GEWEX

Global Energy and Water Cycle Exchanges Project

Global Land-Atmosphere System Studies (GLASS) Panel Update at WGNE-37

Kirsten Findell and Anne Verhoef, GLASS co-chairs
With materials from the GLASS Panel Project Leaders

Michael Ek, GLASS-WGNE liaison

37th Meeting of the Working Group on Numerical Experimentation (WGNE-37)
NCAR, Boulder, Colorado, USA
8-10 November 2022

GLASS
Global Land - Atmosphere System Studies
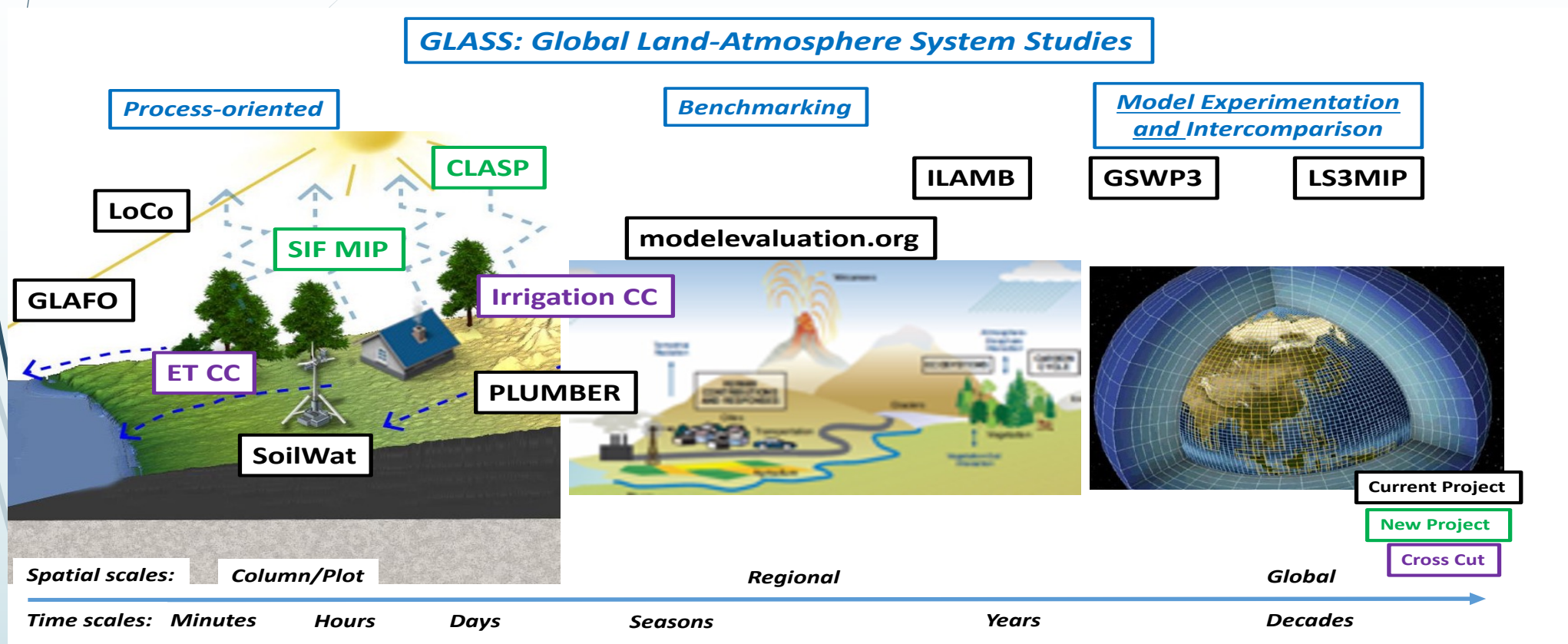
GLASS Science Objectives and Activities

