GEWEX Global Land Atmosphere System Study (GLASS):

Update at WGNE-30

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

30th session of the CAS/WCRP
Working Group on Numerical Experimentation

College Park, Maryland, USA, 23-26 March 2015

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 Project Updates:

Projects, some cross-cut:

PALS-PLUMBER – Land model benchmarking.

DICE – Land-atmosphere interaction, links to GASS.

ALMIP2 – AMMA Land surface Model Intercomparison Project (ALMIP2), West Africa monsoon region.

GLACE-CMIP5 –Global Land-Atmosphere Coupling Experiment (GLACE) allowed a quantification of respective feedback processes in a modeling framework.

LUCID – Land-Use and Climate: IDentification of robust impacts - Land use/change.

Recently launched or to be launched:

PILDAS – Project for the Intercomparison of Land Data Assimilation Systems.
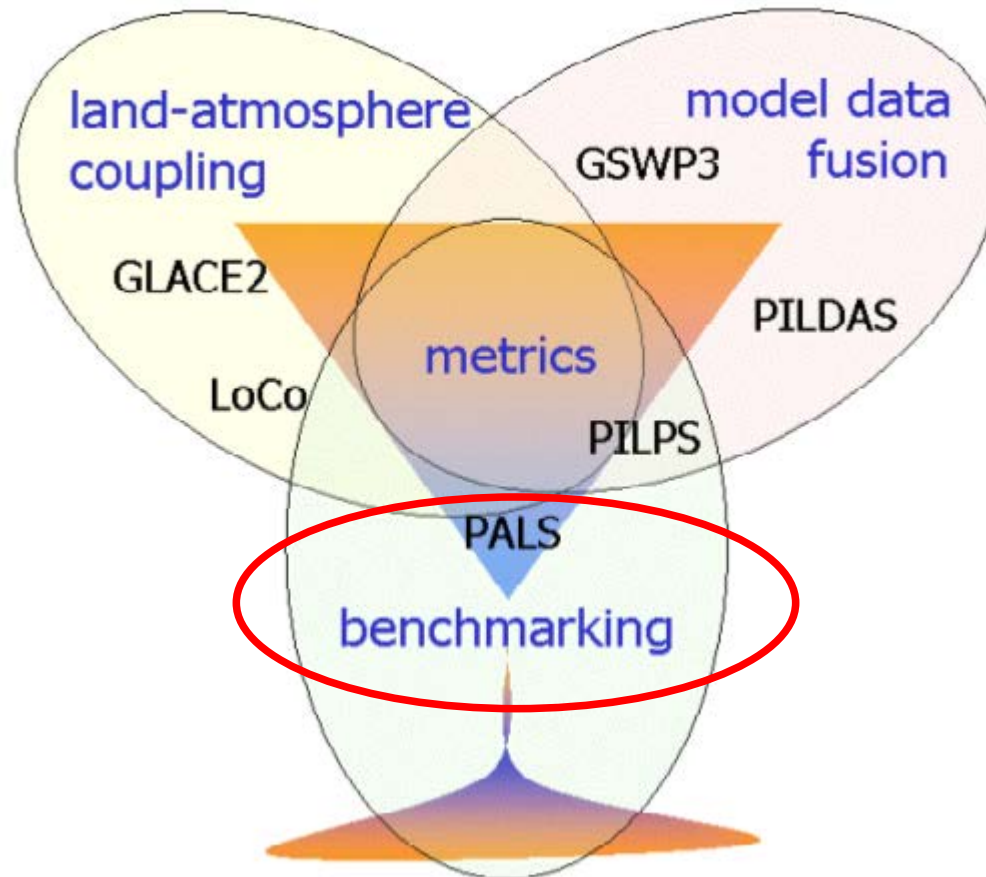
LoCo – Local Coupled Land-Atmospheric Modelling.

GABLS4 "DICE-over-ICE" – land-atmos interaction, joint GASS-GLASS.

GSWP3 - Global Soil Wetness Project Phase 3, 20C land retrospective.

Global Land Atmosphere System Study (GLASS)

PALS/PLUMBER

land-atmosphere coupling

model data fusion

GSWP3

GLACE2

PILDAS

LoCo

metrics

PILPS

PALS

benchmarking

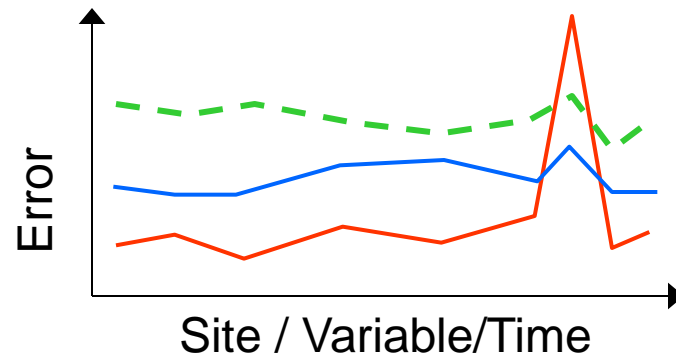# *Benchmarking vs Evaluation:*

- ## Evaluation

  - ➢ Run model
  - ➢ Compare output with observations and ask:
    - ❑ How good is the model?

- ## Benchmarking

  - ➢ Decide how good model needs to be

  - ➢ Run model and ask:

    - ✓ Does model reach the level required?

—— **Model A**

—— **Model B**

– – – **Benchmark**

Protocol for the Analysis of Land Surface models

"Experiment" structures - internal PALS structuring to allow:

Either **point-based**, catchment-based, regional or global experiments

Each experiment defined by resolution, grid and evaluation variable(s)

All analysis now controllable / editable by experiment owner – no need for coding.

<u>User-defined benchmarks:</u>

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 that benchmarks are requested for).

<u>Report generation facility:</u>

Create tables of scalar metrics comparing a model with its nominated benchmarks for all experiments where benchmarks are available.

