Water for the Food Baskets of the World

The WCRP Grand Challenge on Water Availability

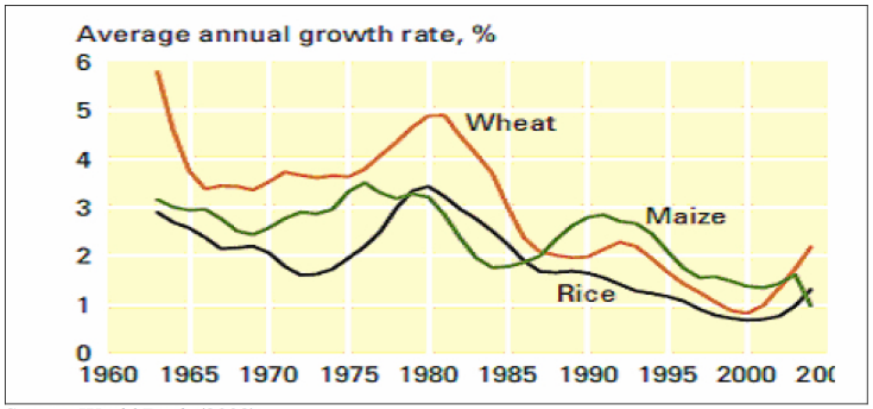
Version: 2.0.0 (April 25 , 2016)

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...

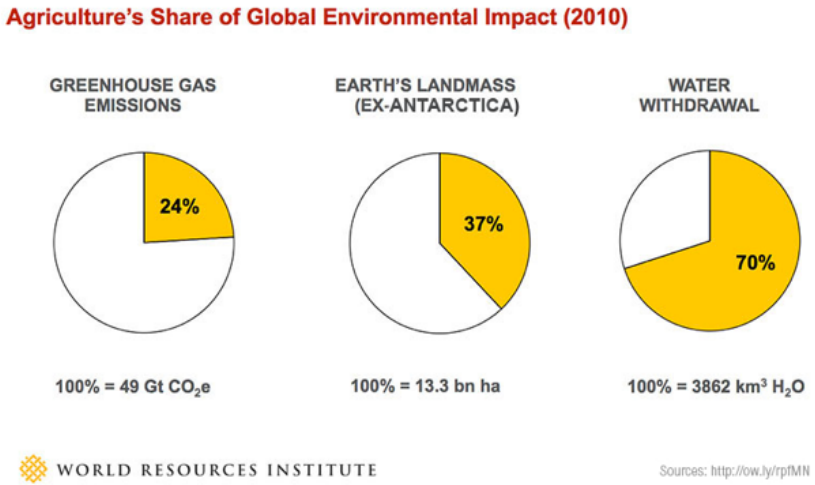
Current State

Challenges for Food Production

Growth rates of yields for major cereals, 1960 - 2000



Source: World Bank (2008)



- 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

GEWEX

WCRP World Climate Research Programme

Food Security

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

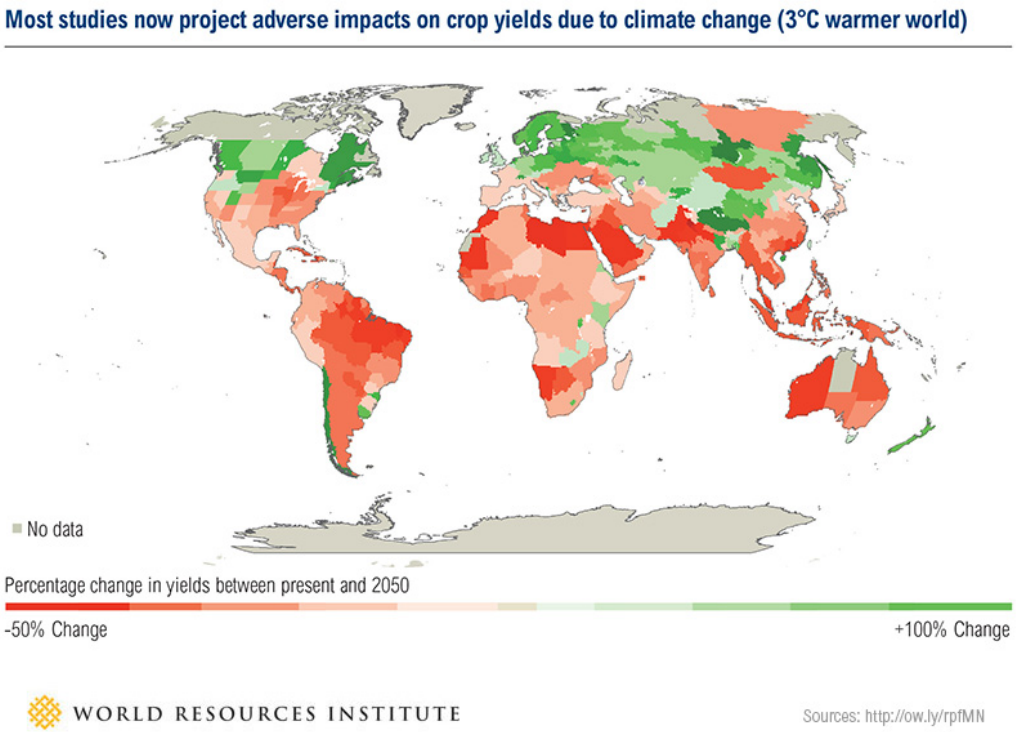
Four main dimensions of food security are;

