ABOUT
WATER, ENERGY,
& CLIMATE

Observations and Modelling of Precipitation in High Mountain Regions

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And many others!

Global Energy and Water EXchanges

A Core Project of the World Climate Research Programme

GEWEX

WCRP
World Climate Research Programme

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!

Why monitoring Precipitation?

Preaching to the choir….

- 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)

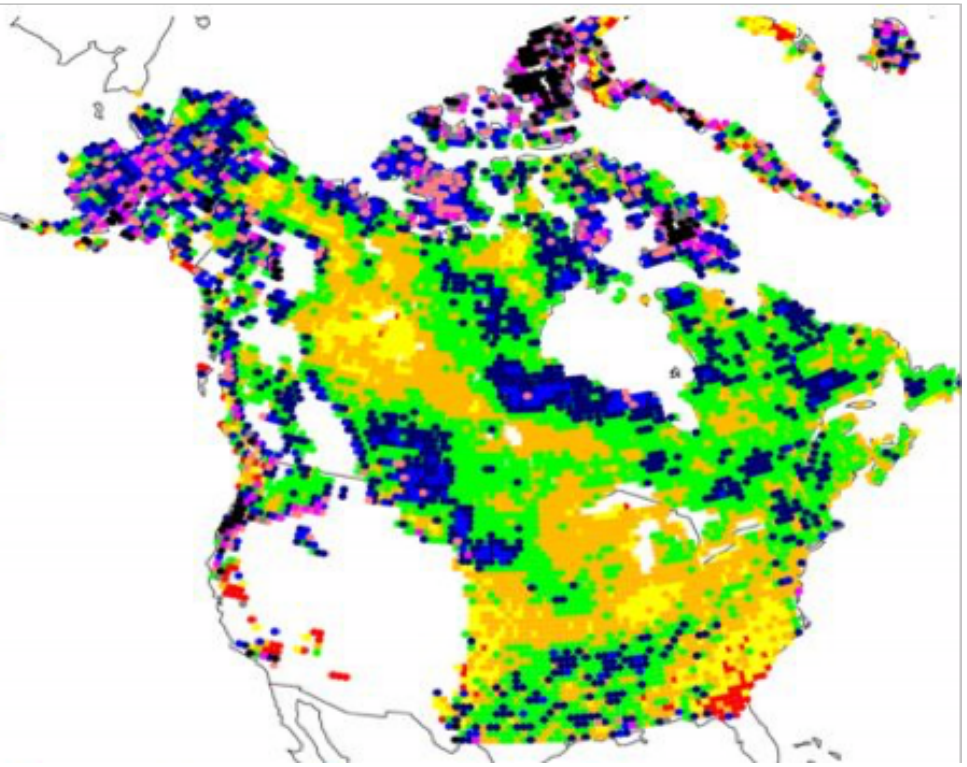
- GEWEX Science Questions: Reservoirs and Fluxes, Human Foot Print
- High mountain regions prove to be very challenging in this regard!

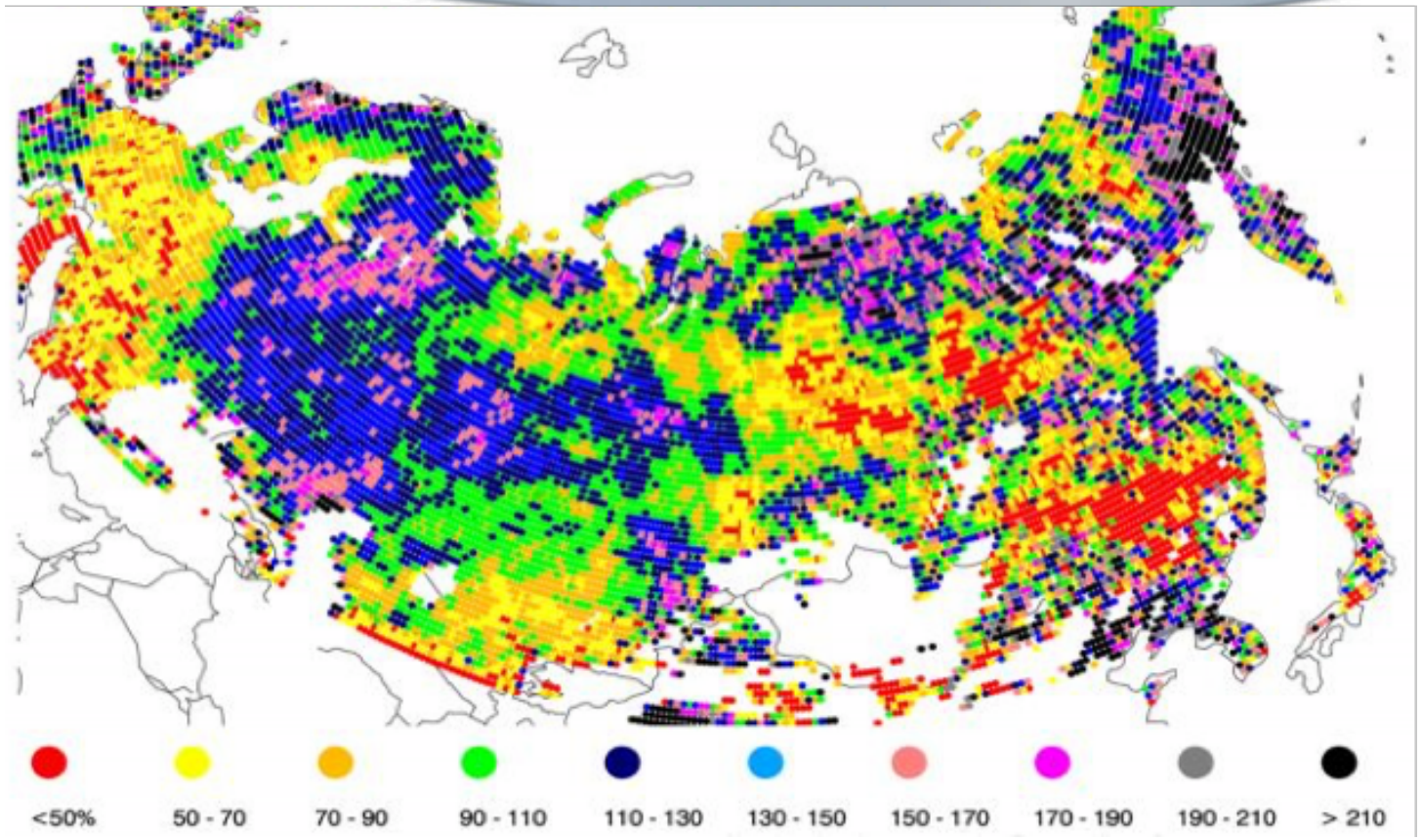
GEWEX Activities relevant to Precipitation in High Mountain Regions

