WGNE meeting and presentations:

World Climate Research Programme (WCRP)
Global Energy and Water Cycle Exchanges Project (GEWEX)
Global Land/Atmosphere System Study (GLASS)

Michael Ek (NCEP/EMC) and
Gab Abramowitz (UNSW),
GLASS Co-chairs

GLASS panel members and other GEWEX collaborators

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.

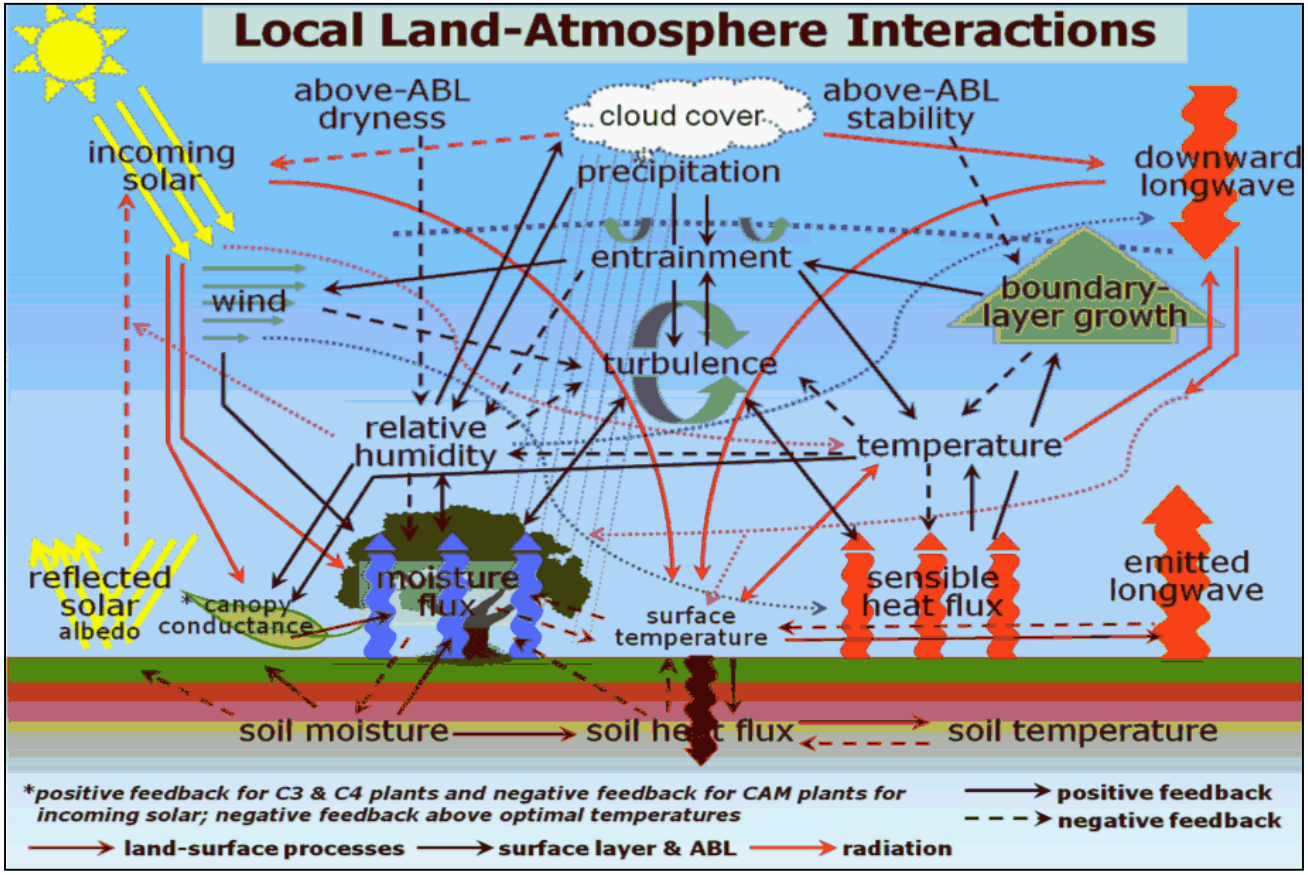

Fig. 3.1. Schematic of the complex interactions between the land surface, atmospheric boundary layer (ABL), and radiation via many variables (temperature, relative humidity, wind and associated turbulence, cloud cover, etc). Adapted from Ek and Holtslag (2004 J. Hydromet., 5, 86-99), courtesy Mike Ek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

