2020 GLASS Panel Meeting

Virtual Meeting
23–25 November 2020

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The GEWEX Global Land-Atmosphere System Study (GLASS) Panel met virtually for three partial days at the end of November 2020 to share progress in the 15 months since our last meeting. Despite the difficult circumstances of 2020, there was much to share. Discussion during the meeting was primed by a set of pre-recorded screen-casts shared by the project leads 1–2 weeks in advance of the meeting. Our core projects stem from process-based inquiries, to benchmarking activities, to global model intercomparisons, and now includes the GEWEX/GLASS Land-Atmosphere Feedback Observatories (GLAFO) initiative. The goal of the GLAFO initiative is to establish a network of long-term observing stations focused on the land-atmosphere system from groundwater, through the surface and vegetation, to the top of the boundary layer. In addition to the project updates summarized below, we welcomed new members Volker Wolfmeyer and Yijian Zeng, heard from guests describing projects relevant to GLASS, and marked the end of Mike Ek's tenure as GLASS Co-Chair. Anne Verhoef now joins Kirsten Findell as Co-Chair. We look forward to continued progress in the year ahead, and hope for an in-person meeting in later 2021 where we can properly thank Mike for a job well done and thank Anne for taking on the next four years!

Core Project Updates: Process-Oriented Projects

GLAFO (and New GLASS Panel Member Volker Wulfmeyer)

New GLASS Panel member Volker Wulfmeyer shared some background on his journey from physics student to designer of new observational instrumentation to multi-faceted meteorologist tackling a new frontier of boundary layer observational capabilities. These strands of expertise contribute to the GEWEX Land Atmosphere Feedback Observatories (GLAFOs, Wulfmeyer et al., 2020). GLAFOs will observe the relevant processes and variables with respect to mass, energy, water vapor, and momentum transport with unprecedented spatial and temporal resolutions, from bedrock to the lower troposphere. Volker presented how the GLAFOs will be designed in order to characterize all relevant interactions and feedback loops between the subsurface, vegetation, and the atmosphere. The measurements will be realized through the synergistic use of in situ instruments and ground-based scanning active remote sensing systems. This approach was pioneered during the Land-Atmosphere Feedback Experiment performed at the Atmospheric Radiation Measurement program's Southern Great Plains (ARM SGP) site in August 2017 (Wulfmeyer et al., 2018). By observing profiles of the mean, gradient, and turbulent fluctuations (if applicable) of all relevant variables, unprecedented data sets will be provided for the study of land-atmosphere (L-A) feedbacks. Such data include surface and entrainment fluxes, advection, and the evolution of key variables in the other compartments of the critical zone (such as ground water levels, soil moisture, and vegetation temperatures), from the diurnal cycle, via seasonal/annual to ideally climatological time scales. Due to the high resolution and accuracy of the observations, the measurements can also be used for operational data assimilation in numerical weather prediction (NWP) models as well as for tests and developments of parameterizations. It is envisioned that the GLAFOs will be set up and operated in all climate zones with different levels of complexity.

LoCo

The local land-atmosphere coupling (LoCo) project update was presented by Joe Santanello. LoCo consists of 20 international scientists across academic and government institutions. LoCo has continued to focus on three near-term objectives to enhance our ability to understand, quantify, and improve land-atmosphere coupling and prediction: (1) promote the importance and development of improved observations of the L-A system, namely in the planetary boundary layer (PBL), as well as improved utilization of soil moisture and surface fluxes measurements in models; (2) pursue adoption of LoCo metrics by operational NWP and climate centers; and (3) expand the scope and reach of LoCo in terms of processes and scales beyond that of warm season thermodynamics and beyond that of 1-D column assumptions. The GLAFO observational measurement system and the Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE) field campaign both plan extensive PBL measurements, and a number of initiatives are underway in response to the National Aeronautics and Space Administration (NASA)'s Decadal Survey prioritization of PBL measurements and spaceborne mission concepts. In addition, the National Oceanic and Atmospheric Administration (NOAA)'s Climate Process Team project (Coupling of Land and Atmospheric Subgrid Parameterizations, CLASP), led by five GLASS members, is working towards applying current and developing new LoCo L-A coupling metrics for Global Climate Model (GCM) development, as well as incorporating LoCo metrics into the International Land Model Benchmarking (ILAMB) package. To advance L-A science, the LoCo Working Group (WG) continues to convene annual American Geophysical Union (AGU) and American Meteorological Society (AMS) meeting sessions (which have become some of the largest in the hydrology sessions and conferences). The WG also influences and responds to agency solicitations that now reflect the priorities of LoCo and supports outreach to the scientific, modeling, and observational communities.

