Global Land Atmosphere System Study (GLASS)

Reporting period: 1 September 2011 – 30 September 2012
URL: http://www.gewex.org/glass.html

Chair(s) and term dates:
Joseph Santanello 2011 – 2014
Martin Best 2009 – 2012 (will step down 31 Dec)
Aaron Boone 2013 – 2016 (will begin 1 Jan)

GLASS Overview and Summary:
"Support improved estimate and representation of (land) states and fluxes in models, the interaction with the overlying atmosphere, and maximize the utilized fraction of inherent predictability."

The aim of GLASS is to promote community activities that improve our best estimates and the model representation of state variables (e.g., soil moisture) and fluxes (e.g., evaporation), or to improve our understanding of land/atmosphere feedbacks and the role of land surface in predictability. To achieve these aims, GLASS has been re-structured into three elements: Benchmarking, model data fusion and land-atmosphere coupling. The concept of benchmarking (rather than validation) will enable the modelling community to identify the current strengths and weaknesses of our models in relation to their required applications. This is a complete shift of focus for the modelling community and will require careful definitions of the a priori metrics that a model needs to achieve. The new Benchmarking/PALS project will directly address this theme with the goals of demonstrating this approach to benchmarking for the community through an AMS session and GEWEX Newsletter article.

The second strand of model data fusion will bring data assimilation techniques to both the initial value problem and to constrain the bounds of unknown parameters by using historical datasets. In the past land data assimilation has been limited due to restrictions in observational data of the land components (e.g. soil moisture), but new satellite data enables an opportunity to explore more advanced data assimilation techniques. The new PILDAS project led by Reichle will directly address this theme of GLASS.

The final strand of GLASS aims at understanding the physical interactions between the land and the atmosphere and how feedbacks can change the subsequent evolution. Whilst the GLACE1 and GLACE2 projects have demonstrated regions of the globe and situations where the land can have a significant impact on atmospheric evolution, they also highlighted large differences between modelling systems. Hence GLASS will help to facilitate two aspects of land/atmosphere coupling, the first being to understand the physical processes whilst the second will strive to understand how both land and atmospheric parameterisations interact. The focus is at both the process/local level (LoCo) and the global behaviour of the coupling (GLACE). This understanding will help to maximise the inherent predictability of the coupled land/atmosphere system.

In summary, the adoption of new TORs for the panel has already improved the expectations of and for panel members, shed former members who were no longer contributing, brought new experienced and young scientists into the fold, and allow the outside community better access to and understanding of the panel operations. GLASS currently has a good mix of established and new projects getting off the ground and in the planning stages, each of which maps well to the themes (MDF, Benchmarking, LAC). GLASS has reached out substantially to GHP on a number of projects, is launching projects with GABLS, and continues to engage WGNE on benchmarking and data assimilation activities. The interaction with GDP could be improved, however, particularly with regards to Landflux activities and modelling.

Panel Activities and Science Highlights

GSWP3 (Hyungjun Kim)
A follow-up project to the Global Soil Wetness Project 2 is in the near-launch stage, with a kick-off meeting scheduled for 5-7 November 2012 in Tokyo. The new components being considered for this project are:

- Cover a longer period of the 20th Century (~1900 – recent), which includes some interesting global trends in hydrology, but is also long enough for carbon processes

- Include carbon models, to explore/attribute a possible carbon-related effect or changes in eco-system functioning on these trends. This could make a bridge to the terrestrial carbon cycle modelling community.
- Explore uncertainties in (precipitation) forcings by using multiple data sets
- Include simulations using CMIP5 models, both present day and future conditions.
- Use a routing scheme (TRIP) and GRACE data for evaluation and diagnostics.

Over the last year, a great deal of bias correction has been applied to the forcing dataset (20CR forcing), which uses global dynamical downscaling and CRU observations for 2m fields. Radiation correction is applied using the GEWEX SRB product. A "white paper" (experimental protocol) has been refined since the 2011 GLASS panel meeting, from which a 2-pager will be produced and circulated with the carbon community to get their buy-in before the project begins. This will enable both carbon and water and energy cycle land surface models to be included, and simultaneously evaluated in them (e.g. the hydrology of carbon models and vice-versa). After the kick-off meeting, it is anticipated the project will begin in early 2013, but depending on the carbon community might be pushed back a bit.