Scientific Objectives and Activities 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.
- 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 models.
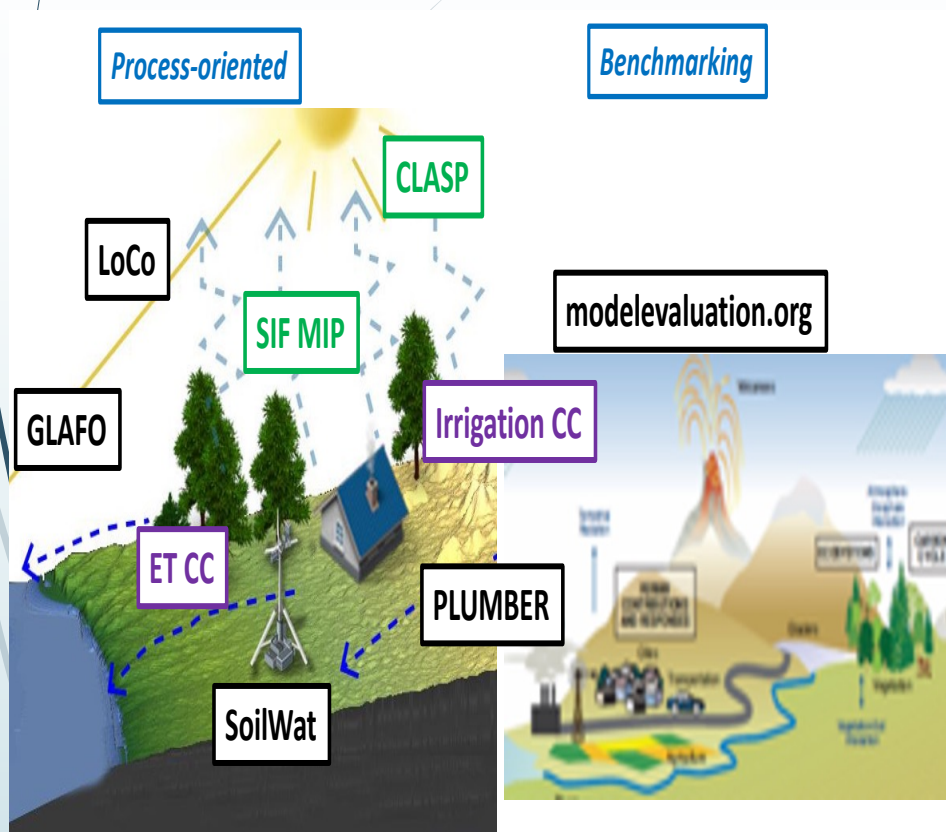
GLASS activities/projects support GEWEX Science Goals:

- **#1:** Determine the extent to which Earth's water cycle can be predicted.
- **#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.
- **#3:** Quantify anthropogenic influences on the water cycle and our ability to understand and predict changes to Earth's water cycle.

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GLASS Panel Projects:
From column (process) to global scale

GLASS: Global Land-Atmosphere System Studies

Process-oriented

Benchmarking

Model Experimentation and Intercomparison

CLASP

ILAMB   GSWP3   LS3MIP

LoCo

SIF MIP

modelevaluation.org

GLAFO

Irrigation CC

ET CC   PLUMBER

SoilWat

Current Project

New Project

Cross Cut

Spatial scales: Column/Plot   Regional   Global

Time scales: Minutes   Hours   Days   Seasons   Years   Decades

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Relevant to WGNE: GLASS process-oriented and land model benchmarking projects

- **LoCo**: Local Coupling Working Group: Land-atmosphere interactions at local to regional (to global) scales.

- **GLAFO**: GEWEX/GLASS Land-Atmosphere Feedback Observatories.

- **PLUMBER2**: The Protocol for the Analysis of Land Surface Models (PALS) Land Surface Model Benchmarking Evaluation Project, phase 2: Offline land model experiments. Modelevaluation.org.

- **SoilWat**: Soils and Subsurface processes: Improve understanding and representation of soil physics & groundwater transport in local to global models.

