

Transferability Working Group (TWG)

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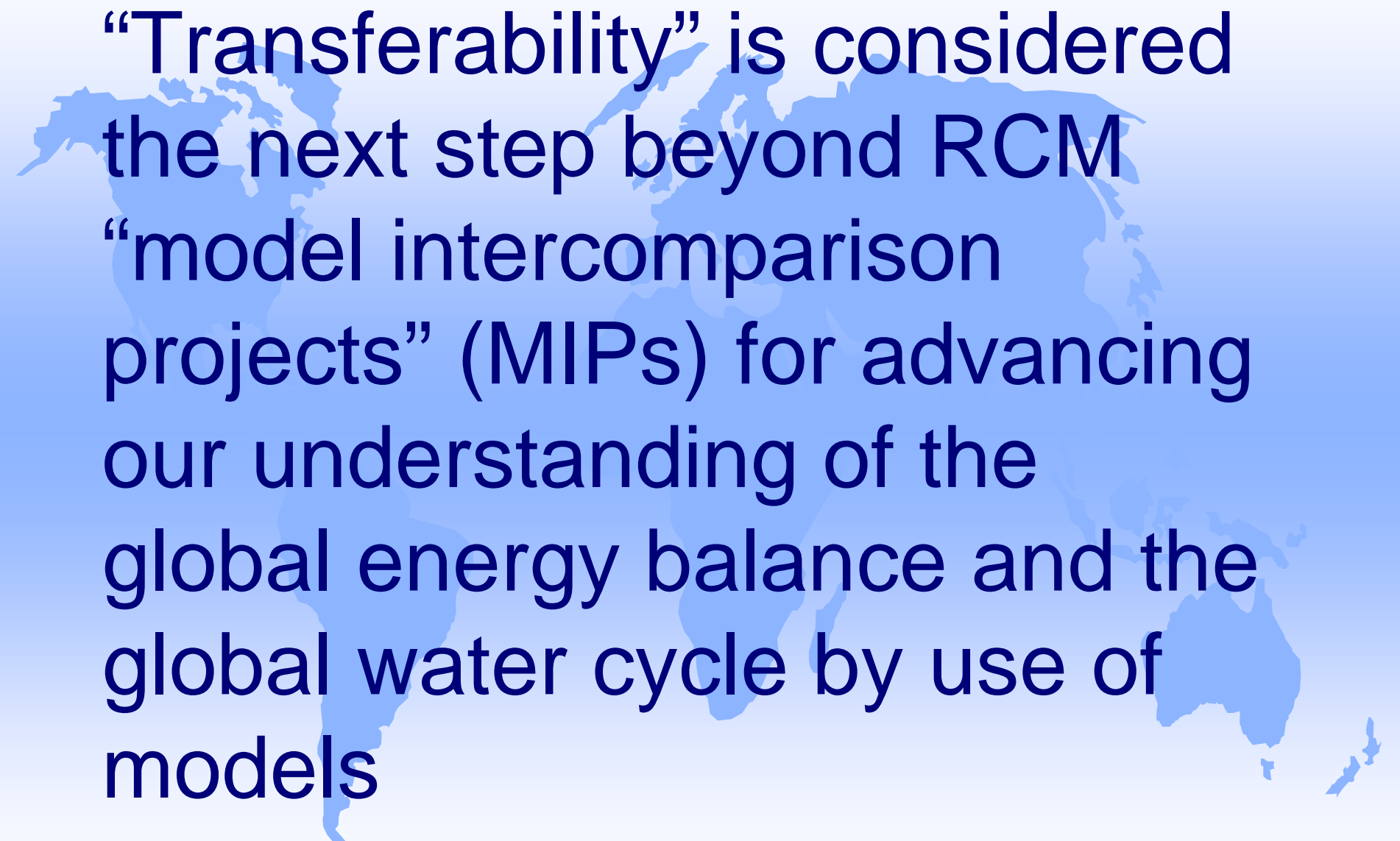
Pan-GEWEX, Frascati, Italy, 9-13 October 2006

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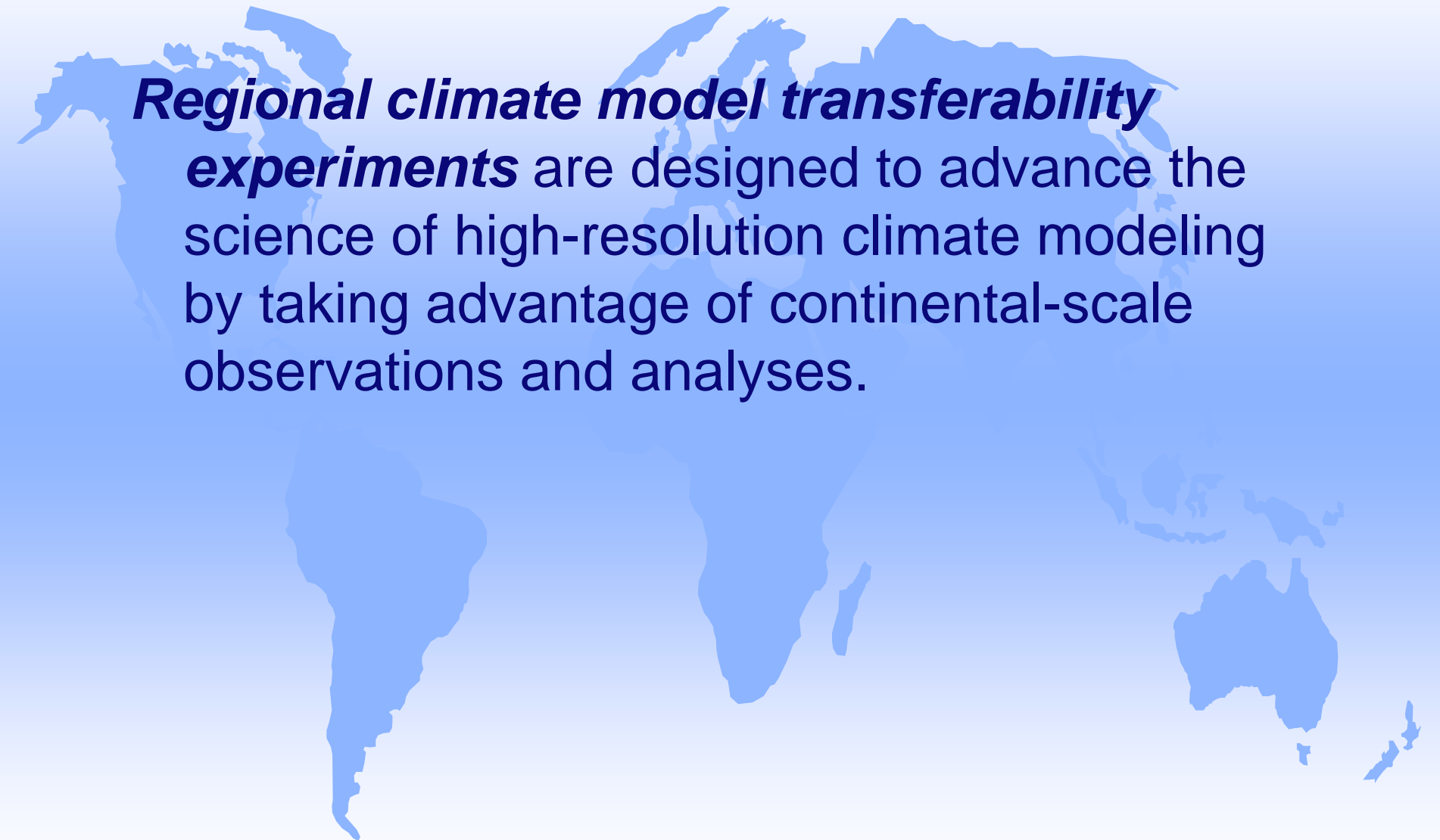
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“Transferability” is considered the next step beyond RCM “model intercomparison projects” (MIPs) for advancing our understanding of the global energy balance and the global water cycle by use of models

Transferability Objective



Regional climate model transferability experiments are designed to advance the science of high-resolution climate modeling by taking advantage of continental-scale observations and analyses.

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Regional climate model transferability experiments are designed to advance the science of high-resolution climate modeling by taking advantage of continental-scale observations and analyses.

MIPs have helped modelers eliminate major model deficiencies. Coordinated studies with current models can advance scientific understanding of global water and energy cycles.

Use of Regional Models to Study Climate

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Use of Regional Models to Study Climate



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- How much does “tuning” limit the general applicability to a range of climatic regions?
- Can we recover some of the generality of “first-principles” models by examining their behavior on a wide range of climates?