- **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**

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



- **CO2 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

GEWEX

WCRP World Climate Research Programme

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**

GEWEX

WCRP World Climate Research Programme

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

GEWEX

WCRP World Climate Research Programme

Products and Deliverables

How will a warming world affect the available fresh water resources globally and how does that translate specifically to the bread basket regions of the world?

- **This grand challenge in particular expands on questions related to changes in water supply and storage both temporally and spatially with respect to reservoirs, ground water, snowpack depth etc. and in order to answer that we need to address both the water supply and demand side:**
- **Set of sub questions see next slide:**
- **Answers to these questions are the main outcome of this grand challenge. To enable the research needed we set up this grand challenge in tiers both in the regional sense as well as in research sense**

Set of Sub Questions

WCRP Grand Challenge of Water Availability

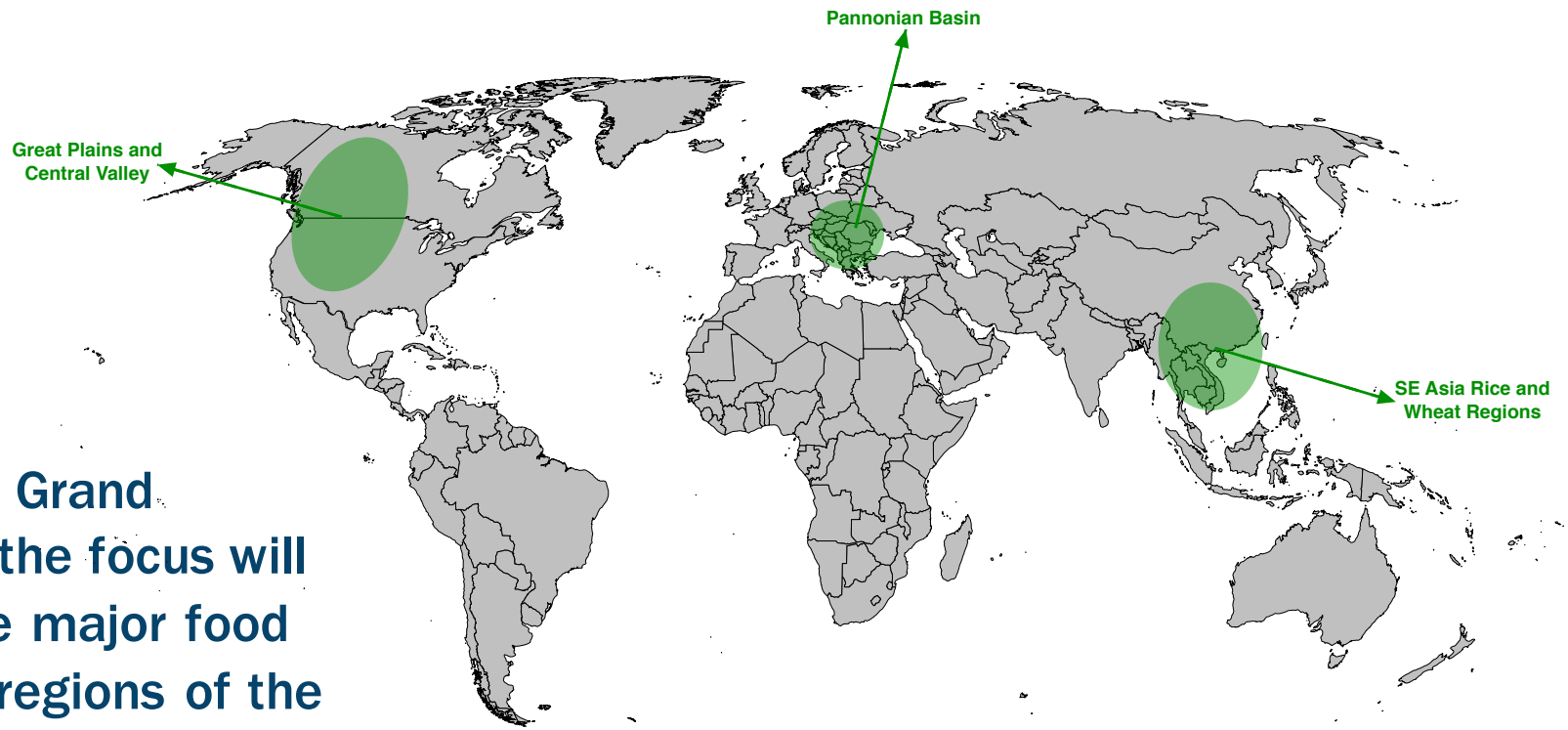
- What are the effects of changes in the character of precipitation (snow vs. rain, snow water equivalent etc.)?
- How do the temporal changes in precipitation regimes affect water availability?
- How will changes in the mean and variability of precipitation affect human infrastructures ?
- Which regions will see an increase vs. decrease in precipitation?
- Which regions will see an increase vs. decrease in actual and potential evapotranspiration?
- Which regions will see an increase vs. decrease in the climatically available water (P-E)
- How is groundwater recharge and availability affected?
- In which regions can groundwater pumping be sustained in a warmer climate?
- How is snow cover, depth and water equivalent affected?
- In which regions is food productions endangered by the expected changes in the water cycle?
- Which actions need to be undertaken to improve our water management and maintain a viable agriculture?
- How will climate change modify competing interests for water?
- How are land water exchanges affected by climate change, or affecting themselves regional climate responses (e.g. temperature and precipitation means and extremes)
- How are changes in land-use/land cover affected by the water availability or affecting the water availability?