SoilWat

Anne Verhoef gave an update on SoilWat, describing a number of ongoing activities focused on providing reliable soil hydraulic and thermal properties for land models, and

exercises describing the impact of these properties on the land fluxes. This also included recommendations to harmonize pedotransfer functions (PTFs) used in land models and related model intercomparison projects (MIPs) to avoid artifacts originating from the choice of PTFs rather than from different model structures. A number of corresponding publications are near submission or have just been submitted. An ongoing activity includes conducting a global soil hydraulic parameter MIP that could leverage ILAMB (described below). A recently-started activity is the compilation of a data set of globally-distributed soil thermal properties, ideally combined with hydraulic properties, where the data set would serve to support development and verification of models simulating thermal properties. Near-future work includes testing both single and combined influences of hydraulic and thermal properties in models. Finally, establishing a global soil temperature database for land model verification is planned, which would also fit nicely with ILAMB work by providing independent verification data. Yijian Zeng has now taken over from Anne as the SoilWat lead and rapporteur; his expertise spans detailed mechanistic land surface modeling, remote sensing, and in situ observations (see below for more information). Finally, note that the SoilWat activity cuts across the GLASS and International Soil Modelling Consortium (ISMC, *https://soil-modeling.org*) communities.

Core Project Updates: Benchmarking Projects

PLUMBER2, modelevaluation.org, and Urban-PLUMBER

Gab Abramowitz described the Protocol for the Analysis of Land Surface models (PALS) Land Surface Model Benchmarking Evaluation Project, Phase 2 (PLUMBER2) that is well underway, with contributions across land surface, carbon cycle, hydrological, and empirical model approaches contributing to a broad focus on land surface flux predictability. Data from 170 flux tower sites have been through a lengthy quality control process and some groups are already producing final simulation suites, although many have still yet to engage, with submission timelines extended into 2021. Ten of approximately thirty groups have begun submitting simulations via modelevaluation.org (*http://modelevaluation.org/*) to date. The modelevaluation.org web application has faced a range of logistical challenges this year, with the ramp up of PLUMBER2 and Urban-PLUMBER providing the first heavy-use cases. While these challenges are being resolved and have not greatly affected the progress of these experiments, broader engagement beyond a single institution to develop a shared, community-based model benchmarking resource would likely improve its longer-term security. To this end, the Centre of Excellence for Climate Extremes (CLEX) at the University of New South Wales (UNSW, Australia) and the MetOffice (UK) are intending to develop a modelevaluation.org-based automated testing system for model development that is model agnostic, incorporating details from process-based site diagnostics to global ILAMB-based analyses. In regards to Urban-PLUMBER, the initial feedback for Phase 1 (a single urban site) has been provided to the 26 participants, and results are being finalized and written up. The project webpage publishes submitted metadata and plots all requested variables, where observed energy fluxes will be compared with benchmarks. Data for Phase 2 (~25 urban sites) is being quality-controlled and standardized, and will be provided to participants starting in February and finishing in mid-2021.

ILAMB

Dave Lawrence provided an update on ILAMB, which is a model data intercomparison and integration project designed to improve the performance of land models and, in parallel, improve the design of new measurement campaigns to reduce uncertainties associated with key land surface processes. The ILAMB package has been run on the Coupled Model Intercomparison Project Phase 5 (CMIP5) and Phase 6 (CMIP6) historical simulations. Across the majority of models that participated in both CMIP5 and CMIP6, we are seeing general improvements from CMIP5 to CMIP6 across carbon, water, energy, and surface climate metrics, indicating improved model performance. ILAMB is also being utilized in the assessment of land-only versus coupled model simulations to help understand the role of climate biases in coupled models on key land carbon and water flux and state variables. Finally, ILAMB continues to expand, with over 30 variables being assessed against more than 80 global, regional, and site-level data sets and incorporating new metrics and methods to account for observational uncertainty.

Core Project Updates: Model Intercomparison Projects

LUMIP

Dave Lawrence also provided an update on modeling human land-use activities that have resulted in large changes to the Earth's surface, with resulting implications for climate. The Land Use Model Intercomparison Project (LUMIP) aims to further advance understanding of the impacts of land-use and land-cover change (LULCC) on climate through coordinated model experiments. A series of manuscripts have been published or are in preparation, including key papers on the new LULCC data set and on the multi-model response to idealized deforestation (see list of publications and projects at *https://www.cesm.ucar.edu/projects/CMIP6/LUMIP/*). Significant lack of agreement in terms of biogeophysical and biogeochemical impacts of LULCC on land surface fluxes and variables, as well as L-A feedbacks, persists across models.

