GEWEX
Global Land/Atmosphere System Study (GLASS)

Aaron Boone (CNRM, Météo-France)
Michael Ek (NCEP/EMC)
GLASS Co-chairs
GLASS panel members and other GEWEX collaborators

GEWEX Scientific Steering Group meeting (SSG-28)
Zurich, Switzerland, 25-28 January 2016

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.

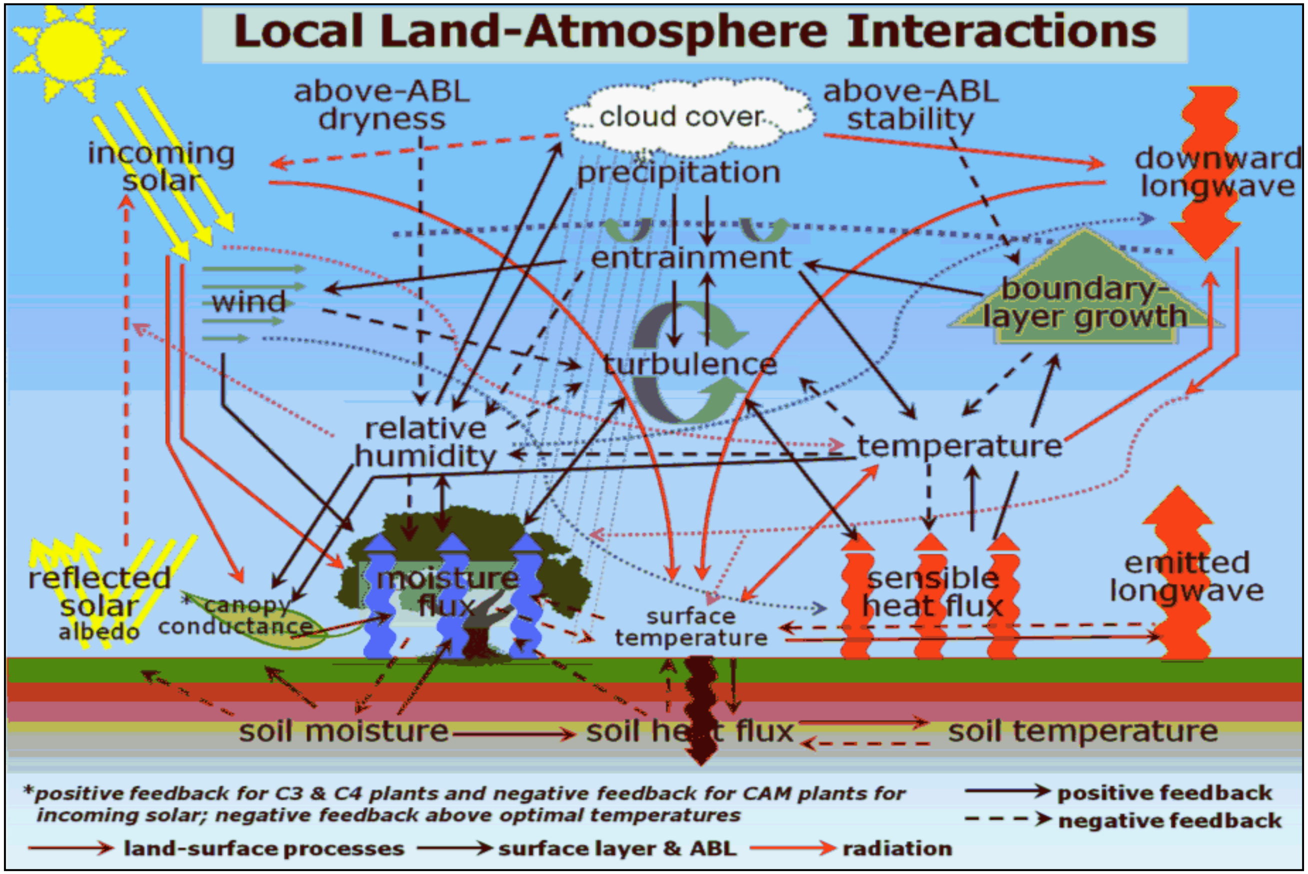


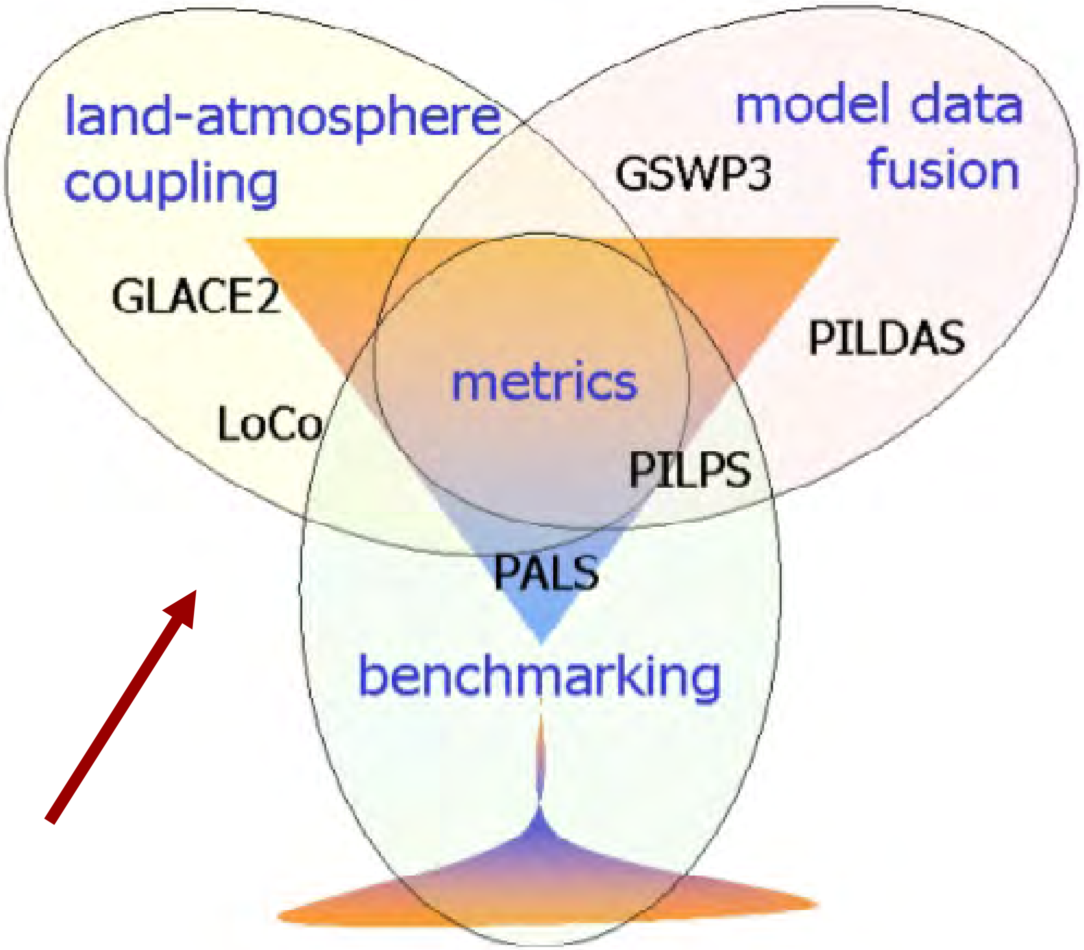
Fig. 3.1. Schematic of the complex interactions between the land surface, atmospheric boundary layer (ABL), and radiation via many variables (temperature, relative humidity, wind and associated turbulence, cloud cover, etc). Adapted from Ek and Holtslag (2004 J. Hydromet., 5, 86-99), courtesy Mike Ek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

Global Land/Atmosphere System Study (GLASS)

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:

PALS-PLUMBER	The PALS Land sUrface Model Benchmarking. Evaluation pRoject
ALMIP2	AMMA Land surface Model Intercomparison Project phase 2
GLACE-CMIP5	Global Land Atmosphere Coupling Experiment – Coupled Model Intercomparison Project
DICE	DIurnal land/atmosphere Coupling Experiment
LUCID	Land-Use and Climate, Identification of Robust Impacts
PILDAS	The Project for the Intercomparison of Land Data Assimilation Systems
GSWP3	Global Soil Wetness Project phase3
LoCo	Local (land-atmosphere) Coupling
GABLS4	GEWEX Atmospheric Boundary Layer Study (Dome C, Antarctica)
LS3MIP	Land surface, snow, and soil moisture MIP (CMIP6)
GSW	GEWEX Soils and Water initiative

Water Management in Models - Anthropogenic Influences on Global Water Cycle

GLASS Projects: cross-cuts

Cross-Cutting projects/actions:

PALS-PLUMBER – Land model benchmarking, future planned links to GHP, GSWP3

ALMIP2 – West Africa monsoon region, links to GHP

GLACE-CMIP5 – land surface adding to predictability (heritage to LS3MIP)

DICE – Land-atmosphere interaction, links to GASS

LUCID – Land use/change, links to iLeaps

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.

GSWP3 – Offline 20C runs, Links to carbon community (iLeaps), LMIP (CMIP6)

GABLS4 "*DICE-over-ICE*" – land-atmosphere interaction (stable BL-Antarctica), links to GASS

Water Management in Models –Anthropogenic influences : Irrigation, dams, reservoirs, groundwater...) links with GHP

GSW - datasets, improved processes (interactions with atmosphere?) potential links with GDAP, GHP

PILDAS: Project Overview/Goals/Objectives

Leads:

Rolf Reichle (NASA/GSFC)
Jean-François Mahfouf (CNRM/Météo-France)
Qing Liu (NASA/GSFC)

1. Enable better communication among developers of land data assimilation systems (LDAS).
2. Develop and test a framework for LDAS comparison and evaluation.
3. Compare land assimilation methods, e.g. EnKF, EKF, etc.
4. Conduct sensitivity studies of assimilation input parameters, such as model and observation errors.
5. Provide guidance and priorities for future land assimilation research and applications.
6. Ultimately, produce enhanced global datasets of land surface fields for model initialization.

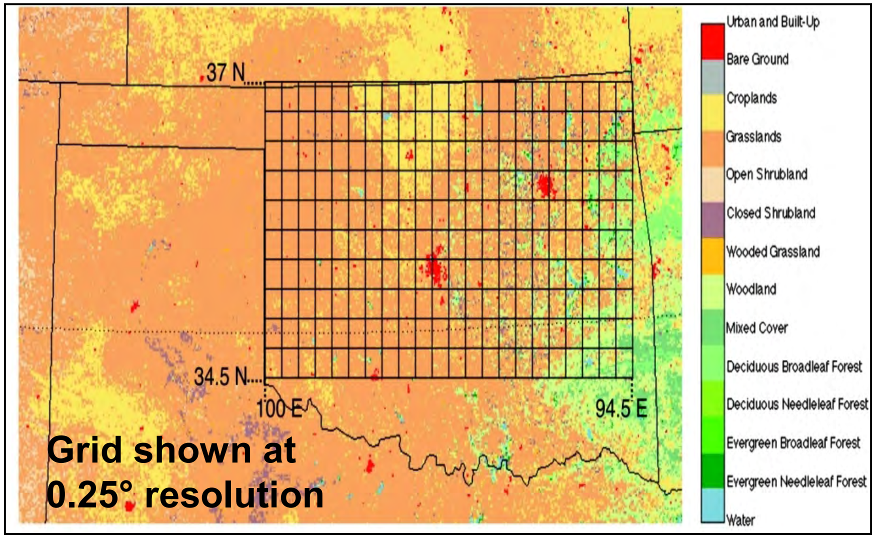
PILDAS: Participants/Institutes/Contributions

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

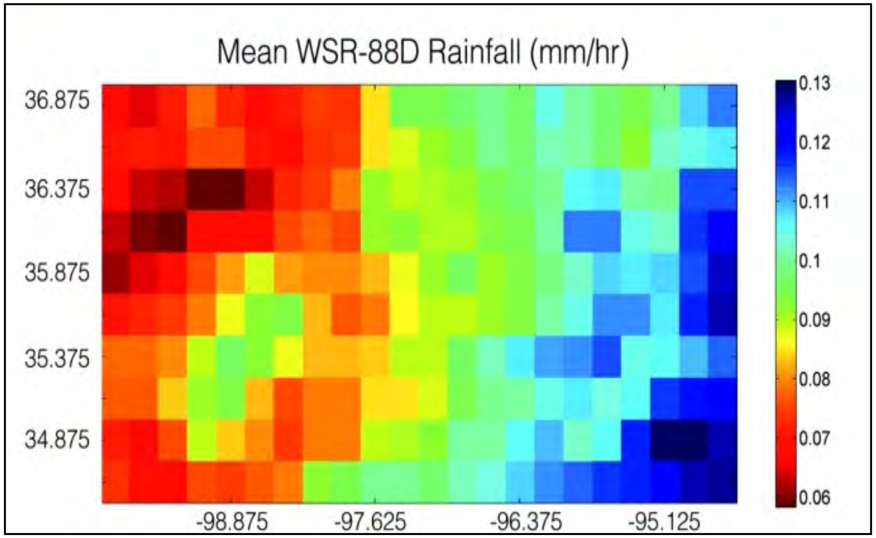
PILDAS: Experiment Domain

Tentative experiment setup:

- Domain: 34.5°-37°N, 100°-94.5°W
- Exchange grid: 0.125 deg lat/lon
- Duration: 2001-2011



Annual mean precipitation [mm/h]



- Forcing data provided and LDAS output is expected on exchange grid.
- Participating systems may run on their native modeling/assimil grids.
- Participating systems use native model parameters (land cover, soil texture, vegetation,etc).

PILDAS: Status of Current Work Plan

1. PILDAS launch delayed into 2015, slowly spinning up in 2016 (Lead PI is on the SMAP science team).
2. The experimental design essentially complete, with pilot study by project leads using two land-surface models with one DA algorithm in NASA's Land Information System (LIS).
3. Delays also due to modifications to the ALMA model output convention made by GLASS panel requiring considerable software updates (still ongoing).
4. Recent progress at ECMWF (P. de Rosnay) and USDA (Wade Crow):
   - obtained PILDAS forcing data from NASA/GMAO.
   - working to set up their systems to read forcing data and generate their versions of the "truth" data set.
   - expected completion time of this phase sometime in winter or spring of 2016.

PILDAS: Future Work

1. Phase-1 still focused on operational centers (rather than specific research projects), use of synthetic obs, and different DA algorithms with different LSMs for a 1/8-degree domain over the Southern Great Plains (US).
2. GLASS will take the experimental plan and initial results to WGNE (which has interest in land DA) to entice other centers not currently participating, e.g. from Asia.
3. Later phases will focus on coupled DA systems and use of actual satellite observations from SMOS and SMAP.
4. NASA Pis will continue to lead the effort and make initial experiments in the next phases of PILDAS.

Diurnal land/atmosphere coupling experiment (DICE)

Project started April 2013 to *study the interactions between the land-surface & atmospheric boundary layer*.

- Leads: Adrian Lock, Martin Best (UKMO).
- Joint activity between GLASS (land-surface modellers) and GASS (atmospheric boundary-layer modellers).
- 12 models participating.
- Follow-on to GABLS-2, where land-atmosphere coupling was identified as a important mechanism.

CASES-99 Experiment (Southern Great Plains, USA)

Workshops:

- 1st: 14-16 Oct 2013, UK Met Office.
- 2nd: 14-18 Jul 2014, GEWEX conf./Neth.
- 3rd: 20-22 May 2015, Météo-France.