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GLASS Vision and Mission

The GEWEX Vision

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

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

The GEWEX Mission

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

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

GLASS Structure

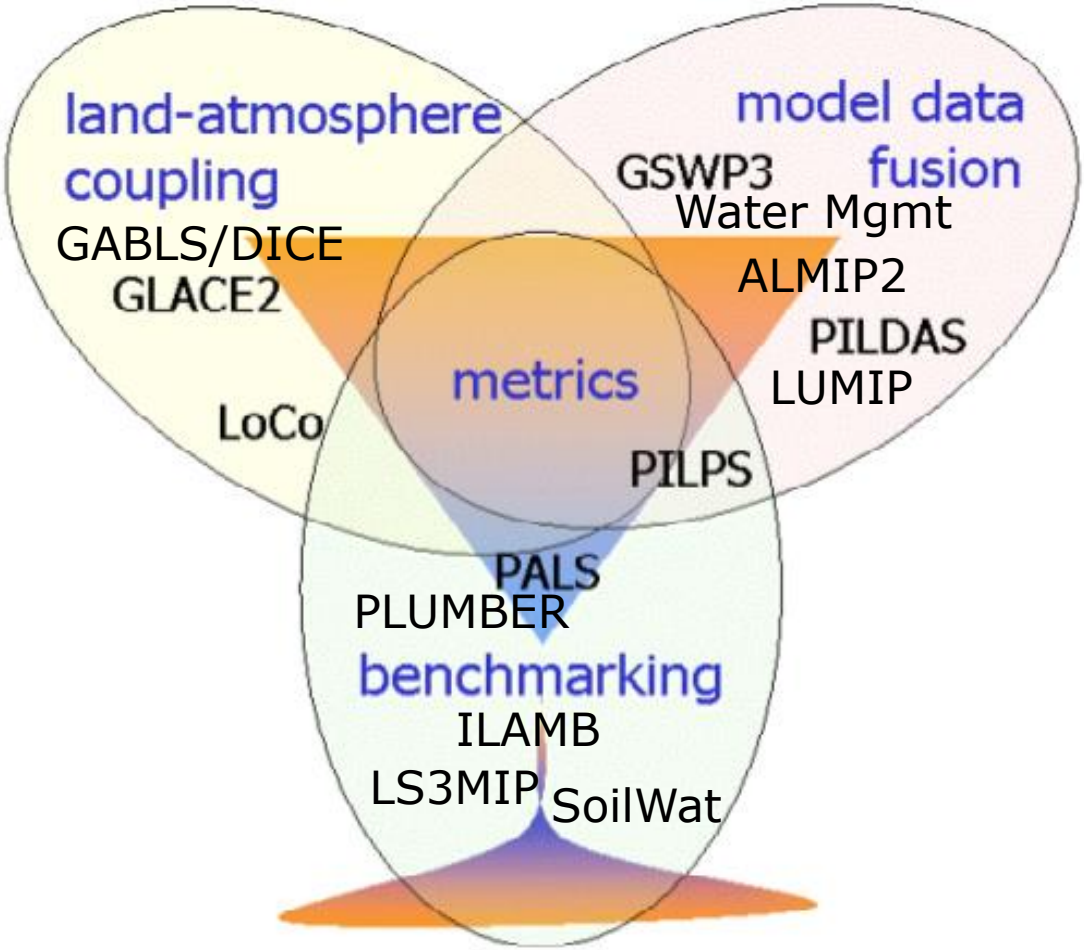
The aim of GLASS is to promote community activities that improve:

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

1. **our understanding of land/atmosphere feedbacks**

1. **our understanding of the role of land surface in predictability**

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



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GLASS Projects

BENCHMARKING:

PALS Protocol for the Analysis of Land Surface models
PLUMBER PALS Land sUrface Model Benchmarking Evaluation pRoject
ILAMB International Land Atmosphere Model Benchmarking activity
GSWP3 Global Soil Wetness Project phase 3
LS3MIP Land surface, snow, and soil moisture MIP (CMIP6)
SoilWat GEWEX Soils and Water initiative

LAND-ATMOSPHERE INTERACTION:

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

MODEL DATA FUSION:

LUMIP Land Use Model Intercomparison Project
PILDAS Project for the Intercomparison of Land Data Assimilation Systems
ALMIP2 AMMA Land surface Model Intercomparison Project phase 2
Human Dimensions/Water Management Anthropogenic Influences on/Water Management of Global Water Cycle