GSWP3 and LS3MIP

Hyungjun Kim shared the current status of the Land Surface, Snow, and Soil Moisture Model Intercomparison Project (LS3MIP) of CMIP6. In LS3MIP, 13 modeling groups have submitted the tier one experiment results from the land-only configuration [i.e., land-hist, which shares the protocol with the Global Soil Wetness Project Phase 3 long-term retrospective experiment (GSWP3 EXP1)], and six of them submitted the results of the tier one coupled experiments (i.e,

amip-lfmip-pdLC and amip-lfmip-rmLC). Three synthesis papers are being developed describing the first analysis results: (1) overview and benchmarks (led by Hyungjun Kim), (2) land water and carbon balances (led by Ryan S. Padrón, Swiss Federal Institute of Technology), and (3) simulation of cold processes (led by Lawrence Mudryk, University of Toronto) based on the land-hist experiment. Up-to-date data holding status of LS3MIP can be checked at *https://pcmdi.llnl.gov/CMIP6/ArchiveStatistics/esgf_data_holdings/LS3MIP/index.html*.

Updates from Liaisons and Other Initiatives

GASS

John Edwards summarized progress on projects organized by the GEWEX Global Atmospheric System Studies (GASS) Panel. The results of the intercomparison of large-eddy models participating in the GEWEX Atmospheric Boundary Layer Study Phase 4 (GABLS4) project on the boundary layer over the Antarctic Plateau have now been published (Couvreux et al., 2020). The models were able to simulate the very stable boundary layer, provided high resolution was used. Several new projects were launched following the second Pan-GASS Meeting in 2018. Recently-published results from the COnstraining ORographic Drag Effects (COORDE) intercomparison of orographic drag schemes (van Niekerk et al., 2020) demonstrate the large variation in parameterized drag between models and show that it is frequently underestimated over land. The Elucidating the Role of Clouds-Circulation Coupling in Climate (EUREC4A) field campaign was concluded successfully in February 2020 and an intercomparison of simulations of shallow convection based on these data will shortly be initiated. Good progress has been made in analyzing results from the intercomparisons of fog modeling and (sub-)diurnal precipitation.

GHP

Craig Ferguson gave a short presentation on the activities of the GEWEX Hydroclimatology Panel (GHP) before handing over the baton of GLASS-GHP liaison to Josh Roundy. There were three activities identified with particular relevance to GLASS. The first is the proposed Regional Hydroclimate Project (RHP) called the Third Pole Environment, led by Yaoming Ma. It has a large focus on measurements of land-atmosphere interactions across the Tibetan Plateau (with hopes to expand across Eurasia) and could be linked to the GLAFO project. The second is the Quantifying Evapotranspiration (ET) crosscut, led by Joan Cuxart, which aims to improve process-based ET estimates. The second workshop relating to this cross-cut topic took place remotely between 10–12 February 2021. Finally, the emerging U.S. North American proposed RHP, led by Timothy Schneider, aims to bring together multiple U.S. agencies on a focused hydroclimatological study over the U.S. This US-RHP is formulating an umbrella strategy of U.S. continental-scale modeling paired with intensive field studies and observational transects to better understand, represent, and predict coupled water and energy processes at the Earth's surface. Additional information can be found in a pair of recent *GEWEX Quarterly* articles (Schneider and van Oevelen, 2020; Scott and Schneider, 2020). For all of these projects, links between GLASS and GHP will continue to be developed and strengthened over the next year.

LIAISE

Aaron Boone provided an update on the international LIAISE project, where the overall objective of this new activity is to improve our understanding of the impact of surface heterogeneity (notably that induced by anthropization) on the water cycle in terms of land-atmosphere-hydrology interactions in a water resource-limited bread-basket region. However, the understanding of the impact of anthropization and its representation in models have been inhibited due to a lack of consistent and extensive observations. The project depends on an international intensive field campaign which consists of in situ and remotely-sensed measurements of (1) land surface physiographic parameters, biophysical and land state variables, and turbulent and radiative fluxes; and (2) atmospheric state and turbulence measurements within the atmospheric boundary layer. The campaign will extend over a Long Observation Period (LOP: April–September) and will consist of continuous monitoring of the surface and the lowest 50 m of the atmosphere, and two Special Observation Periods (SOPs). The SOPs will also include both in situ and remotely-sensed atmospheric measurements: five days in May or June with the objective of monitoring a typical dry-down event, and a 15-day SOP in late July with a focus on measurements over the entire study domain. This allows the inclusion of different representative land cover types over two strongly contrasting zones, one with extensive irrigation, the other over a bare-soil dry natural grass and rain-fed agricultural surface. LIAISE was delayed by the COVID-19 pandemic, but the research teams are tentatively moving forward for a campaign in summer 2021, where there is a planned expansion of some surface, atmospheric, and remotely-sensed measurements.