LoCo and the SGP Testbed (Joe Santanello)
The LoCo Working Group has spent the last year producing and publishing work on diagnostics of L-A interactions and coupling across an array of scales and models. A trilogy of papers has been written based on the coupling of NASA's LIS with the WRF Mesoscale model that includes model coupling behaviour evaluation during wet and dry extreme periods over the U. S. SGP. Other diagnostics have produced global maps of coupling metrics from GCM output and reanalysis products such as NARR and MERRA. A wide net has been cast in developing coupling metrics and producing maps, but it is recognized that now is the time to reel in these efforts, and synthesize them to get at more science-driven questions of coupling. Some examples of these diagnostics are the traditional mixing diagrams, LCL-deficit, Findell-Eltahir diagnostics of triggering of convection, revised relative humidity tendency variables, McNaughton coupling coefficient, and TFS/AFS. To this end, the LoCo WG is embarking on a testbed project (see details below) that will produce a ARM-supported dataset for coupling studies over the U. S. SGP. This dataset will allow the array of diagnostics to be applied consistently to the same location in order to understand their hierarchy and to develop a classification system based on the metrics.

PALS and Benchmarking (Gab Abramowitz)
The Protocol for the Analysis of Land Surface models (http://pals.unsw.edu.au) has progressed to a more advanced version that includes gap filling, empirical benchmarks, and automated metrics along with a large suite of Fluxnet data. PALS been designed to analyse in a standard way uploaded single site model simulations with site observations. Extensions to other datasets and the development of benchmarking tests are under development. For example, implementation of the Manabe bucket model and the Priestly-Taylor approach to flux estimation will be performed in order to use as standard benchmarks of the 'goodness' of current LSMs. The joint GHP-GLASS project to demonstrate benchmarking through PALS is ramping up with a deadline to produce results for the AMS Annual Meeting and GEWEX Newsletter. Site and model selection is to take place in the coming weeks, with a subset of contributions to be the focus for January deadline.

LUCID (Andy Pitman)
2 papers have been published in the last year summarizing the LUCID1 and LUCID2 results. This includes evaluation the impact of land cover change in 5 GCMs using the LUH dataset. A key result supports the need to engage LSM and LCC dataset providers both, to see how to intelligently implement LCC in models. LUCID would also like to gauge interest of the LCC community in c20c/CMIP5, but it has been tough to get their attention. There may be linkages between GSWP3 and the landcover treatment in the 20c simulations and LUCID efforts that will be investigated.

GLACE2-CMIP5 (Sonia Seneviratne and Bart van den Hurk)
Exp#1A and #1B of GLACE2-CMIP5 has been completed. This involved AR5 reruns of climate change projections using a 1971-2000 soil moisture climatology versus using a seasonal transient cycle of soil moisture and evaluated during the 2070-2100 period. 3 groups have completed (GFDL, ECHAM, CESM) the full analysis and papers have been submitted. Future phases of experiments involve land cover change. Highlights show that the imposed SM anomalies show similar regions as those projecting drought increase, and a larger impact of soil moisture change on daily max temperature. Precipitation changes are less clear, and additional analysis will be conducted to analyze the feedbacks and water balance (E-P). This is expected to be completed over the next 12 months.

PILDAS (Rolf Reichle)
PILDAS is expected to launch in early 2013, once participants from all the major operational centers have confirmed participation. The experimental design is nearly complete, and a pilot study is underway by the project lead to use 2 LSMs with 1 DA algorithm in NASA's LIS.
Phase-1 is focused on operational centers (rather than niche research projects), synthetic obs, and different DA algorithms w/different LSMs for a 1/8 degree domain over the SGP. Later phases will focus on coupled DA systems and actual satellite observations from SMOS and SMAP. GLASS will take the experimental plan and pilot results to WGNE to put pressure on centers that are not currently listed (e.g. UK Met).

