The Global Energy and Water Cycle Experiment (GEWEX)

Dennis P. Lettenmaier
Co-Chair, GEWEX Hydroclimatology Panel (GHP)

GEO-UNESCO Joint Workshop on Earth Observations and Capacity Development in African River Basins

Nairobi

January 12, 2012
Climate and Cryosphere

Climate Variability and Predictability

Global Energy and Water Cycle Experiment

Stratospheric Processes and their Role in Climate
Vision statement

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 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.
GEWEX achieves its goals through data set development and analysis, process studies and model improvement.
GEWEX Project Organization

RADIATION

GRP GEWEX Radiation Panel (C. Kummerow; J. Schultz)

- BSRN Baseline Surface Radiation Network (E. Dutton)
- CIRC Continuous Intercomparison of Radiation Codes (L. Oreopoulos)
- GACP Global Aerosol Climatology Project (M. Mishchenko)
- GCP Global Precipitation Climatology Project (R. Adler)
- ISCCP International Satellite Cloud Climatology Project (W. Rossow)
- I3RC Intercomparison of 3-D Radiation Codes (R. Cahalan)
- LandFlux Land Surface Fluxes (W. Rossow)
- RAMI Radiation transfer Model Intercomparison (J-L Widlowski)
- SeaFlux Sea-Surface Fluxes (C. Clayson)
- SRB Surface Radiation Budget Project (P. Stackhouse)
- WGDMA Working Group on Data Management and Analysis (W. Rossow)

Assessment Working Groups:
- Aerosols (S. Christopher; J. Reid)
- Clouds (C. Stubenrauch)
- Radiation (P. Stackhouse)

MODELING AND PREDICTION

GCSS/ GABLS GEWEX Cloud System Study (J. Petch; C. Bretherton)
- GEWEX Atmospheric Boundary Layer Study (B. Holtslag; G. Svensson)

- *ACPC Joint GCSS/GLEAPS Project on Aerosols, Clouds, Precipitation and Climate (B. Stevens/GCSS; A. Meinrat/GLEAPS)
- *DIME Data Integration for Model Evaluation (R. Rossow)

GCSS Working Groups
- Boundary Layer Clouds (A. Lock)
- Cirrus Cloud Systems (S. Dobbie)
- Cloud Climate Feedback
  - CFMIP-GCSS Intercomparison of LES and SCMs (M. Zhang; C. Bretherton)
  - Cloud Microphysics (U. Lohmann)
- GCSS Pacific Cross-section Intercomparison (J. Teixeira)
- Solar Clouds (J. Pinto; H. Morrison)
- Precipitating Convective Cloud Systems (J. Petch)

GLASS Global Land/Atmosphere System Study (B. van den Hurk; M. Best)
- ALMA Assistance for Land-surface Modeling Activities
- GLACE-2 Global Land/Atmospheric Coupling Experiment (R. Koster)
- GSWP-3 Global Soil Wetness Project (T. Oki)
- LoCo Local land-atmospheric Coupling (B. van den Hurk)
- LUCID Land-Use and Climate, Identification of robust impact (A. Pitman)
- PILPS Project for the Intercomparison of Land-surface Parameterization Schemes (A. Pitman)

HYDROCLIMATOLOGY

GHP GEWEX Hydroclimatology Panel (D. Lettenmaier; TBD) J. Polcher

Regional Hydroclimate Projects (RHPs)
- AMMA African Monsoon Multidisciplinary Analysis Project (T. Lebel)
- BALTEX Baltic Sea Experiment (H. Isermeyer)
- CPPA Climate Prediction Program for the Americas (J. Huang)
- HyMeX HYdrological cycle in the Mediterranean Experiment (P. Drobinski)
- LBA Large-Scale Biosphere-Atmosphere Experiment in Amazonia (J. Maia)
- LPB La Plata Basin Project (H. Berbery)
- MAHASRI Monsoon Asian Hydro-Atmosphere Scientific Research and Prediction Initiative (U. Matsumoto)
- MDB Murray-Darling Basin Water Budget Project (J. Evans)
- NEESPI Northern Eurasia Earth Science Partnership Initiative (P. Groisman)

Regional Studies
- Cold Region (T. Ohata)
- High Elevation (G. Tartari)
- Monsoon (J. Matsumoto; H. Berbery; W. Lau)
- Semi-arid (C. Fu)

Data Management
- Reference Sites, River Basins (S. Williams)
- Model Output (M. Lautenschlager)
- Satellite Data (T. Koike)
- Data Integration and Dissemination (T. Koike)
- Central Data Integration (T. Koike)

Cross-Cutting Studies
- Water and Energy Budget Studies (K. Yang)
- Extremes (R. Stewart)
- Isotopes (D. Noone; K. Yoshimura)
- Aerosols (W. Lau)

Modeling Studies
- Global Models (M. Bosilovich)
- Regional Models
  - Inter-Continental Transferability Study (B. Rockel)
  - Scale Interaction Evaluation Experiment (R. Arritt)
- Land Surface Models (M. Rodell)
- Hydrologic Applications Project (E. Wood)

Affiliated Global Organizations
- GPCC Global Precipitation Climatology Centre (U. Schneider)
- GRDC Global Runoff Data Centre (U. Looset)
There is a new WCRP structure post 2013: how does GEWEX fit?