S2S

Paul Dirmeyer highlighted the International Subseasonal-to-Seasonal (S2S) Prediction Project, which involves mostly operational forecast modeling centers, with one of the S2S sub-projects focusing on the role of the land surface as a source of predictability beyond weather time scales. Operational model output is being evaluated for model skill and the potential role of soil moisture as a skill source for droughts and heat wave forecasts. Land surface temperature anomalies over elevated terrain is the focus of the ongoing Impact of Initialized Land Temperature and Snowpack on Sub-seasonal to Seasonal Prediction (LS4P) project of GASS, which is shifting focus from the Tibetan Plateau to the U.S. Rocky Mountains and high plateaus of western North America. In the near future, in addition to the proposed Vegetation-Global Land-Atmosphere Coupling Experiment (Veg-GLACE) modeling experiment (described below), another relevant effort regarding S2S forecasting and the role of the land surface as a source of predictability is the

NOAA-community effort to develop and implement the next generation Unified Forecast System (UFS) of models, where medium to extended range and S2S are an emphasis for the UFS.

Veg-GLACE

During discussion time, we learned from Souhail Boussetta and Gianpaolo Balsamo about Veg-GLACE, a new multi-model experiment that has been proposed to examine S2S predictability coming from improved vegetation modeling and based on the experience from a previous GLACE2 experiment (Koster et al., 2011) and the Snow-Global Land-Atmosphere Coupling Experiment (SNOWGLACE, Orsolini et al., 2013). The concept is developed within a new European Horizon project called the CONsistent representation of temporal variations of boundary Forcings in reanalysES and Seasonal forecasts (CONFESS, *https://confess-h2020.eu/*), and will allow us to investigate the impact of a satellite-based vegetation data set, where a set of experiments based on a multi-model [initially Météo-France, the European community Earth-System Model (EC-Earth), and the European Centre for Medium-Range Weather Forecasts (ECMWF)] will be run to evaluate the impact of realistic vegetation variability on subseasonal to seasonal forecast skill. The experimental protocol of Veg-GLACE will be tested within the CONFESS project and consolidated in 2022 to be proposed to WCRP/World Weather Research Programme (WWRP) and Working Group on Subseasonal to Interdecadal Prediction (WGSIP) modeling groups. The GLASS Panel Meeting welcomed the initiative and different modeling groups have already expressed an interest in contributing.

New GLASS Panel Member Yijian Zeng

New GLASS panel member Yijian Zeng presented his research on "Soil-Water-Plant-Energy Interaction in Cold Regions–Tibetan Plateau as the Research Testbed", with the goal of understanding soil-water-plant-energy interaction in cold regions. This uses an integrated modeling framework coupling a physically-based soil freeze-thaw model with groundwater and biogeochemical models. This allows study of the uncertainty in soil physical properties that cause uncertainties in soil hydro-thermal properties that then propagate further into the estimate of land surface states and fluxes. A comprehensive forward observation simulator is therefore suggested (i.e., a physically-based coupled-process model combined with a radiative transfer model) to assimilate remotely-sensed Earth observations [e.g., from the Soil Moisture and Ocean Salinity (SMOS) and Soil Moisture Active Passive (SMAP) missions] for a physically-consistent estimate of soil properties and surface states and fluxes. This then addresses the role of the land-surface in understanding water, energy, and carbon cycles at both local and global scales. Such an approach will in particular contribute to the GEWEX-ISMC SoilWat Initiative described above.

GDAP

GEWEX Data and Analysis Panel (GDAP) Co-Chair Rémy Roca (with input from fellow GDAP Co-Chair Tristan L'Ecuyer) provided an update on his Panel's activities. He noted that the precipitation data set from the centennial reanalysis elaborated under GSWP3 has now been added to the Frequent Rainfall Observations on GridS (FROGS) database (*http://frogs.ipsl.fr*), where users can easily download many precipitation products, including those from various reanalysis products. They expect that this new addition will be included in the future assessment run by GDAP as a way to provide some feedback to GLASS on these unique data sets. Further discussion will be facilitated in the coming year by the newly-appointed GLASS-GDAP liaison, Yunyan Zhang. There are also plans that began at the GEWEX SSG meeting in January 2020 regarding a possible land-atmosphere energy and water cycle closure and consistency assessment that could link local-scale surface processes to global-scale data sets, specifically the GEWEX Integrated Product. This was to have been discussed further at a workshop later in Spain, but was postponed due to the pandemic; we hope to address this in the near future as a GEWEX cross-Panel activity.

