WORLD CLIMATE RESEARCH PROGRAM

YESS/YHS ECR Workshop
WCRP GEWEX Open Science Conference

ABOUT

WATER, ENERGY, & CLIMATE

Global Energy and Water EXchanges

A Core Project of the

World Climate Research Programme

GEWEX

WCRP
World Climate Research Programme

WCRP and Future Science Leaders

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

Support in 2017 for:

Hundreds of early career and senior researchers from **46** countries

70 international conferences, meetings and workshops, including **6** summer schools

YHS

APECS Association of Polar Early Career Scientists

WMO

WCRP World Climate Research Programme

Future of ECR Networks

- WCRP and global partners urge all ECR networks to be **vehicles to identify and pursue new science agendas**…!
- Ongoing ECR activities at WCRP - **how** do you/we enhance and validate quality science input from the ECRs to WCRP core activities?
- Events, conferences, workshops - is this the only way to consolidate ECR input to the international science coordination? **What** can be future ways to embed ECRs in WCRP activities?
- Should there be a systematic approach to realise (and contribute to) cross-cutting activities of WCRP groups and with partners, through the interaction among ECR networks?

ABOUT
WATER, ENERGY & CLIMATE

Outline

Part I: WCRP GEWEX Science & Structure
Part II: Showcase - GEWEX Challenges
Part III: Showcase - WCRP Grand Challenges
"Water for the Food Baskets of the World"
"Extremes"

GEWEX

WCRP
World Climate Research Programme

PART I: WCRP GEWEX Science & Structure

What We Do

The Global Energy and Water EXchanges (GEWEX) project of the World Climate Research Programme (WCRP) facilitates, enables, coordinates international climate and related research activities with an emphasis on land – atmosphere processes and interactions.

From sub-surface processes related to hydrology to atmospheric processes including interactions between the troposhere and the stratosphere as well as the human dimension

GEWEX

WCRP Structure

Joint Scientific Committee

Joint Planning Staff

Modeling Advisory Council

Data Advisory Council

Working Groups on: Numerical Experimentation (WGNE), Subseasonal to Interdecadal Prediction (WGSIP), Coupled Modeling (WGCM), Regional Climate (WGRC)

CliC	CLIVAR	GEWEX	SPARC	CORDEX
Cryosphere	Ocean-Atmosphere	Land-Atmosphere	Troposphere - Stratosphere	Regional Climate Downscaling

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CliC | CLIVAR | GEWEX | SPARC | CORDEX

- Melting Ice & Global Consequences
- Regional Seal Level & Coastal Impacts
- Water for Food Baskets
- Weather & Climate Extremes
- Clouds, Circulation & Climate Sensitivity
- Near-Term Prediction (Decadal)
- Carbon & Climate

World Climate Research Programme

GEWEX Focus

Water & Energy (and Carbon) – People & Environment

- **Water is a local 'challenge' driven by global processes**
- **GEWEX focuses on improved understanding of the relevant geophysical processes of water and energy and the human interaction therein to better model and predict changes**
- **Water and Energy Security are intrinsically related to Food Security – The Water-Energy-Food Nexus -> PEOPLE**

ICSU-WMO-IOC Review recommendations *(partial)*

EARTH SYSTEM PROCESSES ACROSS SCALES
Jointly with WWRP

Energy, Water and Carbon Cycles;
Fundamental Atmospheric Physics (e.g. Convection);
Land-Atmosphere Coupling;
Ocean-Atmosphere Coupling; Cryosphere Processes

CLIMATE VARIABILITY, PREDICTABILITY & PREDICTION

Ocean, Land, Cryosphere; Atmosphere & Solar Drivers;
Climate Dynamics, Modes of Variability & Teleconnections; Monthly to Decadal Predictability & Prediction

CLIMATE CHANGE AND EARTH SYSTEM FEEDBACKS
Jointly with AIMES

Climate Change Forcing & Sensitivity; Climate Change Attribution; Climate Change Projections (Global & Regional) for Mitigation & Adaptation; Abrupt Climate Change; Geoengineering Assessment

WCRP Strategic Plan 2019-2029 (Draft)

1) Understanding the climate system

2) Determining predictability on weekly to decadal timescales

3) Determining projectability on decadal to centennial time scale

4) Connecting climate science to policy and decision making

The GEWEX Approach is

An integrated approach to quantify links between energy & water and critical Earth System feedbacks that result. The approach involves:

- Stewardship of observations, observing system assessment & definition
- Advance process understanding fundamental to hydrological & hydrometeorological ap[illegible] and to climate change
- Promote improvement in global, regional and process level modeling, in obs analysis and observing system definition

GEWEX

Two Big Science Questions that motivate GEWEX & we are encroaching more & more onto a third

- ❑ *Where does the heat go?*
- ❑ *How is the fresh water on the planet changing?*
  - ❑ *Where does the carbon go?*

3 fundamental 'reservoir' questions

GEWEX

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3 fundamental 'reservoir' questions

- ❑ *How does the weather change with climate?*
- ❑ *How does climate influence the habitability of the Earth and its regions?*

from 'Climate research must sharpen its view'

GEWEX

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3 fundamental 'reservoir' questions

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Seamlessness, basic weather system research and Earth system predictability and prediction all intimately tied to circulation

from 'Climate research must sharpen its view'

GEWEX

GEWEX MISSION

ABOUT
WATER, ENERGY & CLIMATE

To measure and predict global and regional energy and water variations, trends, and extremes (such as heat waves, floods and droughts), through improved observations and modeling of land, atmosphere and their interactions; thereby providing the scientific underpinnings of climate services.

World Climate Research Programme

Sponsored by the World Meteorological Organization, the International Council for Science and the Intergovernmental Oceanographic Commission of UNESCO.

- **The WCRP Mission: 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 the WCRP are:**
- **1) *to determine the predictability of climate*, and**
  2) *to determine the effect of human activities on climate*
- **Progress in understanding climate system variability and change makes it possible to address its predictability and to use this predictive knowledge in developing adaptation and mitigation strategies. Such strategies assist the global communities in responding to the impacts of climate variability and change on major social and economic sectors including food security, energy and transport, environment, health and water resources.**

Changing

WCRP Review: A New Framework in Development – Under Construction

WMO/IOC

GLOBAL CLIMATE OBSERVATIONS, ANALYSES & MONITORING

ECVs; Climatologies; (Coupled) Global & Regional Reanalyses; Climate Change Detection

WCRP CAPABILITY THEMES

EARTH SYSTEM PROCESSES ACROSS SCALES
Jointly with WWRP

Energy, Water and Carbon Cycles; Fundamental Atmospheric Physics (e.g. Convection); Land-Atmosphere Coupling; Ocean-Atmosphere Coupling; Cryosphere Processes

CLIMATE VARIABILITY, PREDICTABILITY & PREDICTION

Ocean, Land, Cryosphere, Atmosphere & Solar Drivers; Climate Dynamics, Modes of Variability & Teleconnections; Monthly to Decadal Predictability & Prediction

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WCRP CROSS-CUTTING RESEARCH PROJECTS *(on occasions with WWRP, Future Earth....)*

Examples: Regional Sea Level Rise, Coastal Impacts and Cities,
Weather and Climate Extremes, now and in the future
Water Cycle and the Food Baskets of the World
Fate of the Antarctic and Greenland Icesheets
Is the Jet Stream changing its Behaviour?
Climate Change and Human Health

WCRP WORKING GROUP ON CLIMATE MODEL DEVELOPMENT *jointly with WGNE*

Identifying Systematic Errors; Improving Climate Models & Building Next Generation Earth System Models; Planning for Exascale Computing

WCRP WORKING GROUP ON CLIMATE INFORMATION FOR REGIONS

Regional downscaling methods; Application-inspired Climate Science; Transdisciplinary Engagement

