GEWEX
Global Land/Atmosphere System Study (GLASS)

Michael Ek (NCEP/EMC)
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GLASS panel members and other GEWEX collaborators

GEWEX Scientific Steering Group meeting (SSG-29)
Sanya, Hainan Province, China, 6-10 February 2017

Complexity of land-atmosphere Interactions

GEWEX Imperatives

GEWEX Plans for 2013 and Beyond:

Diagnostics of stand-alone model components are more straight-forward, but there has been difficulty to establish metrics for coupled systems (e.g., land-atmos.) to quantify strength of the interactions.

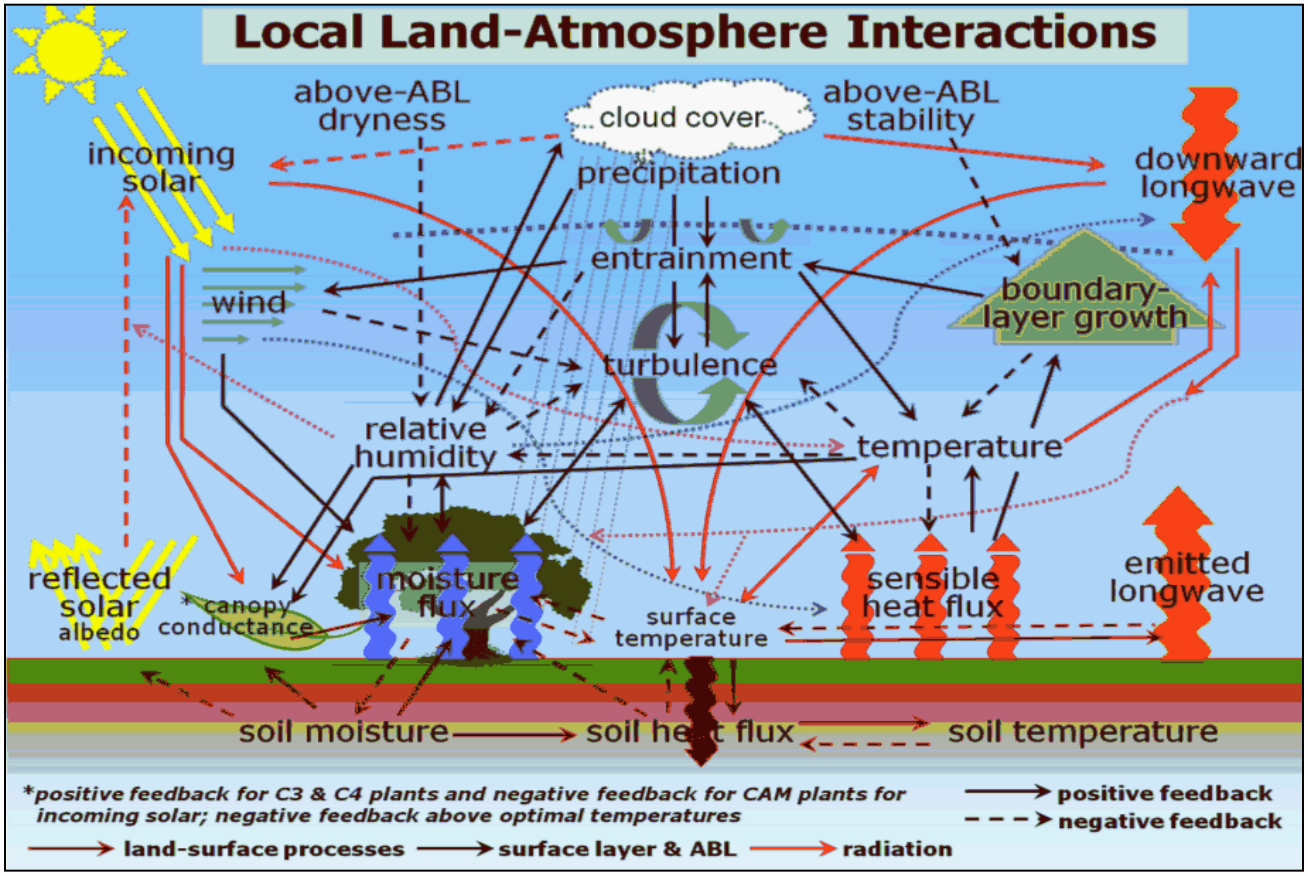


Fig. 3.1. Schematic of the complex interactions between the land surface, atmospheric boundary layer (ABL), and radiation via many variables (temperature, relative humidity, wind and associated turbulence, cloud cover, etc). Adapted from Ek and Holtslag (2004 J. Hydromet., 5, 86-99), courtesy Mike Ek & Kevin Trenberth.

GLASS Vision and Mission

The GEWEX Vision

Water and energy are fundamental for life on Earth. Fresh water is a major pressure point for society owing to increasing demand and vagaries of climate. Extremes of droughts, heat waves and wild fires, as well as floods, heavy rains, and intense storms increasingly threaten to cause havoc as the climate changes. Other challenges exist on how clouds and aerosols affect energy and climate. Better observations and analysis of these phenomena, and improving our ability to model and predict them, will contribute to increasing information needed by society and decision makers for future planning.

GLASS role: Better representation of the Earth System by understanding the role of land.

The GEWEX Mission

To measure and predict global and regional energy and water variations, trends, and extremes, such as heat waves, floods, and droughts, through improved observations and modeling of land, atmosphere, and their interaction, thereby providing the scientific underpinnings of climate services.

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

GLASS Structure

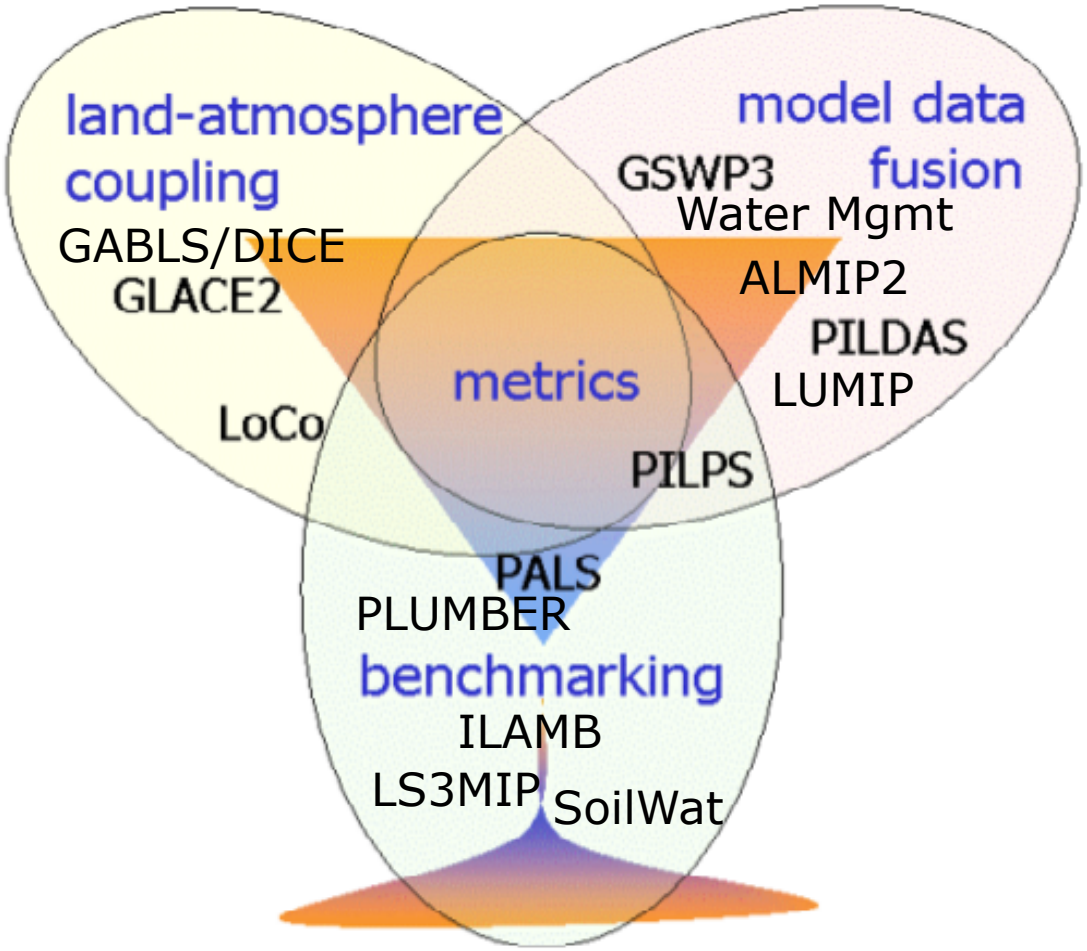
The aim of GLASS is to promote community activities that improve:

1. our best estimates and the model representation of state variables

2. our understanding of land/ atmosphere feedbacks

3. our understanding of the role of land surface in predictability

To best achieve these aims, GLASS has been re-structured into three elements:



GLASS Projects

BENCHMARKING:

PALS Protocol for the Analysis of Land Surface models

PLUMBER PALS Land sUrface Model Benchmarking Evaluation pRoject

ILAMB International Land Atmosphere Model Benchmarking activity

GSWP3 Global Soil Wetness Project phase 3

LS3MIP Land surface, snow, and soil moisture MIP (CMIP6)

SoilWat GEWEX Soils and Water initiative

LAND-ATMOSPHERE INTERACTION:

LoCo Local (land-atmosphere) Coupling

GABLS/DICE DIurnal land/atmosphere Coupling Experiment, including GEWEX Atmospheric Boundary Layer Study GABLS4/DICE-over-ICE (Dome C, Antarctica) –separate GABLS presentation

MODEL DATA FUSION:

LUMIP Land Use Model Intercomparison Project

PILDAS Project for the Intercomparison of Land Data Assimilation Systems

ALMIP2 AMMA Land surface Model Intercomparison Project phase 2

Human Dimensions/Water Management Anthropogenic Influences on/Water Management of Global Water Cycle

GLASS Projects: Cross-cuts

Cross-Cutting projects/actions:

PALS, PLUMBER – Land model benchmarking, future planned links to GSWP3 / LMIP
ALMIP2 – West Africa monsoon region, links to GHP
GSWP3 – Offline 20C runs, Links to carbon community (iLeaps), LMIP (CMIP6)
LS3MIP – land surface adding to predictability (like GLACE-CMIP5)
DICE – Land-atmosphere interaction, links to GABLS, including GABLS4
"*DICE-over-ICE*" – land-atmosphere interaction (stable BL-Antarctica), links to GASS
LUMIP – Land use/change, links to iLeaps, hertiage of LUCID?

Recently launched or to be launched:

PILDAS – Land data assimilation in NWP systems : links to WGNE
LoCo – SGP testbed, assessment of land-atmosphere coupling diagnostics.
Water Management in Models –Anthropogenic influences : Irrigation, dams, reservoirs, groundwater...) links with GHP
SoilWat - datasets, improved soil process representation (interactions with atmosphere?) potential links with GDAP, GHP

GLASS achievements 2016 – benchmarking coordination

- The PLUMBER benchmarking MIP from 2015 continued into 2016 with new publications and activities
- PALS is nearing release of a new generation online benchmarking system
  - Likely to facilitate a 'PLUMBER2'; Urban LSM MIP?
- ILAMB had considerable uptake and buy-in within the land community in 2016
- Work is ongoing to bring PALS and ILAMB (and potentially LVT) together

GLASS achievements 2016 – LS3MIP

- Cemented formally as a CMIP6 MIP
- LMIP proceeding well due to overlap with GSWP3
- Detailed protocol and motivation paper published

Geosci. Model Dev., 9, 2809–2832, 2016
www.geosci-model-dev.net/9/2809/2016/
doi:10.5194/gmd-9-2809-2016

Geoscientific Model Development
Open Access
EGU

LS3MIP (v1.0) contribution to CMIP6: the Land Surface, Snow and Soil moisture Model Intercomparison Project – aims, setup and expected outcome

Bart van den Hurk[1], Hyungjun Kim[2], Gerhard Krinner[3], Sonia I. Seneviratne[4], Chris Derksen[5], Taikan Oki[2], Hervé Douville[6], Jeanne Colin[6], Agnès Ducharne[24], Frederique Cheruy[7], Nicholas Viovy[8], Michael J. Puma[9], Yoshihide Wada[10], Weiping Li[11], Binghao Jia[12], Andrea Alessandri[13], Dave M. Lawrence[14], Graham P. Weedon[15], Richard Ellis[16], Stefan Hagemann[17], Jiafu Mao[18], Mark G. Flanner[19], Matteo Zampieri[20], Stefano Materia[20], Rachel M. Law[21], and Justin Sheffield[22,23]

[1]KNMI, De Bilt, the Netherlands
[2]Institute of Industrial Science, the University of Tokyo, Tokyo, Japan
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GLASS achievements 2016 - LoCo

1. The results of offline projects such as PILPS and GSWP are limited by the lack of atmospheric feedback, and GLACE cannot isolate and evaluate the processes implied in the coupling that lead to model development.
2. To accurately represent the relationship between soil moisture (SM), surface fluxes, PBL development and precipitation (P), and coupling strength in models, it is necessary to carefully examine and quantify the full series of interactions and feedbacks (i.e., links in the chain) at the process-level, including the planetary boundary layer (PBL) feedback.
3. To this end, the LoCo initiative and WG was established nearly a decade ago to focus on development of quantitative process-based metrics/ diagnostics of L-A coupling that could be applied equally to observations and models across scales.

4. LoCo has galvanized the land-atmosphere observing and modeling community in terms of new observations/field programs, establishing new useful "coupling" metrics, and engaging and training a number of young scientists, and putting them in positions of leadership is this effort.

GLASS achievements 2016 - LoCo

- The LoCo effort just reached the 10-year mark, and held a dedicated session at the 2016 GLASS panel meeting devoted to the status and future plans of LoCo and the LoCo WG.
- There are many studies and publications from the WG in recent years focused on various metrics, models, and applications (see GEWEX-LoCo website and presentations from the meeting).
- Nice synthesis from Paul Dirmeyer can be found here: http://cola.gmu.edu/dirmeyer/Coupling_metrics.html
- LoCo coupling metrics toolkit from Ahmed Tawfik can be found here: http://www.coupling-metrics.com/
- Observations of L-A processes and the need for assessment/ improvement has been a recent point of emphasis of the LoCo WG, with focused field campaigns/insitu observations, and even observations from space.

GLASS Issues, Bottlenecks and Discussion Items What to do?

Physical processes: Further study on cold season/high latitude processes, Groundwater, (Distributed) Hydrology, Anthropogenic processes/Water Management, Semi-arid processes, High resolution/ scale dependencies (~10^2m/LSM "grey zone")?

Focus be on specific events/phenomena such as drought (via seasonal and interannual) prediction as well. How to prioritize?

Models "broadening" (e.g. water/energy, carbon/BGC, human dimenstions) and disciplines colliding to answer larger questions. How to enhance cooperation? How to balance adding further complexity to our models (both NWP and climate) in order to better represent the Earth System, with what's practical (in terms of compute resources, observable/measurable quantities and parameters).

From 2016 SSG-28: Transition Period for GEWEX/WCRP: How should GLASS follow?

GLASS Issues, Bottlenecks and Discussion Items
Collaborations and Communication with Partners

Interaction with other GEWEX panels and other external groups. GABLS/DICE a good example. Further DICE studies?

How to strengthen GASS activities with relevance to GLASS (and vice versa)? Radiation?

Stronger collaborations with GDAP and use of satellite data sets could benefit GLASS benchmarking projects.

GHP has been strengthened via the recent (October 2016) joint GHP-GLASS workshop on water management, and joint sessions at GLASS and GHP meetings.

