ABOUT
WATER, ENERGY,
& CLIMATE

The continued importance of global climate processes monitoring: precipitation

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GEWEX

Global Energy and Water EXchanges

A Core Project of the World Climate Research Programme

WCRP
World Climate Research Programme

A GEWEX 'science and applica ons traceability matrix'

Provides traceability from WCRP strategies, to core science, to de ned metrics to applica ons and to programs

The GEWEX Mission: Quan ta ve understanding and predic on of the coupling of energy and water in the changing Earth system

WCRP SP	GEWEX Goals	Overarching Science Questions	Objectives	Quantified metrics	Societal applications	Programmatic Links	WCRP IP
		GEWEX SATM is s ll work in progress					

SSG

SSG

WCRP strategy

Panels : Bedrock science

WORLD METEOROLOGICAL ORGANIZATION

United Nations Educational, Scientific and Cultural Organization

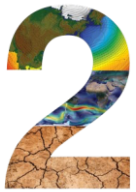
Intergovernmental Oceanographic Commission

International Science Council

WCRP implementation

World Climate Research Programme

GEWEX Goal 1

WCRP SP	GEWEX Goals	Overarching Science Questions	Objectives	Quantified metrics	Societal applications	Programmatic Links	WCRP IP
WCRP science Objectives **Contributes to :**   	**Determine the extent to which Earth's water cycle can be predicted?**	**1) Reservoirs:** What is the rate of expansion of the atmospheric reservoir, what is its spatial character and and what factors determine this? **2) Fluxes**: To what extent are the fluxes of water between Earth's main reservoirs changing and are these changes predictable? **3) Extremes:** How will local rainfall and its extremes change under climate change across the regions of the world?	**O1** Quantify and explain space time changes to water vapor and clouds and associate to processes that influence them **O2** Soil moisture characterization **O3** Provide quantitative assessment of fluxes of water between Earth's water reservoirs, including their space/time variability and uncertainty. **O4** Global assessment of the weather features that cause rainfall including extremes **O5** Assessment of climate models' ability to simulate the rain-bearing weather systems? **O6** Reduction of model systematic errors in rainfall to within the observational uncertainty **O7** Reduction of observational uncertainty in global daily rainfall products	Assessment reports on rain-bearing weather features Assessment report on model's ability to simulate the weather-to-rainfall connection Model systematic error in rainfall is within observational uncertainty Observational uncertainty reduced by 30%	Hazard prediction Adaptation Planning Insurance Risk assessment …	WWRP Hydrology activities CLIVAR …	**WCRP science Objective** 

GEWEX Goal 2

WCRP SP	GEWEX Goals	Overarching Science Questions	Objectives	Quantified metrics	Societal application	Programmatic Links	WCRP IP
WCRP science Objectives **Contributes to :**   	**Determine the interrela onships between Earth's energy and water cycles.**	1) How can we improve the understanding of climate forcings and feedbacks formed by energy and water exchanges? 2) To what extent are the proper es of the the ABL de ned by energy and water exchanges at the Earth's surface and within the atmosphere? 3) To what extent are exchanges between water and energy determined by the circula ons of the atmosphere and oceans?	*Comment - the objectives will address forcings that involve aerosol and aerosol-cloud and water based feedbacks including water vapor, cloud, precipitation and surface related feedbacks* *Comment – will involve fluxes of energy and water exchanges, P, E and ET at surface, PLBL clouds, etc I can imagine a PROES – we have global PBL heights for decade + that are barely studied* *O# - PBL diurnal cycle*		Climate policy, et …	WWRP Hydrology ac vi es CLIVAR CLIC SPARC CFMIP and CMIP6 Clouds/ circula on GC	**WCRP science Objective** 

