ABOUT
WATER, ENERGY,
& CLIMATE

The WCRP Grand Challenge
Water for the Food Baskets of the World
and Convection-Permitting Modeling

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GEWEX

Global Energy and Water EXchanges

A Core Project of the World Climate Research Programme

WCRP
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Current State

Challenges for Food Production

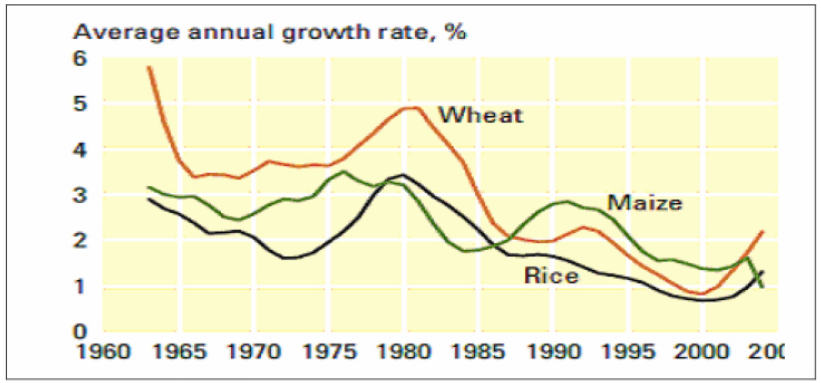
TABLE 5.1 INCREASE IN AGRICULTURAL PRODUCTION REQUIRED TO MATCH PROJECTED DEMAND, 2005/2007-2050 (PERCENT)

	2005/2007	2012-2050	2005/2007 2012	2013-2050
World				
As projected in AT2050 [1]	100	159.6	14.8	44.8
With updated population projections (UN, 2015) [2]	100	163.4	14.8	48.6
Sub-Saharan Africa and South Asia				
As projected in AT2050	100	224.9	20.0	104.9
With updated population projections (UN, 2015)	100	232.4	20.0	112.4
Rest of the world				
As projected in AT2050	100	144.9	13.8	31.2
With updated population projections (UN, 2015)[2]	100	147.9	13.8	34.2

[1] World Agriculture Towards 2030/2050: the 2012 revision. ESA Working Paper No. 12–03. Rome, FAO. Alexandratos and Bruinsma, 2012

[2] FAO Global Perspectives Studies, based on UN, 2015. Available at **https://esa.un.org/unpd/wpp.** Accessed November 2016

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

Food production increase is slowing down!