Transferability Working Group (TWG) Overall Objective

*To understand physical processes underpinning the global energy budget, the global water cycle, and their predictability through systematic intercomparisons of regional climate simulations **on several continents** and through **comparison** of these simulated climates **with coordinated continental-scale observations and analyses***

Examples of Past Advances due to “Transferability”:

Applications of Non-US Models to North American Domain*

- u Australian model run over the US revealed need for a much more robust vegetation model to capture strong feedbacks not common in Australia
- u Canadian model run over the US revealed need for more accurate convective parameterization for strong convection not found in Canada
- u Swedish model run over the US severely tested its convection, interaction of convection with the PBL and turbulent representation of the LLJ (which is not prevalent in Europe). Provided new ideas for linking convective activity to convective cloudiness.

* From Project to Intercompare Regional Climate Simulations (PIRCS)

Types of Experiments



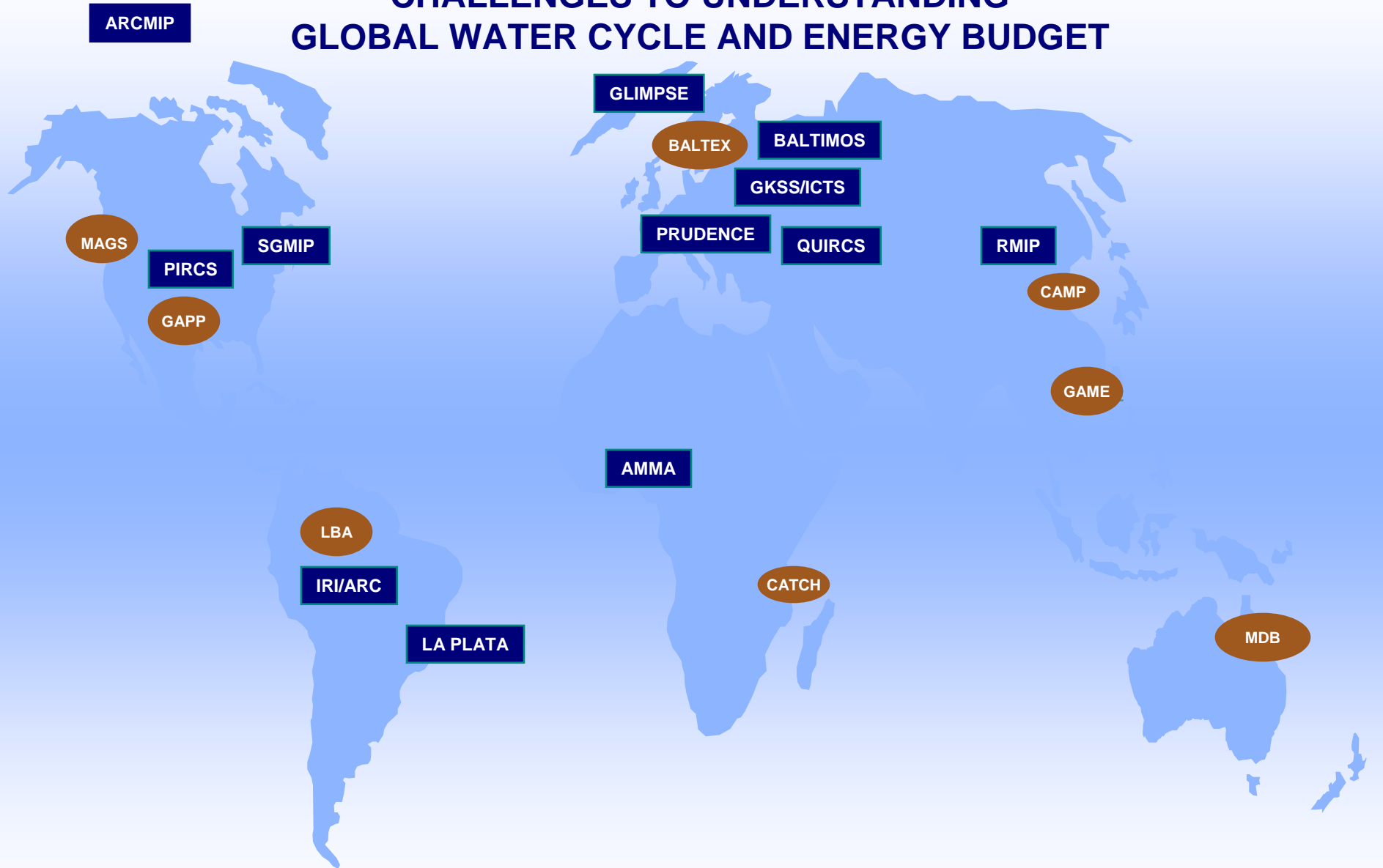
- ↳ Multiple models on multiple domains (MM/MD)
 - Hold model choices constant for all domains

Types of Experiments



- ∪ Multiple models on multiple domains (MM/MD)
 - Hold model choices constant for all domains
- ∪ Not
 - Single models on single domains
 - Single models on multiple domains
 - Multiple models on single domains

TRANSFERABILITY EXPERIMENTS FOR ADDRESSING CHALLENGES TO UNDERSTANDING GLOBAL WATER CYCLE AND ENERGY BUDGET



Specific Objectives of TWG



- o Provide a framework for systematic evaluation of simulations of dynamical and climate processes arising in different climatic regions

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- Evaluate “transferability”, that is, quality of model simulations in “non-native” regions
- “Meta-comparison” among models and among domains

Strategy



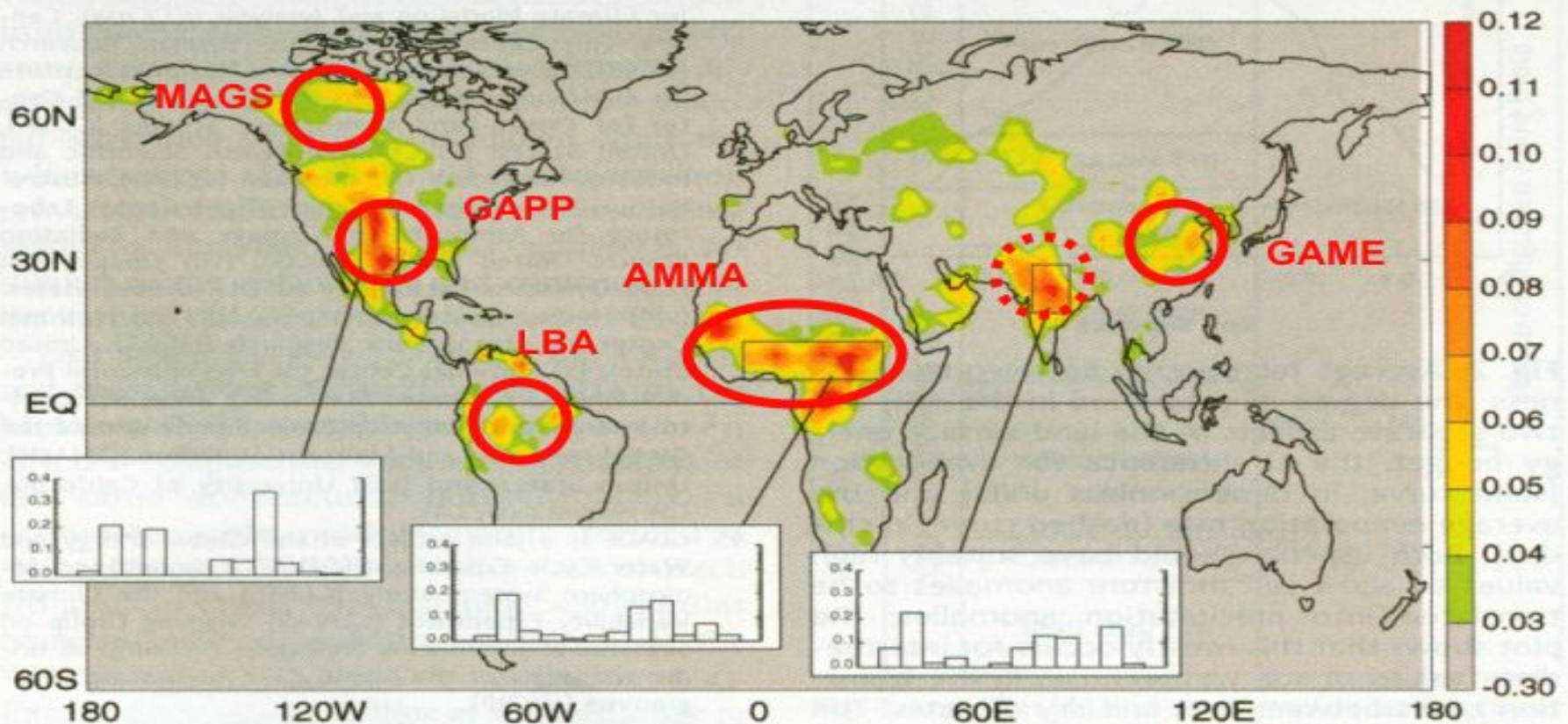
- ↳ Identify key processes relating to the water cycle and energy budget that express themselves to different degrees in different climatic regions

Strategy



- Identify key processes relating to the water cycle and energy budget that express themselves to different degrees in different climatic regions
- Create hypotheses that can be tested by use of MM/MD experiments.

