

GEWEX
Global Land/Atmosphere System Study (GLASS)
Project Updates

Michael Ek (NCEP/EMC)
Kirsten Findell (GFDL/NOAA)
GLASS Co-chairs

GLASS panel members and other GEWEX collaborators

The 31st GEWEX Scientific Steering Group meeting
February 2019

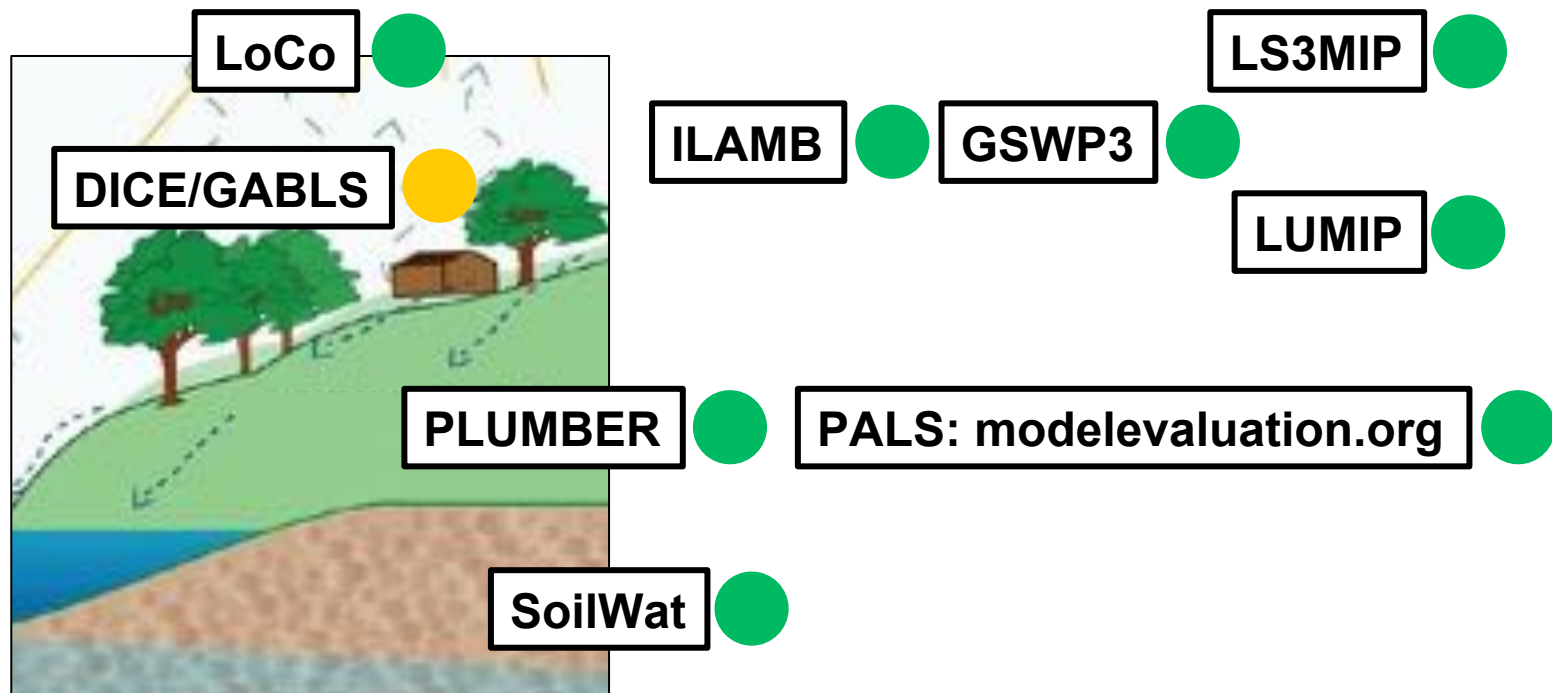
GLASS Structure

GLASS role: Identify and improve modeling of land-surface processes and land-atmosphere interactions to support the GEWEX Mission.

Process-oriented

Benchmarking

Model Intercomparisons



PLUMBER: Aims + results

PLUMBER PALS Land sUrface Model Benchmarking Evaluation pRoject (Protocol for the Analysis of Land Surface models)

Gauge whether LSMs are performing as well as they could, given the information they're provided with, and if not, identify practical avenues for model improvement.

- First phase of PLUMBER was a site-based MIP using out-of-sample empirical models as benchmarks to define LSM performance expectations
- Found that simple, out-of-sample empirical models could outperform LSMs: LSMs can perform much better than they currently do, given the amount of information they are provided with in meteorological forcing data
- LSMs were consistently outperformed by linear regressions against downward shortwave when predicting sensible heat flux
- *Participants:* Gab Abramowitz, Martin de Kauwe, Anna Ukkola, Martin Best, Martyn Clark, Sujay Kumar, Dave Lawrence, Grey Nearing and more...