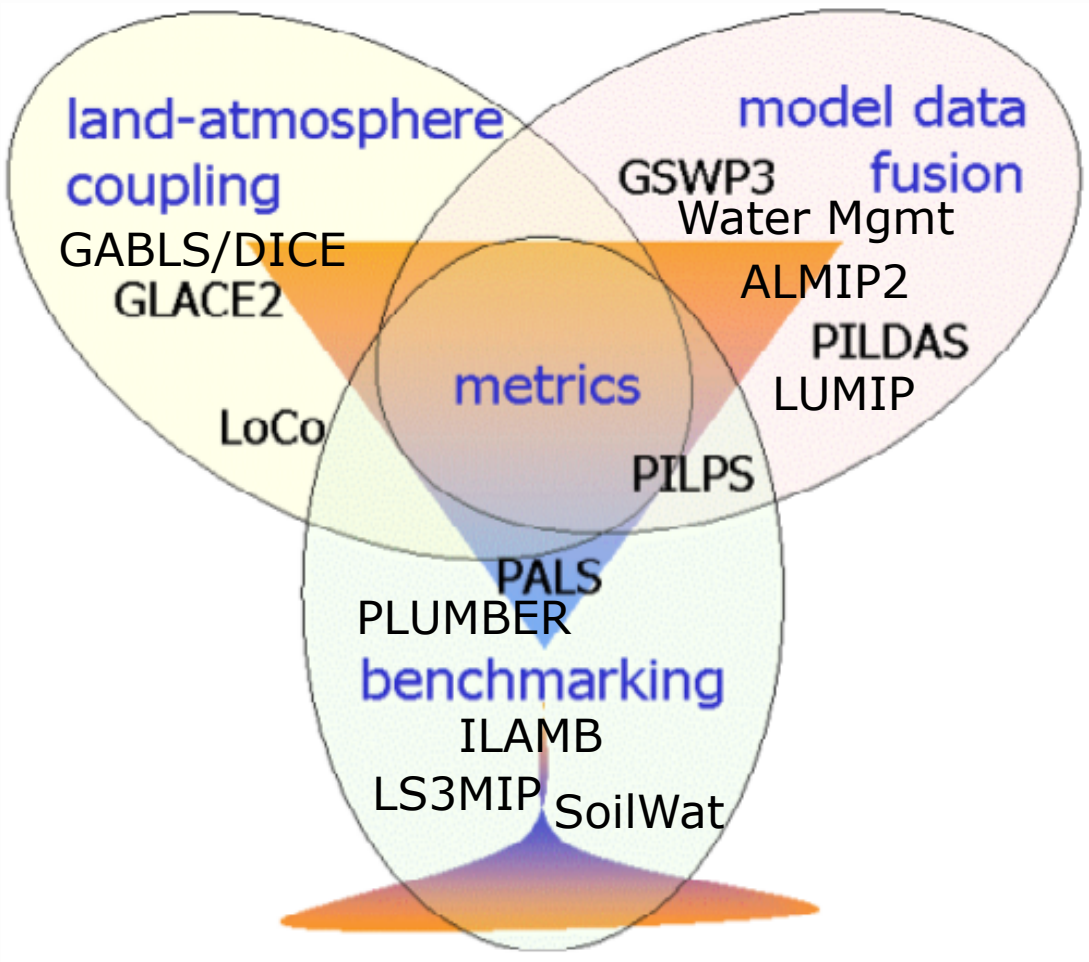
Strengthen interaction with other WCRP groups, e.g. CliC (cryosphere/cold season processes).

Strengthen interaction with "outside" groups, e.g. ILEAPS (BGC cycles, land-atmosphere chemistry). Mutual interest in land.

Status of RHP in US.? Partner with GHP, others.

Pan-GLASS meeting in 2020? Include joint sessions with relevance to GASS, GHP, GDAP, others.

GLASS Projects – Benchmarking



Scoring system:

PALS – orange

PLUMBER – green

ILAMB – green

GSWP3 – orange

LS3MIP – green

SoilWat – green

Protocol for analysis of Land Surface models (PALS)

- A web application for automated evaluation and benchmarking of LSMs. PALS hosts Experiments:
  - Data sets required to drive/force and evaluate a model for an experiment
  - Users run their models locally upload their model simulations for an experiment (including ancillary files)
  - PALS automatically runs analysis of the model output, comparing with evaluation data products, other models and empirical benchmarks
- First generation PALS site had around 250 users from 60+ institutions:
  - Used both for MIPs (e.g. PLUMBER, SavannaMIP) and model development
  - Currently offline, with second generation in testing & dev

PALS: Participants/Institutes/Contributions

1. Strong initial uptake, users at: UKMO, NASA, NOAA, NCAR, ECMWF, ORNL, CSIRO, BureauMet, USGS, COLA, Yale, Imperial, UExter, Ureading, BostonU, UColorado, UWashington, ColumbiaU, UArizona, UMaryland, Stony Brook, UOklahoma, ANU, MonashU, UNSW, 40+ others, 20+ countries

2. Development, however, has been very slow: only 1 part time developer, sporadic funding (all at UNSW Australia), not managed to get external collaborators yet.

3. Second generation PALS system ('modelevaluation.org') not specific to LSMs, much more flexible, partly to attract new funding possibilities (e.g. discussing linkage with NSW state govt - air quality modelling)

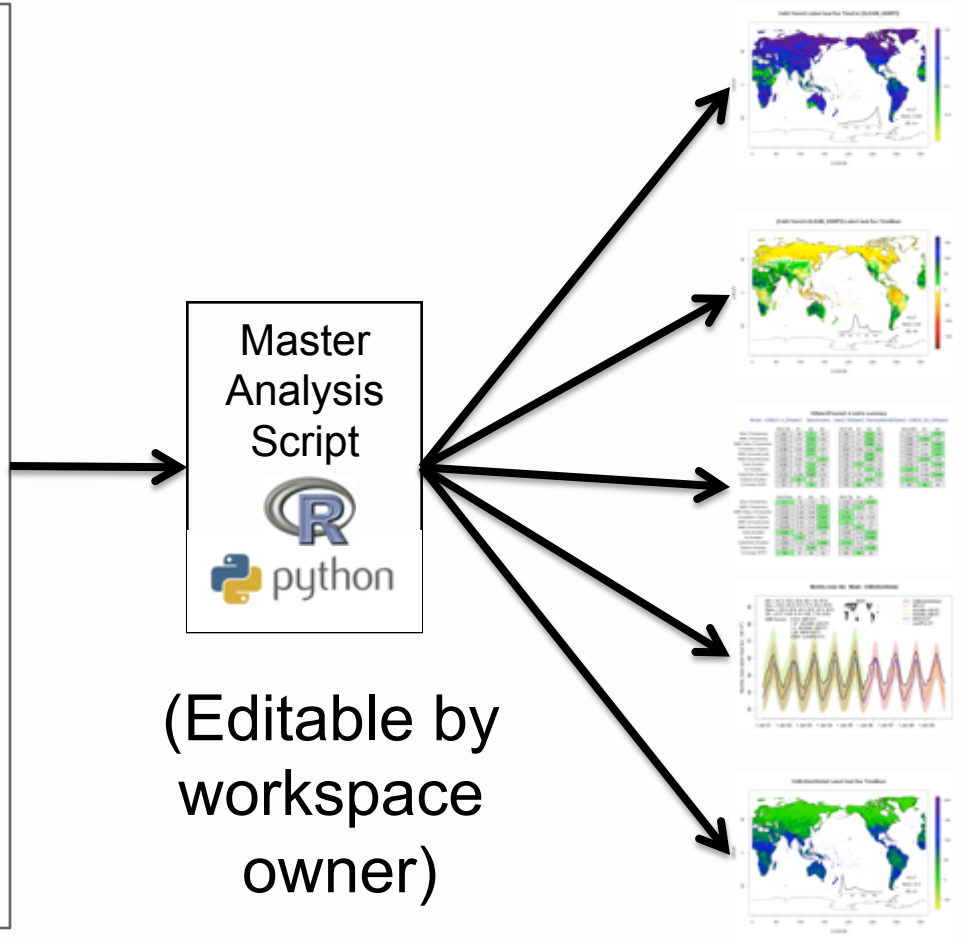
4. Any thoughts on possible resolutions welcome…

In development – what's new in PALS phase 2

Analysis not specific to particular package / language (e.g. R, Python, NCL, Matlab, Fortran etc all possible) – ILAMB, LVT, PALS

Information sent to the Analysis Script when a Model Output is uploaded to a given Experiment (including paths, meta-data):

- All **Data Sets** associated with the Experiment
- All **Model Outputs** that have been uploaded to the Experiment (within current Workspace)
- Model Output that is being uploaded and is triggering the analysis
- User's nominated **Benchmarks** associated with this Model Output

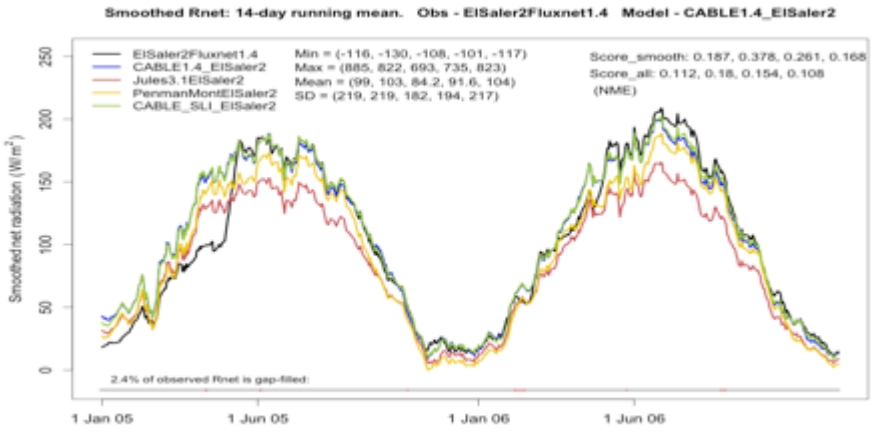


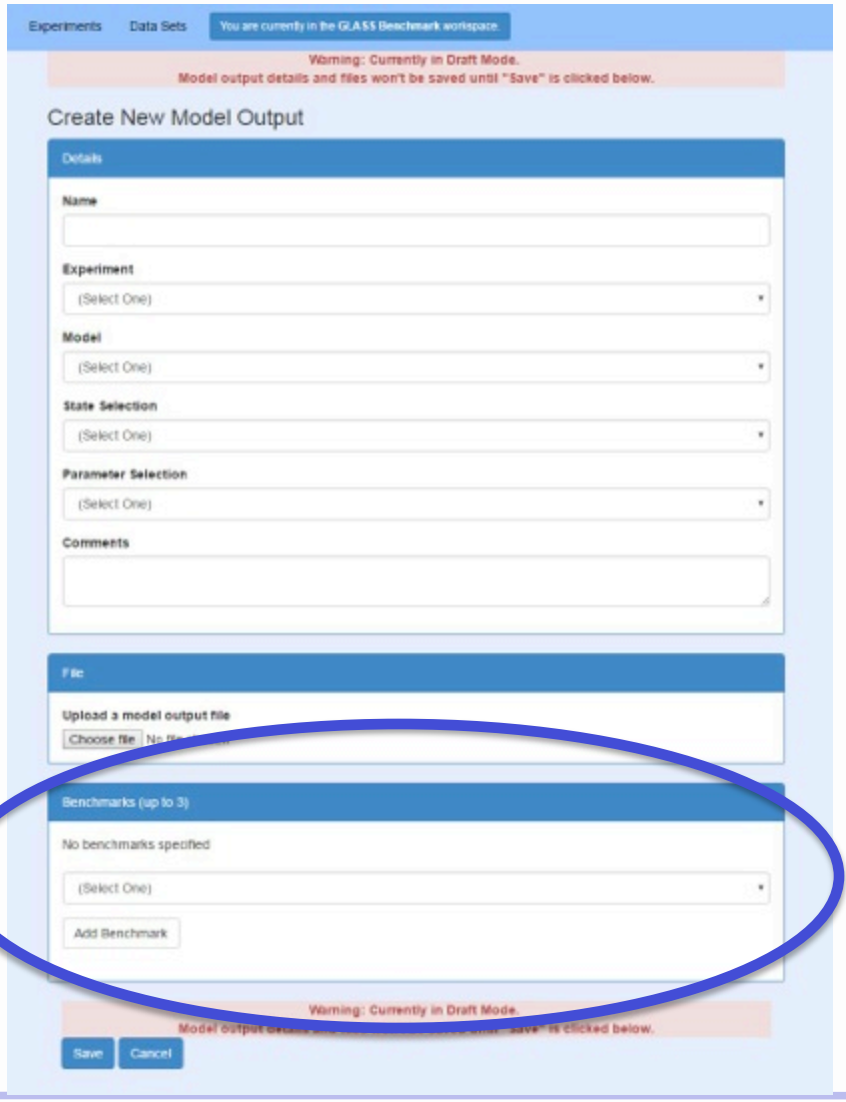
In development – what's new in PALS phase 2

Benchmarks

Now defined by the user – choice of up to 3 model outputs that has already been submitted to an Experiment:

- Previous model versions
- Other LSMs you're jealous of
- Empirical benchmarks as before (but are now created and submitted manually)





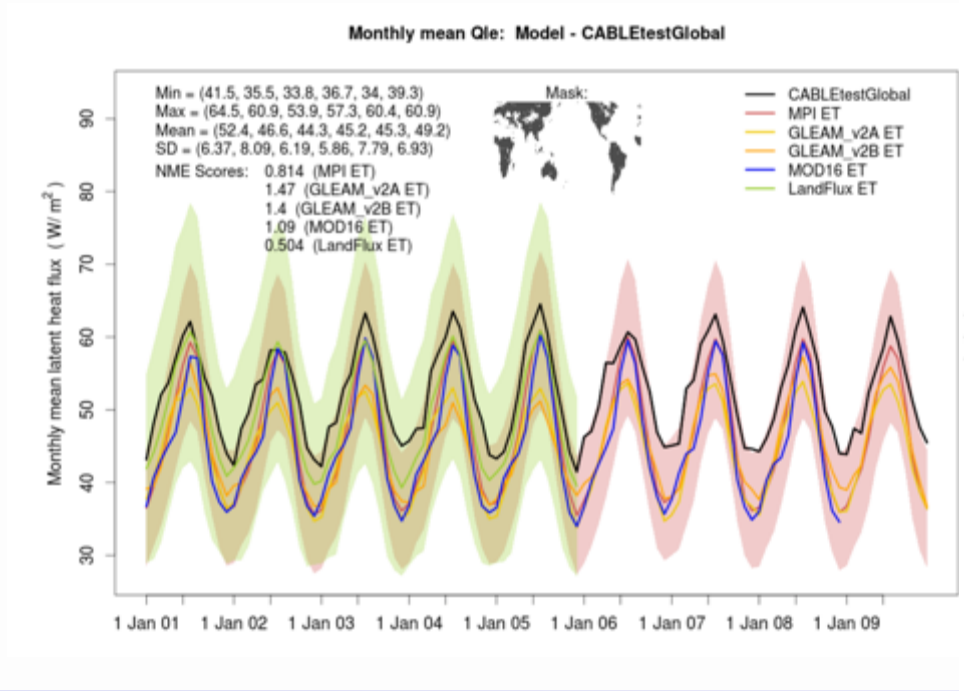
In development – what's new in PALS phase 2

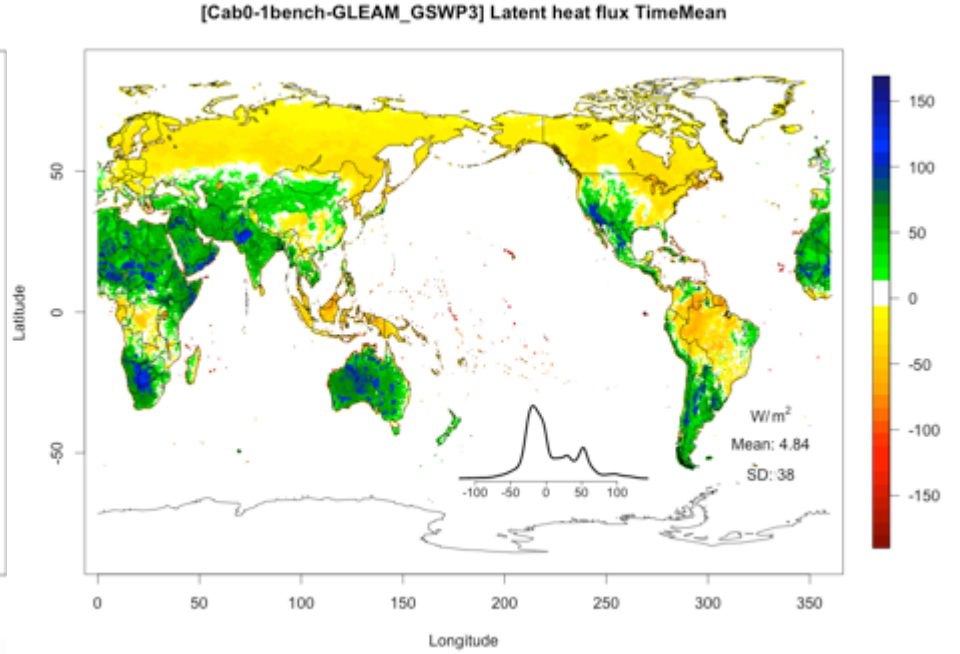
- Distributed architecture aims to allow analysis to be co-located with big model outputs:
  - 'Worker' nodes (e.g. R / Python analysis servers) can be installed on VMs across multiple locations, co-located with large data sets
  - 'Upload' of files to the system simply stores path: (a) if local worker node is present, files are not copied (b) local worker not present, files are uploaded

- Attempt to be increasingly strict about enforcement of provenance and ancillary data collection
  - Aid reproducibility
  - Capture what caused performance history throughout model development
  - Utilise ancillary / meta-data as part of automated analyses in MIPs

PALS: Outline of Future Work

- Simply to get this system up, functioning, and adopted by the community as a community owned project. MIPS will follow.
  - All source code is on GitHub
  - Working with ORNL to get ILAMB in as alternative analysis engine (two day visit in December 2016)





The PALS Land sUrface Model Benchmarking Evaluation pRoject (PLUMBER)

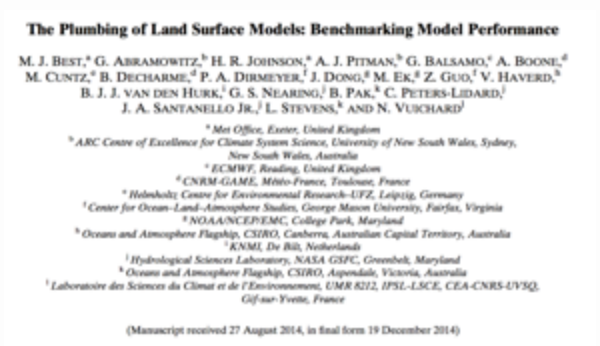
- MIP that compared LSMs to benchmarks – i.e. defined performance expectations *a priori*, before simulations are submitted
- Two 1st generation LSMs and 3 empirical models constitute the 'benchmarks'
- 15 LSMs, 20 flux tower sites across 9 IGBP vegetation types / 5 continents, sensible and latent heat flux, 8 metrics.
- Empirical models were only used out-of-sample – they were not compared to LSMs at sites that are used to train them.
- While LSMs perform markedly better than 1st generation LSMs, they perform poorly against empirical models, especially for sensible heat flux

PLUMBER: Participants/Institutes/Contributions

1. 15 different LSM variants participated, including from UKMO, ECMWF, CNRM, LSCE, NOAA, NASA, COLA, CSIRO.