ALMIP2 (Aaron Boone)
The 2nd AMMA Land MIP was launched in Spring 2012 and currently is wrapping up phase 1 with submissions due in mid-September. 22 LSMs, 5 hydrological models, and 1 ET model are all included in this first phase. In this experiment, the focus is on a much higher spatial resolution (5km) than in ALMIP1, to focus on the subtle hydrology and vegetation processes that dominate there (occasionally very large rooting depths, land use change, sloping bedrocks removing water from the catchment, strong variability in runoff), and to enable use of high resolution satellite data. The period covers 4 years, where the forcing is coming from a blend of in situ and radar/Landsat/other satellite data. The project will give recommendations on the parameterization of runoff scaling. As this project has regional hydrological aspects, it is also considered to be in ideal candidate for a collaborative project between GLASS and GHP to foster close working relationships. However, efforts to connect with GHP failed despite circulating the white paper and experiment details.

Science Issues

1. The GSWP3 science details still need to be well defined and issues ironed out with regards to the forcing data choice and corrections applied. A 2-page document summarizing the key goals and methods of GSWP3 has been commissioned by the GLASS co-chairs before the kick-off meeting, such that it can also be distributed to entrain the carbon community up front.
2. The definition of 'local' vs. 'non-local' coupling and representation of each by the array of LoCo diagnostics is a non-trivial issue. This will be addressed directly by the SGP Testbed dataset and diagnostic intercomparison, and will include the effect on coupling metrics of spatial and temporal scales.
3. Forcing height used to force the PILDAS experiments needs to be resolved (either 2/10m or lowest model level). There is not an optimal best solution here at the moment, as some models have only one or the other available.

New Projects in Place

ALMIP2, PILDAS, and GSWP3 are in the 'just-launching' phases. Specifically:
- Launch of the GSWP3 project will happen in November 2012 in collaboration with the terrestrial carbon cycle modelling community.
- ALMIP2 is underway in phase 1 and about to begin phase 2, and is in collaboration with GHP.
- Refinement of a white paper and completion of experimental design for PILDAS has taken place. A pilot study is underway and contributors will be finalized by Spring 2013.

Workshops/Meetings Held
GLASS panel meeting at Pan-GASS: Boulder, CO, 13-14 September 2012
GLASS/GABLS breakout session at Pan-GASS: Boulder, CO, 12 September 2012
LoCo/SGP Testbed breakout session at Pan-GASS: Boulder, CO, 11 September 2012

New Projects and Activities Planned

1) The GLASS/GABLS DIurnal Coupling Experiment (DICE) has been presented during a breakout session at the Pan-GASS meeting in Boulder. It was decided to proceed with phase 1 that will culminate in a workshop to be arranged for the fall of 2013. This project will involve the GABLS and GLASS members running fully coupled SCMs at the CASES 99 experiment (which was the GABLS2 project) and controlling for surface fluxes vs. atmospheric forcing in each component to isolate the impact of land-atmosphere coupling in the models over the full diurnal cycle (stable and unstable PBLs). Project leads of Martin Best, Bert Holtslag, Gunilla Svensson and Adrian Lock will ensure that progress is made in both communities.

2) The LoCo/SGP Testbed Project was presented during a breakout session at Pan-GASS where the ARM data providers attended and the community was invited to participate in a data needs survey for L-A coupling studies. The ARM group has agreed to produce a Climate Best Estimate data product for LoCo at the ARM SGP site, which will then be used to establish a benchmark of L-A coupling based on LoCo-derived diagnostics by the working group. Craig Ferguson and Joe Santanello will be leading this effort.

3) A Benchmarking study has been proposed through GLASS whereby the PALS system will be demonstrated using data acquired in conjunction with GHP. The first phase will involve GLASS members' land surface model contribution to PALS at an array of sites (10-15). The results will be presented at AMS in January 2013 during a GLASS-hosted benchmarking session, and also published as a GEWEX Newsletter article.

4) GABLS Stable Boundary Layer project. GLASS would like to be involved in terms of assessing the thermal coupling and momentum flux in a polar climate (to date has been lacking in terms of GLASS activities and focus). However it was agreed that GLASS does not currently have members with the right skills to investigate cold region processes in such a climate, so a link to CLiC needs to be established. An approach to CLiC will be made to find someone who could join the GLASS panel and form a link between GLASS, GABLS and CLiC for this project. It was also agreed at the Pan-GASS GABLS breakout session that the first step of a joint project should have both communities concentrating of their components of the system to fully understand these. A second step could then investigate the impact of land/atmosphere coupling in this environment.

