CEOP Components: Crosscutting Studies

Water and Energy Budget Study (WEBS)

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Motivation

- Data
  - How to quantify accuracy, uncertainties of energy and water components data, particularly for RHP regions?
  - How to integrate in situ, model and satellite data to develop the "best water and energy budgets", for the land regions associated with RHP?
- Model
  - How to identify deficiencies of model parameterizations and satellite algorithms to improve simulations of water and energy cycles?
- Science
  - How to characterize differences and inter-connections of regional water and energy budgets, and their temporal variability, particularly for hydroclimate "hotspots" and extreme events?
  - What is the role of land-atmosphere interactions in hydroclimate "hotspots" and extreme events?

WEBS Objectives

- Identify suitable data sets (model output and satellite products) with descriptions of their biases and uncertainties for water and energy budget studies;
- Examine deficiencies in the parameterizations for the land-surface, convection, and boundary layer processes;
- Understand and quantify climatology and temporal variability of water and energy budgets for regional hydroclimate “hotspots”, extreme events, low-frequency climate events, and their possible connections

Positioning of WEBS

- A data-based project, and needs strong collaboration from RHPs, NWP centers, space agencies, data integration centers;
- An analysis and assessment project, though it covers modeling and data assimilation occasionally;
- Address regional water and energy budget more than global one.

Recent Scientific Achievements

- WEBS in Europe (EMC)
- WEBS in USA (ECPC, Princeton)
- WEBS in Tibet (ITP, UT)

Recent Scientific Achievements

- **WEBS in Europe (EMC)**
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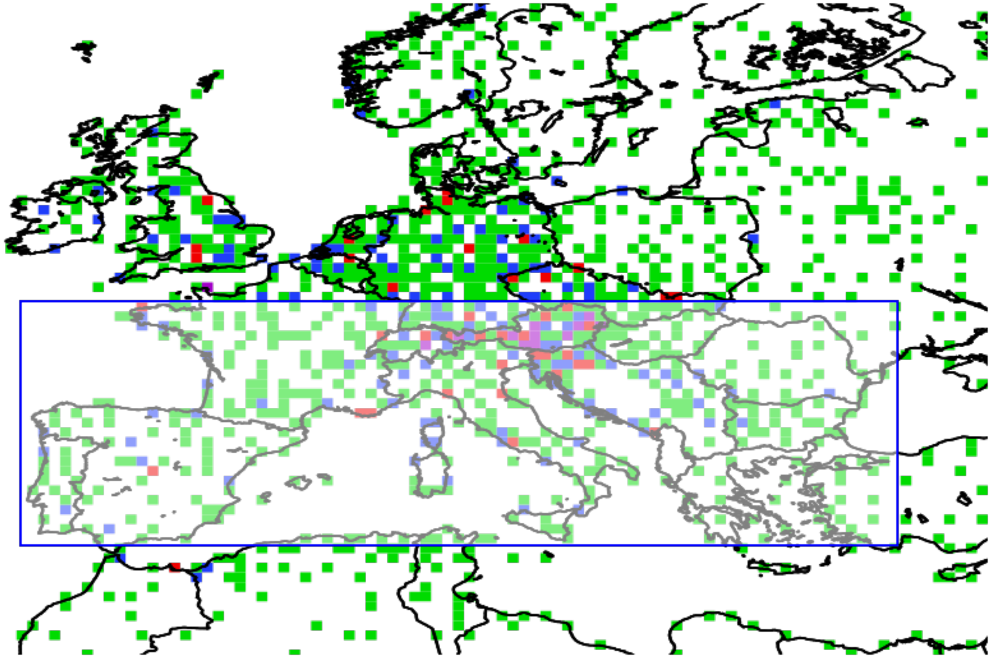
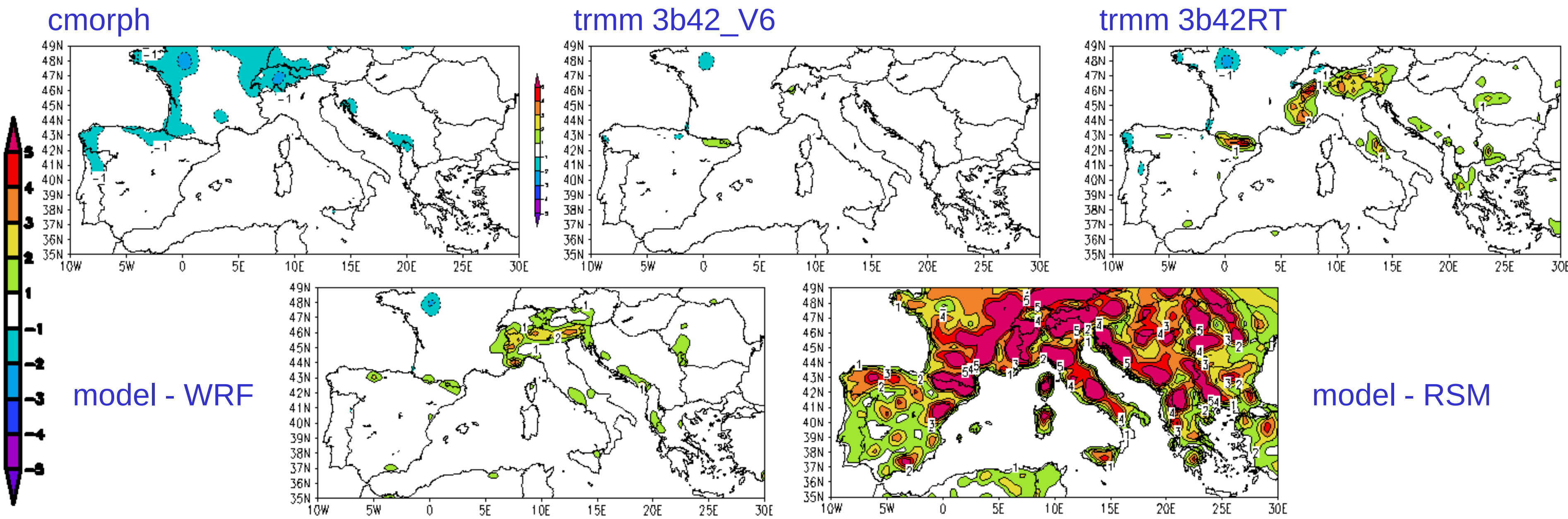
VALIDATION OF HIGH RESOLUTION SATELLITE-DERIVED RAINFALL ESTIMATES AND OPERATIONAL MESOSCALE MODELS FORECASTS OF PRECIPITATION OVER SOUTHERN EUROPE