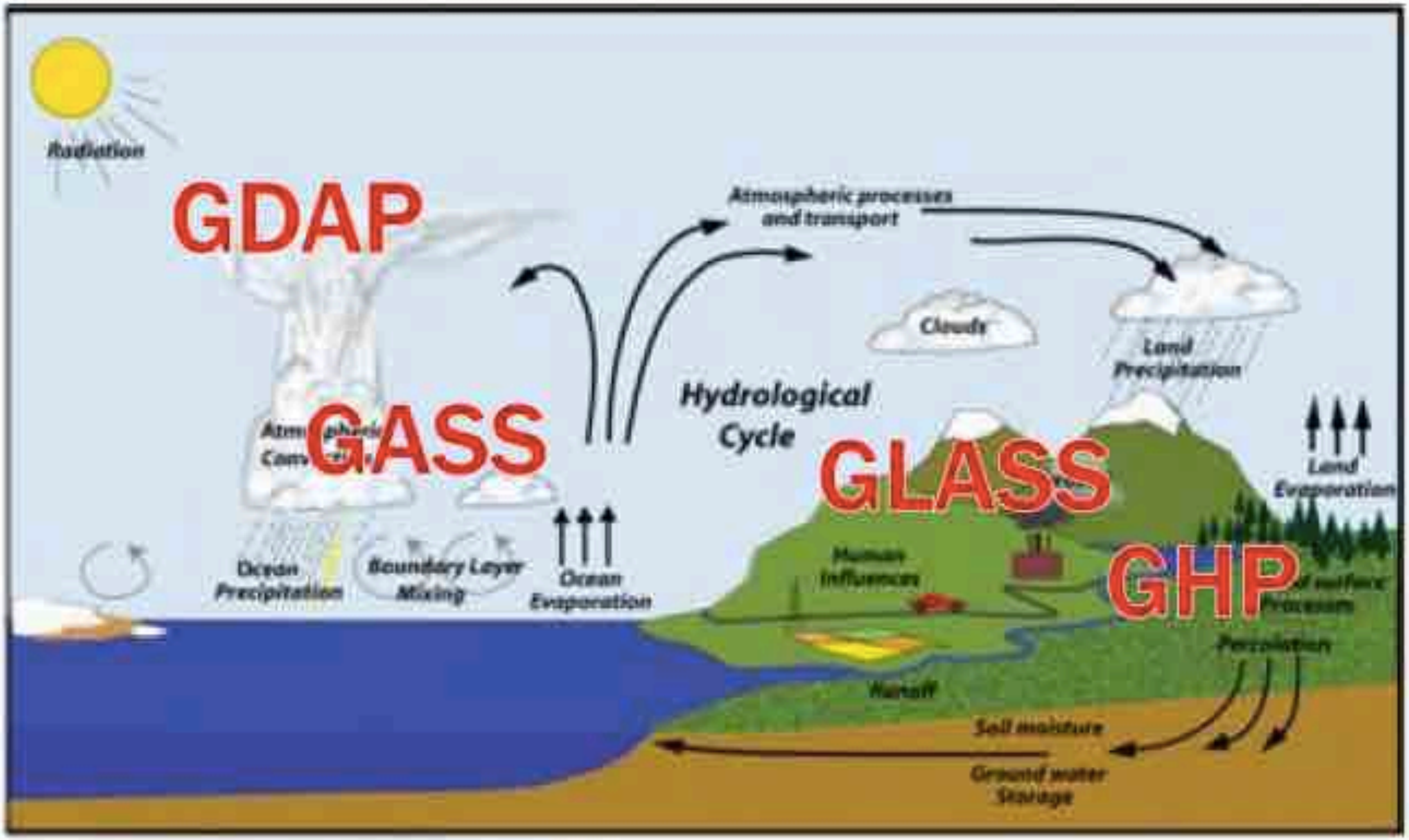
WMO/ICSU

GLOBAL ATMOSPHERIC COMPOSITION

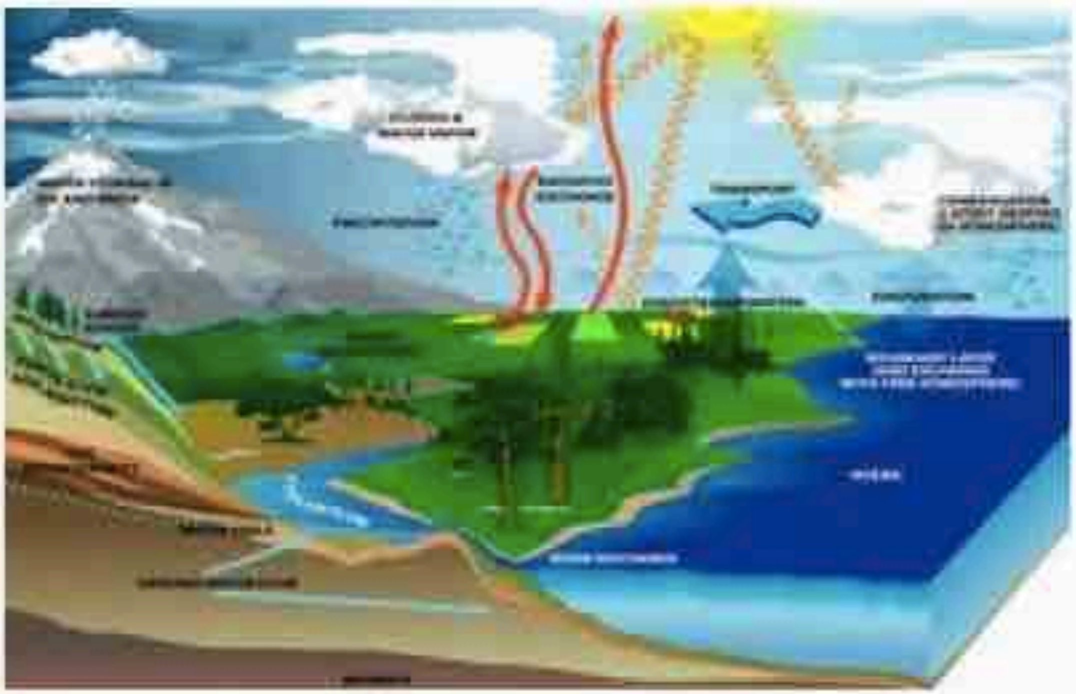
GHG Monitoring; Air Quality Prediction; Atmospheric Chemistry Processes & Modelling

CLIMATE CHANGE ASSESSMENTS AND CLIMATE SERVICES (UNFCCC, IPCC, GFCS, Copernicus, VIACS, ...)

GEWEX: Major Components



The GEWEX Approach : Fundamentally addresses its goals framed around the activity of its four main core projects and cross-cut projects (like PROES)



GASS: Global Atmospheric System study

GLASS: Global Land System Study

GDAP: GEWEX Data Analysis Panel

GHP: GEWEX Hydroclimatology Panel

Four GEWEX Science Questions

For the next 5 to 10 years

1	Observations and Predictions of Precipitation
2	Global Water Resource Systems
3	Changes in Extremes
4	Water and Energy Cycles and Processes

GEWEX

Four GEWEX Science Questions

For the next 5 to 10 years

1 *How can we better understand and predict precipitation variability and changes*

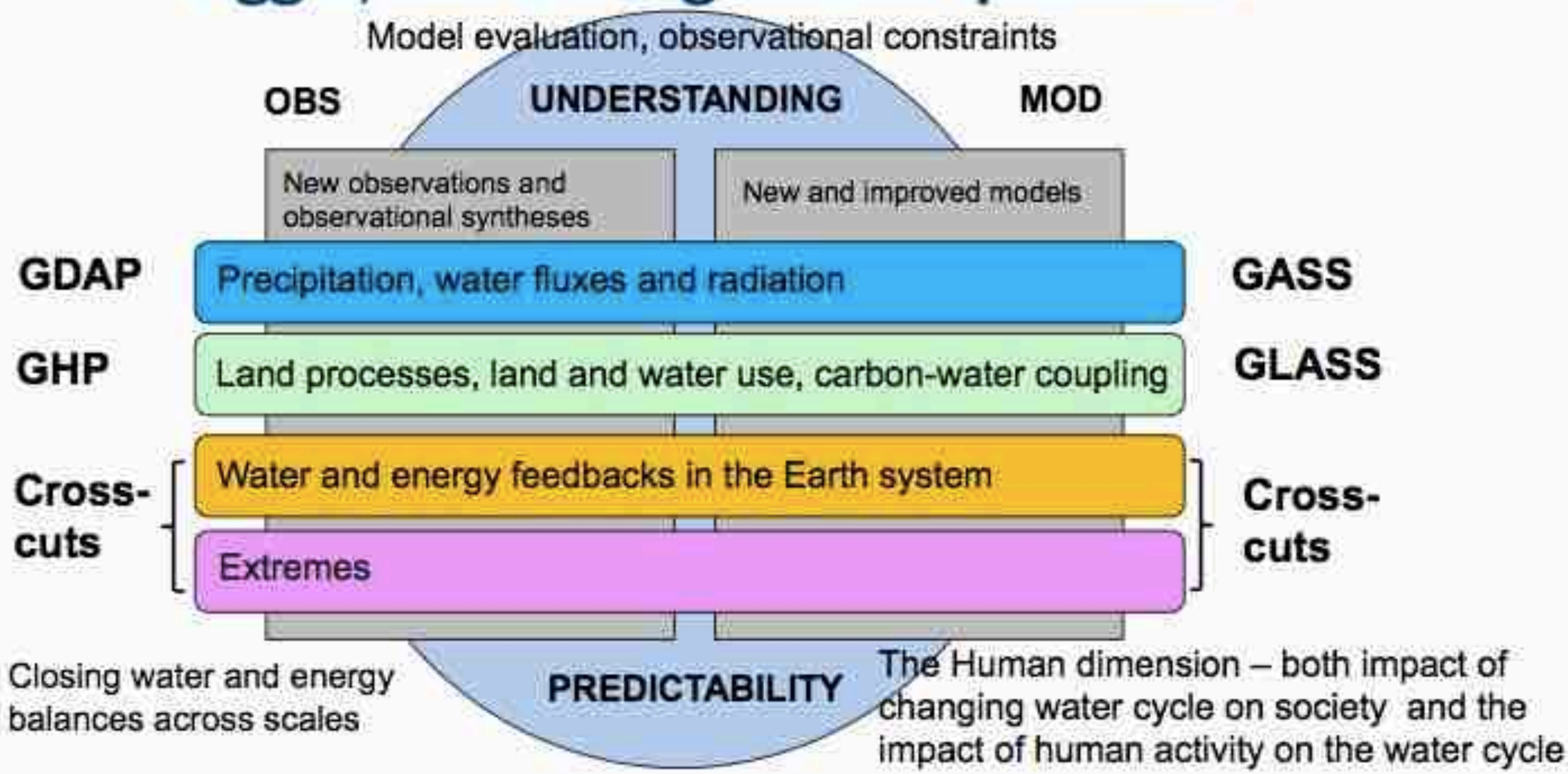
2 *How do changes in land surface and hydrology influence past and future changes in water availability and security?*

3 *How does a warming world affect climate extremes, esp. droughts, floods, and heat waves, and how do land area processes, in particular, contribute?*

4 *How can understanding of the effects and uncertainties of water and energy exchanges in the current and changing climate be improved and conveyed?*

GEWEX

The 4 GEWEX Science Questions sit under these bigger, overarching science questions



GEWEX

GEWEX Imperatives

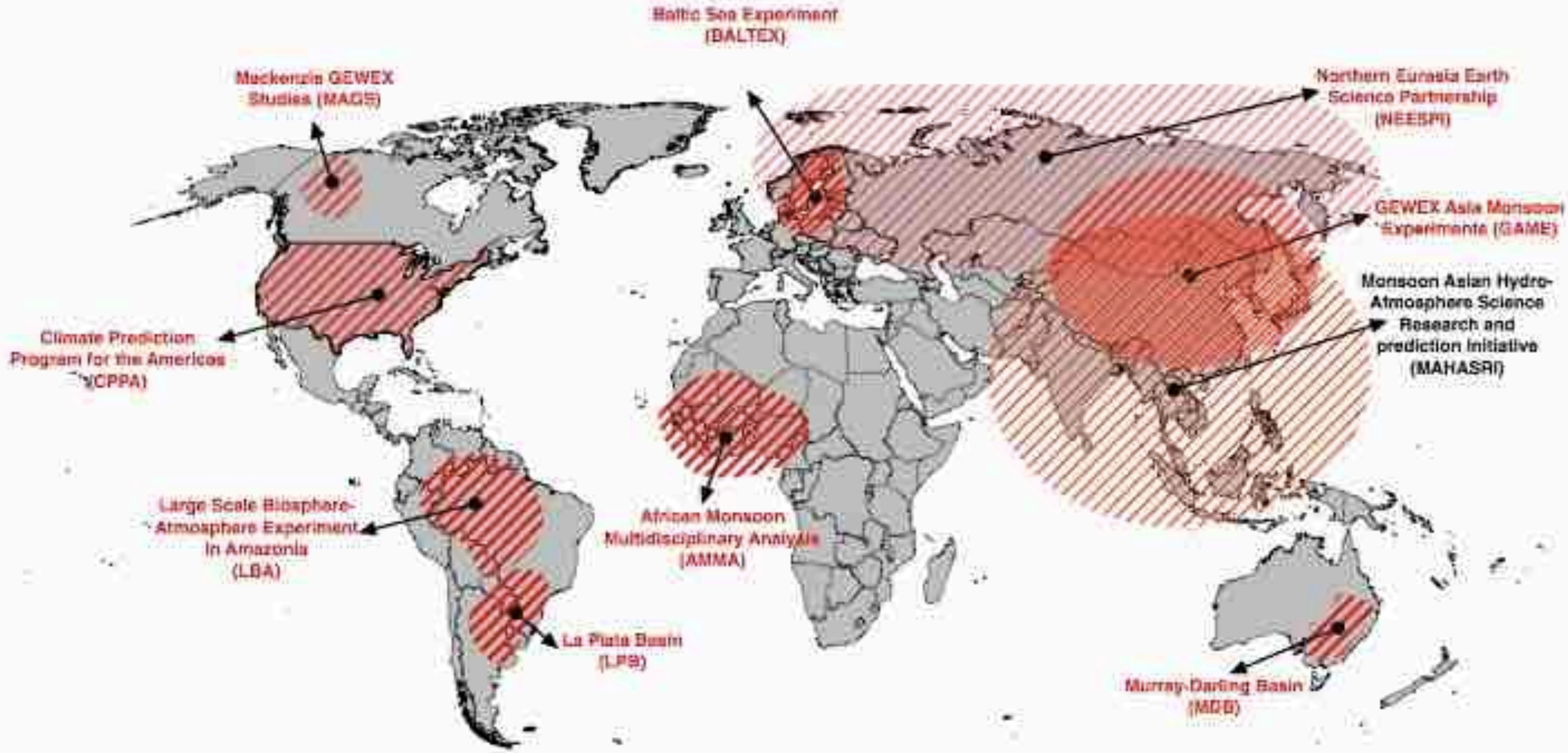
The Imperatives – things that must be done - provide a strategic view of GEWEX activities for 15 years beyond 2013. They form the framework for a more focused set of GEWEX Science Questions (GSQs) whose main focus is on the 5-10 year period from 2013-2022.