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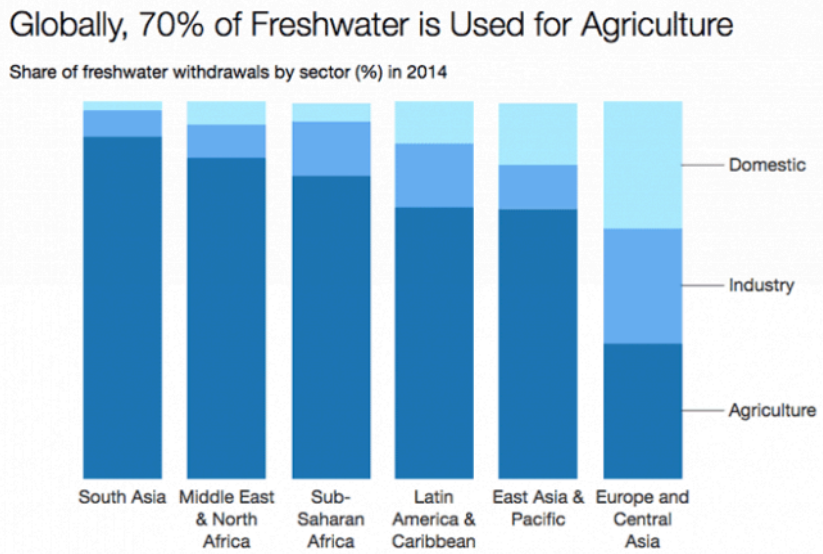
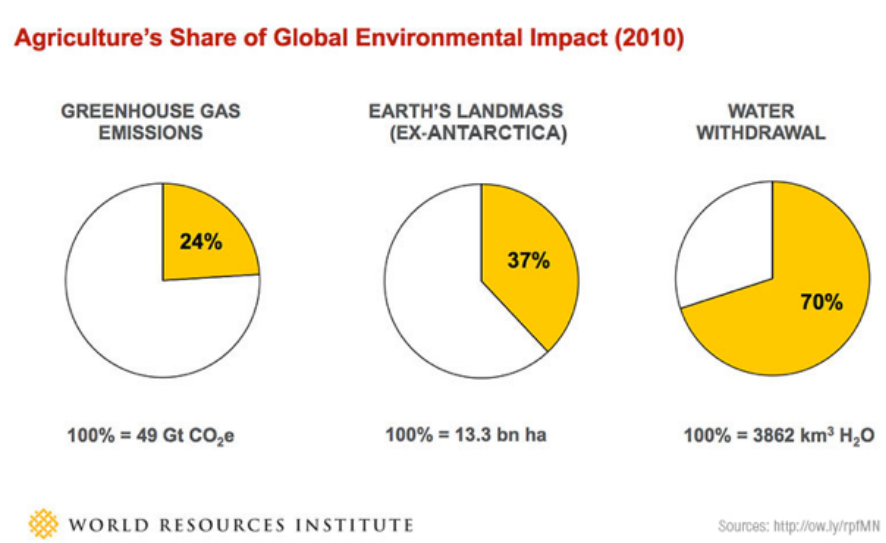
Agriculture & fresh water





In most regions of the world, over 70 percent of freshwater is used for agriculture.

By 2050, feeding a planet of 9 billion people will require:
- an estimated 50 percent increase in agricultural production and
- a 15 percent increase in water withdrawals.

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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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Objectives

Initial goals

- Link to agriculture and vegetation/crop modeling at the appropriate scale(s)
- Incorporate irrigation/water extraction and other human water resources activities into our modeling
- Interface with human aspects / socio-economical factors
- Explore other relevant aspect including land use/land cover change

- Understand the complexity of predictive aspect of human behavior in this context
- Improve the biogeophysical processes in our modeling to support the above
- Interface with appropriate community on socio economics/human aspects

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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 factors such 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 needs to be treated at very high resolution.
- Many problems exist both terrestrial as well as atmospheric including: human dimension, LULC etc.

Proposed implementation plan

What we need to do!

- Observational based studies :
- Should be based on RHP *in regions of intense agriculture*.
- Better quantify human control on the water cycle.
- Process studies on surface atmosphere interactions.
- Promote *inter-disciplinary analysis*.

- Enhancing predictive capabilities :
- Propose *model inter-comparisons to promote model development*.
- Re-visit the past evolution which combine climate change and increasing human intervention.
- Consolidate process knowledge in our models (incl. crop, biosphere etc.).

Convection-Permitting modeling is at the core of many activities!

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Essential link to agricultural modeling

- The human dimension has many aspects. In this GC we focus on the aspects directly related to food and water
- 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