2. Two papers in JHM (2015, 2016) on PLUMBER work, each with 20+ coauthors, lead by Martin Best (UKMO) and Ned Haughton (UNSW) – first has 39 cites so far (G Scholar)…

3. Other work (e.g. Ukkola et al, 2016, ERL) using PLUMBER data continues...



The Plumbing of Land Surface Models: Benchmarking Model Performance

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(Manuscript received 27 August 2014, in final form 19 December 2014)

The Plumbing of Land Surface Models: Is Poor Performance a Result of Methodology or Data Quality?

Ned Haughton,[a] Gab Abramowitz,[a] Andy J. Pitman,[a] Dani Or,[b] Martin J. Best,[c] Helen R. Johnson,[c] Gianpaolo Balsamo,[d] Aaron Boone,[e] Matthias Cuntz,[f] Bertrand Decharme,[e] Paul A. Dirmeyer,[g] Jaibus Dong,[h] Michael Ek,[h] Zichang Guo,[g] Vanessa Haverd,[i] Bart J. J. van den Hurk,[j] Grey S. Nearing,[k] Bernard Pak,[l] Joe A. Santanello Jr.,[m] Lauren E. Stevens,[l] and Nicolas Vuichard[n]

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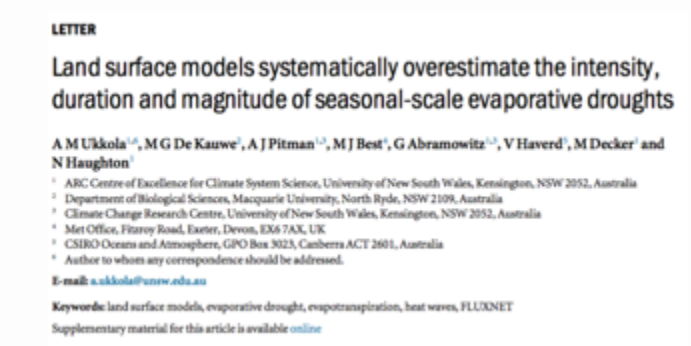
(Manuscript received 16 September 2015, in final form 27 January 2016)



LETTER

Land surface models systematically overestimate the intensity, duration and magnitude of seasonal-scale evaporative droughts

A M Ukkola[1,4], M G De Kauwe[2], A J Pitman[1,3], M J Best[4], G Abramowitz[1,3], V Haverd[5], M Decker[2] and N Haughton[1]

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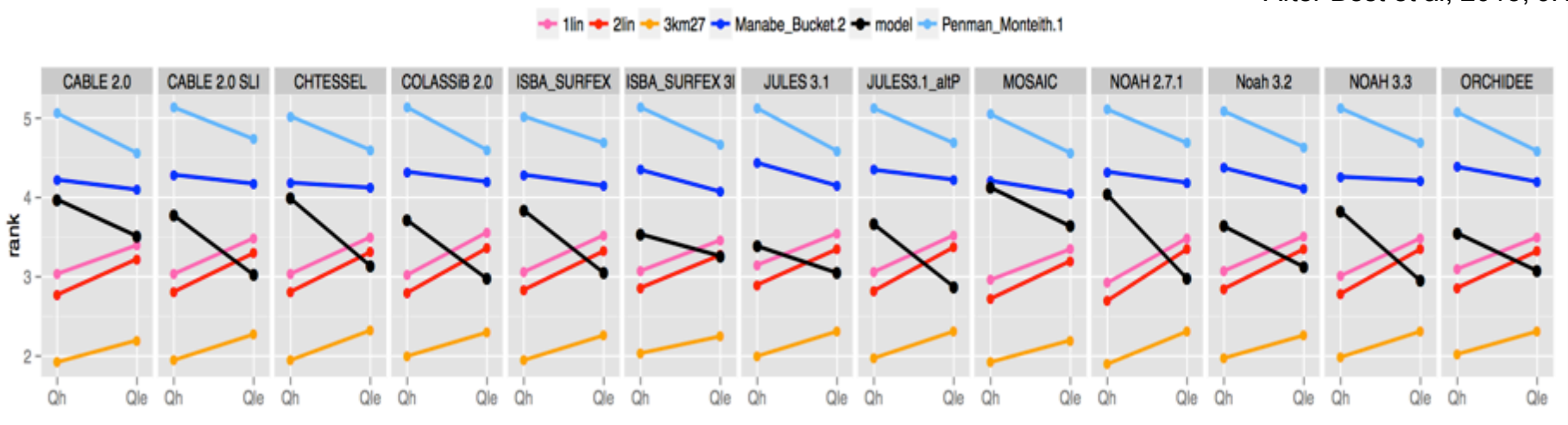
Keywords: land surface models, evaporative drought, evapotranspiration, heat waves, FLUXNET

Supplementary material for this article is available online

Headline result from PLUMBER

After Best et al, 2015, JHM



Vertical axis: rank of each LSM (black) against the 5 benchmarks, averaged over:

20 Flux tower sites, 4 metrics: bias, correlation, SD, normalised mean error

- On average, LSMs outperform Penman-Monteith and Manabe bucket
- On average, LSMs sensible heat prediction is worse than an out-of-sample linear regression against downward SW radiation
- For all fluxes, models are comfortably beaten by out-of-sample regression against Swdown, Tair and RelHum

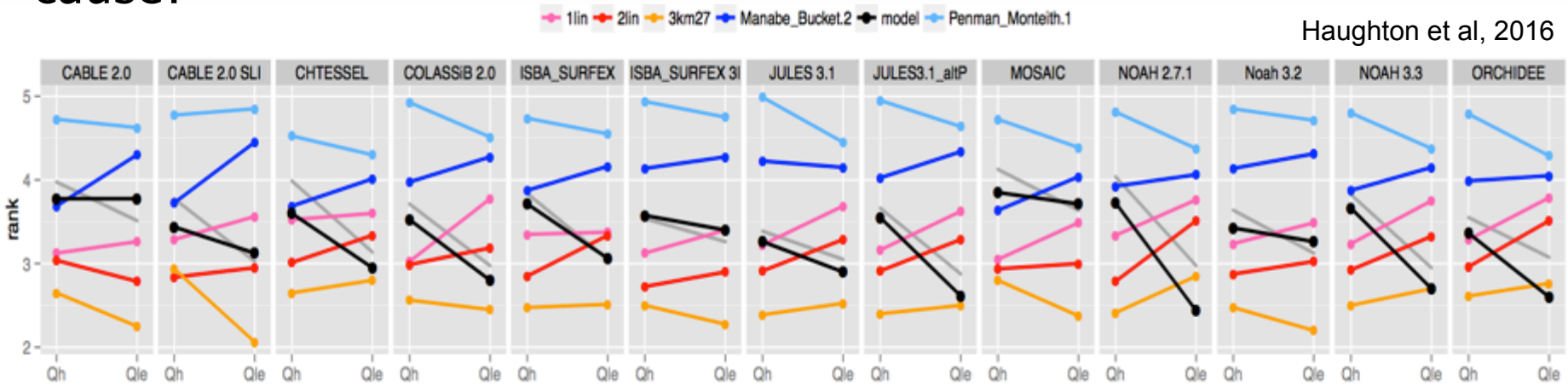
PLUMBER: Summary of follow-up / current work

2nd PLUMBER paper (Ned Haughton) thoroughly examined methodology:

- Lack of flux tower energy conservation advantaging empirical models?
- Time scale – daily, monthly, seasonal rather than per time step performance?
- Time of day – diurnal biases in flux tower favouring empirical models?
- Poor LSM initialisation?
- Are ranks not representative of metric values?
- Biased by metric choice?
- Biased by site choice?

PLUMBER: Summary of follow-up / current work

Example: lack of energy conservation in flux tower data not the cause:



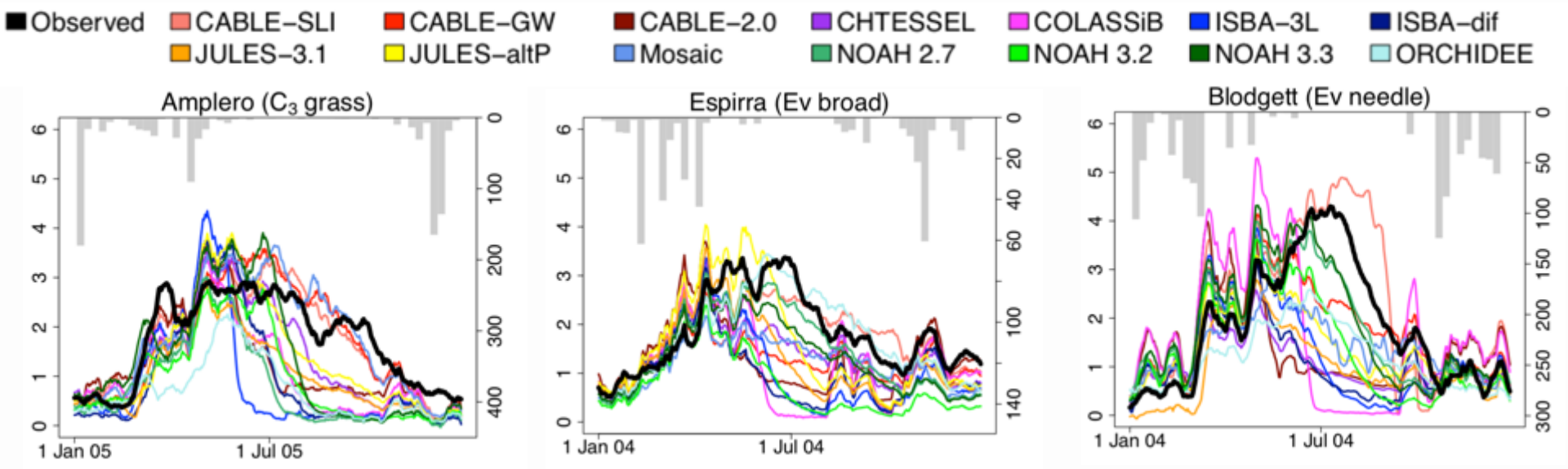
Haughton et al, 2016

- Constrain each empirical model to have the same latent + sensible heat flux as the LSM at every time step
  - Each empirical model then effectively has the same Rnet and ground heat flux as the LSM it's being compared to – and conserves energy.
- Results are mixed but the regression against SWdown, Tair and RelHum still comes out on top, especially for sensible heat flux.

PLUMBER: Summary of follow-up / current work

Ukkola et al, 2016, ERL: Dry-down events at PLUMBER sites

- Systematic under-prediction of ET in dry-downs
- Common over estimate of ET in early growing season



Ukkola et al, 2016

PLUMBER: Outline of Future Work

1. Ned Haughton currently building broader hierarchy of empirical models:
    - Another 3 tiers of more capable empirical models, testing out-of-sample, as per original PLUMBER work
    - Try to understand how much information about latent /sensible heat flux is available in met forcing data (i.e. predictability of sensible, latent heat flux)
    - LSM performance can then be assessed by utilisation of information

2. A PLUMBER2 is likely – more sites (~100), using broader spectrum of empirical models, using new PALS site (as an ongoing, automated MIP): 2018?

International Land Model Benchmarking (ILAMB) Project

Building upon past model evaluation studies, the goals of the International Land Model Benchmarking (ILAMB) project are to:

1. Develop internationally accepted benchmark experiments for land model performance by drawing upon international expertise and collaboration
2. Promote the use of these benchmarks by the international community for model intercomparison
3. Strengthen linkages among experimental, remote sensing, and climate modeling communities in the design of new model tests and new measurement programs
4. Support the design and development of open source benchmarking tools.

ILAMB: Participants/Institutes/Contributions

- Project is mainly lead/funded through DOE Regional Climate Modeling Program. Project leadership team includes Forrest Hoffman (ORNL), Jim Randerson (UCI), Bill Riley (LBNL), David Lawrence (NCAR), and Gretchen Keppel-Aleks (U. Michigan).
- Collaboration with PALS is under discussion.
- ILAMB is currently being utilized by the international land modeling research community.
- ILAMB hosted a workshop in May, 2016 at DOE with approximately 50 participants from around the world. The workshop report, which will be released in spring 2017, provides a roadmap for land model benchmarking/assessment activities going forward.

Examples/Samples Of Current Work: Variables and Visualization within ILAMB

- Currently integrates analysis of 25 variables in 4 categories from ~60 datasets
  - Above ground live biomass, burned area, carbon dioxide, gross primary production, leaf area index, global net ecosystem carbon balance, net ecosystem exchange, ecosystem respiration, soil carbon
  - evapotranspiration, latent heat, sensible heat, runoff, evaporative fraction, terrestrial water storage anomaly
  - albedo, surface upward SW radiation, surface net SW radiation, surface upward LW radiation, surface net LW radiation, surface net radiation
  - surface air temperature, precipitation, surface relative humidity, surface downward SW radiation, surface downward LW radiation
- Graphics and scoring system
  - annual mean, bias, relative bias, RMSE, seasonal cycle phase, spatial distribution, interannual variability, variable-to-variable
  - Global maps, time series plots averaged over specific regions, individual measurement sites, functional relationships