GEWEX Imperatives

Datasets	1	Applications	5
Analysis	2	Technology Transfer	6
Processes	3	Capacity Building	7
Modeling	4		

A Global Perspective - Regional Foci

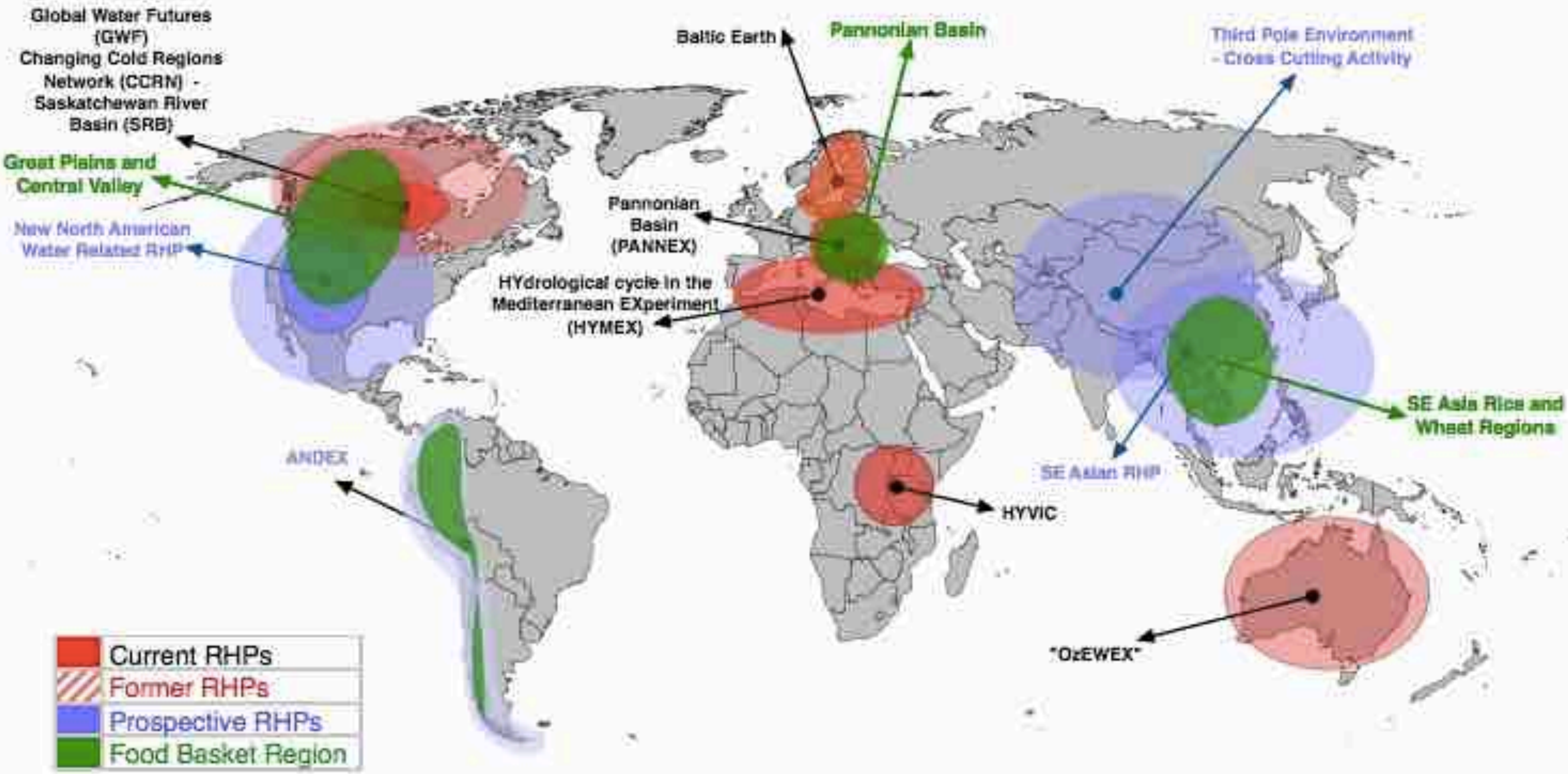
From CSEs to RHPs: 1991 – 2017 Past CSEs and RHPs



CSE: Continental Scale Experiment
RHP: Regional Hydroclimate Project

GEWEX

Regional Hydroclimate Projects



2018 Current and Prospective RHPs

GEWEX

The Pannonian basin (Initiating RHP)

- Since the 19th century flood control measures were introduced along the Danube and its tributaries
- Fields were drained to make them arable.
- The Danube was developed as a waterway (Tiza river was shortened by 453km between 1846 and 1880).

Blue regions used to be floodplains !

GEWEX

A Regional Hydroclimate Project for the Rocky Mountains

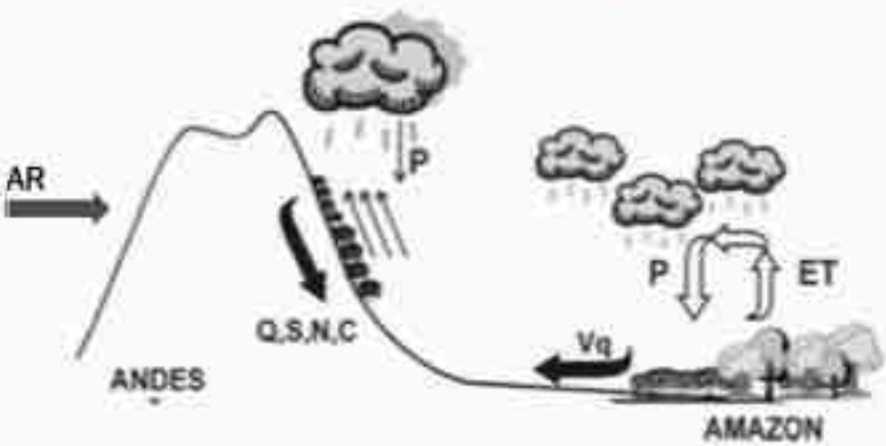
integrate ongoing research activities in Canada and the USA

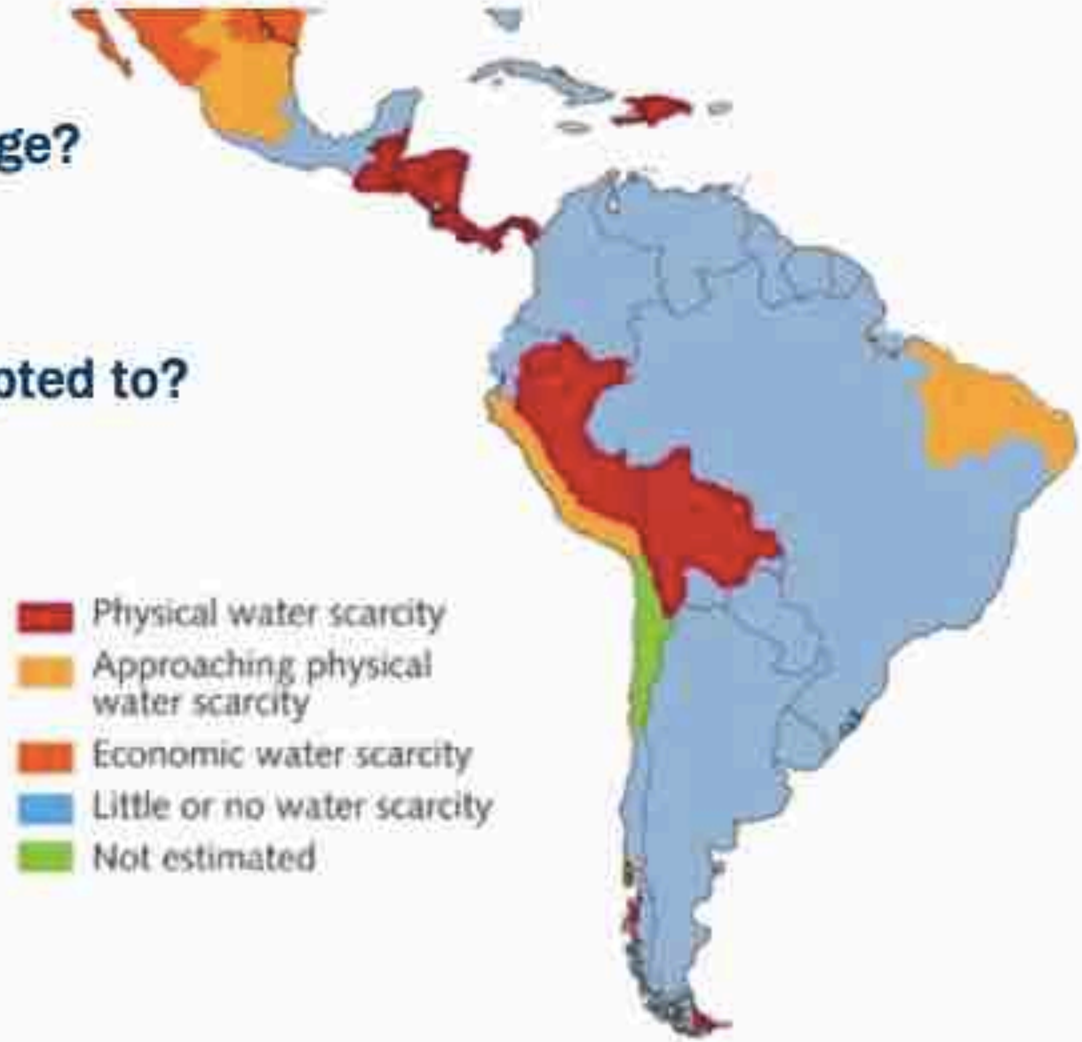
- **Understanding the impacts of climate variability and change on water availability across the river basins of the Rocky Mountains**
- **Research needs:**
- ***Observational synthesis:***
  - *Coordinated multi-scale field and remote sensing campaigns to quantify cross-scale controls on regional hydroclimatic processes*
  - *Understanding of key processes and compilation of data to test model hypotheses*
- ***Modeling synthesis:***
  - *Controlled comparison of different modeling approaches*
  - *Improved model physics parameterization development for integrated water cycle projections*

GEWEX

Water Scarcity in Latin-America

- How stable under climate change?
- How could it change?
- What is it that needs to be adapted to?
- What can be mitigated?