Examples of Research Topics

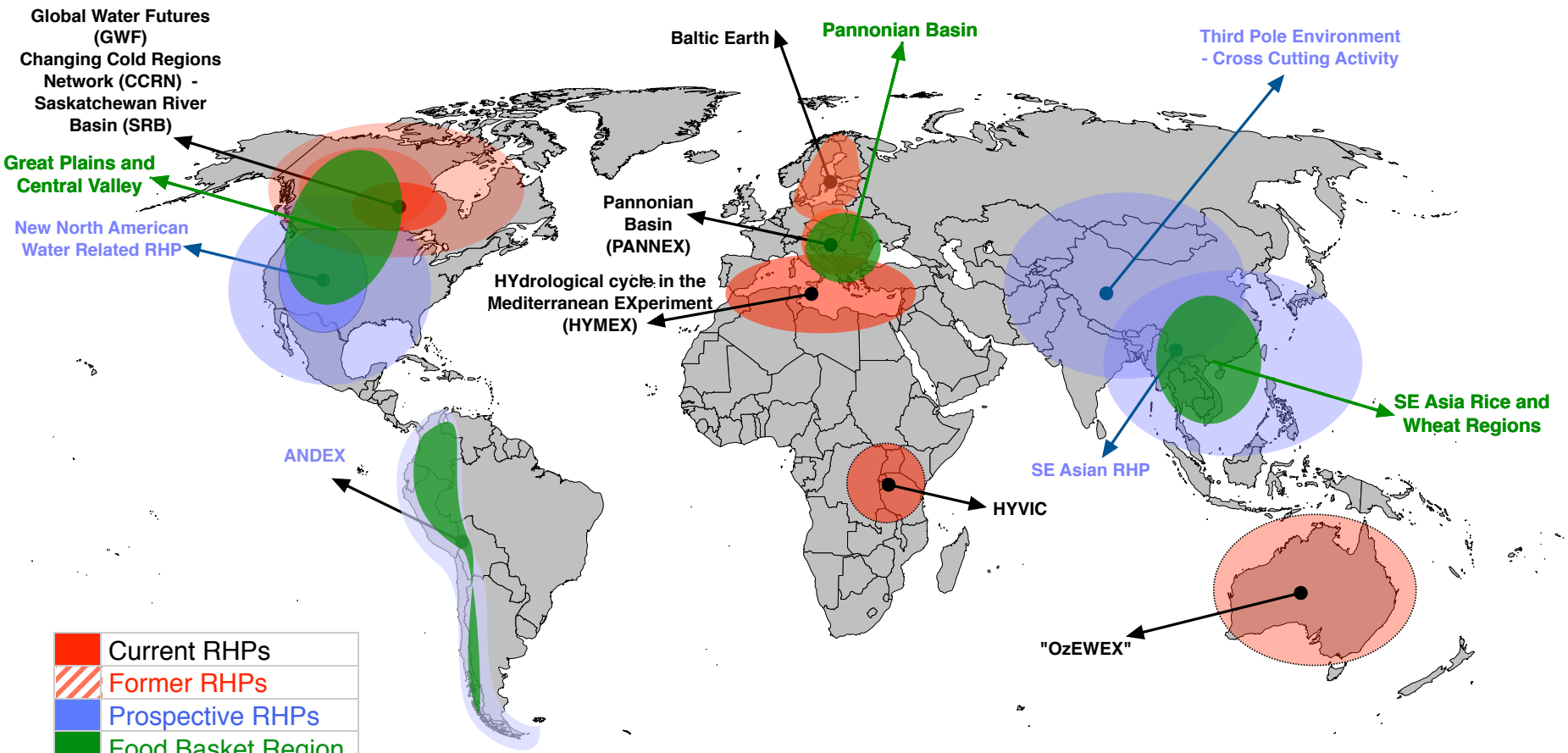
Representation of effects of land use and land cover changes (LULCC)

- 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)

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.
- Have our models capable to better link to other societal issues