GASS GEWEX WCRP Global Atmospheric System Studies

Manuscript in preparation (for JHM).

http://appconv.metoffice.com/dice/dice.html

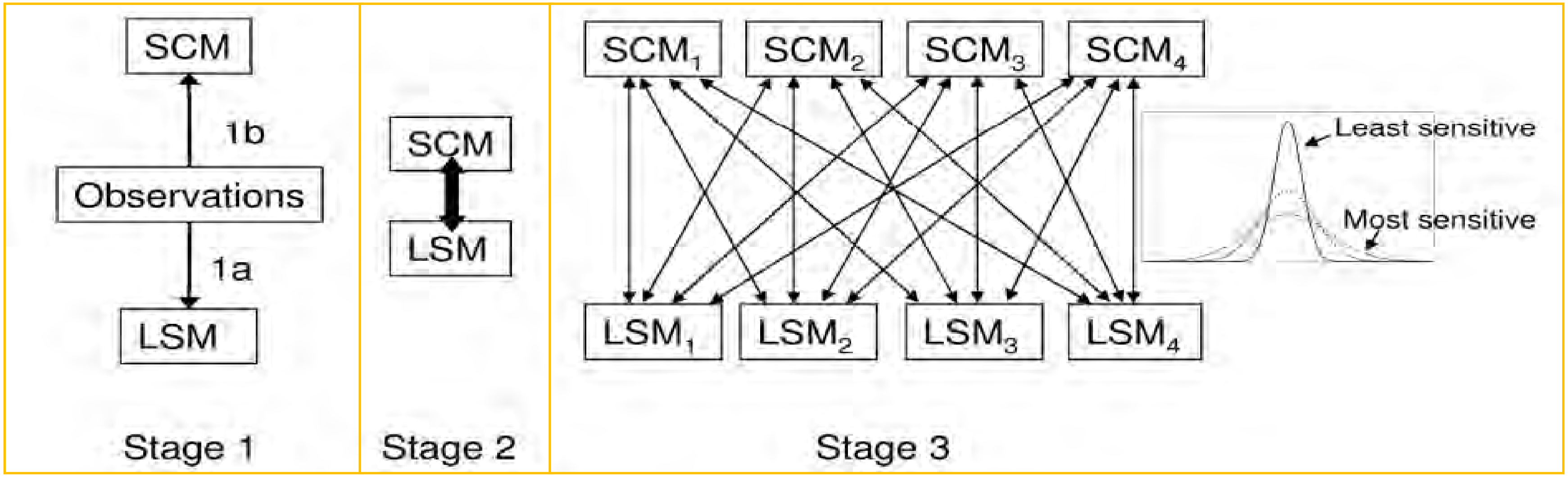
DICE-GABLS: Participants/Institutes/Contributions

Model	Contact scientist	Institute	Stages submitted	Levels	Sensitivity tests
Arome	Eric Bazille	Meteo France	All	60/70	resolution
Arpege	Eric Bazille	Meteo France	All	60/70	resolution
ECEARTH	Reinder Ronda	Wageningen	SCM only	91	LAI
GDPS3.0	Ayrton Zadra	CMC	All	79	
GFDL	Sergey Malyshev	Princeton	All	24	
GISS_E2	Ann Fridlind, Andy Ackerman	GISS	All	40	
IFS/HTESSEL	Irina Sandu, Gianpaolo Balsamo	ECMWF	All	137	LAI
MESO_NH	Maria Jimenez	UIB	All	85	Bare soil
UM/JULES	Adrian Lock, Martin Best	Met Office	All	70	Vegetation
WRF-NOAH	Weiguo Wang	NUIST	All	60	Lots!
WRF	Wayne Angevine	NOAA	?	119	PBL scheme
CAM5, CLM4	David Lawrence	NCAR	1a, 1b	?	
PBCM	Pierre Gentine	Columbia	Not yet		

DICE Experimental Design

Objective: Assess impact of land-atmosphere feedbacks.
Stage 1: stand alone land, and single column model (SCM) alone.
Stage 2: Coupled land-Single Column Model (SCM).
Stage 3: Sensitivity of LSMs and SCMs to variations in forcing.

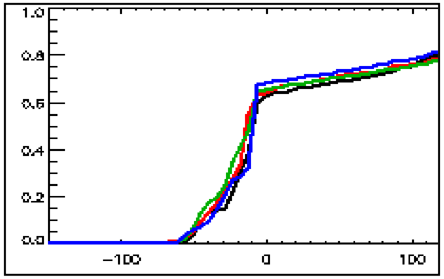
Data Set: CASES-99 field experiment in Kansas, 23-26 Oct 1999 using 2.5 days and 3 nights with intermittent turbulence (night one), continuous (two), radiatively-driven/no turbulence (three).

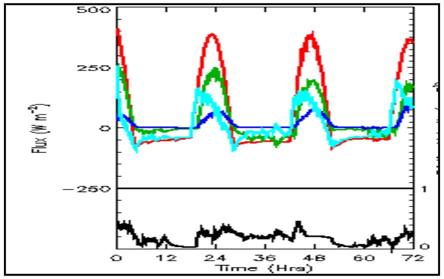


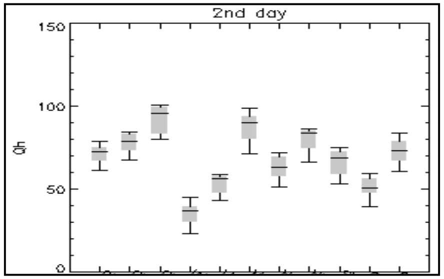
Martin Best and Adrian Lock (UKMO) et al.

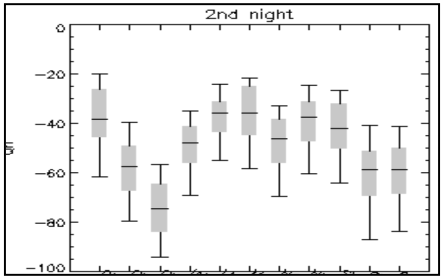
DICE Status/Summary

- 12 pages and 80 figures of results for stages 1, 2, 3!
- 9-year spin-up for LSMs.
- SCM: no relaxation of time-varying geostrophic wind (uniform with height); subsidence of T,q; horizontal advection of T,q,wind; radiation switched on in all simulations.
- Stage 1a (LSM): LHF generally far too large (LSMs didn't account for dead grass, adversely affecting bowen ratio); SHF and stress too large at night; 55m forcing too high for LSMs (vs 10m) especially for stable nighttime conditions.
- Stage 1b (SCM): Difficulty with wind profiles, particularly 1st night (intermittent turbulence); large differences in daytime parameterized entrainment; potential inaccuracy of (prescribed) large-scale forcing; SCM generally can be forced by observed fluxes and stresses.









DICE Status/Summary (page 2)

- Stage 2 (LSM+SCM): excessive drag from LSMs generate deeper/less stratified SBLs; soil-surface coupling sensitivity at night; daytime PBL differences dominated by LSM surface fluxes, with RH dominated by SHF; more spread in PBL moisture; daytime PBL temperature evolution a "slave" to surface fluxes with PBL moisture more complicated.
- Stage 3a (LSM ensemble spread due to PBL variability forcing): largest variation in SHF during day & at night for more continuous turbulence.
- Stage 3b (PBL ensemble spread due to LSM variability forcing): day-time PBL: T, q dominated by sfc fluxes with variability between different SCMs similar, but sensitivity of inversion height very different.
- *Summary: surface momentum flux and momentum profiles should be examined by DICE community; large errors in evaporation may dominate signal and the impact of coupling; further examine nocturnal fluxes and boundary layers and soil-surface coupling sensitivity.*
- *Repeat for many other sites (DICEs), e.g. GABLS project for Antarctica: GABLS4 or "DICE-over-ICE" (next page).*
- *Differences in different models' (LSM+SCM) sensitivity to changes in forcing are likely important in GCMs; needs to be better understood.*

GABLS4: "DICE-over-ice"

Project started in 2015 to *study the interactions between the ice/snow-surface & atmospheric boundary layer under conditions of strong stability*.

Leads: E. Bazile, F. Couvreux, P. Le Moigne (Météo-France)

- Joint activity between GLASS and GASS.
- Several models/centers participating.
- Follow-on to earlier GABLS studies with focus on very stable conditions, and a surface with low conductivity and high cooling potential over snow/glacier, and following the earlier DICE experimental design, as well as including LES studies.

•Initial results presented at GABLS4-DICE Workshop, 20-22 May 2015, Météo-France.

Dome C - Antarctica
(Southern Great Plains, USA)

http://www.cnrm.meteo.fr/aladin/meshtml/GABLS4/GABLS4.html

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"!

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 average, it rains most on days with high soil moisture". Courtesy: 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).

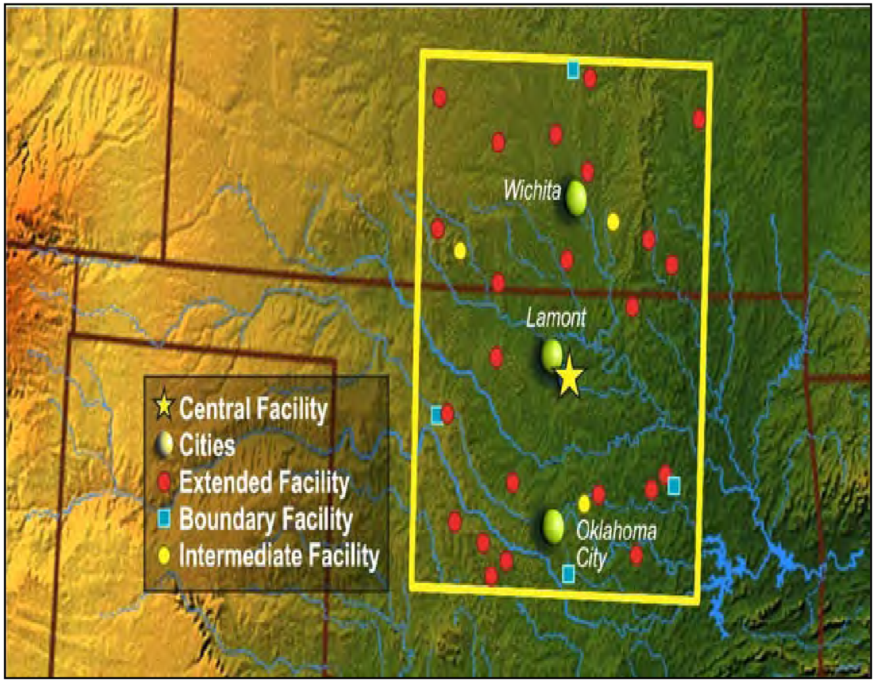
LoCo-SGP (Southern Great Plains) Testbed

"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.

The Plumbing of Land Surface Models

PALS Land sUrface Model Benchmarking Evaluation pRoject (PLUMBER, Best et al 2015):

- Undertook a multi-model examination of LSMs in the context of defined metrics.
- Examined performance of 13 LSMs consisting of variants from 8 distinct models at 20 flux tower sites worldwide.
- Assessed performance using four common metrics.

Martin Best, Gab Abramowitz, et al, 2015: The Plumbing of Land Surface Models: Benchmarking Model Performance. *J. Hydrometeor.*, **16**, 1425–1442. doi: http://dx.doi.org/10.1175/JHM-D-14-0158.1.

M. J. Best, G. Abramowitz, H. R. Johnson, A. J. Pitman, G. Balsamo, A. Boone, M. Cuntz, B. Decharme, P. A. Dirmeyer, J. Dong, M. Ek, Z. Guo, V. Haverd, B. J. J. van den Hurk, G. S. Nearing, B. Pak, C. Peters-Lidard, J. A. Santanello Jr., L. Stevens, and N. Vuichard, 2015: The Plumbing of Land Surface Models: Benchmarking Model Performance. *J. Hydrometeor*, 16, 1425–1442.
doi: http://dx.doi.org/10.1175/JHM-D-14-0158.1

The Plumbing of Land Surface Models: Benchmarking Model Performance

M. J. Best,[a] G. Abramowitz,[b] H. R. Johnson,[a] A. J. Pitman,[b] G. Balsamo,[c] A. Boone,[d] M. Cuntz,[e] B. Decharme,[d] P. A. Dirmeyer,[f] J. Dong,[g] M. Ek,[g] Z. Guo,[f] V. Haverd,[h] B. J. J. van den Hurk,[i] G. S. Nearing,[j] B. Pak,[k] C. Peters-Lidard,[j] J. A. Santanello Jr.,[j] L. Stevens,[k] and N. Vuichard[l]

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[c] *ECMWF, Reading, United Kingdom*

[d] *CNRM-GAME, Météo-France, Toulouse, France*

[e] *Helmholtz Centre for Environmental Research–UFZ, Leipzig, Germany*

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[k] *Oceans and Atmosphere Flagship, CSIRO, Aspendale, Victoria, Australia*

[l] *Laboratoire des Sciences du Climat et de l'Environnement, UMR 8212, IPSL-LSCE, CEA-CNRS-UVSQ, Gif-sur-Yvette, France*

Abstract

The Protocol for the Analysis of Land Surface Models (PALS) Land Surface Model Benchmarking Evaluation Project (PLUMBER) was designed to be a land surface model (LSM) benchmarking intercomparison. Unlike the traditional methods

The Plumbing of Land Surface Models: II

"PLUMBER II" (Haughton et al 2015)
Examined whether:
- Metrics or sites influenced results.
- Results change according to time-scale aggregation.
- Lack of energy conservation in flux SITE data gives empirical models advantage.

Findings:
- **Energy conservation** in observational data **not responsible** for result.
- **Partitioning** between sensible and latent heat fluxes in LSMs, rather than the calculation of available energy, is the cause of the original findings.
- Nature of **partitioning problem likely shared** between all contributing LSMs.

N. Haughton, G. Abramowitz, A. J. Pitman et al, 2015: The plumbing of land surface models: why are models performing so poorly? *J. Hydrometeor*. (submitted).

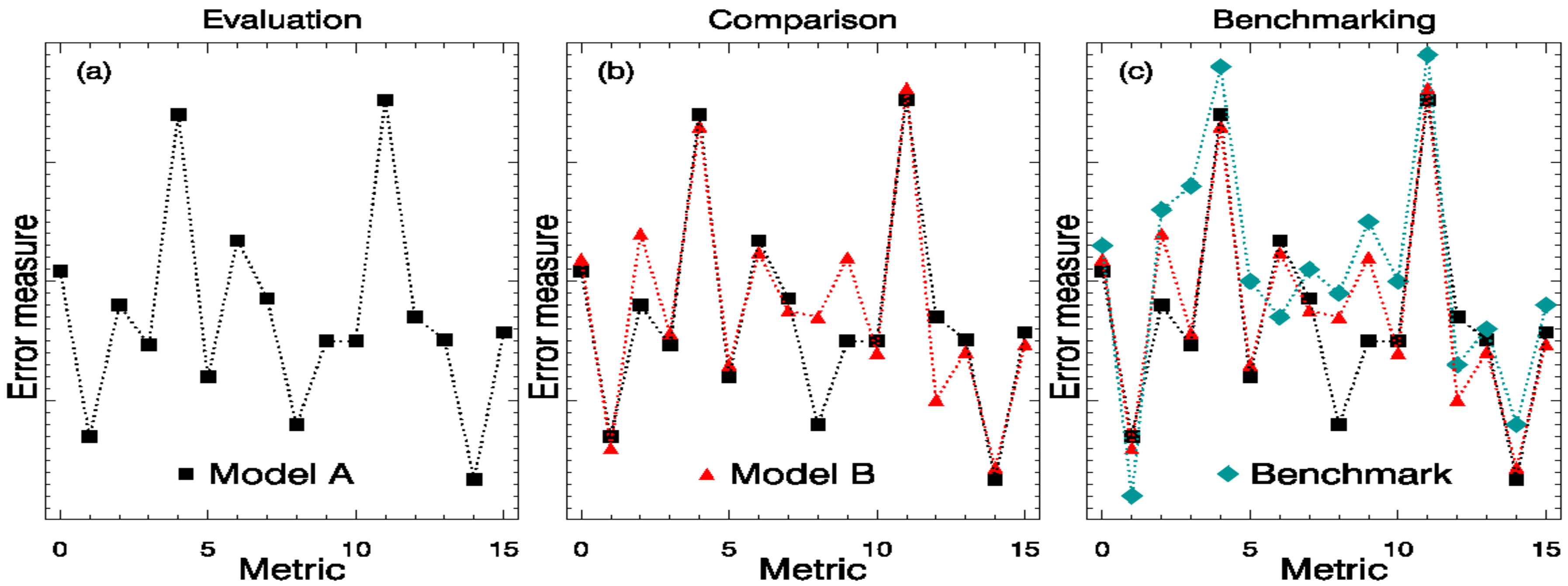
The plumbing of land surface models: why are models performing so poorly?

