WORLD CLIMATE RESEARCH PROGRAMME

GEWEX highlights for JSC 43, June 2022

Jan Polcher, Xubin Zeng, Peter van Oevelen and all GEWEX panel leaders.

GEWEX

WMO IOC ICSU International Council for Science WCRP World Climate Research Programme

GEWEX Science Goals

Goal # 1

- Determine the extent to which Earth's water cycle can be predicted … and observed !

Goal # 2

- Quantify the inter-relationships between Earth's energy, water and carbon cycles to advance our understanding of the system and our ability to predict it across scales.

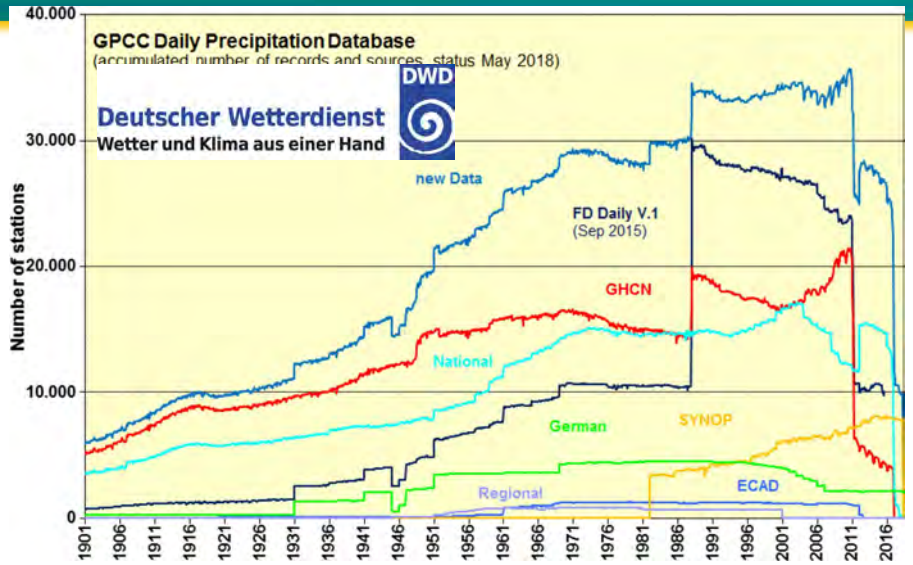
Goal # 3:

- Quantify anthropogenic influences on the continental water cycle and our ability to understand and predict its changes.

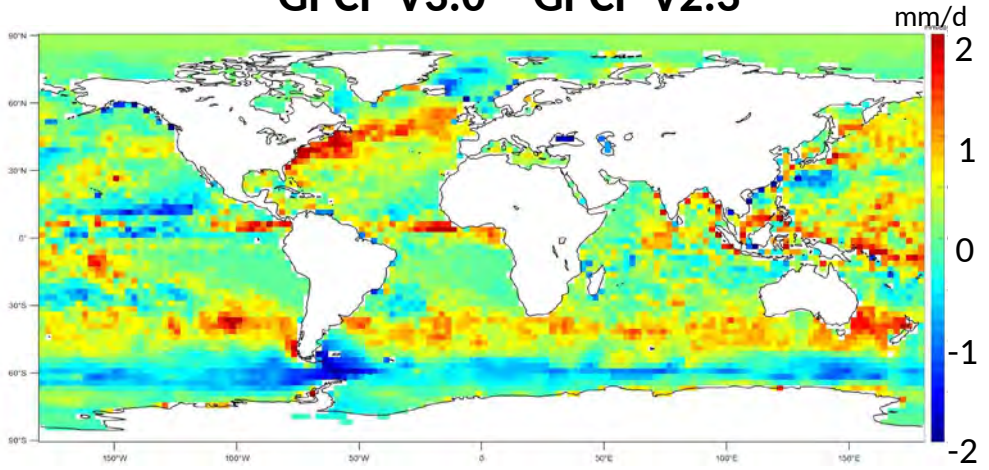
The activities towards these goals are organized through 4 panels.

Precipitation estimate assessment

- IPWG/GEWEX Joint Precipitation Assessment, 2021
- In situ-based estimates are moving to sub-diurnal products (GPCC, INTENSE).
- Satellite derived products use new sensors and refine their estimates.



GPCP V3.0 - GPCP V2.3



~6.7 % increase in global Oceanic precipitation compared to GPCP V2.3 at different months.

Mountain precipitation remains an issue

None of the observational based products (in-situ or remote sensed) produce estimates consistent with what we know from mountain hydrology.

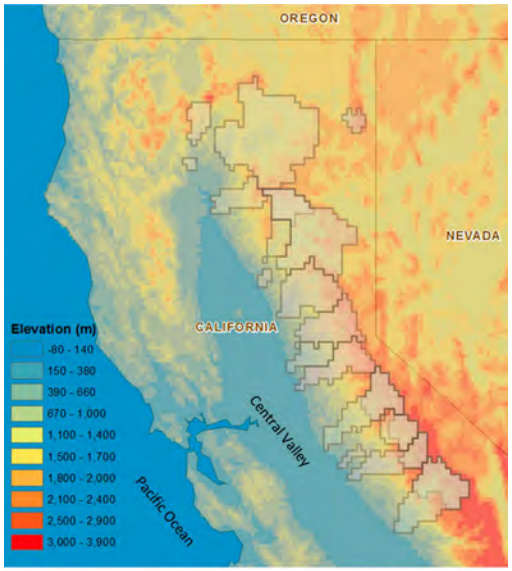
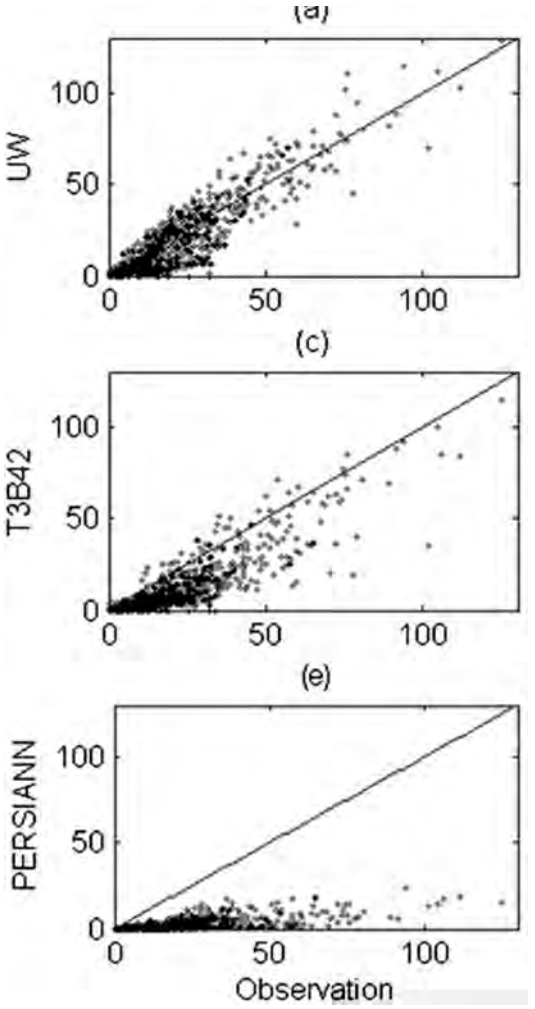


FIG. 1. Geographical location of the 22 studied basins shown with underlying topography.