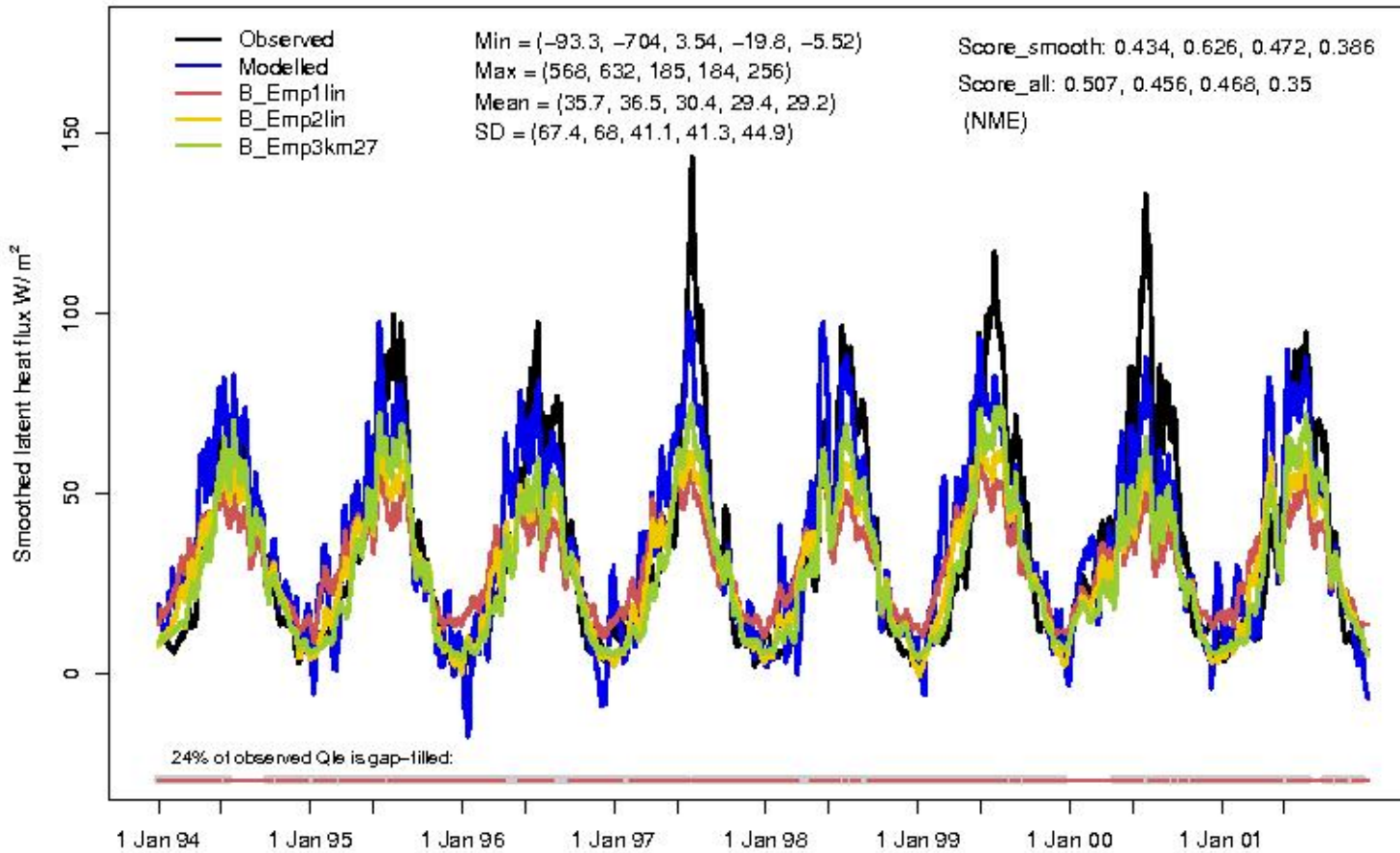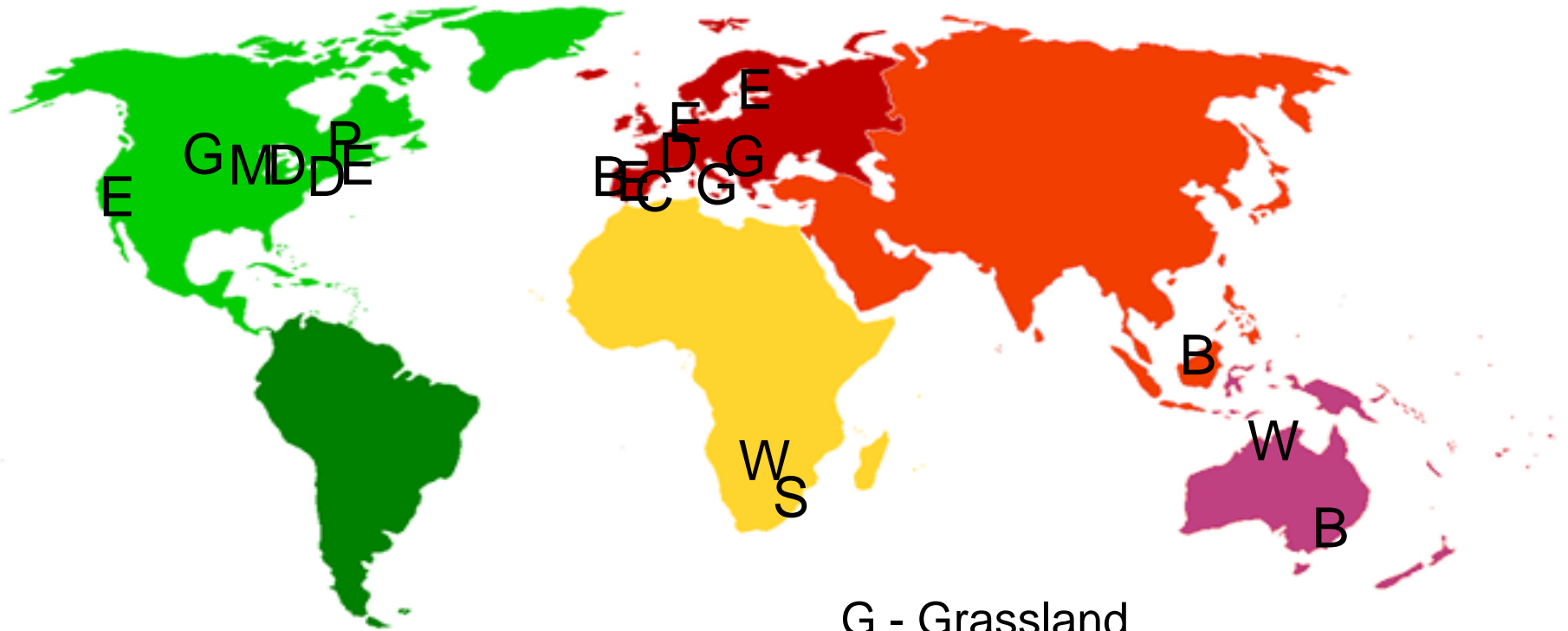Useful for model development / management.

