

Annual GLASS Science Panel Meeting

Canmore, Alberta, Canada
3–4 May 2018

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The Global Land/Atmosphere System Study (GLASS) Science Panel Meeting was held prior to the 8th GEWEX Open Science Conference at the Coast Canmore Hotel and Conference Centre in Canmore, Alberta, Canada from 3–4 May 2018, with 21 panel members and guests attending (six remotely). As in previous meetings, community activities under the three GLASS Panel elements were reviewed: (1) land model benchmarking to improve understanding and representation of land surface processes, (2) land-atmosphere interaction and feedbacks, and (3) the role of land surface in predictability, as well as associated GEWEX projects and related crosscut activities.

LoCo

The Local Land-Atmosphere Coupling (LoCo) project and working group (WG) updates were presented by Joe Santanello. LoCo science, modeling, and observational advances made over the last year include publishing a *Bulletin of the American Meteorological Society* overview article in June 2018, convening Land-Atmosphere (L-A) sessions at the American Geophysical Union and American Meteorological Society meetings, producing numerous WG publications across an array of L-A focal areas, launching field campaigns focused on L-A interactions (Land-Atmosphere Feedback Experiment, LAFE; August 2017) and irrigation (Great Plains Irrigation Experiment, GRAINEX; summer 2018), pushing to improve planetary boundary layer (PBL) observations in the 2017 National Research Council (NRC) Decadal Survey, and providing input to the U.S. Climate Modeling Summit on advancing L-A coupling metrics in global climate models (GCMs). Much progress has been made over the last decade on developing and applying a range of integrated metrics across scales (Fig. 1 on the next page), and producing public resources such as the LoCo Metrics “Cheat Sheets” (http://cola.gmu.edu/dirmeyer/Coupling_metrics.html) and Coupling Metrics Toolkit (CoMeT; <http://www.coupling-metrics.com>). As the broader atmospheric and hydrological/land surface communities continue to learn the importance of integrated, quantitative diagnostics in model development, LoCo will continue to grow and play a pivotal role in delivering metrics and approaches to improving L-A understanding and prediction.

PLUMBER, PALS, and Land Data Assimilation

Martyn Clark led a discussion on the next phase of the land model benchmarking experiment called Protocol for the Analysis of Land Surface models (PALS) Land Surface Model Benchmarking Evaluation Project-2 (PLUMBER2), which will have a greater process-oriented focus. The goal is to ask all participants to run their models for a larger number of sites and to provide much more comprehensive model output, such as all states, fluxes, and parameter values. More model output will allow us to reconstruct model parameterizations (e.g., by plotting fluxes against states) and hence figure out why different models behave differently. More sites will enable us to examine the data in different ways, and understand model behavior under different environmental conditions. This experiment will greatly improve our insight into land model weaknesses. As part of PLUMBER2, a land data assimilation (DA) component will be introduced where model-run variants employing assimilation of remote sensing data will be encouraged and later used to assess the utility of remote sensing data towards model benchmarking. The PALS web application used for the original PLUMBER experiment is transitioning to a new, more flexible workflow and architecture at <https://modevaluation.org> (“PALS2”). Creating new and more varied analyses, PALS2 will support public community participation in the analysis of the new process-oriented PLUMBER2 experiment. It also allows use of observational datasets for analyses that are not downloadable by users, potentially removing a barrier to better integration of the land-surface modeling and data collection communities.

GSWP3 and LS3MIP

Hyunjun Kim gave an update on the status of the Global Soil Wetness Project Phase 3 (GSWP3) and the Land Surface, Soil-moisture, and Snow Model Intercomparison Project (LS3MIP). The GSWP3 forcing dataset has been updated in response to community feedback, and the official version has been tested carefully and packaged for release. LS3MIP had a kick-off meeting in September 2017 with participants from 15 institutions where nine modeling groups reconfirmed their contributions. A wiki has been set up to share feedback and up-to-date information (<https://wiki.c2sm.ethz.ch/LS3MIP>). Also, Hyunjun is acting as a liaison between the GLASS and Coupled Model Intercomparison Project (CMIP) communities to expand Climate and Forecast (CF) metadata conventions to cover variables newly requested by LS3MIP. Some technical features to be incorporated in CMIP6, including data requests, are still being adjusted.