Main project areas include:

- Core projects retained but with revised responsibilities to facilitate climate system research at the interface of the physical Earth system components:
  - Ocean-atmosphere (think CLIVAR)
  - Land-atmosphere (think GEWEX)
  - Cryosphere (think CliC)
  - Stratosphere-troposphere (think SPARC)

- Within each core project there is a common set of basic “themes”:
  - Observations and analysis
  - Model development, evaluation and experiments
  - Processes and understanding
  - Applications and services
  - Capacity building
Some Key Issues for GEWEX

- The new GEWEX has adopted the mission of “land-atmosphere”

However GEWEX has also decided to be much more:

- **GEWEX will continue to embrace the global energy and water cycles**

- **GEWEX also embraces activities spanning Earth system domains and other integrating themes**
  - monsoons
  - extremes ...
Mission statement

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 interactions; thereby providing the scientific underpinnings of climate services.
Datasets: Foster development of climate data records of atmosphere, water, land, and energy-related quantities, including metadata and uncertainty estimates.

Analysis: Describe and analyze observed variations, trends and extremes (such as heat waves, floods and droughts) in water and energy-related quantities.

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

Modeling: 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.

Applications: Attribute causes of variability, trends and extremes, and determine the predictability of energy and water cycles on global and regional bases in collaboration with the wider WCRP community.

Technology transfer: Develop diagnostic tools and methods, new observations, models, data management, and other research products for multiple uses and transition to operational applications in partnership with climate and hydro-meteorological service providers.

Capacity building: Promote and foster capacity building through training of scientists and outreach to the user community.
Example: Imperatives: 1

DATASETS: Foster development of climate data records of atmosphere, water, land, and energy-related quantities, including metadata and uncertainty estimates.

Lead: GRP, CEOP; Partners: SCOPE-CM, CEOS, WOAP

Actions:

• Reprocess GEWEX datasets, provide advice on other efforts and lead evaluations.
• Continue evaluation and refinement of sensor algorithms, influencing next generation space-born platforms and reprocessing.
• Development of appropriate calibration/validation/evaluation datasets to confront models.
• Devise robust ways of dealing with the more diverse, complex, higher spatial and temporal resolution, and much greater volumes of data.
• Build on CEOP experience in data management, archival and access.

Trenberth et al 2009; 2010
2. **Analysis:** Describe and analyze observed variations, trends and extremes (such as heat waves, floods and droughts) in water and energy-related quantities.

Precipitation from observations and reanalyses (courtesy D. Dee)

Runoff trends 1948 to 2004 (Dai et al 2009)
3. **Processes**: Develop diagnostic approaches to improve process-level understanding of energy and water cycles in support of improved land and atmosphere models.

**Local Land-Atmosphere Interactions**

- **Incoming solar**
- **Wind**
- **Relative humidity**
- **Soil moisture**
- **Canopy conductance**
- **Moisture flux**
- **Reflected solar albedo**
- **Above-ABL dryness**
- **Precipitation**
- **Entrainment**
- **Cloud cover**
- **Above-ABL stability**
- **Downward longwave**

**Albedo effect**
- **Clean**
- **Larger drops**
- **More rain**
- **Less cloud-active aerosol**
- **Less cloud**

**Lifetime effect**
- **Polluted**
- **Smaller drops**
- **Less rain**
- **More cloud-active aerosol**
- **More cloud**

*positive feedback for C3 & C4 plants on incoming solar; negative feedback above land-surface processes*

*Courtesy Mike Ek, K Trenberth, Stevens and Feingold 2009*
• Continental Scale Experiment (CSE) concept developed (1990s)
  – development, diagnosis, and testing of coupled land-atmosphere models
  – focus on water and energy budget closure at near-continental scale.
  – E.g. Mississippi basin well instrumented and analyzed GAPP
• Regional Hydrometeorological Projects extend this concept to other regions: MAGS, BALTEX, GAME, LBA, AMMA
• GEWEX Hydrometeorological Panel (GHP) coordinated these
• Coordinated Enhanced Observing Period: second phase of GEWEX 2001-2006
• Combined with GHP and evolved to Coordinated Energy and Water Cycle Observations Project (CEOP) in 2007-2008
• GEWEX Hydroclimatology Panel (GHP) in 2010
GEWEX HYDROCLIMATOLOGY PANEL

GEWEX REGIONAL HYDROCLIMATE PROJECTS

Regional water cycles
Revitalizing GHP

• Reference sites vs flux towers
• 10 year data set; mission creep
• Archive for regional projects

New Phase

• Need to reinvigorate RHPs
  – Type I (core; criteria) and type II (affiliated)
• Stronger hydrological activities: foster the next generation of hydrologically realistic land surface schemes (cf. home for PILPS)
4. **Modeling**: 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.