CORDEX Urban Project

Aude Lemonsu gave an update on the Urban Coordinated Regional Downscaling Experiment (CORDEX Urban) project, which began at the last International Conference on Regional Climate (ICRC)-CORDEX conference when a group proposed a Flagship Pilot Study project dedicated to urban areas and related issues. The proposal for "URBan environments and Regional Climate Change" (2021–2025) is coordinated by Tomas Halenka (Charles University) and Gaby Langendijk (The Climate Service Center Germany, GERICS) and involves more than 20 partners. The main objective is to understand the effect of urban areas on regional climate and the impact of regional climate change on cities with the help of coordinated experiments with urbanized regional climate models (RCMs). One important scientific question is to identify what urban processes need to be included in RCM simulations to account for urban effects and feedbacks on higher resolution and convection-permitting scales. In a related effort, Aude is coordinating a 4-year French research project with the urban region of Paris as a case study that will contribute to the preparation of the 2024 Olympic Games, and includes a large experimental component dedicated to the study of surface and atmosphere interaction processes and the impacts of urban areas on the dynamics of boundary layers and other meteorological phenomena. At the same time, a World Meteorological Organization (WMO)-approved research demonstration project has started, and includes several meteorological centers and research groups at the international level with the objective to advance high-resolution modeling of urban areas, and the predictability of certain meteorological phenomena (storms, heat waves) in cities.

iLEAPS

Eleanor Blyth and Xianhong Meng briefed the GLASS Panel on the Integrated Land Ecosystem-Atmosphere Processes

Study (iLEAPS). The focus of iLEAPS is on the biosphere as a mediator of Earth system processes, with study of the land and atmosphere together as a system involving physical, chemical, and biological processes. Land-atmosphere systems include important feedbacks between atmospheric chemistry and plants that have an impact on society and on the Earth system, where iLEAPS scientists also address key societal challenges related to health, biodiversity, climate, food and fuel security, and promote scientific excellence through developing international science initiatives that are multi-disciplinary. A Land Modelling Summit, co-sponsored by GEWEX, iLEAPS, and the Analysis, Integration and Modeling of the Earth System (AIMES) project, will be held 12–16 September 2022 in Oxford, UK, and the 6th Open Science Conference sponsored by iLEAPS is planned for February 2022 in Auckland, New Zealand. A Special Collection in the *Journal of Advances in Modeling Earth Systems* on "Next Generation Land Surface Modeling" will tie iLEAPS, GEWEX (GLASS), and AIMES together, with issues linking water and energy, carbon and the anthropogenic impact. Xianhong Meng is the new iLEAPS-GLASS liaison.

WGNE and WMAC

Mike Ek provided a general briefing on the WMO Working Group on Numerical Experimentation (WGNE) and the WCRP Modelling Advisory Council (WMAC), where WGNE and WMAC are interested in improving global NWP and climate models, and on coordinating high-level aspects of modeling across WCRP, respectively. The GLASS presence in these groups focuses on improving land modeling and land-atmosphere interaction in models. The new WCRP structure calls for designing a new "model-data home" that brings together WMAC and the WCRP Data Advisory Council.

WCRP Lighthouse Activities

Peter van Oevelen reported on the WCRP Lighthouse Activities (LHAs, *https://www.wcrp-climate.org/wcrp-ip-la*) that have been initiated to highlight major experiments and high-visibility projects as part of the new WCRP, where such activities truly integrate the capabilities (scientific, technical, infrastructure) across WCRP and with partners. Hyungjun Kim is serving on the Safe Landing Climates LHA (*https://www.wcrp-climate.org/images/documents/WCRP_Implementation_Plan/Safe%20Landing%20Climates.pdf*), and Kirsten Findell (as co-chair) and Mike Ek are serving on the Explaining and Predicting Earth System Change LHA (*https://www.wcrp-climate.org/images/documents/WCRP_Implementation_Plan/Explaining%20and%20Predicting%20Earth%20System%20Change.pdf*), where they see their role as leveraging GLASS and GEWEX activities on process-level understanding and modeling.

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