- Regional Hydroclimate Projects (RHPs) & Networks
  - Modeling, Observations, Impacts studies etc.
- Crosscutting Activities
  - *TeamX (new), Mounterrain (new), INTENSE, Near 0°C Precipitation*
- Global Observational Data Sets Assessment and Analyses <-> IPWG
- Process Studies -> PROES
- Regional Observational Campaigns (short and long term) -> e.g. LIAISE

- Note:
  - Observation of Processes / Process variables relevant to Precipitation
  - Observation of Precipitation

Freezing rain days





Freezing rain days change (%) in the past 13 years (2005-2017) compared to the previous 26 years (1979-2004) over North America (left) and northern Europe/Asia (right).

- increased over northern and eastern Europe, the Canadian Arctic, Alaska, and northern Great Plains,
- decreased over western Europe, the boreal zone of western Canada as well as southeastern and midwestern U.S.

Courtesy: Ron Stewart and Pavel Groisman

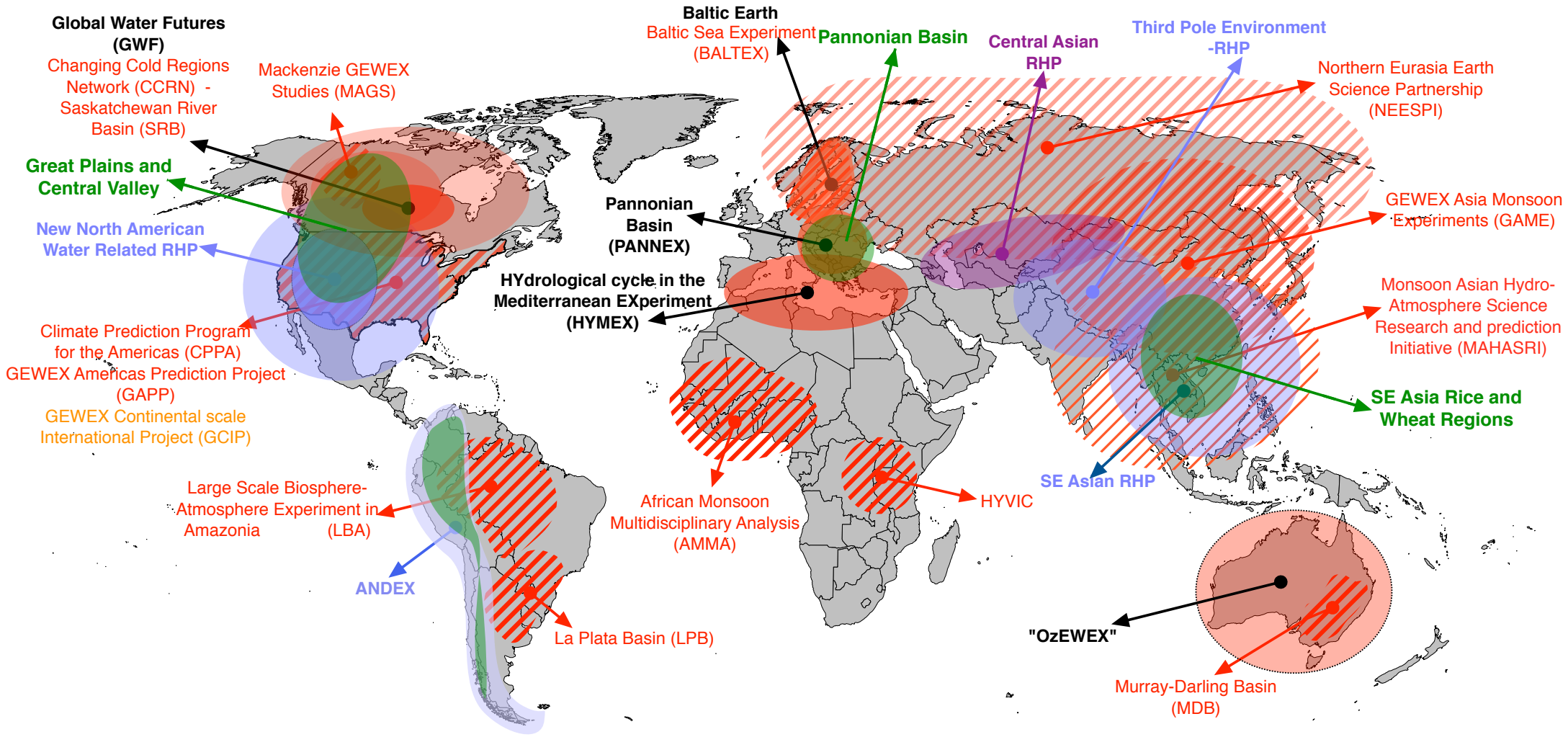
Regional Hydroclimate Projects (RHPs)

