Global Energy and Water Cycle Exchanges Project

Global Land-Atmosphere System Studies (GLASS) Panel: Brief Update

Mike Ek and Kirsten Findell, GLASS co-chairs
Anne Verhoef, incoming co-chair

WGNE Meeting (virtual)
2-5 November 2020

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GLASS Science Objectives and Activities

- **Scientific Objectives of GLASS**:
  - To improve understanding of energy and water cycling on land and in the coupled land-atmosphere system; to improve representation of these processes in earth system models.

- **Activities of GLASS**:
  - To facilitate and support international projects that use observations, process studies, and numerical model experiments to develop and improve the representation of the land and land-atmosphere system in climate models.

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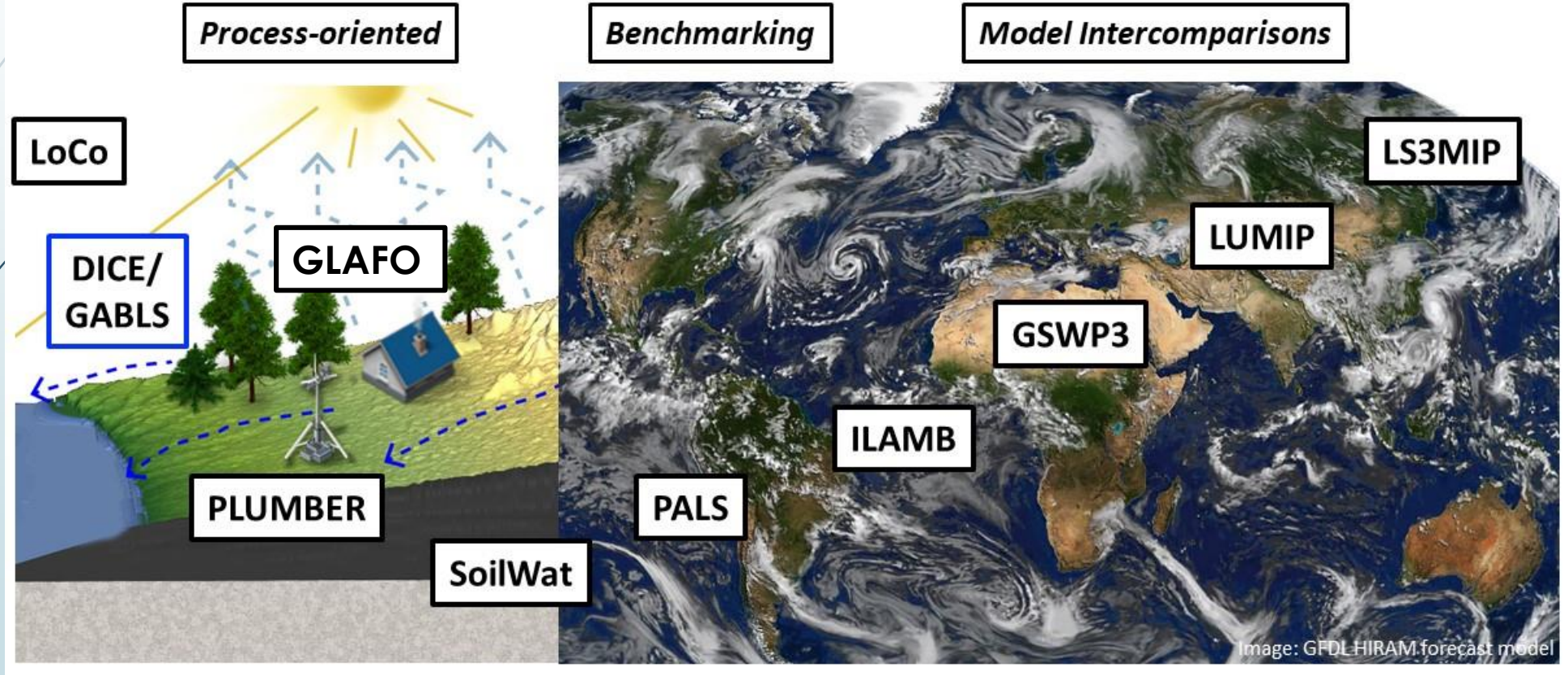
GLASS Panel Projects: From process to global scale