PALS Website:

www.pals.unsw.edu.au/pals/Welcome.action

PALS Analysis:

Smoothed Qle: 14–day running mean.   Obs – HarvardFluxnet.1.4   Model – Harvard_J3.1
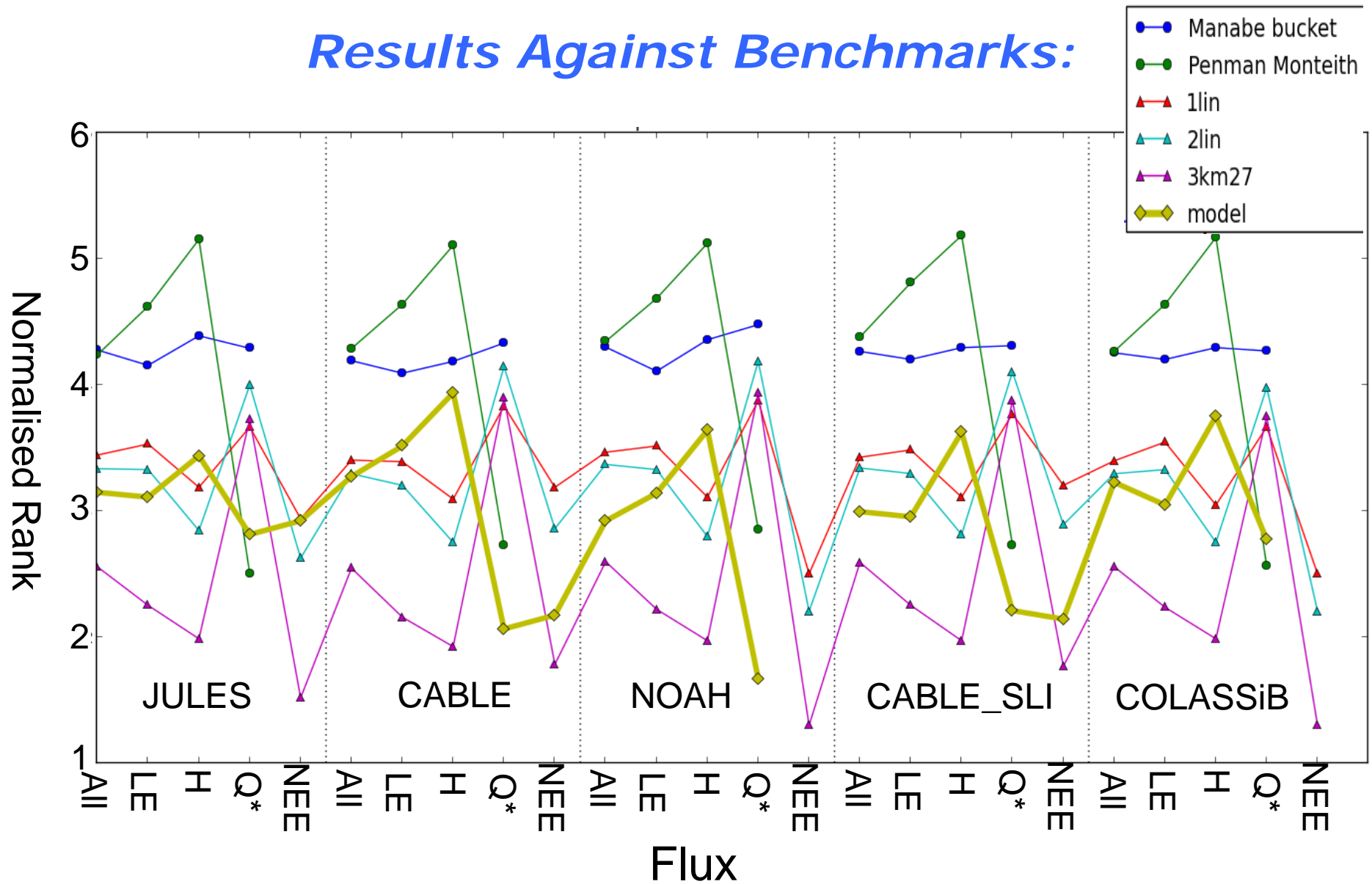
The PALS Land sUrface Model Benchmarking Evaluation pRoject (PLUMBER)

E – Evergreen Needleleaf
B – Evergreen Broadleaf
D – Deciduous Broadleaf
M – Mixed Forest

G - Grassland
C – Cropland
W – Woody Savanna
S – Savanna
P – Permanent Wetlands

Results Against Benchmarks:

PLUMBER Summary (to date):

- PALS is a useful tool for benchmarking
  - ➢ Individual studies
  - ➢ Community experiments

- Models pass simple model benchmarks

- Models do not pass regression benchmarks
  - ➢ Particularly for sensible heat flux
  - ➢ Models' rankings similar to regression results overall
  - ➢ Models do not make full use of information from atmospheric forcing

- Results from initial stage of PLUMBER presented at conferences (e.g. AMS, January 2014) and an overview paper (co-authored by many GLASS panel members) currently under review for Journal of Hydrometeorology.