Examples/Samples Of Current Work: ILAMB global analysis summary table

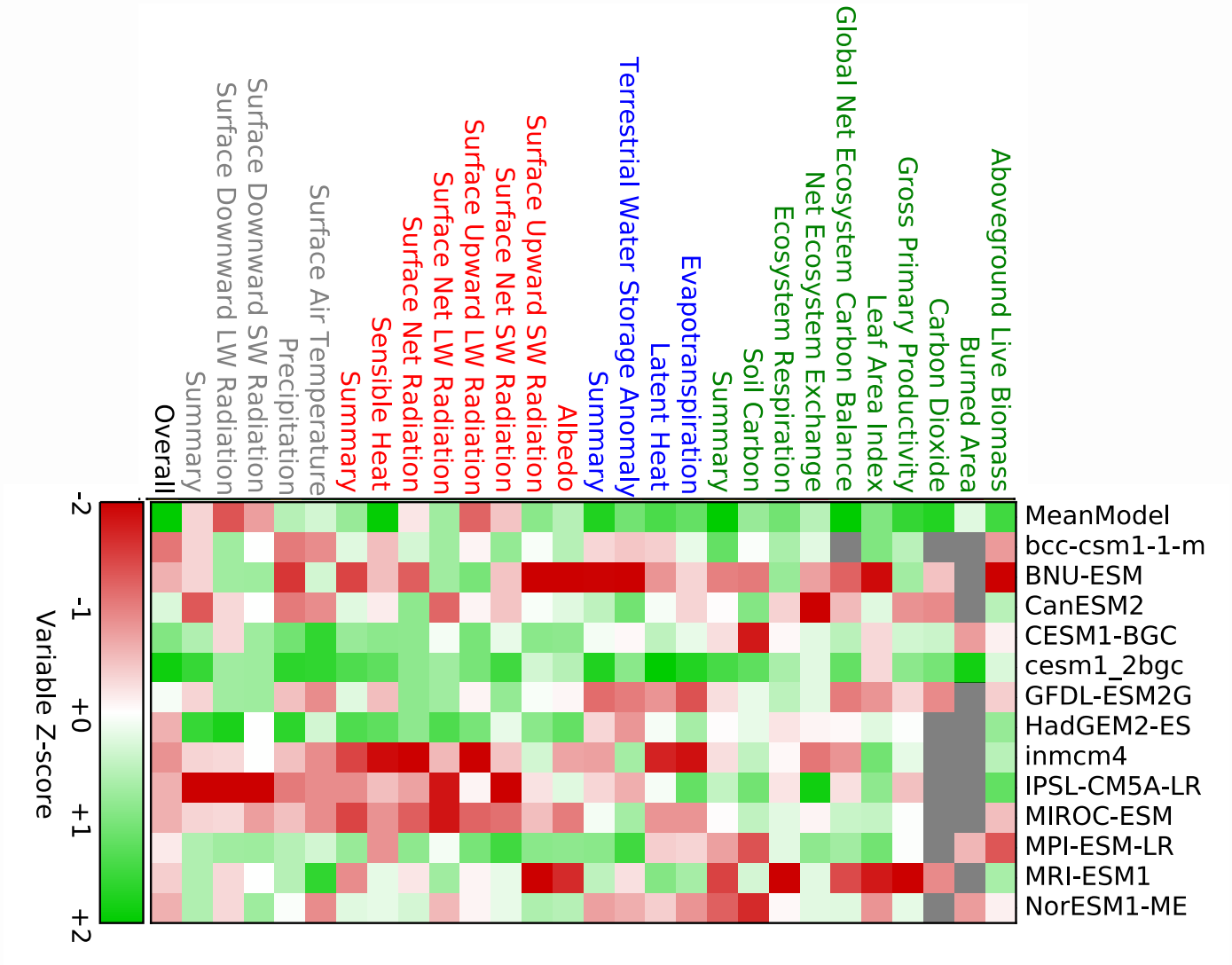
Global Variables (Info for Weightings)

	MeanModel	bcc-csm1-1-m	BNU-ESM	CanESM2	CESM1-BGC	GFDL-ESM2G	HadGEM2-ES	inmcm4	IPSL-CM5A-LR	MIROC-ESM	MPI-ESM-LR	MRI-ESM1	NorESM1-ME
Live Biomass Carbon	0.73	0.68	0.33	0.65	0.60	0.62	0.72	0.50	0.56	0.62	0.58	0.56	0.57
Burned Area	0.38	-	-	-	0.37	-	-	-	-	-	0.38	-	0.38
Carbon Dioxide	0.85	-	0.65	0.65	0.78	0.65	-	-	-	0.79	0.68	0.68	0.75
Gross Primary Productivity	0.77	0.72	0.73	0.64	0.70	0.67	0.68	0.70	0.67	0.69	0.69	0.53	0.70
Leaf Area Index	0.66	0.66	0.41	0.60	0.53	0.49	0.59	0.68	0.66	0.62	0.68	0.43	0.50
Global Net Ecosystem Carbon Balance	0.58	-	0.38	0.27	0.38	0.18	-	0.46	0.25	0.38	0.42	0.27	0.40
Net Ecosystem Exchange	0.49	0.47	0.47	0.39	0.48	0.49	0.46	0.44	0.53	0.48	0.50	0.48	0.48
Ecosystem Respiration	0.75	0.72	0.72	0.65	0.67	0.71	0.66	0.70	0.67	0.68	0.68	0.47	0.66
Soil Carbon	0.55	0.50	0.42	0.56	0.38	0.51	0.51	0.53	0.57	0.53	0.41	0.53	0.39
Summary	0.64	0.62	0.51	0.55	0.55	0.54	0.60	0.56	0.55	0.59	0.55	0.50	0.54
Evapotranspiration	0.75	0.73	0.72	0.72	0.73	0.70	0.74	0.69	0.75	0.70	0.73	0.73	0.72
Evaporative Fraction	0.84	0.76	0.77	0.81	0.81	0.75	0.81	0.81	0.72	0.75	0.75	0.80	0.79
Latent Heat	0.80	0.76	0.77	0.77	0.78	0.74	0.77	0.72	0.77	0.75	0.76	0.78	0.76
Runoff	0.61	0.59	0.60	0.58	0.64	0.59	-	0.62	0.57	0.56	0.66	0.70	0.62
Sensible Heat	0.76	0.69	0.70	0.71	0.75	0.69	0.75	0.66	0.69	0.69	0.69	0.72	0.72
Terrestrial Water Storage Anomaly	0.38	0.37	0.36	0.38	0.38	0.38	-	0.38	0.37	0.38	0.38	0.38	0.38
Summary	0.68	0.65	0.65	0.66	0.67	0.64	0.77	0.64	0.64	0.63	0.66	0.68	0.66
Albedo	0.72	0.71	0.61	0.71	0.73	0.69	0.74	0.67	0.71	0.67	0.73	0.64	0.72
Surface Upward SW Radiation	0.77	0.74	0.67	0.74	0.78	0.74	0.77	0.74	0.73	0.72	0.78	0.67	0.76
Surface Net SW Radiation	0.84	0.86	0.84	0.85	0.86	0.86	0.86	0.84	0.82	0.83	0.87	0.85	0.85
Surface Upward LW Radiation	0.89	0.91	0.91	0.91	0.92	0.91	0.92	0.89	0.90	0.91	0.92	0.91	0.91
Surface Net LW Radiation	0.81	0.82	0.81	0.79	0.81	0.81	0.83	0.80	0.78	0.78	0.81	0.81	0.81
Surface Net Radiation	0.78	0.79	0.76	0.80	0.80	0.81	0.80	0.74	0.77	0.77	0.81	0.78	0.80
Summary	0.80	0.80	0.77	0.80	0.81	0.80	0.82	0.77	0.78	0.78	0.82	0.78	0.81
Surface Air Temperature	0.87	0.87	0.85	0.85	0.88	0.85	0.87	0.85	0.87	0.85	0.88	0.88	0.87
Precipitation	0.71	0.69	0.67	0.69	0.72	0.69	0.73	0.69	0.69	0.69	0.72	0.70	0.70
Surface Relative Humidity	0.81	-	0.80	0.76	0.82	-	-	0.79	0.82	-	-	0.83	0.81
Surface Downward SW Radiation	0.86	0.88	0.87	0.87	0.88	0.87	0.87	0.87	0.83	0.86	0.88	0.86	0.88
Surface Downward LW Radiation	0.89	0.92	0.91	0.91	0.92	0.92	0.92	0.90	0.89	0.91	0.93	0.91	0.91
Summary	0.82	0.83	0.81	0.80	0.83	0.82	0.84	0.81	0.81	0.82	0.84	0.83	0.82
Overall	0.69	0.54	0.59	0.61	0.64	0.57	0.48	0.58	0.57	0.59	0.61	0.59	0.63

Notes: 4 Categories are divided: Ecosystem and Carbon Cycle, Hydrology and Turbulent Flux, Radiation and Energy Cycle, and Forcings.

ILAMB Examples/Samples Of Current Work:

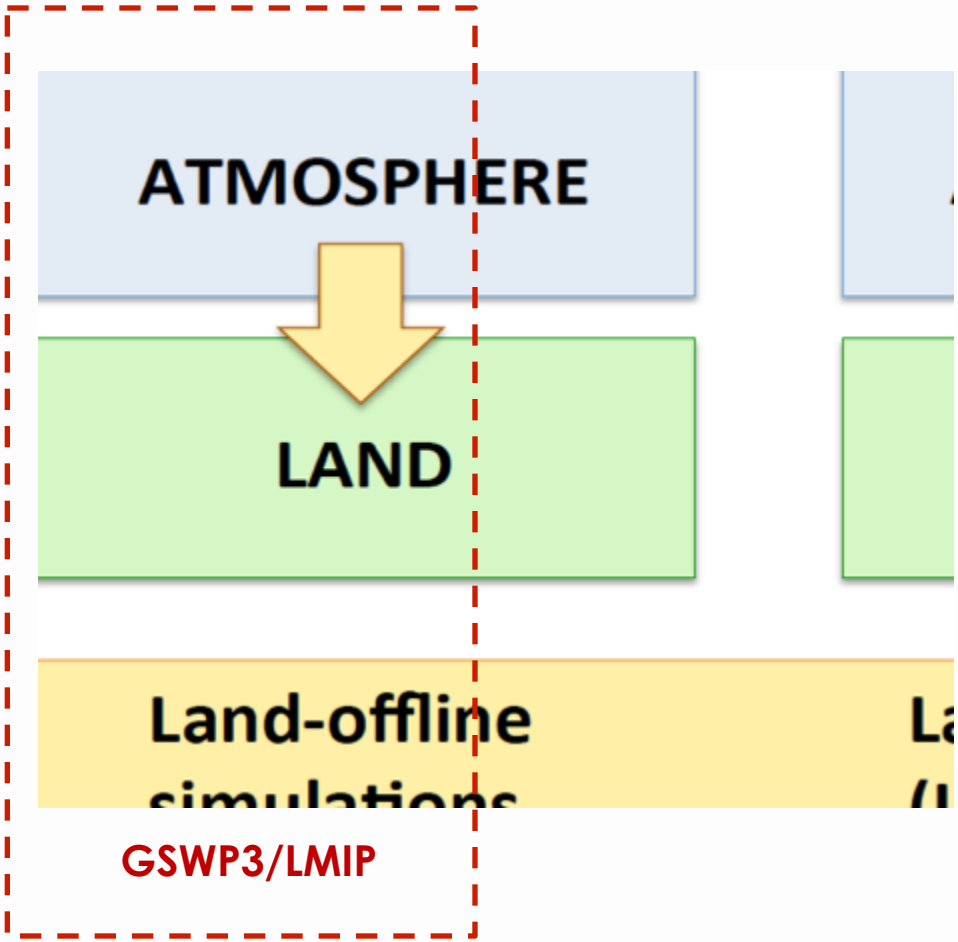
scores for RMSE, interannual variability, pattern correlation, variable-to-variable comparisons



ILAMB: Outline of Future Work

- ILAMB will continue to be augmented with new metrics introduced by international collaborators.
- ILAMB will utilized in CMIP6 assessments, including assessments of LS3MIP land-only simulations.
- Integration with PALS is being explored.

GSWP3 and LS3MIP



LS3MIP =

LMIP
+ LFMIP
[+ ESM-SnowMIP]

GEWEX + CLiC

GSWP3 and LMIP goals

1. Estimation of terrestrial energy/water/carbon balance and variability during 250-years (1850-2100)

2. Evaluation/benchmarking of state-of-the-art land surface schemes of ESMs (GSWP3/LMIP) and additional models of broader fields (GSWP3-ISIMIP)

3. Data production as a long-term land reanalysis with periodical update (GSWP3)

LFMIP

Aims to assess land surface, snow and soil moisture feedbacks on climate variability and climate change, including:

1. land-atmosphere coupling and its impacts (for climate trends, water resources, predictability);
2. linking patterns and trends of ECVs to land model properties and biases;
3. mapping (uncertainty of) water resources over the 20th century (and beyond);
4. explore model-dependent land-atmospheric coupling;
5. investigate the ability of climate models to capture observed rates of spring snow cover (ESM-SnowMIP)
6. understand the linkage between snow-albedo feedback and 21st century warming (ESM-SnowMIP)

LFMIP experiments include land-atmosphere as well as land-atmosphere-ocean coupled simulations, with combinations of prescribed land conditions, sea surface temperatures and smoothed boundary conditions used to asses the roles of land-climate and land-climate-ocean feedbacks on ECVs and seasonal predictability.

Participants of LMIP

Model name	Institute	Country
ACCESS	CSIRO/Bureau of Meteorology	Australia
ACME Land Model	U.S. Department of Energy	USA
BCC-CSM2-MR	BCC,CMA	China
CanESM	CCCma	Canada
CESM	NCAR	USA
CMCC-CM2	Centro Euro-Mediterraneo sui Cambiamenti Climatici	Italy
CNRM-CM	CNRM-CERFACS	France
EC-Earth	SMHI and 26 other institutes	Sweden and 9 other European countries
FGOALS	LASG, IAP, CAS	China
GISS	NASA GISS	USA
IPSL-CM6	IPSL	France
MIROC6-CGCM	AORI, University of Tokyo	Japan
MPI-ESM	Max Planck Institute for Meteorology (MPI-M)	Germany
MRI-ESM1.x	Meteorological Research Institute	Japan
NorESM	Norwegian Climate Service Centre	Norway
hadGEM3	Met Office	UK

Participants of GSWP3

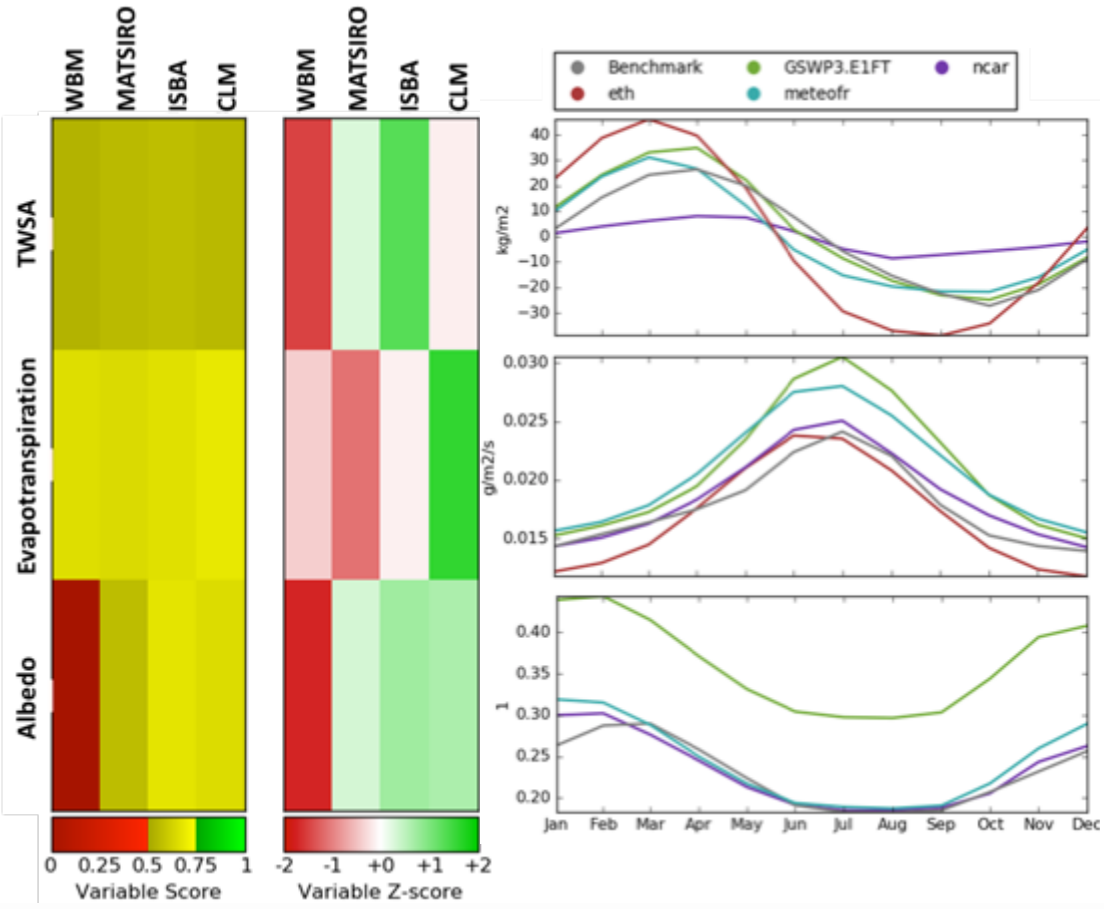
1. EXP1 Fast-track (1901-2010)

Model name	Institute	Country
CLM	NCAR	USA
ISBA	MeteoFrance	France
MATSIRO	University of Tokyo	Japan
TESSEL	ECMWF/KNMI	UK/Netherland
WBM	ETH	Germany

2. Actual Phase of EXP1 will have more participants also from different communities (e.g., LSMs of LS3MIP, hydrological & ecosystem models from ISI-MIP & Trendy)

GSWP3/LMIP: Examples/Samples Of Current Work

- EXP1 Fast-track results are being analyzed.



- Forcing data (beta version) is being tested/updated.