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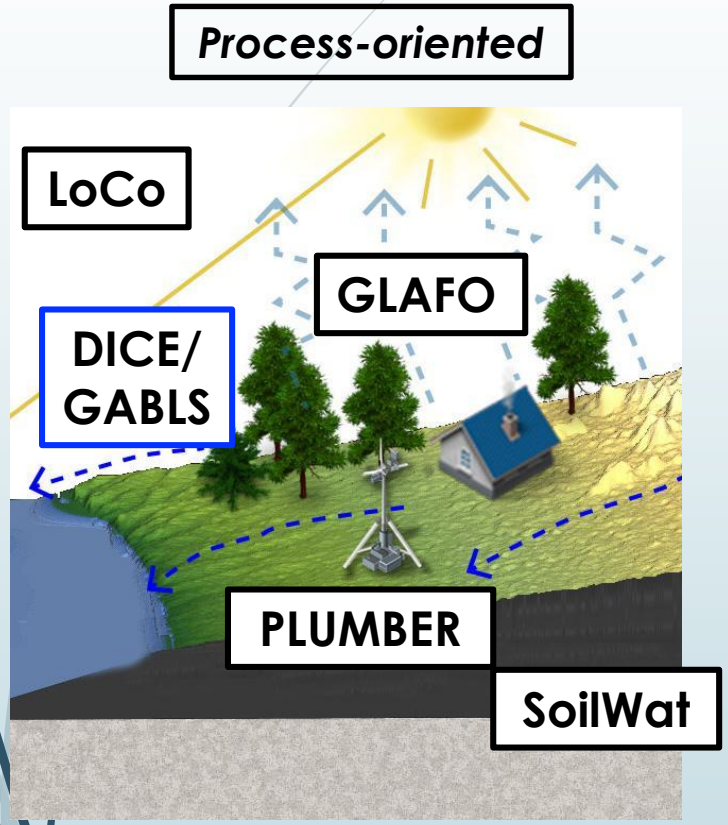
Process-oriented GLASS projects



- **LoCo**: Local Coupling Working Group
  - Land-atmosphere interactions at local to regional (to global) scales.
- **PLUMBER2**: The Protocol for the Analysis of Land Surface Models (PALS) Land Surface Model Benchmarking Evaluation Project
  - Offline single-column land model experiments.
- **SoilWat**: Soils and Subsurface processes
  - Understanding and improving representation of soil physical processes and groundwater transport in earth system models at local to global scales.
- **GLAFO**: GEWEX Land-Atmosphere Feedback Observatories
  - Standard set of instruments to observe processes, variables and fluxes with respect to mass, energy, water, and momentum transport with unprecedented spatial and temporal resolutions, from the subsurface to the lower troposphere.
- **DICE**: "Diurnal Land-Atmosphere Coupling Experiment"
  - Joint GLASS-GASS project to identify interactions, sensitivities and feedbacks between the land surface and the atmospheric boundary layer using Single Column Models.

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Local Land-Atmosphere Coupling (LoCo)

LoCo Working Group Objective

To understand, model, and predict the role of local land-atmosphere coupling in the evolution of land-atmosphere fluxes and state variables and the respective water and energy cycles, including clouds.

Goals

- Promote the importance and development of ***improved observations*** of the L-A system, namely PBL profiles, as well as improved utilization of soil moisture and surface fluxes measurements in models.
- Pursue ***adoption of LoCo land-atmosphere coupling metrics*** by operational NWP and Climate Centers.
- ***Expand the scope and reach of LoCo*** in terms of processes and scale beyond that of warm season thermodynamics and beyond that of 1-D column assumptions.

Successes

- Outreach and collaborations to address the goal of entraining the operational centers into the LoCo paradigm and to promote LoCo metrics for integrative analysis.
- Coordination of LoCo-based analysis activities from recent and planned campaigns such as LAFE, GRAINEX, and LIAISE.