Land-atmosphere coupling strength (JJA), averaged across AGCMs



GEWEX CONTINENTAL-SCALE EXPERIMENTS WITH HIGH COUPLING

- MAGS = Mackenzie GEWEX Study
- GAPP = GEWEX Americas Prediction Project
- LBA = Large-Scale Biosphere-Atmosphere Experiment
- AMMA = African Monsoon Multidisciplinary Analysis
- GAME = GEWEX Asian Monsoon Experiment

Locations of “hotspots” having high land-atmosphere coupling strength as identified by Koster et al. (2004) with GEWEX Continental Scale Experiments overlain.

Considerations for Developing Hypotheses



- Exploit the availability of CEOP data
 - Vertical profiles at isolated points
 - Components of energy budget and hydrological cycle
 - Sub-daily data
 - High-resolution observations of events

Candidate Issues Highly Relevant to Hypotheses on the Water and Energy Cycles



u Static stability (CAPE)

- Diurnal timing
- Seasonal patterns
- Spatial patterns

u Monsoon characteristics

- Diurnal timing of precip
- Onset timing
- Precip spatial patterns

u Snow processes

- Rain-snow partitioning
- Snow-water equivalent
- Snowmelt
- Snow-elevation effects

u Soil moisture

u Frozen soils

u Cloud formation

Expected Outcomes



- Improved understanding of the water cycle and its feedbacks on the energy budget and circulation system



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- Improved capability to model climate processes at regional scales
- Improved applicability to impacts models

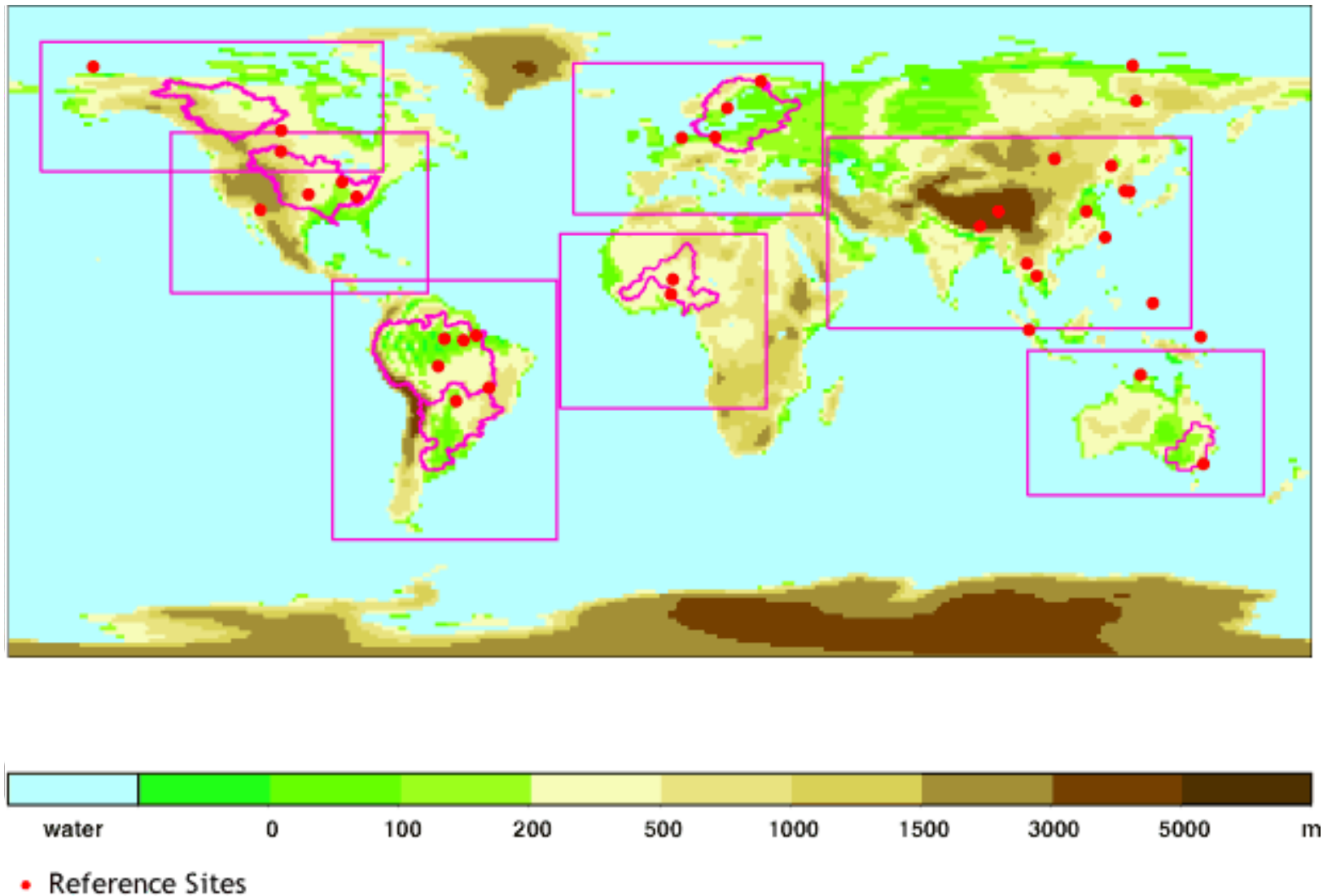
Plan of Work

- Phase 0: Write an article for BAMS summarizing lessons learned from various “MIPs” and describe how transferability experiments will provide new insight on the global climate system, particularly the water cycle and energy budget, report preliminary results

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Transferability Domains and CSE Reference Sites



Slide source: B. Rockel

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- u Phase 3: Prediction, global change, new parameterizations

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- Phase 1: Conduct sensitivity studies
- Phase 2: Perform sensitivity studies on key processes related to the water cycle. Create and test hypotheses related to the water cycle.
- Phase 3: Prediction of future climate change, new parameterizations

Completed

In Progress

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Work in Progress: Examples of Analyses

At GHP-10 TWG was challenged to develop *testable hypotheses* as a means of advancing our understanding of water and energy cycles

TWG Hypothesis 1



Models show no superior performance on domains of origin as evaluated by accuracy in reproducing diurnal cycles of key surface hydrometeorological variables.

True: Where do models show superior accuracy and why?

False: How can models be improved on non-native domains *while maintaining/improving* home-domain accuracy?

Hypothesis Test

Use hourly CEOP data from GAPP, Baltex, MAGS, LBA and CAMP for period of CEOP-1 (1 July 2001 – 30 September 2001):

| <u>CSE</u> | <u>Site</u> | <u>Lat</u> | <u>Long</u> | Model | |
|------------|-------------|------------|-------------|------------|-------------|
| | | <u>Lat</u> | <u>Long</u> | <u>Lat</u> | <u>Long</u> |
| Baltex | Cabauw | 51.97 | 4.93 | 52.00 | 5.00 |
| Baltex | Lindenberg | 52.17 | 14.12 | 52.00 | 14.00 |
| MAGS | Berms | 53.99 | -105.12 | 54.00 | -105.00 |
| GAPP | Ft. Peck | 48.31 | -105.10 | 48.50 | -105.00 |
| GAPP | Bondville | 40.01 | -88.29 | 40.00 | -88.50 |
| LBA | Pantanal | -19.56 | -57.01 | -20.00 | -57.00 |
| CAMP | Mongolia | 45.74 | 106.26 | 45.50 | 106.50 |

Hypothesis Test

Compare measured values with model simulations at indicated grid points for diurnal cycles of