- RHPs are generally large, regionally-focused multidisciplinary projects that aim to improve the understanding and prediction of that region's weather, climate, and hydrology.

- All RHPs address the physical processes surrounding water and energy exchanges within a region, thus addressing the GEWEX Science Questions/Objectives.

- Most RHPs are broader than this, often addressing questions related to the biosphere and carbon cycle, human interaction in the landscape, and even socio- economic factors.

Regional Hydroclimate Projects 1991 - 2019



Current RHP Status - 2019

Currently Active in 4 continents:

Europe:

HyMEx (2010-2020) =====> High-impact weather events, societal response

Baltic Earth (2016-) =====> Sea and land changes, biogeochemical processes

PannEx (2018-) =====> Agronomy, air quality, sustainability & water mgnt

North America:

GWF (2018-2023) => Cryospheric, ecological, hydrological interactions

Recently finished:

North America:

CCRN (2014-2018) ==> Cryospheric, ecological, hydrological interactions

Asia: ***MAHASRI*** (2007-2016) ==> Asian Monsoon

Eurasia: ***NEESPI*** (2004-2015) ==> Northern Eurasian climate-ecosystem-societal interact.

Prospective:

Andex

TPE RHP

AsiaPEX

In discussion:

(Western) USA

Central Asia – first network building

GHP Network: **OzeWEX** (Australia)

High Elevation Regions of the World & RHPs

TDX Global 3D elevation model – from DLR
The twin satellites TerraSAR-X and TanDEM-X fly in close formation only a few hundred metres apart, capturing data for digital elevation models.