PLUMBER: future

Future:

- PLUMBER2 launch likely April: flux tower data processing nearly complete (200-300 sites).
- PLUMBER2 protocol has received feedback from 10+ panel members, essentially ready.
- Increased focus on process representation: more model variables, input-state-flux pathway analysis, variable ratio analysis, budget analysis.
- Improved empirical models and information-theory based analyses.
- Synthetic forcing experiments to diagnose model behaviour.
- In discussion with Sujay Kumar for land DA within PLUMBER2 --active discussion on amongst several land DA leaders: Clara Draper (NOAA), Clément Albergel (M-F), Patricia De Rosnay (ECMWF).
- In discussion with Mat Lipson, Sue Grimmond, Martin Best for urban-PLUMBER in 2020.
- Include a hydrological component in the future (Martyn Clark).

Modevaluation.org (previously PALS): Aims

PALS Protocol for the Analysis of Land Surface models

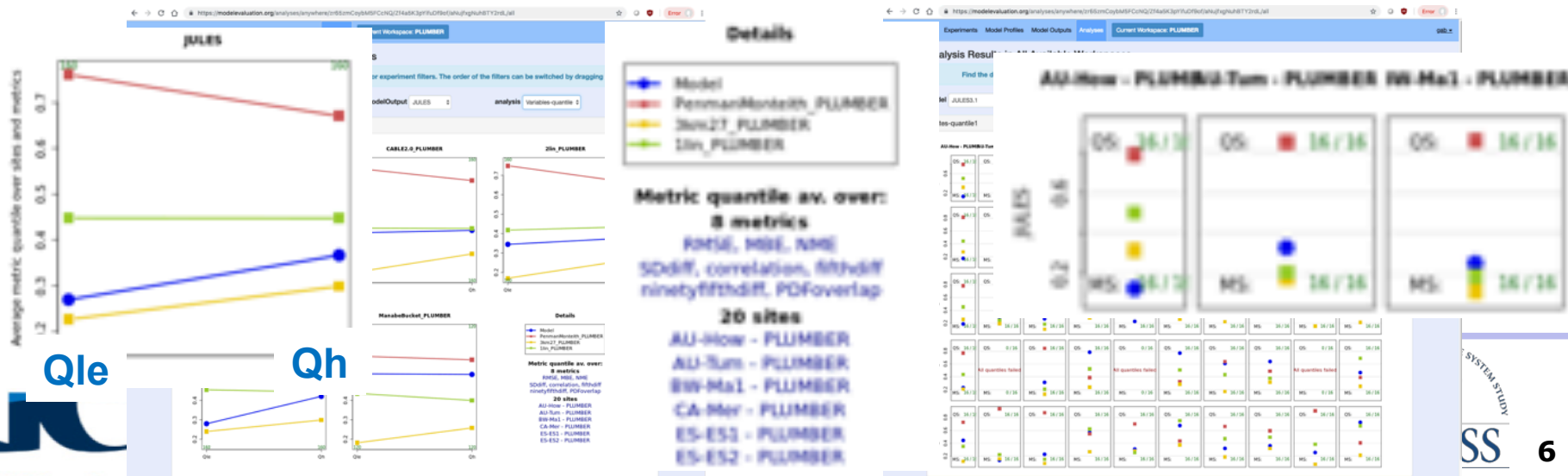
Provide a web-based testbed and workflow environment to aid standardisation of LSM evaluation, with a particular focus on a priori benchmarking



The screenshot shows the homepage of ModelEvaluation.org. The browser address bar displays "https://modevaluation.org". The navigation menu includes "Home", "Data Sets", "Experiments", "Model Profiles", "Model Outputs", "Analyses", and "Current Workspace: PLUMBER". The main content area features a "Welcome to ModelEvaluation.org" message, a brief description of the application, and a section titled "How does it work?". Below this, logos for funding and research coordination bodies are displayed: ABC Centre of Excellence for Climate Extremes, GEWEX, OzEWEX, NCI, and TERN. On the right side, there is a world map titled "[GABLE-D0L-D0] Lowest heat flux Time00" with a color scale ranging from -20 to 140. The map shows a global distribution of heat flux, with a color bar on the right. At the bottom of the page, there are links for "Software", "Terms and conditions of use", and "Contact".