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Local Land-Atmosphere Interactions Processes
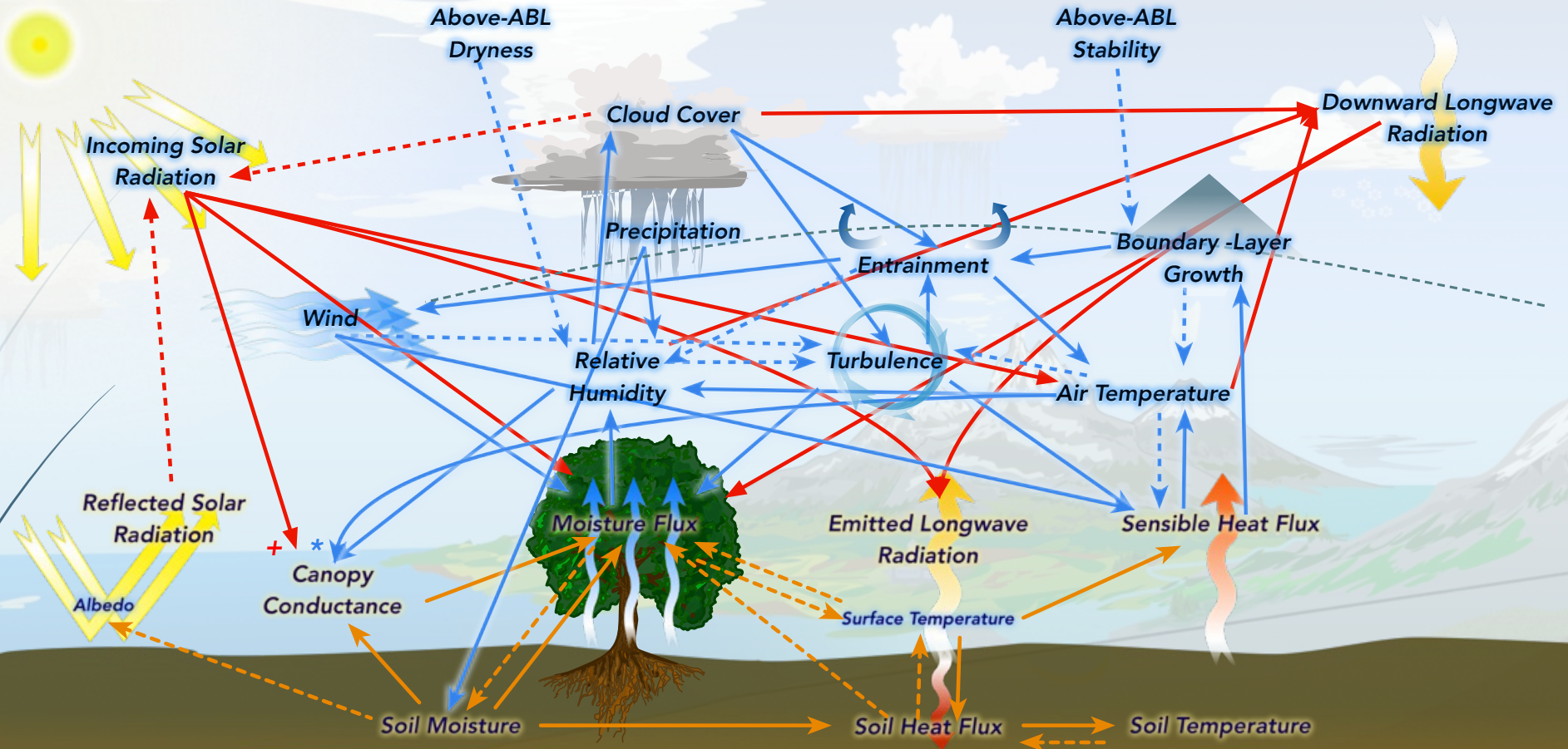
Many processes and interactions to observe, understand and model!
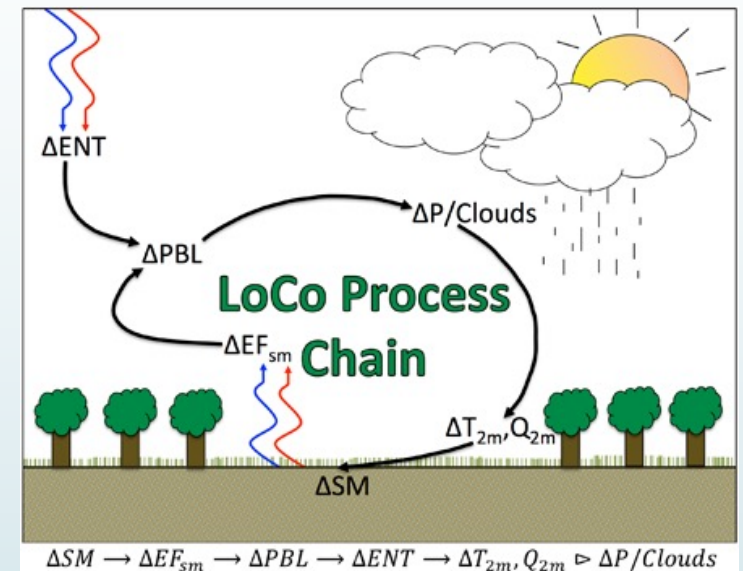
Local Land-Atmosphere Coupling (LoCo) Working Group