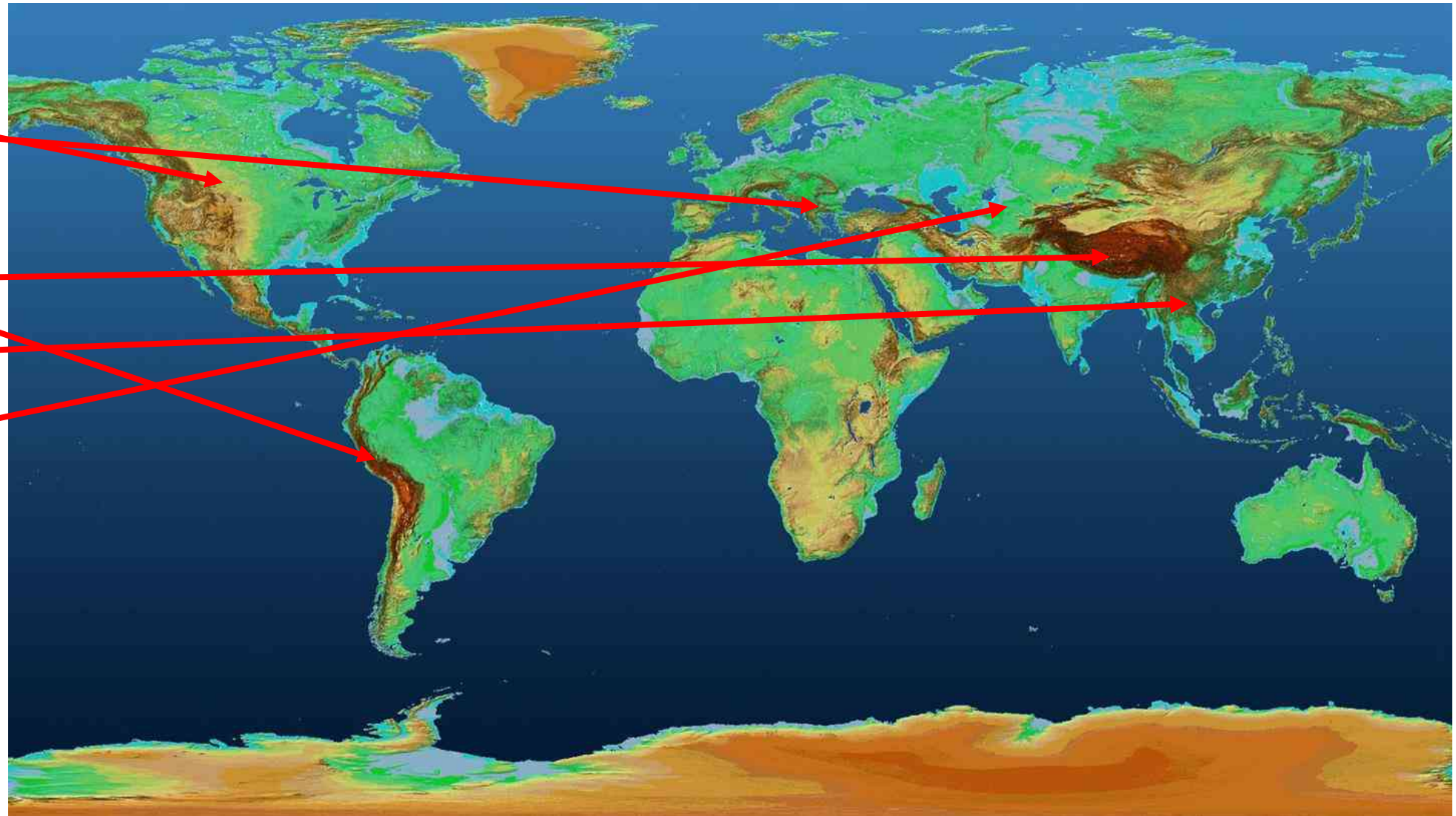
Current:
GWF
PANNEX

Initiating/Prospective:
ANDEX
TPE – RHP
AsiaPEX

In Development:
Central Asia

ADD:

New Zealand
Eastern Africa/Ethopia



InARCH

With basins in Europe, S. America, N. America and Asia

The International Network for Alpine Research Catchment Hydrology

A cross-cut project of the GEWEX Hydroclimatology Panel to better understand alpine cold regions hydrological processes, improve their prediction and find consistent measurement strategies

New Initiatives/GHP Cross Cuts:

Mounterrain

TeamX

The WCRP Grand Challenge on Water Availability

Water for the Food Baskets of the World

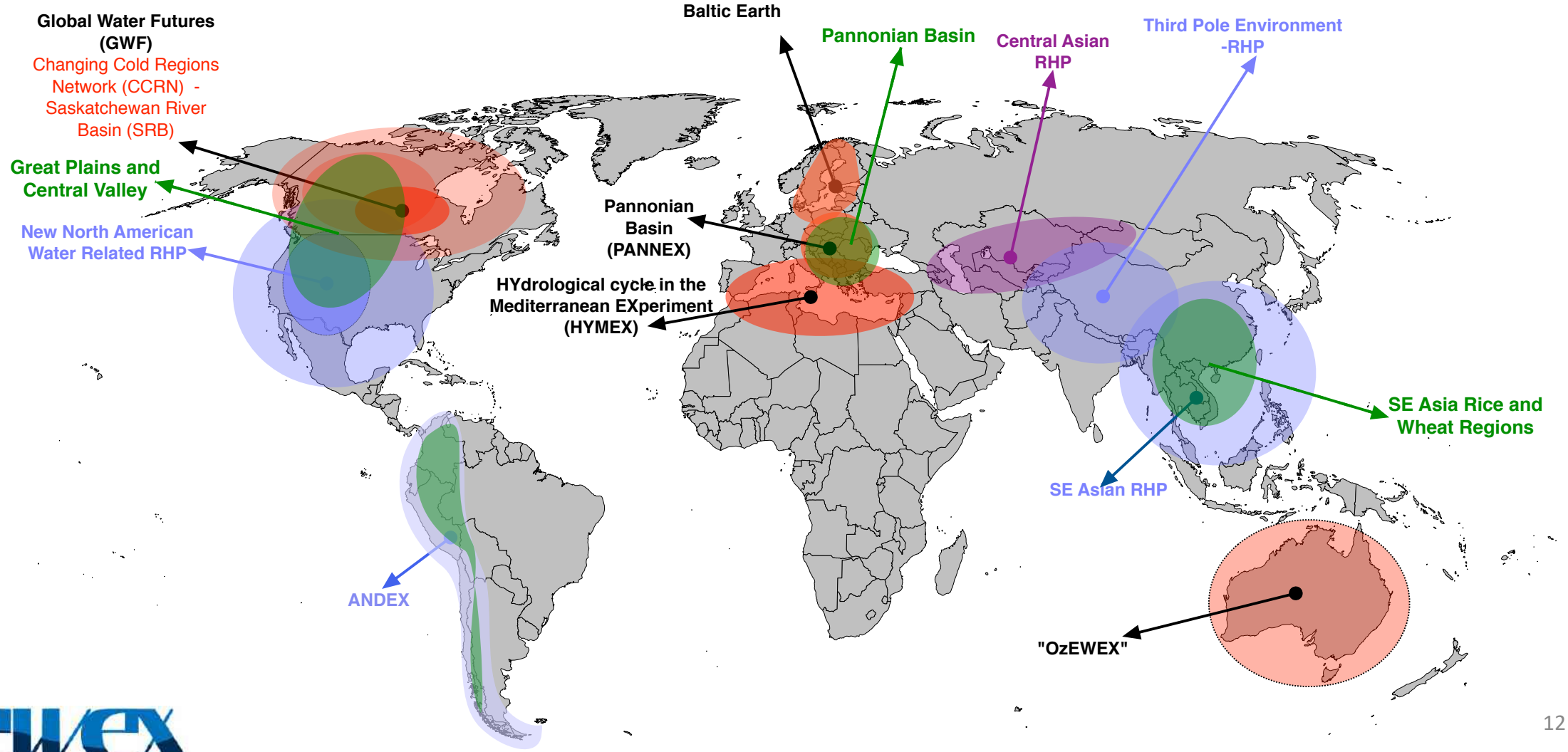
- Water Cycle the Main Driver of Food Production (~70% of water usage worldwide)
- A Warmer Climate Pushes the Water Cycle into Unknown Territory
- The Terrestrial Water Cycle is not Natural Anymore
- Urgency to Understand the New State of the Water Cycle and Food Production in which Natural and Anthropogenic Processes Interact

Precipitation and EvapoTranspiration are Key!