Workshops/Meetings Planned

GSWP3 Kick-off meeting: Tokyo, November 2012
WGNE Annual Meeting (GLASS presentation): Toulouse, November 2012
AMS Annual Meeting (Benchmarking session hosted by GLASS): Austin, January 2013
GLASS/GABLS Diurnal Cycle Workshop, TBD Fall 2013
'Land Conference' idea has been proposed for 2014 timetable
GLASS Panel Meeting, TBD Fall 2013

Contributions to GEWEX Science and Fit to Imperatives

GLASS contributes most directly to the following GEWEX Imperatives:

1) Develop diagnostic approaches to improve process-level understanding of energy and water cycles in support of improved land and atmosphere models.

- Identify feedbacks and the interactions among different processes, and build confidence in their replication in models (GLACE2, LoCo).
- Spin-up activities in *advanced diagnostics* through a joint pan-GEWEX effort/workshop (GRP, GLASS, GHP, and others).
- Develop metrics to aid benchmarking activities for both un-coupled and coupled modeling activities.
- With the current and expected increasing complexity of land models in terms of various hydrologic and vegetation treatments, model optimization (i.e., parameter estimation approaches) will continue to be relevant to GLASS efforts (through Model Data Fusion).
- Investigate alternative representations of sub-grid processes in land surface schemes (heterogeneity).
- Develop improved understanding of climate variability and change on land surface properties, including soils, vegetation and hydrological processes, and an associated modeling capability (GSWP3).
- Investigate the scope for development of next generation land surface models with improved representation of subsurface hydrology, including groundwater processes; identify suitable areas for their evaluation.

2) Improve global and regional simulations and predictions of precipitation, clouds, and land hydrology, and thus the entire climate system, through accelerated development of models of the land and atmosphere.

- Coordinate the construction of a global land reanalysis system, building on ongoing and preparatory activities in Landflux, GSWP3, GLDAS and operational weather centers.

- Develop a framework and infrastructure for evaluation of land-atmosphere feedbacks. This should include the development of more quantitative estimates of uncertainty in the land condition and how this uncertainty propagates through to the atmosphere (e.g., PBL, convection, water and energy). This objective will be advanced in conjunction with the Processes Imperative in developing diagnostics.
- Organize coordinated intercomparison experiments for a range of model components in state of the art land models, especially with regard to: groundwater hydrology; surface water treatment (snow, river routing, lakes, irrigation, and dynamic wetlands); vegetation phonology and links between carbon and water; and Land Data Assimilation systems (follow-up the PILDAS initiative).
- Evaluation of these land model components will also have to be considered in their interactive (coupled) context with the PBL, while taking into account and developing more quantitative measures of uncertainty in the land parameters and states will enable more robust evaluation of data assimilation systems.

List contributions to the GEWEX Grand Science Questions and plans to include these.

#1: How can we better understand and predict precipitation variability and changes?

*The GLASS activities below address the linkages of precipitation (and its accuracy) to land surface processes and LSM predictability.

Related current GLASS activities:
GLACE – Land/SM impact on precipitation and predictability (POC: Sonia/Bart; 1 and 2 complete; CMIP in progress)

LoCo – Regional/Local Process-Level Quantification of land-PBL interactions and impact of land surface on precipitation (POC: Joe)

ALMIP2 – Specific precipitation event studies and heterogeneity issues in soil moisture-precipitation feedbacks (POC: Aaron)

PILDAS – Land DA of soil moisture; multi-variate coupled DA (precip and SM) in a future phase (POC: Rolf)

GSWP3 – Precip as a key forcing for 20th Century simulations – this effort should quantify the error bounds on the 'land reanalysis' generated due to precipitation uncertainty (POC: Hyungjun)

Benchmarking – How does Precip uncertainty impact offline and coupled model evaluation – spread of LSM physics vs. spread due to precipitation errors (POC: Martin, Gab)

Future activities:
Incorporation of new satellite products (GPM, SMOS, SMAP) into these efforts more explicitly.

#2: How do changes in the land surface and hydrology influence past and future changes in water availability and security?