Submitted 3 September 2015

Ned Haughton AND Gab Abramowitz AND Andy J. Pitman AND Dani Or AND Martin J. Best AND Helen R. Johnson AND Gianpaolo Balsamo AND Aaron Boone AND Matthias Cuntz AND Bertrand Decharme AND Paul A. Dirmeyer AND Jairui Dong AND Micahel Ek AND Zichang. Guo AND Vanessa. Haverd AND Bart J. J. van den Hurk AND Grey S. Nearing AND Bernard Pak AND Joe A. Santanello Jr. AND Lauren E. Stevens AND Nicolas Vuichard

ARC Centre of Excellence for Climate Systems Science

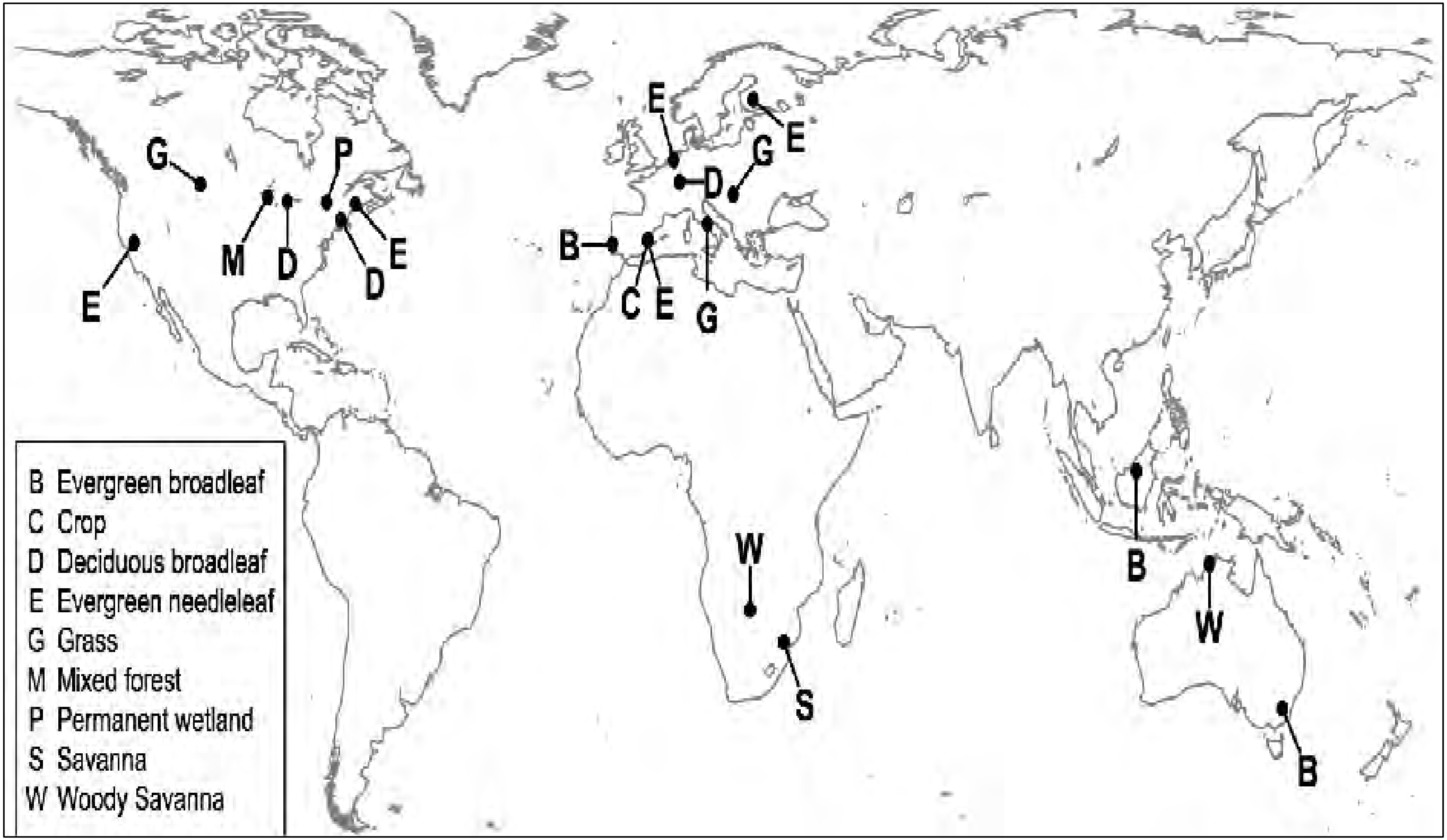
PALS-PLUMBER: Land Model Benchmarking

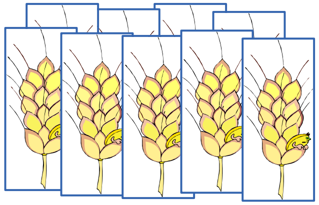


Reminder: ***Evaluation & Comparison versus Benchmarking***

- Evaluation & Comparision: Run model and compare output with observations or another model, & ask: *How good is the model?*
- Benchmarking: Decide how good model needs to be, run model and ask: *Does model reach the (benchmark) level required?*

PALS-PLUMBER: PLUMBER Fluxnet Sites

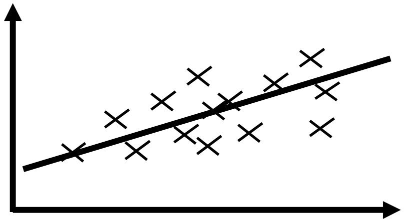




Penman-Monteith
(well-watered)

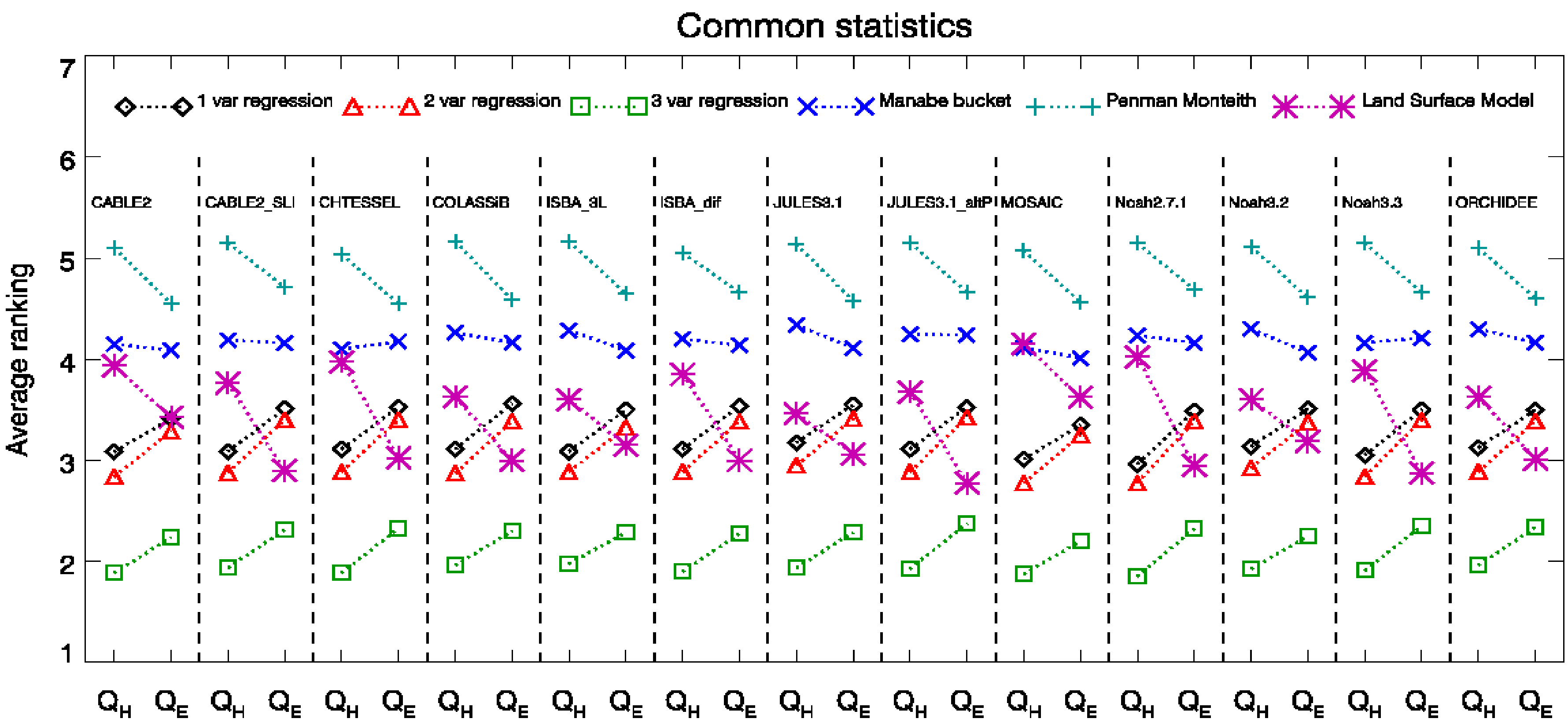
Manabe bucket model

Linear regressions



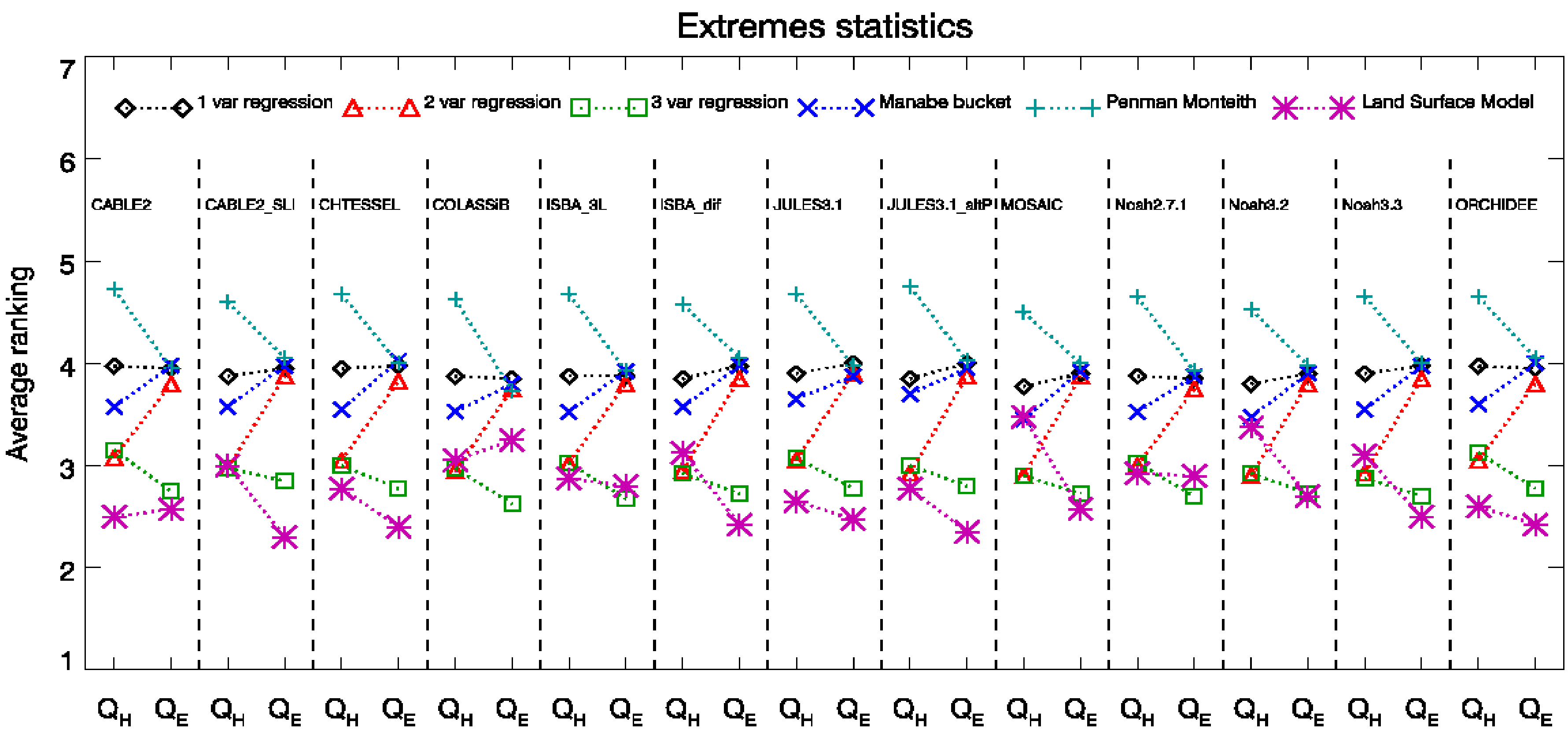
- Linear 1 var: $S_{W\downarrow}$
- Linear 2 var: $S_{W\downarrow}$, T_a
- Piecewise linear 3 var: $S_{W\downarrow}$, T_a, q_a

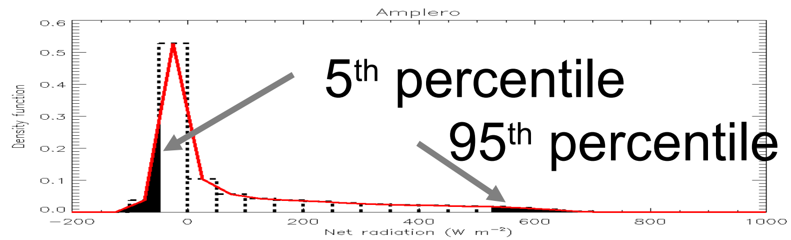
Benchmarking Against Common Statistics



Mean Bias Error	MBE
Normalised Mean Error	NME
Standard Deviation	sd
Correlation coefficient	r

Benchmarking Against Common Extremes





PALS-PLUMBER: PALS Updates

The Protocol for the Analysis of Land Sfc models (PALS):

- Web-based database of model simulation and observational land surface datasets.
- Integrated diagnostic analysis tools (Abramowitz 2012).
- Instrumental in introducing standardised benchmarking into the field of land surface model intercomparison.

"Experiment" structures-internal PALS structuring allows:

- Either *point-based, catchment-based, regional or global experiments*.
- Each experiment defined by resolution, grid and evaluation variable(s).
- All analysis controllable/editable by experiment owner–no coding need.

User-defined benchmarks:

- Allow users to specify benchmarks other than empirical models (up to 3), e.g. previous model versions, other models internationally where they have completed experiments for which benchmarks are requested.

Report generation facility:

- Create tables of scalar metrics comparing model with its nominated benchmarks for all experiments where benchmarks are available.
- Useful for model development and management.

PALS-PLUMBER: PALS Future

So far in 0.5 degree format (for PALS/Global GSWP3 Grid):

- LandFlux ET.
- GLEAM ET.
- MODIS ET.
- MPI Jena ET, NEE.
- MODIS Vis, NIR albedo.
- For both Global and Australia.

Currently working on:

- Including QA/QC information in plots.
- Plot class that incorporates all related (e.g. ET) products at same time.
- How best to incorporate runoff or streamflow constraint.

The difficulty is not producing these plots, it is doing so reliably in an automated system.

Future:

- Additional variables and metrics, e.g. land state validation, surface-layer turbulence/momentum stress, land-atmosphere coupling.
- “Mirror” PALS web site elsewhere, e.g. NCAR/NOAA, NASA.