Yet we at the same time we need information on human influence, extraction and discharge etc.

Regional Hydroclimate Projects

Proposed Food Basket of the World Focus Regions



UNIVERSITY OF SASKATCHEWAN

Global Water Futures

GWF.USASK.CA

Focus Region:
Western Canada and Rocky Mountain Watersheds

Timeline:
2019 – 2023

Extensive portfolio of research activities
Strong multidisciplinary effort
Socio hydrology and indigenous people

PI: John Pomeroy

Precursors:
Saskatchewan River Basin Project (SasRB)
Changing Cold Regions Network (CCRN)

PANNEX

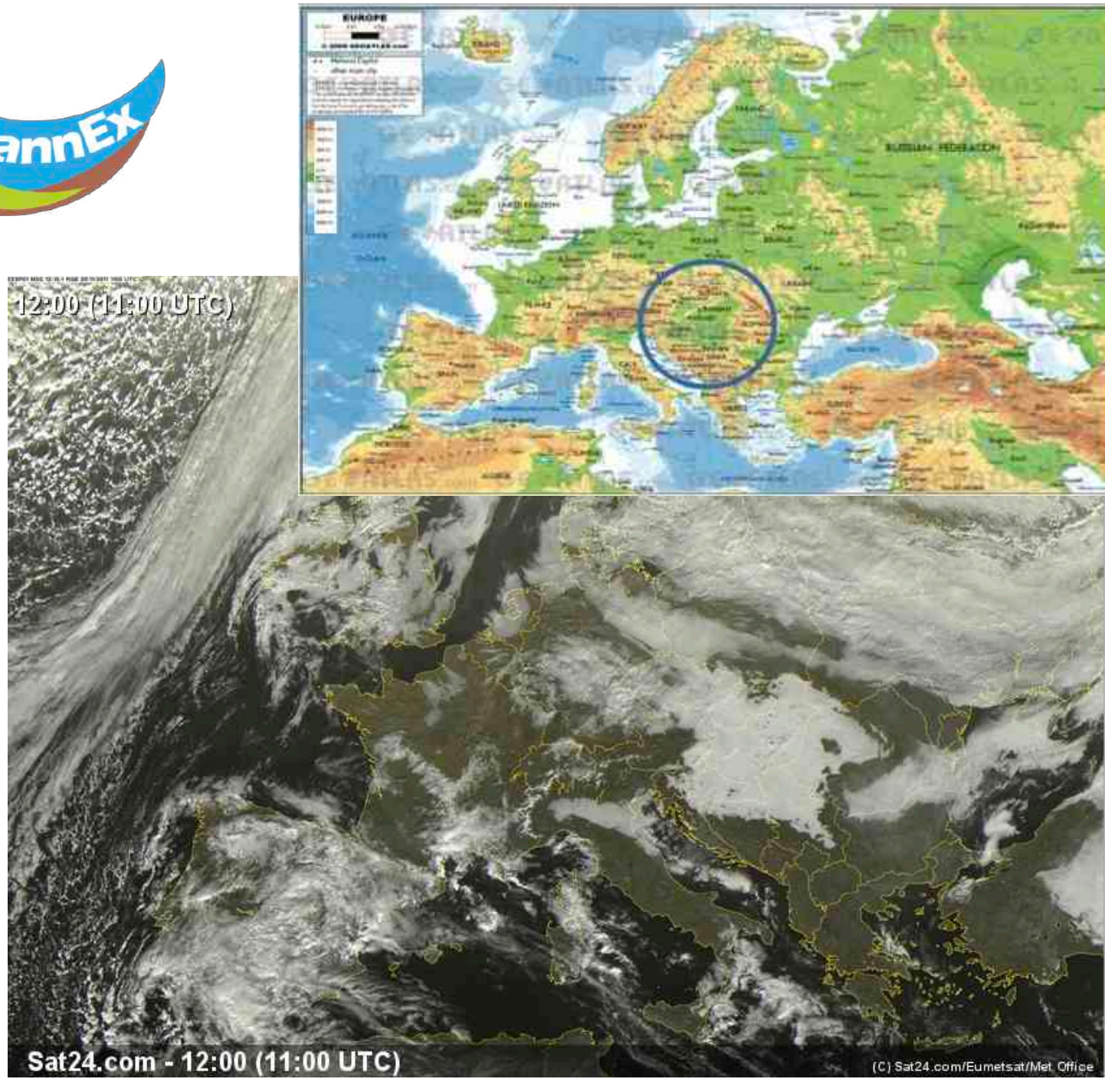
Pannonian Basin Experiment

Focus Region:
Pannonian Basin and Surrounding Mountain Regions

Timeline:
2018 –

i) Agroclimatological and Agrobiological Systems,
ii) Energy Production,
iii) Special Observations and data analysis,
iv) Ecosystem services,
v) Urban climate and air quality
vi) Outreach and education,
vii) Micrometeorology and agro. process modelling
viii) Water balance at the basin scale,
ix) Modelling from Climate to Flash Floods