LoCo WG Objective:

- To understand, quantify, model, and predict the **role of local land-atmosphere (L-A) coupling** in the evolution of land-atmosphere fluxes and state variables and the respective water and energy cycles, including clouds in weather & climate models.

Goals:

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

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$$\Delta SM \rightarrow \Delta EF_{sm} \rightarrow \Delta PBL \rightarrow \Delta ENT \rightarrow \Delta T_{2m}, Q_{2m} \rhd \Delta P/Clouds$$

LoCo "Process Chain".

Local Land-Atmosphere Coupling (LoCo) Working Group (cont.)

Achievements:

- **Engage operational centers**, e.g. via U.S. NOAA/DOE *"Coupling of Land and Atmospheric Subgrid Parameterizations"* (CLASP project), NOAA Unified Forecast System Land WG has multiple LoCo members members; Developmental Testbed Center (DTC) outreach/adoption of LoCo metrics: WGNE Blue Book contribution on Hierarchical System Development.

- **Influence/lead PBL observational advancements** via NASA Decadal Survey Incubation (DSI), AmeriFlux, NOAA, and DOE activities.

- Continue to **influence LoCo components of field campaigns** (LAFE, GRAINEX, LIAISE, DOE-AMF3).

- **Explore coordinated expansion of LoCo scope** via collaborative proposals and experiments.