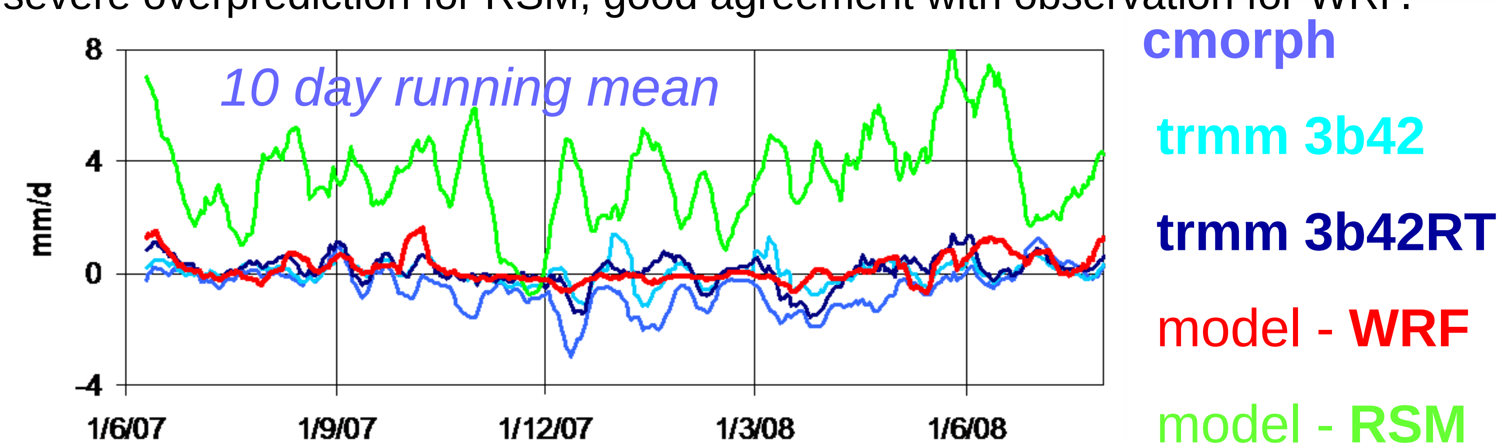
Laura Bertolani, Alessandro Perotto and Raffaele Salerno
Epson Meteo Centre (EMC), Milan, ITALY