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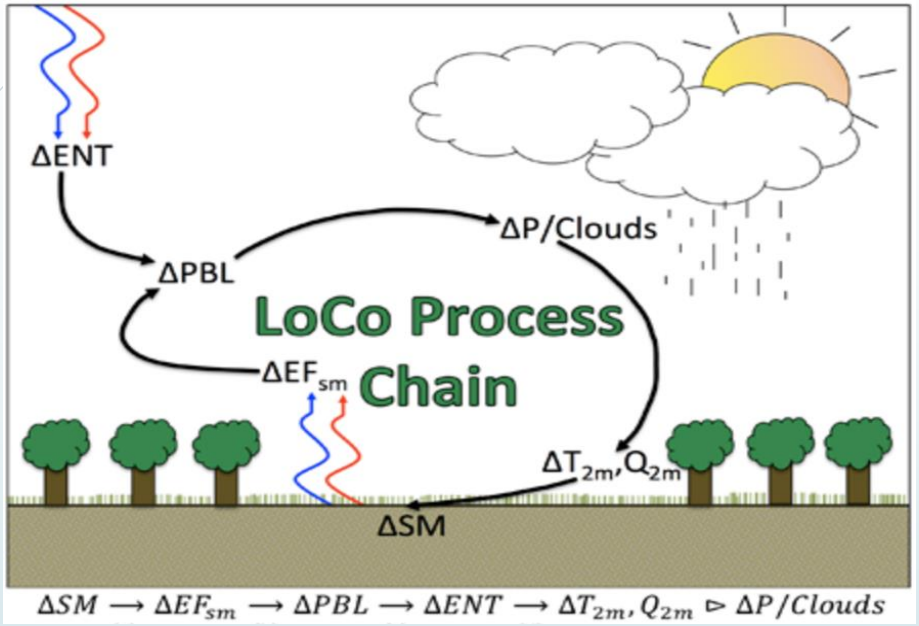
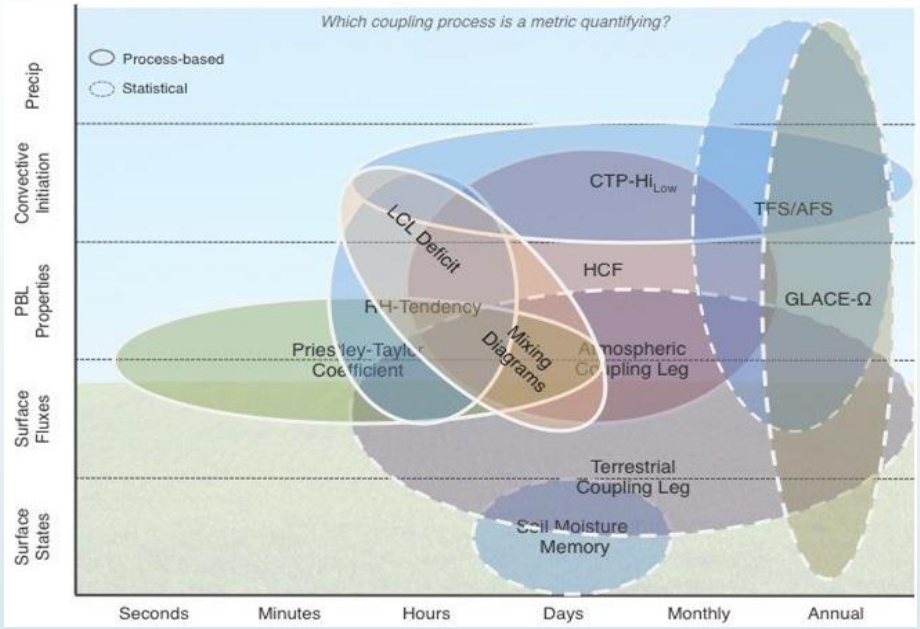
LoCo Metrics



Impact of soil moisture anomalies (ΔSM) on cloud development and subsequent precipitation (ΔP) depends on sensitivities: (a) surface fluxes (EFsm) to SM; (b) PBL evolution to surface fluxes; (c) entrainment fluxes at the PBL-top (ENT) to PBL evolution; and (d) the collective feedback of the atmosphere (through PBL) on ambient weather (2-meter T & q).