The Comprehensive Assessment of Water Management in Agriculture, FAO, 2007

GEWEX role in Earth Observations

- **Data stewardship**
  - Clouds- ISCCP
  - Precipitation- GPCP
  - Surface radiation budget
  - Water vapor (GVaP)
  - Surface ocean/land fluxes (E/ET)
  - ...Ground water/soil moisture (u.d.)
- **Data assessments**
  - Clouds
  - Precipitation (with APWG)
  - Energy balance
  - Other (soil moisture, water vapor, aerosol)
- **Next generation observing systems**
  - ISCCP-NG (under development)
  - Continued precip measurements (NASA DS more in terms of process related measurement vs mapping of precip)
  - A low latitude (tropics-like) set of measurements and a contribution to this, such as being considered by JAXA in the form of a constellation of Ku band small radars, is enthusiastically supported by GEWEX.

GEWEX

ISCCP-NG

Next Generation Cloud Climatology Products

GEO-KOMPSAT-2A AMI (Advanced Meteorological Imager)

- Multi-channel capacity: 16 channels
- Temporal resolution: within 10 minutes for Full Disk observation
- Flexibility for the regional area selection and scheduling
- Lifetime of meteorological mission: 10 years

Bands		Center Wavelength (Minimum)	Center Wavelength (Maximum)	Band Width (Max, um)	Resolution (km)	GOES-R (ABI)	Himawari-8 (AHI)
VNIR	VIS0.4	0.431	0.479	0.075	1	0.47	0.46
	VIS0.5	0.5025	0.5175	0.0825	1		0.51
	VIS0.6	0.625	0.66	0.125	0.5	0.64	0.64
	VIS0.8	0.8495	0.8705	0.0875	1	0.865	0.86
	NIR1.3	1.373	1.383	0.03	2	1.378	
	NIR1.6	1.601	1.619	0.075	2	1.61	1.6
	NIR2.2				2	2.25	2.3
MWIR	IR3.8	3.74	3.96	0.5	2	3.90	3.9
	IR6.3	6.061	6.425	1.038	2	6.185	6.2
	IR6.9	6.89	7.01	0.5	2	6.95	7.0
	IR7.3	7.258	7.433	0.688	2	7.34	7.3
	IR8.7	8.44	8.76	0.5	2	8.50	8.6
LWIR	IR9.6	9.543	9.717	0.475	2	9.61	9.6
	IR10.5	10.25	10.61	0.875	2	10.35	10.4
	IR11.2	11.08	11.32	1.0	2	11.2	11.2
	IR12.3	12.15	12.45	1.25	2	12.3	12.3
	IR13.3	13.21	13.39	0.75	2	13.3	13.3

MSG- SEVIRI

Central wavelength	Spectral interval (99 % encircled energy)	SNR or NEΔT @ specified input
N/A (broad bandwidth channel)	0.6 - 0.9 µm	4.3 @ 1 % albedo
0.635 µm	0.56 - 0.71 µm	10.1 @ 1 % albedo
0.81 µm	0.74 - 0.88 µm	7.28 @ 1 % albedo
1.64 µm	1.50 - 1.78 µm	3 @ 1 % albedo
3.92 µm	3.48 - 4.36 µm	0.35 K @ 300 K
6.25 µm	5.35 - 7.15 µm	0.75 K @ 250 K
7.35 µm	6.85 - 7.85 µm	0.75 K @ 250 K
8.70 µm	8.30 - 9.10 µm	0.28 K @ 300 K
9.66 µm	9.38 - 9.94 µm	1.50 K @ 255 K
10.8 µm	9.80 - 11.8 µm	0.25 K @ 300 K
12.0 µm	11.0 - 13.0 µm	0.37 K @ 300 K
13.4 µm	12.4 - 14.4 µm	1.80 K @ 270 K

These tables exemplify the channels now available from the new generation imagers on geostationary met satellites. This enhanced channel information provides new and improved cloud properties not currently part of ISCCP. ISCCP-Next Generation will be developed around these new capabilities and other EO capabilities not currently exploited

PART II: GEWEX Challenges

Showcase GEWEX Science

Showcase The Challenges

The GEWEX Science Questions shown through two major scientific challenges

The grand environmental challenges facing human society involve the changing of Earth's water cycle.

With a warming planet, perhaps the two most pressing questions facing us are:

Not Shown
Here

- Will the availability of fresh wa … how?
- By how much will sea level rise?

and our challenge is to develop an understanding that can provide quantitative answers to them.

Note to the challenges

- Those two questions are not independent
- Water availability is a (re)distribution issue (global available water is constant) -> hydrological cycle
- Is the hydrological cycle changing – intensifying?
- Focus on fresh water
- From the global to the local view

Availability of Fresh Water

Will it change and how?

Inadequacy of Surface Observations

Global Telecommunication System meteorological stations. Air temperature, precipitation, solar radiation, wind speed, and humidity only.

Eight countries make groundwater data publicly available through the Global Groundwater Monitoring Network.

River flow observations from the Global Runoff Data Centre. Lighter circles indicate greater latency in the data record.

USGS Groundwater Climate Response Network.

Issues include coverage gaps, delays, measurement continuity and consistency, data format and QC, political restrictions

GEWEX

NASA Earth Science Missions
Current & Planned
Formulation
Implementation
Primary Ops
Extended Ops
NI-SAR
PACE
SWOT
TEMPO
GRACE-FO (2)
ICESat-2
CYGNSS
SAGE III on ISS
SMAP
OCO-2
TRMM
QuikSCAT
SORCE
EO-1
Landsat-7
ACRIMSAT
Aquarius
Terra
Soomi NPP
(NOAA)
Aqua
CloudSat
Landsat-8
CALIPSO
Aura
GPM
GRACE (2)
OSTM/Jason 2
(NOAA)

ESA Earth Observation Programmes

esa

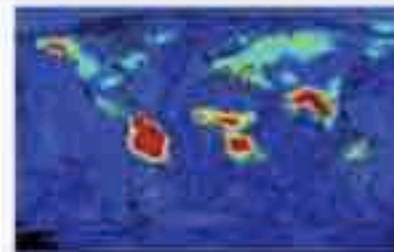
Surface Water balance

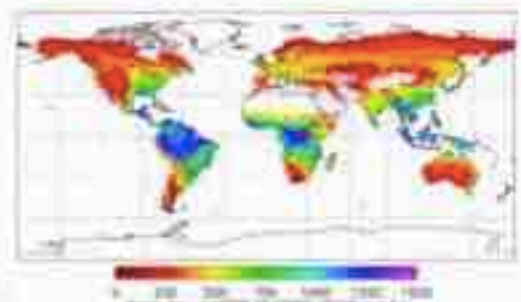
$$\Delta S = P - Q - ET$$

- **Precipitation (P)**
  - In situ: Rain gauges, Snotel
  - RS (**TRMM, CloudSat, AMSR-E, IR**,....)
- **Change in storage (ΔS)**
  - In situ: Groundwater recharge/flow, soil moisture, standing water, wells
  - RS (**GRACE**, SWOT, AMSR-E→SMOS→SMAP)
- **Runoff (Q)**
  - In situ: Stream gauges, Global Runoff Data Center,
  - RS (SWOT)
- **Evaporation/Evapotranspitation (ET)**
  - In Situ: Fluxnet
  - RS Quickscat, AMSR-E, MODIS, **ACOS/OCO,...**

    (RS of ET also requires surface net radiation)

- **Global accuracy/consistency/ability?**



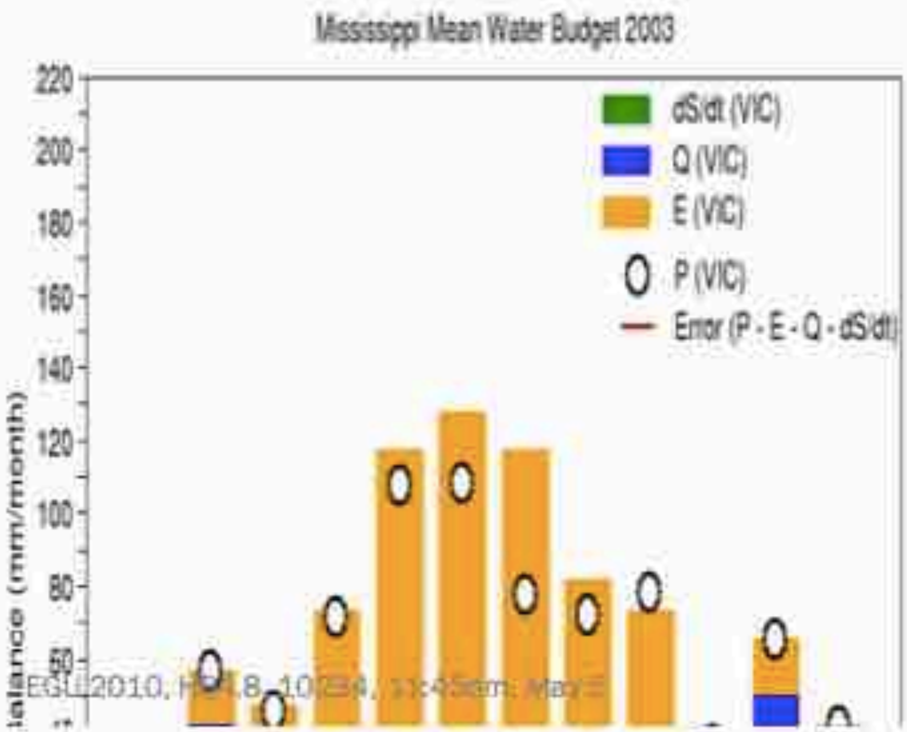


A challenge for Hydrology:

Creating Climate Data Records for the terrestrial water budget using in-situ, remote sensing observations and LSM?

$$\frac{dS}{dt} = P - ET - Q$$

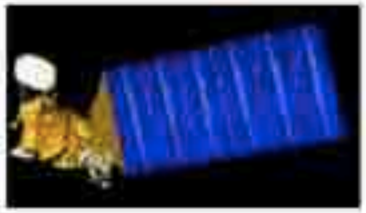
What the budget should look like?
(from off-line modeling, forced closure)