GEWEX Goal 3

WCRP SP	GEWEX Goals	Overarching Science Questions	Objectives	Quantified metrics	Societal application	Programmatic Links	WCRP IP
WCRP science Objectives **Contributes to :**   	**Quantify the anthropogenic influences on the water cycle**	1) To what extent has the changing greenhouse effect modified the water cycle over the continents? 2) To what extent do water management practices modify the water cycle on regional to global scales? 3) How do hydrological processes and warer & land use affect the variability of the continental water cycle ?	O1 Quantify the effects of water withdrawals and usage on the freshwater flows into the oceans O2 Attribute observed changes to the continental water cycle to climate change and water management. O3 Quantify effects of water withdrawal on river discharge within climate variability O4 Quantify effects of irrigation on land-atmos interaction O4 Extremes in a managed environment.	1) Add human influence to coupled high res models (eg USRHP/water GC)	☐ Water resources ☐ Water management	ILEAPS, CORDEX, IHP, WMO-Hydro, ...	**WCRP science Objective :** 

Rationale

- Precipitation ↓ and Evapotranspiration ↑ are the fluxes that 'represent' the key processes within the water cycle
- To better understand and predict these fluxes we need to observe all relevant aspects of the relevant processes
- Just monitoring of the fluxes itself although crucial is not sufficient!

The WCRP Grand Challenge on Water Availability

Water for the Food Baskets of the World

- Water Cycle the Main Driver of Food Production (~70% of water usage worldwide)
- 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 and Food Production in which Natural and Anthropogenic Processes Interact

- Precipitation key input variable!!

Why monitoring Precipitation?

- Precipitation is central to the energy and water cycle,
- Key hydrological input -> runoff, water resources modeling
- Strong impact -> floods/drought -> water resources
- Strong perturbation under climate change in time and space
  - Global
  - Regional
  - Extremes (high impact events)

- GEWEX Science Questions: Reservoirs and Fluxes, Human Foot Print

A cursory view of precipitation research in GEWEX panels

- GDAP – GEWEX Data Analysis Panel
  - Assessments of data sets related to (global) water and energy fluxes and their consistency
  - Uncertainty and error characterization and understanding in flux observations from space borne observation (again mostly global)
  - GEWEX/GDAP has played a big role in supporting global data sets such as ISCCP and GPCP now it is time to let those evolve on their own, and shift the focus to where and how to improve these (type of) products in a long term consistent approach
- GHP - GEWEX Hydroclimatology Panel
  - Cross cut on Precipitation Extremes Observations
  - Mounterrain
- GASS – GEWEX Global Atmospheric System Studies
  - Process Evaluation Studies (PROES) – Warm Rain, Cloud Physics
- GLASS – GEWEX Global Land Atmosphere System Studies
  - Land Atmosphere Feed Backs and precipitation

Quality of Precipitation Observations

- Assessment of quality is difficult (both for in situ and remotely sensed)