Modevaluation.org (previously PALS): Aims

- Provide a suite of standard reference tests for the LSM community at a variety of spatial and temporal scales, and a variety of process representations
- Provide benchmarking capability to gauge how well LSMs are performing in these reference tests, beyond simply classifying some models as better than others.
- Provide a simple to use workflow environment to use both of the above, that allows simple comparability between results from different researchers and institutes internationally.
- The project is ongoing - no 'end date' equals success.
- Participants: Gab Abramowitz, Danny Eisenberg, Martin de Kauwe



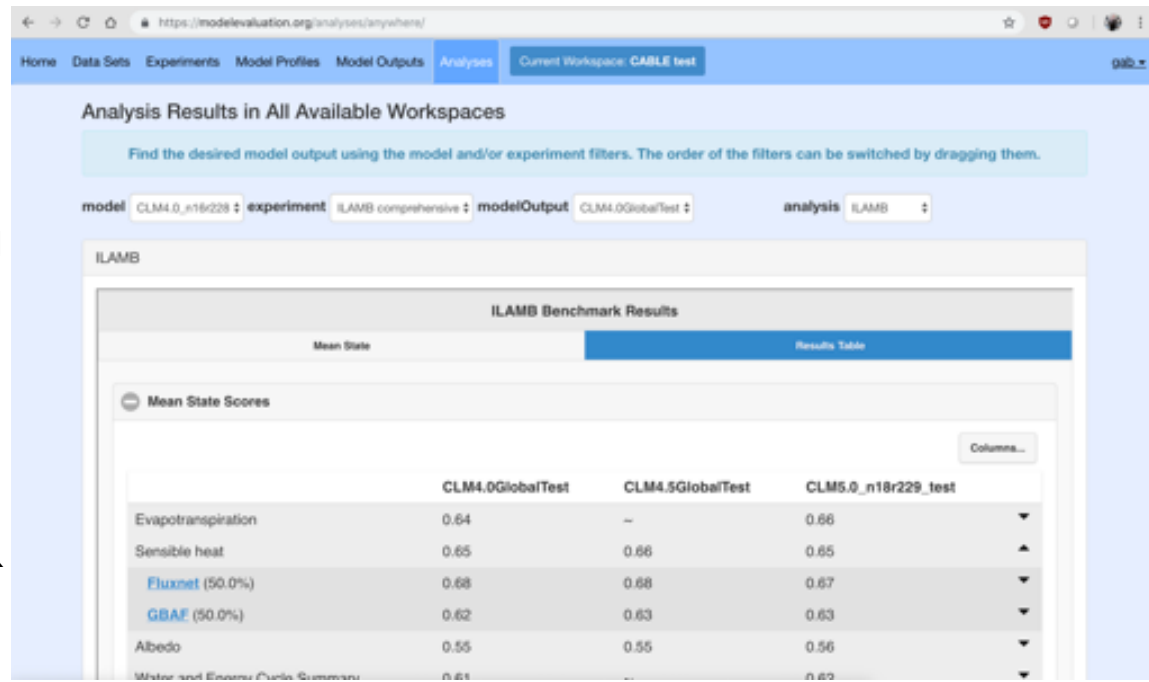
Modevaluation.org (previously PALS): results and future

Results

- Integrated ILAMB as analysis engine
- Basic (non-ILAMB) global + site-based analysis R package implemented
- Replicated PLUMBER in modevaluation.org
- Ready to host PLUMBER2 and urban-PLUMBER
- Reprocessing/QC of FLUXNET2015 + LaThuile + OzFlux data 90% complete – ready for PLUMBER2 March/April.

Future

- Release of reprocessed flux tower data
- Will host PLUMBER2 starting mid 2019 – all analyses in modevaluation.org
- Range of ease-of-use improvements
- Aim to host urban-PLUMBER 2020



SoilWat Project

SoilWat

GEWEX Soils and Water initiative

1. 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.
2. Participants: *Dani Or, Matthias Cuntz, Anne Verhoef, Harry Vereecken, Lutz Weihermuller, Lukas Gudmundsson, Peter Lehmann, Stefan Kollet, Simone Fatichi, Mehdi Rahmati* plus many others
3. Activities: review paper on "**Infiltration** for land surface modelling"; Surveying **hydraulic/thermal pedotransfer functions** used in land surface models; Discussion paper on **groundwater** in global hydrological/climate models; conducting a **global soil parameter MIP**; Assessing the effects of **soil structure on land surface fluxes**; Using SoilGrids to revise **global surface evaporation**
4. Outline of future work: Determination of **global thermal properties** from soil texture and mineralogy data; **New generation PTFs** to inject soil structure into soil hydraulic properties

SoilWat Project

$$L_G = L_C + \frac{L_C \cdot E_0}{K_{eff}} \rightarrow L_C = \frac{L_G}{1 + E_0/K_{eff}}$$

Or and Lehman, 2019: A novel, direct and simple method for estimating soil evaporation from soil properties considering regional rainfall characteristics and accounting for internal drainage dynamics (via Van Genuchten hydraulic parameters mainly).