The hydrological model run over a number of catchments produces correct discharge for a re-analysis based rainfall (UW), but underestimates it for satellite derived estimates (T3B42 & PERSIANN)

Behrangi et al. 2014

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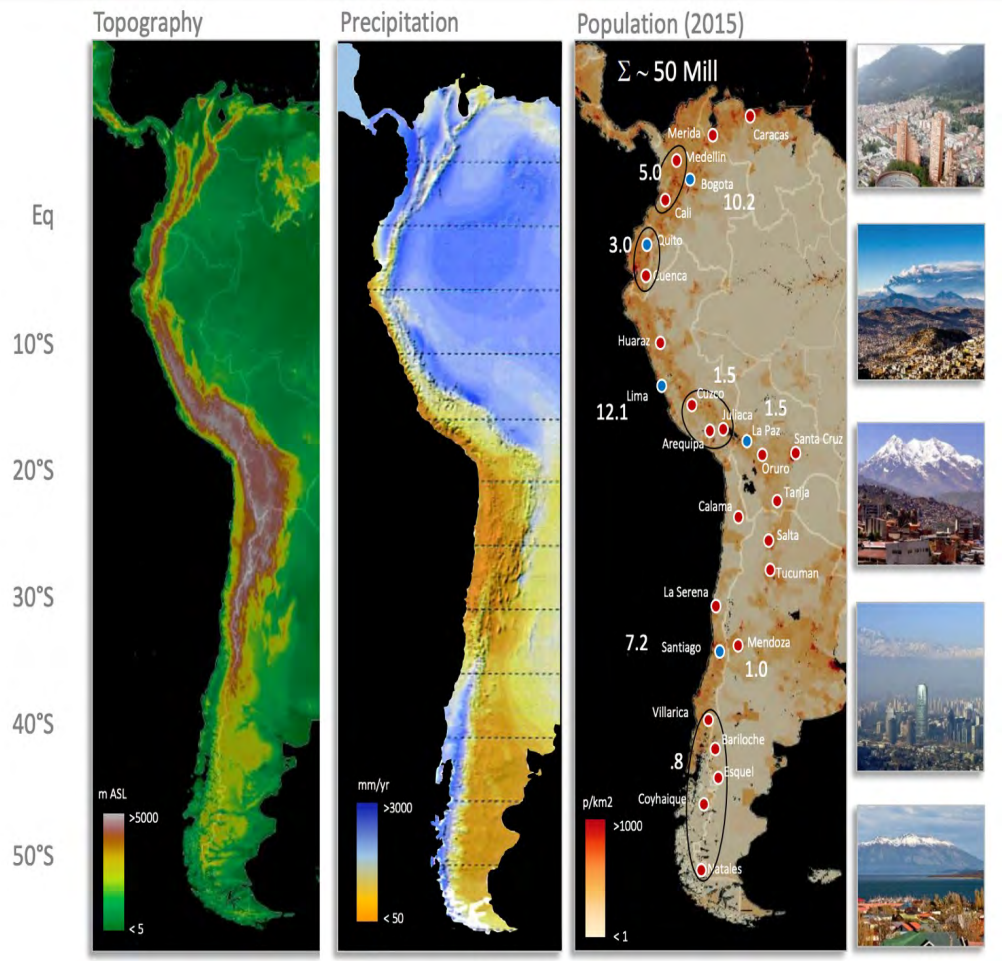
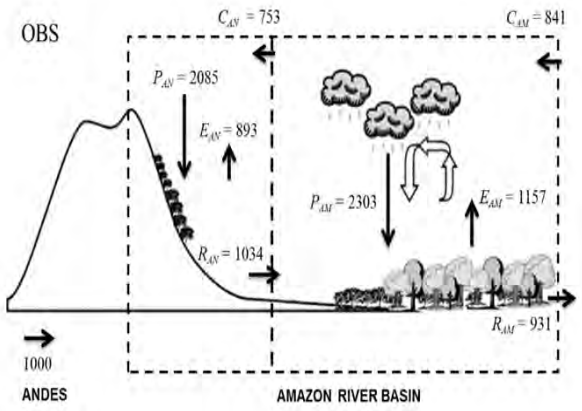
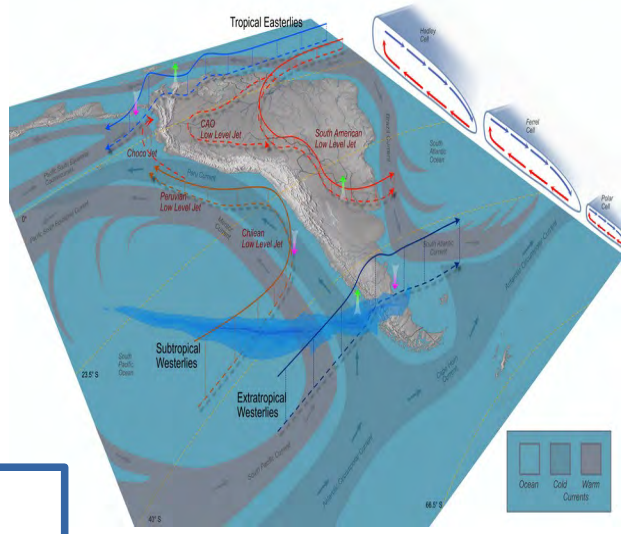
ANDEX focuses on the Andes Mountains







Interactions with other parts of the continent are also critical.

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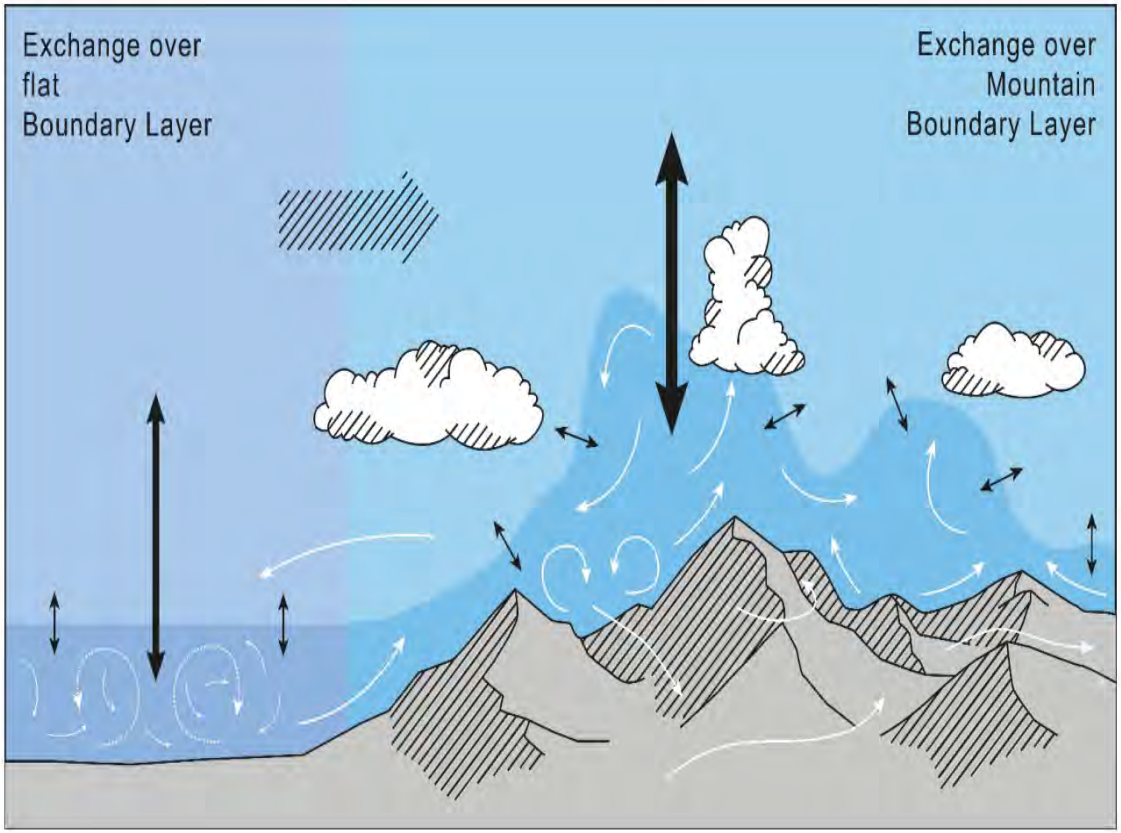
TEAMx : atmospheric exchange processes induced by mountains.

- *Exchange processes induced by mountains*: Transfer of heat, momentum and mass (water, CO_2, aerosols) between the ground, the PBL and the free atmosphere.
- High-resolution observation and modelling possible, but non-trivial. Model spatial resolutions outpacing observations.
- Special challenges over mountains: Spatial heterogeneity, wide range of relevant scales of motion.