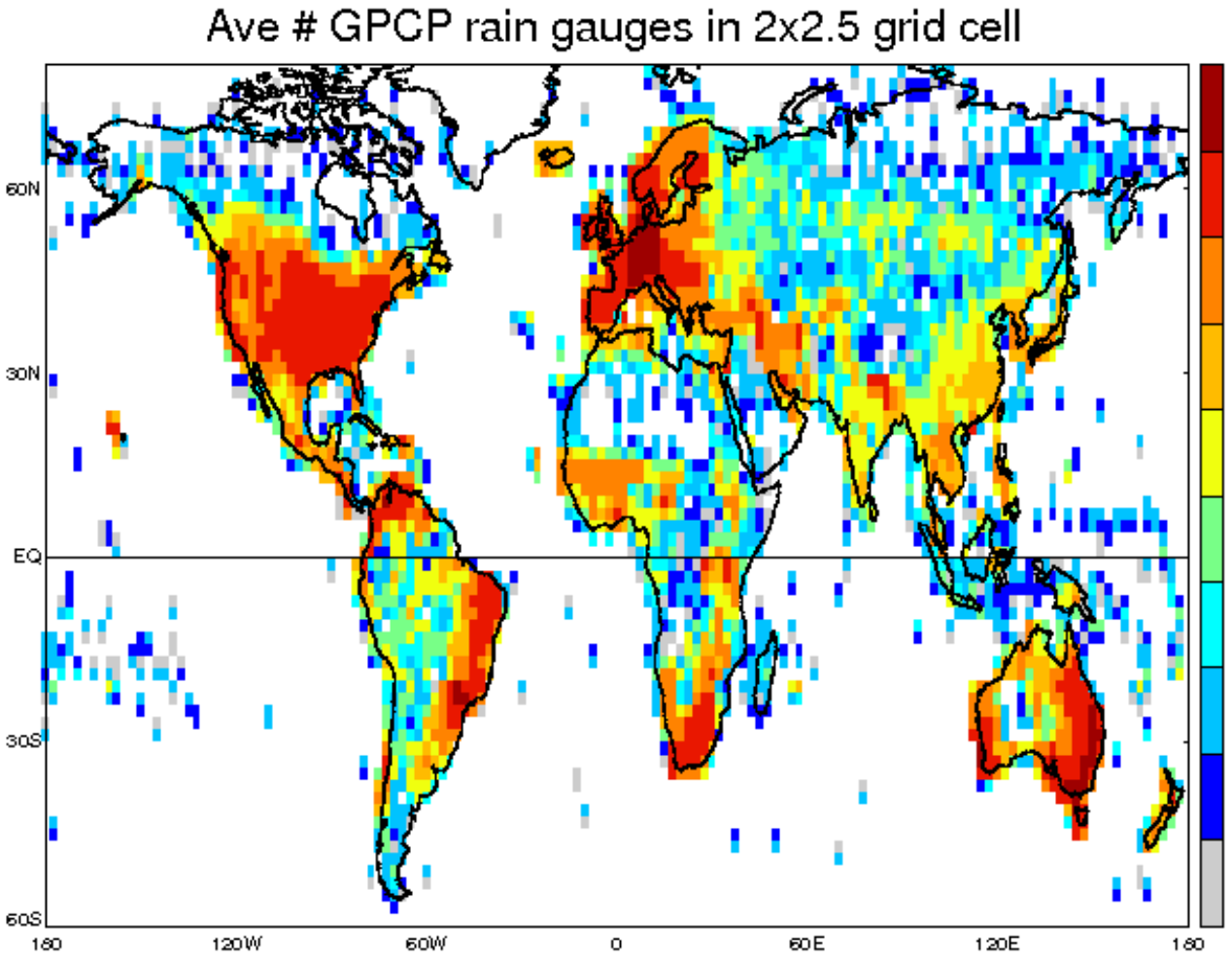
- Intermittent, non-continuous process in both space and time
- Large dynamic range from 0.1 to 300 mm/h
- Phase changes: snow, ice, liquid precipitation is a challenge
- No established reference data sets

Note:

- *Changing considerations for CDRs and other long term satellite data records*
  - *what is the baseline? -> Longest possible sat. record? 'Best' possible product? Highest spatial/temp. res?*
  - *Cf. ReAnalyses - Data Reprocessing more costly at higher resolutions*
  - *Recurring issue and answers might vary depending upon community/field of appliction*

Why Satellite Observations of Precipitation?

Low number of rain gauges over land, none basically over the ocean



Each grid box is ~50,000 *km* in area

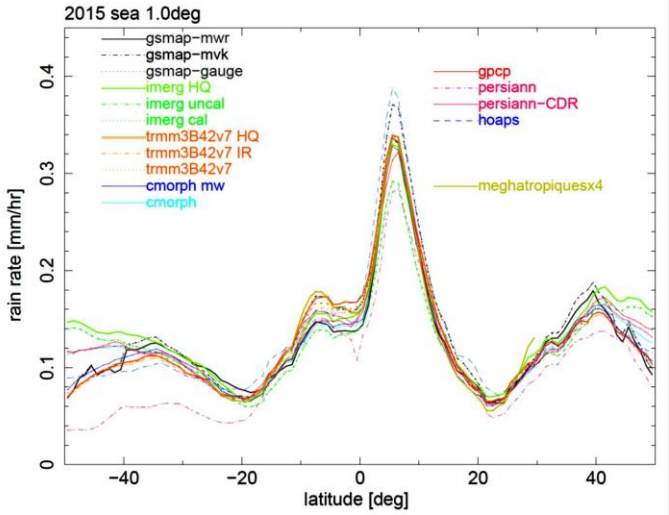
Figure: Koster et al. (2011) doi:10.1175/2011JHM1365.1.