Global Land Atmosphere System Study (GLASS)

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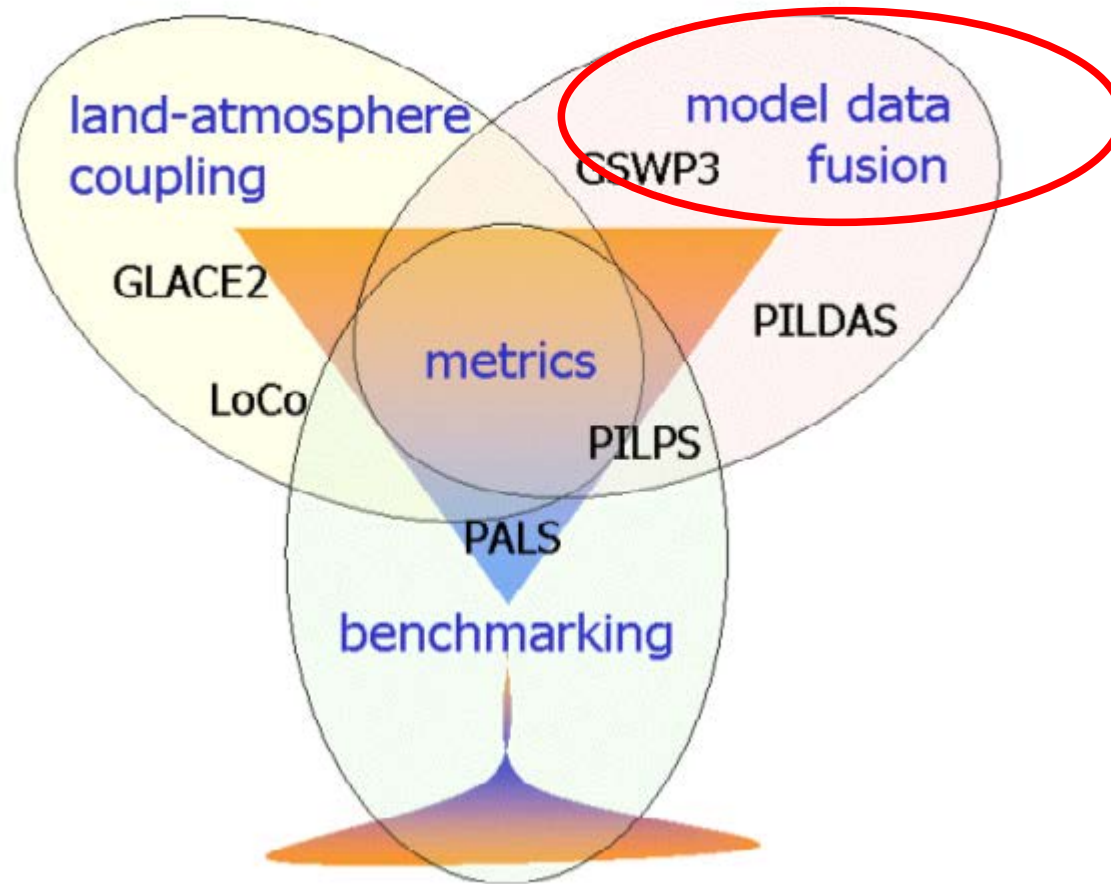
Project for the Intercomparison of Land Data Assimilation Systems (PILDAS)

PILDAS-1 Update

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

PILDAS: Objectives

Enable better communication among developers of land data assimilation systems (LDAS)

Develop and test a framework for LDAS comparison and evaluation
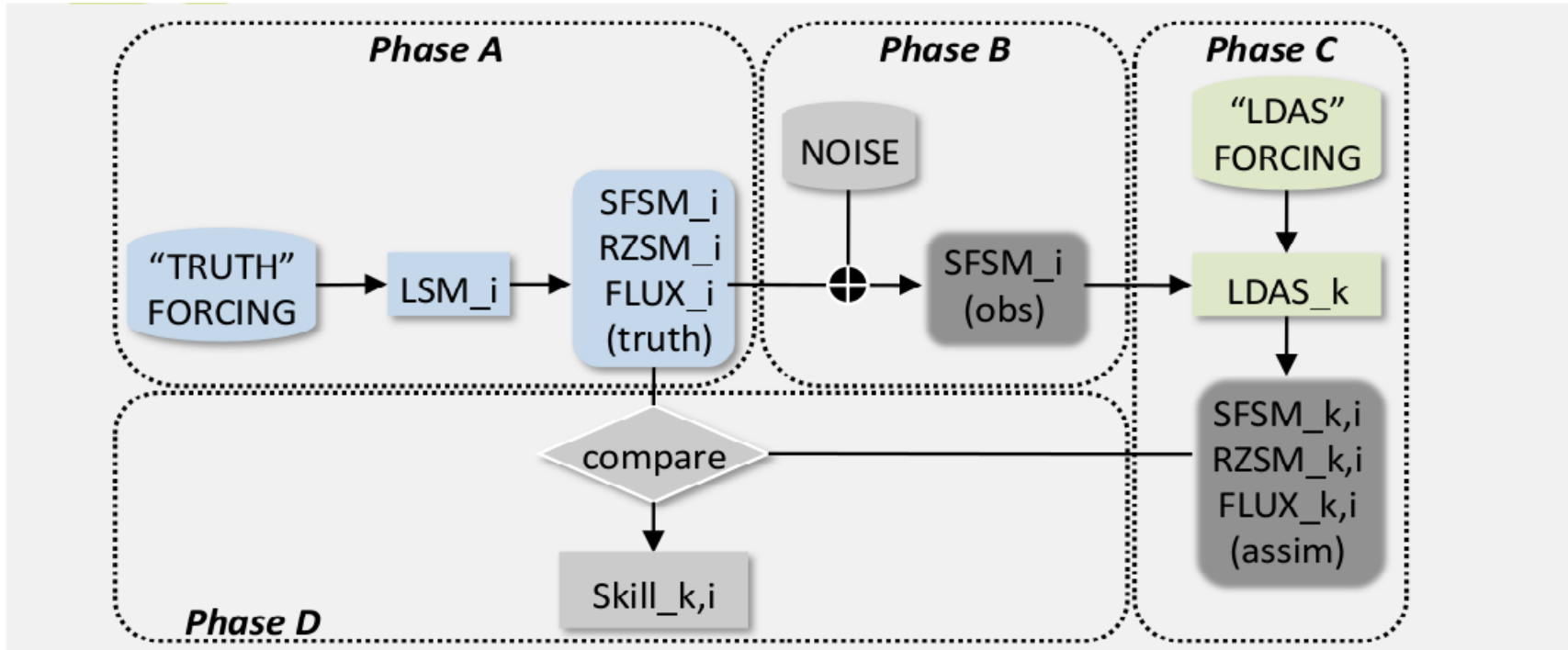
Compare land assimilation methods (EnKF, EKF...).

Conduct sensitivity studies of assimilation input parameters (such as model and observation errors).