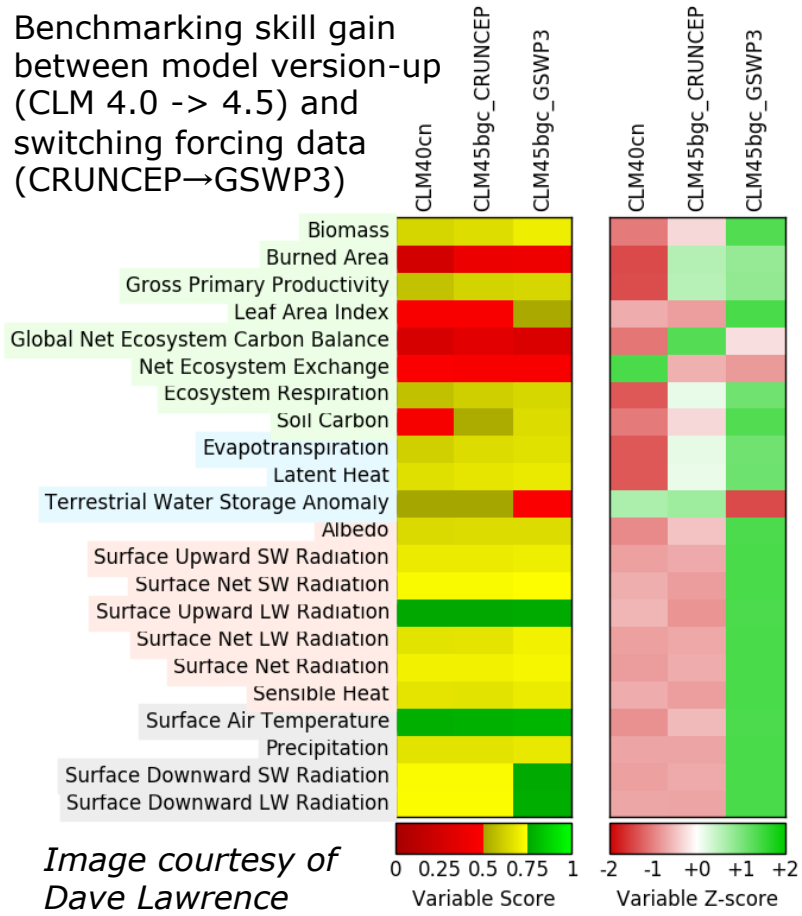


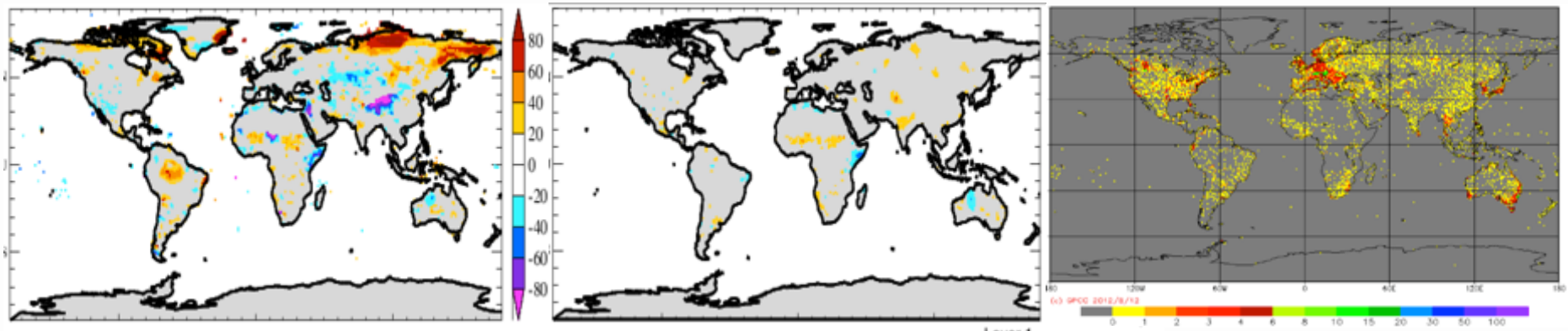
Image courtesy of Dave Lawrence

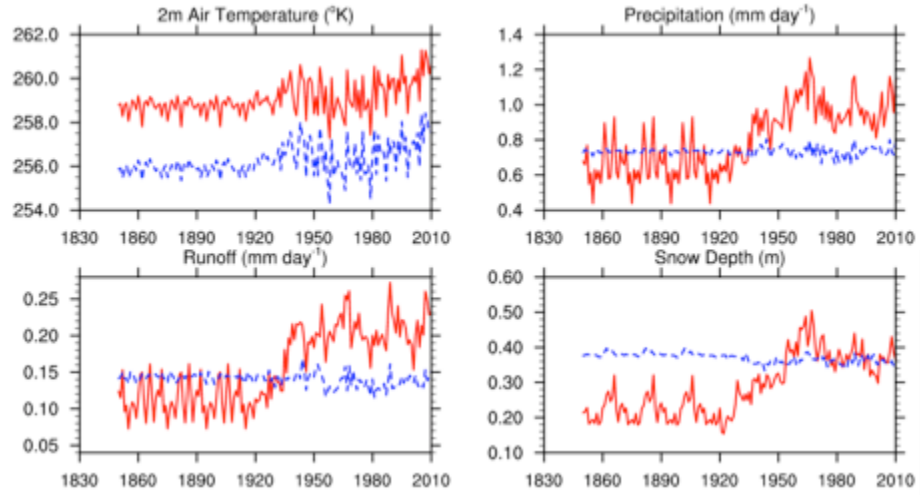
GSWP3/LMIP: Examples/Samples Of Current Work

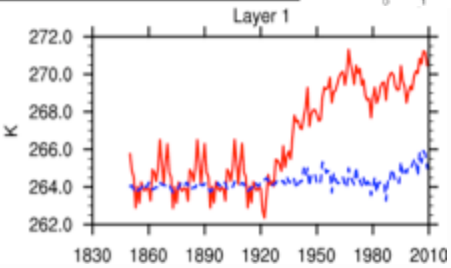
- Know problem in forcing data

Spurious precipitation trend during early 20th century over high latitude

GSWP3 (GPCC) 1901-1955 % change in P CRUNCEP (CRU) # of stations per grid box GPCC







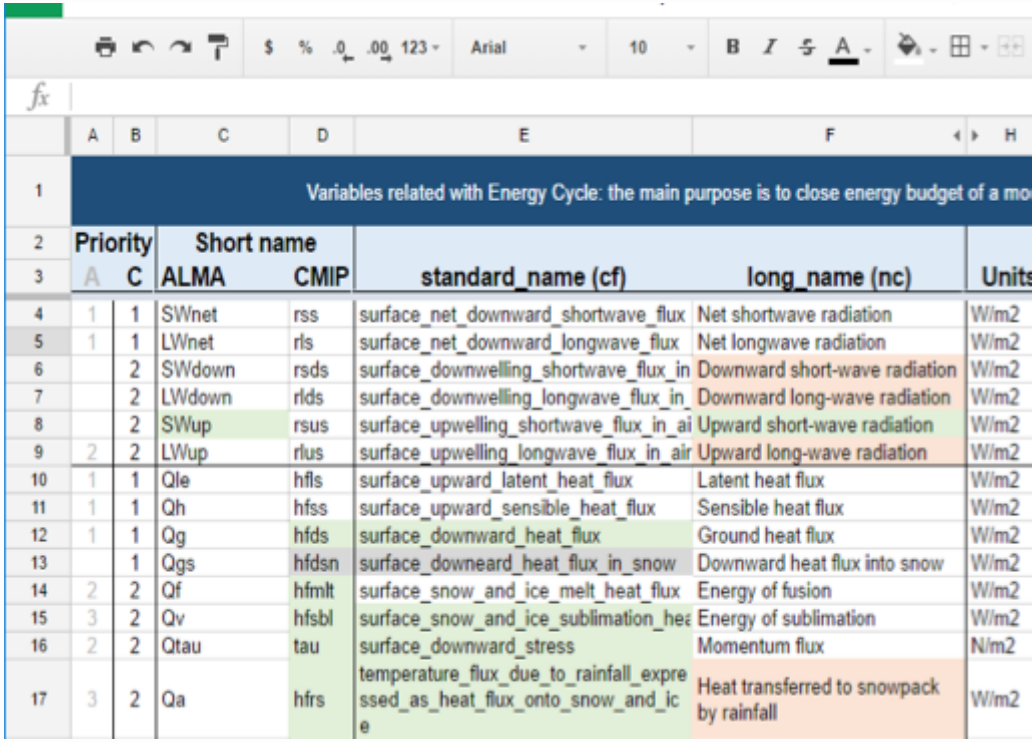
Analysis by D. Lawrence, NCAR

- Significant snow increase causes excessive runoff and snow insulation effect
- Correcting GPCC dataset

GSWP3/LMIP: Examples/Samples Of Current Work

- Housekeeping Variable Naming Convention
  - Conversion table between ALMA and cf convention
  - Update ALMA & Newly defined ~40 cf variables
  - New variables, particularly, in cold process and water management
  - https://goo.gl/DRXSey

- Synergy with Other Projects
  - ISIMIP (PIK)
  - ESM-SnowMIP (CliC)
  - SoilWAT (ISMC)
  - PALS (GLASS)
  - ILAMB (DoE)



	A	B	C	D	E	F	H
1	Variables related with Energy Cycle: the main purpose is to close energy budget of a mo						
2	Priority		Short name				
3	A	C	ALMA	CMIP	standard_name (cf)	long_name (nc)	Units
4	1	1	SWnet	rss	surface_net_downward_shortwave_flux	Net shortwave radiation	W/m2
5	1	1	LWnet	rls	surface_net_downward_longwave_flux	Net longwave radiation	W/m2
6		2	SWdown	rsds	surface_downwelling_shortwave_flux_in	Downward short-wave radiation	W/m2
7		2	LWdown	rlds	surface_downwelling_longwave_flux_in_	Downward long-wave radiation	W/m2
8		2	SWup	rsus	surface_upwelling_shortwave_flux_in_ai	Upward short-wave radiation	W/m2
9	2	2	LWup	rlus	surface_upwelling_longwave_flux_in_air	Upward long-wave radiation	W/m2
10	1	1	Qle	hfls	surface_upward_latent_heat_flux	Latent heat flux	W/m2
11	1	1	Qh	hfss	surface_upward_sensible_heat_flux	Sensible heat flux	W/m2
12	1	1	Qg	hfds	surface_downward_heat_flux	Ground heat flux	W/m2
13		1	Qgs	hfdsn	surface_downeard_heat_flux_in_snow	Downward heat flux into snow	W/m2
14	2	2	Qf	hfmlt	surface_snow_and_ice_melt_heat_flux	Energy of fusion	W/m2
15	3	2	Qv	hfsbl	surface_snow_and_ice_sublimation_hea	Energy of sublimation	W/m2
16	2	2	Qtau	tau	surface_downward_stress	Momentum flux	N/m2
17	3	2	Qa	hfrs	temperature_flux_due_to_rainfall_expressed_as_heat_flux_onto_snow_and_ice	Heat transferred to snowpack by rainfall	W/m2

GSWP3/LMIP: Summary of Current Work

1. Beta version forcing data has been tested.
   - mostly, positive feedback (overall performance is good)
   - precipitation over high latitude during early 20thC needs to be corrected.
   - a few LSMs reports problems for humidity over Tropics (dry bias) and arctic (super-saturation)

2. Official release will be very soon.
   - with final experiment protocol and forcing data documentation

3. GSWP3 EXP1 Fast-track results are being analyzed. It will be reported soon.

GSWP3/LMIP: Outline of Future Work

1. Freeze and distribute the final version of historical (EXP1) forcing data as soon as possible (originally planned by the end of Jan. 2017).

2. GSWP3-ISIMIP Joint Workshop at Tokyo, 17-19 May, 2017
   : First round results of GSWP3 will be reported.
   : GLASS Panel meeting will be at the same venue, 15-16 to create synergy across communities.

3. LMIP may not start before CMIP6/DECK finish (later half of 2017?) in each modeling group. Also, Data Request of CMIP6-endorsed-MIPs is still being updated.

4. GSWP3-EXP2/EXP3 will follow after GSWP3-EXP1/LMIP (most probably in 2018; also EXP2 depends on CMIP6/ScenarioMIP).

New project: GEWEX Soils Initiative (SoilWat)

- Initiative born of International Soil Modeling Consortium (ISMC) and GEWEX communities
- Aims to improve interactions and integration of soil and subsurface processes in present climate models
- Planning workshop June 2016 in Leipzig, 25-30 people, 2 days:

1. survey representation of soil processes in climate models with emphasis on revisiting the pedotransfer functions used to convert soil information to parameters for modeling (Harry Vereecken and Anne Verhoef)
2. assess the utility of more resolved soil maps, a sensitivity analysis (SoilParameterMIP) to evaluate several climate models using old and new soil maps and parameters (Lukas Gudmundsson, Matthias Cuntz)
3. survey of groundwater database and strategies for incorporating groundwater in climate models (Stefan Kollet, Anne van Loon and Peter van Oevelen)

SoilWat: Initiative 1

Evaluation of pedotransfer functions for calculation of hydraulic and thermal soil properties in global climate and hydrological models (Harry Vereecken and Anne Verhoef).

Objectives:

1. Summarize functional descriptions used in LSMs and hydrological models
2. Provide an overview of all PTFs (and their fitting parameters) and compare LSM approaches with state of the art PTFs used in soil science.
3. Quantify uncertainty in water and energy fluxes and states generated by aggregation or upscaling.
4. To perform 1D simulations using state of the art soil models to assess the impact of PTFs and the inherent uncertainties embedded in these equations on key soil processes.

SoilWat: Initiative 2

Soil Parameter MIP (Lukas Gudmundsson, Matthias Cuntz)

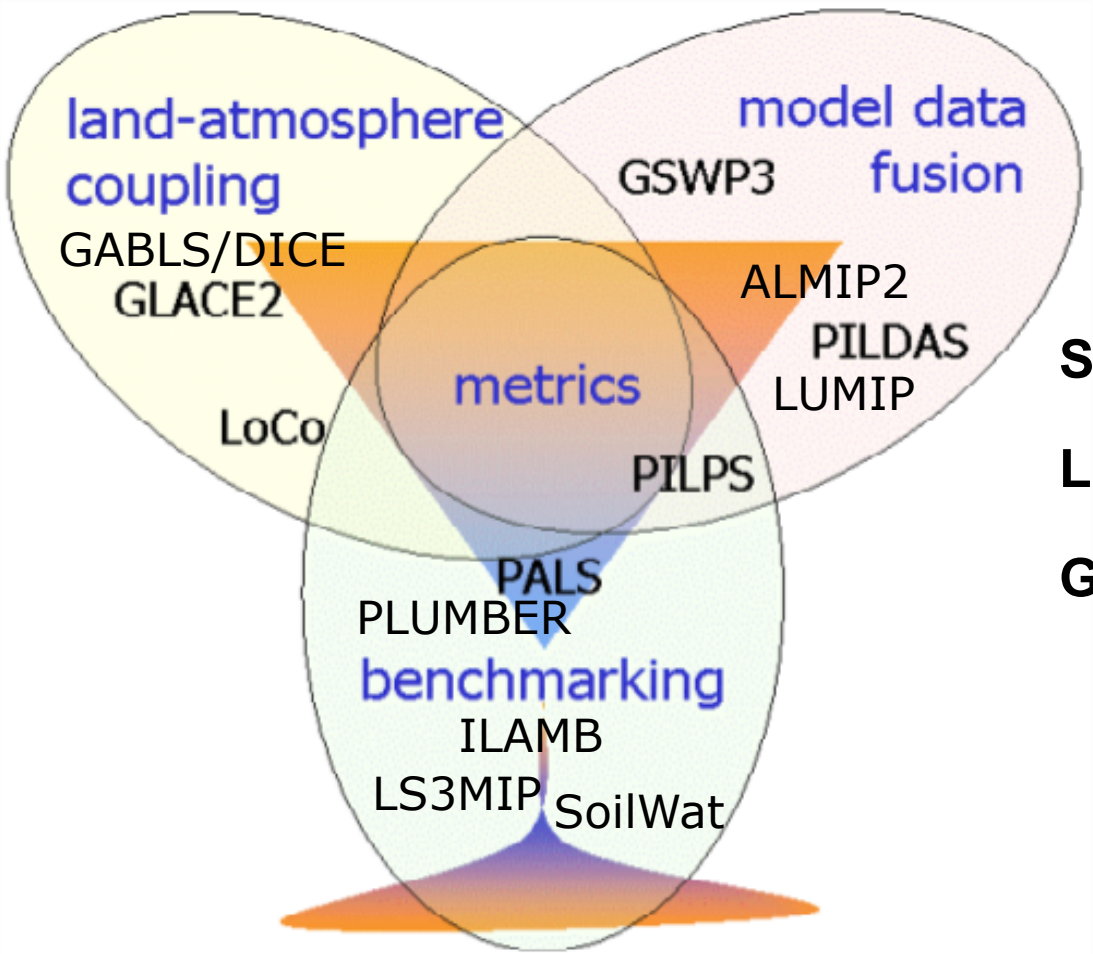
- Models run globally, GSWP3 forcing (0.5°) from 1900-2014.
- Four Tier 1 experiments, leading to 6 model runs:
  1. Reference run with all models in their status quo.
  2. Soil parameters (see below) for all land points given by SP-MIP.
  3. Soil textural properties (see below) provided by SP-MIP on all land points.
  4. 3 times uniform soil parameters for the whole globe given by SP-MIP.