ALMIP2 Project Overview/Goals :

ALMIP AMMA Land Surface Model Intercomparison Project Phase2

CATCH

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?

Participants/Institutes/Contributions

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		

AMMA CATCH zone

<u>Data from :</u>
M. Anderson & C. Hain (USDA)
ALEXI (Evap)

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

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

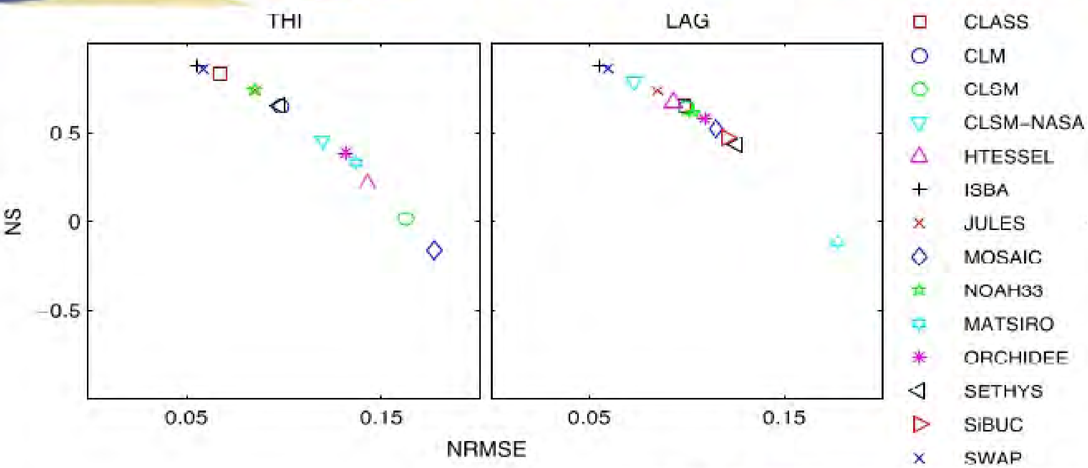
Downwelling Radiation from the LAND-SAF
(processing by K. Ramage, IPSL, Paris)

Atmospheric state variables (ECMWF-fc)

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

Examples/Samples Of Current Work

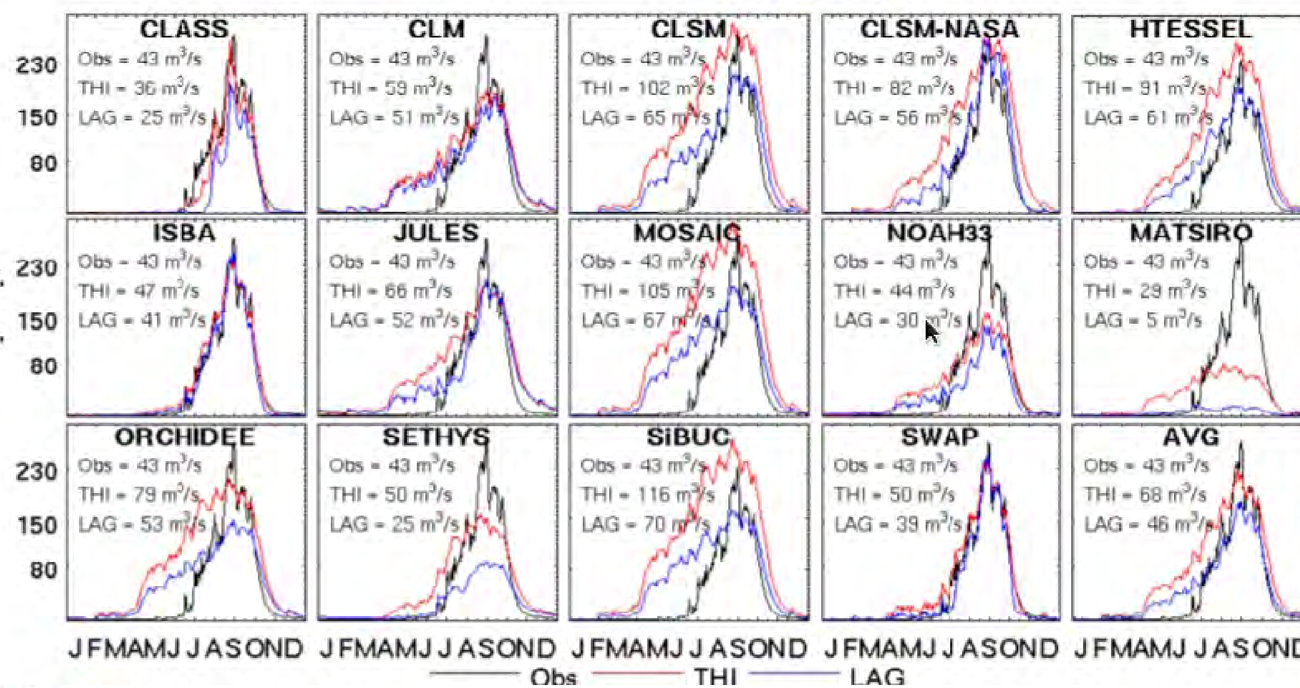
ALMIP AMMA Land Surface Model Intercomparison Project **Phase 2**



After optimization of streamflow parameters, the LAG (Lagrangian krigged) rainfall performs better than the THI (Thiessen) input

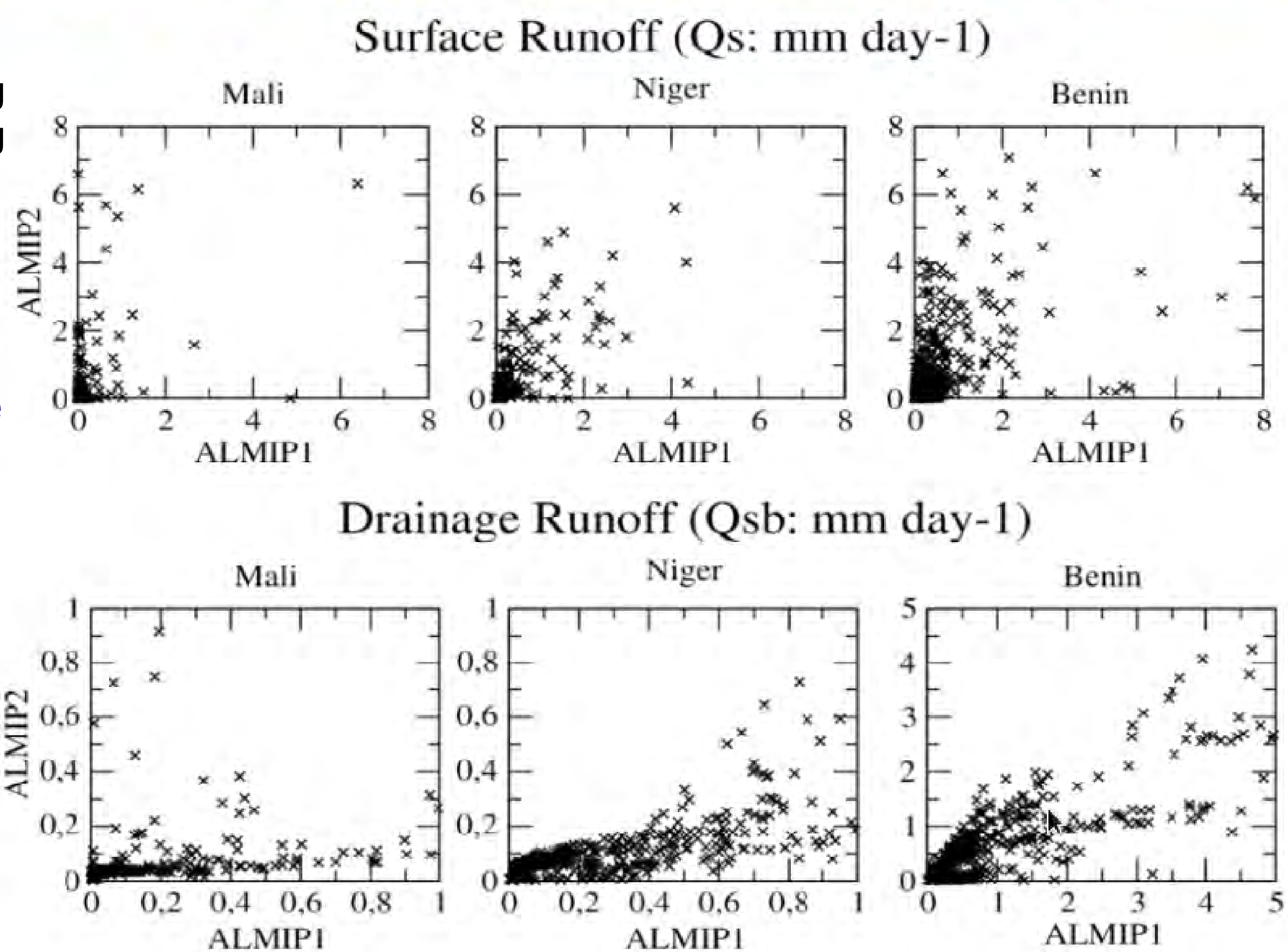
2005-2008

Daily discharge (at Beterou) for the THI and LAG rainfall inputs after optimization



Getirana et al., 2016, for *J Hydromet*

Examples/Samples Of Current Work



ALMIP1 0.50 deg
ALMIP2 0.05 deg

LSMs are highly scale dependent (rainfall intensity and duration) via surface runoff processes

Summary of Current Work

- 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?)

Outline of Future Work

- 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)

Global Soil Wetness Project phase 3 (GSWP3) Project

Overview/Goals

[1,2]Hyungjun Kim, [3]Satoshi Watanabe, [4]Eun-Chul Chang,
[1,4]Kei Yoshimura, [3]Yukiko Hirabayashi, [2]James Famiglietti, and [1]Taikan Oki

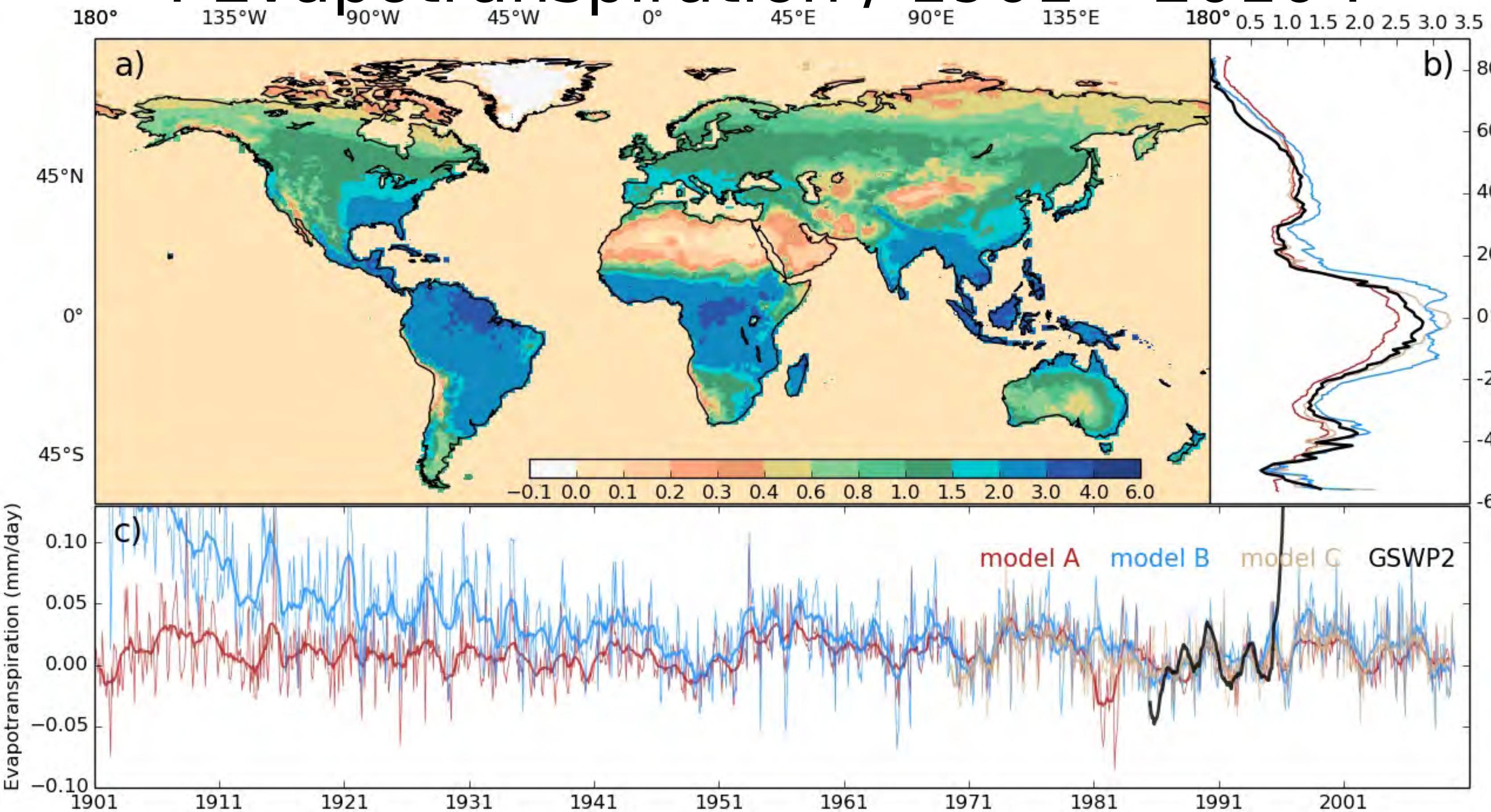
[1]Institute of Industrial Science, The University of Tokyo, Tokyo, Japan
[2]Univserity of California Center for Hydrologic Modeling, Irvine, California, USA
[3]Institute of Engineering Innovation, The University of Tokyo, Tokyo, Japan
[4]Atmosphere and Ocean Research Institute, The University of Tokyo, Tokyo, Japan

1. What will be the balances and variability of the hydro-energy-eco system over land in 20th and 21st centuries?
2. How the interactions between natural processes have changed through long-term period under changing climate in Anthropocene?
3. How do state-of-the-art land surface models perform and can be improved?