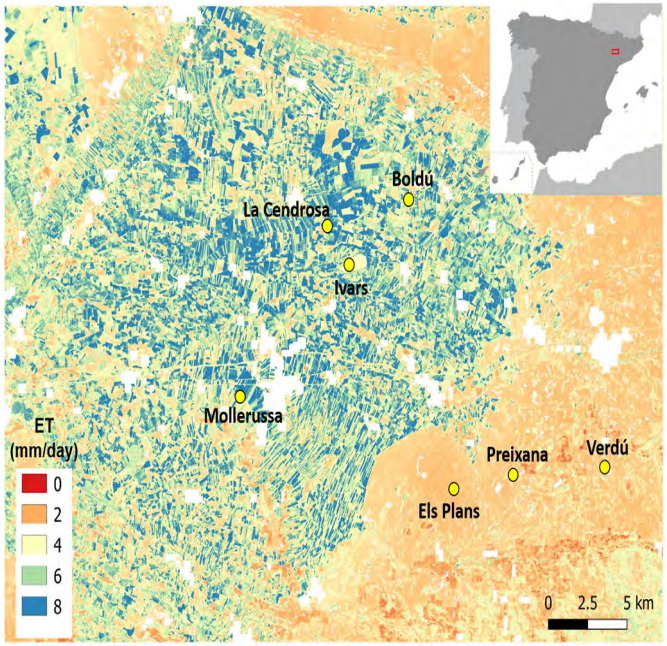
INARCH-II : hydrological processes in alpine cold regions

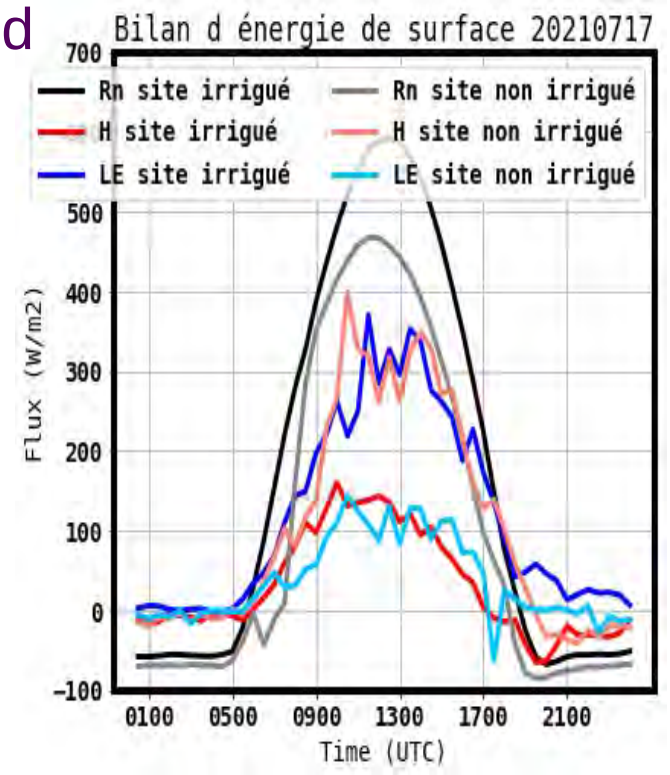
It follows the very successful INARCH activity.

LIAISE field campaign : July 2021

- During two weeks a number of sites (irrigated and natural) were instrumented.
- Research aircraft flew different instruments (turbulence, soil moisture and fluorescence)

Surface/atmosphere interactions over the different surfaces and weather situations could be observed.





LIAISE heat & moisture budget: LoCo approa

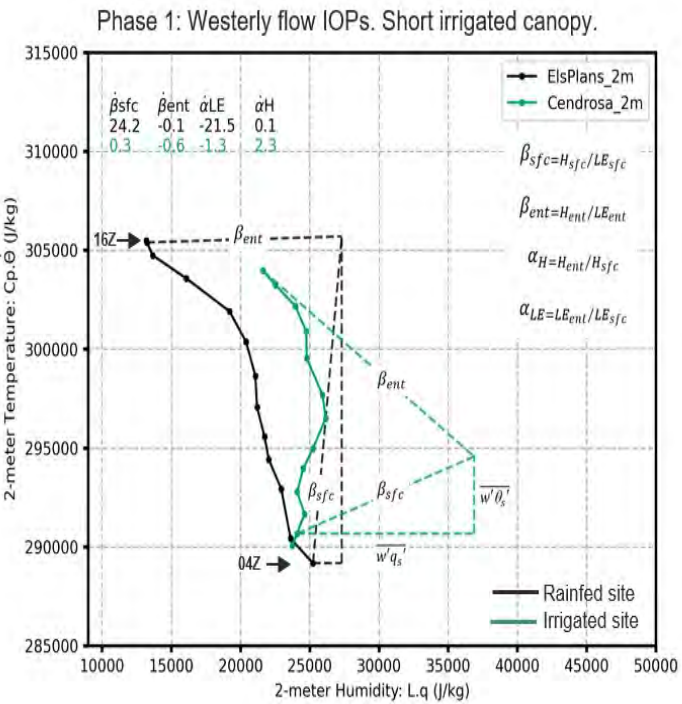
J. Brooke, et al.

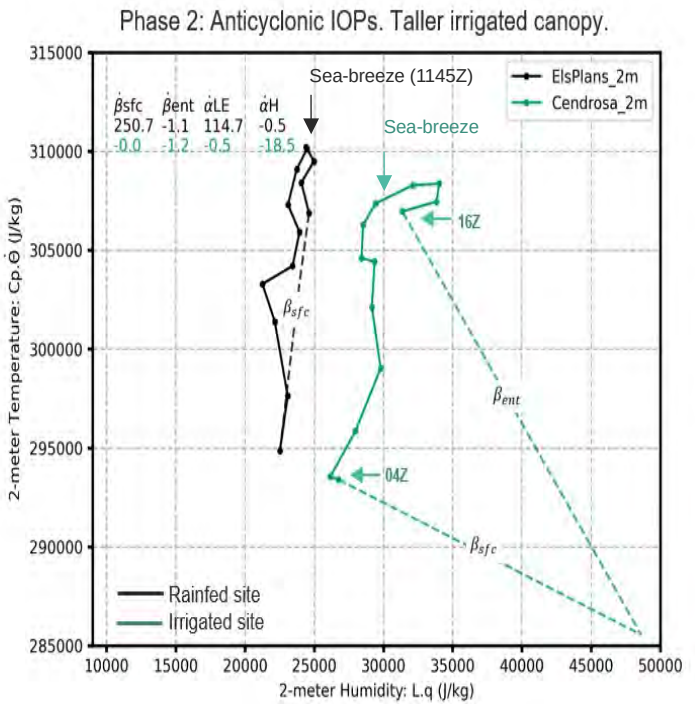
Application of GEWEX Local Land-Atmosphere Coupling (LoCo) to LIAISE observations.

LoCo mixing diagram approach: to understand the relative roles of surface (heat and moisture fluxes) and entrainment (heat and moisture) fluxes on the boundary layer evolution using surface level observations & PBL height (hourly radiosondes during LIAISE).

Irrigation leads to significant contrasts in 2-m heat and moisture evolution. Both the meteorological flow regime, and growing irrigated vegetation canopy height (strongly influence the flux partitioning & Bowen ratio, β_{sfc}) play a role in the mixing diagram evolution.