Methodology

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

The WCRP Grand Challenge on Water Availability

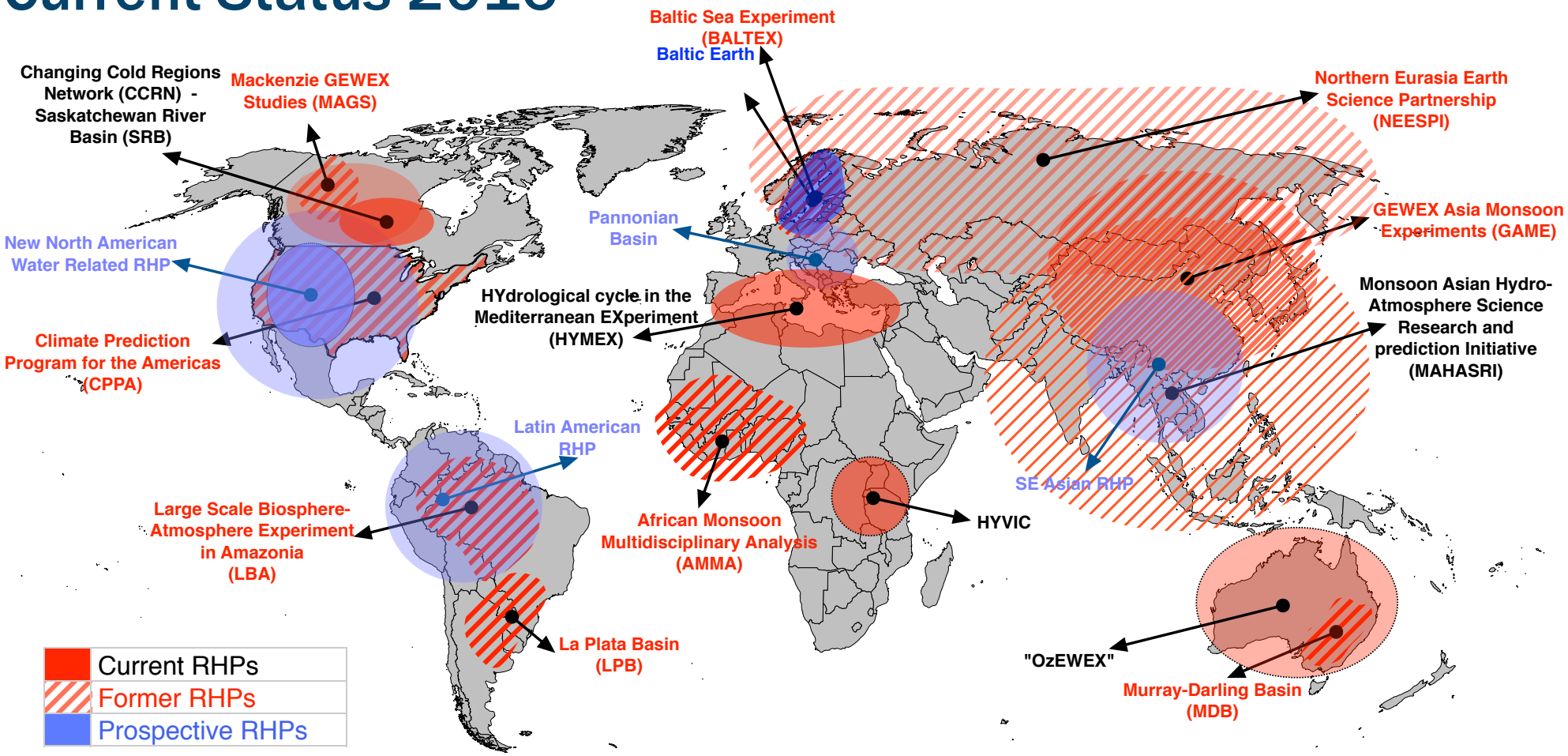
Water for the Food Baskets of the World