Participants/Institutes/Contributions

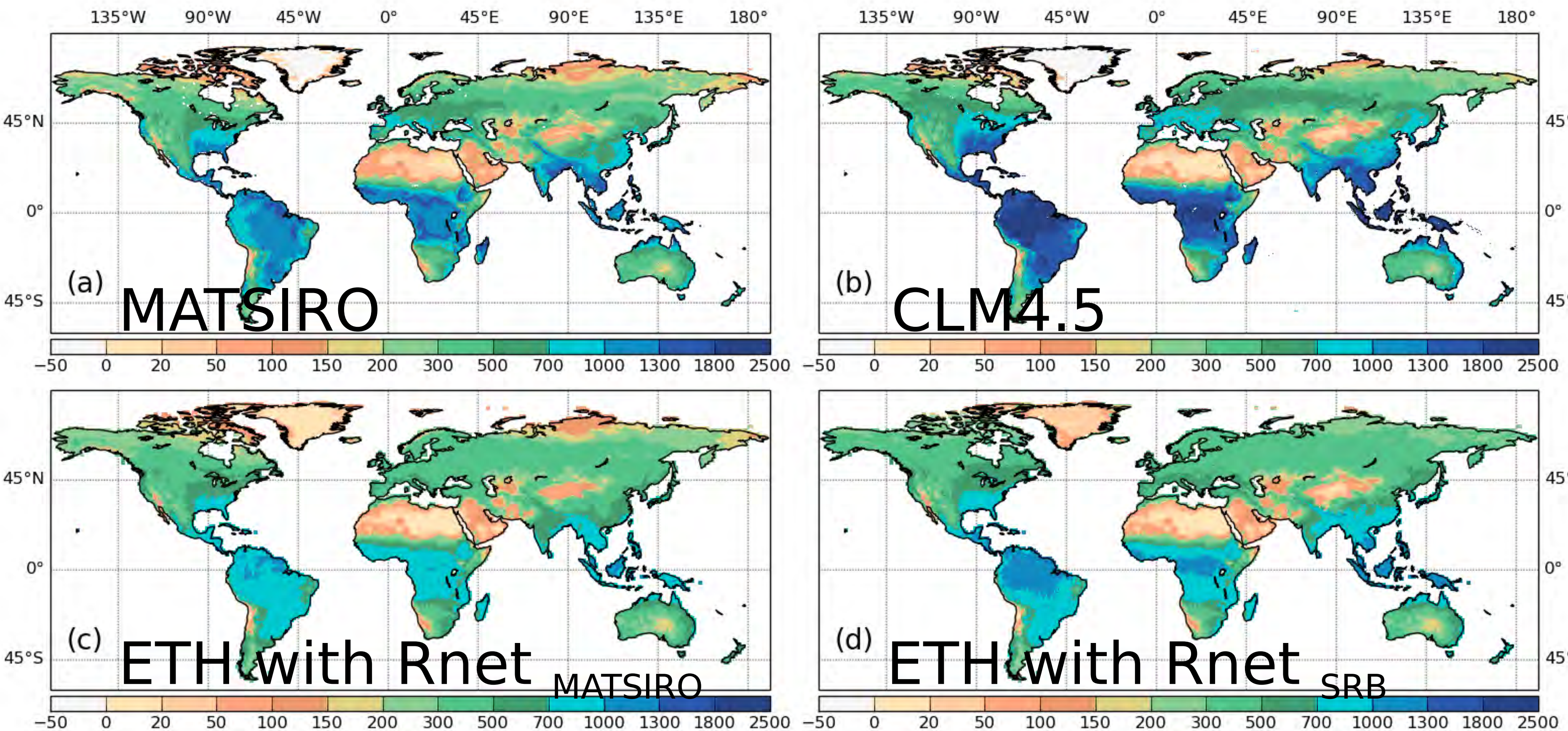
MODEL	INSTITUE	# of Vars*	Period
CLM4.5	NCAR	29	1970 – 2010
WBM-R_{net}UT	ETH	4	1901 – 2009
WBM-R_{net}SRB	ETH	4	1984 – 2010
MATSIRO-GW	U-Tokyo	41	1901 – 2010
MATSIRO-MIROC5	U-Tokyo	41	1901 – 2010
ISBA	MeteoFrance	57	1901 – 2010
HTESSEL	ECMWF/KNMI	?	1901 – 2010

The 1st Realistic Simulation for Entire 20th Century : Evapotranspiration / 1901 – 2010 :



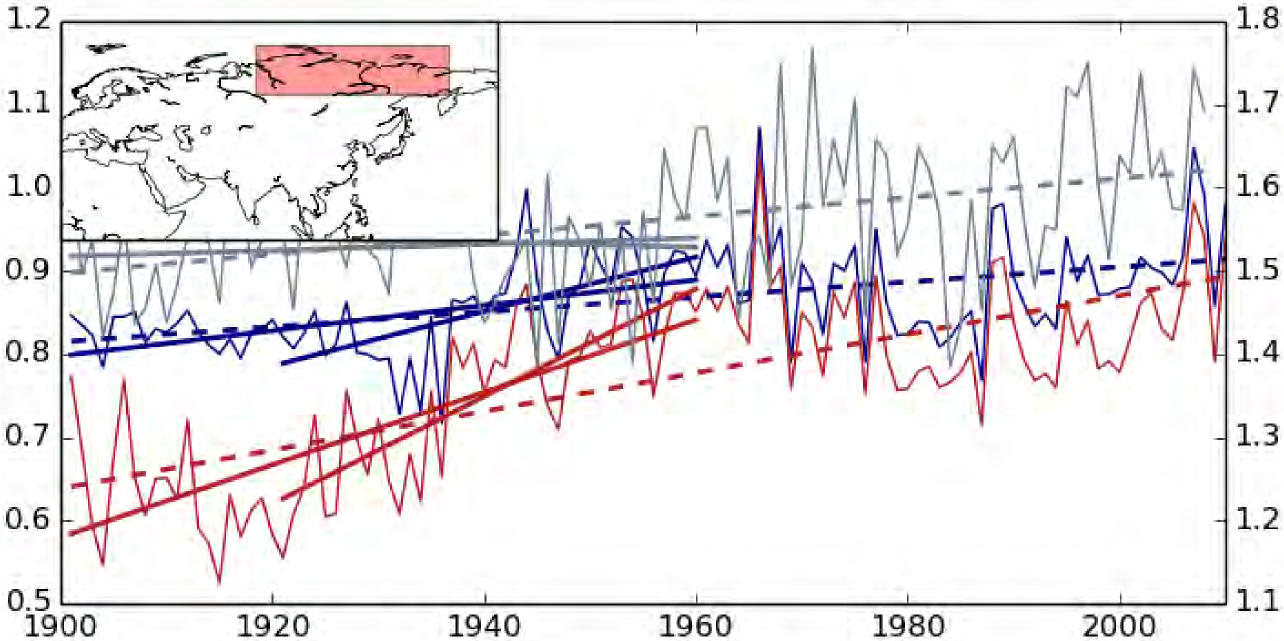
Examples/Samples Of Current Work

Large Discrepancy Still Exists



LandMIP Workshop @ ETH, Zurich, Switzerland

Examples/Samples Of Current Work



Spurious Trend on Precipitation over High Latitudes

	Mean	1920-1960	1901-1960	1901-2010
20CR	1.56	-0.0003	0.0004	0.0011
GPCC	0.76	0.0065	0.0044	0.0023
CRU	0.86	0.0033	0.0015	0.0009

Summary of Current Work

- GSWP3 EXP1 is the first global model estimation with a realistic forcing dataset which covers entire 20 Century.
- Six simulation sets have been submitted, and the first round analysis and validation is underway.
- Compliant variables list for ALMA and cf convention were prepared considering further efficiency in the synergy with CMIP6. (https://goo.gl/FYTb2J)
- It is found that state-of-the-art land surface schemes still demonstrate considerable discrepancy each other.

Outline of Future Work

A few known issues on the forcing data will be resolved and distributed to the communities (GLASS/GEWEX, CMIP6, and ISI-MIP) in March 2016, and actual phase of EXP1 will progress with CMIP6.

- Experiment design, current status and problems, and the result of "Fast-track" will be wrapped up and submitted to a scientific journal.

- EXP2 (long-term future runs; present-2100) will follow afterwards.

Land-Use and Climate, IDentification of robust impacts (LUCID)

iLEAPS

ARC CENTRE OF EXCELLENCE FOR CLIMATE SYSTEM SCIENCE

Laboratoire des Sciences du Climat et de l'Environnement

Leads : Nathalie de Noblet-Ducoudré (LSCE, Gif-sur-Yvette, France) & Andy Pitman (Univ. of New South Wales, Sydney)

The main objective is to identifyand quantify the impacts of land- used induced land-cover changes on the evolution of climate between the pre-industrial epoch and present-day

Use a) multi-model and b) ensemble simulations to *assess the significance and robustness of the identified changes*.

Assessments of the impacts of land cover change *will explore the mean climate*, *climate variability* and *climate extremes*.

Participants/Institutes/Contributions

GCM	LSM
EC-Earth	TESSEL
SPEEDY	LPJmL
LMDz (IPSL)	ORCHIDEE
ARPEGE	ISBA
CCAM	CABLE
CCSM	CLM
ECHAM5	JSBACH

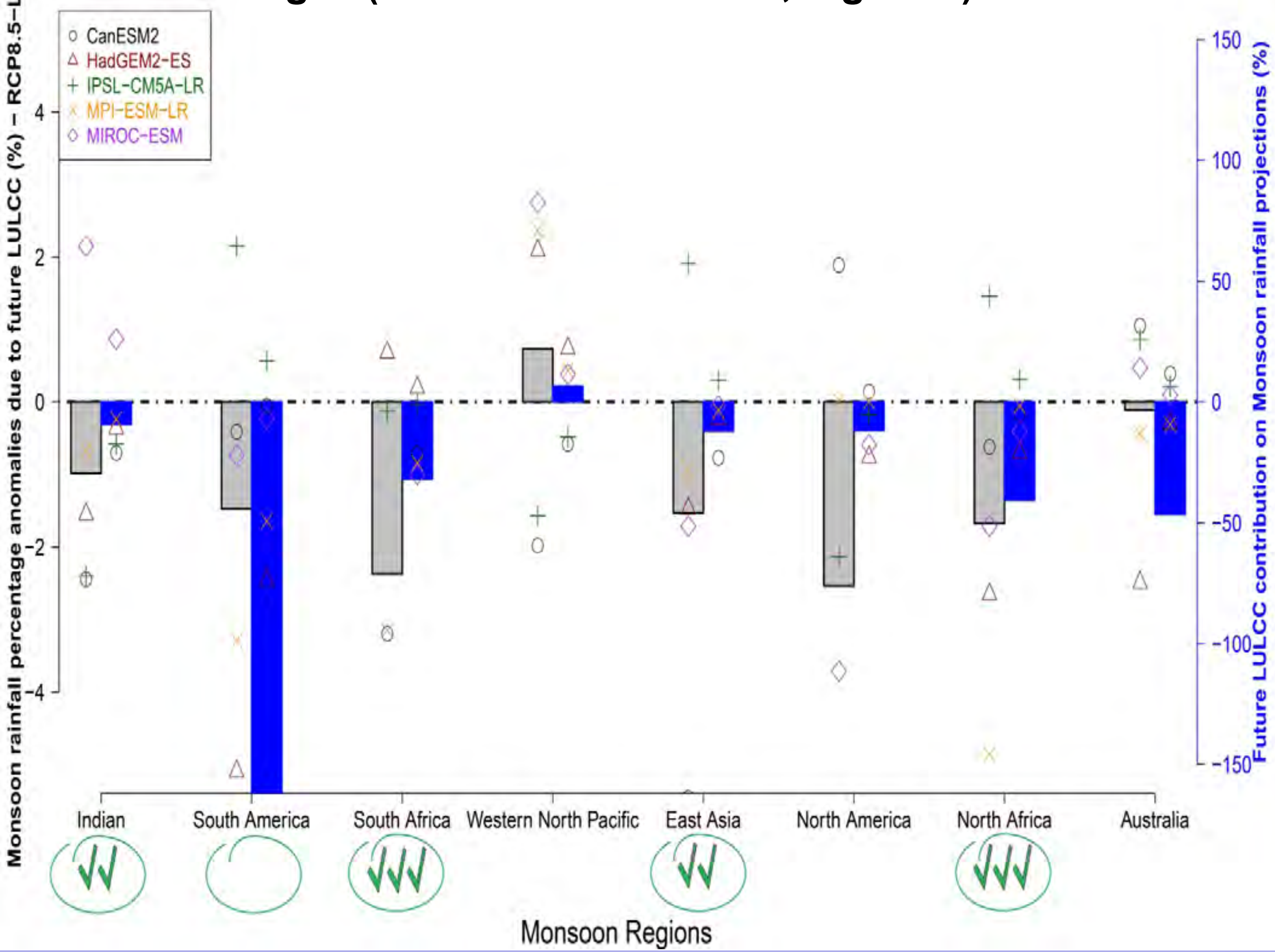
Participants include: Nathalie de Noblet-Ducoudré, Andy Pitman, Juan-Pablo Boisier, Faye Cruz, G.B. Bonan, V. Brovkin, M. Claussen, E.L. Davin, C. Delire, L. Ganzeveld, V. Gayler, B.J.J.M. van den Hurk, P.J. Lawrence, M.K. van der Molen, C. Müller, C.H. Reick, S.I. Seneviratne, B. J. Strengers, A. Voldoire.

LUCID-CMIP5 simulations have been run by:

GCM	LSM
Can-ESM2	CTEM
IPSL-CM5A-LR	ORCHIDEE
MIROC-ESM	SEIB-DGVM
HadGEM2-ES	JULES
MPI-ESM-LR	ISBACH

Examples/Samples Of Current Work

Monsoon rainfall teleconnections in response to future land use and land cover changes (Quesada et al. subm.; Figure 1)



Seasonal rainfall changes due to future LULCC and relative contribution of LULCC to future projections (RCP8.5) in monsoon intensity in the 8 monsoonal regions. DJF for southern hemisphere regions and JJA for northern hemisphere regions on 2071-2100 period. Bars indicate the results for the LUCID-CMIP5 ensemble mean (ENS-FUT). On left axis, grey bars indicate monsoon rainfall percentage anomalies) and, on right axis, blue bars indicate the contribution of future LULCC (RCP8.5-L2A85) w.r.t future projections (RCP8.5-HIST). Symbols are shown for individual results of each LUCID-CMIP5 model.

Summary of Current Work

• Seven papers published during 2012-2014 summarizing LUCID and LUCID CMIP5 results -- includes evaluation impact of land cover change in 7 GCMs using LUH dataset

• LULCC matters at the regional scale - Detection / Attribution studies must include LULCC

• Differences in LSM parameterizations explain ~1/2 to 2/3 of the inter-model dispersion

• We need better ways to evaluate our land models & to evaluate for changes as well as means, Need to examine capacity to simulate extremes more, Need serious progress in crops (AgMIP ?), All opportunities to use PALS …

• Differential amounts of forests removed explain ~1/3 of the inter-model dispersion - We need to homogeneize our LULCC implementation strategies

• CMIP-6 --global scale energy and water budgets unlikely to be affected by LULCC. Global scale carbon budgets are linked to LULCC.

Outline of Future Work

- Engage LSM and LCC dataset providers – how to implement LCC in models, e.g. new methodology to include LUC within DGVMs (N. De Noblet-Ducoudré).
- Plans linking LUCID and GLACE are emerging building on Lorenz et al. (2014). The issue of how land coupling affects climate sensitivity to land cover change will require coordinated experiments in AMIP-style and could be combined with C20C simulations.
- EURO-CORDEX and regional projections - downscaling future scenarios of global climate change-EURO-CORDEX community to carry out regional European simulations with different land-use scenarios. This will finally happen this year (2016) and a first meeting is scheduled January 25, 2016 in Hamburg/Germany)
- Meetings of the LUMIP scientific steering committee have helped further refined the simulations to be carried out within CMIP6. Many of those are off-line simulations to test the impacts of land management on surface stocks and fluxes. Fully coupled simulations include idealized deforestation experiments (global and/or per latitudinal band) at pre-industrial levels of GHG, and future RCP scenarios with various land-use changes (issued from various SSPs).