GLASS Projects: Cross-cuts

Cross-Cutting projects/actions:

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

Recently launched or to be launched:

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

Recent GLASS achievements: benchmarking coordination

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

Recent GLASS achievements: LS3MIP

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

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

Geoscientific Model Development
Open Access
EGU

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

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

[1]KNMI, De Bilt, the Netherlands
[2]Institute of Industrial Science, the University of Tokyo, Tokyo, Japan
[3]LGGE, CNRS, Grenoble, France

Recent GLASS achievements: LoCo

1. The results of offline projects such as PILPS and GSWP are limited by the lack of atmospheric feedback, and GLACE cannot isolate and evaluate the processes implied in the coupling that lead to model development.
2. To accurately represent the relationship between soil moisture (SM), surface fluxes, PBL development and precipitation (P), and coupling strength in models, it is necessary to carefully examine and quantify the full series of interactions and feedbacks (i.e., links in the chain) at the process-level, including the planetary boundary layer (PBL) feedback.
3. To this end, the LoCo initiative and WG was established nearly a decade ago to focus on development of quantitative process-based metrics/diagnostics of L-A coupling that could be applied equally to observations and models across scales.
4. *LoCo has galvanized the land-atmosphere observing and modeling community in terms of new observations/field programs, establishing new useful "coupling" metrics, and engaging and training a number of young scientists, and putting them in positions of leadership is this effort.*

Recent GLASS achievements: LoCo (cont.)

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

GLASS Connections to Other Projects

GLASS-GASS: DIurnal land/atmosphere Coupling Experiment, including recent GEWEX Atmos. Boundary Layer Study GABLS4 (Antarctica).

Monsoons: joint initiative of GEWEX and CLIVAR
-> Importance of land-atmosphere interactions within monsoons.

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

GHP: land-atmosphere data sets from RHPs for process studies, e.g.:
-> Hydrological Cycle in the Mediterranean Experiment (HyMeX).
-> Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE) (Iberian Peninsula).
-> Anthropogenic water management in models.

ILEAPS: biogeochemical cycles, land-atmosphere chemistry.

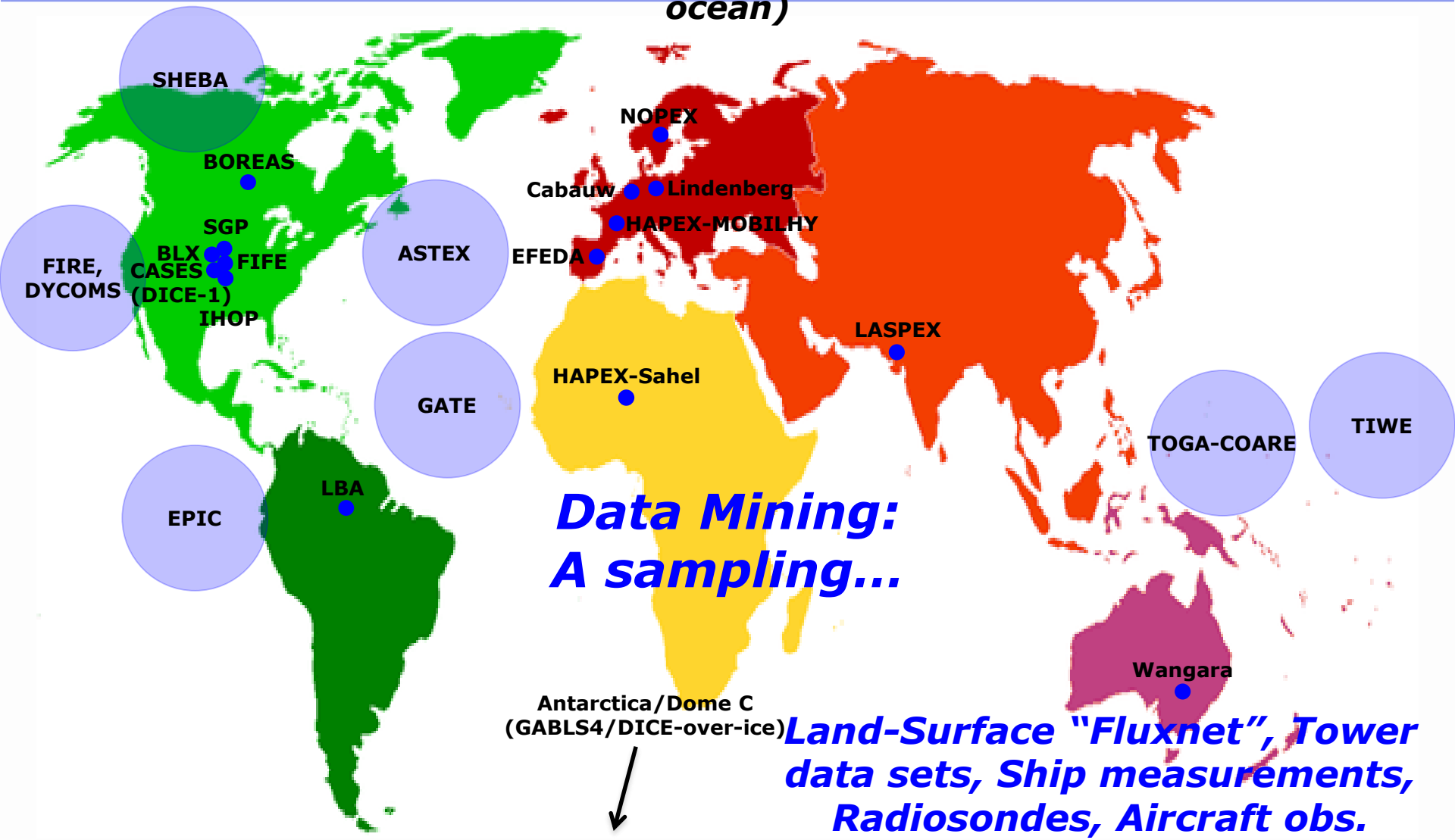
Cold Seasons Process: GHP, ILEAPS, CliC, ILEAPS focus on snow, frozen soils/permafrost, tundra, e.g. Saskatchewan & Mackenzie river basins.