- Tier 2 experiments are possible depending on interest of the modellers that could assess the effects of aggregation on model outputs.

GEWEX Soils Initiative (SoilWat) status

- Now drafting perspective paper to clarify needs, objectives, future directions of the SoilWat initiative (Sonia Seneviratne, Peter van Oevelen, Gerrit de Rooij, and Dani Or)
- *Initiative 1:* survey already underway
- *Initiative 2 (SP-MIP):* scoping document distributed
- *Initiative 3:* discussion underway seeking a global groundwater database, historical and current, with the aim of committing contributing countries/monitoring authorities to submit their data to the database and possibly create a global archive of historical groundwater data.
- Second SoilWat workshop planned in 2017 to report progress and discuss processes not addressed in this workshop (e.g. soil and plant processes, human interactions)

GLASS Projects – Land-Atmosphere Coupling



Scoring system:

LoCo – green

GABLS/DICE – green/orange

LoCo: Project Overview/Goals

LoCo WG: Joe Santanello (NASA/GSFC), Paul Dirmeyer (GMU), Kirsten Findell (NOAA/GFDL), Pierre Gentine (Columbia Univ.), Benoit Guillod (ETH), Craig Ferguson (SUNY-Albany), Josh Roundy (U. Kansas), Ahmed Tawfik (NCAR)

LoCo: GEWEX-GLASS core theme to understand, model, and predict the role of local land-atmosphere coupling in the evolution of land-atmosphere fluxes and state variables, including clouds.

Answer the following questions:

1. What role do land-atmosphere interactions (i.e., coupling strength) play in hydrologic extremes and abrupt shifts in regional climate?
2. What are the trends in regional coupling strength over the period of record? Where has coupling enhanced (or suppressed) the global warming signal?
3. How do we measure and benchmark coupling?

LoCo WG continues to grow & support initiatives on L-A coupling, supporting a new generation of L-A coupling leaders–"incubator"!

Local Land-Atmosphere Coupling (LoCo) Working Group

1. The results of offline projects such as PILPS and GSWP are limited by the lack of atmospheric feedback, and GLACE cannot isolate and evaluate the processes implied in the coupling that lead to model development.

2. To accurately represent the relationship between soil moisture (SM) and precipitation (P) and coupling strength in models, it is necessary to carefully examine and quantify the full series of interactions and feedbacks (i.e., links in the chain) at the process-level, including the planetary boundary layer (PBL) feedback.

3. To this end, the LoCo initiative and WG was established nearly a decade ago to focus on development of quantitative process-based metrics/diagnostics of L-A coupling that could be applied equally to observations and models across scales.

LoCo: Participants/Institutes/Contributions

1. The LoCo WG is comprised of ~15 GLASS panel and non-panel members. It is not meant to be exclusive, and has a high proportion of young scientists who have been motivated by L-A interaction studies.

2. LoCo has closest links with GASS/GABLS and DICE, due to the inherent importance of the PBL and model development focus in each. E.g., Joe and Mike are working on a paper bringing the LoCo metrics to bear on the DICE results.

3. LoCo is also filing a request to CMIP6 (via GSWP and LS3MIP) for an increased set of L-A variables to be included in the standard output of participants.

LoCo: Examples/Samples Of Current Work

- The LoCo effort just reached the 10 year mark, and held a dedicated session at the GLASS panel meeting devoted to the status and future plans of LoCo and the LoCo WG.

- There are many studies and publications from the WG in recent years focused on various metrics, models, and applications (see GEWEX-LoCo website and presentations from the meeting).

- Nice synthesis from Paul can be found here : http://cola.gmu.edu/dirmeyer/Coupling_metrics.html

- LoCo coupling metrics toolkit from Ahmed can be found here: http://www.coupling-metrics.com/

LoCo: Examples/Samples Of Current Work

- Observations of L-A processes and the need for assessment/ improvement has been a recent point of emphasis of the LoCo WG
    - Focused on: PBL (Joe), soil moisture (Paul), and fluxes (Pierre).
    - Field campaigns
        - Enhanced Sounding for Local Coupling Studies (ESLCS) @ SGP (Craig, Joe, Pierre) in Summer 2015
        - Improved soil moisture and co-located L-A measurements from DOE-ARM (Joe, Pierre)
        - NY State Mesonet (Craig)
        - Land-Atmosphere Feedback Experiment (LAFE : Volker Wulfmeyer, NASA, NOAA) @ SGP in Summer 2017.
    - In addition, Joe has received funding for a Science Task Group at GSFC focused on PBL retrieval from space.

LoCo: Outline of Future Work

The future of LoCo and a three-pronged approach was discussed at GLASS16 :

a) **Continue to follow and broaden the science of LoCo and WG participation**

Suggestions: snow, geology, carbon, LULCC, momentum, radiation, fluorescence, monsoon – each are evolving naturally via independent research

b) **Synthesize what we have now in terms of metrics and message**

Craig's roadmap

What are the variable and obs requirements – doable?

Leverage off existing MIPs: LoCo-Plumber, LoCo-DICE, LoCo-CMIP

c) **Engage and entrain the operational/model development community**

Ahmed and Craig – convective schemes + observing networks

CMIP6 variable request (in process)

LoCo: Publications, Summer School

- **Many publications!**
- **LoCo Summer School; 54 students, 200 applicants!**

see 2016 GLASS report

How Rain Depends On Soil Moisture 06.03.2015

06.03.2015 17:12 Age: 62 days

It rains in summer most frequently when the ground holds a lot of moisture. However, precipitation is most likely to fall in regions where the soil is comparatively dry. This is the conclusion reached by researchers at ETH Zurich following an analysis of worldwide data. Their study contributes to a better understanding of soil moisture, a little explored climatic factor.

by Inken De Wit, ETH Zurich

The water content of soil has a great impact on the regional climate, but many of the connections are still not clear. Researchers at ETH Zurich's Institute for Atmospheric and Climate Science, together with colleagues from Belgium and the Netherlands, examined when and where it rains most frequently on summer afternoons.

Benoit Guillod: "On averag it rains most on days with high soil moisture". Courte ETH

They wanted to clarify whether more rain fell on days when the soil was dry or moist. And where exactly it was most likely to rain on these days. The contradictory findings of other scientists was the reason for their study. Some researchers observed afternoon precipitation in particular on days with high soil moisture, while others seemingly came to the

Course XXIII

Land-Atmosphere Interactions

Valsavarenche, Valle d'Aosta (Italy), 22 June - 1 July, 2015

Directors of the Course:

Pierre Gentine - Columbia University, NY, USA
Albert A. M. Holtslag - Wageningen University, The Netherlands

Scientific Secretary:

Silvia Terzago - CNR-ISAC, Italy

Lecturers:

Dennis Baldocchi - UC Berkeley, CA, USA
Anton Beljaars - ECMWF, UK
Alan Betts - Atmospheric Research, USA
Fabio D'Andrea - ENS, France
Dara Entekabi - MIT, MA, USA
Kirsten Findell - NOAA/GFDL, USA
Klaus Fraedrich - Max-Planck Institute for Meteorology, Germany
Pierre Gentine - Columbia Univ., NY, USA
Chiel van Heerwaarden - MPI, Germany
Cathy Hohenegger - MPI, Germany
Albert A.M. Holtslag - Wageningen Univ., The Netherlands
Gabriel Katul - Duke Univ., NC, USA
Benjamin Lintner - Rutgers Univ., NJ, USA
Guido Salvucci - Boston Univ., MA, USA
Joe Santanello - NASA, USA
Sonia Seneviratne - ETH, Switzerland
Gert-Jan Steeneveld - Wageningen Univ., The Netherlands
Bart van Stratum - Max-Planck Institute for Meteorology, Germany
Chris Taylor - CEH Wallingford, UK
Jordi Vila-Guerrau - Wageningen Univ., The Netherlands

LoCo Coupling Metrics Toolkit

- Ahmed Tawfik (NCAR): working on a land-atmosphere (L-A) coupling metrics toolkit written in modular Fortran 90.
- Based on 'cheat sheet' compilation of Paul Dirmeyer.
- Allow broader exposure/use of these techniques if metrics are well-documented, relatively standardized, and modular.
- Release on github, after getting permission from various authors.

Metrics:

- The Heated Condensation Framework (completed).
- Mixing diagram variables like Entrainment Ratios (completed).
- RH-Tendency from Mike Ek's work (partially completed).
- Intrinsic Biophysical Factors.
- Soil Moisture Memory using lagged auto-correlation (not started yet).
- Terrestrial Coupling Index via Paul's 2011 GRL paper (not started yet).
- CTP-HI-low Findell metrics (not started yet) + Coupled Drought Index (J. Roundy).

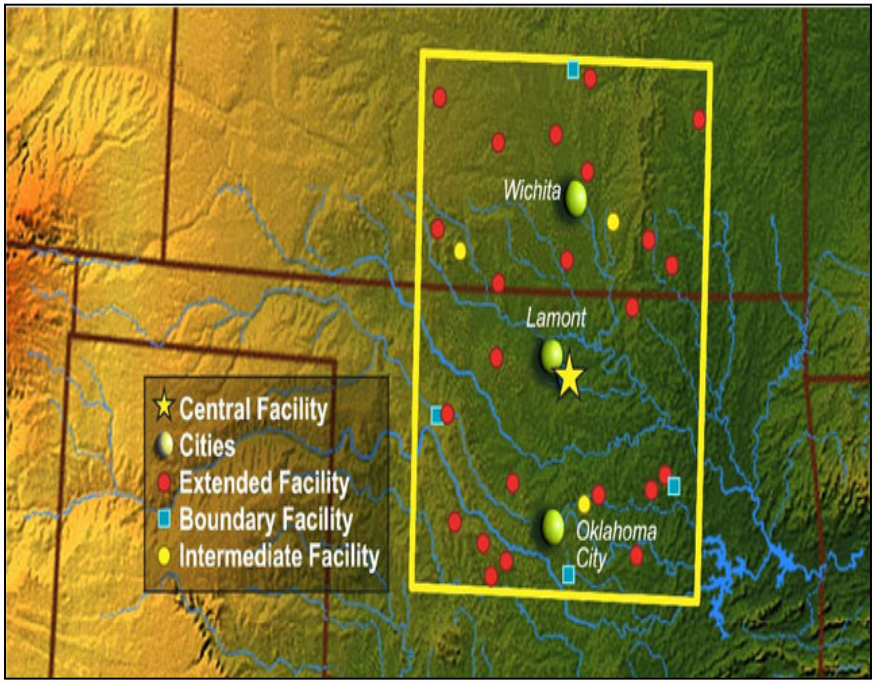
LoCo-SGP (Southern Great Plains) Testbed

"Enhanced Soundings for Local Coupling Studies"

•PIs: C. Ferguson, J. Santanello, P. Gentine

•15 June - 31 August 2015 at ARM-SGP Central Facility.

•12+ IOP days chosen by PI's, based on regime, soils/ET, and PECAN connection(nighttime convection) campaign.



- 14-sounding supplement to standard 6-hourly sonde launches, with hourly launches (daytime) and 10 minute lagged launch every 3-hours.
- Data set for evaluation of models, LoCo metrics.

LoCo-SGP Testbed: Future of DOE/ARM

U.S. DOE workshop on ARM-SGP:

• DOE/ARM traditionally focused on atmosphere (radiation, clouds, aerosols, shallow/deep convection).

• New phase of ARM-SGP for next 5-10 years in development, with focus on LES/CRM-scale domain, high-density spatial measurements for process eval studies.

•Santanello sole "land/L-A" representative.

Reduced domain ~100x100km w/ focused 30x30km inner (LES) grid

Next phase of ARM-SGP:

• Serious attention paid to needs/concerns of our community in terms of land surface state and flux measurements and connection to PBL.

• Recommendations for horizontal and vertical implementation/augmentation/ coordination of soil moisture and flux networks.

• Draft land input and final report available (contact J. Santanello).

High priority measurement activities *(redeployment, evaluation, augmentation):* 4 atmos profiling sites, optimize coupling land, PBL, rad. measurements, new L-A coupling sites, SGP land characterization survey.

LoCo: Connection to GLASS Community Projects

LoCo unique as a WG instead of a MIP, that contributes across projects from different angles and informs on future observing networks.

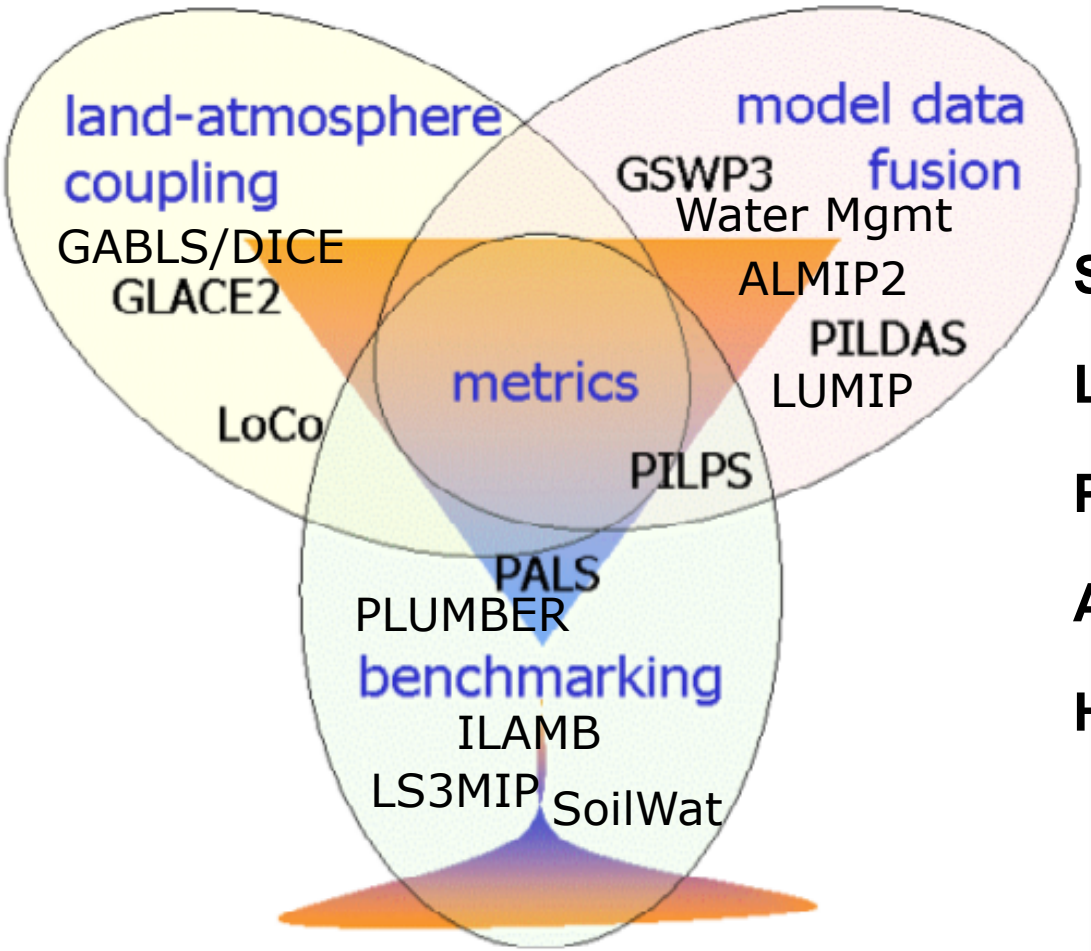
Diagnostics can be used in current GLASS efforts:

- DICE: 1st order quantification of impact of land-PBL coupling in Single Column Model (SCM) framework over SGP; currently focus on one-at-a-time site evaluation of fluxes, PBL, etc.
- PALS/Benchmarking: Looking ahead to distributed (spatial) benchmarking. Extend to examining coupled benchmarks (beyond offline). Single-site first, e.g. other DICE efforts, LoCo-AMMA(?).

