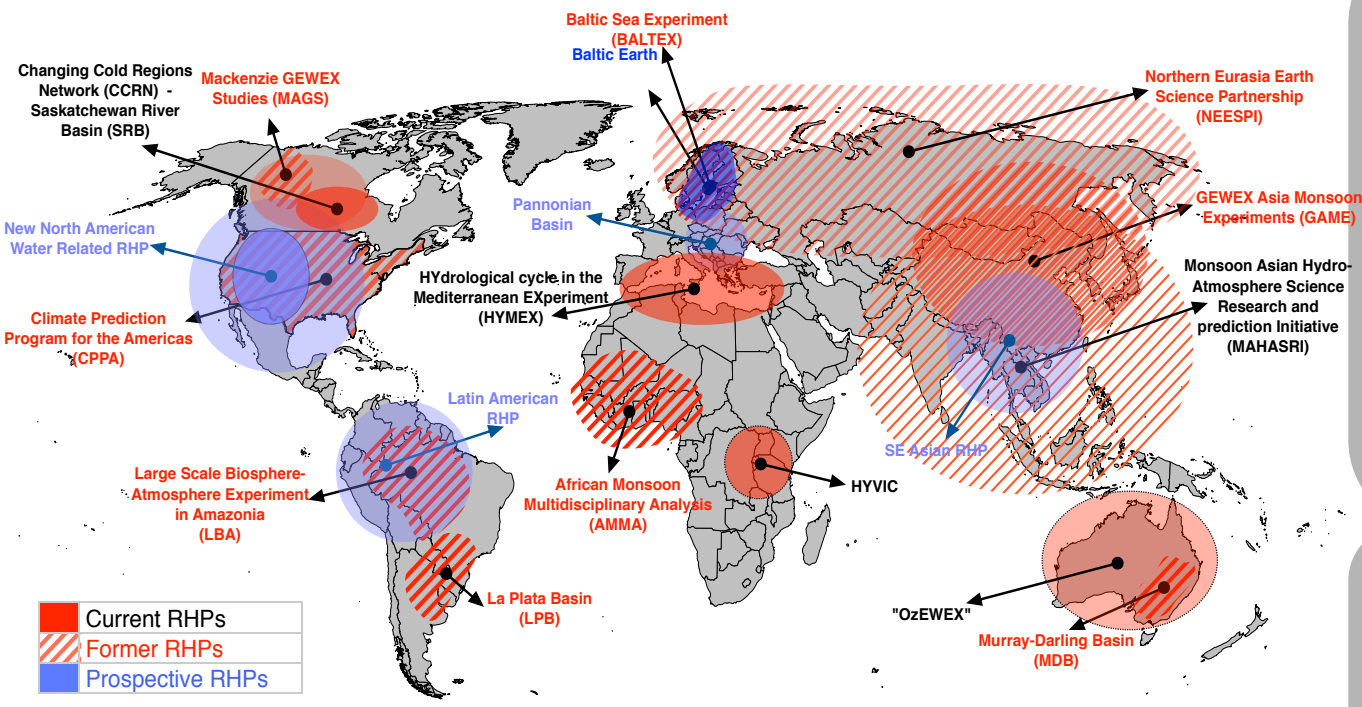



What are the main causes of contemporary regional sea level variability and change?

How predictable is sea level on a regional scale and how can we improve the predictability?

What is the contribution of land ice to near-future sea level rise?

# Water for Food Baskets




How will a warming world affect the available fresh water resources globally? (Focus on the geophysical processes and the anthropogenic influences on these processes)

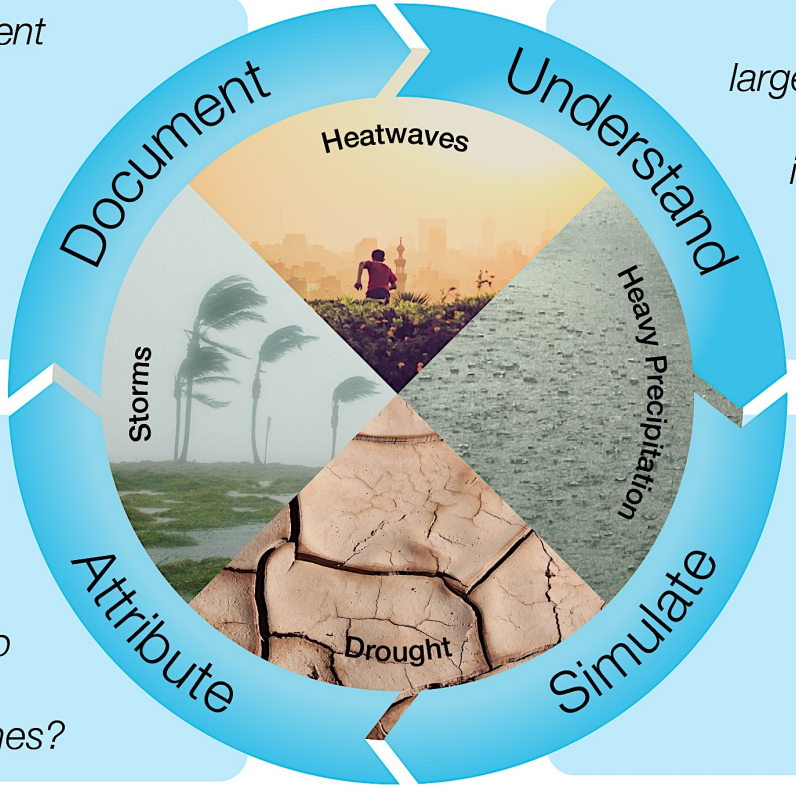
How does this translate specifically to the food basket regions of the world?

WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

# Climate & Weather Extremes

*Are existing observations sufficient to underpin the assessment of extremes?*

*What are the relative roles of large-scale, regional and local scale processes, as well as their interactions, for the formation of extremes?*

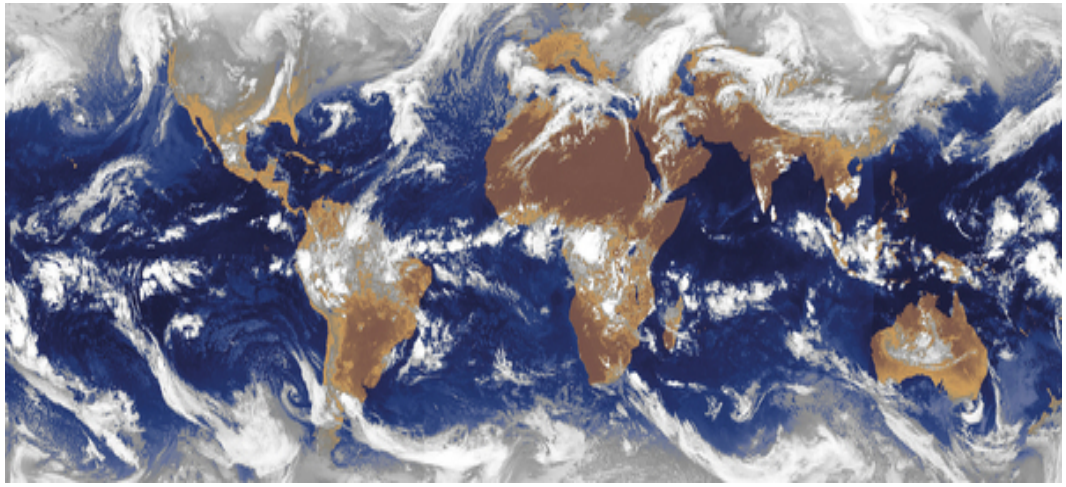



*What are the contributors to observed extreme events and to changes in the frequency and intensity of the observed extremes?*

*Are models able to reliably simulate extremes and their changes, and how can this be evaluated and improved?*

WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

# Clouds & Circulation

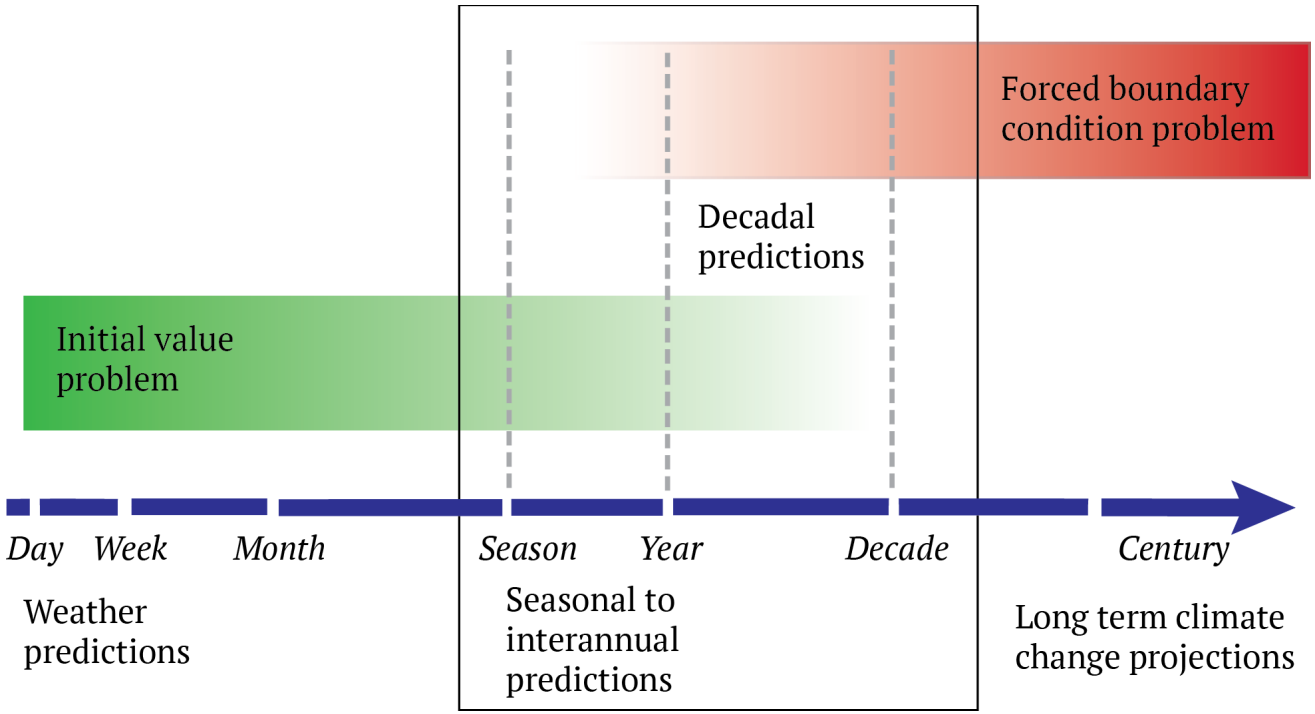


*NASA Earth Observatory*

How will clouds and circulation respond to global warming or other forcings?

How do clouds couple to circulations in the present climate?