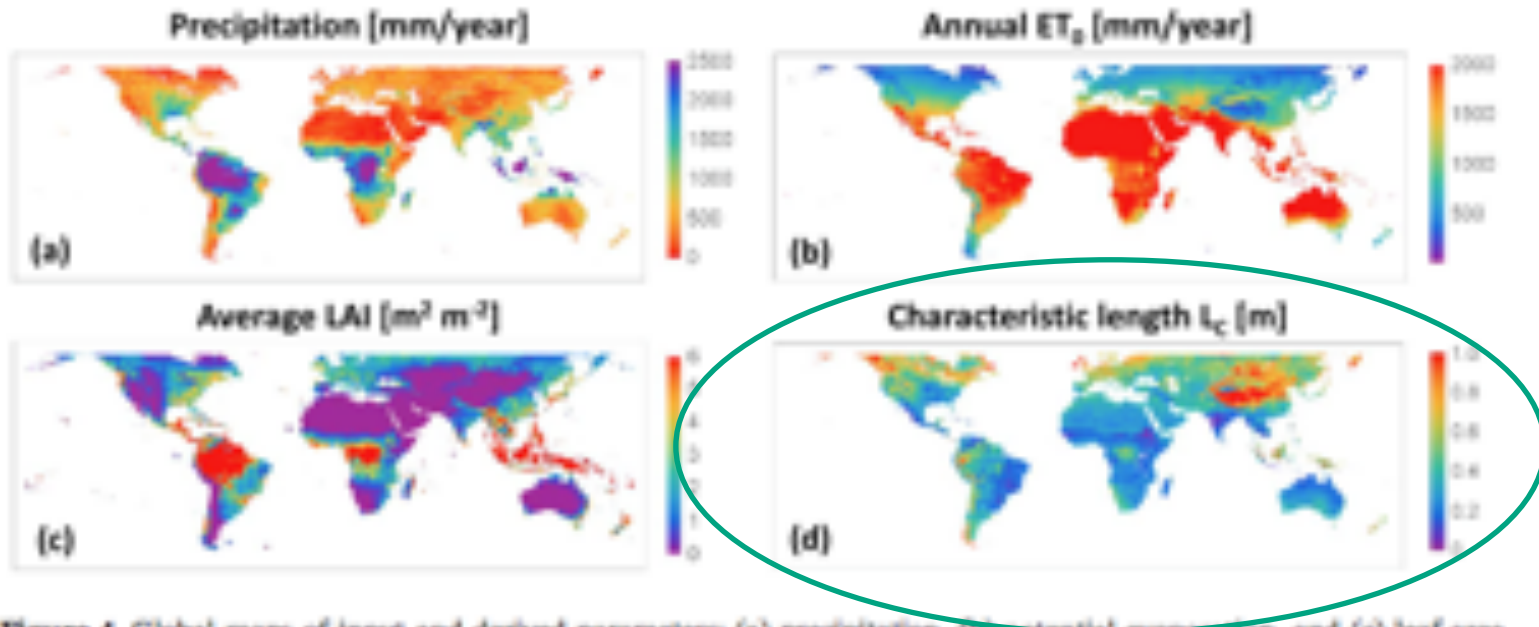


Figure 4. Global maps of input and derived parameters: (a) precipitation, (b) potential evaporation, and (c) leaf area index), required for determining surface evaporation at global scale with data obtained from publicly available databases (references are listed in text). The potential yearly evapotranspiration ET_0 (b) was computed using the approach of Jensen and Haise (1963; see evaluation in Appendix A and Lehmann et al., 2018). The evaporation characteristic length L_C (d) that defines the thickness of the soil evaporation capacitor was computed with equation (6).

International Land Model Benchmarking (ILAMB) project

ILAMB International Land Atmosphere Model Benchmarking activity

1. Science topics:
 - Develop internationally accepted benchmarks for land model performance
 - Promote use of ILAMB by international community for model intercomparison
 - Strengthen linkages among experimental, remote sensing, and climate modeling communities in the design of new model tests and new measurement programs
2. Leads: Dave Lawrence, Forrest Hoffman, Jim Randerson, Bill Riley
3. Activities
 - ILAMB documentation paper (Collier et al., 2018, JAMES), ILAMBv2.4 release
 - CLM Documentation paper (Lawrence et al, 2019, in review JAMES)
 - Now assessing 28 variables utilizing 70+ datasets
4. Outline of future work
 - Diurnal cycle metrics
 - Implement new GEWEX-sponsored datasets (DOLCE, WECANN)
 - Introduce methods to account for observational uncertainty
 - Runoff response metrics (response to T and/or P change)

GLASS: ILAMB



1. ILAMB assessment of CLM versions
2. Improvements for most variables despite increase in complexity
3. Assessment depends on forcing dataset (GSWP3 vs CRUNCEP)
4. ILAMB will be applied to CMIP5 and CMIP6 models