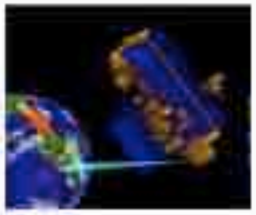
Potential Remote Sensing Datasets

dS/dt from GRACE

ET from
SRB/ISCCP → LandFlux



P from TRMM/CMORPH
PERSIANN → GPM



Q from
TOPEX/POSEIDON/JASON
→ SWOT

Potential global water cycle data sources

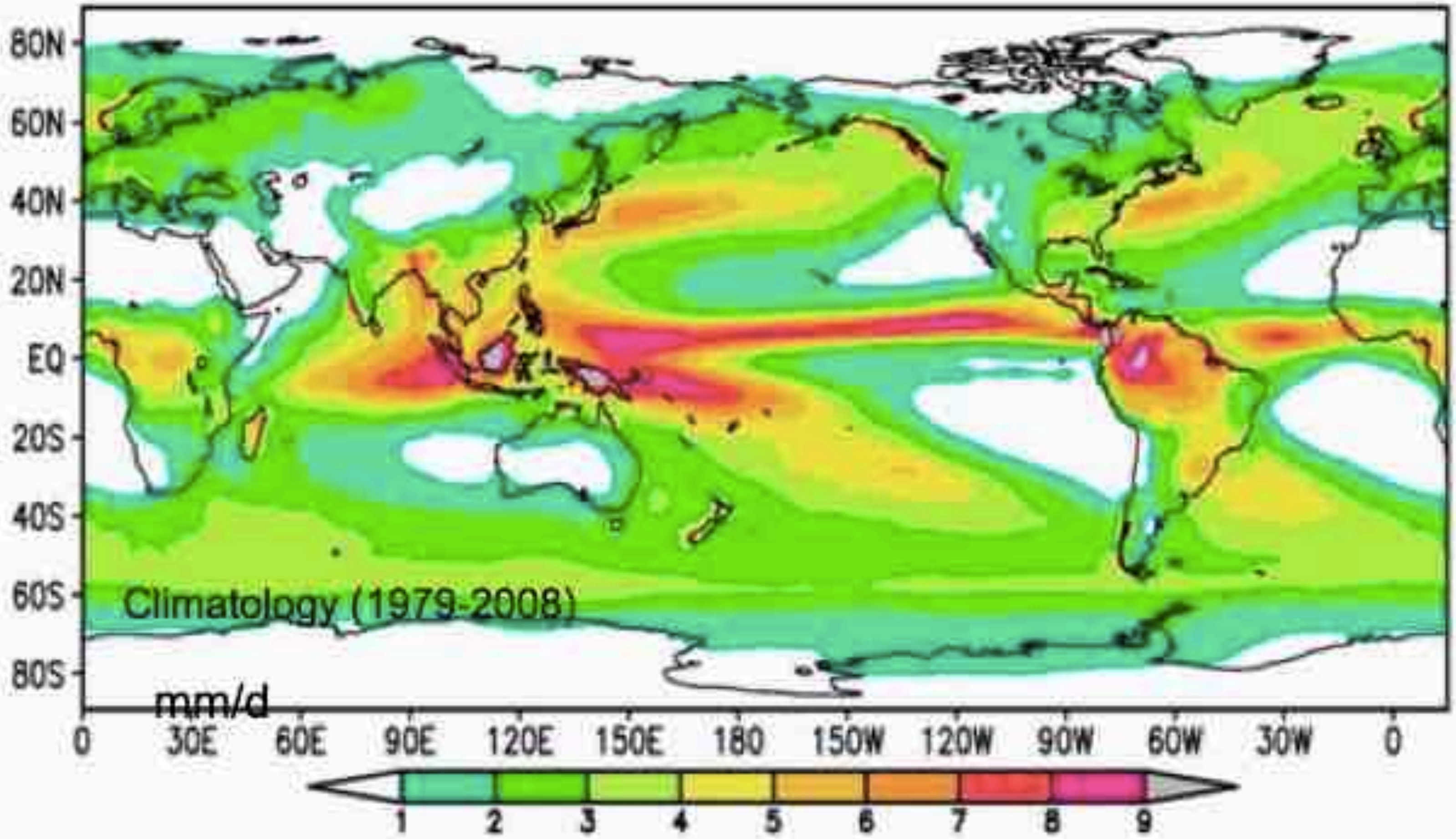
Variable/Source		Type	Period	Resolution	Reference
p	CPC	In-situ	1950-	1º	Chen et al., 2002
	CRU	In-situ	1901-	0.5º	Mitchell & Jones, 2005
	WM	In-situ	1900-	0.5º	Willmott & Matsuura, 2010
	GPCC	In-situ	1900-	0.5º	Schneider et al., 2008
	GPCP/TMPA	RS/in-situ	1998-	0.25º-1º	Huffman et al
e	ET (LandFlux) (4 algorithms)	RS	1984-2006	1º	Vinukollu et al., 2010; Ershadi etal., 2013
	ERA-Interim	Reanalysis	1989-	T255	Simmons et al., 2006
	MPI	In-situ	1989-	T255	Jung et al (2009)
	VIC	LSM	1948-	1/2ºx1/3º	Sheffield &Wood, 2007
q	GRDC	In-situ	1900-	basin	GRDC, 2010
	VIC	LSM	1948-	1º	Sheffield &Wood, 2007
Δs	GRACE	RS	2002-	basin	Swenson &Wahr, 2002
	VIC	LSM	1948-	1º	Sheffield et al., 2008

Precipitation

- Direct EO Measurements e.g. GPCP, TRMM, GPM
- Understanding clouds and precipitation processes e.g. Cloudsat
- Aerosols and water vapor
- Rain gauge data e.g. GPCC
- Global Climate Models precipitation representation

Global Precipitation Climatology Project (GPCP)

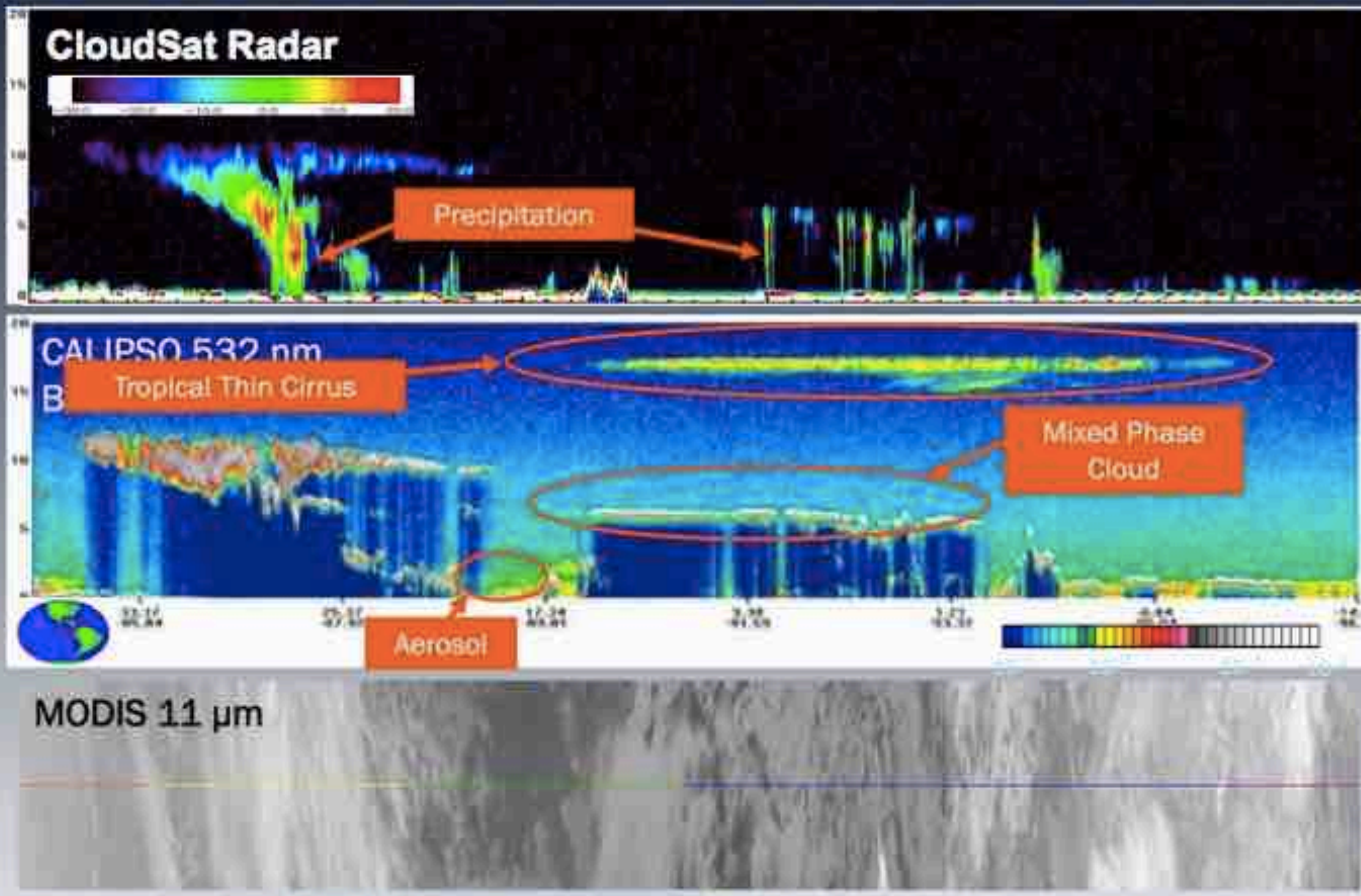
Robert Adler, U. of Maryland-College Park, USA



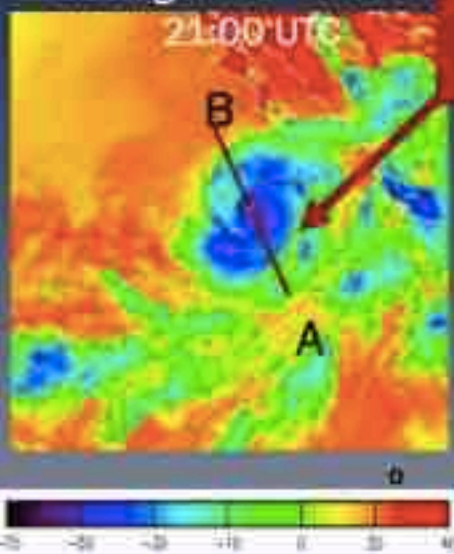
GPCP data used in > 1500 journal articles