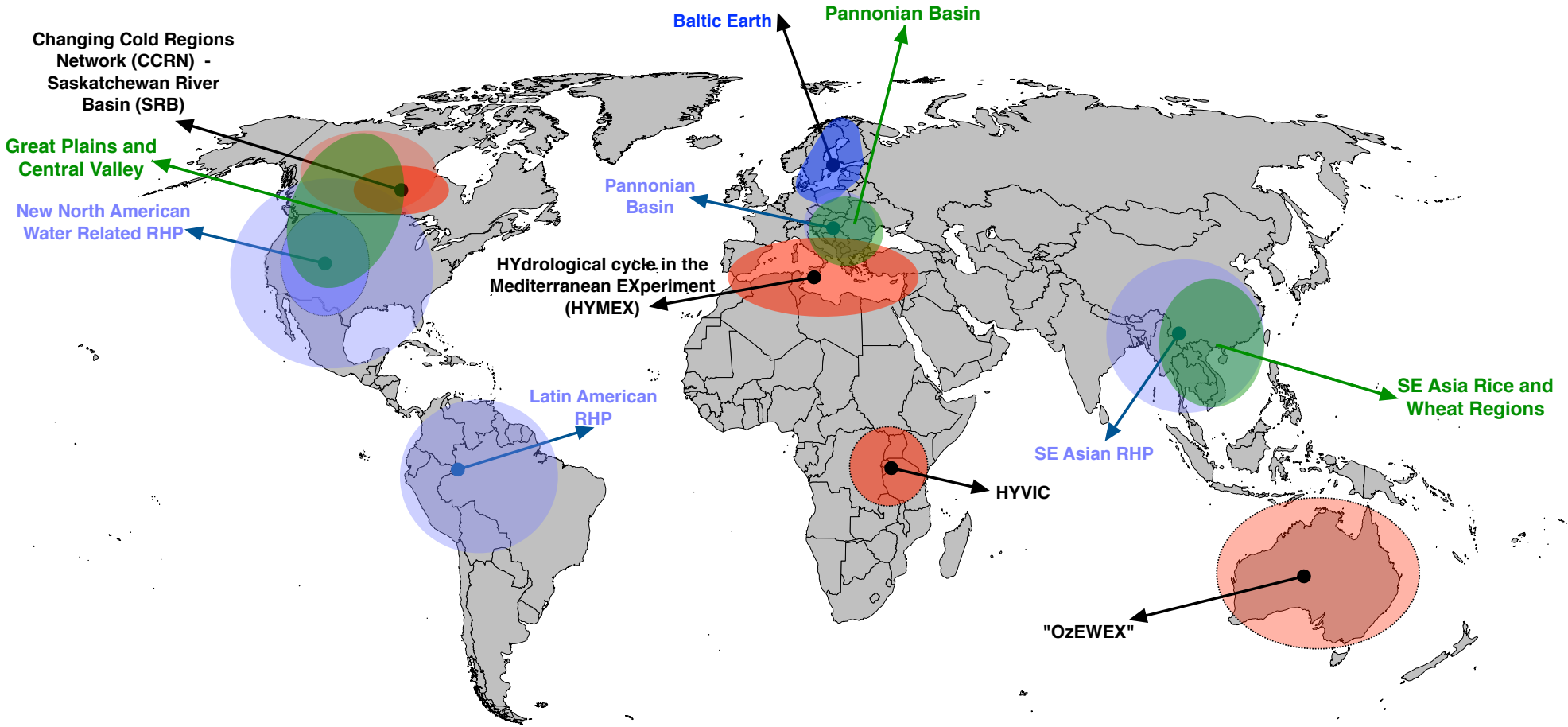
- **Within this Grand Challenge the focus will be on three major food producing regions of the world in the context of climatic change**