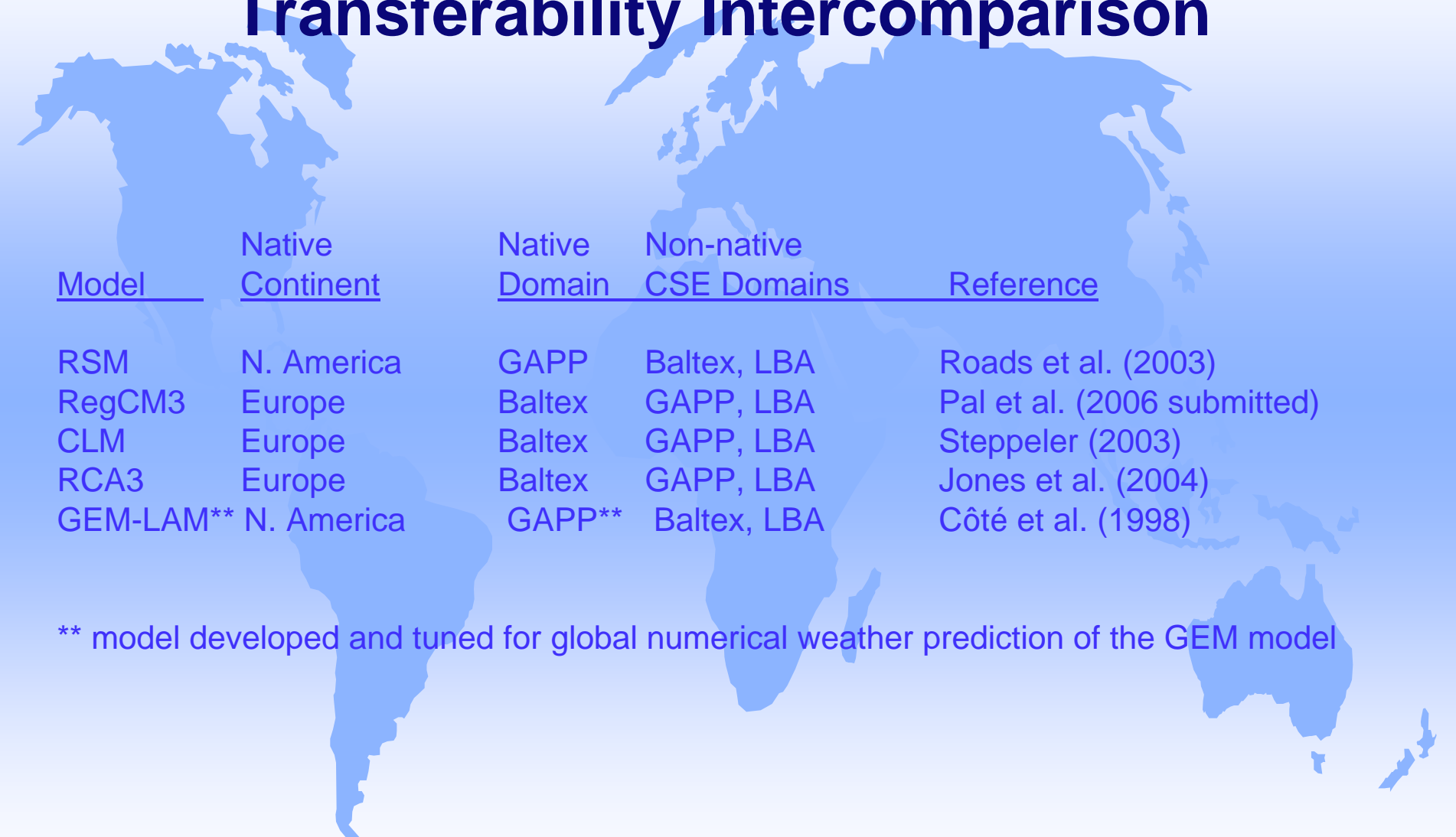
- ∪ Surface sensible heat flux
- ∪ Surface latent heat flux
- ∪ Monthly Bowen ratio
- ∪ Surface relative humidity
- ∪ Surface air temperature

Hypothesis Test

Compare measured values with model simulations at indicated grid points for diurnal cycles

- ∪ Compute monthly mean and quartile values of hourly measurements of each variable.
- ∪ Compute correlation coefficient for the 24 values of the diurnal cycle of mean and quartiles for each variable
- ∪ Compute amplitude of diurnal cycle
- ∪ Evaluate and compare model vs. observations for distributions of extremes by use of 4th quartile populations

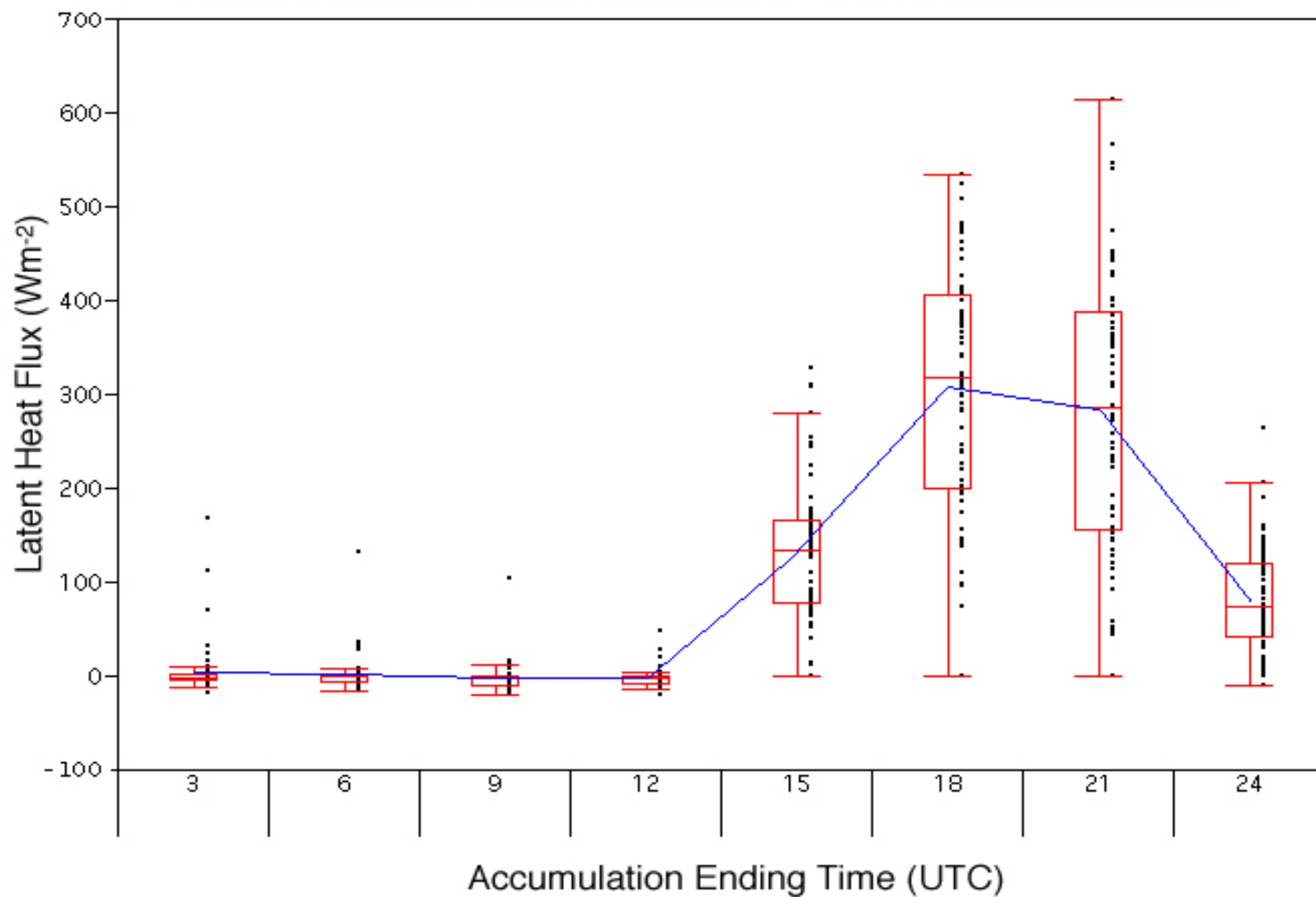
Models and Domains Used in Preliminary Transferability Intercomparison