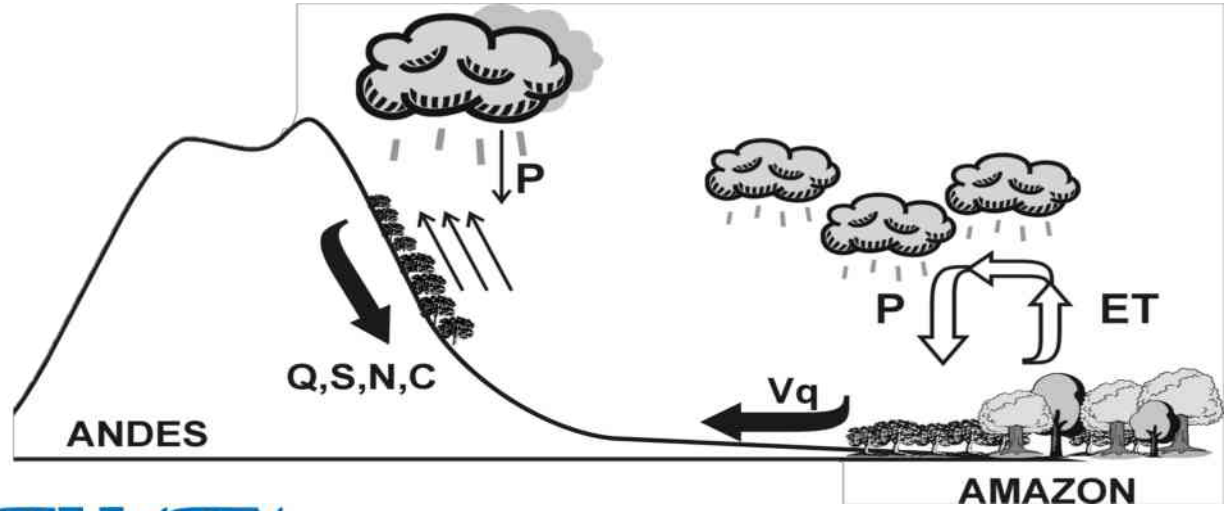
PI: Monika Lakatos, Ivan Guettler

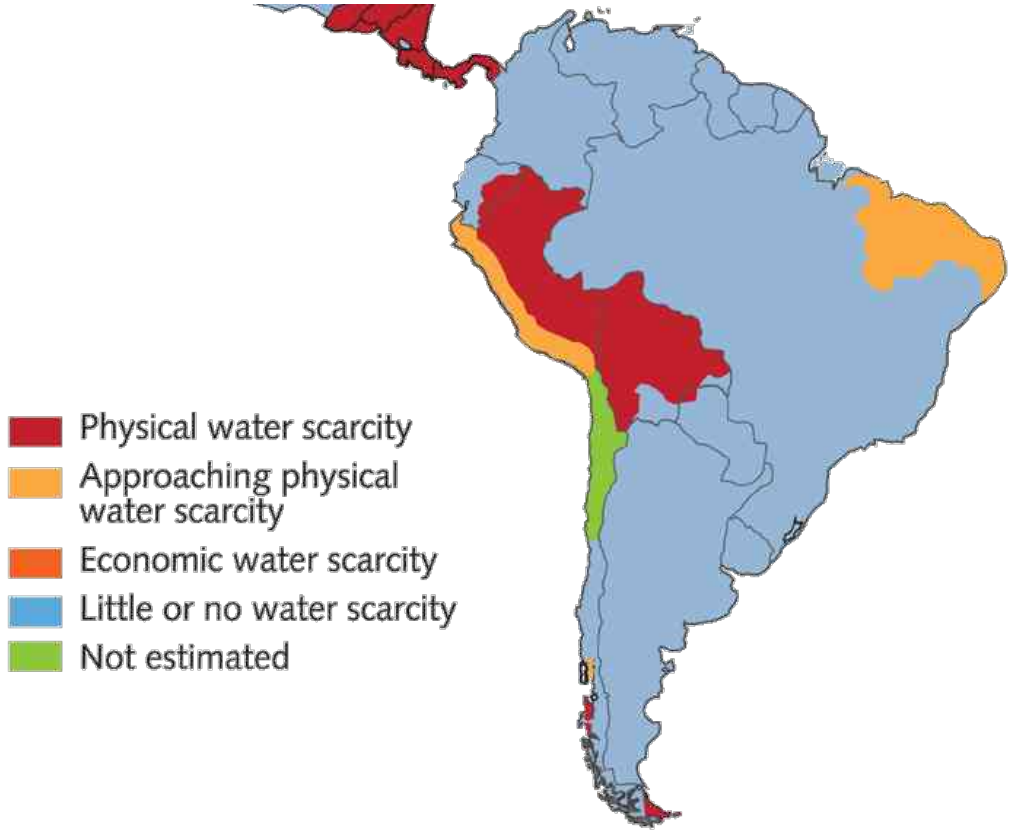


ANDEX - A Prospective RHP in South America

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

AsiaPEX - A South East Asian RHP

Linking the Himalayan Mountains to the Coastal Zone of SE Asia

- A follow up initiative to MAHASRI
- In early stages
- One of the Key Sci. Questions: *What is Mountain Precipitation and hydrological cycles?*