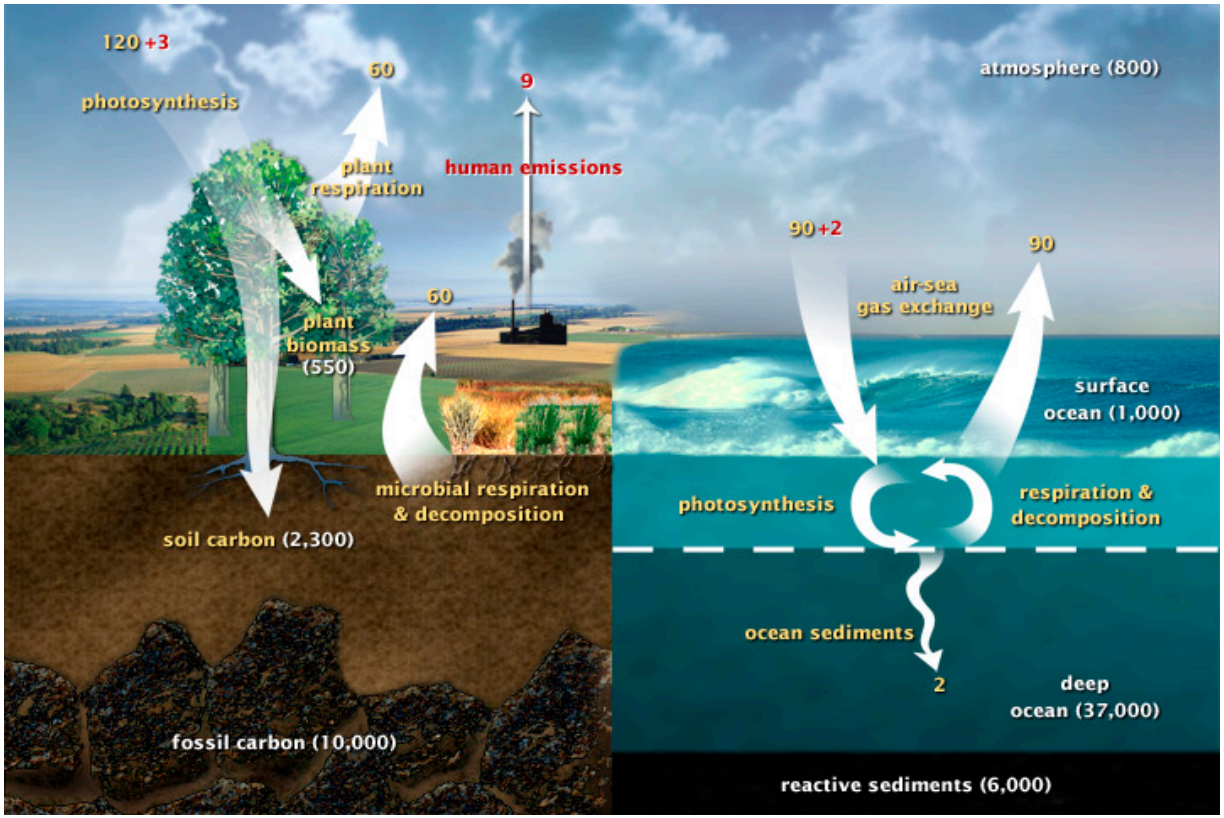
# Near Term Prediction




How can we enhance the understanding of sources of decadal predictability?

How can we serve decadal prediction information as is already done for seasonal prediction?

# Climate & Carbon




A conceptual illustration of the carbon cycle. NASA Earth Observatory.

What are the drivers of land and ocean carbon sinks?

What is the potential for amplification of climate change over the 21st century via climate-biogeochemical feedbacks?

How do greenhouse gases fluxes from highly vulnerable carbon reservoirs respond to changing climate?

# WDAC *WCRP Data Advisory Council*

To serve as a focal point for all observational and data matters across the programme

- ***Promote open data policies***, protocols and standards across the programme
- ***Recommend best practices*** for ECV data set development and assessments
- ***Coordinate reanalysis intercomparison efforts***
- Promote and publish observational and reanalysis data sets to support climate modeling
- Coordinate flux research and promote development of associated data sets
- Review adequacy of observations and data assimilation techniques
- Sponsor ***International Data Prize***

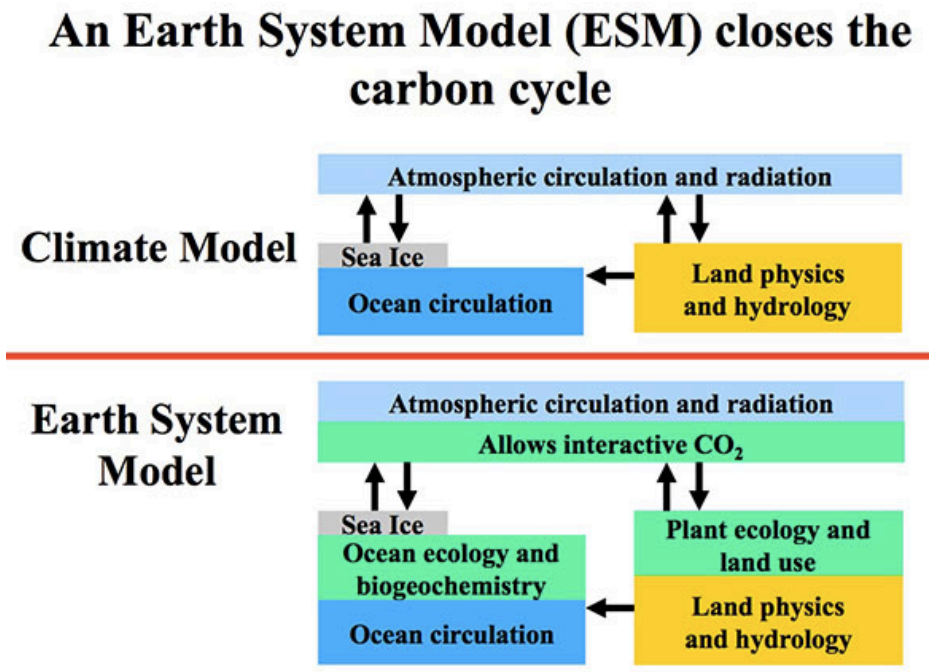


WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

# WMAC *WCRP Modelling Advisory Council*

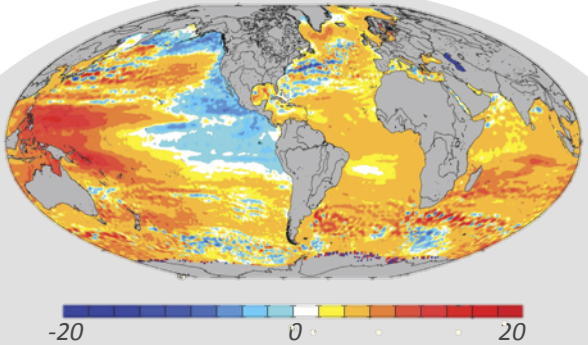
To coordinate high-level aspects of modelling across WCRP, and act as a single entry point for all WCRP modelling activities