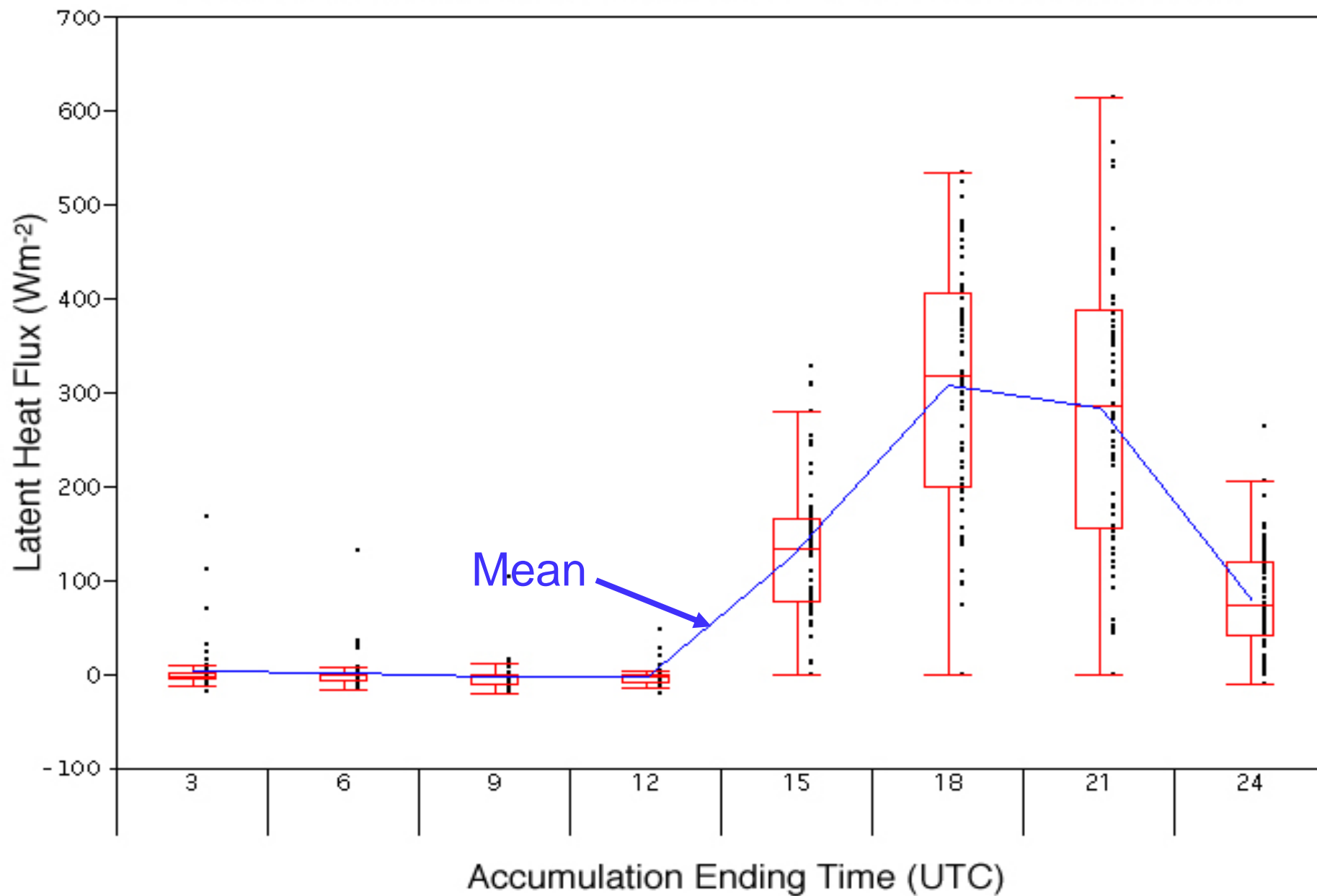
| <u>Model</u> | <u>Native Continent</u> | <u>Native Domain</u> | <u>Non-native CSE Domains</u> | <u>Reference</u> |
|--------------|-------------------------|----------------------|-------------------------------|-----------------------------|
| RSM | N. America | GAPP | Baltex, LBA | Roads et al. (2003) |
| RegCM3 | Europe | Baltex | GAPP, LBA | Pal et al. (2006 submitted) |
| CLM | Europe | Baltex | GAPP, LBA | Steppeler (2003) |
| RCA3 | Europe | Baltex | GAPP, LBA | Jones et al. (2004) |
| GEM-LAM** | N. America | GAPP** | Baltex, LBA | Côté et al. (1998) |

** model developed and tuned for global numerical weather prediction of the GEM model

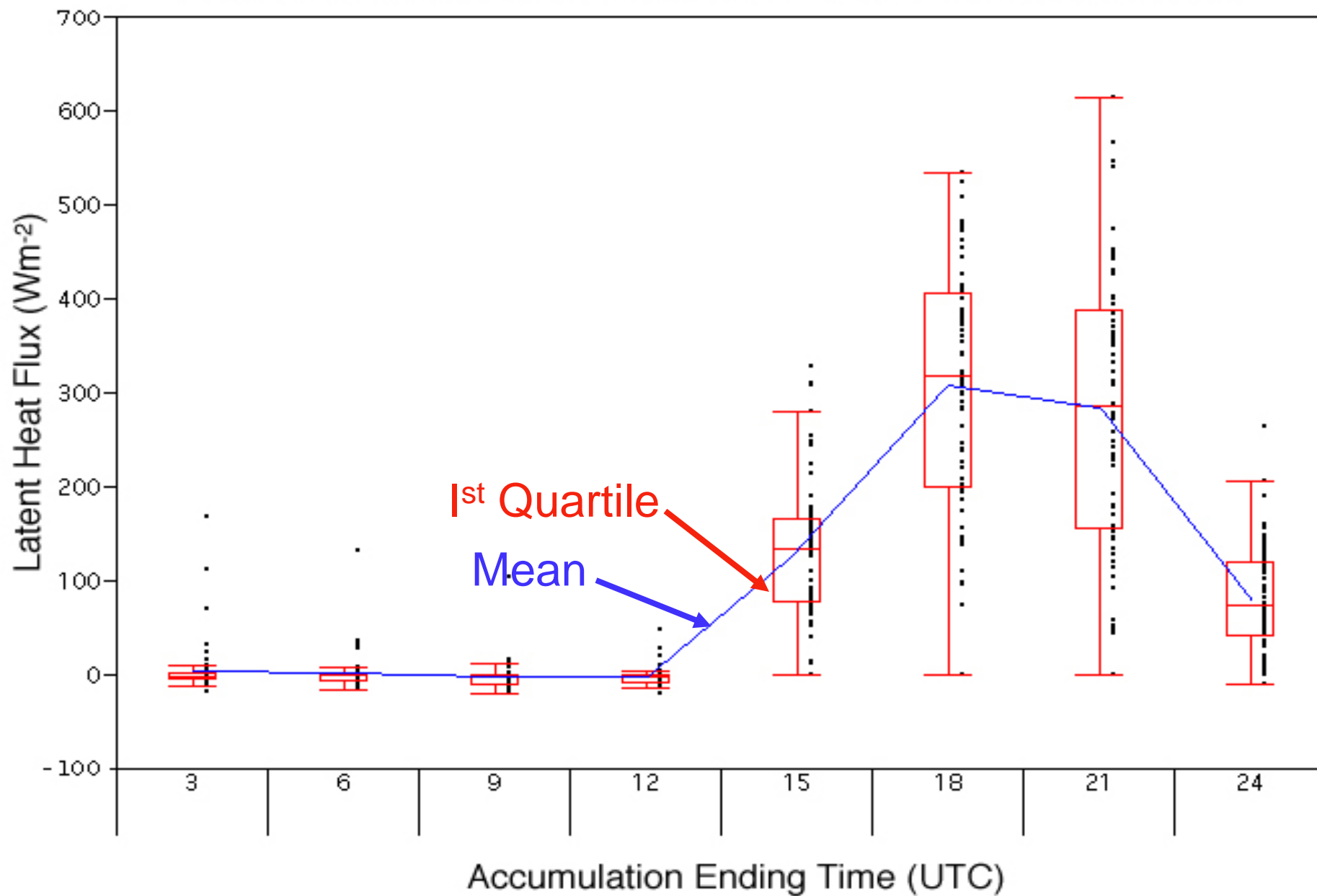
Mean Diurnal Latent Heat Flux: CEOP-1 Bondville JAS 2001 Obs