WMAC: Promoting model development and coordination across WCRP.

WGNE: Data assimilation & process-level improvement to model physical parameterizations (e.g. PILDAS, PALS/PLUMBER, LoCo & DICE).

WMO: Other working groups, e.g. within WWRP.

Possible Future GLASS-GASS DICE efforts: Field Programs for Model Physics Development, Surface-Atmos. Interaction (land, ice, ocean)



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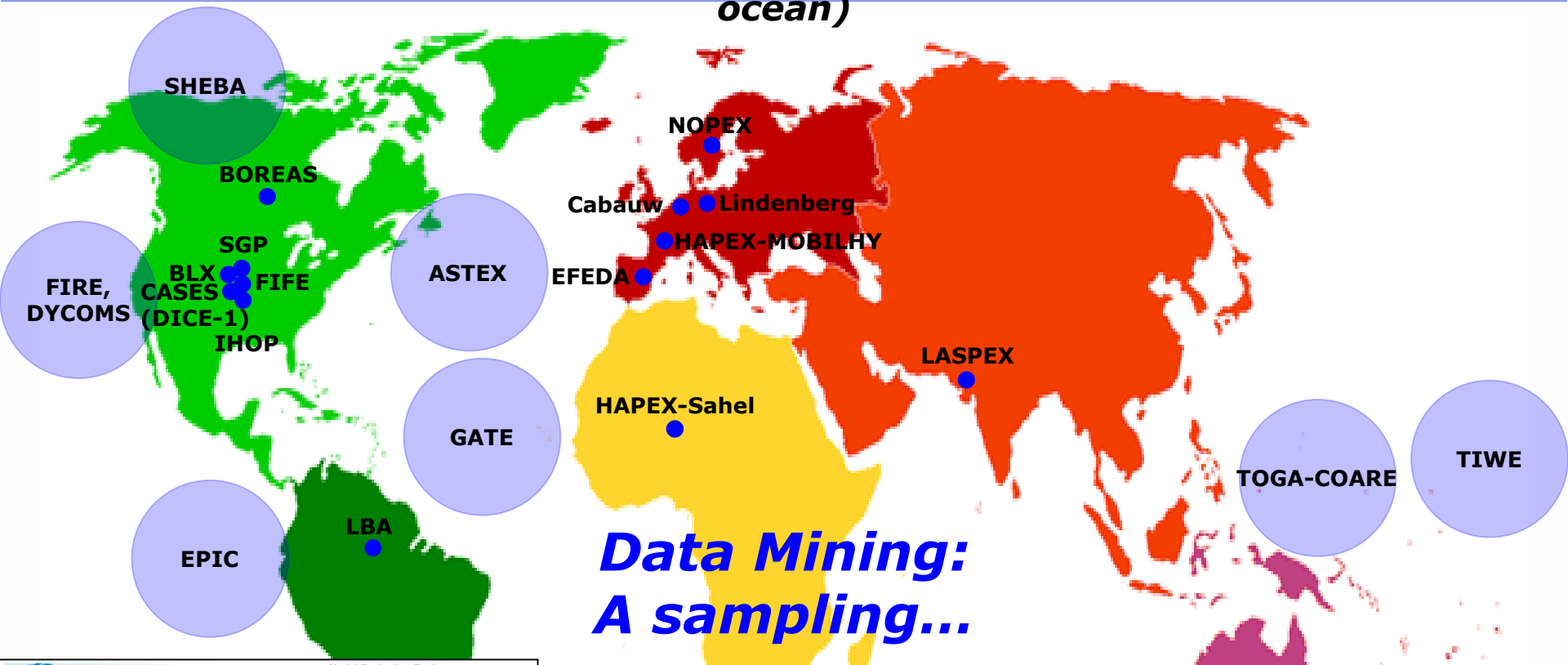
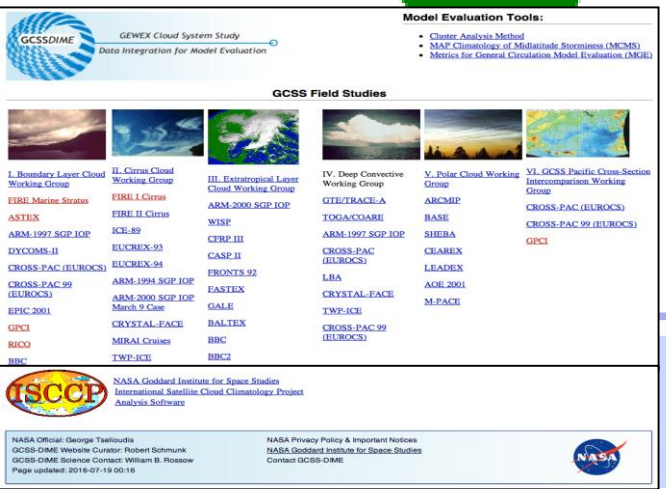


Data Mining:
A sampling…



Land-Surface "Fluxnet", Tower data sets, Ship measurements, Radiosondes, Aircraft obs.