Irrigated supersite 50m tower (La Cendrosa)





Rainfed supersite 50m tower (Els Plans)

Contact: jennifer.brooke@metoffice.gov.uk

A wind, temperature, H2O and CO2 scanning lidar mobile observatory

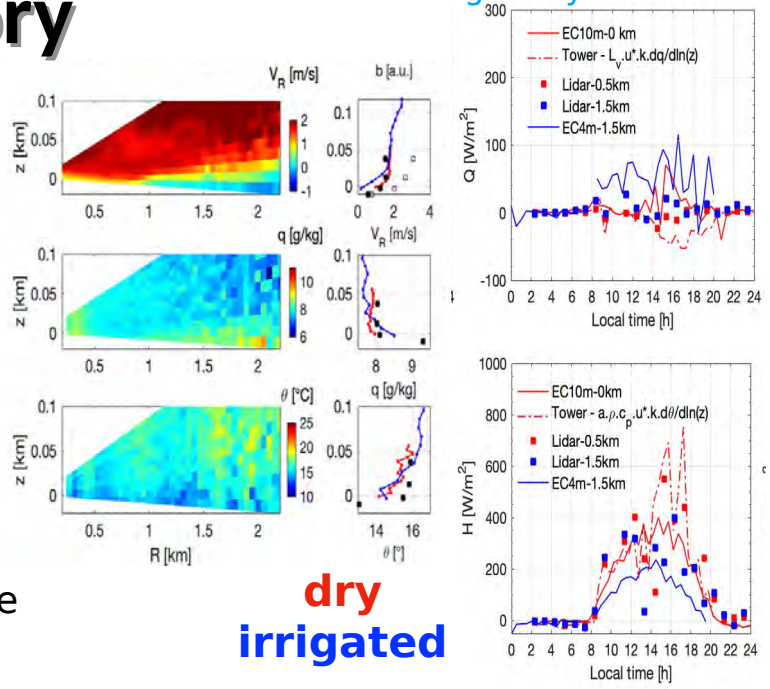
F. Gibert, et al.

Instrumentation:
3D- lidars mobile station (first experiment)
COWI : **CO2 & wind** , Doppler and DIAL system at 2 µm
TERA: **temperature & H2O**, Raman lidar at 0.355 nm

Measurements
- basic: 3D profiling of particles, wind speed, temperature, H2O & CO2
- specific: integral scales, gradients, high order moments, fluxes, dissipation rate, skewness

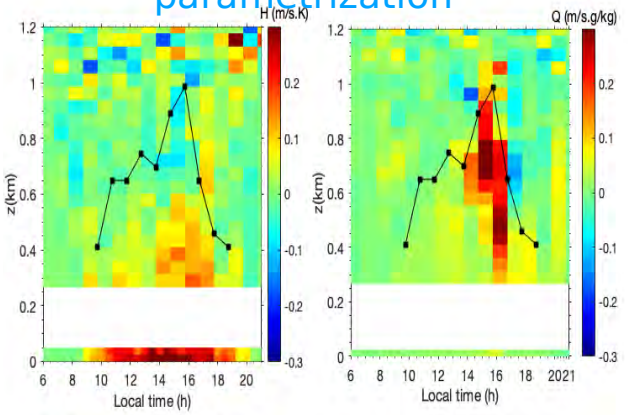
Scientific objectives:
- address the issue of surface **scalar flux heterogeneity** (dry and irrigated region)
- address the issue of **scalar transport dissimilarity** (GHGs space mission interest)
- find advanced **model parametrizations** of transport processes for both convective and stable boundary layers in different climate regions (temperate and semi-arid in HILIAISE)

Vertical cross-section of the atmosphere and MOST application to study surface flux heterogeneity



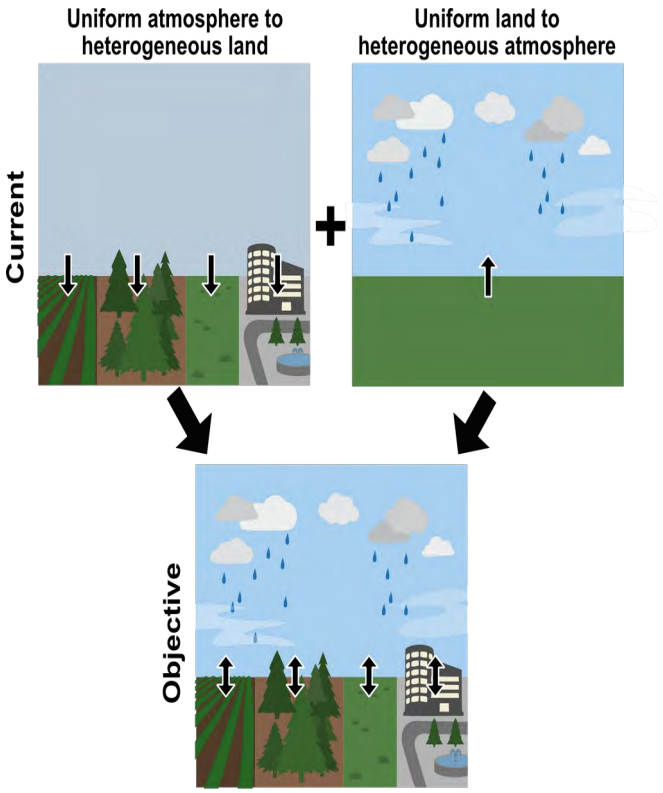
dry
irrigated

Turbulent flux profiles and entrainment layer parametrization

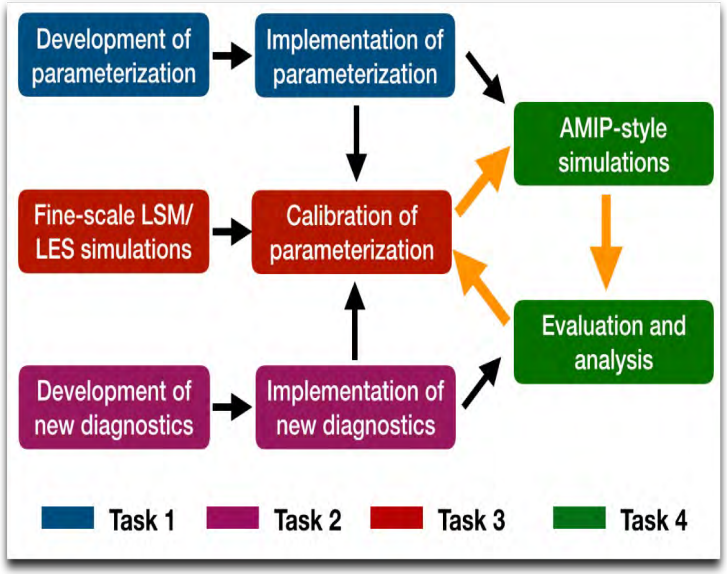


CLASP

Coupling of Land and Atmospheric Subgrid Parameterizations

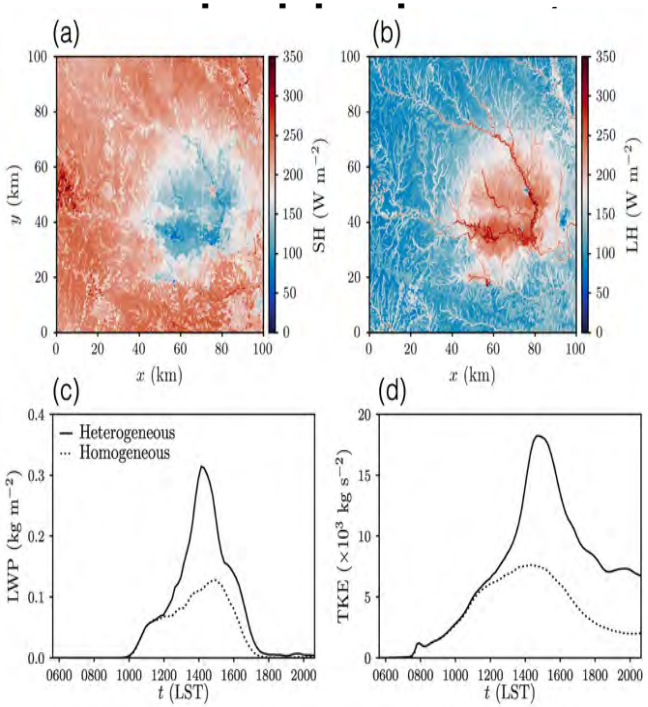


Objective: Parameterize the heterogeneous sub-grid exchange between the land and atmosphere and characterize its implications for surface climate, variability, and extremes.