Provide guidance and priorities for future land assimilation research and applications

Ultimately, produce enhanced global datasets of land surface fields

PILDAS: 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).

PILDAS: Current Participants

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 interests WGNE
- Maybe get some centers from Asia involved
- <u>Future experiments</u> : assimilate sat data (SMOS, SMAP), use coupled systems
- Calender: delayed, but should begin this year ...upcoming months with initial testing at NASA.

Global Land Atmosphere System Study (GLASS)

DICE
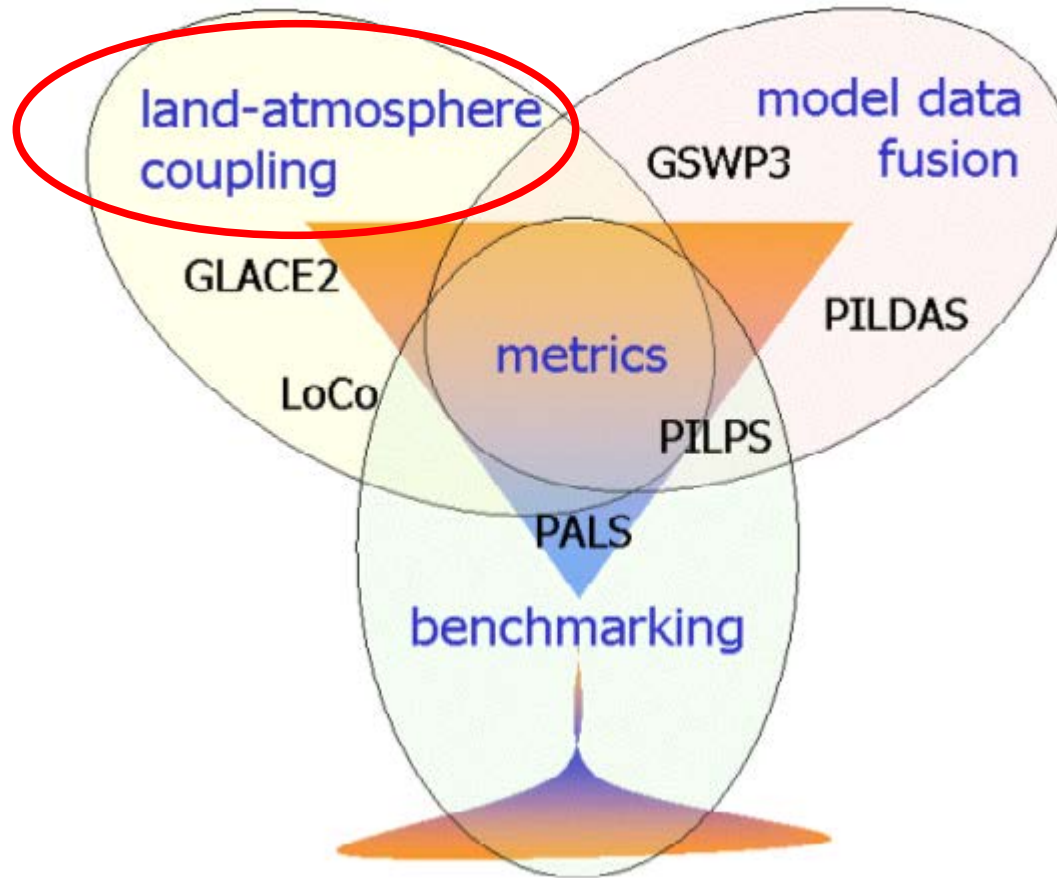
Diurnal land/atmosphere coupling experiment (DICE)

Study interactions between atmosphere and land surface.

- New project released April 2013.
- Joint activity between GASS (atmospheric boundary layer modellers) & GLASS (land surface modellers).

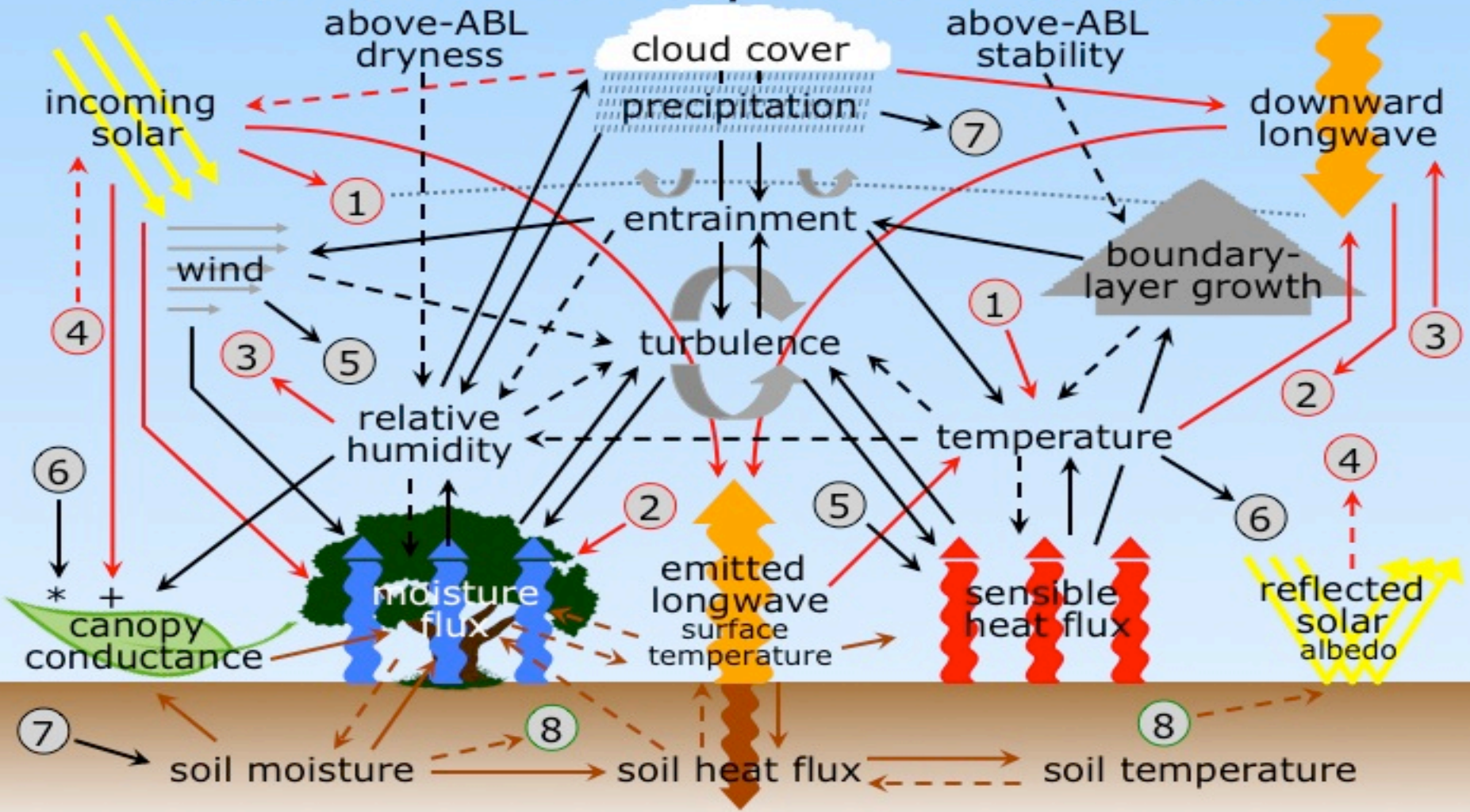CASES-99 Experiment
Southern Great Plains, USA