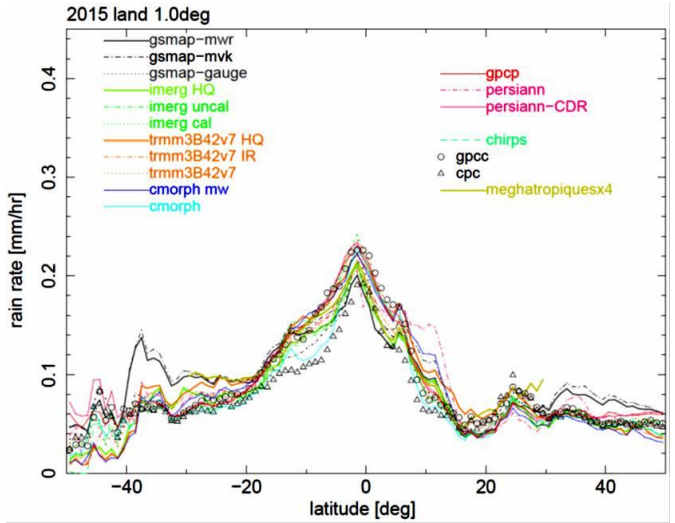
Satellite Observations of Precipitation

- 30+ years record of SSM/I
- New Gen. of Satellites with active sensors (GPM) and constellation based approach
- From the GPCP only era to currently 20+ products (monthly 2.5° to instanaeous 3h at 0.1 °)

- Large uncertainty in these observations that are poorly understood
- large random error at fine scale -> 1° x 1° x 1 day is a good tradeoff for most applications and for the products perspective