CLASP : New understanding of the role of surface heterogeneity

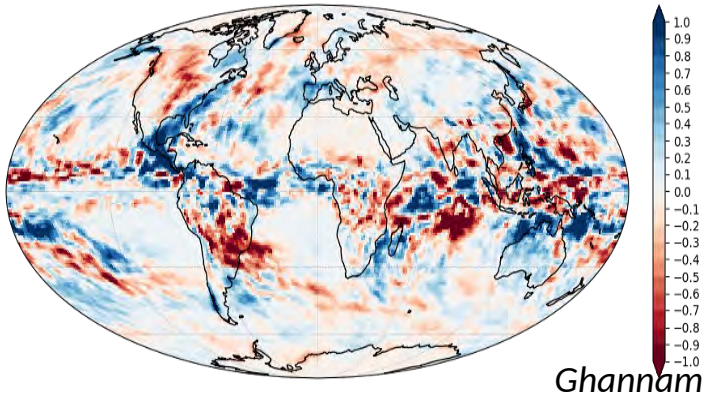
LES experiments at ARM-SGP show a key role of sub-grid heterogeneity



Homogeneous and heterogeneous WRF-LES experiments are run for 9/24/2017 over a 100 km domain in Oklahoma at a 100-m spatial resolution using offline simulated surface fields of latent heat (a) and sensible heat (b) fluxes. The heterogeneous experiment uses the fields "as is" while the homogeneous experiments use their spatial mean (mimicking the existing sub-grid coupling in ESMs). The differing response is summarized via the different time series of LWP (c) and TKE (d).

Simon et al., 2021

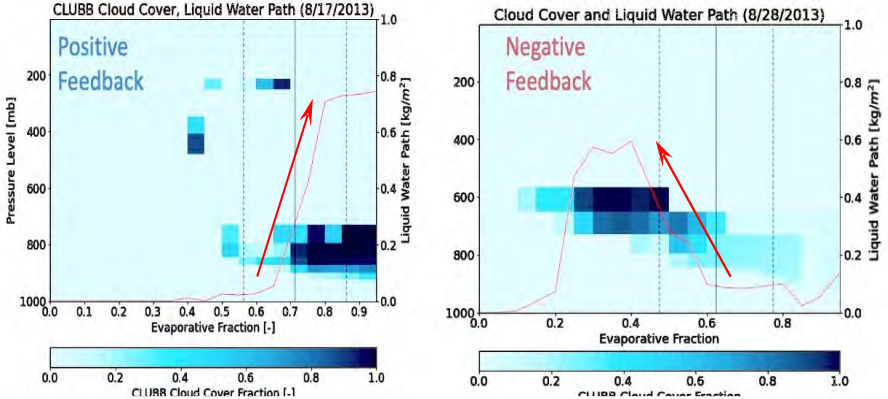
Difference in annual precipitation (mm/day) using CLASP parameterization in GFDL AM4



GFDL's CLASP-modified boundary layer parameterization allows for time-varying updraft area fraction, with dependence on the standard deviation of surface temperature

Ghannam et al., In prep.

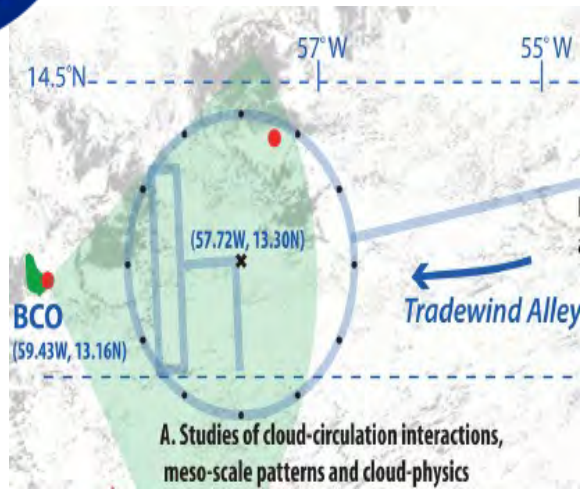
Boundary layer coupling sensitivity to evaporative fraction



Cloud cover (shading) and vertically integrated cloud liquid water (red line) as a function of EF and pressure for a day showing (left panel) clear positive feedback of evaporation on cloud formation and (right panel) clear negative feedback. Solid vertical line shows analysis daily mean EF, and dotted lines are ±0.15, enveloping a reasonable range of EF one might expect from surface heterogeneity over an area of 10^3-10^5 km².

Hay-Chapman et al., In preparation

Observe convection organisation



EUREC⁴A, field campaignJan-Feb 2020

Western tropical Atlantic (Barbados)

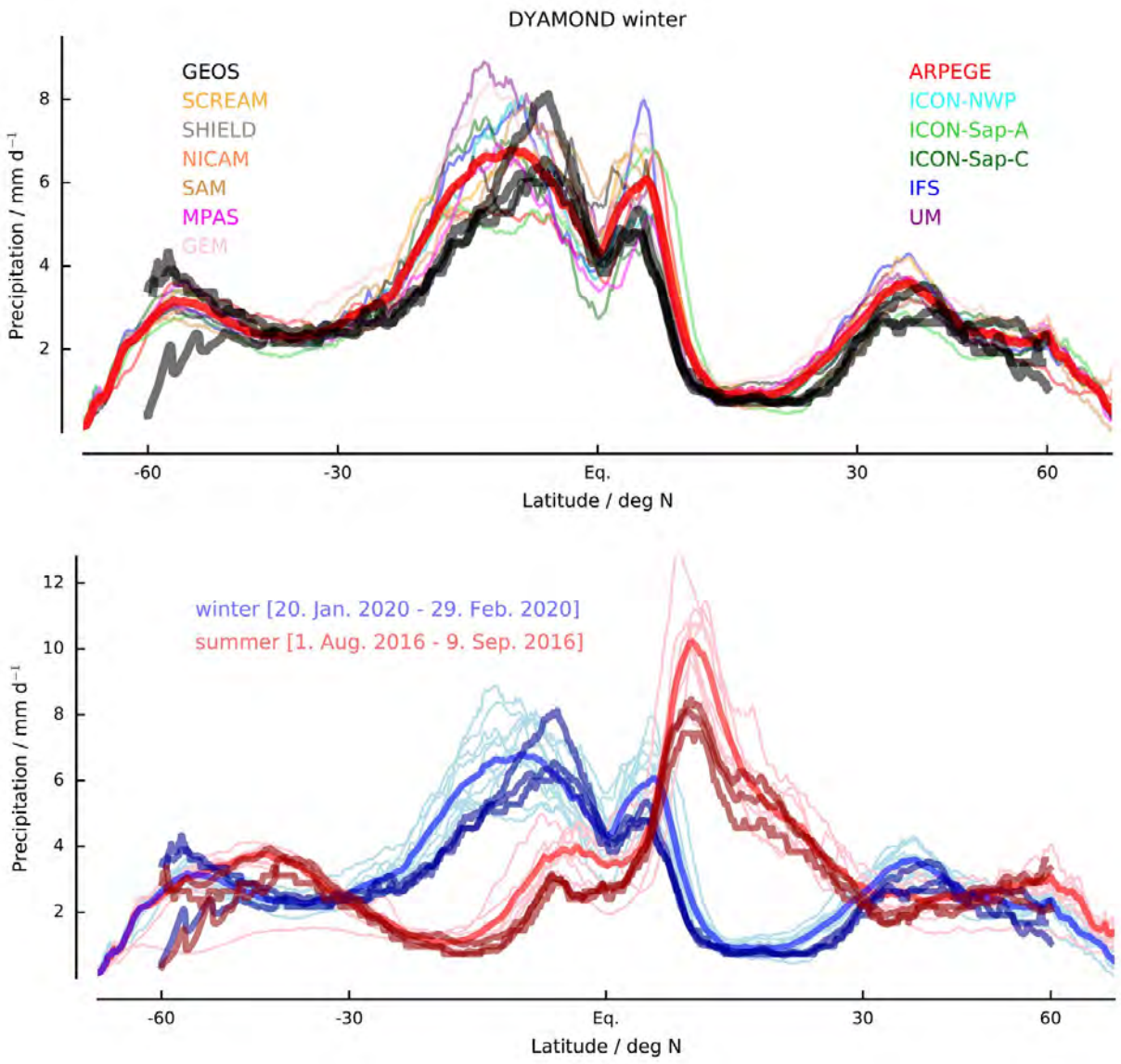
A field campaign designed to study cloud feedback processes and mesoscale organization

(Bony et al. 2017, Stevens et al. 2021)

Km-scale models resolve some mesoscale organization

Global runs (40 days) of 13 models at resolution from 1.5 to 5km. Many ran for the very first time at km-scales :
- Black thick lines are observations.
- Red thick lines is model ensemble.