- ***Review modelling issues*** and advise the JSC on strategic matters
- ***Promote seamless approaches*** across timescales and towards Earth System Models
- Organization of Model Development Schools
- Develop model development training material
- ***WCRP-WWRP International Prize for Model Development***



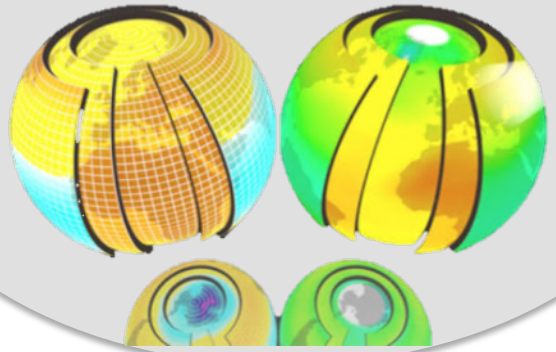
# Working groups

Numerical Experimentation
WGNE

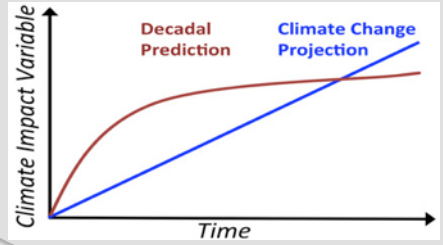



Regional Climate
WGRC

WGCM
Coupled modeling



WGSIP
Subseasonal to Interdecadal Prediction

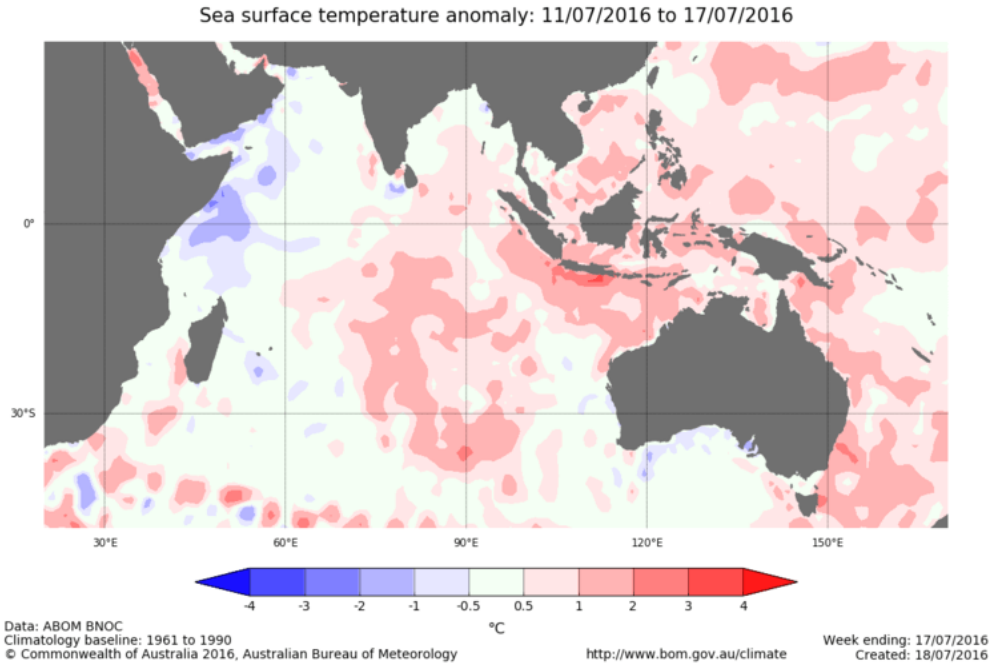



WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

# WGRC *Working Group on Regional Climate*

Prioritize and coordinate regional climate research within WCRP

- Regular ***assessment*** of regional activities across WCRP
- ***Guidance on the development***, implementation and progress of regional climate projects to emphasize the role of those activities as scientific ***contributions to climate services***
- ***Facilitating and promoting regional activities*** that advance research and capacity development




Indian Ocean sea surface temperature anomalies, relative to 1961-90 average. Bureau of Meteorology, Author provided.

WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

# WGSIP *Working Group on Subseasonal to Interdecadal Prediction*

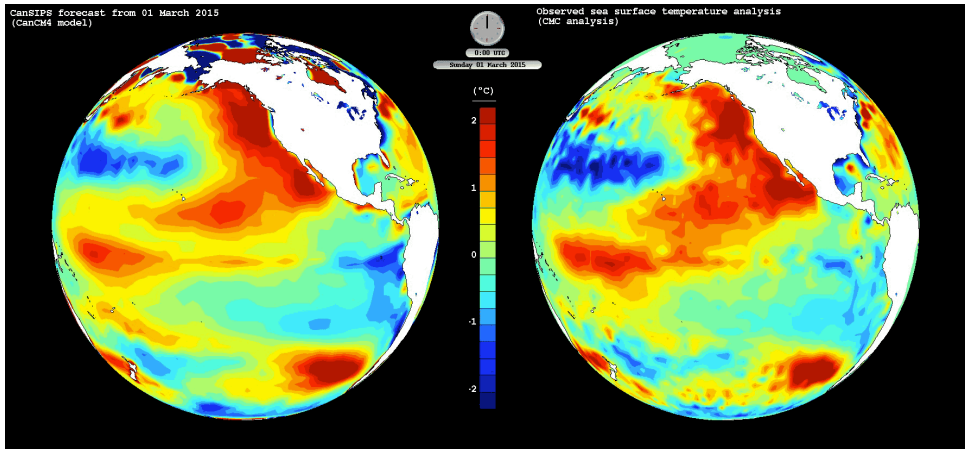
Advancing research in subseasonal to interdecadal prediction and its societal applications

*Principal aims and activities:*

- Developing a programme of ***numerical experimentation*** for climate variability and predictability over a range of time scales, with an emphasis on ***assessing and improving predictions***
- Evaluating data assimilation, model initialization and forecasting procedures for ***initialized climate predictions***