Science

- To Understand Asian Monsoon Land Precipitation;
- Observation and Estimation of Variation and Extremes in Asian
- Land Precipitation and Important Variables
- Process Studies of Asian Land Precipitation Focusing on Diverse Land-Atmosphere Interactions
- Understanding and Prediction of Variability of Asian Monsoon from Subseasonal to Interdecadal Time Scales
- High Resolution Land Surface Hydrological Modeling and Monitoring Incorporating Impacts of Human Water Withdrawal, Agriculture, Vegetation and Cryosphere
- Coordinated Observation and Modeling Initiatives
- Detection and Projection of the Climate Change Impact on Regional Precipitation in the Asian Monsoon Region

Third Pole Environment

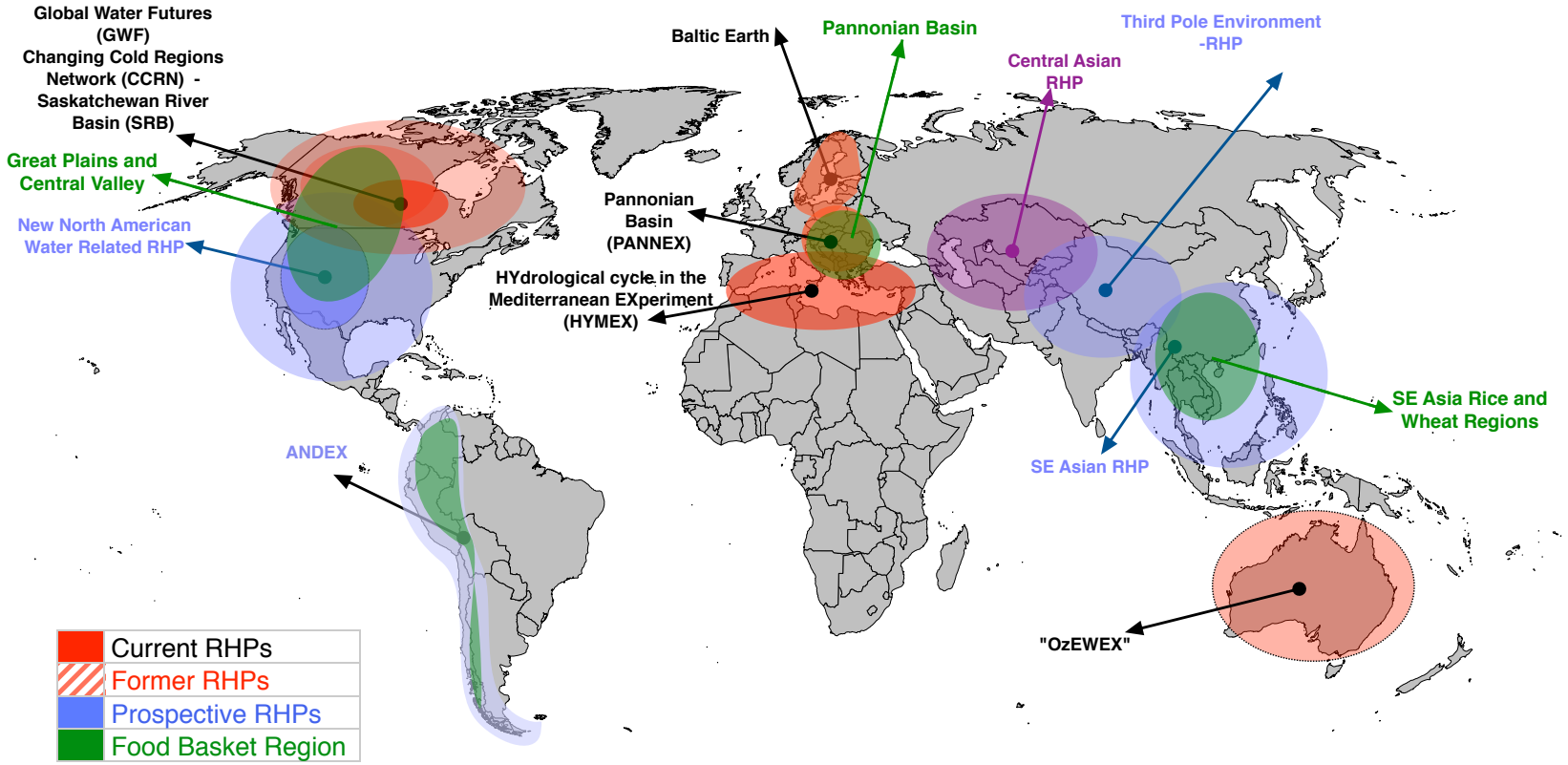
A TPE RHP on Water Sustainability – From cross cut to RHP?

- Atmospheric circulation in high-latitude and the Third Pole region
- Remote sensing and data retrieval for cryosphere
- Land-surface interaction water resources/cycles in high- latitude and the Third Pole region
- Climate modelling and future project on for Third Pole
- Natural hazards and human adaptation in Third Pole

A Regional Hydroclimate Project for Central Asia & The Caspian Sea

Initiate new and integrate ongoing research activities in Central Asia outside of HKH

A missing region and research community



Understanding the impacts of climate variability and change on water availability and food security across mountain ranges and river basins of Central Asia

The GLASS Land Atmosphere Feedback Observatories (GLAFOs)

Vision:

We propose to design and to develop observatories in different climate regions based on the LAFE setup in order to make corresponding measurements operational and to refine these by additional instrumentation.