Lawrence et al, 2019, in review JAMES)

Land Use Model Intercomparison Project (LUMIP)

LUMIP

Land Use Model Intercomparison Project

1. Science questions:
 - What are the effects of LULCC on climate and biogeochemical cycling (past-future)?
 - What are the impacts of land management on surface fluxes of carbon, water, and energy and are there regional land-management strategies with promise to help mitigate against climate change?
2. Leads: Dave Lawrence and George Hurtt and LUMIP SSC
3. Activities
 - Development of updated/expanded historical and future land-use data
 - An experimental protocol for specific LUMIP experiments for CMIP6
 - Definition of metrics and diagnostic protocols that quantify model performance, and related sensitivities, with respect to LULCC.
4. Outline of future work
 - Simulations underway as part of CMIP6
 - 11 groups have registered interest in performing analyses

GLASS: Land Use harmonization (LUH2, LUMIP)

New History

- Hyde 4-based
- Landsat F/NF constraint
- Multiple crop types (5)
- Multiple pasture types (2)
- Updated forest cover/
biomass
- Updated wood harvest
- Updated shifting cultivation

0.25° resolution
850 to 2100 (8 SSPs)

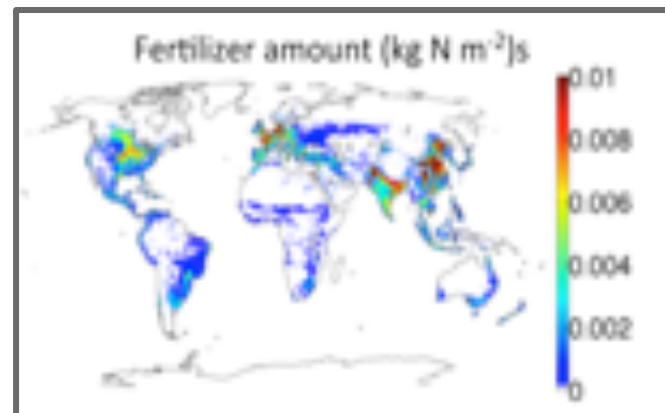
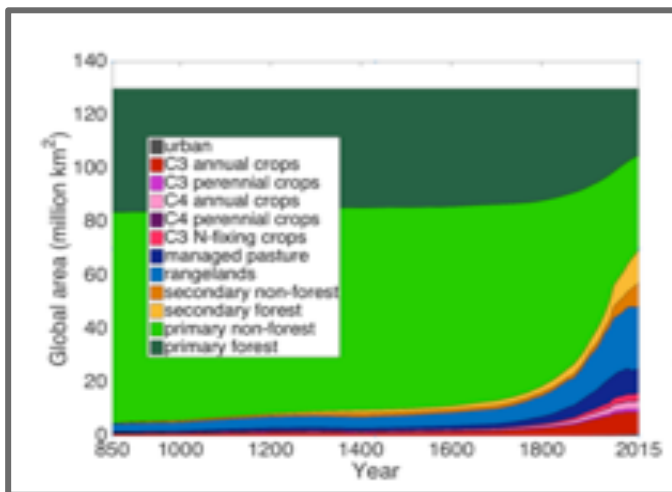
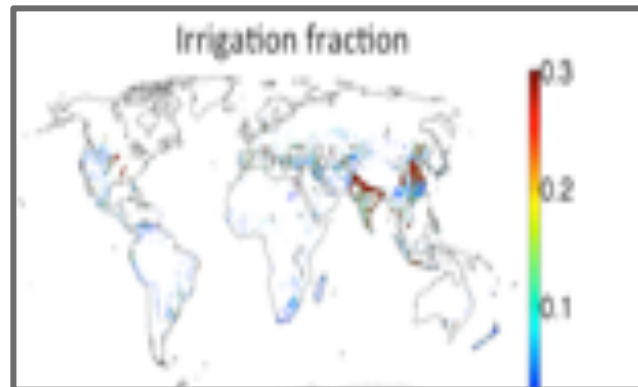
New Management Layers

Agriculture

- % cropland irrigated
- % cropland flooded
- % cropland fertilized (industrial)
- %cropland for biofuels
- Crop rotations

Wood Harvest

- % used for industrial products
- % used for commercial biofuels
- % used for fuelwood



LS3MIP & GSWP3: Science Questions

LS3MIP GSWP3

Land surface, snow, and soil moisture MIP (CMIP6)
Global Soil Wetness Project phase 3

1. How is the current state of land processes represented in CMIP DECK?
2. What is the role of snow and soil moisture feedbacks in the regional response to altered climate forcings?
3. How do large land surface processes contribute to systematic Earth System model biases and the current and future predictability?
4. Estimate multi-model long-term terrestrial energy/water/carbon cycles