Zonal mean precipitation over ocean





Zonal mean precipitation over land

Example List of the products: Resolution

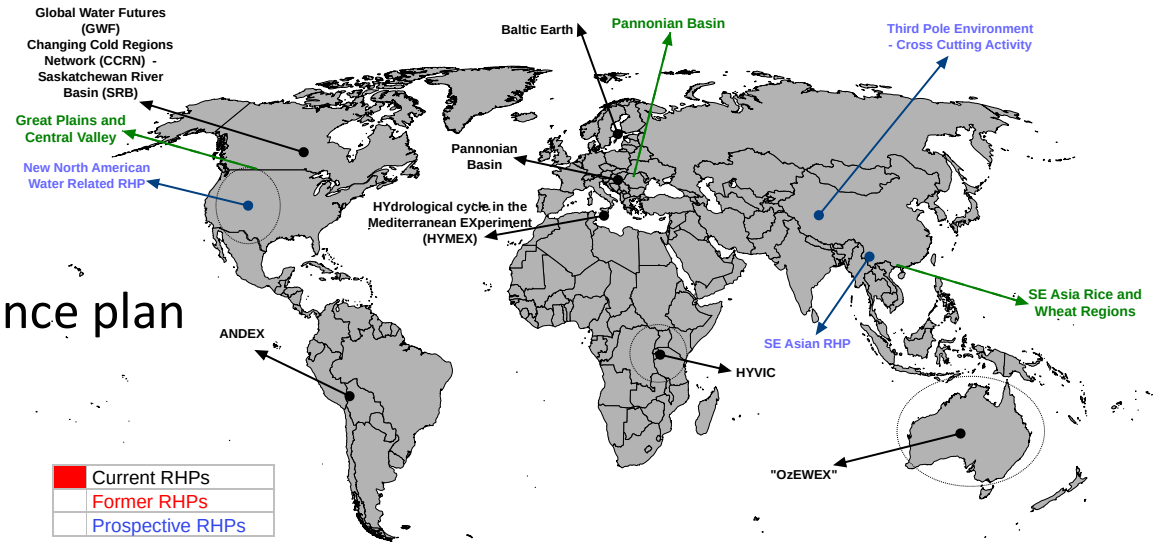
表 1: Table of the used data

Product	Spatial resolution[°]	Time resolution	Version
GSMaP	0.1	Hourly	V04−V7.0000(gauge:7.0001)
			V03−V6.4133(201504∼)
IMERG	0.1	30 min.	V04A
			V03D
TRMM3B42	0.25	3 hrly	V7
CMORPH	0.25	3 hrly	V1.0
GPCP	Mon.:2.5/Daily:1.0	Monthly/Daily	Monthly:V2.3/Daily:V2.3
CMAP	2.5	Monthly	V1604,1703
PERSIANN	0.25	3 hrly(CDR:Daily)	m6s4
HOAPS	0.5	6 hrly	V3.2
meghatropiques(TAPEER)	1.0	Daily	V1.00
CHIIRPS	0.05	Daily	V2.0
CPC	0.5	Daily	V1.0/V1.0RT
GPCC	0.5/1.0(2014∼)	Monthly	full−V7/monitor−V4,5(2014∼

Summary

- Upstream
  - Assessment under GEWEX/GDAP identify some successes & issues with the 22 existing climate oriented datasets -> need for climate driven with uncertainty well characterized
  - Validation sites are needed? Potentially GHP sites from Regionally Hydroclimate Projects?
  - Consistency is key

- Downstream
  - Link to core science questions of the GEWEX science plan
  - Link to WCRP grand challenges on:
    - Water for the food baskets
    - Extremes