Same models but now for two seasons.



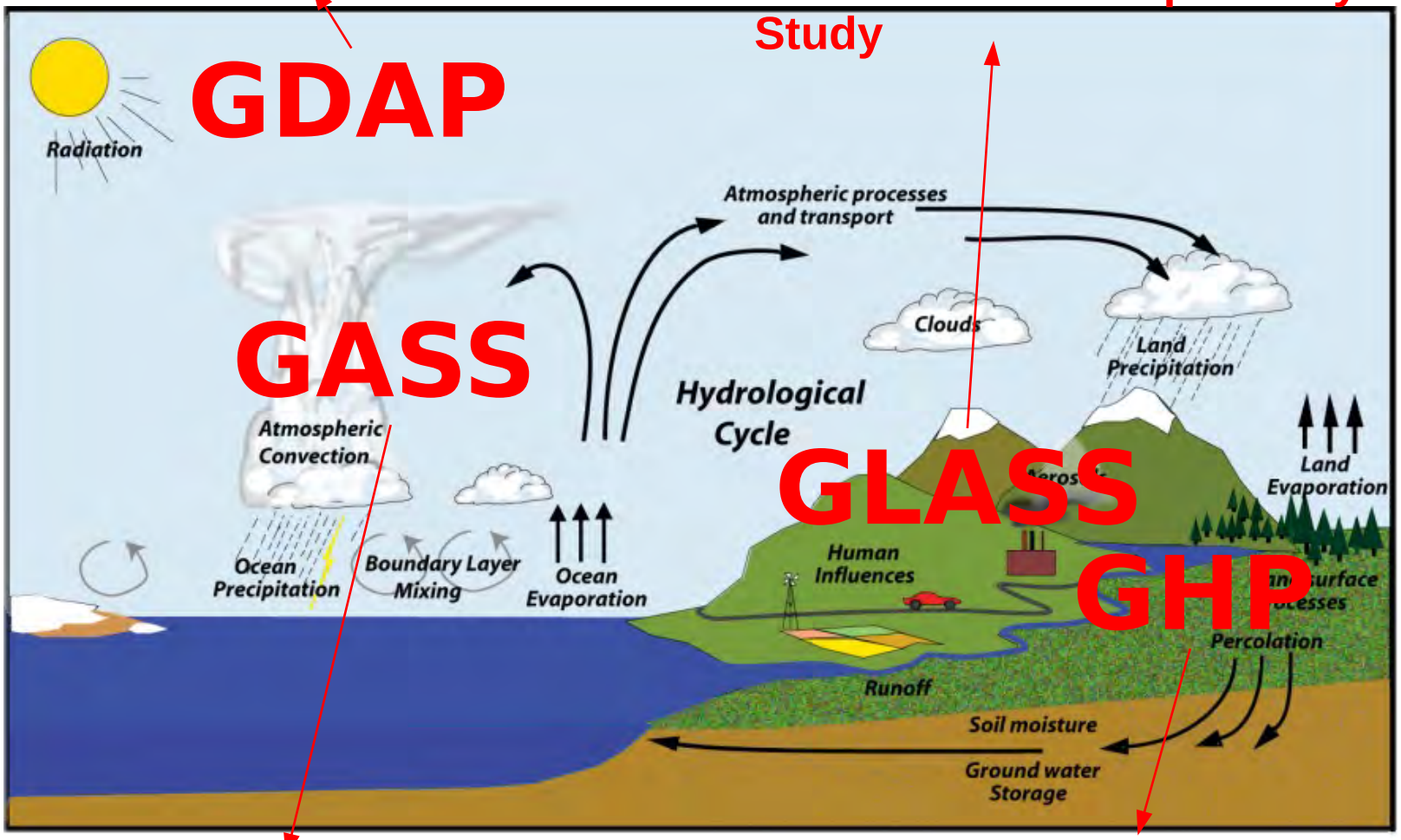
Emerging scientific challenges within GEWEX

- Energy and water cycle at regional scales :
  - Mountain areas are critical for the water/energy exchanges.
- Km-scale observation and modeling of the Earth system :
  - Atmospheric components are getting there but for land surface models fundamental hypothesis need to be revised.
- Mesoscale organization of convection over land :
  - Surface heterogeneity and their impact on the PBL is a critical first step here.

The GEWEX Panels

GEWEX Data and Analysis Panel

Global land/Atmosphere System Study



GEWEX Atmospheric System Studies

GEWEX Hydroclimate Panel

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Interactions with Light House Activities

- GEWEX has been engaged through zoom calls with LHAs leadership.
- Solicited GEWEX Quarterly articles on LHAs
- SSG Discussion in Paris (SSG-34a) with our LHA representatives.

✗ Now that the LHAs have established their strategy a broader discussion is needed :

  - ✗ How far can JSP support all these activities ?
  - ✗ How will the needs of LHAs be supported by Core Programs ?
  - ✗ Refine the modes of interaction.

Programmatic Highlights

- GEWEX Science Plan finished (living document): Strong focus on process studies at all spatiotemporal scales. A good foundation to work with most if not all LHAs!
- GEWEX activities organization strong focus on cross-fertilization (within GEWEX, WCRP and wider community)
  - GASS + GLASS panels continue to expand their contribution to NWP with the successful interactions with WWRP and WGNE.
  - New GEWEX wide cross cutting activities are on-going : Irrigation, Evaporation theory & observation, Floods and Irrigation, Carbon & water processes and Groundwater.
  - GHP continues to work on 3 potential RHPs : Central Asia, US and Mountainous Africa (together with START)
  - ANDEX in next Phase, TPE-Water Security and AsiaPEX expected to follow this year
  - Stronger collaboration between panels by adding liaison members (early-mid career)