(GLACE-CMIP5)
Project Overview/Goals

Leads : Sonia I. Seneviratne[1], Bart van den Hurk[2], Micah Wilhelm[1], Tanja Stanelle[1], Stefan Hagemann[3], Alexis Berg[4,5], Frederique Cheruy[6], Matthew Higgins[7], Ruth Lorenz8Arndt Meier[9], Victor Brovkin[3], Martin Claussen[3], Agnès Ducharne[9], Jean-Louis Dufresne[6], Kirsten L. Findell[4], Joséfine Ghattas[10], David M. Lawrence[7], Sergey Malyshev[11], Andy Pitman, Markku Rummukainen[8], and Ben Smith[12]

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

- (1) ETH Zurich, Switzerland
- (2) KNMI, The Netherlands
- (3) MPI-Met, Germany
- (4) GFDL, USA
- (5) Rutgers University, USA
- (6) LMD/IPSL, France
- (7) NCAR, USA
- (8) UNSW, Sydney, Australia
- (9) CECR, Lund University, Sweden
- (10) Laboratoire Sisyphe/IPSL, France
- (11) Princeton University, USA
- (12) Geography, Lund University, Sweden

1. Investigate the effects of changes in soil moisture content and soil moisture-climate coupling in global CMIP5 projections

2. Investigates the impact of decadal changes in soil moisture on climate

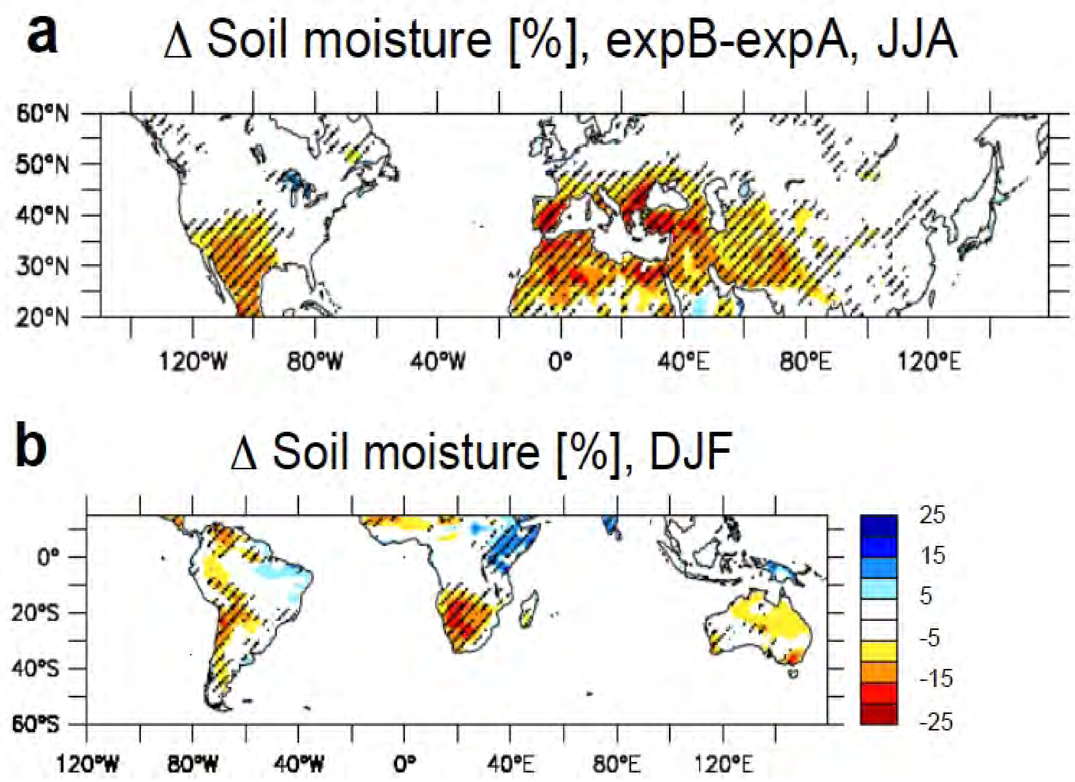
Participants/Institutes/Contributions

Design: ETH Zurich (Sonia Seneviratne), KNMI (Bart van den Hurk)
Database: ETH Zurich (Martin Hirschi, Micah Wilhelm, Tanja Stanelle, Sonia Seneviratne)

MPI-ESM: Stefan Hagemann, Victor Brovkin, Martin Claussen
CESM: Dave Lawrence, Matthew Higgins
EC-Earth: Arndt Meier, Ben Smith, Markku Rummukainen, Bart van den Hurk
GFDL: Alexis Berg, Sergey Malyshev, Kirsten Findell
IPSL: Frederique Cheruy, Agnès Ducharne, Joséfine Ghattas, Jean-Louis Dufresne
ACCESS: Ruth Lorenz, Andy Pitman

Additional interested participants: Paul Dirmeyer, Pierre Friedlingstein, Randy Koster, Julia Pongratz

Examples/Samples Of Current Work



- Consistent sign in 4 out of 5 models

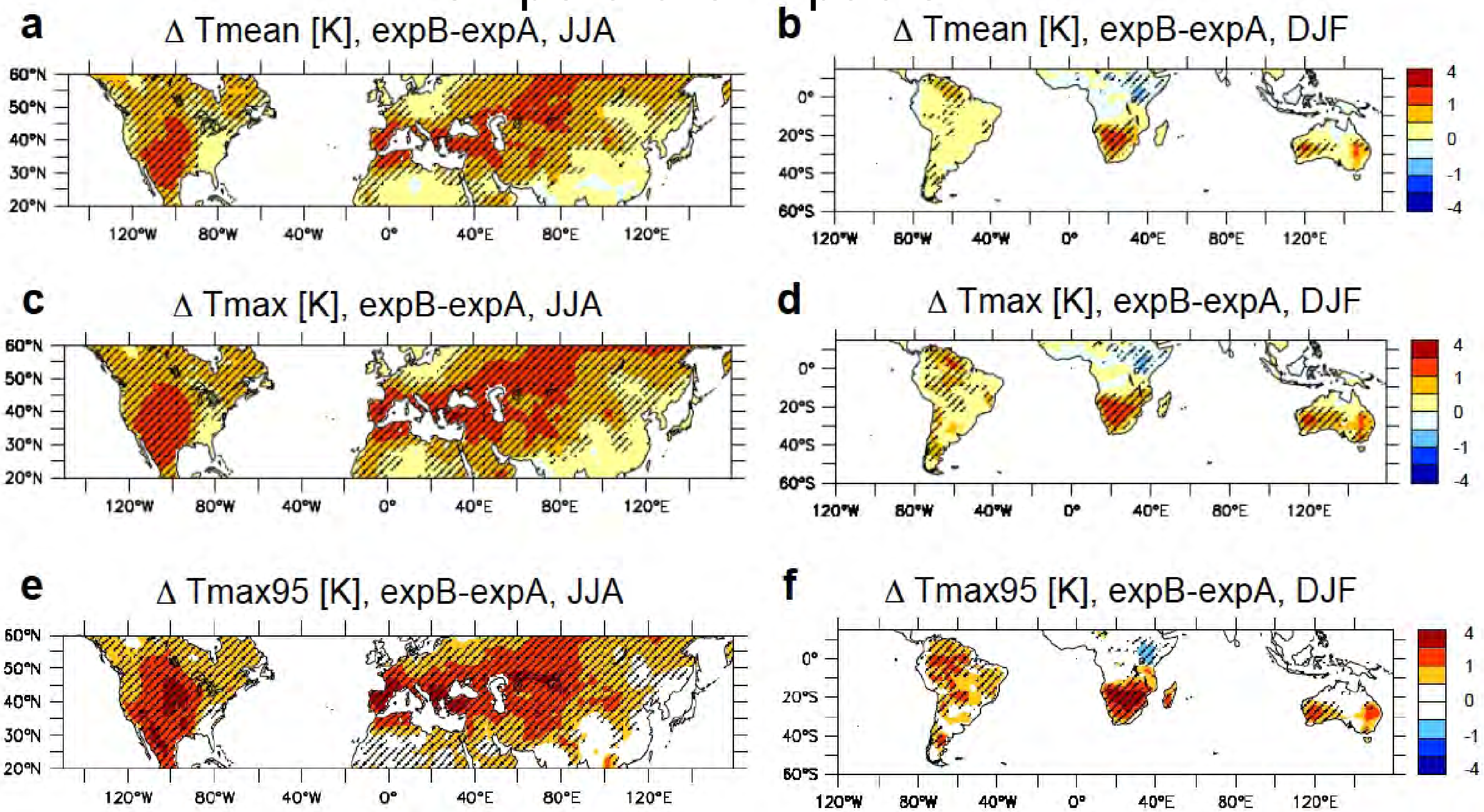
ExpA Rerun AR5 climate change projections for RCP8.5/4.2 (i.e. concentrations-driven) with seasonal cycle of soil moisture set to *1971-2000 climatology*

ExpB (as in A with seasonal cycle of soil moisture set to *transient climatology (running mean over 30-year period; in first 15 years use 1950-1979 climatology, in last 15 years use 2071-2100)*

- **Large imposed anomalies: Consistent with regions projected to be affected by more droughts in CMIP3 and CMIP5** *(e.g. IPCC SREX 2012; Orlowsky and Seneviratne 2012, Climatic Change; Orlowsky and Seneviratne 2013, HESS)*

Examples/Samples Of Current Work

Temperature impacts



- **Stronger impacts on Tmax than on daily mean temperature**
- **Stronger impacts on temperature extremes (Tmax95)**
- **Presence of non local effects (generally downwind)**

Summary of Current Work

New modeling group contributing to GLACE-CMIP5:
ACCESS (R. Lorenz, A. Pitman; UNSW)

New articles and analyses:
A. Berg et al.: T-P correlation (J. Climate, 2015)
W. May et al.: Effects on monsoons (Climate Dynamics, 2015)
R. Lorenz et al.: Impacts on extreme indices (submitted to JGR)
A. Berg et al.: Aridity study (draft completed)
S. Seneviratne / M. Hirschi: Land-atmosphere coupling hot spots
S. Seneviratne, V. Brovkin, et al.: Climate feedback analysis

Confirmation of strong effect of soil moisture-climate feedbacks for temperature extremes in present and future; less clear effects for precipitation extremes

High relevance of soil moisture-climate feedbacks for climate change projections
Clear effect on temperature diagnosed in simulations, strongest for extreme Tmax values
Some effects on precipitation, but more model dependent

Outline of Future Work

- **Several further analyses on-going**
- **GLACE-CMIP5 serves as blueprint for LS3MIP experiment**

GLASS Connections to Other Projects :

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

Objective : bridge the gap between medium-range weather forecasts and seasonal forecasts by improving forecast skill and understanding of the sub-seasonal to seasonal timescale, and to promote its uptake by operational centres and exploitation by the applications communities.

- P. Dirmeyer attends the S2S meetings on a regular basis on behalf of GLASS
- Potential contribution of the land surface to predictability on the S2S timescales
- now 9 models in the ECMWF data server - multi-model analysis of operational models regarding land-atmosphere interactions and land surface model behavior.

Monsoons (interactions with CLIVAR):

Paul Dirmeyer (co-chair of the WCRP/GEWEX-CLIVAR monsoon panel) is a GLASS panel member

- The 2015 panel meeting was originally programmed for the GEWEX conference in Paris
- Article appeared in CLIVAR Exchanges on the importance of land-atmosphere interactions within monsoons, by Y. Xue and P. A. Dirmeyer (see List of key publications).
- A. Turner (monsoon panel co-chair) and P. Dirmeyer are making tentative plans to have a workshop on monsoon land-atmosphere interactions, likely in 2017.

GLASS Connections to Other Projects :

Year of Polar Prediction (YOPP)

YOPP YEAR OF POLAR PREDICTION

"Extended period of coordinated intensive observational and modelling activities in order to improve polar prediction capabilities on wide range of time scales in both polar regions. »

- 2017-2019 (prep starting 2013, post activities through 2022).
- Key activity of WWRP Polar Prediction Project (PPP).
- Cooperation with WCRP Polar Climate Predictability Initiative (PCPI) and Climate and Cryosphere Project (CliC).
- YOPP Summit 13–15 July 2015 at WMO headquarters in Geneva.
- *Key recommendation relevant to GLASS: Important topics of high-latitude land processes, hydrological cycle, land/ice-atmosphere interaction featured more prominently in revised Implementation Plan.*
- Mike Ek reviewed YOPP Implementation Plan, attended YOPP summit (GLASS cap!)
- Relevant to a GLASS-GHP-iLeaps-CliC Cold Season Processes Project (Wheater/CCRN?)

WMO OMM

YOPP Summit 13–15 July 2015, WMO, Geneva

Alignment with WCRP Grand Challenges (GC) andGEWEX Grand Science Questions (GSQ)

	WCRP GC						GEWEX SQ			
GLASS Projects	Regional Climate Information	Sea-level Rise and Regional Impacts	Cryosphere in a Changing Climate	Climate sensitivity: Interactions of clouds, precip, aerosols, radiation	Changes in Water Availability	Science Underpinning Prediction/ Attribution of Extreme Events	Observations & Predictions of Precipitation	Global Water Resource Systems	Changes in Extremes	Water and Energy Cycles and Processes
PALS-PLUMBER	x		x			x	x		x	x
ALMIP2					x			x		x
PILDAS							x	x	x	x
GSWP3					x	x		x	x	x
GLACE-CMIP5/6, LS3MIP				x		x			x	
DICE/GABLS	x		x	x						
LoCo	x			x	x	x	x		x	x
LUCID	x			x		x				
Anthro-influences					x			x		x
Soils Initiative								x		x

GLASS Discussion Items (similar to 2015 SSG)

Gaps, reach, and future initiatives:

- Cold processes (iLEAPS+CliC+GEWEX?), Groundwater, Distributed Hydrology, anthropogenic processes, semi-arid processes, high resolution (~10^2m/LSM grey zone?).
- Should we be more explicitly focused on specific events/phenomena such as drought (via seasonal and interannual) prediction?
- LUCID and LUMIP (now evolving into LSMIP) projects both deal with Land Use Land Cover Change (LULCC) in coupled models – goals of each, communication.

Transition Period for GEWEX/WCRP: How should GLASS follow?

- WCRP GSQ & GEWEX Grand Challenges are not necessarily answered by the traditional 'MIP' framework > need Hypothesis driven?
- Models broadening (carbon and water/energy, distributed) and disciplines colliding to answer larger questions).
- What is the perceived role of process studies and model development vs. model evaluation in the GLASS themes (L-A Coupling/LoCo, DICE, Land model benchmarking)?
- (How to) increase interaction with GDAP?

GLASS Panel Membership

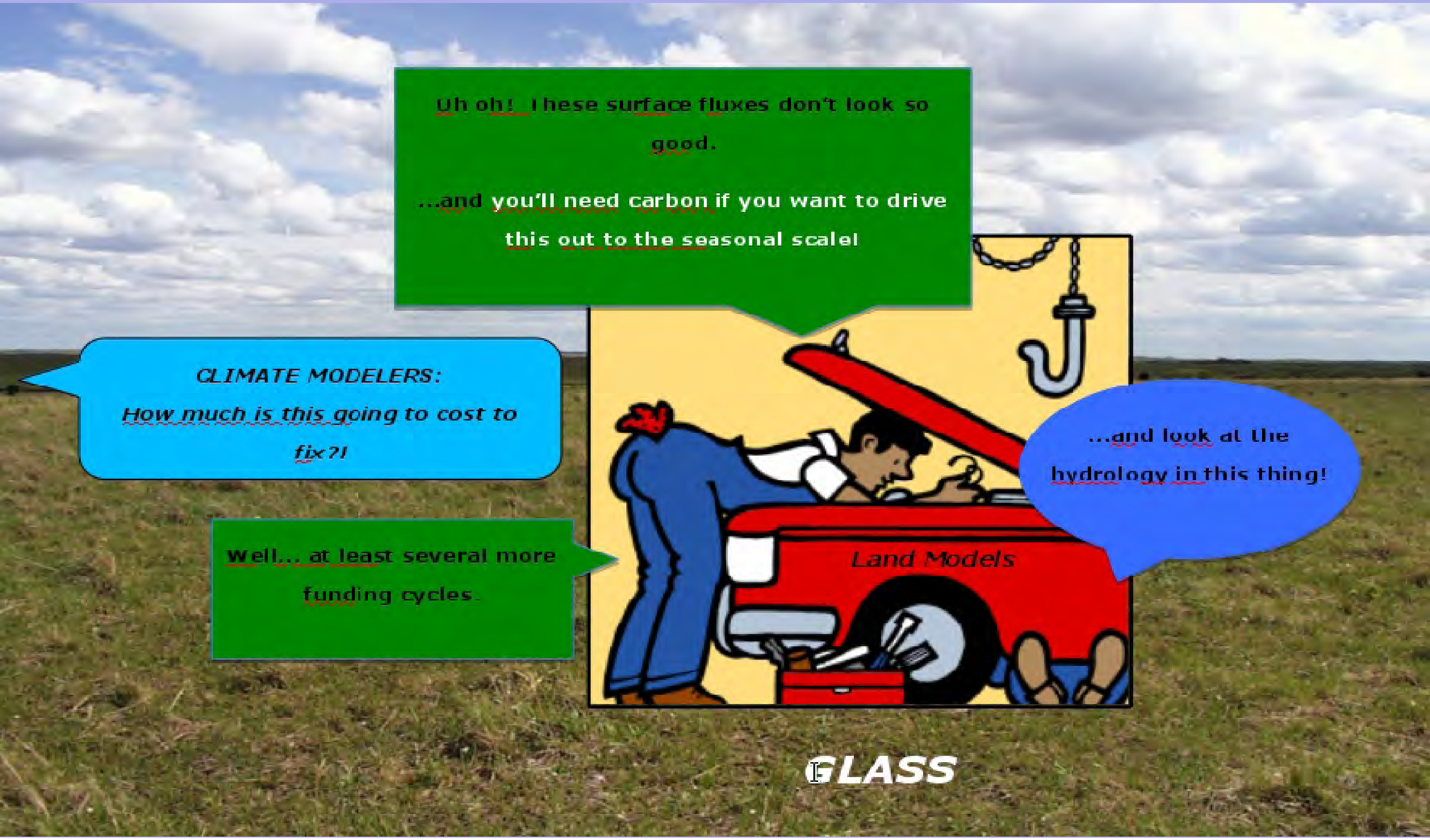
Co-chairs:

Dr. Aaron A. Boone
Centre National de Recherches Météorologiques
CNRM, Météo-France
Toulouse, France
aaron.a.boone@gmail.com
January 2013-December 2016

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

Joe Santanello* (NASA/GSFC)
Hyungjun Kim (Univ. Tokyo)
Rolf Reichle (NASA/GSFC)
Martin Best (UKMO)
Paul Dirmeyer (George Mason Univ.)
Andy Pitman (UNSW)Matt Rodell (NASA/GSFC)
Christa Peters-Lidard (NASA/GSFC)
Patricia de Rosnay (ECMWF)
Sonia Seneviratne (ETH)
Gab Abramowitz (UNSW)
Craig Ferguson (SUNY, Albany)
Nathan Brunsell (Univ. Kansas)
Lifeng Luo (Michigan State Univ.)
Fei Chen (NCAR/RAL)
Pierre Gentine (Columbia Univ.)
Tomo Yamada (Hokkaido Univ.)
John Edwards (UKMO)
Wade Crow (USDA)
Taikan Oki (Univ. Tokyo)
Ahmed Tawfik (NCAR)
Sujay Kumar (NASA/GSFC)
Chiel van Heerwaarden (Wageningen Univ.)
Obbe Tuinenburg (LMD)
Benoit Guillod (ETH)
Josh Roundy (Univ. Kansas)
***previous (most recent) Co-chair**

Global Land/Atmosphere System Study (GLASS)



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:

- Regional Climate Information
- Sea-level Rise and Regional Impacts
- Cryosphere in a Changing Climate
- Changes in Water Availability
- Clouds, Circulation and Climate Sensitivity
- Science Underpinning Prediction/Attribution of Extreme Events

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

GEWEX Science Questions :

To address the contributions that water and energy cycle science can make to society in four major areas.

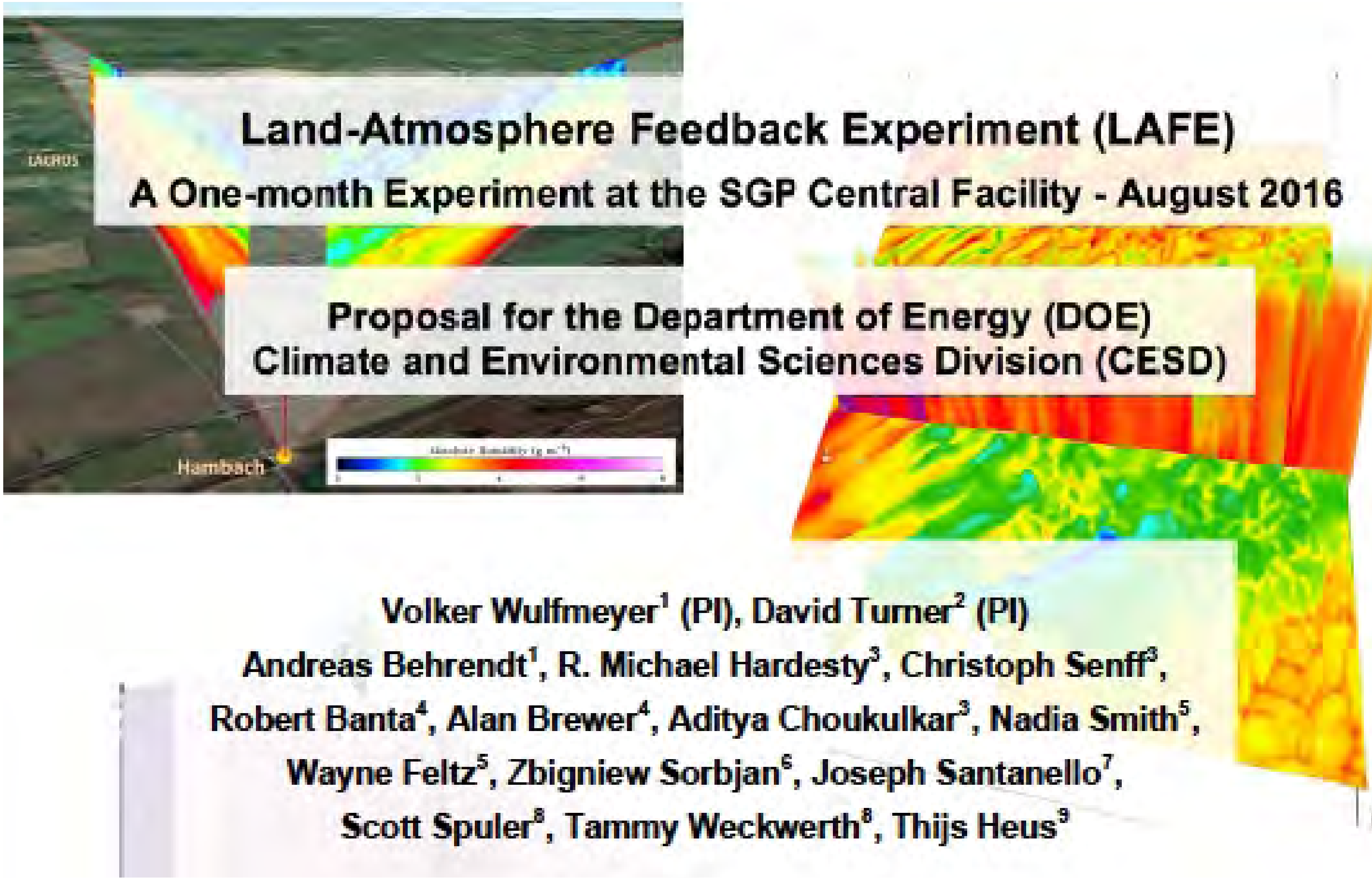
Observations and Predictions of Precipitation: How can we better understand and predict precipitation variability and changes?

Global Water Resource Systems: How do changes in land surface and hydrology influence past and future changes in water availability and security?

Changes in Extremes: How does a warming world affect climate extremes, esp. droughts, floods, and heat waves, and how do land area processes, in particular, contribute?

Water and Energy Cycles and Processes: How can understanding of the effects and uncertainties of water and energy exchanges in the current and changing climate be improved and conveyed?

LoCo-SGP Testbed: LAFE



Land-Atmosphere Feedback Experiment (LAFE)

A One-month Experiment at the SGP Central Facility - August 2016

Proposal for the Department of Energy (DOE)
Climate and Environmental Sciences Division (CESD)

Volker Wulfmeyer[1] (PI), David Turner[2] (PI)
Andreas Behrendt[1], R. Michael Hardesty[3], Christoph Senff[3],
Robert Banta[4], Alan Brewer[4], Aditya Choukulkar[3], Nadia Smith[5],
Wayne Feltz[5], Zbigniew Sorbjan[6], Joseph Santanello[7],
Scott Spuler[8], Tammy Weckwerth[8], Thijs Heus[9]

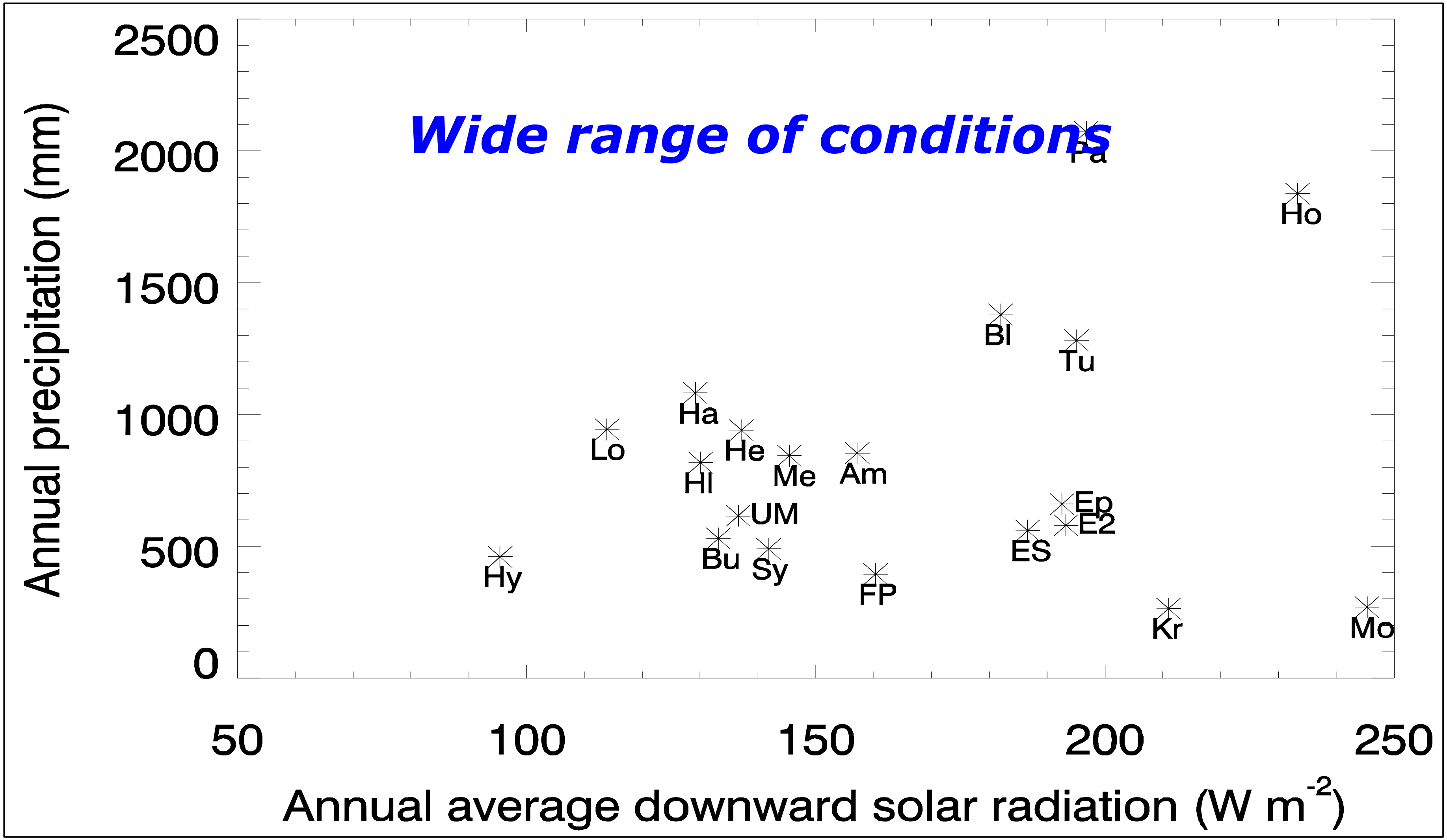
LoCo-SGP Testbed: ARMBELAND

- Based on community feedback and via collaboration between LoCo, ARM, and NASA NEWS program, a new data product called "ARM Best Estimate (ARMBE)–Land" (ARMBELAND) produced for SGP Central Facility, Lamont, OK (PI: Shaocheng Xie, LLNL).
- Critical soil quantities for describing land properties (product type: ARM Evaluation Products, 01/01/1994 - 12/31/2012).
- Currently, ARMBE-Land contains soil states; soil, CO2, momentum flux, and PAR using CO2FLX, EBBR, and SWATS.

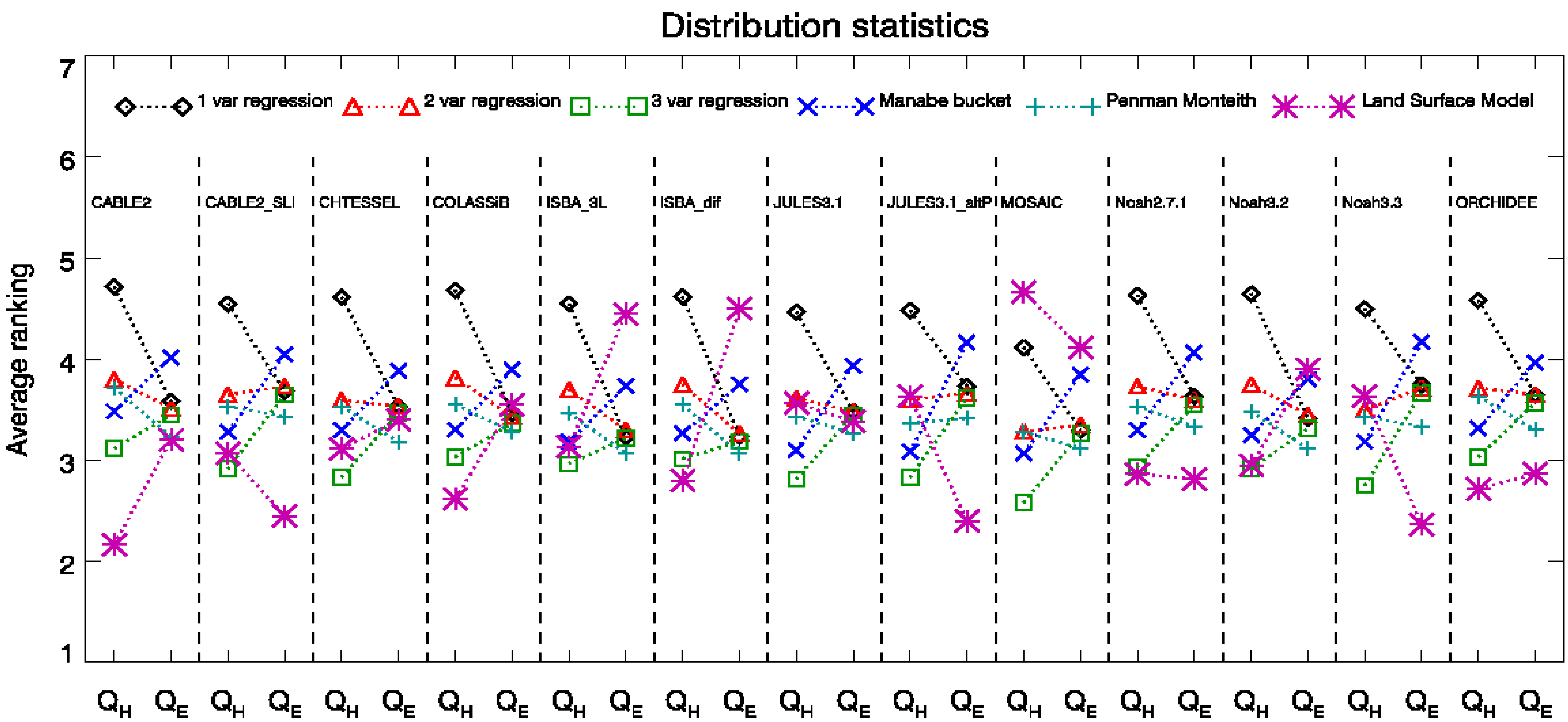
http://iop.archive.arm.gov/arm-iop/0eval-data/xie/armbe-eval/armbeland

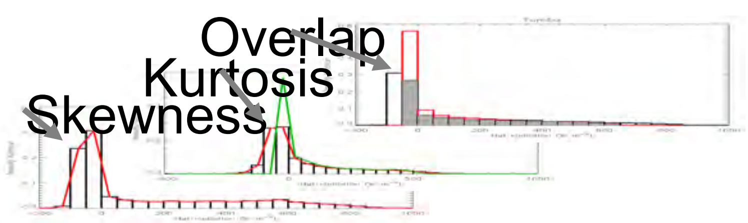
- Work begun on a 2-D gridded (variational analysis) product over broader ARM SGP network, which will include all fields relevant for land-atmosphere coupling studies, as well as sub-grid scale variability.