GEWEX Regional Hydroclimate Projects

Current Status 2016



Food Basket Regions of the World



Three new RHPs:

-US Based

-South East Europe: Pannonian Basin

-South East Asia: link to TPE effort

Regional Topical Leads

- **CCRN and INARCH:**
  - John Pomeroy , Howard Wheater
- **US RHP:**
  - Roy Rasmussen, Ana Barros, Craig Ferguson, Ben Zaitchek
- **Pannonian Basin:**
  - Monika Lakatos, Ivan Guettler
- **Asian RHP:**
  - Xin Li, Taikan Oki, Jan Polcher, James Renwick*

Research Topical Leads

- **Anthropogenic Affects in Hydrology:**
  - Richard Harding, Taikan Oki, Jan Polcher, Aaron Boone
- **High Resolution Modeling:**
  - Roy Rasmussen, Andreas Prein
- **Land-climate interactions: (e.g. LS3MIP)**
  - Sonia Seneviratne, Bart van den Hurk
- **Land-atmosphere interactions (e.g. PLUMBER, DICE, GABLS):**
  - Mike Ek, Aaron Boone, Eleanor Blythe
- **Land use and land cover change:**
  - Nathalie de Noblet, David Lawrence*
- **Precipitation:**
  - German Poveda, John Pomeroy, Ron Stewart*, James Renwick*
- **Ground water and sub surface processes:**
  - Mark Bierkens*, Ger de Rooij
- **Large scale atmospheric circulation and processes:**
  - Graeme Stephens,
- **Water-Energy-Food NEXUS**
  - Yahya Abawi, Richard Lawford, FAO representative

Examples of Research Topics

High Resolution Convection Permitting Model

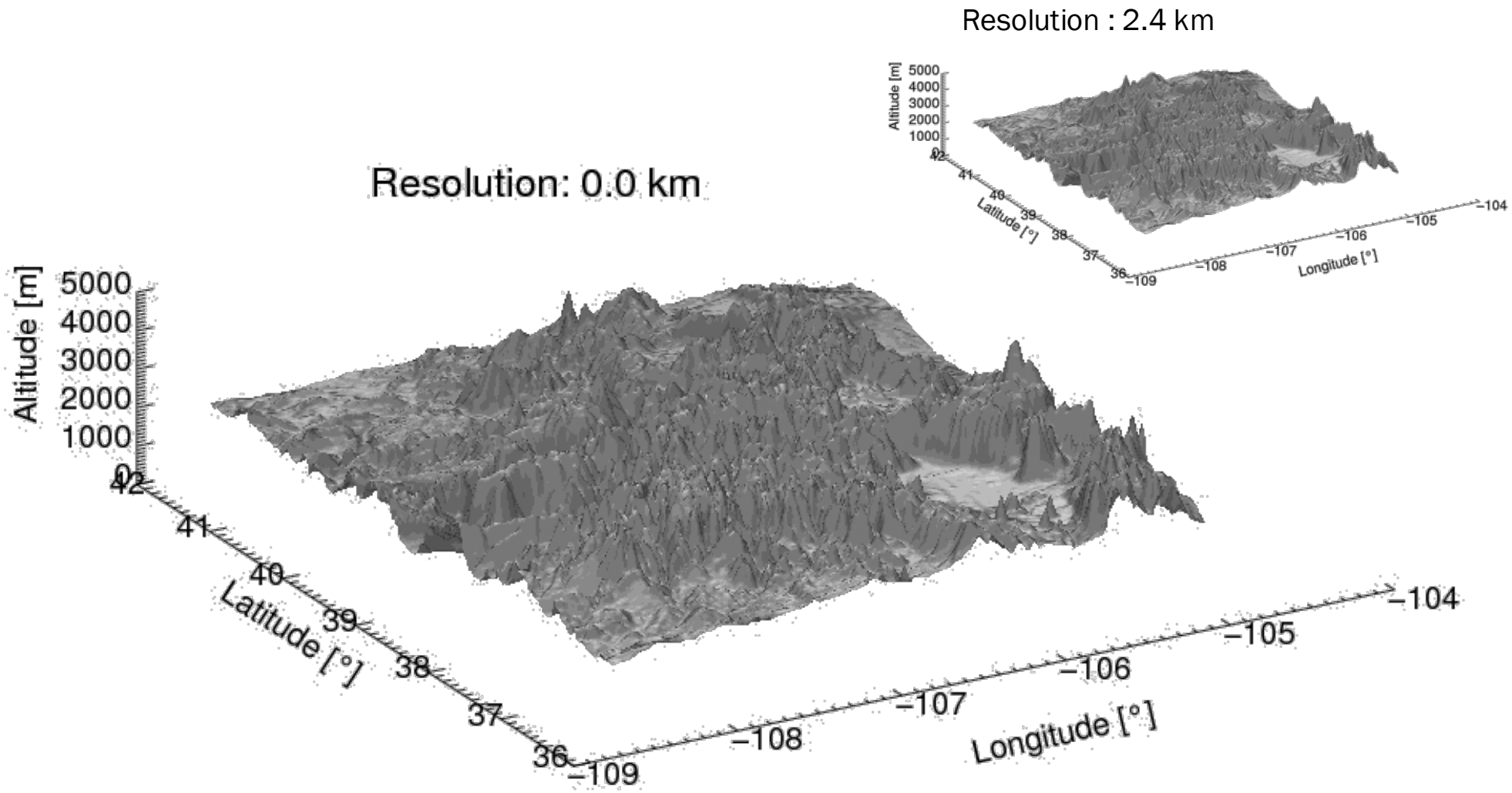
- **Running high resolution model over complex terrain is very important because:**