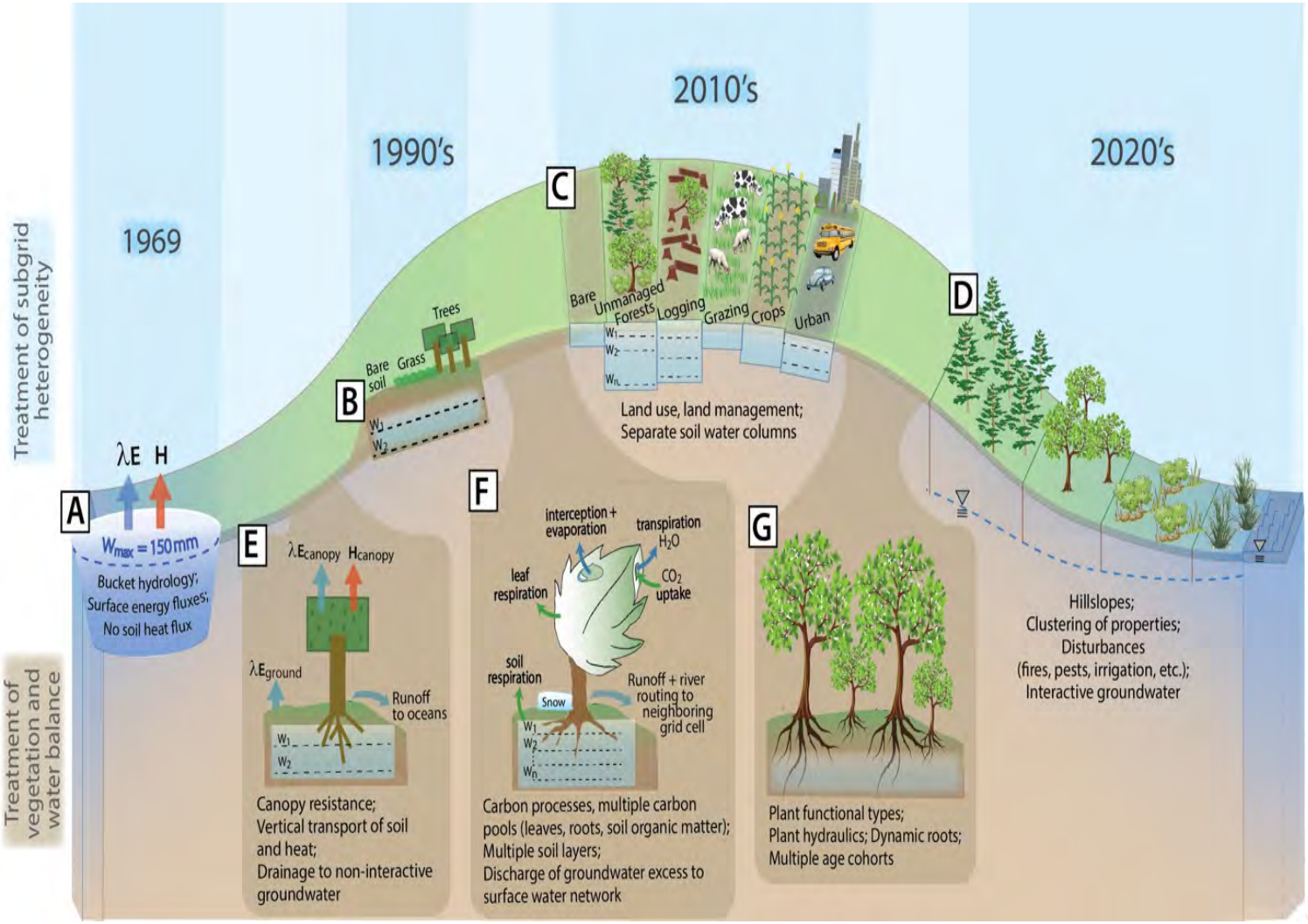
GEWEX resumed in-person meetings

- IPSL hosted the SSG-34a meeting in May in Paris. Internal review of activitied was the focus.
- Pan-GASS meeting => July 24-28, 2022 in Monterey, CA, USA (250 participants expected).
- SSG-34b on 26-27th July (Also in Monterey) will cover interactions with agencies and WMO.
- Pan-GEWEX meeting July 26 – 30, 2022 in Monterey, CA, USA
- Saturday 30th is a GEWEX social day in Monterey for all involved in the program … essential for team building !
- Improved communication strategy (a.o. ~bi-monthly SSG conf calls incl. panel co-chairs)

GEWEX's 30 year paper

- Stephens G. + SSG + panel leaders, 2022 Submitted to BAMS
- Covered all 3 phases of our core program.
- Highlights how over this period the science has evolved.
- Leads into our 3 goals which defined the strategy for the next phase.
- Side-bars highlight some major achievements in the 30 years.

From land surface to land models



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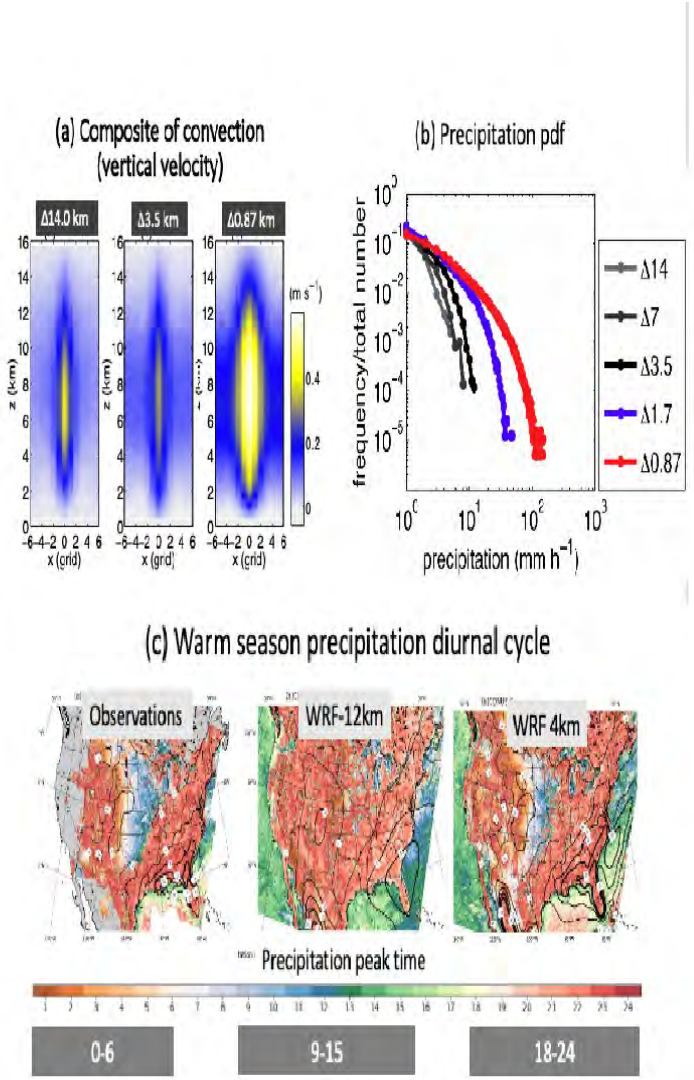
From local cloud resolving to global storm resolving modelling



- An example of how k-scale convection permitting and resolving global and regional simulations impact simulated properties of convective motion and precipitation. (a) The global composite of vertical motion, showing how increased resolution enhances the intensity of updrafts, Kajikawa et al. (2016), (b) The pdf of global precipitation illustrating how the occurrences of more intense precipitation increase with model resolution (Δ14=14km resolution, Miyamoto et al., 2013).

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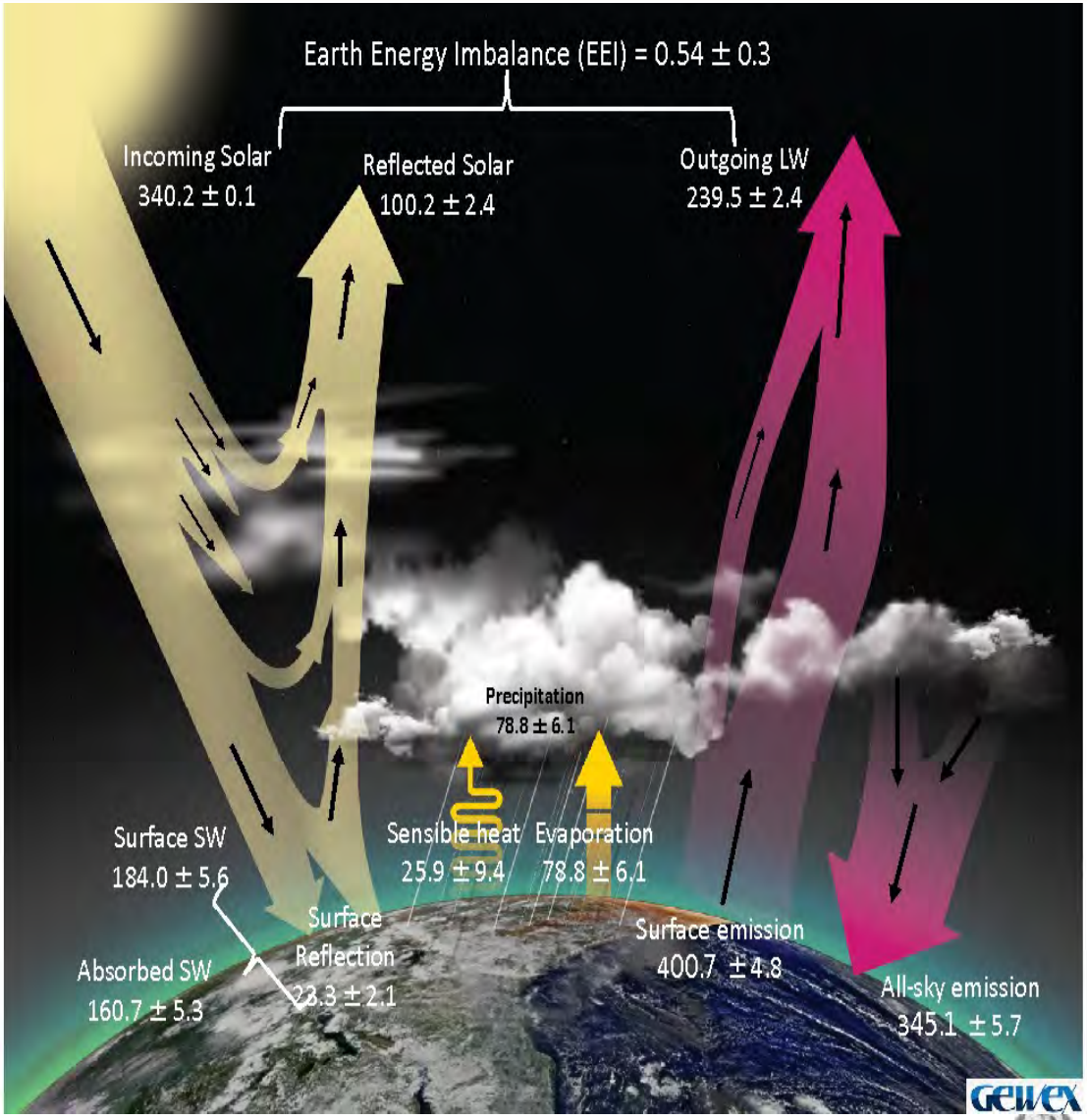
Earth's Energy Budget