THANK YOU

https://www.gewex.org/

GEWEX

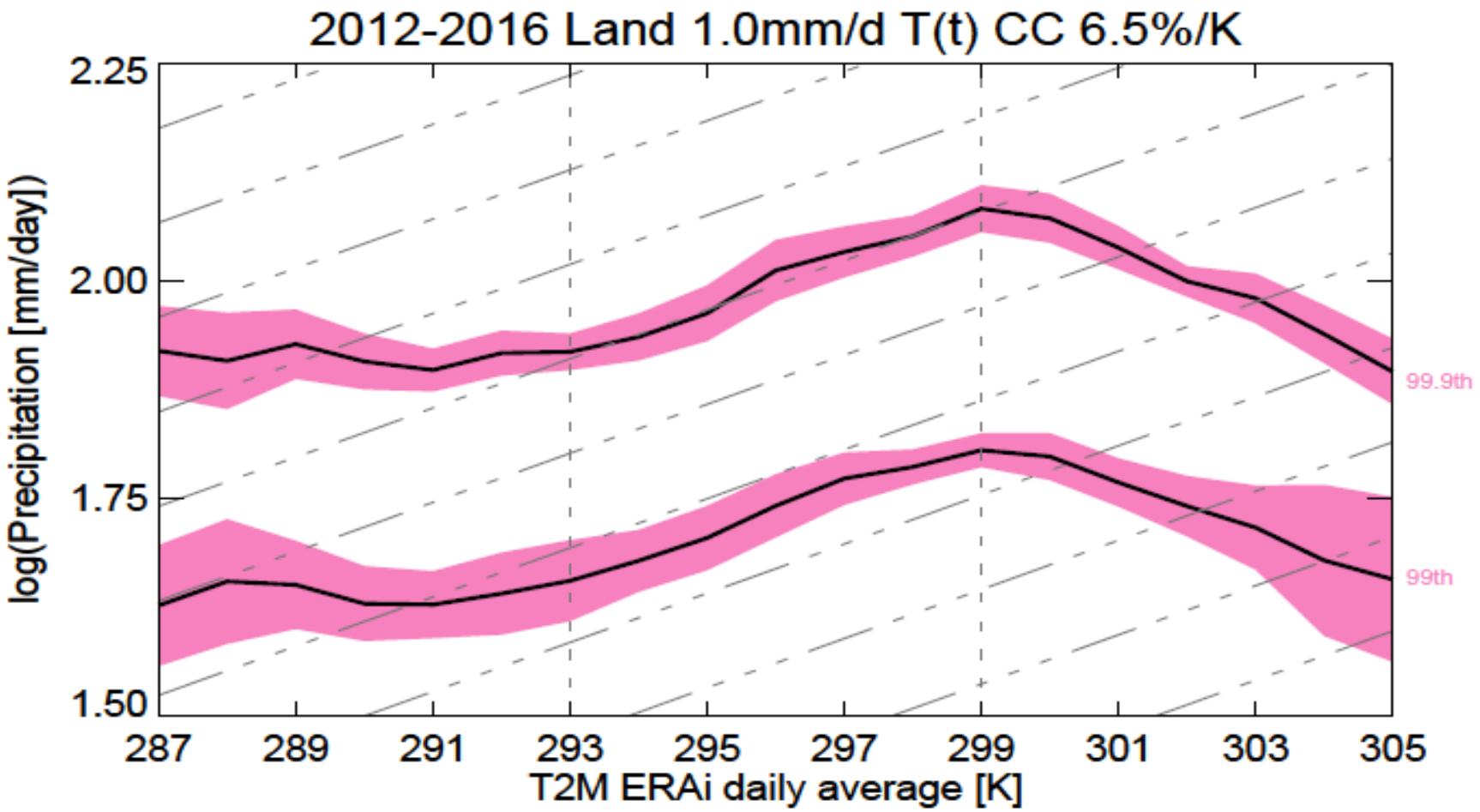
WCRP World Climate Research Programme

Joint GC Extremes and GDAP meeting (2/3)

$$P_e = -\epsilon\left\{\omega_e \left.\frac{dq_s}{dp}\right|_{\theta^*}\right\}$$