LS3MIP & GSWP3: Activity & Current Status

Communication

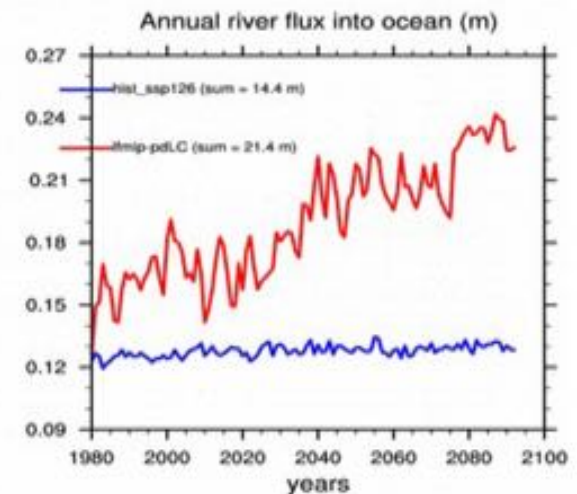
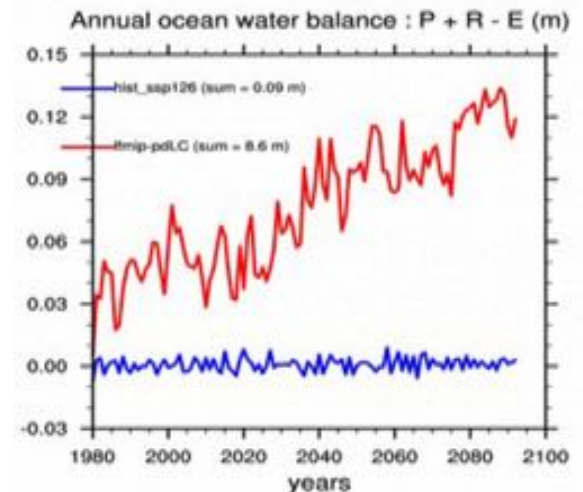
- Merging information into the knowledgebase (LS3MIP wiki@ <https://wiki.c2sm.ethz.ch/LS3MIP>)
- “First result” meeting in the fall 2018 (LandMIP meeting @ Toulouse / 08-12 Oct.)

Off-line forcing data

- GSWP3 forcing data to be extended & Quality issue (e.g., strong Prcp trend in early 20th C) (v1.05 available up to 2014; some defects resolved)
- No specific information on aerosol forcing including nitrogen deposition (should be taken from the generic CMIP6 forcing data repository)

Experiment setup

- Generation of Imip-future forcing (additive & multiplication approach was proposed)
 - Tier 2 simulations of offline runs can wait until mid 2018
 - Issue raised how to treat snow melt in case of nudging the snow component of the land surface
 - **lfmip-pdLC**: LS3MIP 1980-2092 simulation following the ssp126 scenario, with present-day climatology of snow and Soil Moisture
 - **hist_esp126**: Reference simulation for 2015-2100
- * Preliminary results courtesy of CNRM



GSWP3 & LS3MIP: Activity & Current Status

Spatial resolution of submitted offline model results

- Need to converge generate offline model outputs at the native GCM grid.
- Each modeling group is responsible to convert 0.5 degree forcing to their native grids
- Specific participation in GSWP3 requires model groups to submit outputs in 0.5 degree

Data request

- Some ambiguities, unclear definitions and duplicated variables
- Need to reprioritize (select) variables for frozen ground

Commitment to LS3MIP

- Reconfirmed their commitment to LS3MIP
(CAS, CanEnv, CMCC, CCSM, IPSL, MPI, MIROC, MeteoFr, HadCM)
- Can not guarantee but will do so when possible
(CSIRO, EC-Earth)

Status of Experiments

- Offline simulations with GSWP3 have been performed
(CCSM, MeteoFr, IPSL, MPI, HadCM, MIROC)
- IPSL and EC-Earth have done experimentation with various flavors of the soil nudging

Proposed analyses by individual groups

- CCSM will focus on land use change and its effects on land-atmosphere interactions
- EC-Earth wants to run LS3MIP with and without land use change
- CMCC and MeteoFrance are interested in the predictability experiment (LPMIP)

GSWP3 & LS3MIP: Forcing Data Updates

Version 0.5b @ 2014-06-22

- First best release

Version 0.7b @ 2014-10-15 /* distributed to ISMIP community & ORCHIDEE*/

- packaged following ALMA/netCDF convention

Version 0.8b @ 2017-05-12

- correct wind using CRU-CL2.0

Version 0.9b @ 2017-05-13

- correct bias of reference Prcp (GPCC v7) in early 20th Century
- reproduce Rainf/Snowf corresponding to updated wind speed