- 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

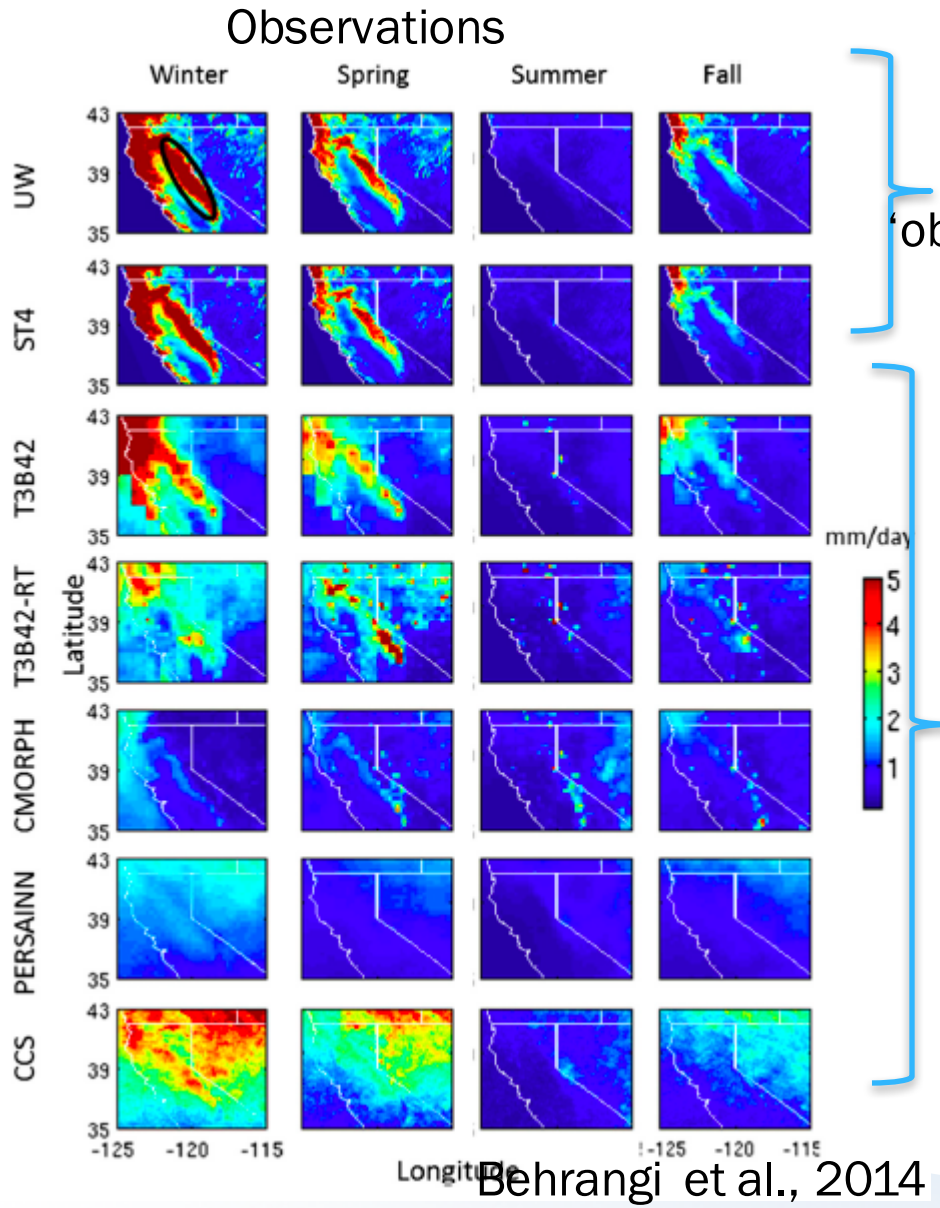
- "Climatically Available Water (P-E)" as we want both P and E at higher spatial (and temporal) resolutions
- Agronomy and the FAO in particular, are limiting themselves to "reference evaporation" without taking into account small scale processes which change water availability.
- Soil moisture availability 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