$$\frac{\delta P_e}{P_e} \propto \frac{\delta q_s^{surface}}{q_s^{surface}}$$

~6-7%/K

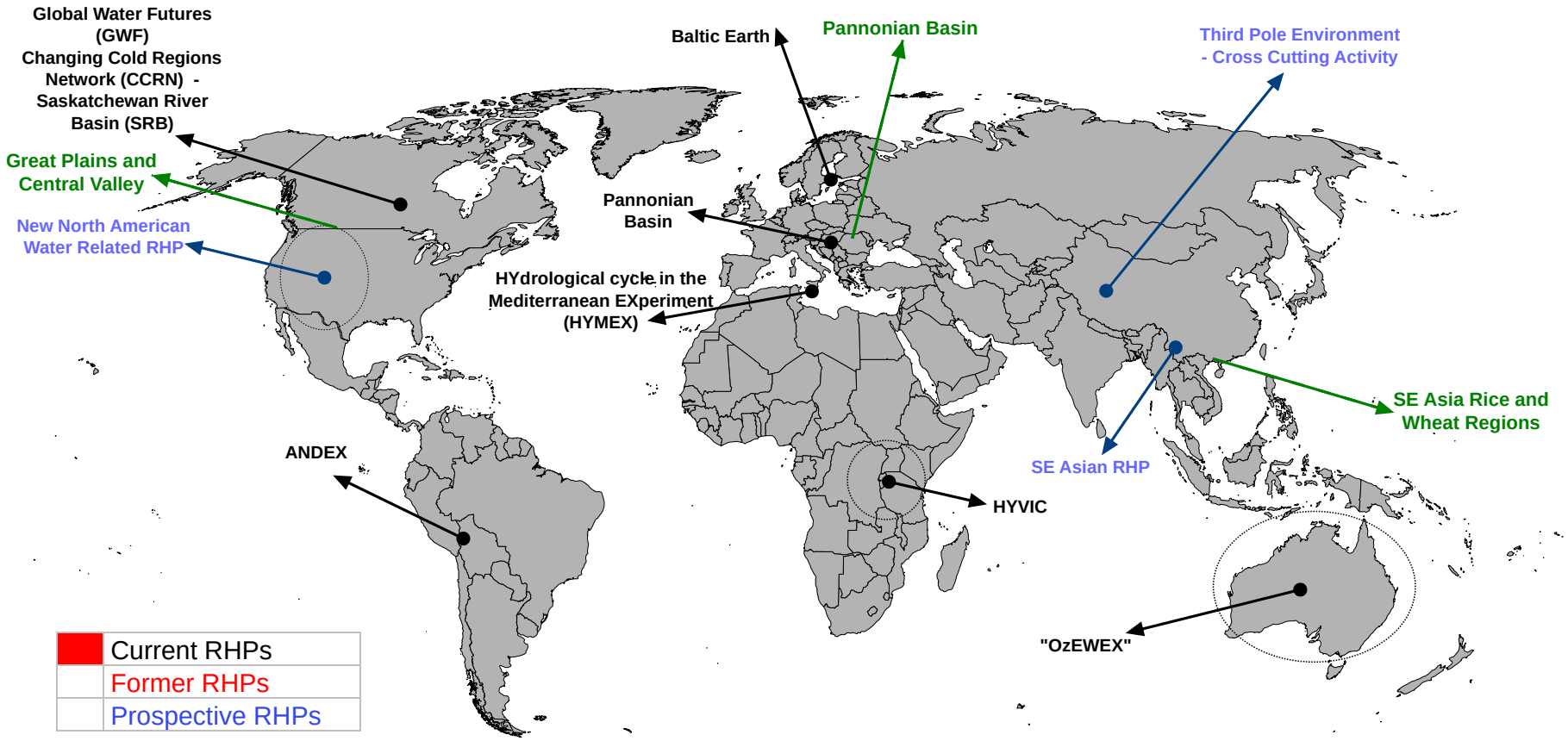


Ensemble of satellite precipitation data using the microwave constellation shows strong consistency with surf Temp confirms the theory for the tropics

- Some Questions:
- Is continuation of GPM or similar EO Precipitation necessary? And why-not-
- What are the alternatives?
- Precip obs. not assimilated in NWP (not yet….)
- Flood forecasting for longer lead times relies mostly on forecasted precip., for shorter lead times and flash floods often rain radar networks are used. Hence, where do the EO Precip come into play?
- How important is continuation of a CDR?

Regional Hydroclimate Projects

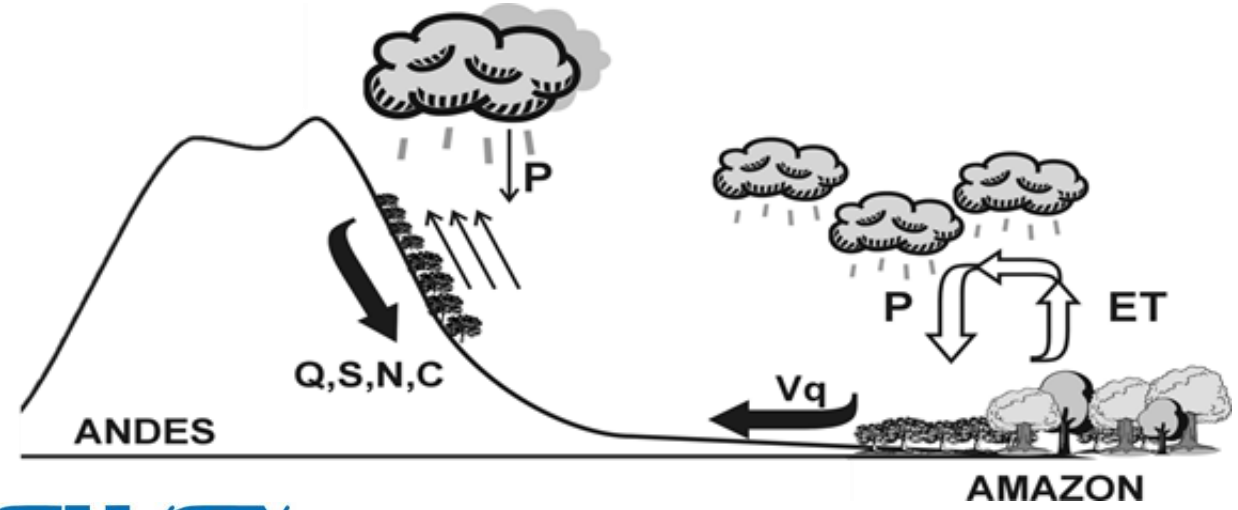
Proposed Food Basket of the World Focus Regions