An update on the mean annual fluxes of the global energy budget (all in Wm^{-2}) for the first decade of the millennium. This budget was achieved using a 'global' optimization described in L'Ecuyer et al (2015) that requires quantitative uncertainties but uses data that produce more consistent set of fluxes.

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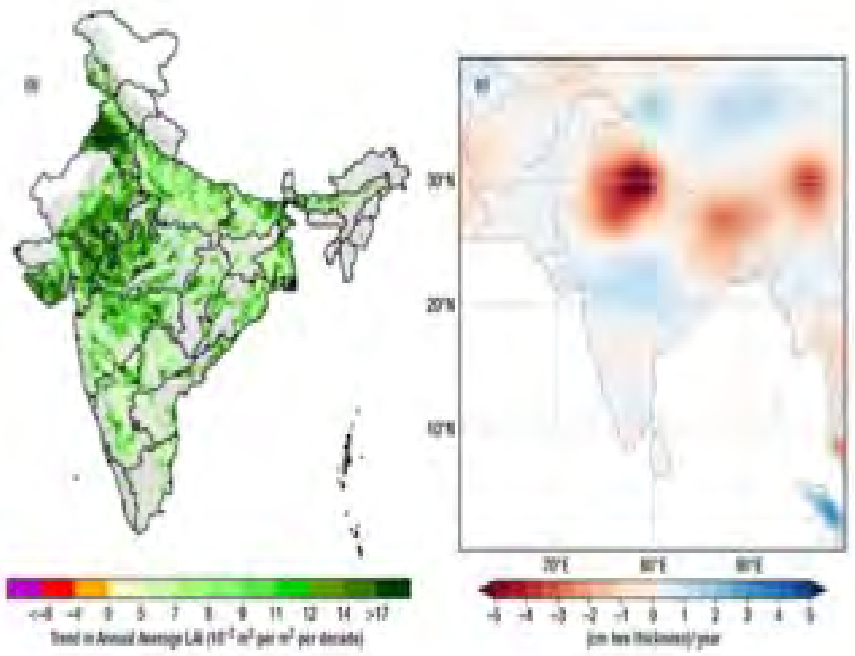
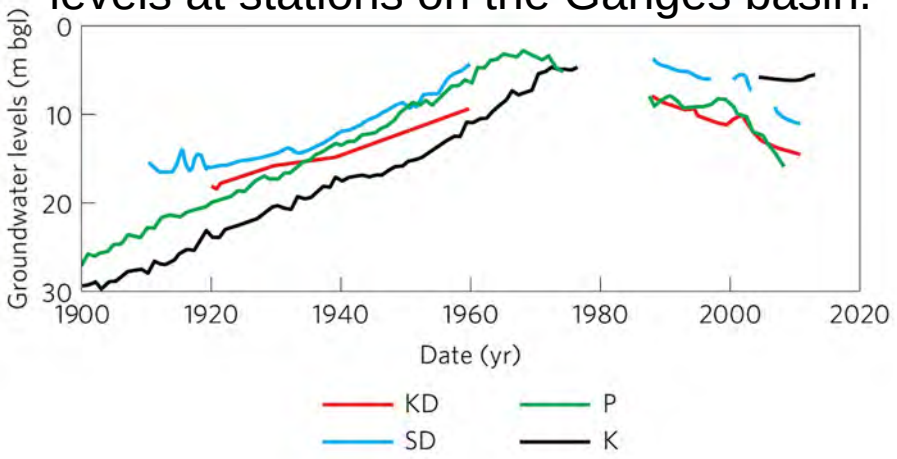
Continental water storage



(a) Trends in annual average MODIS leaf area index (LAI) for 2000–2017 in croplands in India. Statistically significant trends (Mann–Kendall test, p≤0.1) are color-coded. Grey areas show vegetated land with statistically insignificant trends. White areas depict barren lands, permanent ice-covered areas, permanent wetlands and built-up areas. (b) GRACE record length trends (2002–2016) over the Indian subcontinent (in liquid water equivalent (LWE) units in cm per year), showing extensive groundwater depletion in Northwest India (adapted from both Chen et al., 2019 and Stephens et al., 2020).

Longer term evolution of groundwater levels at stations on the Ganges basin.



MacDonald et al. 2016.

4th PAN-GEWEX Meeting

- July 25 – 30, 2022 Monterey CA, USA
- A unique event which brings together the GEWEX panels and SSG to inform all about the broader GEWEX activities.
- Stimulate cross fertilization of activities between 2 or more panels as well as outside actors.
- Progress expected on cross-cut activities.
- Structured discussions about the evolution of GEWEX science and broaden the community.

WMO Hydrology Strategy

- Significant contribution by GEWEX to the research element of WMO's Hydrology strategy.
- The main theme of our comments on the proposed action plan :
    - Adopt an Earth system perspective to hydrological forecasting (i.e. coupled to other components).
    - Consider explicitly climate change, land and water usage in forecasting.
    - Aim for a cooperation between research and operational forecast as it exists today for weather.
    - More open data sharing so that the research community can easily evaluate new data and forecasting tools.

The model for hydrology should be the collaboration between NWP centres and climate researchers have had over the last 30 years !

Ambassadorship and Lifetime Contribution Award

- **GEWEX Ambassadors**
  - To honor colleagues who have contributed a significant amount of their time and energy to GEWEX and who can continue to promote GEWEX in the broadest sense; e.g., encourage other colleagues to be part of the GEWEX community, keep funders and stakeholders abreast of the latest developments when opportunity arises and represent the GEWEX community at selected events.
- **Lifetime Contributors to GEWEX Lifetime Contribution Award**
  - The GEWEX lifetime contribution award is presented to those colleagues who have retired and have had exceptional contributions to GEWEX scientifically or organizationally. (can be posthumously)
- **First nominations will be decided at SSG-34b in July.**

Gender and regional balance (SSG/Panels)

- The GEWEX SSG and panels have a good regionally balance.
- Gender parity is the current situation in panel leadership.
- We are in discussion with 3 women from 3 different continents and disciplines to propose for open positions on our SSG.

✗ Our impression is that the engagement from South East Asia, Africa and South America is not broad enough. It is probably a structural problem of science in these regions. WCRP & GEWEX should work on this issue.

Upcoming workshops organized by GEWEX

- 5-6 September : ANDEX workshop (Buenos Aires).
- 7-9 September : Convection permitting modelling (Buenos Aires)
- 12-15 September : Land surface modelling summit (Oxford)
- 28 November - 1 December : Evaporation cross-cut and LIAISE field campaign.