GEWEX

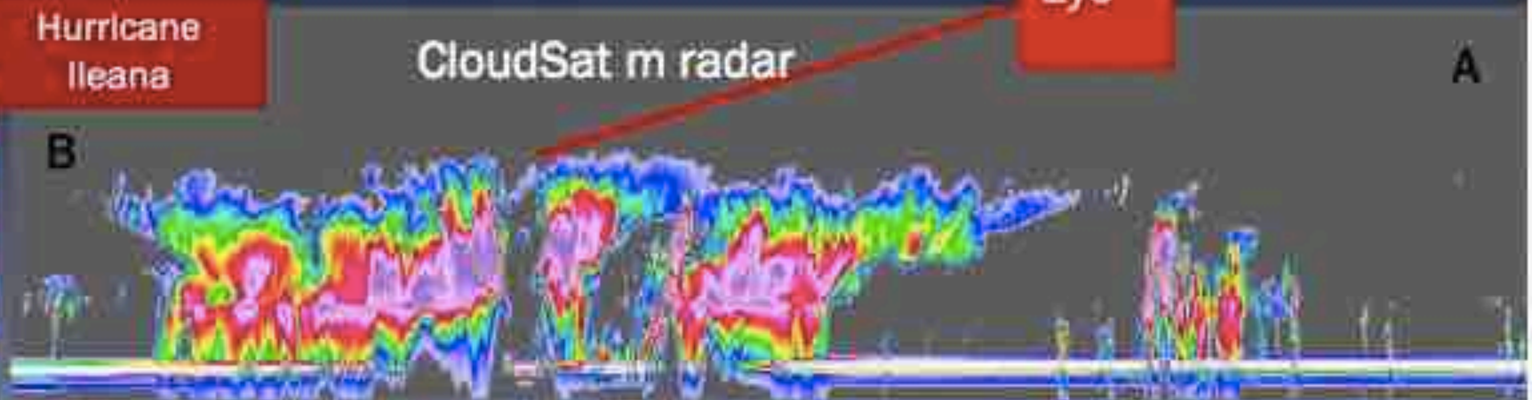
Synergy



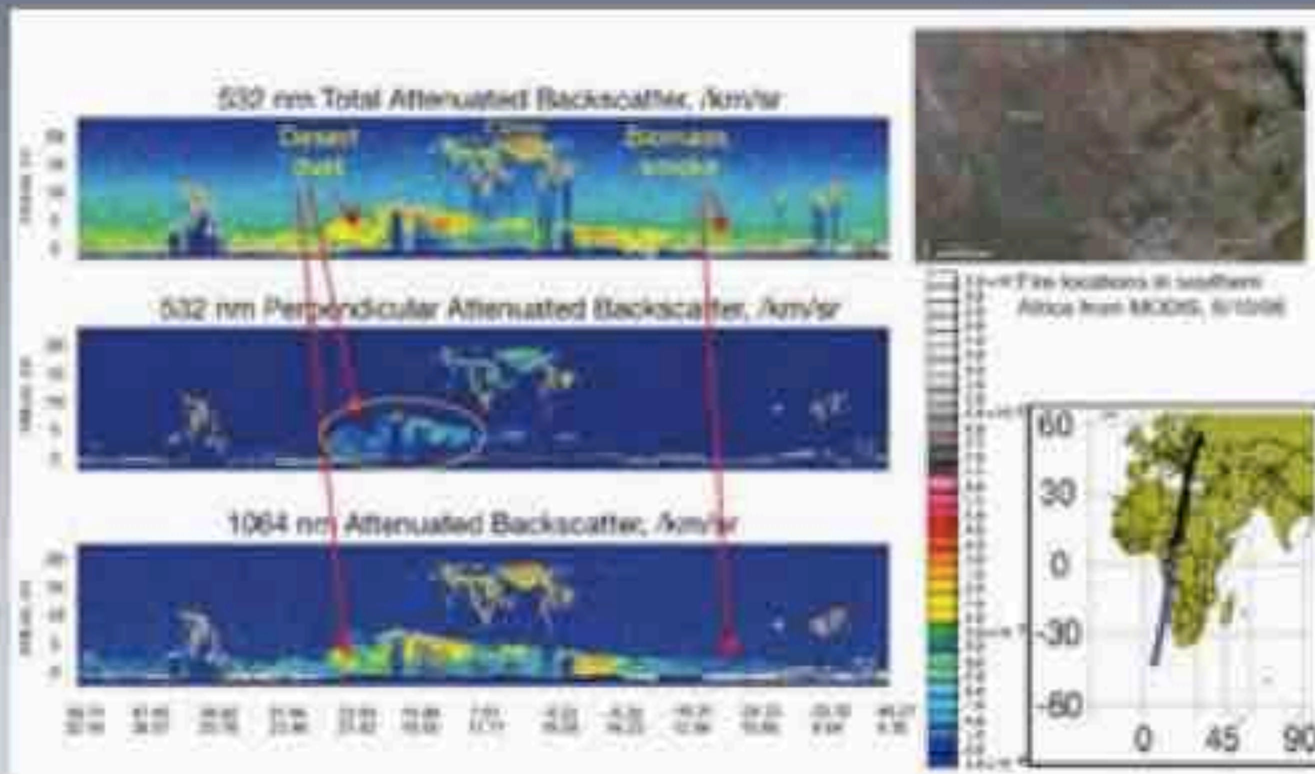
CloudSat Radar
Precipitation
CALIPSO 532 nm
Tropical Thin Cirrus
Mixed Phase Cloud
Aerosol
MODIS 11 μm



Brightness Temperature (C)



CALIPSO Frist light



Challenges - Precipitation

- Models- global models have biases that point to problems in the way precipitation (and cloud) physics is represented. Global models also miss major storm types (e.g. MCSs) that for example deliver large fractions of precipitation to real Earth
- Process perspective- We still do not know the extent to which the water cycle is influenced by aerosol but anecdotal evidence is building
- Observations- we still have a way to go and need to approach the problem in a more integrated way (tie clouds, aerosol and precipitation and then link to soil moisture, etc.) - globally our capabilities to address water cycle processes, while improved, seriously lag behind the science and model development

Change in Storage

Earth Observation

- **Snow**
  - GRACE, GPM
- **Ground water and soil moisture**
  - GRACE, ASCAT, AMSR-E, SMOS, SMAP, Tandem-L?
- **Lakes and rivers**
  - TOPEX/Poseidon, SWOT

Take Home Points

- Continued need for sustained obs.
- Observations, Data, Information and Knowledge are not the same!
  - Action can be taken without the above!!
- Stewardship of existing obs. Networks
- In the era of adaptation and mitigation in the context of climate change: research is more needed than ever! No obs. No monitoring. No Clue. . .
- Data access and sharing need constant attention and improvement
- Earth Observation an essential but not magical part of the observational system
- Integration of networks beyond WMO, Research... e.g. Agriculture, Industry
- Observations of the human dimension (extraction, iwrm, LULC, etc.) CRITICAL

GEWEX

PART III: WCRP Grand Challenge

Understanding and Predicting Climate and Weather Extremes

Water for the Food Baskets of the World

WCRP Grand Challenge on Understanding and Predicting Weather & Climate Extremes

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[Presenter's name and email]
[Title, venue and dates of the event]

GC Weather & Climate Extremes

Driven largely by service needs

- From ***service perspective***: What are frequency and magnitudes of various impact-causing extremes in the near and long term?
- From ***science perspective***: How can we better understand the causes and mechanisms of variability and change in extremes, and improve the prediction of changes in extremes?

Implementation needs to be focused: areas with opportunity for rapid progress

Weather & Climate Extremes

4 main extremes, 4 overarching themes

(Implementation plan Feb. 2016)

Lisa Alexander   Ali Behrangi

Sonia Seneviratne   Olivia Martius   Robert Vautard

Xuebin Zhang   Fredi Otto

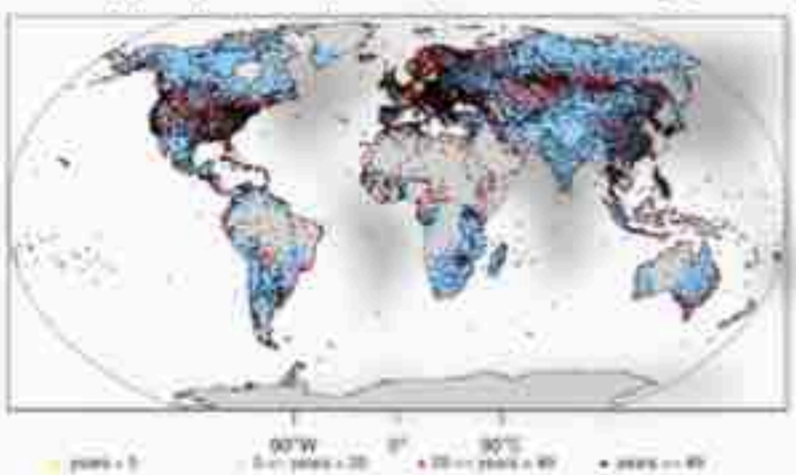
Gabi Hegerl   Jana Sillmann   Erich Fischer

Weather & Climate Extremes

Document

Observations crucial for understanding change and evaluating models, but critical gaps exist in the amount, quality, consistency and availability, especially for extremes

Sub-daily precip stations (HadISD) and SDII coverage (HadEX2)



Source: Westra et al. 2014, Rev. Geophys.

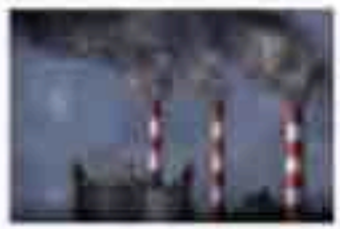
- Permanent destruction of old records
- More data undigitised than digitised (especially pre WWII)
- Many institutions unwilling or unable to exchange data
- Data quality and homogeneity
- Also considers runoff observations

Weather & Climate Extremes

Understand

Interaction between large-scale phenomena (weather types, modes of variability) and regional-scale land-atmosphere feedbacks/forcing