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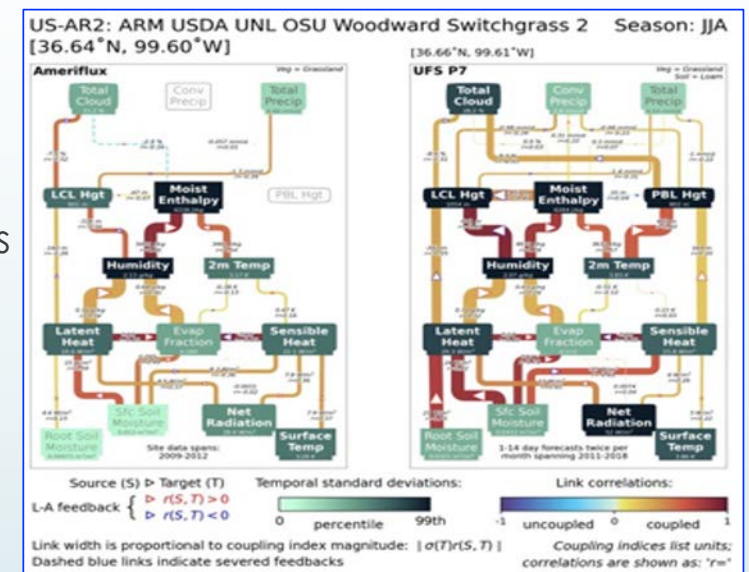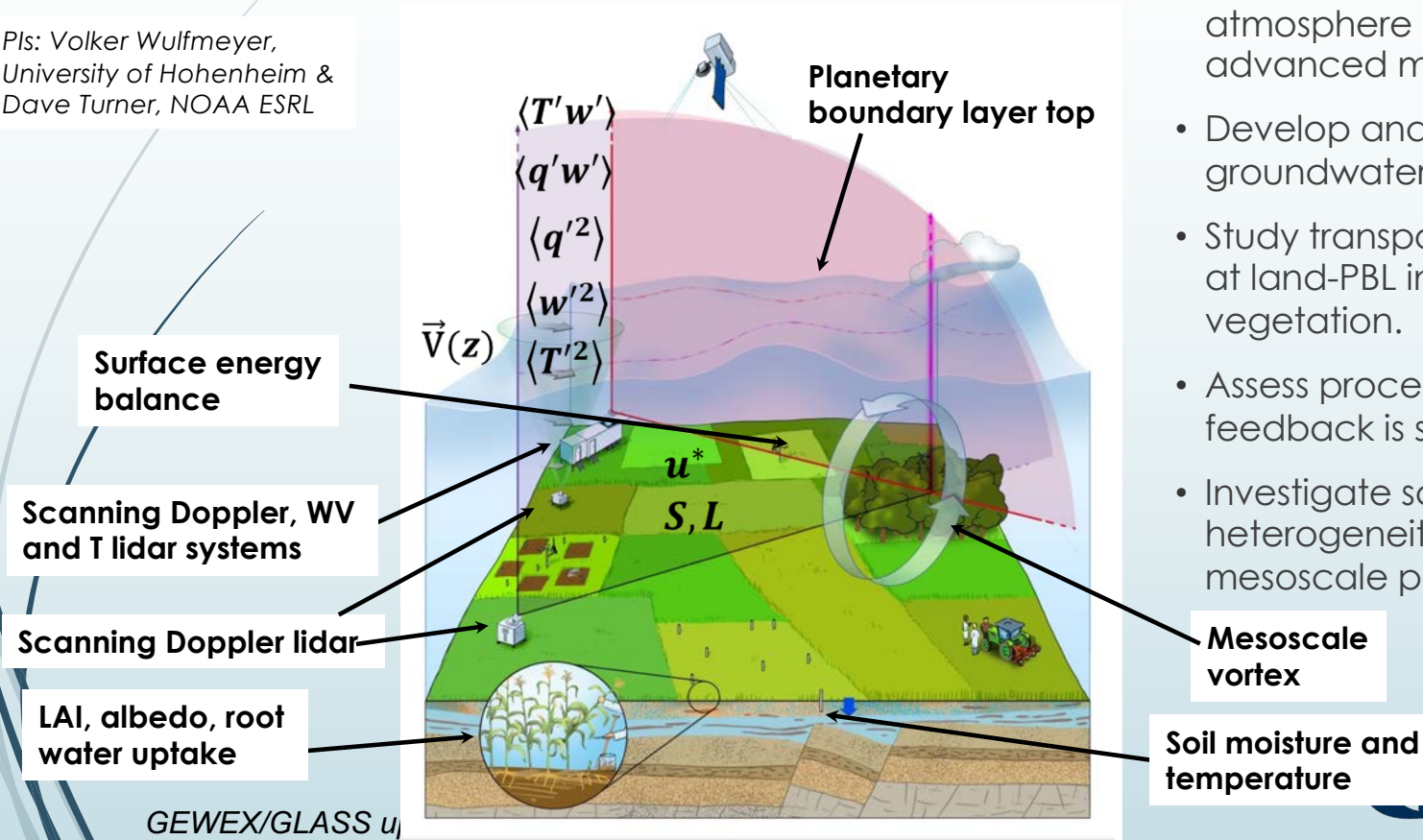

Fluxnet Obs   Model (GFS)

Pipe diagram showing coupling strength indices during JJA at an AmeriFlux site and the corresponding model grid cell. (Paul Dirmeyer, George Mason Univ., US).