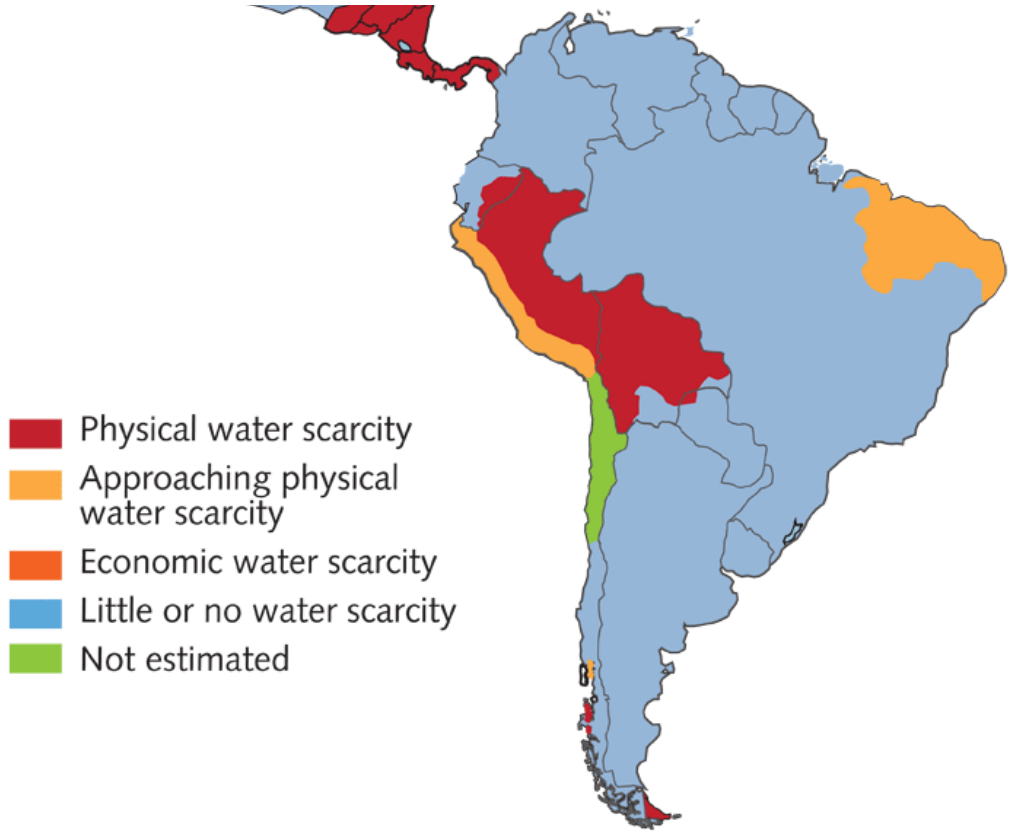


ANDEX - A Prospective RHP in South America

Water Scarcity in Latin-America

- How stable are –water- resources under climate change?
- How could it change?
- What needs to be adapted to?
- What can be mitigated?





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