Proposal from the last JSC meeting for a “**Modeling Council**”: “… the Modeling Council concept would allow the Projects to be better connected to the WCRP modeling efforts.”
GEWEX Modeling

- GCSS and GABLS to be combined
- Replace the GCSS working groups and their chairs by an SSC that oversees projects (about 8?)
- Projects are proposed to the SSC by any member of the community
- There will be a small set of criteria a project has to fulfill (e.g., leadership, timeline, plan)
- GABLS will be integrated into this structure and its participants will propose projects
- GLASS and GCSS/GABLS represent the SSG in WGNE
- GHP hydrological modeling is largely separate
Framework for Atmospheric Model Enhancement (FAME)

**Mission:** Improving the representation of physical and dynamical processes in the troposphere in models for all purposes and especially weather and climate services

**Ingredients**
- PBL (GABLS)
- Clouds and Convection (GCSS)
- Radiation (shared with GRP and SPARC)
- Coupling to dynamical processes
- Coupling to numerics
FAME
Should reside within GEWEX

- GEWEX would not be anything like the same without it
- already there
- maintains links to GLASS
- potentially good links to LAMs and RHPs
- natural focus on energy and water cycle
- deals with “fast processes”
- Will raise visibility of atmospheric model development
FAME: post 2013

- How this develops as a working group or panel within GEWEX but interacting with all of WCRP: CLIVAR, CliC, SPARC and feeding into other modeling WGs is not yet clear.

- WG on Atmospheric Processes and model development for climate (WGAP)?

- Needs to integrate with regional modeling (such as CORDEX)
5. **Applications**: Attribute causes of variability, trends and extremes, and determine the predictability of energy and water cycles on global and regional bases in collaboration with the wider WCRP community.
Monsoon crosscuts

- Concern that, once again, because monsoons cut across land and ocean domains, they may not be adequately addressed in new WCRP structure
- Models do not simulate monsoons well
- How much is resolution (e.g. of topography, land-sea divide)?
- Can models simulate the floods in Pakistan, China, India in summer 2010, and in Australia in their summer 2010-11?
Workshop on metrics and methodologies of estimation of extreme climate events: WCRP-UNESCO (GEWEX/CLIVAR/IHP)

- Chair: Olga Zolina
- 132 from 32 countries
- Oral, poster, discussion sessions; 3 Breakout Groups
- Community white paper, Eos* and BAMS(?) article
- http://www.extremeworkshop.org/

**Goal:** To provide much improved observational datasets and model capabilities on variability and extremes, especially those that have high impacts on society and the environment; and develop a climate information system that include predictions and assessments of future changes in risk from extremes.

*21 Dec 2010 issue*
Reason for focus on extremes

Mean A: 50° F, s.d. 10° F
The focus on extremes highlights a significant shift in climate: from A to B.

Most of the time, the values are the same (green).

The biggest changes in extremes exceed 200%.

**Mean A:** 50°F, s.d. 10°F

**Mean B:** 55°F, s.d. 10°F
Issues for extremes in models

- Model definitions are often different from obs:
- Model grid box value may not be comparable to mean of grid box from observations
- Model results typically not available or archived.
  - Need appropriate output from models (high frequency, stats, ability to generate pdfs)
- Ability and utility of models
  - Model extremes are not well simulated.
  - Is there confidence in the physics?
- Improvements of models (intensity, frequency of precip etc)
- Improvements in resolution
Moral for extremes in models

- Provide a focus for evaluating and development of models wrt how well they replicate extremes:
  - Developing better methods for comparing model grid point values with observations. Compare apples with apples: gridded data
  - Establish extreme-related measures for evaluation of models.
- Ensure that archives of model runs include sufficient high frequency data to assess pdfs and extremes.
  - Improve model archives with hourly data
- Assess ability and utility of models wrt extremes
  - As fn of resolution
  - As fn of parameterizations (e.g. convection)
- Set up specific CMIP5 analysis projects focused on extremes
  - Derive certain mandatory statistics
- What do these mean for impacts: downscaling?
7. **Capacity Building**: Promote and foster the development of capacity through training of scientists and outreach to the user community.

Education: workshops, training, summer schools; observations, data; technology use; interactions with users; outreach.

Participants at a recent La Plata Basin Workshop held in Itaipú Technological Park, Foz do Iguaçu, Paraná State, Brazil.

A panel discussion at the International BACC Conference, May 2006 in Gothenburg, Sweden, providing for science – stakeholder interaction and GEWEX/BALTEX outreach.
Please join us!