*Water Use, Resources, and Sustainability issues are at the heart of this challenge. How can GEWEX be positioned to meet this challenge given the current structure and makeup, currently focused on modeling groups and model intercomparisons with loose ties only (at best) with water resource and planning communities? Current activities are trying to answer various aspects of the science issues here (e.g. soil moisture and drought in a changing climate), but not yet at the stage of integrating the entire terrestrial water budget. GRACE is the only current tool we have in this regard, but is very limited in space and time scales such that regional and diurnal studies and models cannot be improved or assessed using this dataset. Carbon, ecosystem, cryosphere, ground water, and distributed hydrology models are not traditionally GEWEX activities – but fully integrated Earth System and Land models will are the future so we need to be forward thinking. It seems this challenge is really the overarching challenge of all land hydrology for climate studies.

As a result, this challenge also intersects directly with other entities (iLEAPS, iLAMB, CLiC, DMIP, LULCC). This challenge might boil down to coordinating model development from previously disparate disciplines and applications, and based on CMIP5 results in terms of the limitations and

sensitivities to the land hydrology (e.g. LUCID recent results). iLEAPS-GEWEX Newsletter collaboration will be a good start to this.

Related current GLASS activities:
LUCID1/2 (POC: Andy)
ALMIP1/2 (POC: Aaron)
PILDAS/SMAP (DA of surface>root zone will be critical to link with GRACE)
PILPS-Urban (POC: Martin)
LULCC w/iLEAPS (POC: Bart)

Future activities:
TRACE (now NAWP): The first workshop (2011) ended up discussing many of these water resource and sustainability questions, as 'themes' of a potential TRACE RHP. These questions are the ones that agencies seem most willing to support in the current climate, and communication from pure science/models to stakeholders is something we need to address.

#3: How does a warming world affect climate extremes, and especially droughts, floods and heat waves, and how do land area processes, in particular, contribute?

*This seems to be the 'hot topic of the year', e.g. how will the frequency and location of extremes change due to 'x' amount of warming in the future? The NASA Energy and Water Cycle Study (NEWS) chose 'Extremes' as one of it's core integration projects, and could be looked at as a model both of what and what not do, and what can be learned by a limited subset of the community (material available online). Model evaluation and benchmarking becomes critical here as well. Most models are tested offline and only for average conditions, and once into extreme realms of forcing or states tend to behave much differently. Recent LSM calibration/parameter estimation studies suggest that a vastly different set of parameters (lookup tables) is required for extremes vs. average conditions. As observational data improves (e.g. challenge #1), this is no guarantee the models will behave better as a result. DA and Calibration studies should be a focus here. Calibration is a weak component of GLASS currently and should be expanded under 'Model Data Fusion'. You can learn a lot about model behavior and limitations that way, especially in concert with DA.

Related current GLASS efforts:
PILDAS - DA w/ Calibration for improved soil moisture representation during extreme conditions.

LoCo - quantification during extremes to get at model behavior & how LSMs impact the persistence of droughts/floods and feedbacks. Seasonal drought prediction needs a lot of improvement with the emphasis on the land impact (http://www.climatecentral.org/news/lack-of-warning-on-2012-us-drought-reflects-flaws-in-forecasting-14823/)

ALMIP2 - inherently encompasses dry extremes/feedbacks over AMMA with monsoon precipitation.

GLACE2-CMIP is examining impact of SM on extremes in CMIP5 (IPCC report just out on the subject).

Benchmarking - should look at model performance stratified by regime.

Future activities:
CORDEX-GLASS collaboration possibly needs to a) exist and b) accelerate to answer these questions in the context of climate model predictions. This might be most feasible in conjunction with HyMeX over the next 5-10 years.

#4: How can understanding of the effects and uncertainties of water and energy exchanges in the current and changing climate be improved and conveyed?

*This seems to be the most traditional GEWEX-type challenge in that it promotes a lot of activities in the current panels and relies on the strengths of the current makeup. What this challenge also shows is how much more work needs to be done in quantifying and improving W&E cycle prediction in models of all scales and types. Results and improvements as a result are felt throughout the remaining three challenges, WCRP, and other communities as well. In order to close the land surface energy balance, we need to address all the issues and model evaluation and development listed in this challenge, and it will require SMOS/SMAP, GPM, GRACE, etc. to get right.