- Led by Adrian Lock and Martin Best at UK Met Office.
- To date 12 models are participating.
- 1st Workshop 14-16 Oct 2013, UK Met Office, Exeter
- 2nd Workshop 14-18 July 2014 at GEWEX conf, The Hague
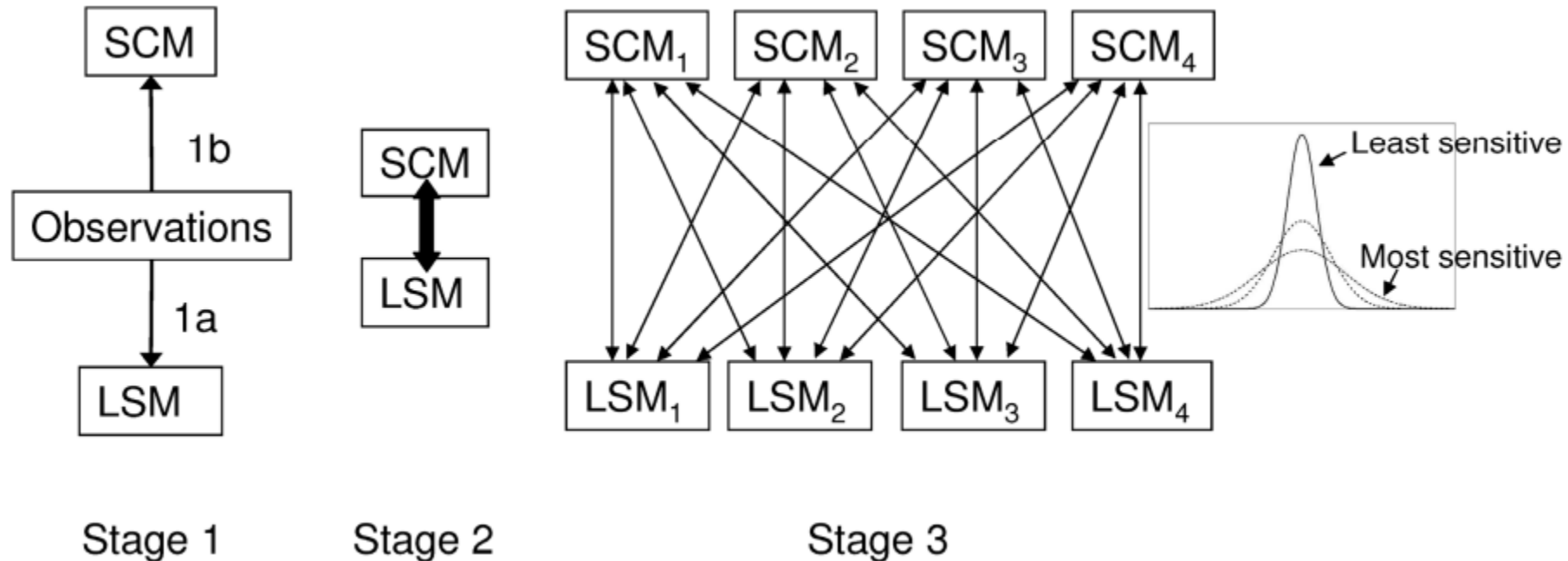- 3rd Workshop 20-22 May 2015 at Météo-France, Toulouse.

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

Local Land-Atmosphere Interactions

Diurnal land/atmosphere coupling experiment (DICE)