Metric Applications and Timescales



http://www.coupling-metrics.com/

LoCo "cheat sheets": http://cola.gmu.edu/dirmeyer/Coupling_metrics.html

http://www.gewex.org/loco/

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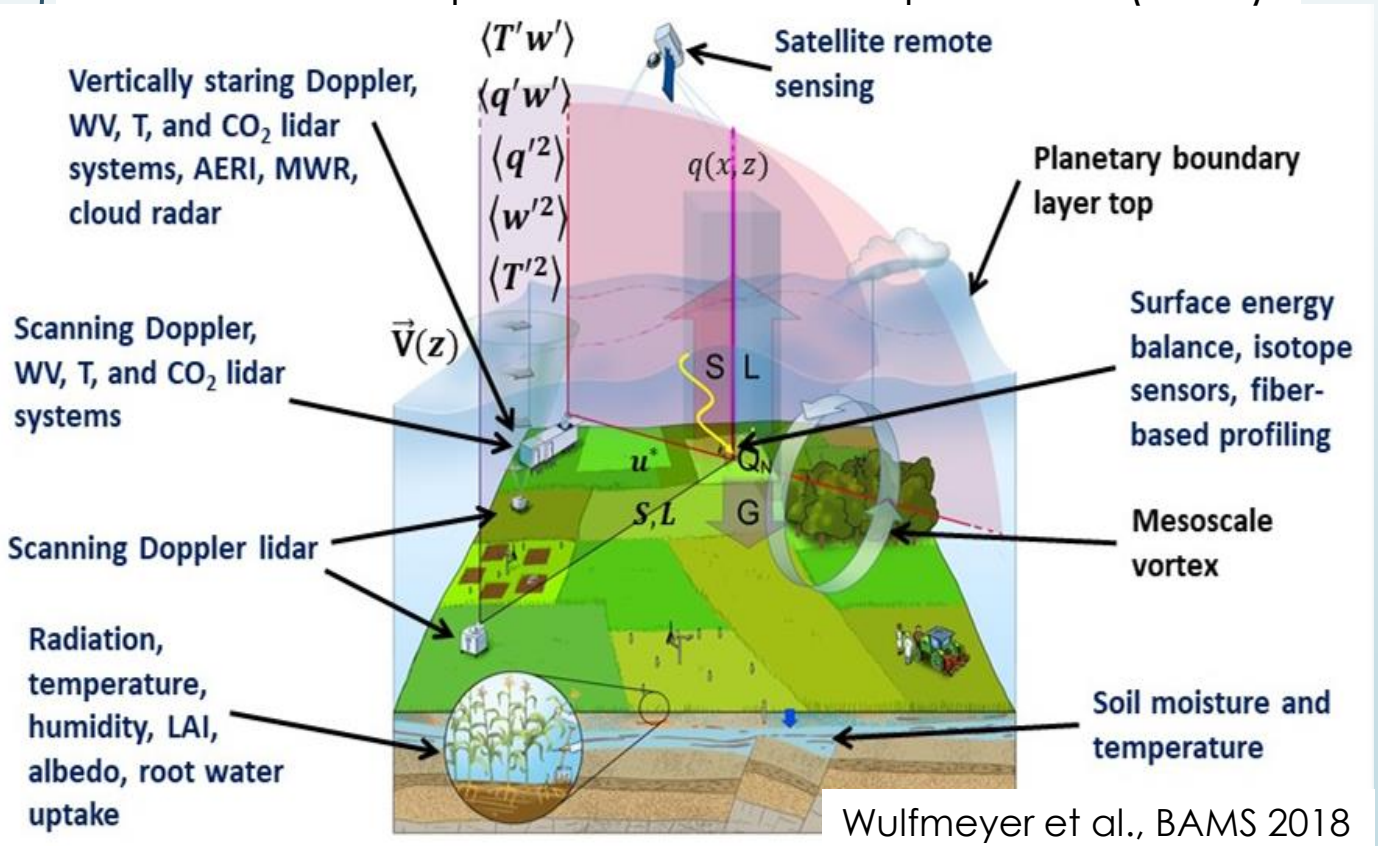
GLASS Proposal: GLAFOs

- Significant advances made in observing the atmospheric surface layer (SL) and lower troposphere including PBL. New synergy of observations were successfully applied during LAFE and led to new insights in processes and parameterizations related to L-A interaction.

The Land-Atmosphere Feedback Experiment (LAFE)



Wulfmeyer et al., BAMS 2018

- We propose the development and operation of multiple

GEWEX/GLASS Land-Atmosphere Feedback Observatories

- These observatories should record long-term, high-frequency observations of soils, vegetation, surface fluxes and the planetary boundary layer.

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GLASS Proposal: GLAFOs

LAFE Goals and Objectives

Wulfmeyer et al., BAMS 2018

1) determine profiles of turbulent moments and fluxes and investigate new similarity relationships among gradients, variances, and fluxes.
2) map surface momentum, sensible heat, and latent heat fluxes using a synergy of scanning wind, humidity, and temperature lidar systems;
3) characterize L–A feedback and the moisture budget at the SGP site in dependence of different soil moisture regimes; and
4) verify LES and improve turbulence parameterizations in mesoscale models.