Observations can be used in current GLASS efforts:

- SMAP: Launched February 2015. Data available this summer, 9km soil moisture product every 2-3 days, SMAP call for proposals (May)
- PBL Profiling: Still a 'gap' in Earth Observations, COSMIC GPS-RO proposal, ESA abstract (Oct 2015), NASA WG on PBL missions.

GLASS Projects – model-data fusion



Scoring system:

LUMIP – green

PILDAS – orange/red

ALMIP2 – green

Human/Water Mgmt – green

Land Use Model Intercomparison Project (LUMIP)

1. What are the effects of LULCC on climate and biogeochemical cycling (past-future)?
2. 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?

3. Three activities:
    1. Development of an updated and expanded historical and future land-use dataset
    2. An experimental protocol for specific LUMIP experiments for CMIP6
    3. Definition of metrics and diagnostic protocols that quantify model performance, and related sensitivities, with respect to LULCC.

LUMIP: Participants/Institutes/Contributions

1. LUMIP SSG: co-leads David Lawrence (NCAR) and George Hurtt (U. Maryland); Almut Arneth (KIT), Victor Brovkin (Max Planck), Kate Calvin (PNNL), Andrew Jones (LBNL), Chris Jones (Hadley Centre), Peter Lawrence (NCAR), Julia Pongratz (Max Planck), Sonia Seneviratne (ETH-Zurich), Elena Shevliakova (GFDL)

2. LUMIP is one of the CMIP6 satellite MIPs and therefore is integrated with all CMIP6 activities. In particular, LUMIP was designed in collaboration with LS3MIP, C4MIP, and DAMIP. LUMIP is cross-cutting across GEWEX and iLEAPS activities.

LUMIP: Examples/Samples Of Current Work

- LUMIP is one of the CMIP6 satellite MIPs and therefore is integrated with all CMIP6 activities
- In particular, LUMIP was designed in collaboration with LS3MIP, C4MIP, and DAMIP.
- LUMIP is cross-cutting across GEWEX and iLEAPS activities
- LUMIP has been presented at many meetings, including AGU, CESM Workshop, ILAMB, and CRESCENDO meetings
- A LUMIP kickoff webinar was held in October, 2016.

Land-Use Model Intercomparison Project (LUMIP)

Co-chairs: David Lawrence (NCAR) and George Hurtt (U. Maryland)

https://cmip.ucar.edu/lumip

Main Questions

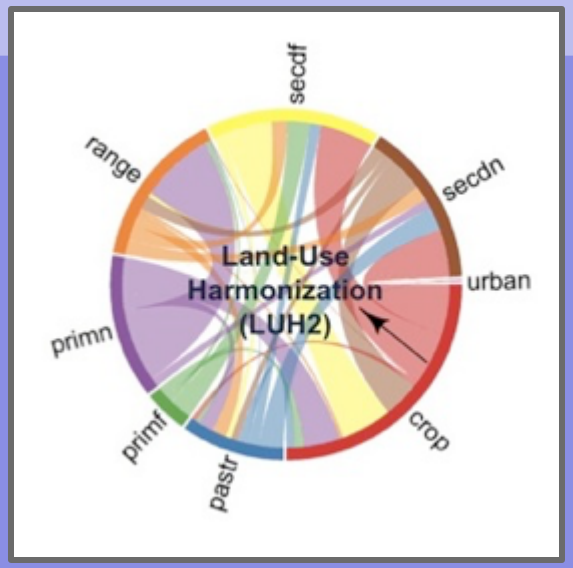
- What are effects LULCC on climate and biogeochemical cycling?
- What are the impacts of land management on surface fluxes of carbon, water, and energy and are there regional land-management strategies with promise to help mitigate against climate change?

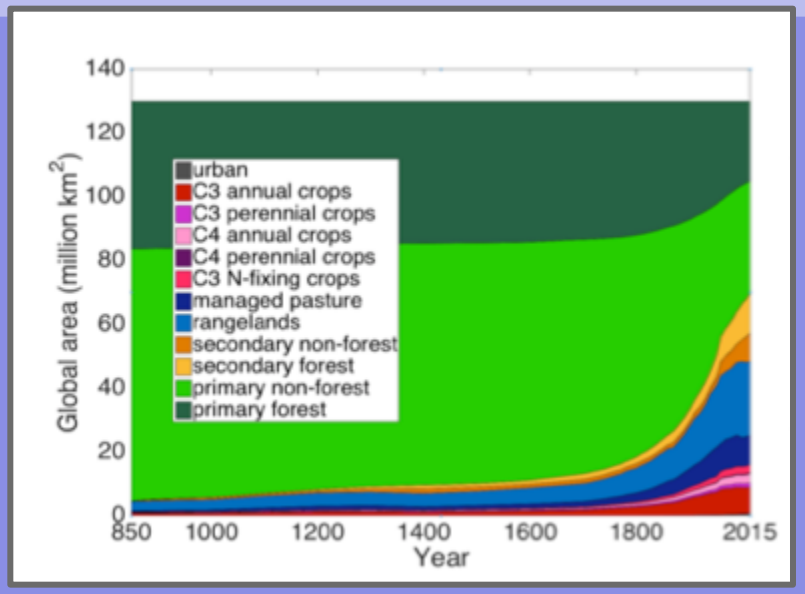
Additional focal topics

- Fossil fuel vs. land use change
- Biogeochemical vs. biogeophysical
- Land cover vs. land use change
- Modulation of LULCC impacts by land-atmosphere coupling strength
- Modulation of CO_2 fertilization by land use change
- Direct versus indirect impacts

Land Use Harmonization Dataset (LUHv2)

0.25° resolution
850 to 2100



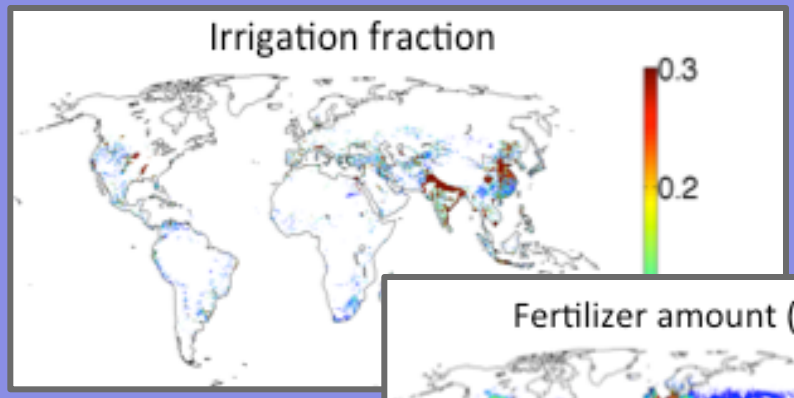


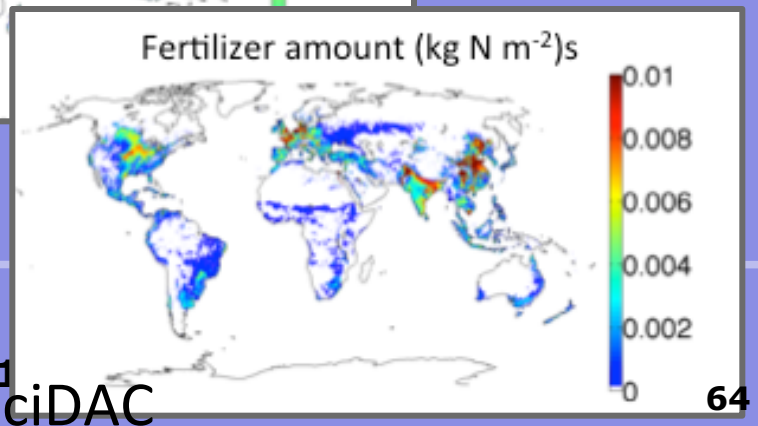
New History

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

New Management Layers

Agriculture
% cropland irrigated
% cropland flooded
% cropland fertilized (industrial)
Industrial Fertilizer
application rates
%cropland for biofuels
Crop rotations
Wood Harvest
% used for industrial products
% used for commercial biofuels





Land-Use Model Intercomparison Project (LUMIP)

Co-chairs: David Lawrence (NCAR) and George Hurtt (U. Maryland)

https://cmip.ucar.edu/lumip

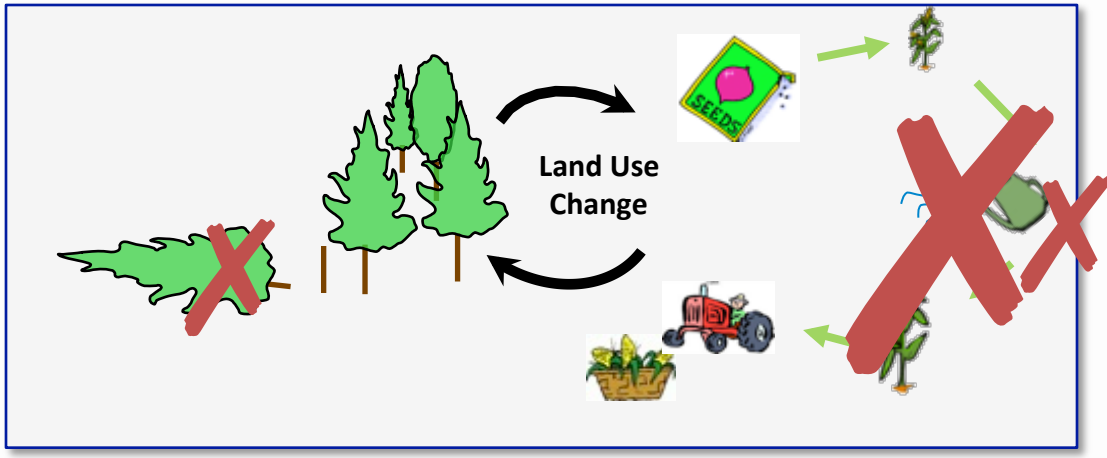
LUMIP
Land Use Change

Main Questions

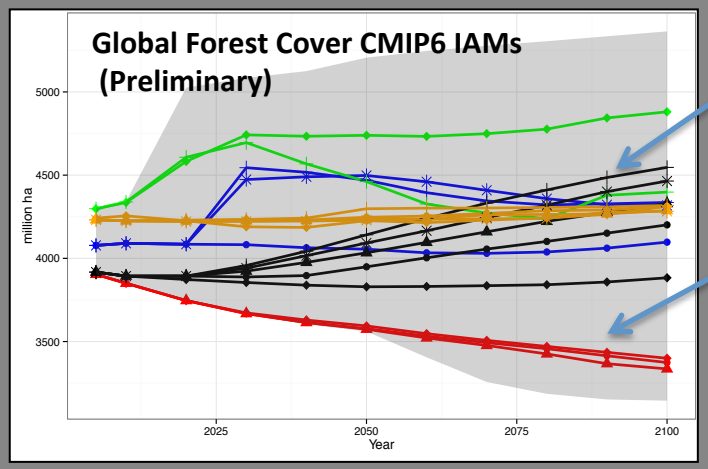
- What are effects LULCC on climate and biogeochemical cycling?
- What are the impacts of land management on surface fluxes of carbon, water, and energy and are there regional land-management strategies with promise to help mitigate against climate change?

Additional focal topics

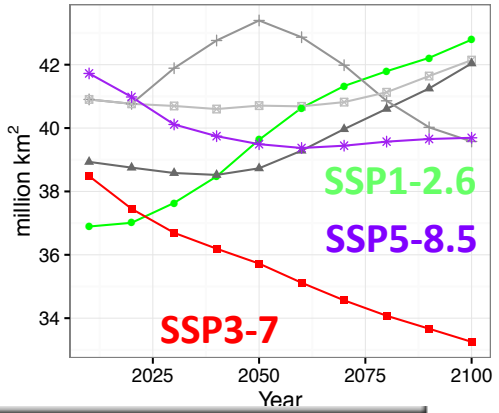
- Fossil fuel vs. land use change
- Biogeochemical vs. biogeophysical
- Land cover vs. land use change
- Modulation of LULCC impacts by land-atmosphere coupling strength
- Modulation of CO_2 fertilization by land use change
- Direct versus indirect impacts



ScenarioMIP C4MIP	SSP3-7 conc	SSP1-2.6 conc	SSP5-8.5 emis
LUMIP	Afforest_sens w/ SSP1-2.6 LU	Deforest_sens w/ SSP3-7 LU	Afforest_mitigate w/ SSP1-2.6 LU



Main Scenario	Land-Use Scenario: SSP1-2.6	Land-Use Scenario: SSP3-7	Land-Use Scenario: SSP5-8.5
SSP1-2.6	ScenarioMIP Conc.-driven	LUMIP Conc.-driven	
SSP3-7	LUMIP Conc.-driven	ScenarioMIP Conc.-driven	
SSP5-8.5	LUMIP Emissions-driven		C4MIP Emissions-driven ScenarioMIP Conc.-driven



Biogeophys climate impacts of LULCC; assess land mgmt for regional climate mitigation

Assess how LULCC impact differs at different climate change and CO_2 levels

Full effects of LULCC through both biogeophys and biogeochem processes

Effects of the climate-carbon cycle feedback on future CO_2 and climate change

LUMIP: Outline of Future Work

1. LUMIP is kicking off in 2017. CMIP6 and LUMIP model experiments will be conducted in 2017 into 2018.
2. LUMIP will host quarterly webinars to discuss implementation of LUH2 dataset and to coordinate analysis in 2017.
3. One or more meetings are being planned for 2018.

Project for the Intercomparison of Land Data Assimilation Systems (PILDAS)

1. GEOS-5 LDAS and NASA LIS systems have been configured to work for the PILDAS experiment; Results with LIS and Noah-MP LSM show good performance in an identical twin experiment setup
2. LIS based PILDAS environment is currently being extended to include the JULES LSM.
3. Dry-run with the two groups/systems (GEOS-5 & LIS) close to being complete
4. ECMWF off-line LDAS now ready. USDA plans to use an anticipated hire for supporting PILDAS.

PILDAS: Participants/Institutes/Contributions

1. NASA Global Modeling and Assimilation Office, NASA GSFC
2. Hydrological Sciences Lab, NASA GSFC

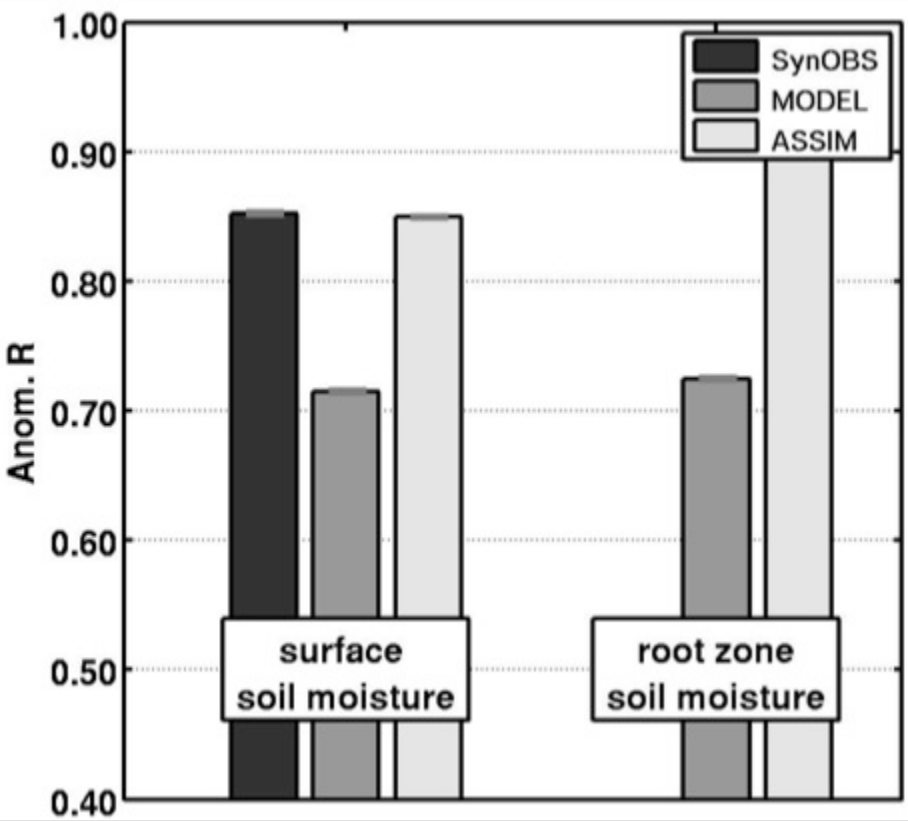
Others that will participate:

Institution	POC	Land model	DA method
ECMWF	P. de Rosnay, G. Balsamo	HTESSEL	EKF
Environment Canada	S. Belair, M. Carrera, B. Bilodeau	ISBA	EnKF
Ghent University	V. Pauwels, N. Verhoest	Toplats	(tbd)
Meteo-France	J.-F. Mahfouf	ISBA	EKF
Monash University	J. Walker	(tbd)	(tbd)
NASA/GMAO	R. Reichle, Q. Liu	Catchment	EnKF
NASA/Hydrological Sciences Lab	S. Kumar, C. Peters-Lidard	LIS models (Noah, Mosaic, CLM, Catchment, VIC, TESSEL, ...)	EnKF
NOAA/NCEP	M. Ek	Noah	EnKF
Norwegian Institute for Air Research (NILU)	W. Lahoz, T. Svendby	ISBA	EKF, EnKF
USDA/ARS Hydrology and Remote Sensing Lab	W. Crow	(tbd)	EnKF

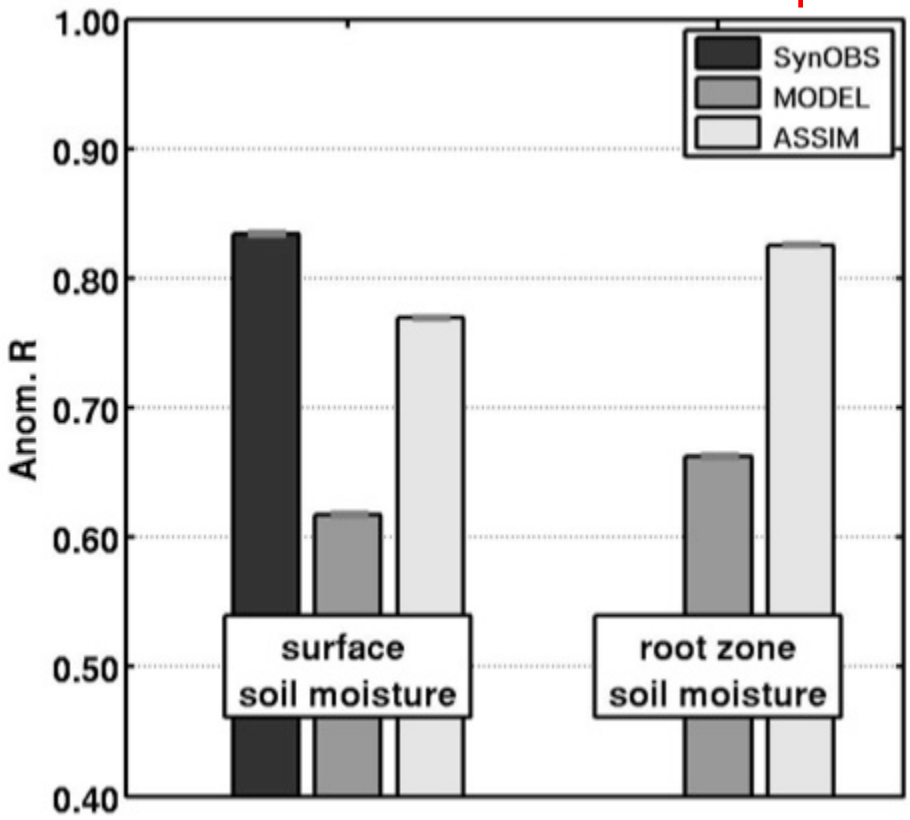
PILDAS: Summary of Current Work

PILDAS-1 Dry-Run (Anomaly R)

LDAS-1 + OBS-1
(vs. Truth-1)
"GEOS-5 **identical** twin exp."



LDAS-1 + OBS-2
(vs. Truth-2)
"GEOS-5 **fraternal** twin exp.



LDAS-1 = GEOS-5/EnKF + MERRA forcing
Truth-1, OBS-1 = GEOS-5/Catchment + NLDAS forcing
Truth-2, OBS-2 = LIS/Noah + NLDAS forcing

PILDAS: Outline of Future Work

1. The test setup with two groups required minimal changes to the PILDAS protocol.
2. Enable participation of the larger community (ECMWF, Environment Canada, USDA, NCEP,…)

ALMIP2 Project Overview/Goals:

ALMIP AMMA Land Surface Model Intercomparison Project Phase2

Leads : Aaron Boone (CNRM/Météo-France) and Christophe Peugeot (MSE, Univ. Of Montpellier, France) With J. Demarty & B. Cappelaere (MSE), M. Grippa & L. Kergoat (GET, Toulouse, France)

1. Which processes are missing or not adequately modeled by the current generation of LSMs over West-Africa (infiltration over crusted soils, plants with defensive water strategies, endorheic hydrology...)?

2. How do the various LSM respond to changing the spatial scale (three scales will be analyzed: the local, meso and regional scales)? The relation between meso and regional scales will be made using ALMIP Phase 1 Results.

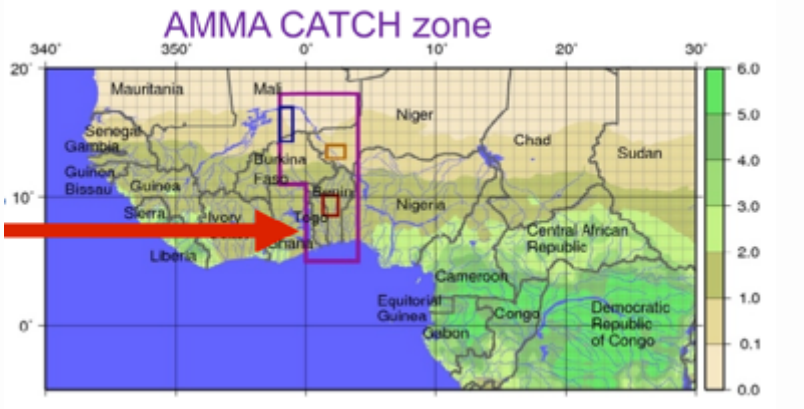
3. How can LSM simulate mesoscale hydrology given their relatively simple representation of such processes?

4. What are the impacts of uncertainties/differences in the precipitation on the surface fluxes and hydrological responses of the LSM models?

5. Can relatively simple LSMs simulate the vegetation response to the atmospheric forcing on seasonal time scale (for several annual cycles) for the diverse climates/vegetation covers?

ALMIP2 Participants/Institutes/Contributions: MANY!

A. Boone	ISBA-SURFEX	CNRM/Météo-France, Toulouse
J. Demarty	ISBA-SURFEX	MSE, Montpellier
B. Cappelaere		
M. Grippa	STEP	GET, Toulouse
L. Kergoat		
A. Ducharne	CLSM-UMPC	UMPC, Paris
S. Gascoin		CESBIO, Toulouse
F. Maignan	ORCHIDEE	LSCE, Paris
S. Ait-Mesbah		LSCE, Paris
J. Polcher		LMD, Paris
C. Ottlé	SETHYS	LSCE, Paris
D. Verseghy	CLASS	Env. Canada
E. Chan		
P. Harris	JULES	CEH, Wallingford (UKMO, Exeter)
C. Taylor		
G. Balsamo	HTESSEL	ECMWF, Reading
R. Koster	CLSM-NASA	NASA-GSFC, Greenbelt, MD
S. Mahanama		
S. Kumar	MOSAIC-LIS	NASA-GSFC
S. Kumar	NOAH-LIS	NASA-GSFC (NCEP)
O. Nasonova	SWAP	Inst. Of Water Problems, Moscow
Y. Gusev		
K. Tanaka	SiBUC	Kyoto Univ.
K. Shunji		
Y. Kazuaki		
A. Shmakin	SPONSOR	Inst. Of Geog., Moscow
V. Sokratov		
D. Turkov		
M.-H. Lo	CLM	National Taiwan Univ., Taipei
C. Peugeot	TOP-AMMA	MSE, Montpellier
A. Getirana	HyMap	NASA-GSFC, CNRM-Météo-France
T. Vischel	DHVSM	LTHE, Grenoble
T. Pellarin		



Data from :
M. Anderson & C. Hain (USDA)
ALEXI (Evap)

A. Kaptué & J.-L. Roujean
(CNRM-Météo-France)
ECOCLIMAP2

T. Vischel (LTHE)
Lagrangian-Krigged & Theissen Rainfall

Downwelling Radiation from the LAND-SAF
(processing by K. Ramage, IPSL, Paris)

Atmospheric state variables (ECMWF-fc)

Fluxes, discharge, rainfall,...
AMMA-CATCH Observational Network

73

ALMIP2 Summary:

- Currently in final analysis/publication phase : 10 papers in preparation for a special ALMIP2 collection in *J. Hydrometeor.*
- Surface fluxes scale reasonably well from 0.05 to 0.5 degrees, but runoff scales quite poorly. Huge discrpencies in models concerning surface (fast) runoff processes, and more pronounced as move northward (into semi-arid conditions)
- It is found that state-of-the-art land surface schemes still demonstrate considerable discrepancy each other, especially for semi-arid conditions and concerning runoff processes. This has a big impact on soil moisture (water budget), Bowen ratio, and discharge.
- Inter-model scatter > inter-annual variability
- Missing key processes (many semi-arid) specific to this region : significant interactions with groundwater, endoric processes, lateral fluxes (seasonal ponding), hydrophobic soils (crusting), deep rooting plants (dry season evap, more memory than cirrently being modeled?)

ALMIP2 Future:

- **This project is spinning down with a number of papers submitted in 2016.**
- ALMIP2 continues as a French initiative (within AMMA2), heavily dependent on AMMA-CATCH. Some new linked actions in the UK
- Model development required especially concerning endoric and lateral flow hydrological processes
- Aerosols : impact on water, energy and Carbon budgets (LAND-SAF initiative)
- Initiative to make an African LDAS
- Longer term : impact of identified physics in coupled GCMs – memory/feedbacks? Impact on WAM position/strength? Depends on progress with item 2 (above): for now, a possible national (France) Project (proof of concept).
- As follow on, in addition to GHP links to AMMA, it was suggested that sensitivity to surface forcing could be further investigated by expanding LoCo or DICE for the AMMA region.

GLASS Connections to Other Projects

Monsoons (interactions with CLIVAR): joint initiative of GEWEX & CLIVAR
-> Importance of land-atmosphere interactions within monsoons.

Seasonal to Sub-seasonal (S2S): joint initiative of WWRP and WCRP
-> Potential contribution of land to predictability on the S2S timescales.

MORE ON MONSOON AND S2S ON WEDNESDAY 08.30-09.00

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).
-> Other RHPs.

ILEAPS: biogeochemical cycles, land-atmosphere chemistry.
Cold Seasons Process: GHP, ILEAPS, CliC, ILEAPS focus on snow, frozen soils/permafrost, tundra, e.g. Saskatchewan & Mackenzie river basins.
WMAC: Promoting model development and coordination across WCRP.
WGNE: Data assimilation & process-level improvement to model physical parameterizations (e.g. PILDAS, PALS/PLUMBER, LoCo & DICE).
WMO: Other working groups, e.g. within WWRP.

GLASS Connections: GHP and others
Anthropogenic water mgmt in large scale models

- Potential for projects arising from joint GHP-GLASS workshop in Gif-sur-Yvette, October 2016.
- strategies for incorporation of relevant processes (without compromising conservation principles) were discussed.
  - E.g. order of incorporation reservoir, groundwater, irrigation, basin transfer…
- Reliant upon large-scale basins with enough available observational data to sufficiently constrain LSMs
  - Ebro and Murray-Darling basins were identified as possible candidates.
  - Remote sensing a necessary part of this effort.
- No specific projects yet…

WCRP Grand Challenges (GC) and GEWEX Grand Science Questions (GSQ)

WCRP engages the international climate research community in a number of Grand Science Challenges through community organized workshops, conferences strategic planning on:

- Melting Ice and Global Consequences
- Clouds, Circulation and Climate Sensitivity
- Carbon Feedbacks in the Climate System
- Understanding and Predicting Weather and Climate Extremes
- Water for the Food Baskets of the World
- Regional Sea-Level Change and Coastal Impacts
- Near-term Climate Prediction

www.wcrp-climate.org/grand-challenges/grand-challenges-overview

GEWEX Science Questions related to following research areas:

- Observations and Predictions of Precipitation
- Global Water Resource Systems
- Changes in Extremes
- Water and Energy Cycles and Processes

www.gewex.org/about/science/gewex-science-questions

Alignment with WCRP Grand Challenges (GC) and GEWEX Science Questions (GSQ)

	WCRP GC							GEWEX GSQ			
GLASS Projects	Melting Ice	Clouds, Circulation and Climate Sensitivity	Carbon Feedbacks	Weather and Climate Extremes	Water for Food	Regional Sea-Level Change and Coastal Impacts	Near-term Climate Prediction	Observations and Predict-ions of Precipitation	Global Water Resource Systems	Changes in Extremes	Water and Energy Cycles and Processes
PALS			✔	✔	✔		✔		✔	✔	✔
PLUMBER				✔	✔		✔		✔	✔	✔
ALMIP2		✔							✔		✔
PILDAS								✔	✔	✔	✔
GSWP3				✔	✔				✔	✔	✔
LS3MIP				✔	✔			✔	✔	✔	✔
Anthro Water		✔			✔				✔		✔
LUMIP			✔	✔	✔				✔	✔	✔
ILAMB			✔	✔	✔		✔		✔	✔	✔
SoilWat			✔	✔	✔		✔		✔	✔	✔
DICE		✔		✔				✔		✔	✔
LoCo		✔		✔				✔		✔	✔

Key science questions in the next 5-10 years (Taken from GLASS SSG-29 Report)

- **Land Impact**: Explore the impact of the land processes on Seasonal/Drought Prediction, and other high-impact "Earth System events" on society.

- **Common Interfaces:** common modular interface for LSMs (new ALMA), common land-atmosphere coupling modularity, continue improving benchmarking methods/tools/datasets for the community.

- **(Land) Model Developments/Improvements:** Improved cold season processes (interactions between permafrost and greenhouse gas emissions), ground water interactions, anthropogenic processes/water management (irrigation, aquifer uptake, crop harvest, improved LULCC), and the LSM "grey zone" (in anticipation of ever-higher resolution research and NWP applications: lateral fluxes of mass and energy), improved representation of soils and their highly heterogeneous nature.

- **How to most effectively improve our Earth System models?** Perhaps component-by-component with increasing levels of coupling, building to a fully-coupled system; a thorough "model development hierarchy" with benchmarks at each level. GLASS activities would be one part of that development chain, e.g. land-only studies and testing (e.g. PALS/PLUMBER), coupled columns (DICE), regional coupling (LoCo), and so on. This would require an extensive "data mining" effort, and in time a highly multi-discipline, but potentially quite fruitful.

GLASS Panel Membership

Co-Chairs:

Dr. Michael B. Ek
National Centers for Environmental Prediction
Environmental Modeling Center, NOAA/NWS
College Park, Maryland, USA
michael.ek@noaa.gov
January 2015-December 2018

Dr. Gab Abramowitz
Senior Lecturer and Postgraduate Coordinator
Climate Change Research Centre and
ARC Centre of Excellence for Climate System Science
UNSW Australia
gabsun@gmail.com / gabriel@unsw.edu.au
January 2017-December 2020

Gab Abramowitz, UNSW
Michael Ek, NCEP
Aaron Boone, CNRM-Météo France
Martin Best, UK Met Office
Nathan Brunsell, Univ. Kansas
Fei Chen, NCAR
Wade Crow, USDA
Paul Dirmeyer, George Mason Univ.
John Edwards, UK Met Office
Craig Ferguson, SUNY
Pierre Gentine, Columbia Univ.
Chiel van Heerwaarden, Wageningen Univ. (YS)
Hyungjun Kim, Univ. Tokyo
Sujay Kumar, NASA
Lifeng Luo, Michigan State Univ.
Taikan Oki, Univ. Tokyo
Christa Peters-Lidard, NASA
Andrew Pitman, UNSW
Rolf Reichle, NASA
Matt Rodell, NASA
Patricia De Rosnay, ECMWF
Joshua Roundy, Univ. Kansas (YS)
Joseph Santanello, NASA
Sonia Seneviratne, ETH
Tomo Yamada, Hokkaido Univ.
Recent invitations:
Martyn Clark, NCAR
Aude Lemonsu, CNRM-Météo France
Martin De Kauwe, UNSW
LoCo WG members
Benoit Guillod, ETH
Patricia Lawston, NASA
Benjamin Lintner, Rutgers Univ.
Ahmed Tawfik, NCAR

Uh oh! These surface fluxes don't look so good.

Ugh! Look at the hydrology in this thing! It's leaking everywhere!

...you're going to need an atmospheric alignment to get the right interactions.

...and its carbon output is way too high...

Atmospheric modellers: But I like it like this... I don't want to have to recalibrate my driving variables (...what about my forecast metrics..!?) how much will this cost?!

Well... at least several more funding cycles. Best book it in for regular servicing.