atmosphere



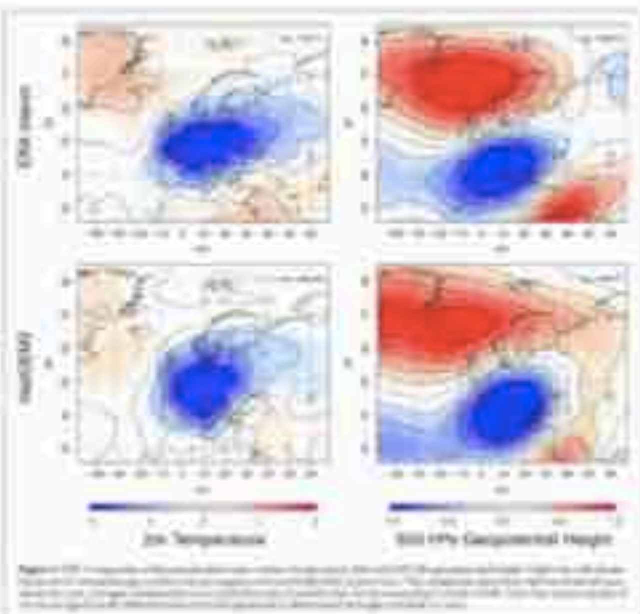
greenhouse gases

oceans

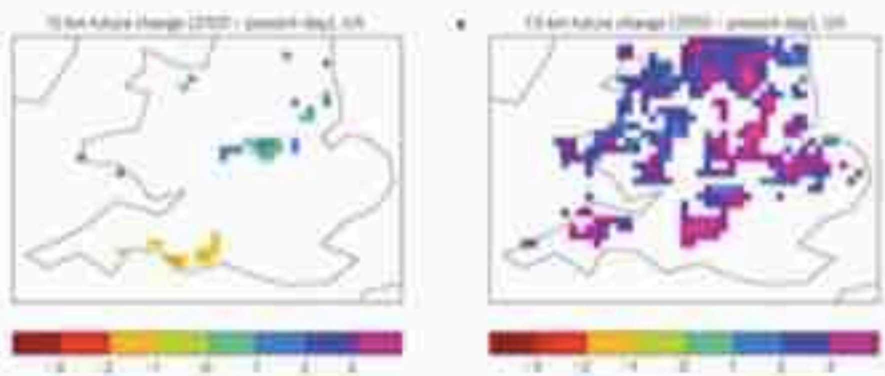
land

Weather & Climate Extremes

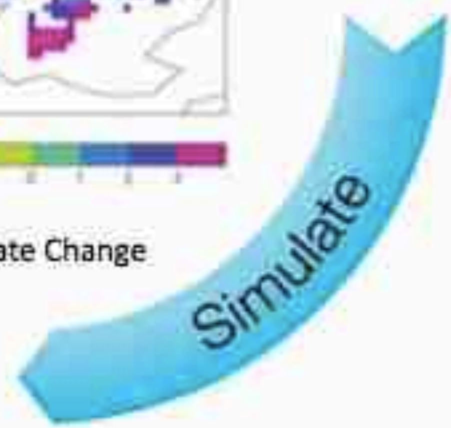
- Do the models simulate extreme events for the right reason?
- How to use both statistical methods for tails and knowledge about mechanisms/storylines?
- What phenomena are GCM and RCM simulations credible for and how can simulations be improved?



Source: Krueger et al., 2015, ERL

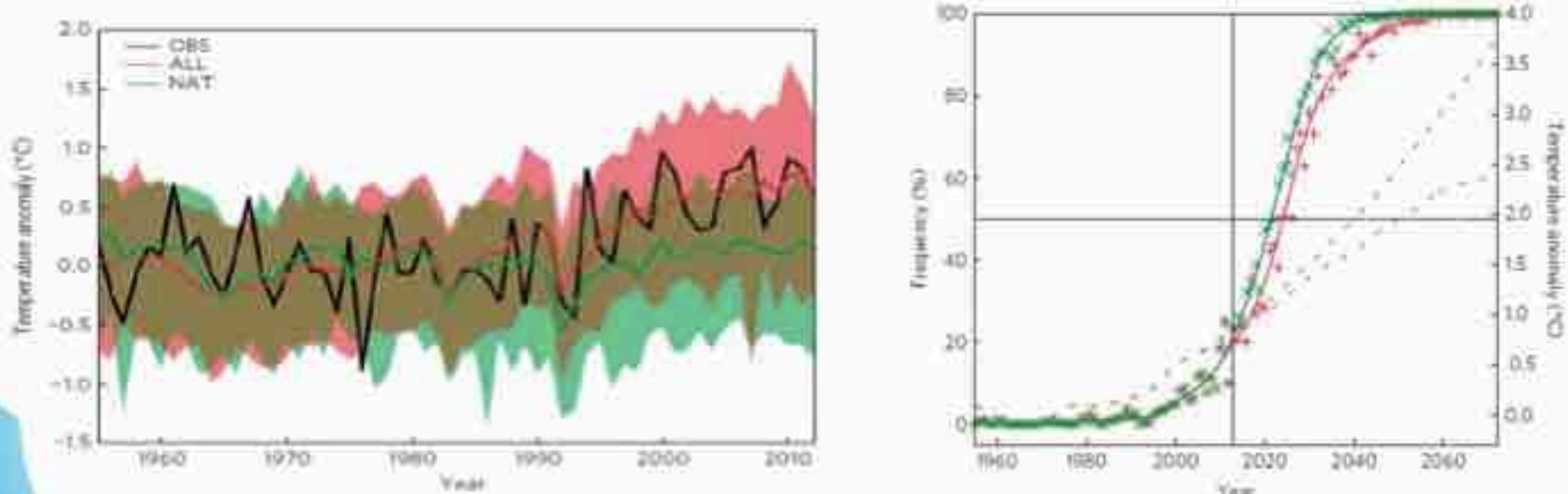


Source: Kendon et al. 2014, Nature Climate Change



Weather & Climate Extremes

A key challenge is to understand the extent to which humans are responsible for changes in extremes and the likelihood of individual extreme weather events.



2013 Summer East China Heatwave

Attribute

Weather & Climate Extremes

GC-Extremes and Sustainable Development Goals

WCRP World Climate Research Programme

Water for the Food Baskets of the World

The WCRP Grand Challenge on Water Availability

Jan Polcher, Roy Rasmussen, Peter van Oevelen

Version: 3.0.0 (April 25 , 2018)

BASED UPON CONTRIBUTIONS FROM: JAN POLCHER, ROY RASMUSSEN, PETER VAN OEVELEN, YAHYA ABAWI, GRAEME STEPHENS, SONIA SENEVIRATNE, KEVIN TRENBERTH, YAOMING MA, MICHAEL EK, MATT RODELL, ERIC WOOD, JOERG SCHULZ, CHRIS KUMMEROW, ROBERT A. SCHIFFER, JUN MATSUMOTO, TOSHIO KOIKE, TAIKAN OKI, ANA BARROS, CRAIG FERGUSON, BEN ZAITCHEK AND MANY MORE...

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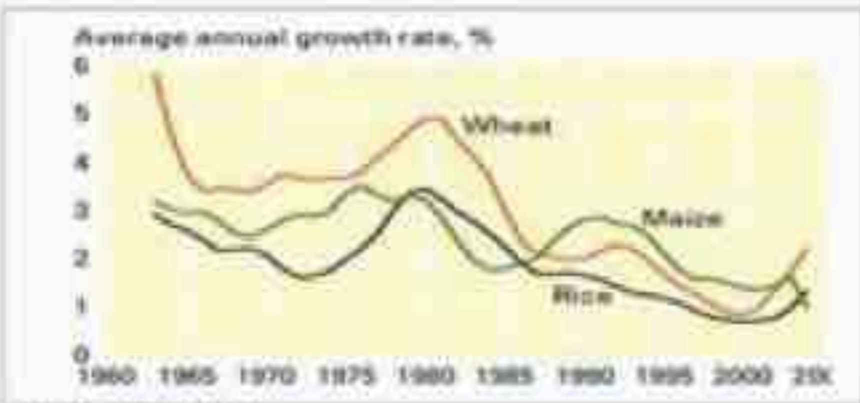
Current State

Challenges for Food Production



- Population growth *(Asia and Africa primarily)*
- Globalization
- Urbanization
- **Water scarcity**
- Declining yield
- **Climate variability and Climate Change**
- Modernization of agriculture has lagged behind industrialization in developing countries
- Transfer of land from the production of food to production of fuel
- Transfer of land to livestock (high protein food)
- Biosecurity issues affecting Free Trade Agreements

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Food Security

"Reliable access to sufficient quantities of affordable, nutritious food to maintain healthy, active lives." – 1996 World Food Summit

Four main dimensions of food security are;

- **Availability – Supply of food as determined by production, stock level and net trade**
- **Access - affected by income, expenditure, markets and prices**
- **Utilisation – nutritional status of what we produce**
- **Stability – Inadequate access to food on periodic basis**

Availability **and** ***Stability*** **are threatened by the impact of climate variability, climate extremes and climate change**

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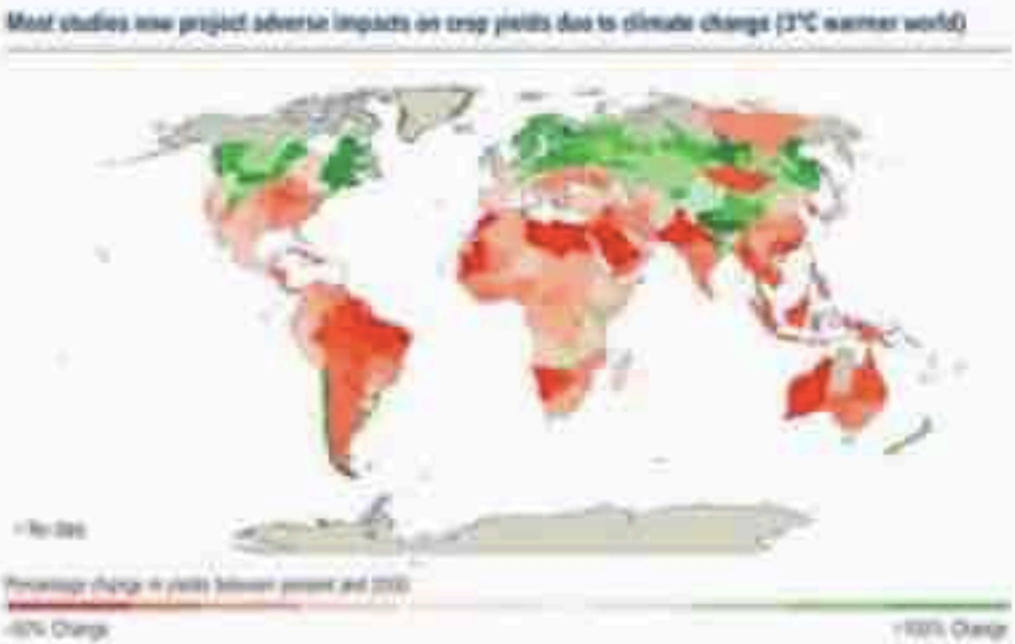
Impact of Climate on Food Production

- Global demand for food is expected to rise faster than population increase
- Population is expected to increases by 30% by 2050 (9.3 Billion People)
- Average income will rise by 120% and change in diet from minimal calorie to high protein



- **CO_2 and Temperature**
- **Pest and Disease**
- **Flooding**
- **Water Availability (Scarcity and Variability)**

- Unprecedented long-term climatic changes are likely to occur from greenhouse warming that will also affect seasonal to interannual variability
- Agriculture, particularly rain-fed is most vulnerable from droughts, extreme events, monsoonal change, heat stress, pest and diseases

Starting Points

- Our knowledge on the water cycle is essentially of a system perceived as natural. How true is that currently?
- How well do we know the processes governing slower reservoirs (groundwater, snow, glaciers, ...) ?
- Climate change will perturb the real system but how relevant is our knowledge of the natural cycle ?
- Practices for water resource management are based on past experience. Have they evolved and taken into account knowledge on climate change ?
- Is our science relevant for the practitioner ... what do we need to make the transfer of knowledge effective ?

The WCRP Grand Challenge on Water Availability

Water for the Food Baskets of the World

- **Water Cycle Main Driver of Food Production**
- **A Warmer Climate Pushes the Water Cycle into Unknown Territory**
- **The Terrestrial Water Cycle is not Natural Anymore**
- **Urgency to Understand the New State of the Water Cycle in which Natural and Anthropogenic Processes Interact**

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The WCRP Grand Challenge on Water Availability

Water for the Food Baskets of the World

How will a warming world affect the available fresh water resources globally, the human interactions with these water resources, as well as their value to society and how does this translate specifically to the food basket regions of the world?