Version 1.0 @ 2017-06-01 /* distributed to CMIP community and others */

- official release of version 1

Version 1.05

- Extended up to 2014
- Wind fields have values over ocean pixels
- DOI issued (doi:10.20783/DIAS.501)

Version 1.06

- Change variable naming convention: amip_name [wss] -> [sfcWind]

Version 1.08

- Despiked air temperature

Version 1.09

- Reprocess specific humidity
- Release for LS3MIP land_hist experiment

LoCo Working Group

LoCo Local (land-atmosphere) Coupling

1. LoCo WG 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.

2. Goals (last 1-2 years)

- 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 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 temperature and humidity and beyond that of 1-D column assumptions.

Membership:

Joe Santanello (lead)
Alexis Berg
Paul Dirmeyer
Michael Ek
Craig Ferguson
Kirsten Findell
Trent Ford
Pierre Gentine
Benoit Guillod
Patricia Lawston
Benjamin Lintner
Joshua Roundy
Ahmed Tawfik (emeritus)
Merja Tölle
Chiel van Heerwaarden
Volker Wulfmeyer
Yunyan Zhang
Ian Williams

LoCo Working Group

3. Principal Achievements

- Published a **LoCo overview article in BAMS** (July 2018), after a decade+ of work in developing a process-level paradigm and suite of metrics for integrative analysis (*currently #4 most accessed AMS article over last 12 months*).

LAND-ATMOSPHERE INTERACTIONS

The LoCo Perspective

JOSEPH A. SANTANELLO JR., PAUL A. DIRMEYER, CRAIG R. FERGUSON,
KIRSTEN L. FINDELL, AHMED B. TAWFIK, ALEXIS BERG, MICHAEL EK, PIERRE GENTINE,
BENOIT P. GUILLOD, CHIEL VAN HEERWAARDEN, JOSHUA ROUNDY, AND VOLKER WULFMEYER

4th most-read on
BAMS website

Metrics derived by the LoCo working group have matured and begun to enter the mainstream, signaling the success of the GEWEX approach to foster grassroots participation.

LoCo Working Group

3. Principal Achievements (continued)

- PBL observations were cited as a most important measurement in the 2017 **NAS Decadal Survey**. The LoCo WG submitted white papers to the DS and galvanized the community as to the importance of PBL measurements, which will result in significant funding opportunities for PBL instrument development and modeling (OSSE and impact studies on NWP and climate models) over the next decade.
- Outreach and collaborations to address the goal of entraining the operational centers into the LoCo paradigm and to promote LoCo metrics for integrative analysis. This included the **US Climate Modeling Summit** (April 2018) which led to the **NOAA CPT solicitation**, as well as the **NASA Energy and Water Cycle Study** (NEWS) solicitation focused on obs-driven LoCo metric application.

4. Near-term Plans

- Continue to coordinate field campaign and LoCo-based analysis activities from recent and planned campaigns such as LAFE, GRAINEX, and LIAISE.
- Engage operational centers via CPT and NEWS, as well as DTC Testbed collaborations.
- Influence PBL mission development via Decadal Survey opportunities (ROSES).
- Explore coordinated expansion of LoCo scope via collaborative proposals and experiment

GLASS Cross-cuts/Connections: GASS

Older continuing projects

- DICE-1 Southern Great Plains case (GABLS follow-on): Mid-latitude diurnal cycle. Intercomparison completed: *to be written up*.
- GABLS4 ("DICE-over-ice"): *Diurnal* cycle of PBL over in Antarctica. Workshop to discuss final results in September. Papers being drafted on (1) intercomparison of surface schemes, (2) SCM, and (3) LES results. Papers on GABLS4 are still on progress. Led by Météo France.
- *Extend the concept to new efforts with many more data sets.*
- For example, SUBLIME, an "Urban DICE".

New GASS Projects initiated after 2nd Pan-GASS Meeting

- COORDE: Understanding orographic drag. 9 participants. Low resolution simulations completed.
- DEMISTIFY: LES & NWP study of fog. 12 participants. Stage 1 in progress. Stage 2 will include the land surface.
- Other projects on diurnal convection and land/snow initialization being initiated.