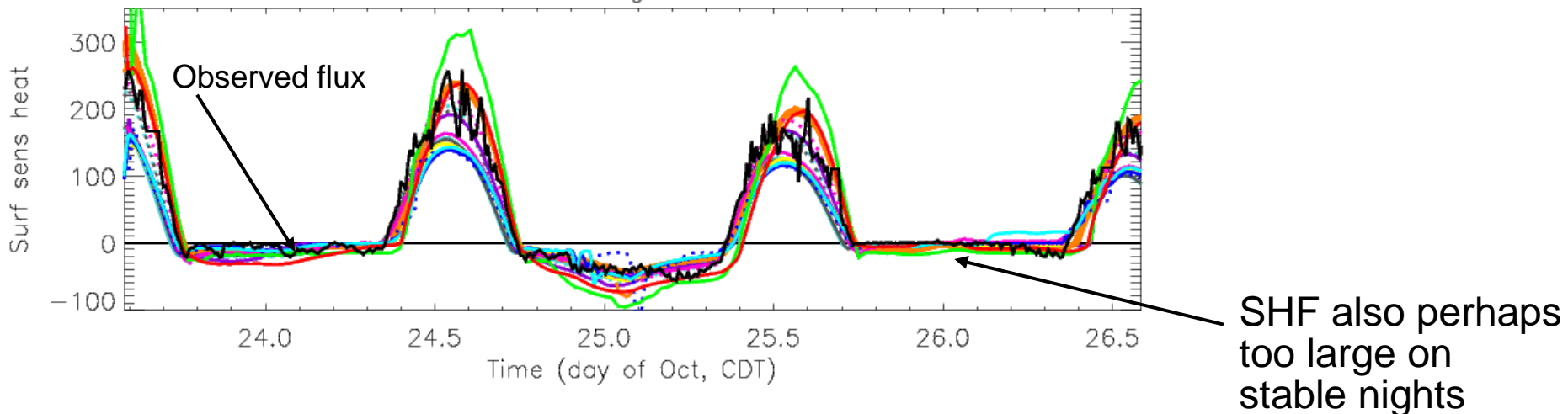Stage 1   Stage 2   Stage 3
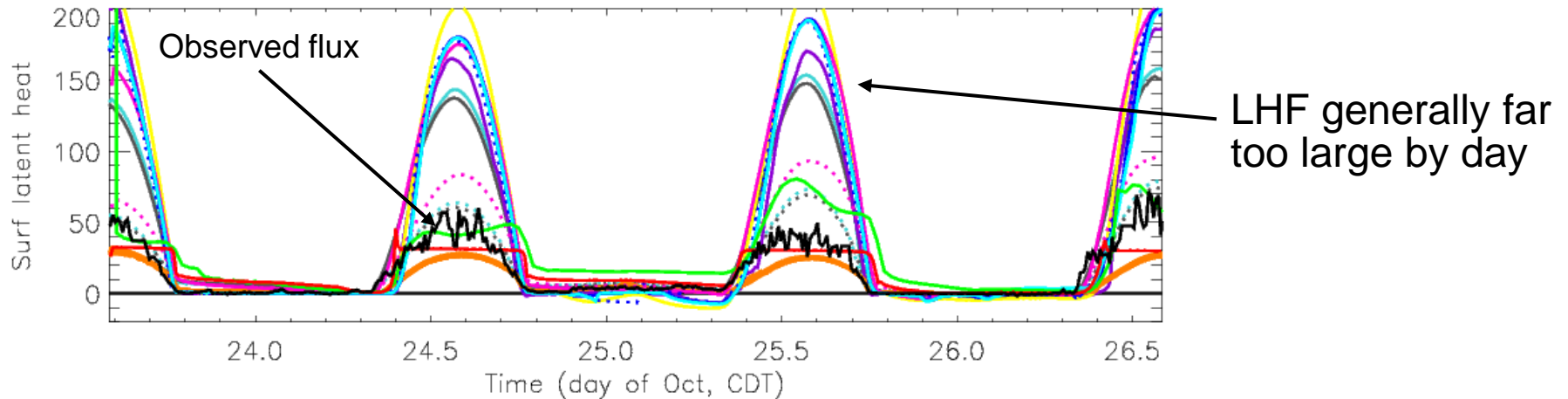
- These stages test:

    - LSM and SCM stand-alone performance against observations (stage 1)

    - What is the impact of coupling? (stage 2)

    - How sensitive are different LSM and SCM to variations in forcing? (stage 3)

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: stage 1a:
Land surface models forced by observations
Surface fluxes

Main issue currently is the difference between living (most models) vs dead (reality) vegetation that controls errors in daytime evaporation

Observed flux

LHF generally far too large by day

Observed flux

SHF also perhaps too large on stable nights

DICE status/summary so far....

- Climatalogical vegetation in LSMs -> large errors in evaporation and dominates signal of impact of coupling.

- Issue: dead vegetation affects bowen ratio; constraints on conopy conductance, LAI, etc.

- Differences in different models' sensitivity to changes in forcing that are likely to be important in GCMs, need to be understood.

- Discussions at the GEWEX conference, July 2014.

- DICE workshop in Toulouse, 20-22 May 2015 with discussion of various "coupling diagnostics" that have been developed.

- DICE manuscript in preparation, with subsequent papers for a special collection publication.

- Details: *http://appconv.metoffice.com/dice/dice.html*

- Proposed GABLS project for Antarctica: GABLS4, "DICE-over-ICE".

Global Land Atmosphere System Study (GLASS)

LoCo

"LoCo" – Local Coupled Land-Atmospheric Modelling

"Understand, model and predict the role of local land-atmosphere coupling in the evolution of land-atmosphere fluxes and state variables, including clouds."

LoCo Working Group
Research Updates and the SGP Test bed

Joe Santanello, NASA-GSFC, Greenbelt, MD, USA

Craig R. Ferguson, SUNY at Albany, Albany, NY, USA

Pierre Gentine, Columbia University, NY, NY, USA

How are GEWEX/GLASS/LoCo currently organized?

Monitoring and diagnosis

Mining of available obs/model output/satellite remote sensing (All)

Coupling metric formulation (Santanello, Findell, Gentine,Tawfik, Dirmeyer) and inter-comparisons (O. Tuinenburg)

ARM-SGP testbed (Ferguson,Santanello,Gentine)

Data gap analysis and proposing new field campaigns (Ferguson, Santanello, Gentine, Findell),

Process understanding

Model construction/evaluation and refinement (Gentine/All)

Impact on seasonal to inter-annual variability (incl. drought and prolonged wet regimes)/ Impact on short-term and seasonal forecast skill (T and P) (Roundy, Ferguson, and Wood, GLACE-2)

Research to Operations

L-A coupling becomes a target/decision metric for calibration and spin-up (Santanello, Roundy)

Clouds to estimate EF (Gentine, Ferguson, Holtslag)

LoCo Science Questions

- What role do land-atmosphere interactions (i.e., coupling strength) play in hydrologic extremes and abrupt shifts in regional climate?

- What are the trends in regional coupling strength over the period of record? Where has coupling enhanced (or suppressed) the global warming signal?

- How do we measure and benchmark coupling → underlies efforts to implement a testbed for LoCo research over the U.S. southern Great Plains.

Ferguson, C.R., J.A. Santanello, and P. Gentine (2012), GEWEX-GLASS LoCo Southern Great Plains Diagnostics Testbed Survey.

Xie, S. et al. (2013), ARM Best Estimate (ARMBE)-Land data set, released.

Ferguson, C.R., J.A. Santanello, and P. Gentine (2014) Application to ARM Climate Research Facility Field Campaign Program entitled "ARM-SGP Enhanced Soundings for Local Coupling Studies", in-review.