*Within the context of the World Climate Research Programme the focus will be on the geophysical processes and the anthropogenic influences on these processes

The WCRP Grand Challenge on Water Availability

Water for the Food Baskets of the World

How will a warmer climate impact water resources and interact with human usages and thus the value of water for society ?

*Within the context of the World Climate Research Programme the focus will be on the geophysical processes and the anthropogenic influences on these processes

Methodology

- **A Regionally Tiered Approach**
  - Focus on Four Main Regions – RHP connected
- **A Research Topic Tiered Approach**
  - NEW: Human Dimension
  - NEW: High Resolution Convection Permitting Modeling
  - NEW: Link to Agricultural Modeling
  - Build upon Existing Efforts (Within and beyond WCRP)
    - UNESCO IHP, HYDROMET Services, iLEAPS, TPE etc.

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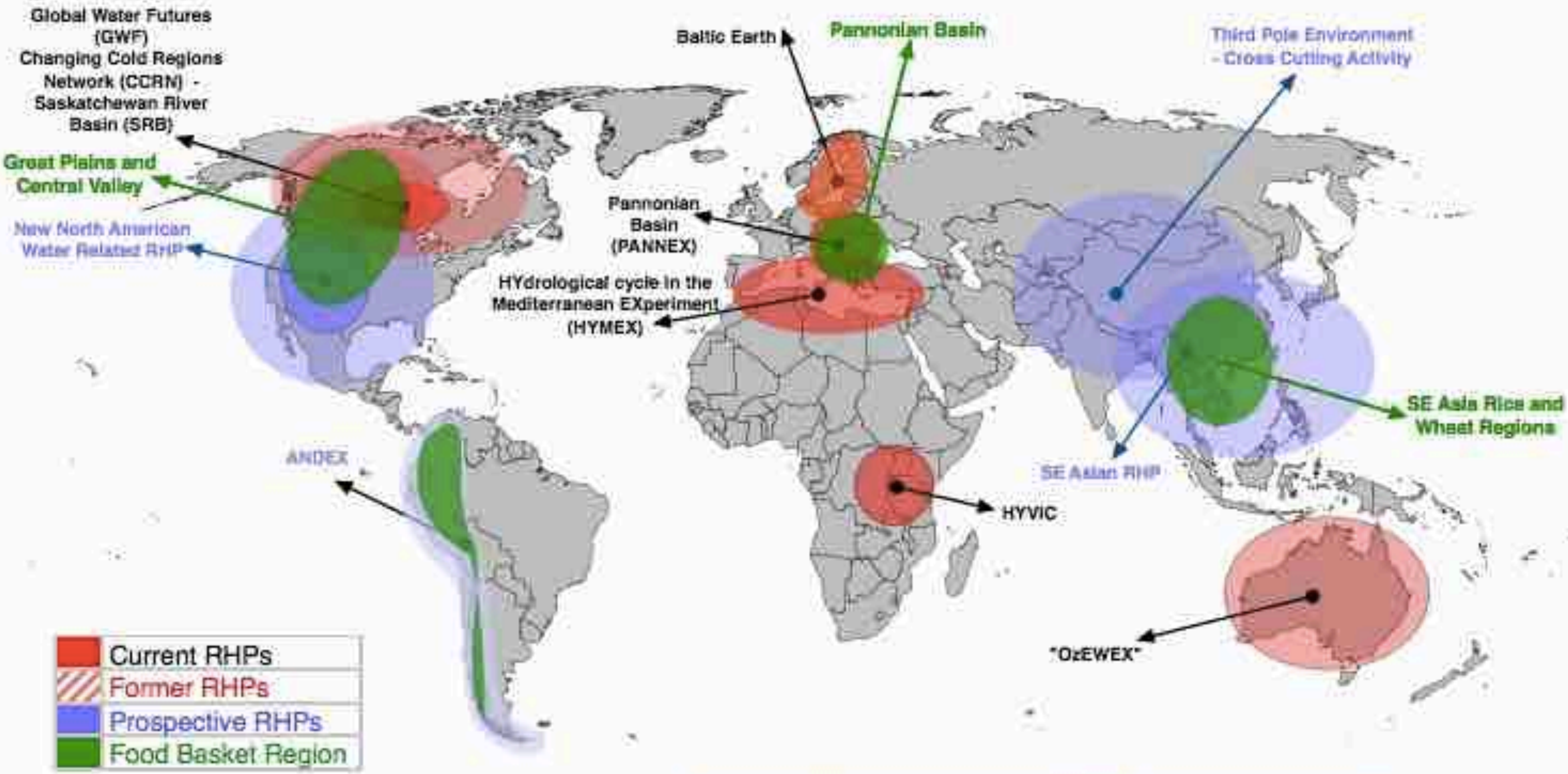
Regional Hydroclimate Projects



- Within this Grand Challenge the focus will be on four selected major food producing regions of the world in the context of climatic change

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Regional Topical Leads

- **CCRN -> Global Water Futures and INARCH:**
  - John Pomeroy , Chris deBeer
- **US "RHP":**
  - Roy Rasmussen, Craig Ferguson, Ben Zaitchek
- **Pannonian Basin:**
  - Monika Lakatos, Ivan Guettler
- **Asian RHP:**
  - Collaboration with TPE and others
- **ANDEX**
  - German Poveda, Rene Garreaud

Examples of Research Topics

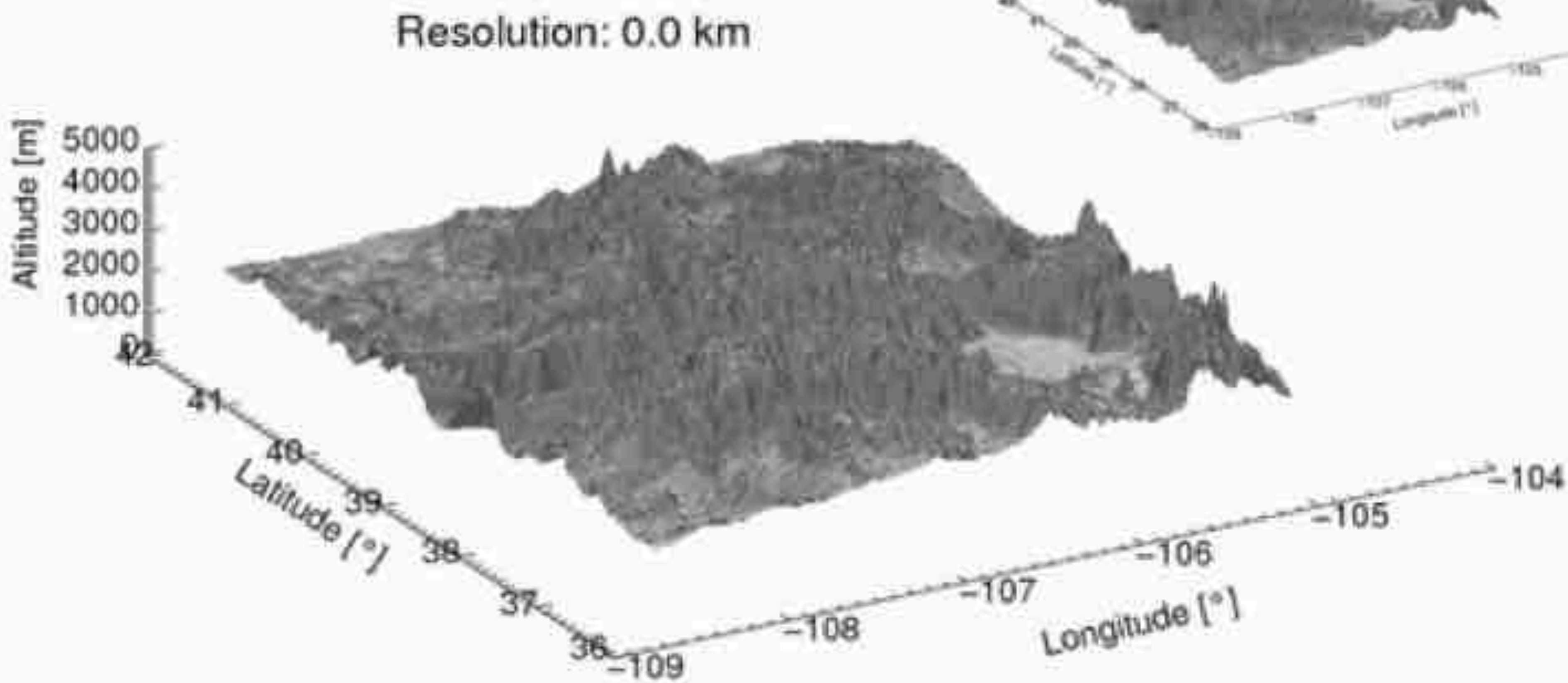
High Resolution Convection Permitting Model

- **Running high resolution model over complex terrain is very important because:**
  - It can resolve vertical motions tied to complex terrain and thus able to produce "close to observed" precipitation pattern.
  - Having accurate spatial distribution of precipitation is important for properly representing hydrologic balance.
  - Better representation of surface processes such as ET LULC

Transition to Convection Permitting Models

- "Climatically Available Water (P-E)" as we want both P and E at higher spatial (and temporal) resolutions
- Agronomy and the FAO in particular, are limiting themselves to "reference evaporation" without taking into account small scale processes which change water availability.
- Soil moisture availability is strongly driven by things as rainfall intensity which has been below our (GEWEX) radar screen for decades
- Most (Pot.) ET formulations used by agronomy are not very useful in a changing climate scenario
- Plenty of evidence that (sub)surface/atmosphere interactions occur at small(er) scales and will not be credible until we reach convection permitting models.
- ==> High resolution modeling but we should not limit it to just the atmospheric processes! It is the entire terrestrial/atmospheric system which need to be treated at very high resolution.
- Many problems exist both terrestrial as well as atmospheric including: human dimension, LULC etc.

Value of high-res. regional model



Courtesy Andy Prein

Essential link to agricultural modeling

Vegetation, crop and agricultural systems modeling

- The human dimension has many aspects. In this GC we focus on the food and water directly related aspects
- The link between water and agriculture is highly non-linear, how to model at weather and climate scales beyond the watershed (regional to global)
- Much more than just irrigation, ground water extraction and reservoir management!
- Linking convection-permitting models (high res < 4km) to agronomy/ag. models

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Expected outcome of the GC

- Progress in land surface modeling with the explicit representation of water management.
- Enhance our knowledge of surface atmosphere interactions in managed environments.
- Build the capability to predict the "real system" at least at the regional scale for weather forecasting as well as climate research.
- Develop our capabilities to predict the water and nutrient fluxes to the oceans.
- Make climate sciences more relevant to hydrological and agronomic sciences in terms of processes and scales considered.

WCRP GC on Water and UN SDGs ✓

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Thank You
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