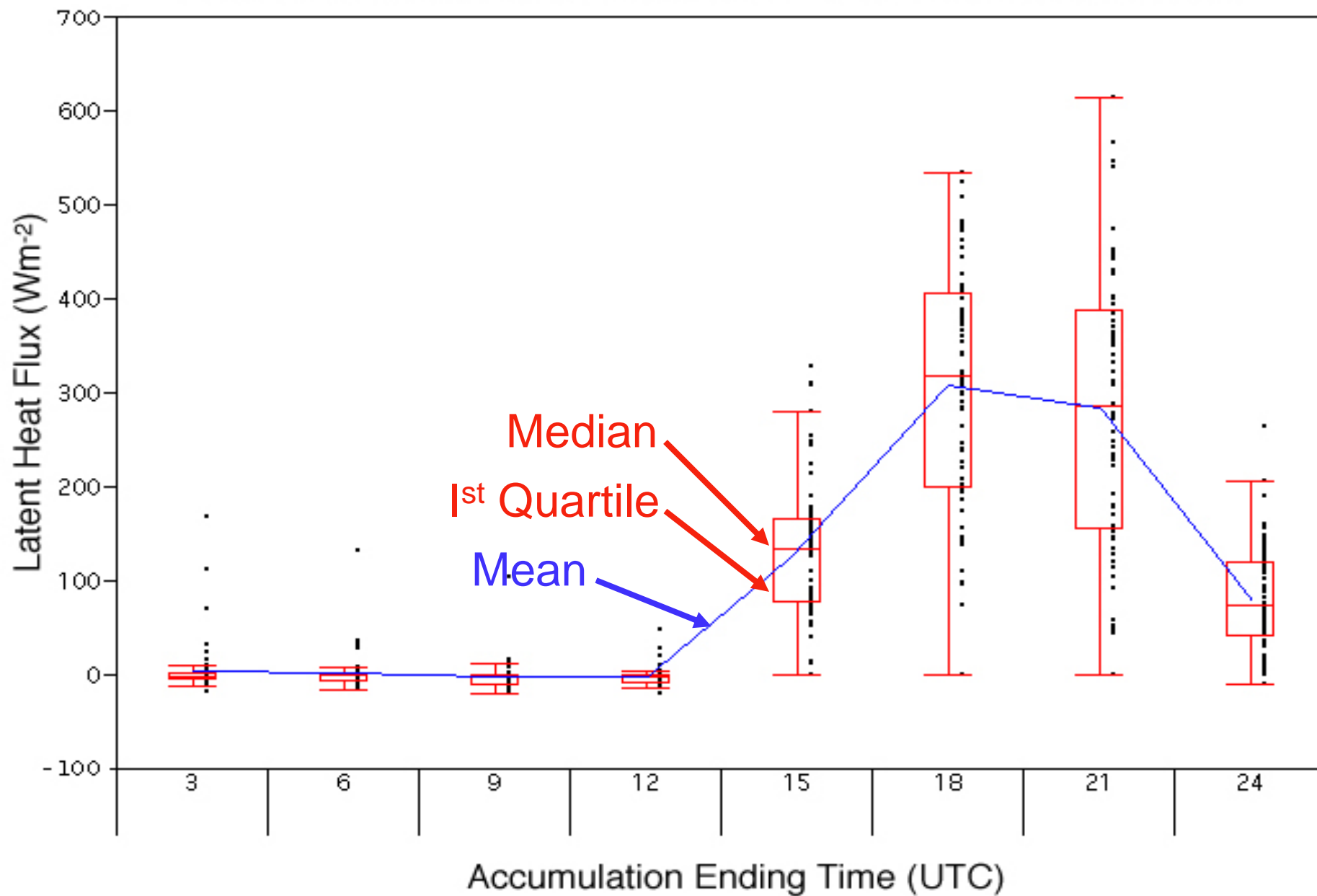
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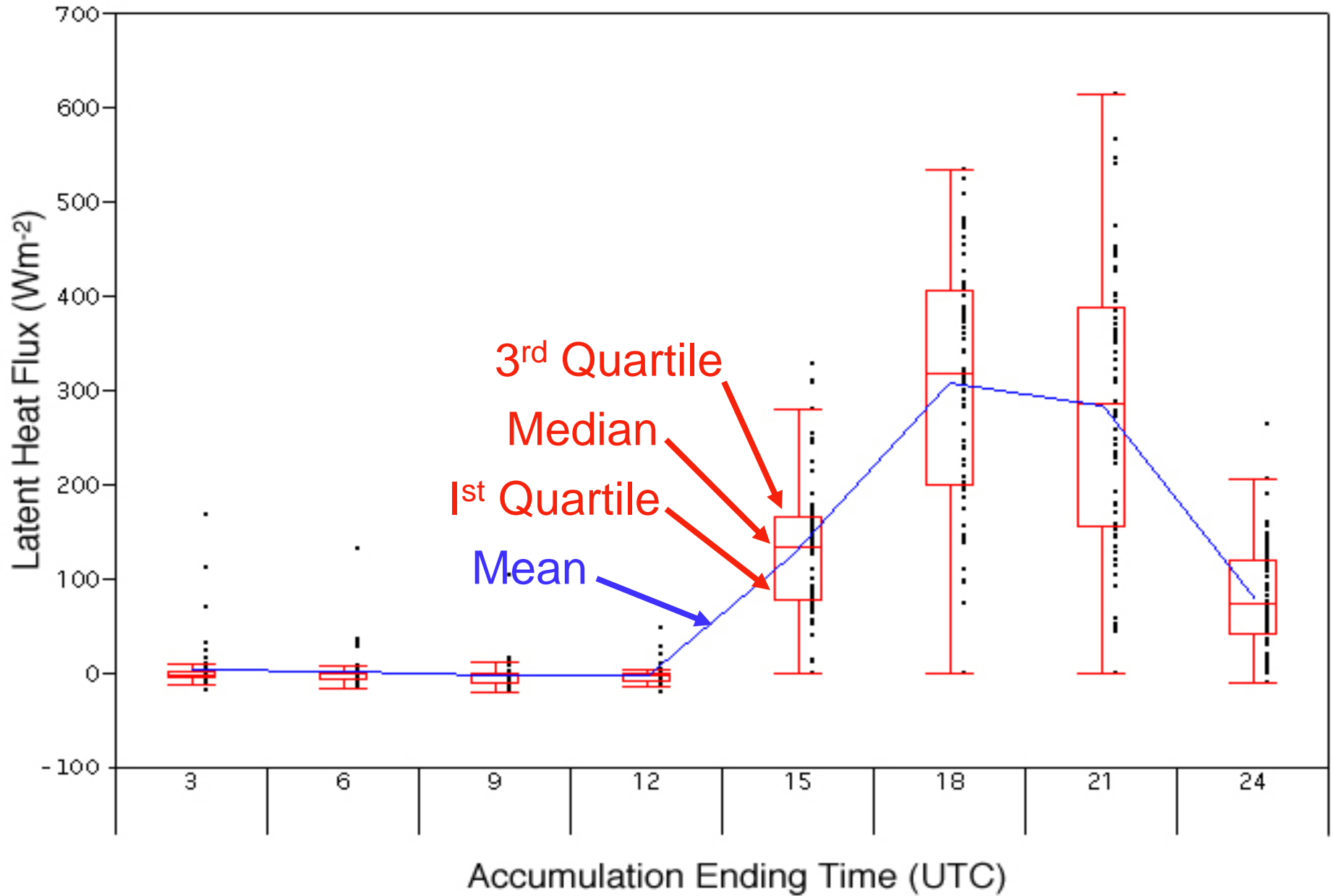
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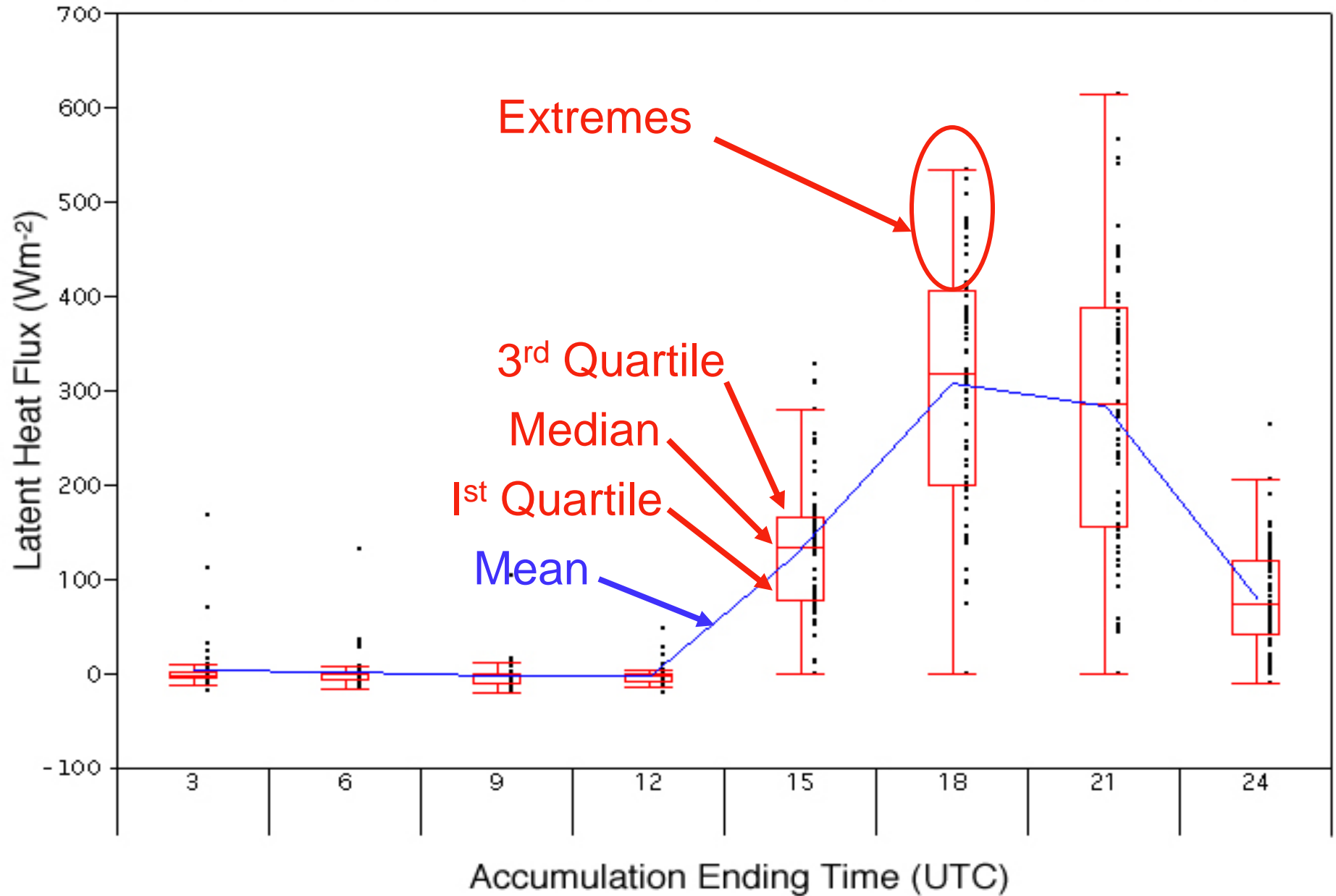
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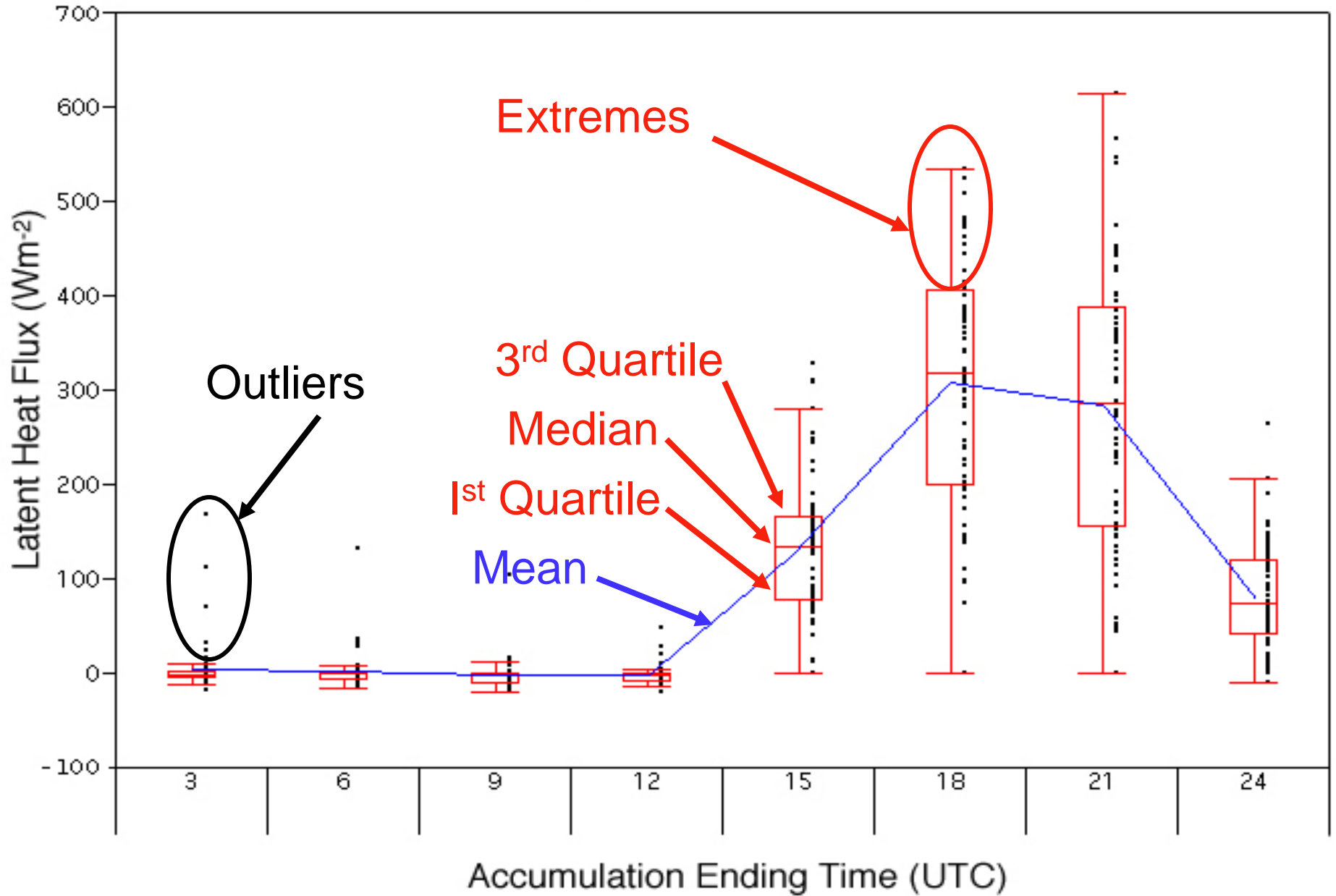
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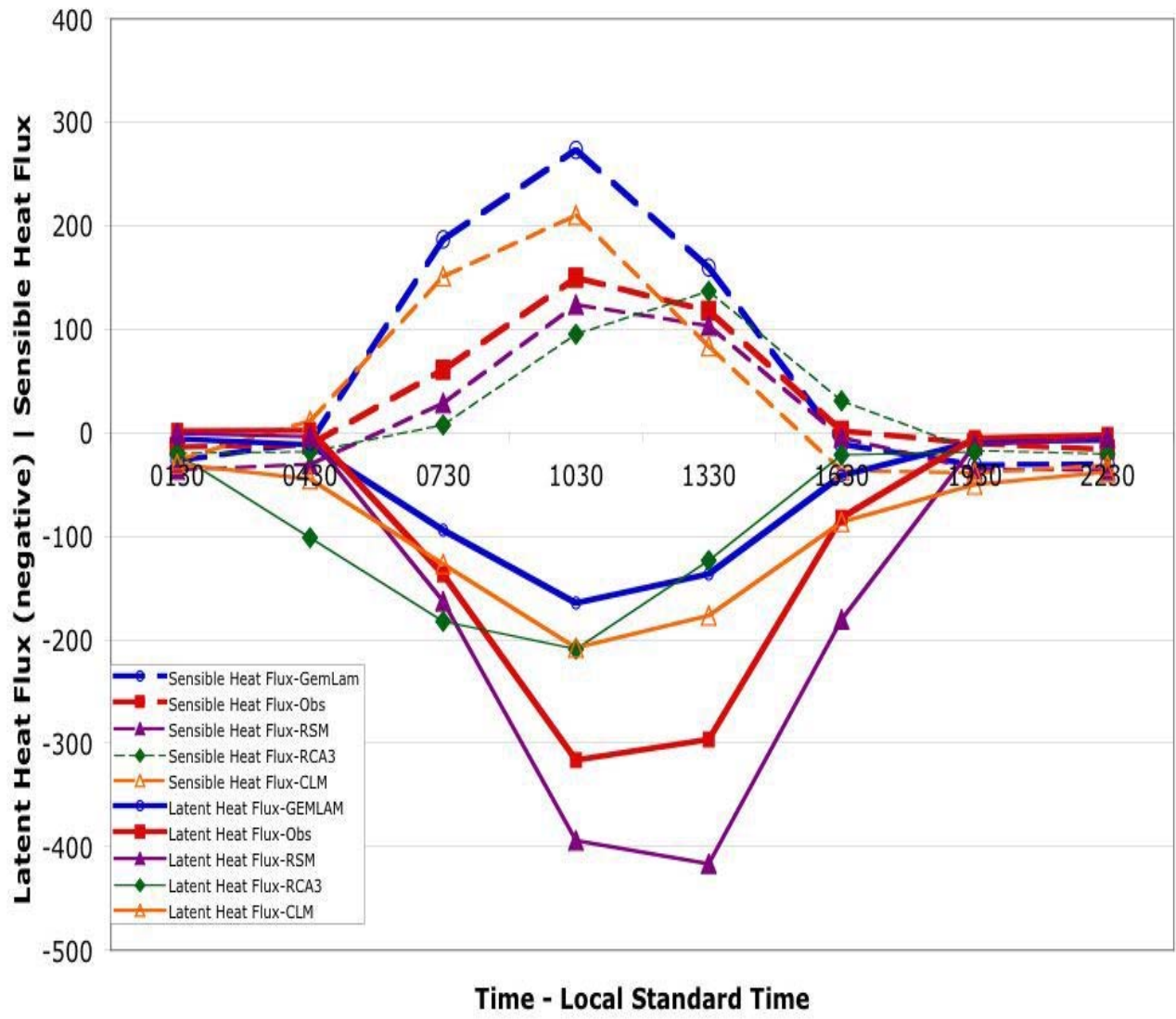
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Mean Diurnal Latent Heat Flux: CEOP-1 Bondville JAS 2001 Obs