- Characterize the diurnal cycle, transitions, mesoscale and seasonal variability of the PBL, land-atmosphere feedbacks, as well as the moisture and energy budgets.
- L-A data assimilation, regional-scale reanalyses.
- Testbeds for observing system synergies.
- Calibration of passive sensors from ground and satellites.
- Training of future research users of these data sets.

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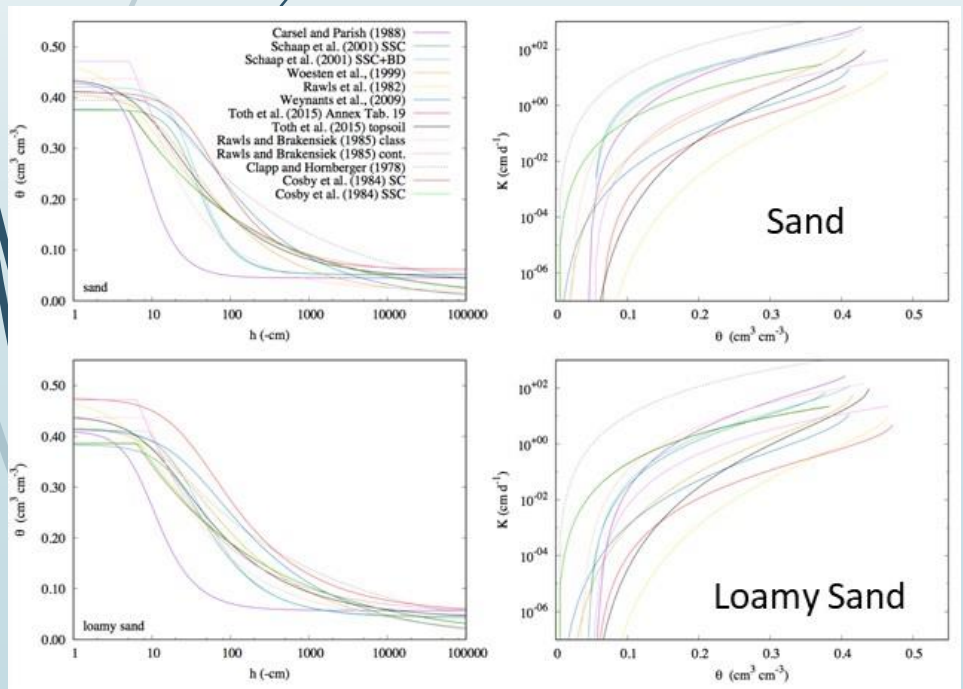
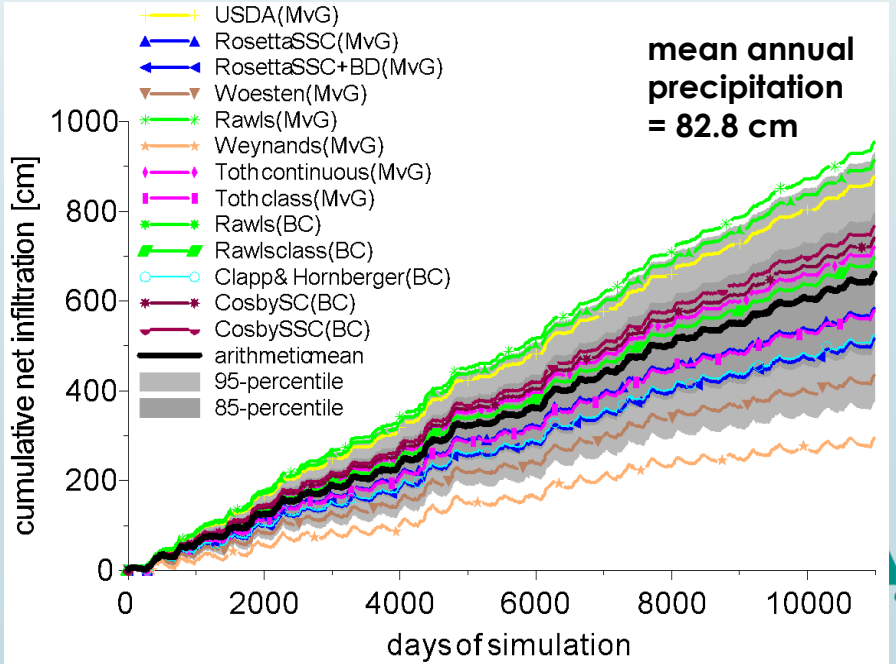
SoilWat