Related current GLASS efforts:
GSWP3 – Land reanalysis and sensitivity of surface fluxes to forcing uncertainties including radiation.

LoCo – Determining Processes; How are land and PBL fluxes quantified and interact with each other.

PILDAS – Constraining LSMs with observations for improved land surface energy balance

Benchmarking – Asses land surface energy balance in models vs. empirical models, and evaluating the 'goodness' of a model prediction.

Future activities:
GLASS-GDAP – Improve connection between SRB, Landflux and GLASS modeling and prediction and consistency between data products and models.

Overall Comment:
*Having reviewed the challenge documents as a GLASS member, I was also trying to envision myself as a GABLS or GASS member. It seems their expertise lies most prominently in Challenge #1, but that is focused on precipitation only. What about all their work on other things like the stable PBL? Otherwise, they are mostly implicit amongst challenges, the majority of which are quantified at the land surface.

Other key science questions that you anticipate your community would want to tackle in the next 5-10 years within the context of a land-atmosphere project (1-3 suggestions)

1. The impact of the land surface, soil moisture and vegetation, and L-A coupling on Seasonal/Drought Prediction.
2. A common modular interface for LSMs, such that different models and components can be more easily transferred to other's platforms, intercompared, and swapped. This would also include a common land-atmosphere coupling modularity such that different atmospheric and land models can be intercompared in order to evaluate the impact of each on the coupling results.

Briefly list any specific areas of your panel's activities that you think would contribute to the WCRP Grand Challenges as identified by the JSC (not covered under 9).

Provision of skillful future climate information on regional scales (includes decadal and polar predictability)
- **o** GSWP3, ALMIP2
- o Benchmarking (defining skillful), MDF (improved prediction and skill), and LAC (process-level improvement in L-A coupling)

Regional Sea-Level Rise
- **o** None

Cryosphere response to climate change (including ice sheets, water resources, permafrost and carbon)
- **o** Possible links to GABLS4 experiment and stable PBL coupling.

Improved understanding of the interactions of clouds, aerosols, precipitation, and radiation and their contributions to climate sensitivity
- **o** None direct, but L-A Coupling theme addressing the soil moisture-precipitation feedbacks.

Past and future changes in water availability (with connections to water security and hydrological cycle)
- **o** GSWP3, GLACE(CMIP), and GPM/GRACE/SMOS/SMAP synergy
- o LAC (process-level improvement in water and energy cycle feedbacks)

Science underpinning the prediction and attribution of extreme events
- **o** See above wrt GEWEX Challenge #3 (strongest contribution from GLASS is here?)

- o Benchmarking (model goodness during extreme conditions), MDF (data assimilation and model calibration during extremes), and LAC (improvements in coupling leading to improved predictability of extreme events from local to global scales)

Cooperation with other WCRP projects (CLIVAR, CliC, SPARC), outside bodies (e,g. IGBP) and links to applications

1) A connection to CliC has been proposed through the GABLS Stable PBL Project over the arctic region. A suitable GLASS representative for both cold processes and stable PBLs has yet to be identified, however.

2) GLASS and iLEAPS are collaborating on a joint newsletter (to be produced by iLEAPS but equally weighted between GLASS and iLEAPS contributions. The iLEAPS IPO are very happy to hear that we all agreed to contribute to the next iLEAPS Newsletter "**Bridging the gap between the iLEAPS and GEWEX land-surface modeling communities**". The deadline for original submissions is **31 October 2012**. The newsletter will include the following:

- Editorial (Gordon Bonan and Joe Santanello as GLASS co-chair)
- NWP-perspective (Mike Ek, NOAA/NCEP)
- ESM-perspective (Nathalie de Noblet, LSCE)
- JULES joint perspective (Martin Best, Chris Jones, UK Met Office)
- CLM joint perspective (Dave Lawrence, Rosie Fisher, NCAR)
- Model benchmarking (Eleanor Blyth, Dave Lawrence)

Issues for the SSG

GHP involvement and data for the Benchmarking/PALS project has been very slow in coming together. Gab has acquired Fluxnet data on his own, but we are awaiting a higher QC set of data from 10-20 sites (formerly CEOP) to participate in the pilot study of PALS. This slow progress has not been from a lack of trying, side meetings, telecons, or email exchanges with GHP (and help from Sam) and we are hopeful that finally this effort will come to fruition in the next 6-12 months.