**Predicted daily SST anomalies 1 Mar 2015 – 28 Feb 2016 (CanCM4 model)**

**Observed daily SST anomalies 1 Mar 2015 – 6 Nov 2015 (CMC analysis)**




WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

# WGNE *Working Group on Numerical Experimentation*

fostering the development of atmospheric circulation models for use in weather prediction and climate studies on all time scales

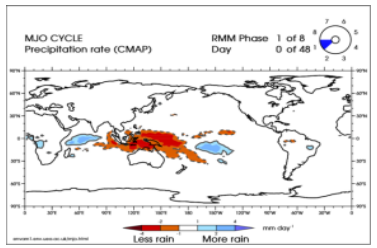
*Objectives are achieved through:*

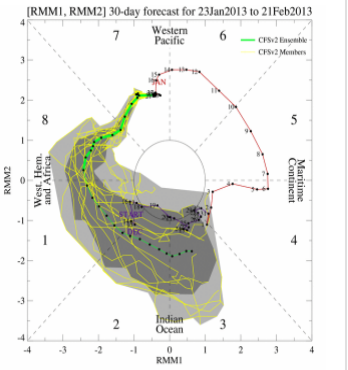
- Identification of ***systematic errors*** common to many models.
- Sharing ***diagnostic tools and techniques*** to get to the root of the error.
- Sharing knowledge around ***sensitivity of errors to model formulation*** (parametrizations, dynamical core, etc.).
- Work with other groups (e.g. GASS & GLASS) to ***develop solutions***.

***Cases of strong or persistent events of aerosol pollution studied by the WGNE Aerosols project***


1) Dust over Egypt: 4/2012 2) Pollution in China: 1/2013 3) Smoke in Brazil: 9/2012

***Real time index forecast activity using 20 forecast models***



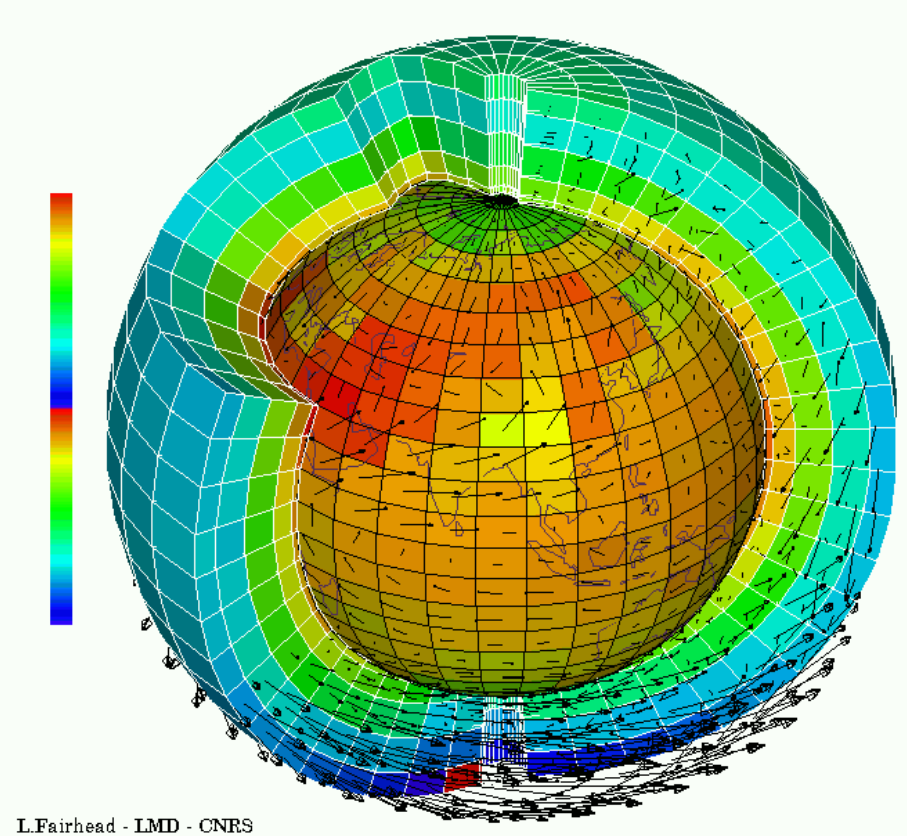




WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

# WGCM *Working Group on Coupled Modeling*

To foster the development and review of coupled climate models

- Organisation of ***model intercomparison projects***
- ***Enhancing understanding*** natural climate variability and predictability on decadal to centennial time scales
- ***Enhancing predicting*** the response of the climate system to changes in natural and anthropogenic forcing




WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

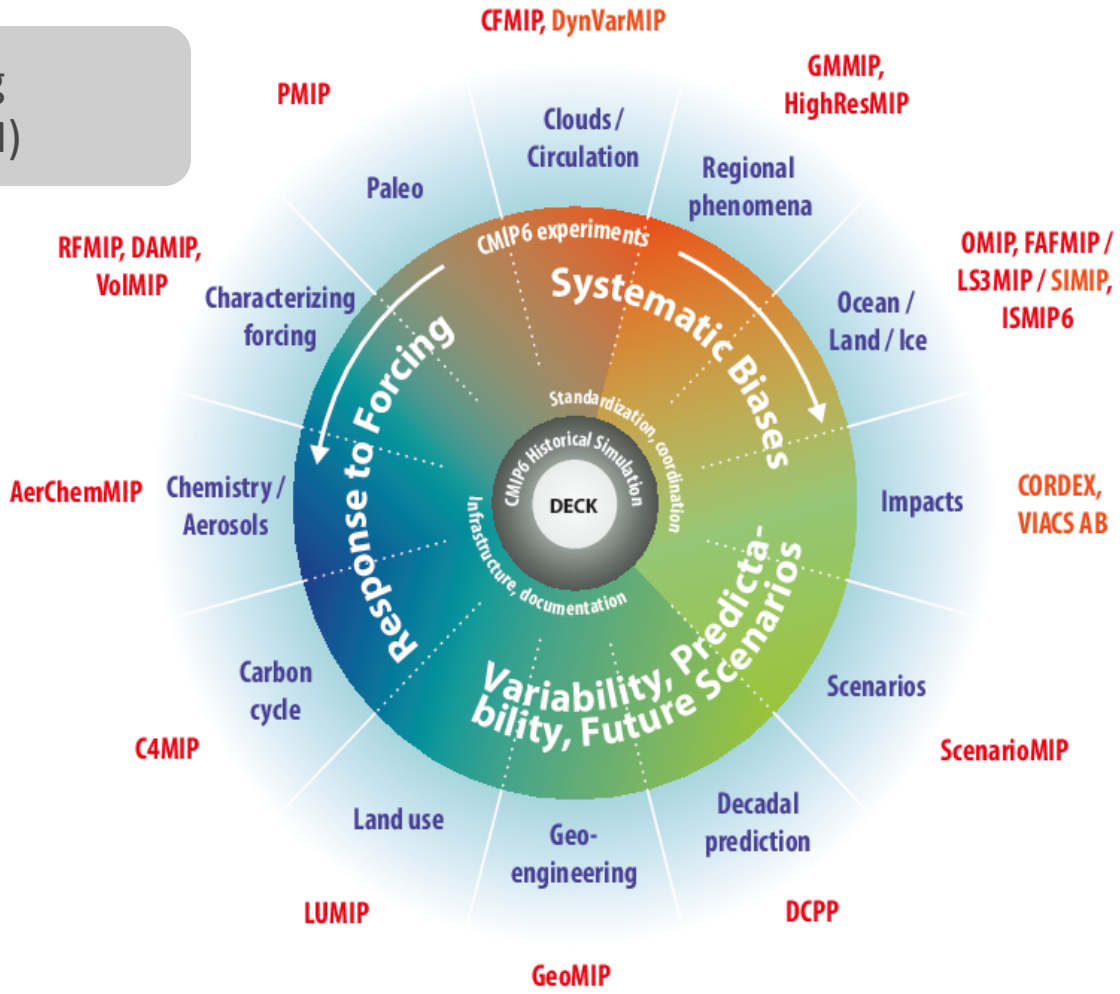
# CMIP

*Coupled Model Intercomparison Project*

CMIP is a project of WCRP's Working Group on Coupled Modeling (WGCM)

CMIP has led to an improved understanding of past, present and future climate change and variability in a multi-model framework

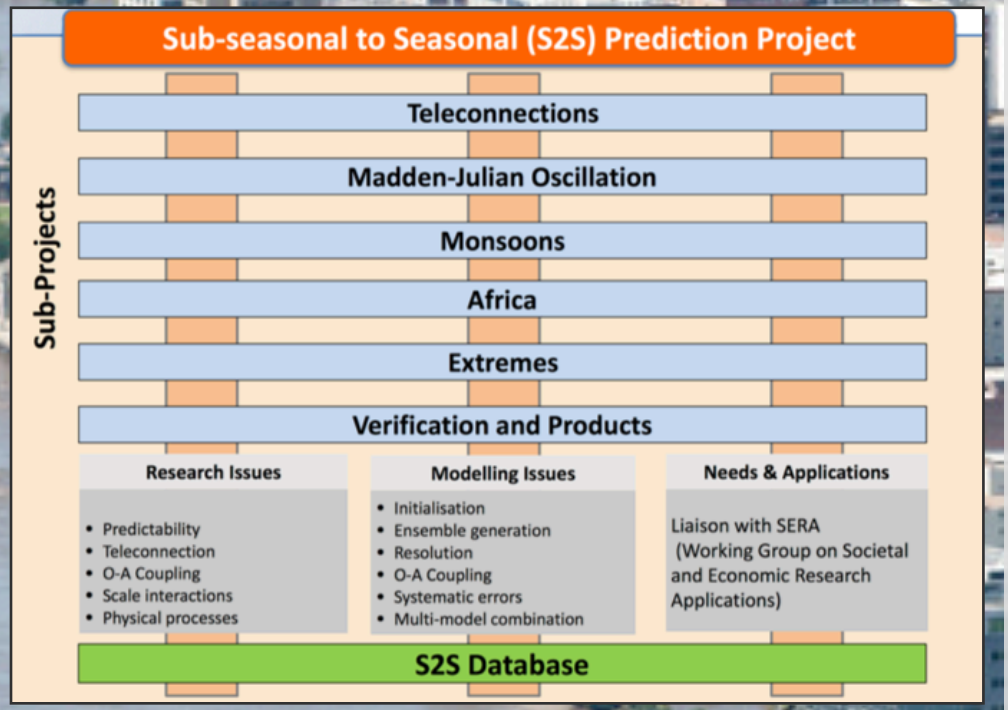
CMIP defines common experiment protocols, forcings and output




**21 CMIP6-Endorsed MIPs**

WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

# Sub-Seasonal to Seasonal Prediction (S2S)




- ***Improve forecast skill and understanding on the sub-seasonal to seasonal timescale*** (2 weeks to a season) with special emphasis on high-impact weather events
- ***Promote the initiative's uptake*** by operational centres and exploitation by the applications community
- ***Expertise from weather and climate research communities*** and link to Global Framework for Climate Services

- The S2S Database, hosted by ECMWF & CMA, contains 10 models
- International Coordination Office hosted by KMA: http://s2sprediction.net

WCRP World Climate Research Programme

# POLAR CHALLENGE

## CONTEXT

The cryosphere plays a fundamental role in the climate system. We need much better monitoring and prediction capabilities for the polar regions.

## CHALLENGES AND OPPORTUNITIES

Polar observations are expensive, risky and sparse. We can expand AUVs' endurance, navigation and communication capabilities to operate under the sea ice.

## VISION

A cost-effective, sustainable and autonomous polar ocean monitoring system to drive a new era for climate research and services.

Be the first to complete a 2000 km continuous mission with an Autonomous Underwater Vehicle (AUV) under the sea ice.