ILAMB and LUMIP

David Lawrence discussed the International Land Model Benchmarking version 2 (ILAMBv2) package that is currently being utilized by several modeling centers. The ILAMB metrics protocol is documented in Collier et al., 2018. New datasets continue to be added, including some for GEWEX-related quantities including snow depth, permafrost extent, and evaporative fraction. A diurnal cycle metrics package is under development. Focus over the next year will be to implement more process-oriented metrics including metrics on

snow thermal insulation, snow-albedo feedbacks, soil carbon turnover times, and potentially dry-down responses. ILAMB continues to prepare for CMIP6 results and will be applied to the LS3MIP land-history simulations. Dave also provided updates on the Land Use Model Intercomparison Project (LUMIP) and the Land-Use Harmonization version 2 (LUH2) dataset. This recently-released dataset describes land use and land management for the years 850 to 2100. LUMIP is mainly on hold at this stage until model simulations start to become available in 2018 and 2019. A “LandMIPs in CMIP6” workshop is planned for October 2018 in Toulouse, France. Groups have begun to register their interest in analyses of the LUMIP simulations at the LUMIP webpage (<https://cmip.ucar.edu/lumip>).

Joint Projects and Crosscut Activities

GASS

John Edwards, GLASS liaison to the GEWEX Global Atmosphere Systems Studies (GASS) Panel, considered several areas

of common interest shared between GLASS and its sister panel. Two continuing GASS projects of particular interest are (1) the Clouds Above the United States and Errors at the Surface (CAUSES) project, which is concerned with identifying the deficiencies in models that lead to a prevalent warm bias in the central U.S. in summer and has led to four papers this year, e.g., Morcrette et al., 2018; and (2) the GEWEX Atmospheric Boundary Layer Study phase 4 (GABLS4), which is concerned with the simulation of the diurnal cycle in summer on the Antarctic Plateau and the role of the stable boundary layer. Potential projects of particular interest to GLASS concern the modeling of fog, the representation of momentum drag, and the influence of the initial state of the land surface and the snow pack on seasonal forecasts.

GHP

Craig Ferguson, GLASS liaison to the GEWEX Hydroclimatology Panel (GHP), reported on current GHP activities and plans. Notably, there are three tentative Regional Hydroclimate Projects (RHPs), the Hydroclimate Research Program