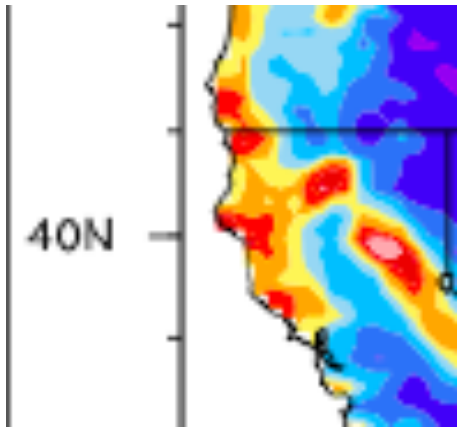
Courtesy Andy Prein

Example of mountain hydrology

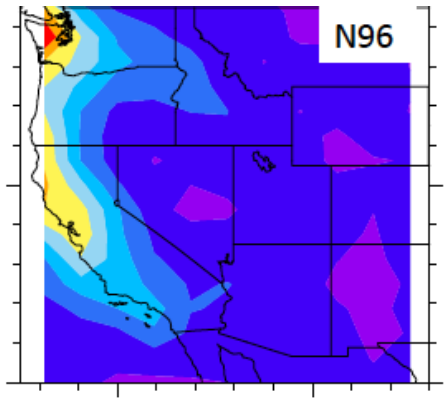


Behrangi et al., 2014

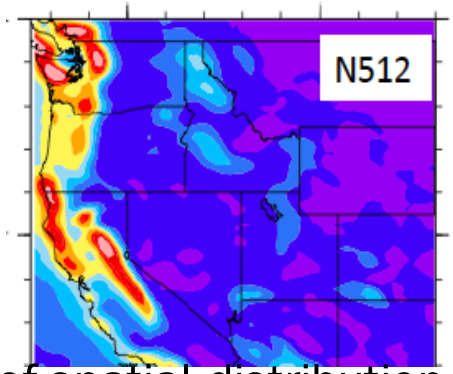
DJF 99% percentile



Obs



Model (135km)



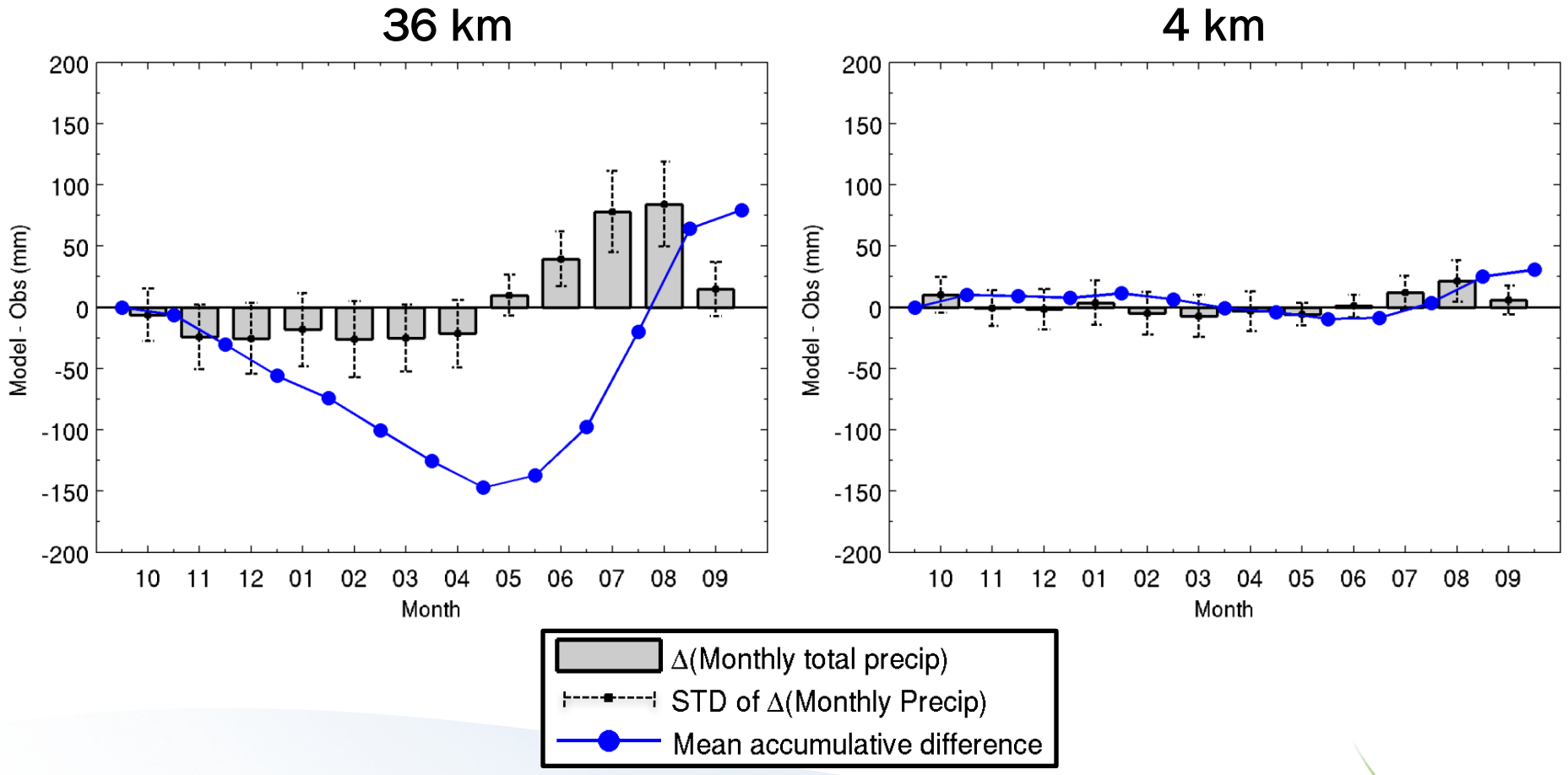
Model (25km)