Regional Hydroclimate Projects

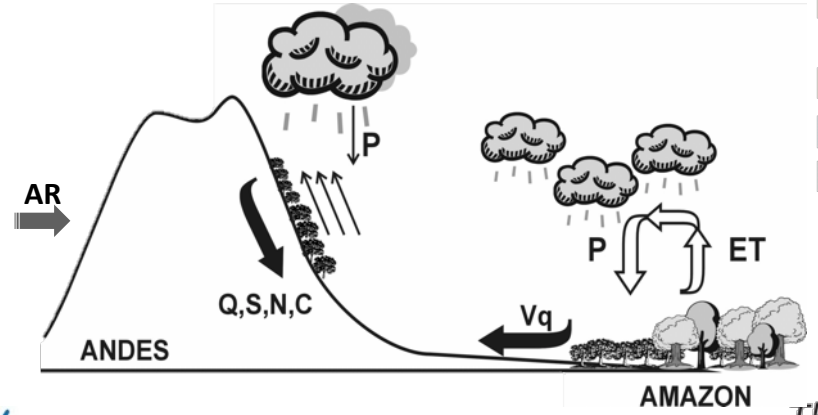


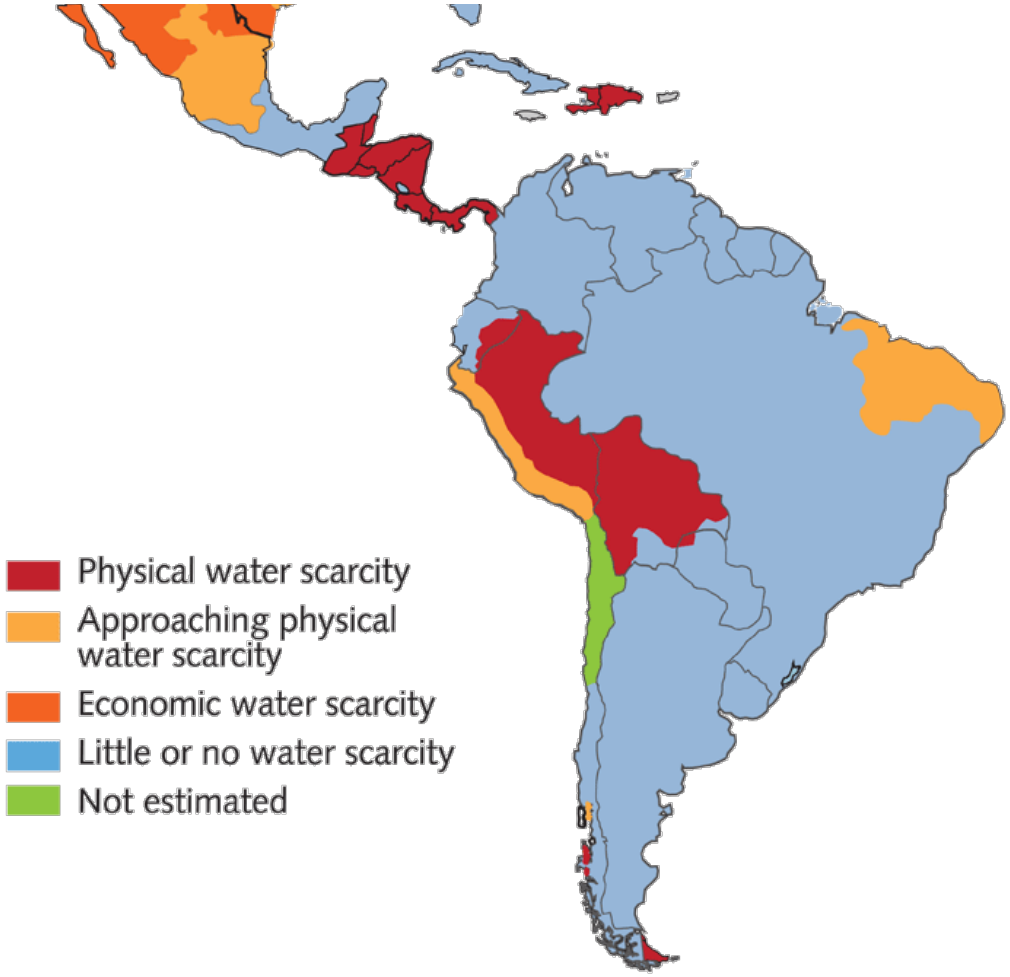
2018 Current and Prospective RHPs

Water Scarcity in Latin-America

ANDEX a proposed RHP

- 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

WCRP GC on Water and UN SDGs

THANK YOU

https://www.gewex.org/about/science/wcrps-grand-challenges/water-for-the-food-baskets-of-the-world/

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