Metric Applications and Timescales

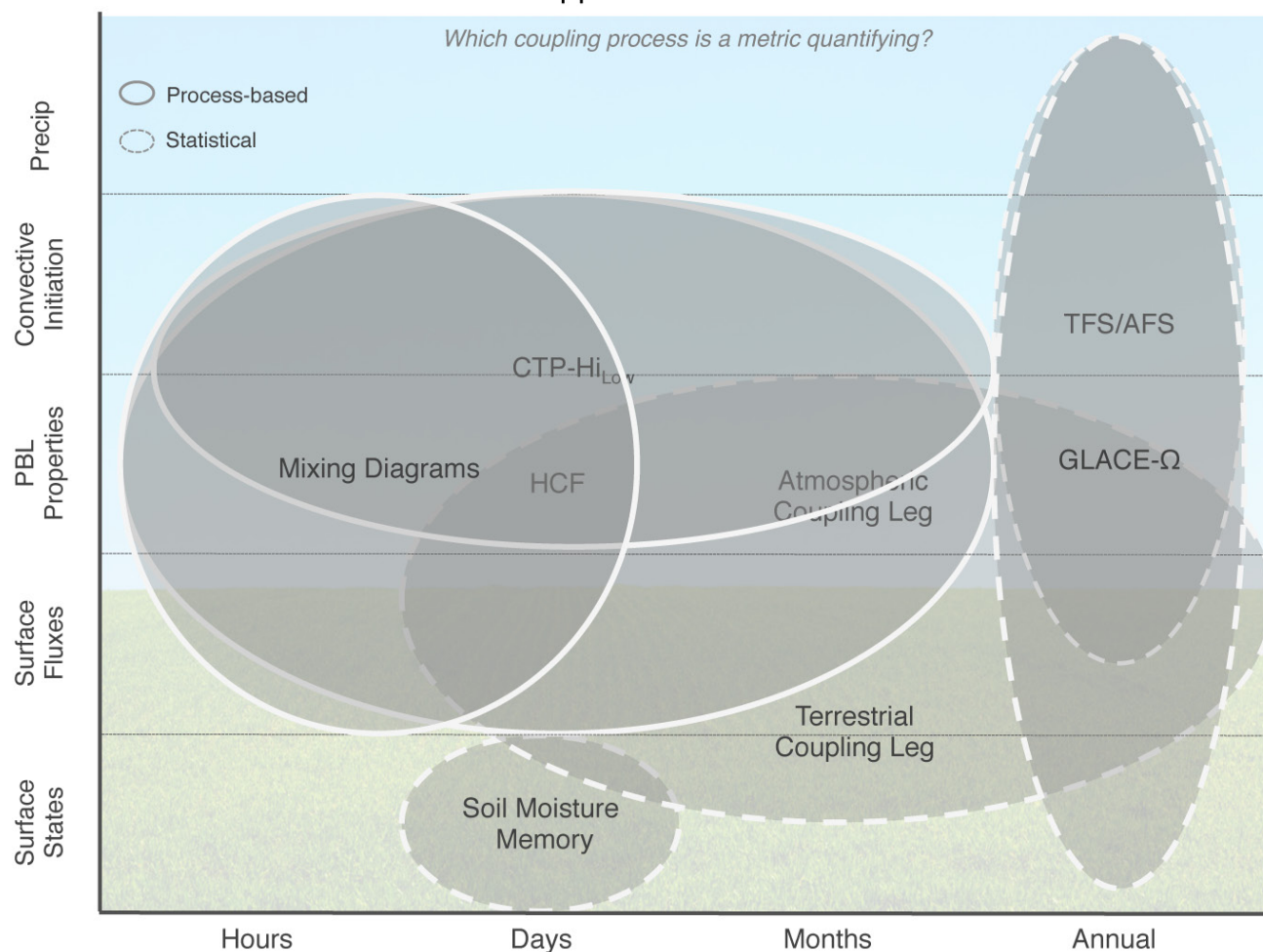


Figure 1. LoCo metrics across temporal scales (x-axis), relationship to the LoCo process-chain connecting soil moisture to precipitation along the y-axis, and statistical vs. process-based nature of each (elliptical outlines). Green background shading indicates land surface related states and fluxes, while blue indicates PBL and atmospheric variables.



Participants at the GLASS Meeting

for the Andes (ANDEX), the Land-surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE) project (discussed below), and a potential U.S. RHP, all responsive to the World Climate Research Programme's GEWEX-led Grand Challenge on Water for the Food Baskets of the World. The fully-active HyMeX and initiating PannEX RHPs also have research thrusts in isolating the role of land and water management on local climate predictability. The proposed GHP crosscut on Water Management in Models would serve to support and coordinate modeling aspects of this work. GLASS is particularly well-positioned to contribute to the development, implementation, and evaluation of water management representation in land models following the PALS/PLUMBER benchmarking framework.

Aaron Boone gave an update on the potential GHP RHP called LIAISE, noting that one of the biggest challenges facing environmental science is understanding future changes in the terrestrial water cycle and the subsequent impact on water resources. In particular, climate projections predict that the Mediterranean region will be a so-called climate change "hot-spot" during the twenty-first century. The LIAISE project seeks to address the challenges posed by modeling semi-arid regions with a field campaign in 2020 that will bring together ground-based and airborne measurements with modeling studies to lead to an improved understanding of processes such as soil moisture, evapotranspiration, and precipitation through atmospheric coupling and the subsequent feedbacks to the Mediterranean atmospheric boundary layer and basin hydrology, including aspects like streamflow and instances of human influence such as irrigation and water extraction methods. In 2018, a workshop was held in January at the University of Barcelona with members of the Spanish research community, and the status of the project was presented during the HyMeX Workshop (May 2018, Lecce, Italy). Currently, the

core members of the LIAISE science team are seeking funds to complete the campaign. It is anticipated that this project will lead to several GLASS-GASS-GHP community experiments.

Pere Quintana Seguí, liaison to the GLASS Panel from the GHP RHP Hydrological cycle in the Mediterranean Experiment (HyMeX), reported that the HyMeX Drought and Water Resources Science Team (HyMeX DWR) is working on an enhancement to the studies of drought at the Mediterranean scale, gathering data that covers the entire region in order to better understand drought and drought-related mechanisms in this area. HyMeX DWR is investing in land-surface modeling and remote sensing to improve knowledge of the continental water cycle, including the impacts of irrigation. The LIAISE field campaign, which was discussed at the HyMeX workshop in May, will study land-surface processes in semi-arid areas and the impact of irrigation on both the atmospheric boundary layer and hydrology.

SoilWat

Anne Verhoef gave a summary of the GEWEX Soil and Water Initiative (SoilWat) Pedotransfer Functions (PTF) activity, which relates to testing and improving soil hydraulic and thermal properties in land-surface models (LSMs). Activities so far involve testing the effect of (1) different PTFs and hydraulic models (Mualem-van Genuchten vs. Brooks-Corey) on water flow simulation and (2) different hydraulic functions and PTFs and thermal functions (and related thermal PTFs) on the energy and water balance, the soil (surface) temperature, and soil moisture content. Model runs were conducted with Hydrus-1D for 14 years (2001-2014) with half-hourly data from Avignon, France for a bare soil profile, with various land model thermal equations implemented in Hydrus-1D for this exercise. Thermal conductivity was also compared with measured values. Large differences were found between the various LSMs, both for the hydraulic and thermal functions and for the fluxes, but less so for the state variables (for the thermal runs). These results will be described in a journal publication. The community plans further activities, including the creation of a global map of thermal parameters. Matthias Cuntz reported on another SoilWat activity, the Soil Parameter Model Intercomparison Project (SP-MIP), which is assessing the influence of soil parameters on the variability of LSMs, where SP-MIP follows LS3MIP conventions as closely as possible. Currently, eight modeling groups have committed, half of which have already started or even finished the experiments, while the other half are scheduled to complete their runs this summer.