The ALMIP2 leads reached out multiple times to GHP as well for feedback on the white paper/proposal before the project launched earlier this year. There was some limited response by GHP and feedback for Aaron, but were hopeful for a more tangible collaboration in this regard.

In response to an earlier SSG request, we have reached out to HyMeX and now have a GLASS representative (Aaron) who attended the HyMeX workhop in Croatia in May 2012. Likewise, HyMeX has provided a representative (Pere) who will attend GLASS meetings in the future. There are many 'land activities' as part of HyMeX, and the length and design of the study make it essential that GLASS at least monitor the modelling activities therein. In addition, the HyMeX-CORDEX connection is something GLASS can look to as we attempt to strengthen the land component of CORDEX going forward (to date non-existant).

The idea of a 'Land Conference' has been loosely proposed by GLASS. This would be similar to Pan-GASS, but for the land modelling community and would be open to land data assimilation, carbon, and distributed modelling communities as well. The timetable would be 2013-2014 and a host/venue would need to be acquired. The idea of Santa Fe, NM was proposed (and likely US-host given funding limitations in Europe). We would coordinate with iLEAPS as well, but not to an extent that the iLEAPS Science Conference would be in conflict. The upcoming GEWEX-iLEAPS joint newsletter (Winter 2013) co-edited by Bonan and Santanello is an ideal opportunity to pursue this idea further.

List of key publications (*where appropriate*)

PALS

Abramowitz, G., 2012: Towards a public, standardized, diagnostic benchmarking system for land surface models, *Geoscientific Model Development*, 5, 819-827, doi:10.5194/gmd-5-819-2012.

Kumar, S. V., C. D. Peters-Lidard, J. A. Santanello, K. W. Harrison, Y. Liu, and M. Shaw, 2012: Land surface Verification Toolkit (LVT) - A generalized framework for land surface model evaluation. *Geosci. Model Development,* **in press.**

LoCo

Santanello, J. A., C. D. Peters-Lidard, and S. V. Kumar, 2011: Diagnosing the Sensitivity of Local Land–Atmosphere Coupling via the Soil Moisture–Boundary Layer Interaction. *J. Hydrometeor*, **12,** 766–786.

Santanello, J. A., C. Peters-Lidard, A. Kennedy, and S. Kumar, 2012: Diagnosing the Nature of Land-Atmosphere Coupling During the 2006-7 Dry/Wet Extremes in the U. S. Southern Great Plains. *J. Hydromet.,* **in press.**

GEWEX-GLASS

Hurk, B. J. J. M, M. Best, P. Dirmeyer, A. Pitman, J. Polcher, J. A. Santanello, 2011: Acceleration of Land Surface Model Development over a Decade of Glass. *Bull. Amer. Meteor. Soc.*, **92,** 1593–1600.

List of members and their term dates (including changes) where appropriate:

The GLASS Terms of Reference have been presented at the panel meetings in 2011 and 2012, and have since been ratified by the GEWEX SSG. These TORs include term limits on chairs of 4 years, staggered in 2-year intervals for continuity of leadership. 2 main categories of panel members have been established and without term limits: Experienced Scientists (including project leads) and Young Scientists, as well as a protocol for new members of each category that they attend the next panel meeting and establish their interest and relevance to the panel activities. Template letters signed by GEWEX/Kevin Trenberth have also been developed to welcome new panel members and to thank departing members for their service.

Martin Best (Co-chair through 31 Dec 2012)
Joe Santanello (Co-chair through 31 Dec 2014)
Aaron Boone (Co-chair beginning 1 Jan 2013)
Michael Ek
Hyungjun Kim
Rolf Reichle
Paul Dirmeyer
Eleanor Blyth
Andy Pitman
Bart vd Hurk
Gianpaolo Balsamo
Matt Rodell
Christa Peters-Lidard
Patricia de Rosnay
Sonia Seneviratne
Gab Abramowitz
Craig Ferguson (*New YS)
Nathan Brunsell (*New ES)
Lifeng Luo (*New ES)
Fei Chen (*New ES)
Pierre Gentine (*New YS)
Tomo Yamada (*New YS)