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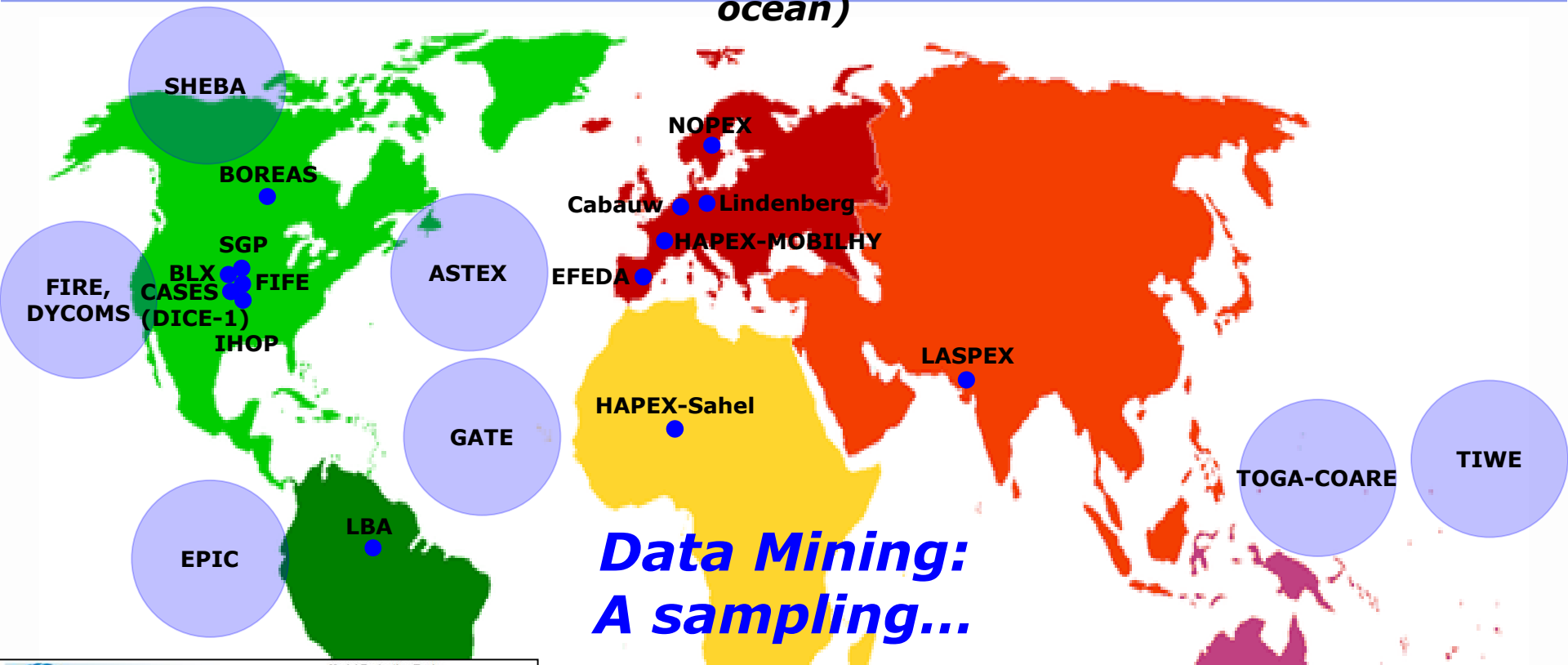
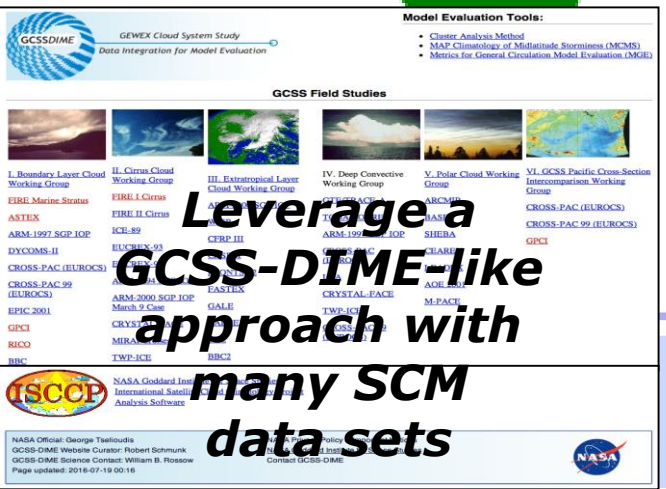
Possible Future GLASS-GASS DICE efforts: *Field Programs for Model Physics Development, Surface-Atmos. Interaction (land, ice, ocean)*



Data Mining: A sampling…



Leverage a GCSS-DIME-like approach with many SCM data sets

Land-Surface "Fluxnet", Tower data sets, Ship measurements, Radiosondes, Aircraft obs.

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

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

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

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

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

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

GEWEX Science Questions related to following research areas:

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

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

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

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

Key science questions in the next 5-10 years
(Taken from GLASS Science Steering Group-29 Meeting Report)

- **Land Impact**: Explore the impact of the land processes on Seasonal/Drought Prediction, and other high-impact "Earth System events" on society.
- **Common Interfaces:** common modular interface for LSMs (new ALMA), common land-atmosphere coupling modularity, continue improving benchmarking methods/tools/datasets for the community.
- **(Land) Model Developments/Improvements:** Improved cold season processes (interactions between permafrost and greenhouse gas emissions), ground water interactions, anthropogenic processes/water management (irrigation, aquifer uptake, crop harvest, improved LULCC), and the LSM "grey zone" (in anticipation of ever-higher resolution research and NWP applications: lateral fluxes of mass and energy), improved representation of soils and their highly heterogeneous nature.
- **How to most effectively improve our Earth System models?** Perhaps component-by-component with increasing levels of coupling, building to a fully-coupled system; a thorough "model development hierarchy" with benchmarks at each level. GLASS activities would be one part of that development chain, e.g. land-only studies and testing (e.g. PALS/PLUMBER), coupled columns (DICE), regional coupling (LoCo), and so on. This would require an extensive "data mining" effort, and in time a highly multi-discipline, but potentially quite fruitful.

GLASS Panel Membership

Co-Chairs:

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

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

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

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

...and its carbon emissions are way too high...

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

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