500K €

ompete for the Prize!
Become a co-sponsor!
www.wcrp-climate.org/polarchallenge

Co-sponsors:

WMO · Environment Canada · Environnement Canada · WWRP · esa · GCOS · GEO Group on Earth Observations · SCOR · IOC

Endorsed by: IASC · SCAR

Industry Partners: Wildlife Computers

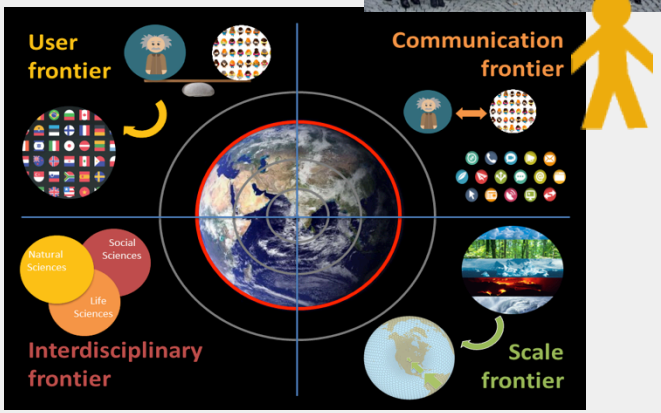
WMO · IOC · ICSU International Council for Science

WCRP World Climate Research Programme

# Capacity development

- Empower ***long-term achievements*** in climate research, promoting current and ***future leadership*** in climate research
- Stimulating ***opportunities*** corresponding to ***specific regional requirements***

*Early career researchers' perspective on future challenges:*





WCRP-JNU Training school on Monsoon Variability (Jan '17)

ICRC CORDEX ECS side event (May '16)


CLIVAR ECS Symposium (Sept '16)

CLIVAR ECS Poster Competition (Sept '16)

YHS

YESS community

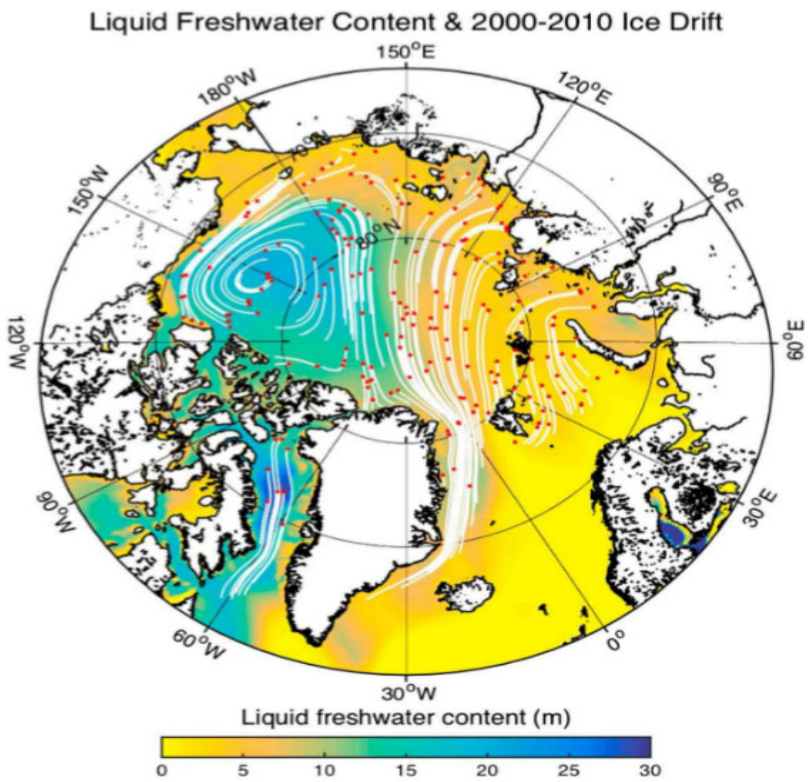
APECS NL Association of Polar Early Career Scientists

WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

# WCRP science findings

*Arctic freshwater*

## Arctic freshwater is expanding and changing




- Arctic freshwater domain expanded, both for the oceans and land
- New freshwater regimes developed
- An un-quantified moisture flux detected, due to the loss of Arctic freshwater ice cover
- Increase of the benefits of freshwater-based resource activities