Southern Great Plains (SGP) Testbed

Goals:
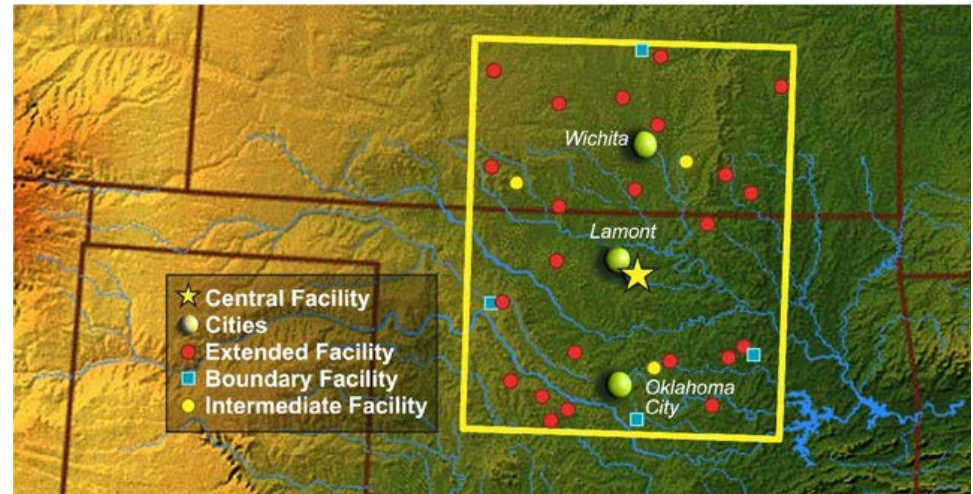
- Provide a multi-year observational and modeled data test bed for the evaluation and inter-comparison of diagnostics.

- Determine the information content source for L-A coupling in terms of temporal and spatial scale, modeled quantities, and observation type.

- Provide a hierarchy of diagnostic tests to identify and subsequently classify coupling.

- Quantify the sensitivity of coupling classification to metric applied.

Opportunity: Can we rally LoCo/GLASS around a field campaign (pulling in D. Gochis and E. Vivioni)**?**
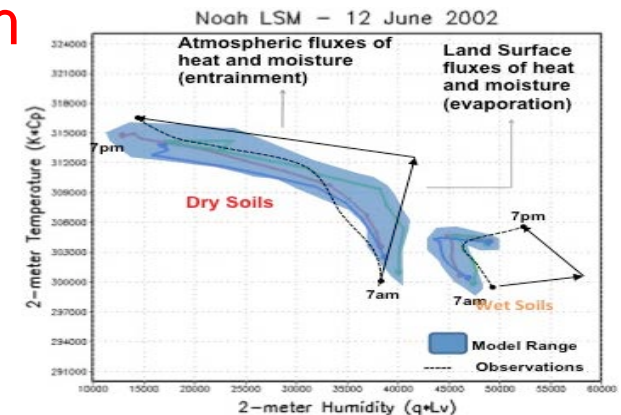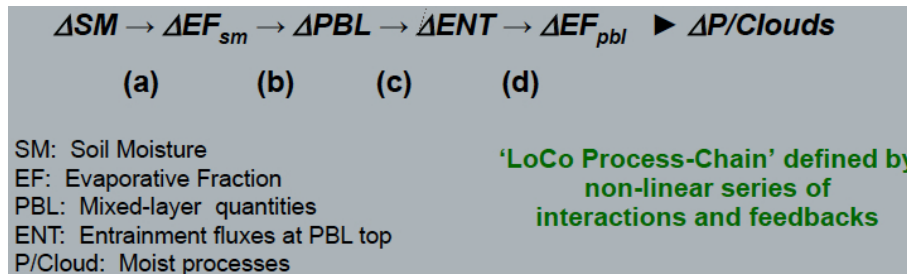
LoCo/GLASS comments:

• No community-wide or supported experiments (as for PILPS, GSWP and GLACE)

• Problem child: Difficult to converge on scope, metrics, and degrees of freedom

• LIS-WRF as a mini-testbed for developing diagnostics

• SCM and 1st order experiments proposed (e.g. last year), but limited by funding and personnel

• How do we best leverage off prior/existing projects?

• Do we need/want a large LoCo MIP? Feasibility?

LoCo/GLASS… but some good news:

- LoCo WG collaborating with U.S. Dept. Energy's ARM-SGP campaign.
- Produced an ARM-supported dataset for coupling studies over the U. S. SGP.
- *Radiosonde campaign led by LoCo WG in Summer 2015 to augment current ARM-SGP sonde launches (more of them) for application to LoCo studies.*
- Assessment of LoCo diagnostics to understand hierarchy and to develop a classification system
- based on the metrics.

$$\Delta SM \rightarrow \Delta EF_{sm} \rightarrow \Delta PBL \rightarrow \Delta ENT \rightarrow \Delta EF_{pbl} \quad \blacktriangleright \quad \Delta P/Clouds$$

(a)　　　(b)　　　(c)　　　(d)

SM: Soil Moisture
EF: Evaporative Fraction
PBL: Mixed-layer quantities
ENT: Entrainment fluxes at PBL top
P/Cloud: Moist processes

'LoCo Process-Chain' defined by non-linear series of interactions and feedbacks

GLASS Project Updates – Broad Recap:

PALS-PLUMBER – Additional flux sites, 2D, PALS website updates.

PILDAS - Land data assimilation project likely underway in 2015.

DICE – Currently sfc fluxes dominate signal of land-atmos interaction.

LoCo – Summer 2015 SGP testbed, assess land-atmos coupling diag.

ALMIP2 - Recommendations on improved parameterized processes for W. Africa, intercomparison of hydro/ET models.

GSWP3 - Links to carbon community (iLEAPS, Integrated Land Ecosystem - Atmosphere Processes Study), extend long-term retrospective back to 1850, consider LULCC), explore land model uncertainties.

LUCID – How land coupling affects climate sensitivity to land cover change require coordinated experiments in AMIP-style and could be combined with C20C simulations; linkages between iLEAPS, GSWP3 & landcover treatment in 20C.

GLACE-CMIP5 – Soil moisture/CO_2 influences; land surface adding to predictability; LS3MIP ("Land Surface, Snow and Soil Moisture MIP") builds in part on the GLACE-CMIP5.