Urban Effects in Land Models

Mathew Lipson presented an overview on including urban effects in land models, i.e., the Project for Intercomparison of Land Surface Parameterization Schemes (PILPS)-Urban, the first (offline) urban land model intercomparison project (Best and Grimmond, 2015). The urban representations providing most benefit were an appropriate urban bulk albedo, radiation reflections within street canyons, separate roof and street canyons, and urban vegetation. However, simpler urban

models performed similarly well for the scales of weather and climate models, so new and more complex processes should not be included unless it can be demonstrated that they provide additional benefits. The Single-column Urban Boundary Layer Inter-comparison Model Experiment (SUBLIME) was also reviewed, where urban land model runs with and without boundary layer interactions were made over central London for two days; submissions are complete and the first results will be presented at the International Association for Urban Climate (ICUC) conference in August 2018. Also discussed was a suggestion to run PLUMBER-style experiments for many urban flux sites that differ in their urban characteristics, with a potential to use the new PALS2 framework. Future foci include urban boundary layer theory, observations and modeling, and human behavioral drivers and impacts (e.g., Barlow et al., 2017).

S2S

Paul Dirmeyer updated the Panel on Subseasonal to Seasonal (S2S) efforts relevant to GLASS. The International S2S Prediction Project (<https://www.s2sprediction.net>) is coming to the end of its original 5-year mandate for global operational centers to produce S2S hindcast and forecast data sets. A proposal for a second 5-year phase, which would have a much stronger emphasis on the role of land surface in S2S prediction, was submitted to WMO in February 2018. Three core questions relevant to GLASS research are proposed: What is the impact of the observing system on land initialization and S2S forecasts? How well are the coupled land-atmosphere processes represented in S2S models? How might anomalies in land surface states contribute to extremes? In the U.S., the National Oceanic and Atmospheric Administration (NOAA)'s S2S Task Force, comprised of investigators funded by the NOAA Climate Project Office, includes two projects with direct GLASS relevance, one led by Trent Ford (Southern Illinois University) and the other by Zhichang Guo (George Mason University). A sister NOAA-supported effort called SubX is similar to the S2S Prediction Project except that it includes research/climate models, enforces greater consistency among models to promote multi-model ensemble studies, and is somewhat better at saving output variables relevant to land-atmosphere interactions. Lastly, the annual U.S. Climate Modeling Summit featured a workshop on land-atmosphere interactions, which was an opportunity to educate U.S. agency leadership at the six U.S. climate modeling centers and their funding agencies about the scientifically-established impact of land surface feedbacks on climate. The U.S. modeling community is now more aware and highly interested in GLASS-led activities and scientific progress, and is exhibiting some momentum to encourage enhanced efforts toward L-A-related model assessment and development.

Other

Paul Dirmeyer and Mike Ek attended the World Climate Research Programme (WCRP) Monsoon Panel side meeting during the May 2018 GEWEX Open Science Conference, where understanding and modeling land-hydrology processes are key in representing monsoon circulations. Eleanor Blyth

talked about synergies between GEWEX and the Integrated Land Ecosystem-Atmosphere Processes Study (iLEAPS) and "Future Earth", including possible collaborations. In particular, PLUMBER2 should include carbon fluxes in addition to energy and water, with a joint workshop on land surface modeling to be held in Oxford in 2020 focusing on the impact of carbon dioxide on water use efficiency. Mike Ek briefed the Panel on liaison activities with the WMO Working Group on Numerical Experimentation (WGNE) and the WCRP Modelling Advisory Council (WMAC). WGNE is interested in improving global weather and climate models and WMAC coordinates high-level aspects of modeling across WCRP. GLASS presence in these groups focuses on improving land modeling and land-atmosphere interaction, particularly land data assimilation in the case of WGNE. Kun Yang noted the high spatial heterogeneity of land properties and the associated uncertainties in specifying parameters used in land model parameterizations. To address this challenge, he suggested that it is perhaps time to promote methods for deriving land parameters and calibrating land surface models through satellite remote sensing and data assimilation (e.g., Yang et al., 2016; Pinnington et al., 2018). This and other related activities should be explored further as possible areas to increase collaboration with the GEWEX Data and Analysis Panel (GDAP).

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