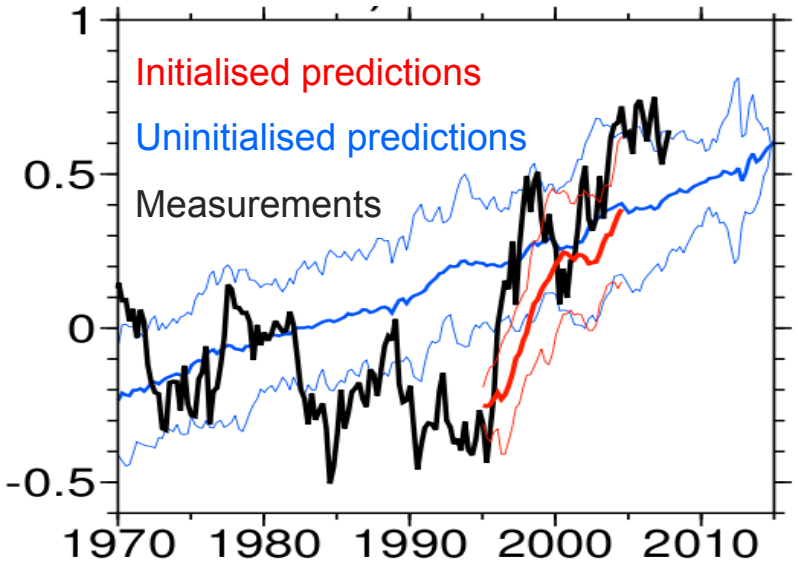
CliC Climate and Cryosphere

WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

# WCRP science findings

*Ocean warming & impacts on hurricanes and rainfall*

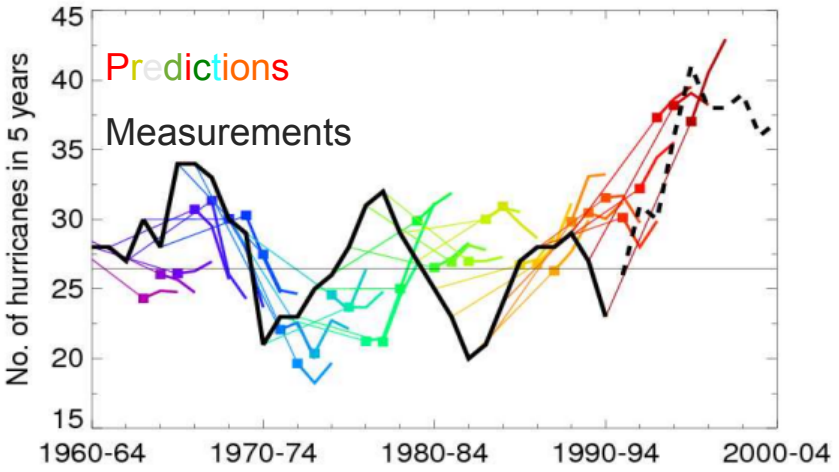
Change in Ocean Temperature in North Atlantic
Predicting the warming event in 1990s



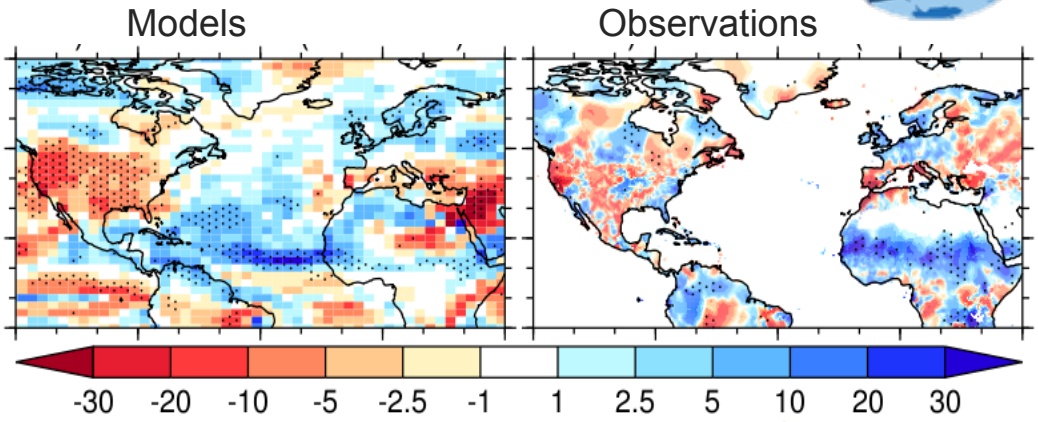

→ **Initialised decadal predictions for ocean warming show good skill**

→ **Higher predictiablilty for hurricanes than for rainfall**

## Hurricanes



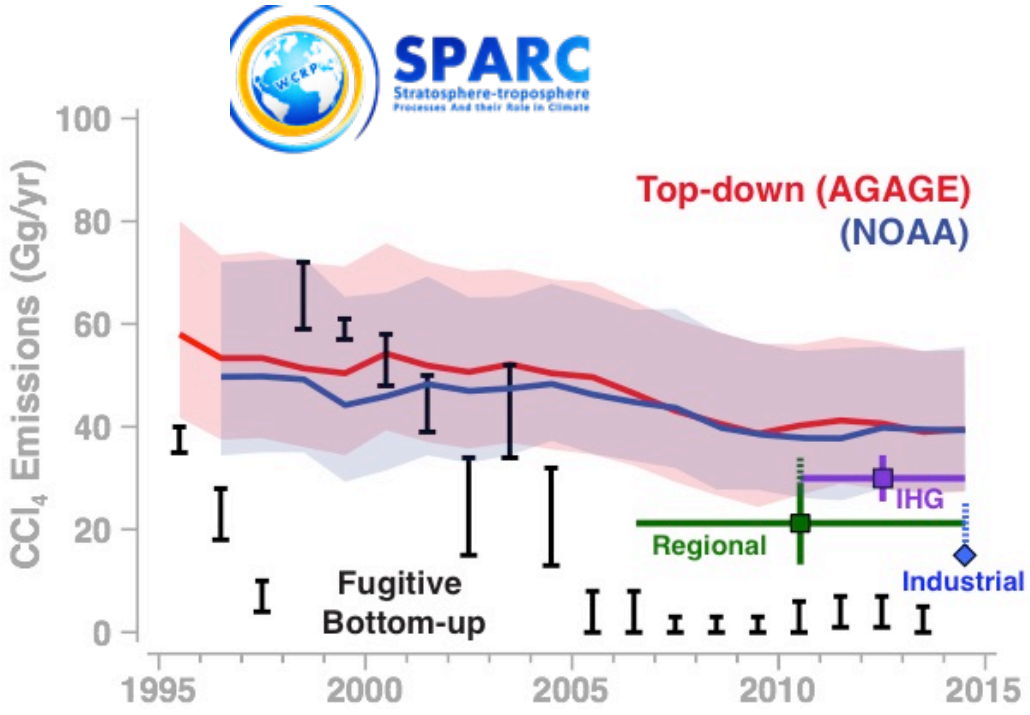

## Rainfall




WMO IOC ICSU WCRP World Climate Research Programme

# WCRP science findings

*Solving the Mystery of Carbon Tetrachloride*




- Disagreement between reported (bottom-up) and calculated (top-down) $CCl_4$ emissions since 1999
- Multi-disciplinary activity using innovative analysis techniques and new observations
- Total lifetime of $CCl_4$ updated
- New emissions estimates (reported + unreported inadvertent industrial emissions) agree within the uncertainty range

**Policy Relevant**: Direct response to stakeholder needs (Parties to the Montreal Protocol)

# WCRP in the global community


Thank You
WCRP
World Climate Research Programme
WMO
IOC
ICSU
International Council for Science
www.wcrp-climate.org
You Tube

# WORLD CLIMATE RESEARCH PROGRAMME

*Name – WCRP*
*Date etc.*

WMO IOC ICSU International Council for Science WCRP