Diurnal Sensible and Latent Heat Flux - Bondville



Appreciation is extended to:

TWG modeling team:

- υ RSM/Scripps: John Roads and Insa Meinke
- υ CLM/GKSS: Burkhardt Rockel
- υ RegCM3/ISU: Bill Gutowski
- υ RCA3/SHMI: Colin Jones, Ulf Hansson, Ulrika Willèn, Patrick Samuelsson
- υ GEM-LAM/MSC-RPN: Colin Jones

JOSS CEOP data archive:

- υ Steve Williams

Past-Year Activities

- ∪ Intercontinental simulations
 - BAMS paper revised and accepted (concept of *transferability* and provides preliminary analysis)
 - EGU session (Arritt, Rockel, Bosilovich)
 - EGU Splinter Group
 - Presentation and participant modeling activities at *Third ICTP Workshop on the Theory and Use of Regional Climate Models*

- ∪ North American Regional Climate Change Assessment Program (NARCCAP) activities
 - seeks to produce multiple regional climate model (RCM) runs driven by multiple GCM runs for the contemporary and future scenario climates for North America
 - Preliminary runs of the RCMs to evaluate model performance against observations is achieved by simulating a 30-year period at the end of the 20th century driven by reanalysis (NCEP/DOE R-2)
 - Reanalysis simulations have been completed by Scripps (RSM), UQAM (CRCM) , and PNL (MM5). The Hadley simulation (HadRM3) is expected to be completed in mid-October. UCSD (RegCM3) is expecting completion soon (October 2006), and PNL (WRF) is into the 6th simulated year.