Simulation of spatial distribution of high-impact precipitation events improves with high resolution

Example of impact of resolution (resolved topography) on snow pack

30% too little precip in the winter and 65% too much in the summer using 36 km model compared to 4 km model (compensating errors)

Evapotranspiration in the 36 km model 38% higher than the 4 km model



GEWEX

WCRP World Climate Research Programme

Examples of Research Topics

Representation of effects of land use and land cover changes (LULCC)

- **Correctly representing the effects of LULCC on climate is essential for projections**

- Changes in LULCC strongly affect mean climate and climate extremes (Pitman et al. 2009, GRL; De Noblet et al. 2012, J. Climate; Davin et al. 2014, PNAS)
- Irrigation represents a major intervention in the water cycle, in particular affecting regional temperature and precipitation (Lobell et al. 2006, GRL; Cook et al. 2011, Clim. Dyn; Wei et al. 2013, JHM)
- Low emissions scenarios keeping Tglob below 2° (e.g. RCP 2.6, van Vuuren et al. 2011, Clim. Ch.) heavily rely on changes in land use (aforestation, bioenergy production)

Institutional and Other Partners

Regionally Focused

- Academic Institutions/Universities
- Federal/National Agencies
- Regional/State/Local Agencies
- International Research Organizations
- HydroMet Services
- Stakeholders
- Young Hydrologic Society/YESS/APECS etc.

Meetings 2016

Meeting	Date	Location	Lead
Water Availability Grand Challenge for North America	May 3-5	Columbia, MD	Van Oevelen , Schiffer
CORDEX Conference	May 17-20	Sweden	CORDEX IPO
GEWEX Hydro-Climate-Sensitivity Workshop	June 20-23,	Exeter, UK	Stephens
GEWEX Soils and Water	June 28-30	Leipzig, Germany	Or, De Rooij, van Oevelen
GEWEX Hi Res Modeling	Sept 6-8	Boulder, USA	Rasmussen
GDAP Meeting	September or October	Washington, DC	Schulz
GHP/GLASS Crosscut on Human Dimension (before GHP)	Sept 28-30	Paris, France	Harding
GHP Meeting	Oct 3-5	Paris, France	Polcher, Evans, Cuxart
GLASS Meeting (colocated with GHP)	Oct 3-5	Paris, France	Ek, Boone
INARCH Meeting (colocated with GHP Panel Meeting)	Oct 6-7	Paris, France	Pomeroy
2nd PANNEX Workshop	Jun 1-3	Budapest	Lakatos, Guettler
Mounterrain	??	??	Renwick


Great Plains and
Central Valley
Pannonian Basin
SE Asia Rice and
Wheat Regions

Thank You