-John Edwards

GLASS Cross-cuts/Connections: GHP

- GHP:** land-atmosphere data sets from RHPs for process studies, e.g.:
- > Hydrological Cycle in the Mediterranean Experiment (HyMeX).
 - > Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE) (Iberian Peninsula), including human effects.
 - > Crosscut on Water Management in Models, LSM incorporate reservoir, groundwater, irrigation, basin transfer.
 - > HyMEX LIAISE campaign (2020), strong observational dataset on which a future Ebro Basin LSM MIP.
 - > Crosscut on Determining Evapotranspiration. Workshop in Sydney Oct 2019. Related: potential DICE-2 activity focus on vegetation stress response during dry down. *Anne Verhoef is one of the writing team of a "position-document" with Joan Cuxart, Toby Marthews and Jason Evans that will soon appear in the GEWEX News.*
 - > Observational campaigns w/irrigation focus, e.g. Pannonian Basin (PannEX) RHP, U.S. Great Plains Irrigation Experiment, GRAINEX, other RHPs.
 - > *Follow-on to ALMIP2? –No concrete plans at this time. -Craig Ferguson*

GLASS Cross-cuts/Connections: Other Projects

Monsoons (interactions with CLIVAR): joint initiative of GEWEX & CLIVAR

-> Importance of land-atmosphere interactions within monsoons. *Update from Françoise Guichard during SSG-31.*

Seasonal to Sub-seasonal (S2S): joint initiative of WWRP and WCRP

-> Potential contribution of land to predictability on the S2S timescales. *Update via Paul Dirmeyer's slides at the end here,*

ILEAPS: biogeochemical cycles, land-atmosphere chemistry. *Update from Eleanor Blyth during SSG-31.*

Cold Season Processes: GHP, ILEAPS, CliC, ILEAPS focus on snow, frozen soils/permafrost, tundra, e.g. Saskatchewan/Mackenzie river basins? *We would still like to do this. Actions?*

WMAC: Promoting model development and coordination across WCRP. *Higher-level connections across WCRP, and with WWRP via WGNE. Action items?*

WGNE: Generally interested in NWP time scales, but Ops Met Centers moving into extended-range/S2S timescales, hence more connections among earth system components (e.g. ocean, sea-ice). Quite interested in (land) data assimilation & process-level improvement to model parameterizations. *GLASS examples: PALS/PLUMBER with a new land DA component, future: hydrology, water mgmt, urban; land-atmos. interaction via LoCo, DICE.*

WMO: Other working groups, e.g. WWRP Year of Polar Prediction (YOPP) project. *No concrete actions; perhaps related to Cold Season Processes.*

Int'l S2S Prediction Project (P. Dirmeyer - liaison)

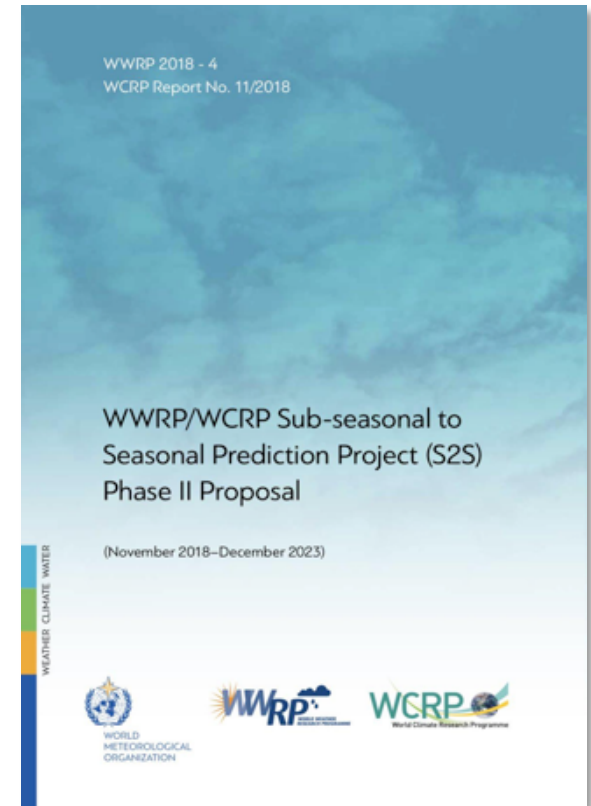
Proposal for a 5-year "Phase II" was approved by WMO.

Expanded research activities include a new focus on land initialization and L-A feedback:

1. What is the impact of the **observing system** on **land initialization** and **S2S forecasts**?
2. How well are the **coupled land/atmosphere processes represented** in S2S models?
3. How might **anomalies in land** surface states **contribute to extremes**?

Clear relevance to GLASS, GASS, GDAP.

Otherwise, more emphasis on data consistency between models, completeness, user applications.



Subseasonal to Seasonal (S2S) Prediction

US has been the world leader in S2S research support, mainly through NOAA, but also NASA, NSF, DoD.

NOAA has moved its S2S program from the Climate Project Office (CPO) to the Oceanic & Atmospheric Research (OAR) Division's Office of Water and Air Quality (OWAQ) and **reduced funding**.

Emphasis in current funding opportunity is on data assimilation, model development (especially UFS), and ensemble generation. Skewing more towards operations, NWP, NWS interests. Unclear what this will mean in the long term.