PALS-PLUMBER: Climate of Sites

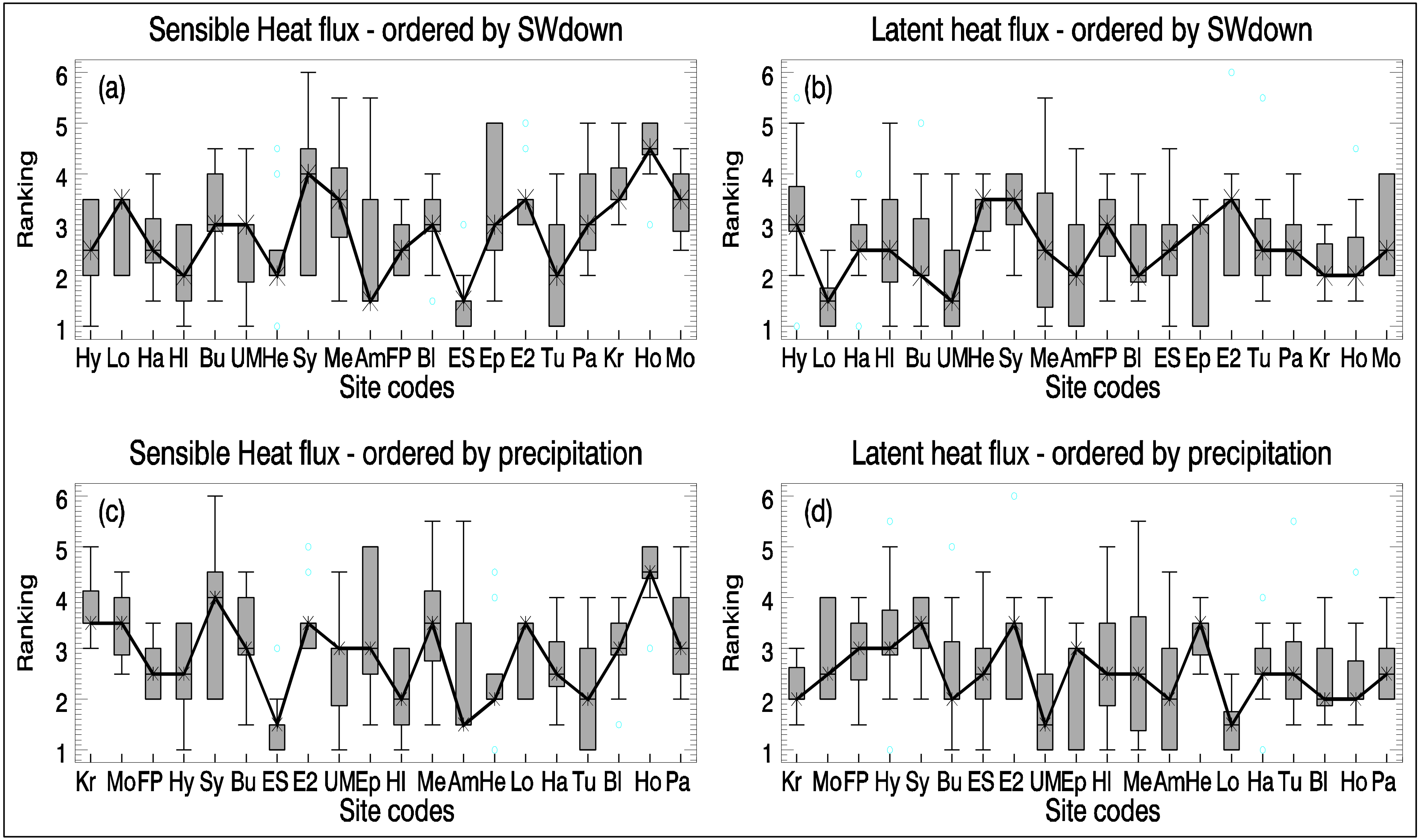


Benchmarking Against Distribution Statistics

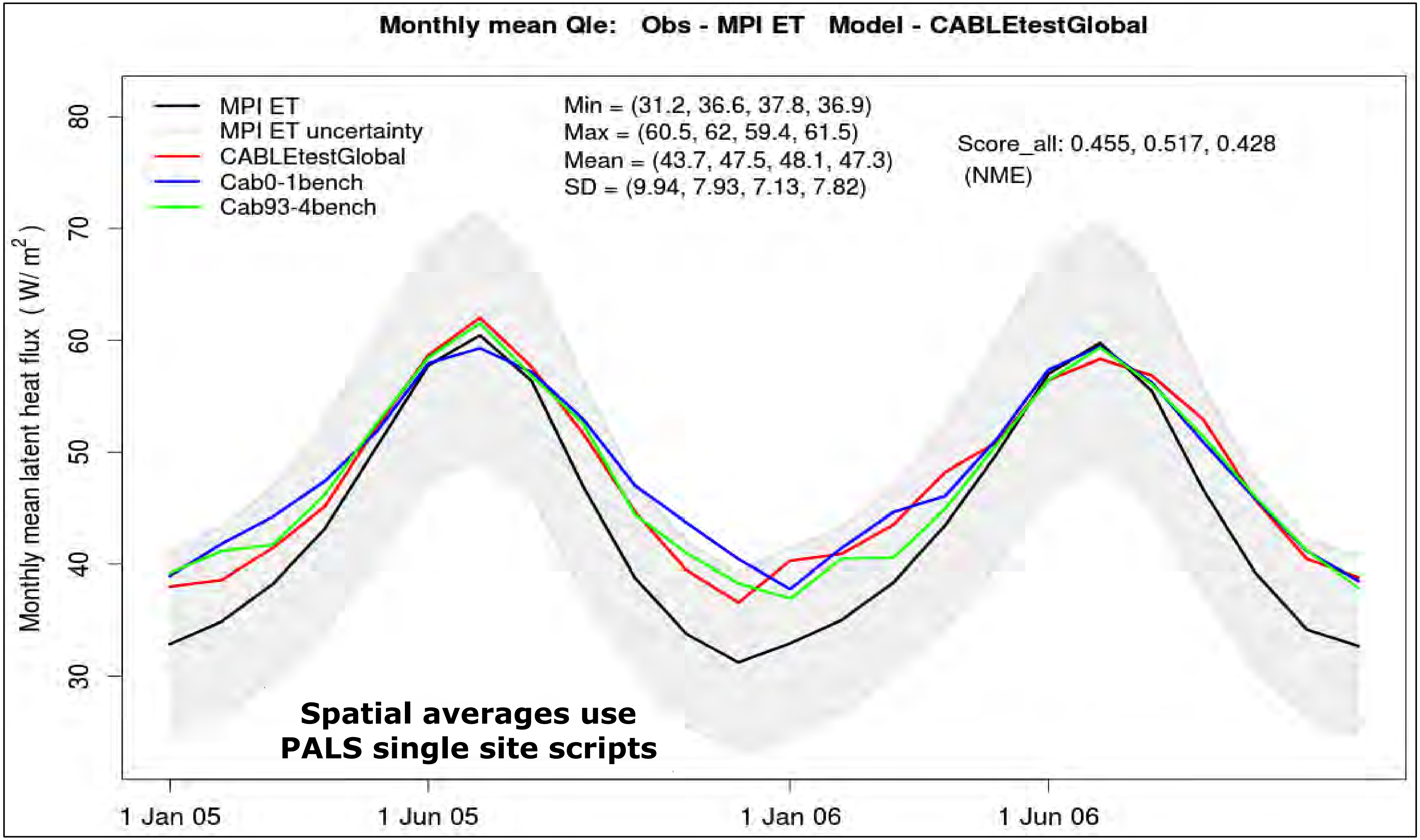




Benchmarking by Climate



PALS Example Experiments - Global GSWP3 Grid



PALS: Single Site Experiments Summary Analysis

ElSaler2Fluxnet1.4 metric summary

Model: CABLE1.4_ElSaler2 Benchmarks: Jules3.1ElSaler2, PenmanMontElSaler2, CABLE_SLI_ElSaler2

	Mod Qle	B1	B2	B3
Bias (Timeseries)	-24	-36	17	-26
NME (Timeseries)	0.8	0.74	0.62	0.66
NME14day (Timeseries)	1.4	1.4	0.71	1.2
Correlation (Taylor)	0.49	0.55	0.87	0.67
NME (AnnualCycle)	1.3	1.5	0.71	1.2
NME (DiurnalCycle)	0.53	0.65	0.57	0.5
Grad (Scatter)	0.45	0.31	1.2	0.48
Int (Scatter)	13	10	2.9	8.5
DailyGrad (Scatter)	0.13	0.086	0.82	0.23
DailyInt (Scatter)	33	25	29	25
%Overlap (PDF)	70	70	76	70

	Mod Qh	B1	B2	B3
Bias (Timeseries)	45	37	-9.3	48
NME (Timeseries)	1.7	1.3	0.85	1.6
NME14day (Timeseries)	2.7	2.1	0.86	2.6
Correlation (Taylor)	0.67	0.68	0.64	0.7
NME (AnnualCycle)	2.8	2.2	0.89	2.7
NME (DiurnalCycle)	1.5	1.2	0.69	1.6
Grad (Scatter)	1.5	1.2	0.62	1.5
Int (Scatter)	37	33	-3.1	39
DailyGrad (Scatter)	1.2	0.78	0.4	1
DailyInt (Scatter)	42	40	0.31	47
%Overlap (PDF)	78	86	71	73

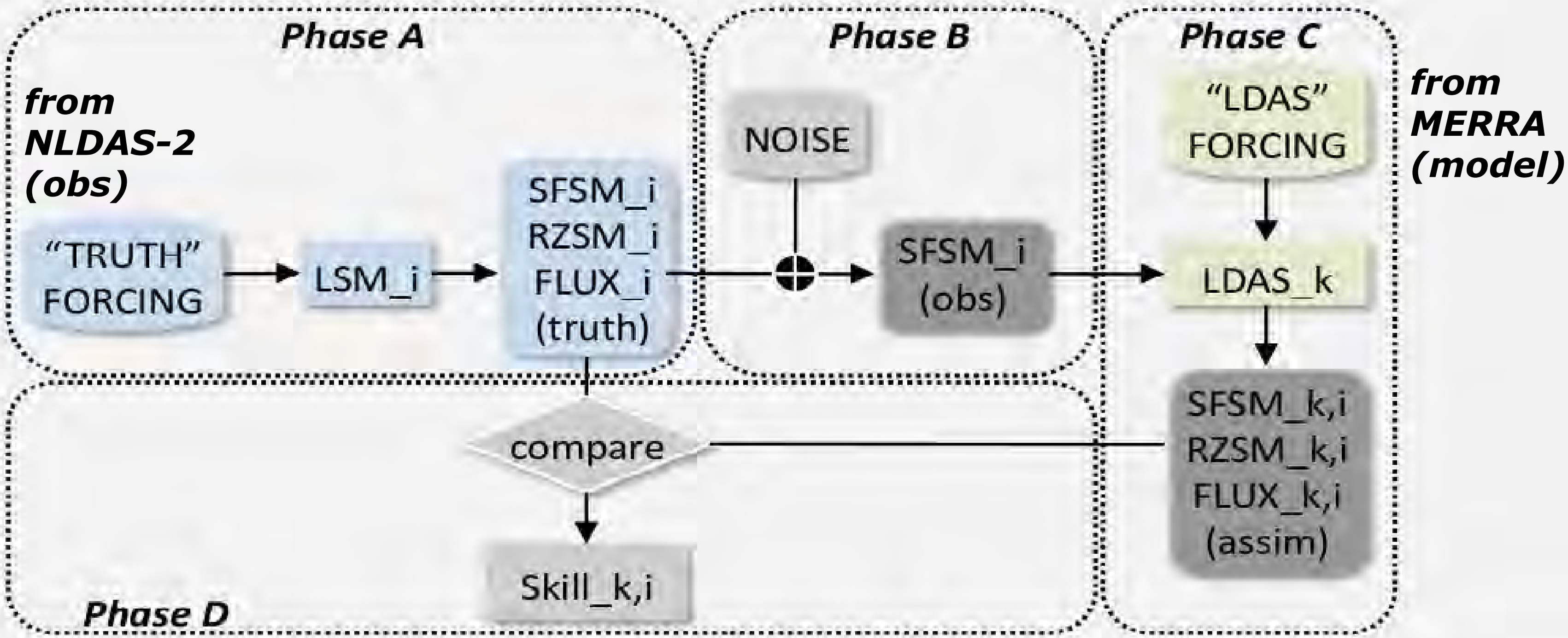
	Mod NEE	B1	B3
Bias (Timeseries)	1.7	1.3	0.97
NME (Timeseries)	0.95	0.87	0.91
NME14day (Timeseries)	0.99	0.96	0.85
Correlation (Taylor)	0.31	0.11	0.43
NME (AnnualCycle)	0.93	0.93	0.81
NME (DiurnalCycle)	0.9	0.79	0.84
Grad (Scatter)	0.13	0.02	0.18
Int (Scatter)	0.27	-0.34	-0.37
DailyGrad (Scatter)	-0.11	-0.063	0.044
DailyInt (Scatter)	-0.11	-0.48	-0.59
%Overlap (PDF)	50	58	44

	Mod Rnet	B1	B2	B3
Bias (Timeseries)	4.1	-15	-7.5	5
NME (Timeseries)	0.11	0.18	0.15	0.11
NME14day (Timeseries)	0.19	0.38	0.26	0.17
Correlation (Taylor)	0.99	0.99	0.98	0.99
NME (AnnualCycle)	0.16	0.32	0.2	0.14
NME (DiurnalCycle)	0.075	0.15	0.12	0.075
Grad (Scatter)	0.99	0.82	0.87	0.98
Int (Scatter)	5.2	2.8	5.1	7.1
DailyGrad (Scatter)	0.95	0.79	0.92	0.96
DailyInt (Scatter)	8.9	5.4	0.45	8.7
%Overlap (PDF)	95	87	88	94

	Mod Qg	B1	B3
Bias (Timeseries)	-1.8	-0.56	-0.27
NME (Timeseries)	2.9	2	2.2
NME14day (Timeseries)	1.2	1.3	1.3
Correlation (Taylor)	-0.16	-0.32	-0.23
NME (AnnualCycle)	1.3	1.5	1.5
NME (DiurnalCycle)	3.5	2.5	2.7
Grad (Scatter)	-0.25	-0.27	-0.23
Int (Scatter)	-1.4	-0.16	0.063
DailyGrad (Scatter)	-0.14	-0.2	-0.2
DailyInt (Scatter)	-1.6	-0.28	-0.06
%Overlap (PDF)	43	49	49

- To summarise the many plots produced
- Old collection of plots still appear as before, except benchmarks can be other models…

PILDAS: Experiment Setup



Phase A: Generate truth for i=1:N_T land models (participants).

Phase B: Generate i=1:N_T sets of synthetic observations (core).

Phase C: Generate N_A open loop and $N_A \cdot N_T$ assim. runs (participants).

Phase D: Analyze results (all).