- Goals: To improve the representation of soil and subsurface processes in climate models and to identify the most pressing challenges and topics related to this effort.
- Various **review papers**, e.g. on "PTFs" (Van Looy et al., 2017) on "Infiltration for land surface modelling" (Vereecken et al., 2019); **Discussion paper** on "Global groundwater modeling and monitoring?: Opportunities and challenges", led by Laura Condon and Stefan Kollet (near finalised);
- Compilation of **soil-related databases**, e.g. global soil hydraulic properties (Montzka et al., 2017); infiltration (Rahmati et al., 2018); Saturated conductivity (ETHZ 2019).
- Conducting a **global soil parameter MIP** (Cuntz and Gudmundsson - ongoing);
- Using SoilGrids to revise global surface **evaporation** (Lehmann and Or, 2019).
- Comparison of **thermal properties** between LSMs (led by Verhoef and Zeng).

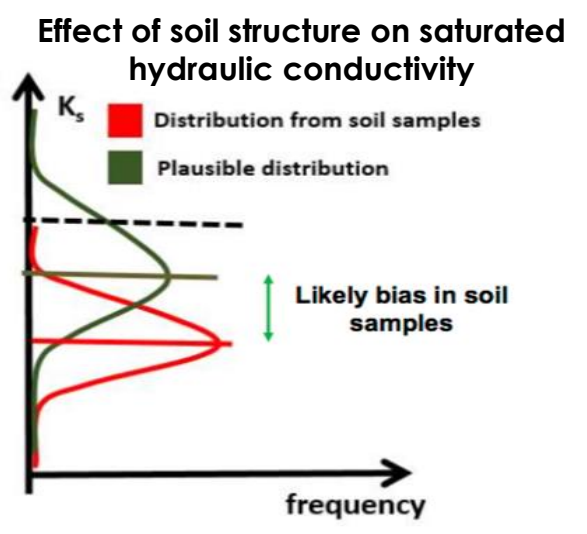
Functional Sensitivity Study of Pedotransfer Functions used in Land Surface Models

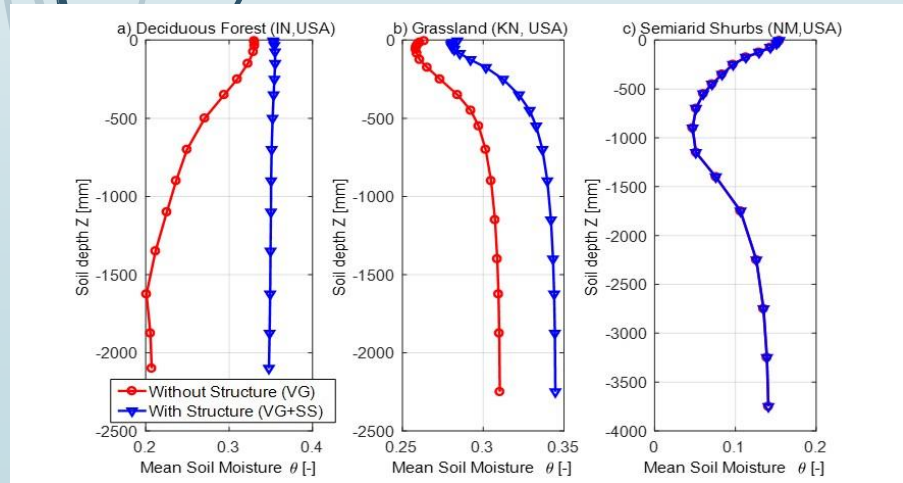
- **Choice of Pedotransfer Functions matters when simulating soil water balance fluxes;** L. Weihermüller*[1,6], P. Lehmann[2], M. Herbst[1], M. Rahmadi[3], A. Verhoef[4], D. Or[3], D. Jaques[5], and H. Vereecken[1,6]
- Different PTF predict different hydraulic functions for the same soil; That has implications for infiltration, runoff, recharge….