These measurements should contain

for the soil: Moisture, temp. profiles, and precip network, ground water level

for the vegetation: Rooting depth, biomass, canopy height, moisture, and temperature, LAI, vegetation type and state

for the SL: EB, isotope measurement of respiration, evaporation, and transpiration, Fiber-based temperature profiles, 10-m tower with measurements at 2 m and 10 m

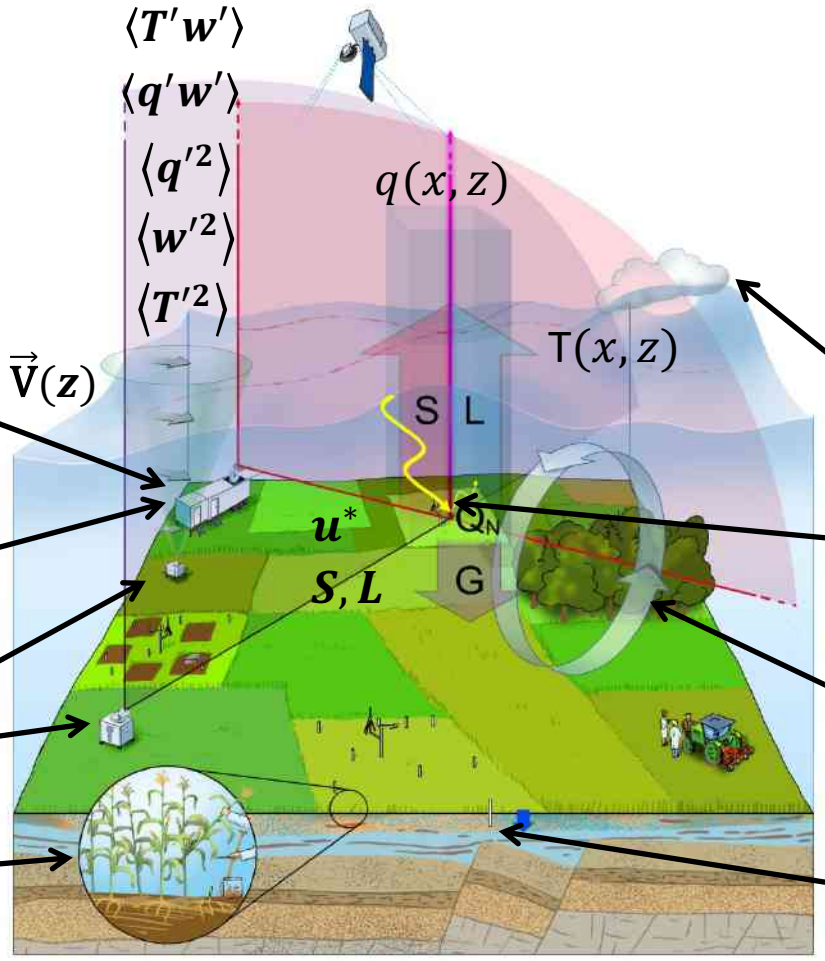
for the PBL: 6-beam staring Doppler lidar (TKE, momentum flux, dissipation rate, and horizontal wind profiles); vertically staring Doppler lidar (vertical wind); scanning temperature, water-vapor, and CO_2 lidar (SL, turbulence and flux profiles); AERI, MWR, scanning cloud and precipitation radar

GEWEX

Slide courtesy: ***Volker Wulfmeyer***

UNIVERSITY OF HOHENHEIM

The GLASS Land-Atmosphere Feedback Observatory (GLAFO)



Vertically staring Doppler, WV, T, and CO_2 lidar systems, AERI, MWR, cloud radar

Scanning Doppler, WV, T, and CO_2 lidar systems

Scanning Doppler lidar

LAI, albedo, root water uptake

Planetary boundary layer top

Surface energy balance, isotope sensors

Mesoscale vortex

Soil moisture and temperature

A combination of vertical staring instruments will be the starting point.
In a next step, scanning instruments will be added.

Wulfmeyer et al. BAMS 2018, DOI:10.1175/BAMS-D-17-0009.1

Slide courtesy: ***Volker Wulfmeyer***

AsiaPEX, BRAIN and GLAFO

- BRAIN: Borderless Radar Information Networking over South and Southeast Asia
- JAXA/JMA integrated precipitation product combining in situ, ground radar and space borne observation
- A proposed high resolution boundary condition/forcing data set for regional off line simulation (Hyungjung Kim) and run associated high res off line simulation
- Convection – permitting modeling in complex terrain
- To have detailed SL and PBL observations in addition to the precipitation observations in a high mountain environment would be a unique endeavor!

Summary and Conclusions

A few take away messages and observations

- The GEWEX RHPs cover most high mountain regions in the world
- A unique opportunity to link these research communities – *most have focus on precipitation, this addresses a universal challenge and can be a great link*
  - **Knowledge and data sharing, resources and tools**
  - **Historical context**
- Better Process Understanding, Observations and High resolution modeling is needed in particular in these high mountain regions
  - **Costs are high both in capacity and resources (computational, storage, accessibility, person months etc.)**
  - **The high res models need much more -in situ- observations of sufficient quality, consistency and continuity**
- Water cycle is not entirely natural anymore and sustainability of the water resources is strongly linked to these –*vulnerable*- mountain regions
- A new GLASS Land-Atmosphere Feedback Observatory (GLAFO) set-up is proposed as an innovative addition regional and global GEWEX activities
- Include New Zealand and Eastern Africa

WMO High Mountain Summit

October 29 – 31, WMO Geneva Switzerland

- http://highmountainsummit.wmo.int/.

THANK YOU

https://www.gewex.org/