GLAFO: GEWEX/GLASS Land-Atmosphere Feedback Observatories

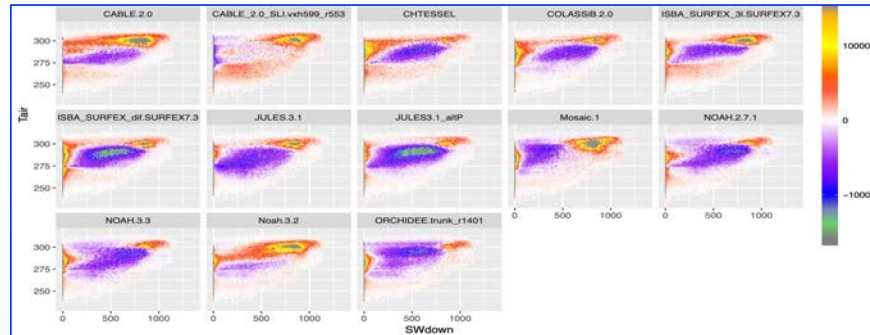*PIs: Volker Wulfmeyer, University of Hohenheim & Dave Turner, NOAA ESRL*

GLAFO Objectives:

- Understand and characterize land-atmosphere (L-A) feedback with advanced metrics.

- Develop and operate GLAFOs from groundwater to lower troposphere.

- Study transport and exchange processes at land-PBL interfaces, including role of vegetation.

- Assess processes/scales at which L-A feedback is sensitive to hydrology.

- Investigate scale interactions and land heterogeneity from turbulent to micro- to mesoscale processes.

$$\langle T'w' \rangle$$
$$\langle q'w' \rangle$$
$$\langle q'^2 \rangle$$
$$\langle w'^2 \rangle$$
$$\langle T'^2 \rangle$$

$\vec{V}(z)$

u^*
S, L

Planetary boundary layer top

Surface energy balance

Scanning Doppler, WV and T lidar systems

Scanning Doppler lidar

LAI, albedo, root water uptake

Mesoscale vortex

Soil moisture and temperature

GEWEX/GLASS u...

GLASS
Global / Land - Atmosphere System Studies

PLUMBER2

Conditional analysis, e.g. Water Use Efficiency and Evaporative Fraction during dry-down events, heat-waves; domain clustering (forcing only, forcing+model states) to identify poor simulation conditions (Abramowitz et al, 2022).

PLUMBER2 Objective:

- **Intercomparison project** for land models, conducted within the Protocol for the Analysis of Land Surface Models (PALS) benchmarking system. PALS is now **modelevaluation.org**.

Goals:

- **Evaluation of multiple leading land and ecosystem models** for water and carbon fluxes.
- **PLUMBER2 provides forcing and evaluation datasets** for model intercomparison, and comparison with empirical models.
- **Dataset from 170 flux tower sites**, spanning multiple biomes and climate zones globally. Provides meteorological variables to force models and flux variables for evaluation. The original data from a number of Fluxnet sources.

Achievements: **Hosts experiments**: forcing data on web platform; users run experiments locally then upload simulations; modelevaluation.org runs analysis routines to compare simulations to benchmarks, empirical models, and other models (e.g. example above).

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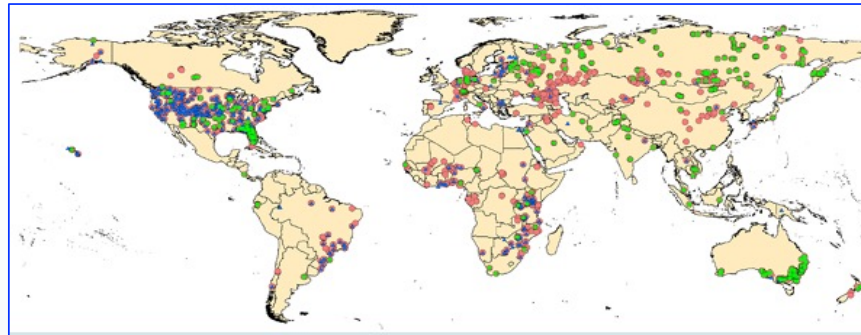
SoilWat

Machine Learning for mapping soil water characteristics curves: Global Soil Hydraulic Properties (GSHP) database (Gupta et al, 2022, Remote Sensing).