SoilWat: Assessing effects of soil structure on land surface fluxes





- **Site level:** Fatichi et al (2019a,b): Ecosystem model run with and without soil structure
  - Impacts on soil moisture profiles
  - Impacts on partitioning between runoff and recharge
- **Global level:** Impacts of soil structure are present but muted by internal variability
- ***Conclusion: Small-scale soil structural features may have large-scale implications in water and carbon cycles and ultimately on climate***

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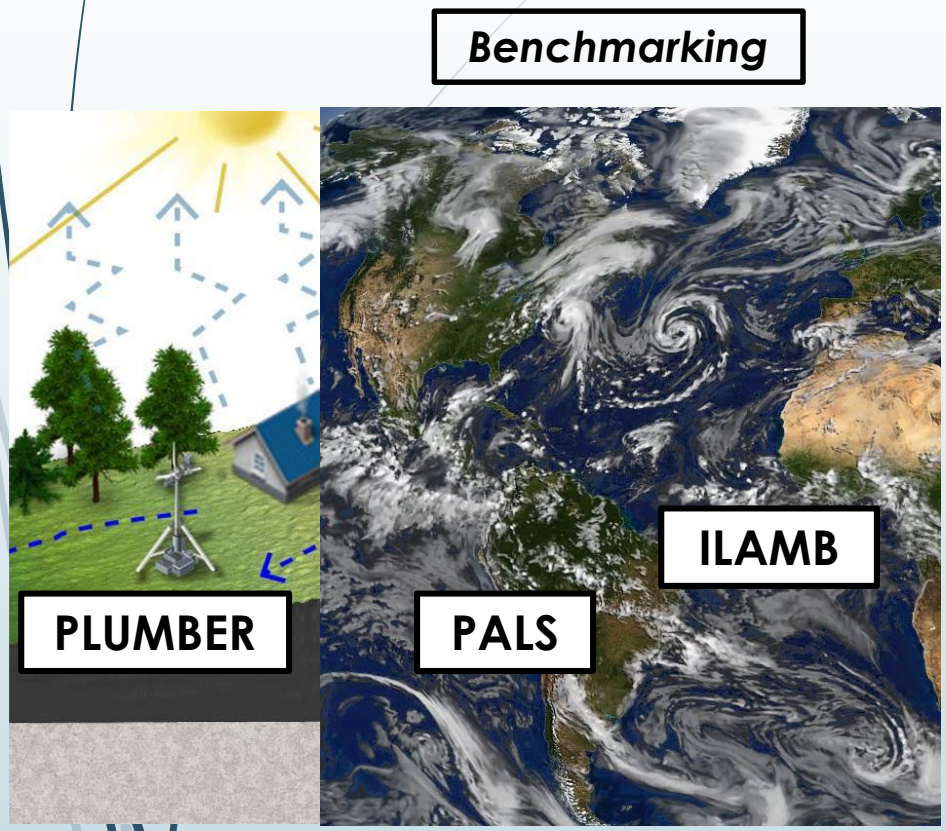
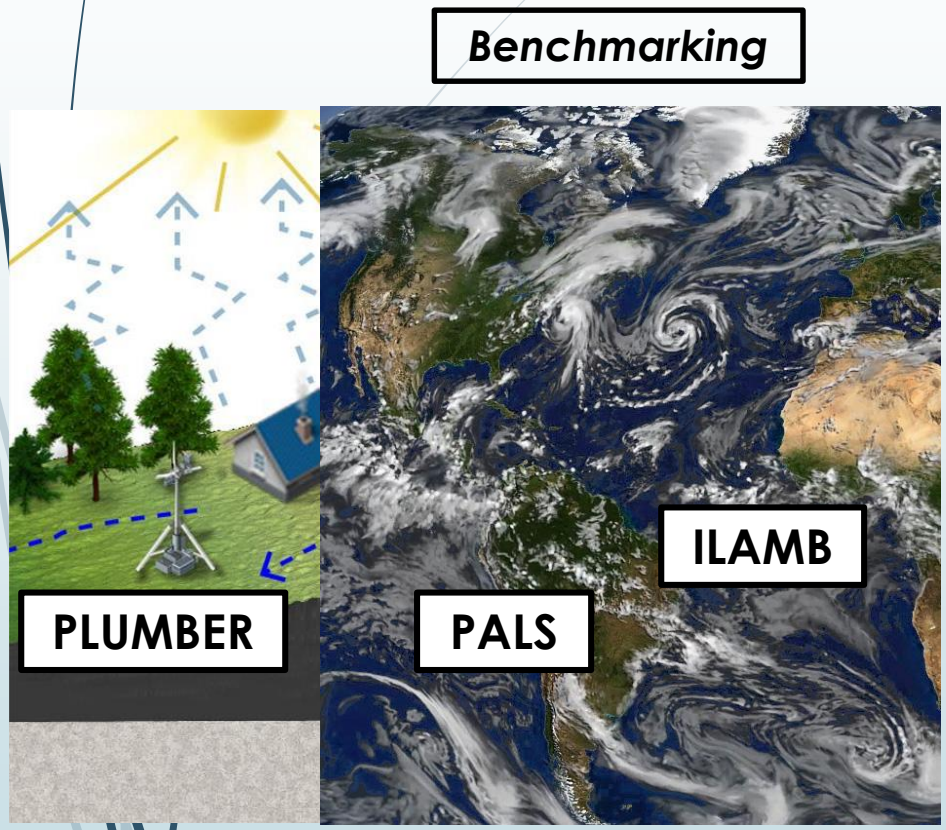
Benchmarking Projects