Publications and Presentations

- u Takle, E. S., J. Roads, B. Rockel, W. J. Gutowski, Jr., R. W. Arritt, I. Meinke, and C. Jones, 2006: Transferability: A global approach to regional climate simulations. *Bulletin of the American Meteorological Society* (in press).
- u Takle, E. S., J. Roads, B. Rockel, W. J. Gutowski, Jr., R. W. Arritt, I. Meinke, C. G. Jones, and A. Zadra, 2006: Diurnal cycle of surface-flux probability distributions in regional climate models. Session CL015: **Generality of Climate Models and their Components**. *European Geophysical Union General Assembly, Vienna*.
- u Takle, E. S., J. Roads, B. Rockel, W. J. Gutowski, Jr., R. W. Arritt, I. Meinke, C. G. Jones, and A. Zadra, 2006: Do regional climate models perform better on their home domains? A transferability intercomparison. Session CL015: **Generality of Climate Models and their Components**. *European Geophysical Union General Assembly, Vienna*.
- u Takle, E. S., B. Rockel, W. J. Gutowski, Jr., J. Roads, R. W. Arritt, I. Meinke, and C. Jones, 2006: Transferability Working Group (TWG) of the GEWEX Hydrometeorology Panel. *Third ICTP Workshop on the Theory and Use of Regional Climate Models*. International Centre for Theoretical Physics, Trieste, Italy 29 May – 9 June 2006. [Invited].
- u Arritt, R.W. for the NARCCAP Team: North American Regional Climate Change Assessment Program (NARCCAP): Producing regional climate change projections for climate impacts studies. American Geophysical Union 2006 Fall Meeting, 11–15 December 2006, San Francisco, CA, USA.

Meetings, Conference Sessions, and Workshops

- u **CL015 Generality of Climate Models and their Components**, European Geophysical Union General Assembly, April 2006, Vienna. Convened by R. W. Arritt, B. Rockel, and M. Bosilovich, this meeting solicited a number of papers on transferability
- u **Transferability Working Group Splinter Session**, European Geophysical Union Annual Meeting April 2006, Vienna.
- u **Transferability Session**, *Third ICTP Workshop on the Theory and Use of Regional Climate Models*. International Centre for Theoretical Physics, Trieste, Italy 29 May – 9 June 2006
- u NARCCAP participants meeting, March 2006, Boulder

Planned Meetings, Conference Sessions, and Workshops



- u NARCCAP participants meeting at American Geophysical Union Fall Meeting, December 2006, San Francisco, CA
- u **Generality of Climate Models and their Components**, European Geophysical Union General Assembly, April 2007, Vienna. To be convened by R. W. Arritt, B. Rockel, and D. Williamson, papers to be solicited on transferability
- u TWG Splinter Meeting, European Geophysical Union General Assembly, April 2007, Vienna (tentative)

TWG has an important role in GEWEX Phase II Strategy



Φ GEWEX Objective 2:

- Enhance the understanding of how energy and water cycle processes function and quantify their contribution to climate feedbacks.

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- Determine the geographical and seasonal characteristics of the predictability of key water and energy cycle variables over land areas and through collaborations with the wider WCRP community and determine the predictability of energy and water cycles on a global basis.

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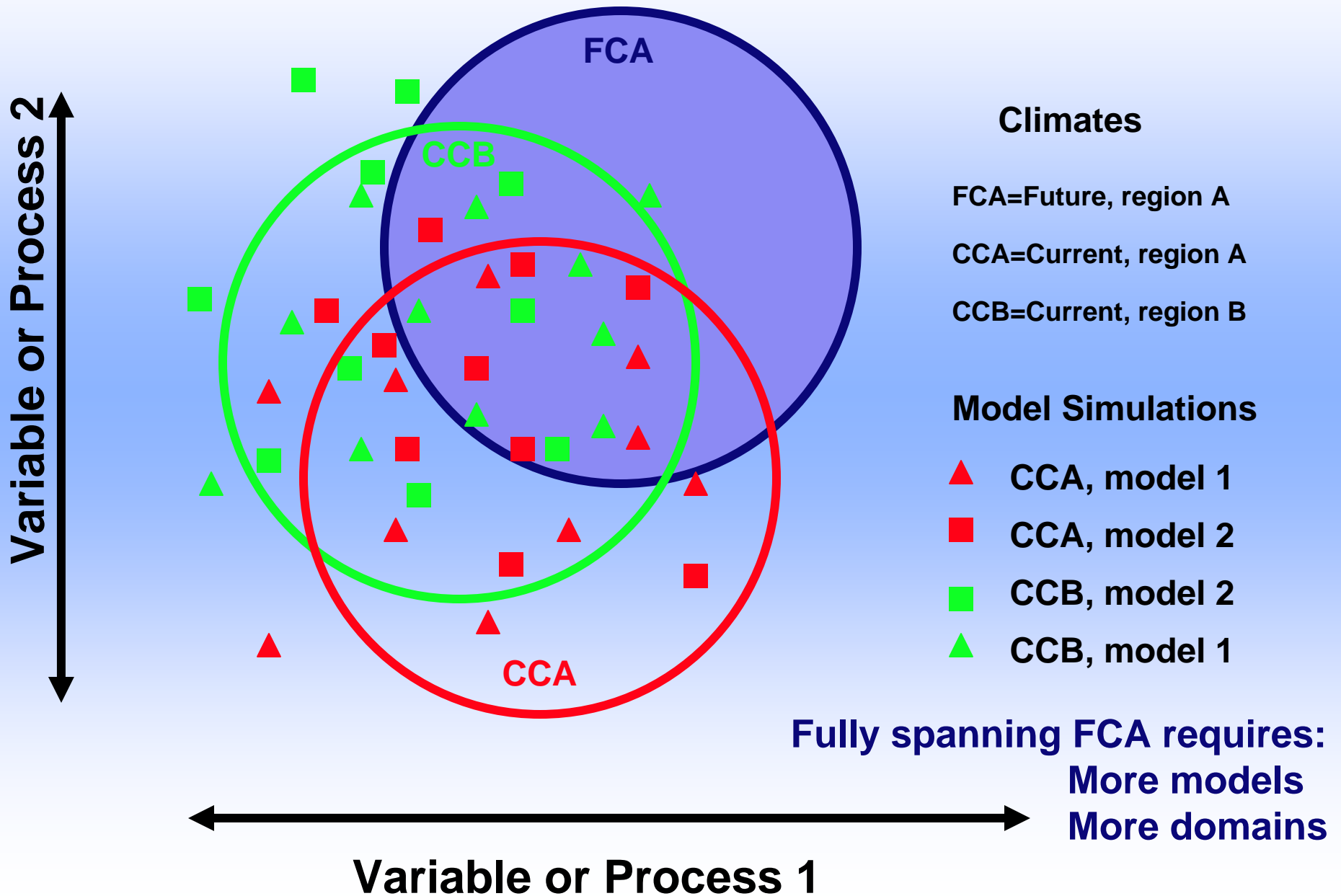
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Φ GEWEX Objective 4:

- Develop better seasonal predictions of water and energy cycle variability through improved parameterisations encapsulating hydrometeorological processes and feedbacks for atmospheric circulation models.

Simulating Future Climates with Models Trained on Current Climates



Summary

- Transferability experiments will allow new insight on global water and energy cycles that will advance climate and weather modeling on all time and spatial scales
- TWG Hypothesis 1, examining the diurnal cycles of key surface hydrometeorological variables, revealed evidence that regional models have a “home domain” advantage
- Modeling groups (including global modeling groups) are invited to participate and simulate periods defined by the CEOP on the transferability domains
- Additional hypotheses are being considered

<http://rcmlab.agron.iastate.edu/twg>

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