SoilWat WG Objective:

- The GEWEX-ISMC* SoilWat Initiative brings together two research communities to improve representation of soil and subsurface processes in models.

Goals: SoilWat is broadly organized around three initiatives:

- How **key soil physical processes and properties** (related to water and heat flow) are represented in land models.
- A systematic assessment of the utility of **resolved soil maps** and **sensitivity of models** to improved the quality and resolution of soil maps: **SP-MIP.**
- Strategies for better incorporation of **groundwater** in models, including soil-groundwater dynamics, and interactions with vegetation and biogeochemical cycles.

Achievements: Providing guidance on the representation of soils, i.e. composition, thermodynamics, hydraulics, data sets; guidance from Soil Parameter-MIP to understand uncertainties in soil hydraulic parameters & land model behavior (e.g. example above).

*International Soil Modelling Consortium

GEWEX/GLASS update at WGNE-37, NCAR, November 2022

Virtual WGNE-36, October 2021

GLASS new initiatives & collaborations

Synergies between GEWEX, WGNE and other projects/panels to improve understanding and address model limitations; coupling between the carbon-, water- and energy balance; closer links with hydrological & weather services, with better predictions of extremes; use of additional in situ & remotely-sensed data sets.

❑ **CLASP** (Coupling of Land and Atmospheric Subgrid Parameterizations): understanding and modeling heterogeneous land connected to heterogeneous atmosphere. LoCo land-atmosphere (L-A) coupling metrics.

❑ **Urban Plumber and Urban PLUMBER-Hydro**: Improve understand and model interactions between urban land surfaces/hydrology and atmosphere. LoCo.

❑ **"Soil-Cloud Cascade"** (role of Soil Properties on L-A Interaction): spatio-temporal distribution of surface temperature, soil moisture, evaporative fraction, effect on convective cloud-forming. CLASP, SoilWat, GLAFO, GDAP, GASS, LoCo.

❑ **SIF** (solar-induced chlorophyll fluorescence): development and integration of canopy-level fluorescence models.

❑ **Surface water**, lakes, reservoirs: important for land heterogeneity, organization of convection. ET and Irrigation cross-cuts projects, GHP, NASA SWOT mission.

GLASS new initiatives & collaborations (cont.)

- ❑ **GHP** (GEWEX Hydroclimatology Panel) "cross-cut" projects to improve irrigation and evapotranspiration representation in models. First irrigation workshop in Nov 2022; a revisit to a 2016 GEWEX workshop on human water management.

- ❑ **GASS** (Global Atmospheric System Studies): new **GABLS** (GEWEX Atmospheric Boundary-Layer Study) projects to understand local L-A interaction/coupling. LoCo; **GASS LS4P** (Land Temperature and Snowpack on Sub-seasonal to Seasonal Prediction): Impact of Initializations. PLUMBER.

- ❑ **LIAISE** (Iberian Semi-arid Environment) project. GHP, GLASS, GABLS, GASS.

- ❑ **WGNE 2019 Systematic Error Survey**: Land-related to errors: surface fluxes, surface temperatures & diurnal cycle are of particular note, and reiterated in discussions during Nov. 2022 WGNE systematic errors workshop. GABLS, LS4P.

- ❑ **WGNE Surface Flux Intercomparison Project** (Charlotte Demott, Colorado State Univ. leads). Focus on ocean surface fluxes. Future land phase with GLASS.

- ❑ **WWRP JWGFVR** (Joint Working Group on Forecast Verification Research): Land-atmosphere coupling metrics. LoCo.

- ❑ **WWRP DAOS** (Data Assimilation & Observing Systems) WG: revisit land and hydrology data assimilation.

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