- **PLUMBER2**: Greatly expanded set of observational site locations; better QA/QC (still proceeding) including energy balance correction; improved empirical benchmarking models.
  - Surface hydrology, data assimilation, urban effects, and water-management efforts being incorporated into the PLUMBER initiative.
- **PALS/modelevaluation.org**: Broader implementation of PLUMBER, web-based platform for benchmarking models against observations.
  - Hosts experiments: forcing data is on web platform, users run experiments locally then upload simulations, me.org runs analysis routines to compare simulations to benchmarks and other models.

Benchmarking Projects



- **ILAMB**: International LAnd Model Benchmarking
  - Global benchmarking toolkit for climate model variables (seasonal to annual).
  - Model-data comparisons: consolidated location for datasets and diagnostics relevant to land and vegetation modeling communities.
  - Documented in Collier et al. (2018); It is being used by several modeling centers and intercomparison projects and to analyze CMIP6 (vs CMIP5) models.

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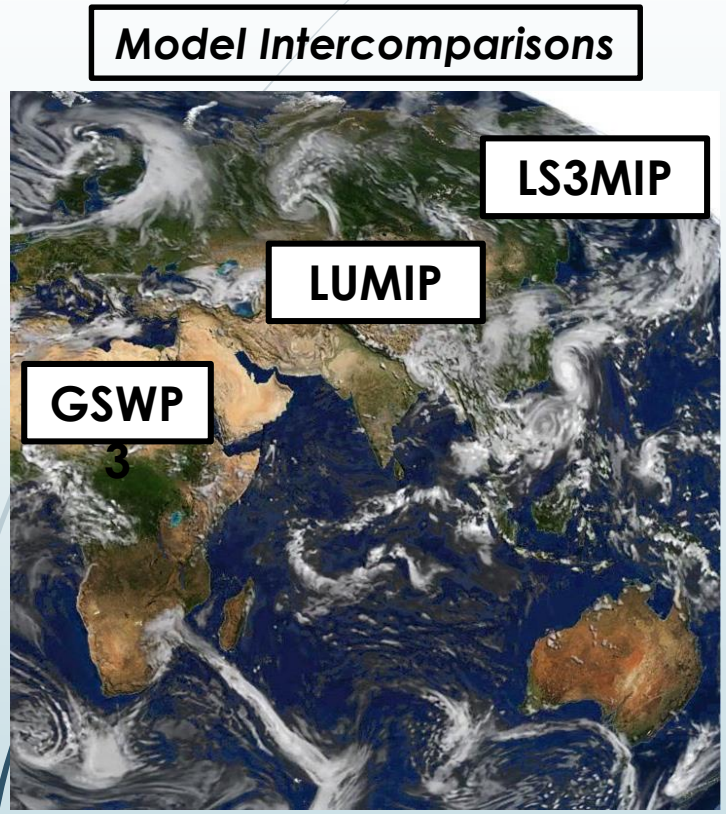
Model Intercomparison Projects



- **GSWP3**: Global Soil Wetness Project, phase 3
  - terrestrial modeling activity, produces a long-term land reanalysis and investigates changes of the energy-water-carbon cycles.
- **LS3MIP**: Land Surface, Snow and Soil Moisture MIP
  - assess the performance of current land surface modules of earth system models and quantify land surface feedbacks in a changing climate.
- **LUMIP**: Land Use MIP
  - understanding the impact of land use and land use change on climate.

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