Continuous Statistics: mean error (mm/d) June 2007 – July 2008

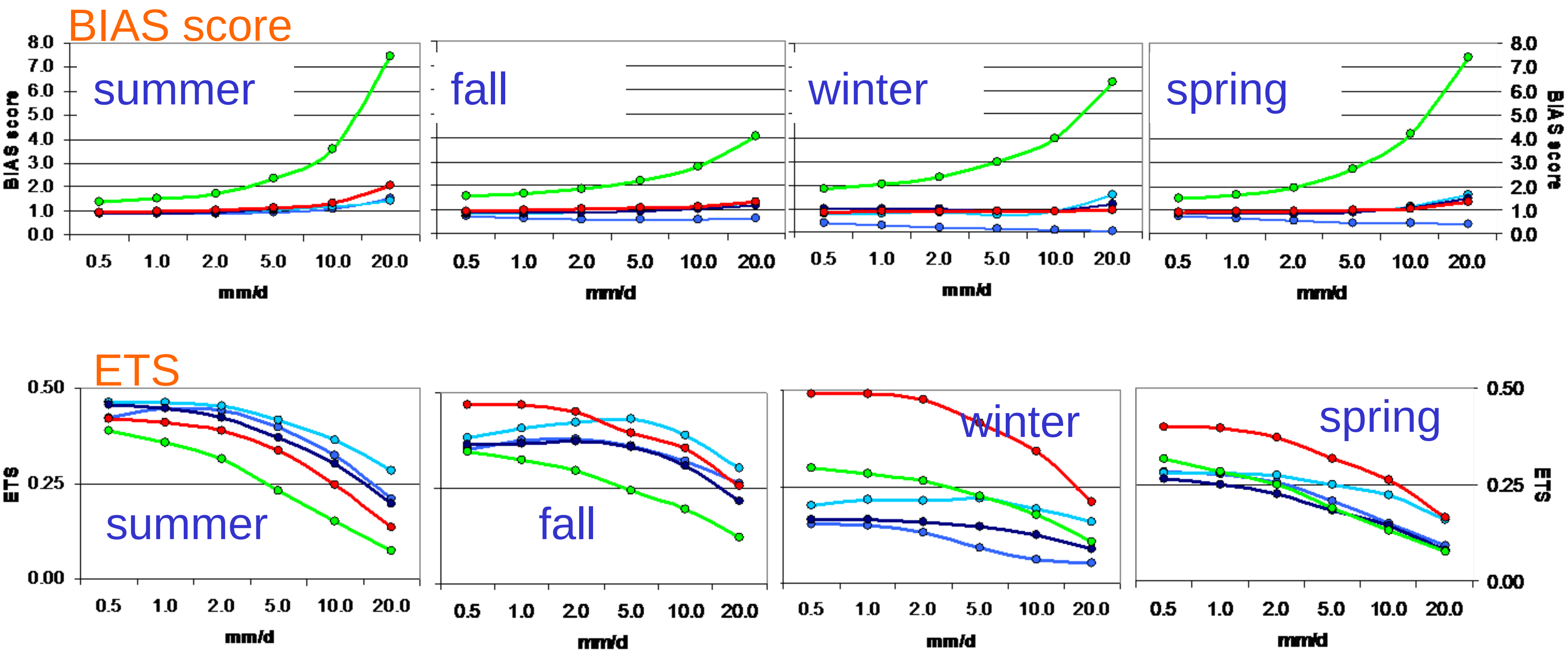


✓ Satellite estimates: marked underdetection and underestimation for cmorph, except during summer; very good agreement with observation for trmm 3b42_v6.

✓ Models: severe overprediction for RSM, good agreement with observation for WRF.



CMORPH TRMM 3b42_V6 TRMM 3b42RT WRF RSM



Conclusions

- ✓ **The satellite - derived estimates** reached the best performance when convective rains prevailed.
- ✓ **The models** showed a very different ability in predicting precipitation over Europe, with WRF greatly outperforming RSM through all the seasons.

Recent Scientific Achievements

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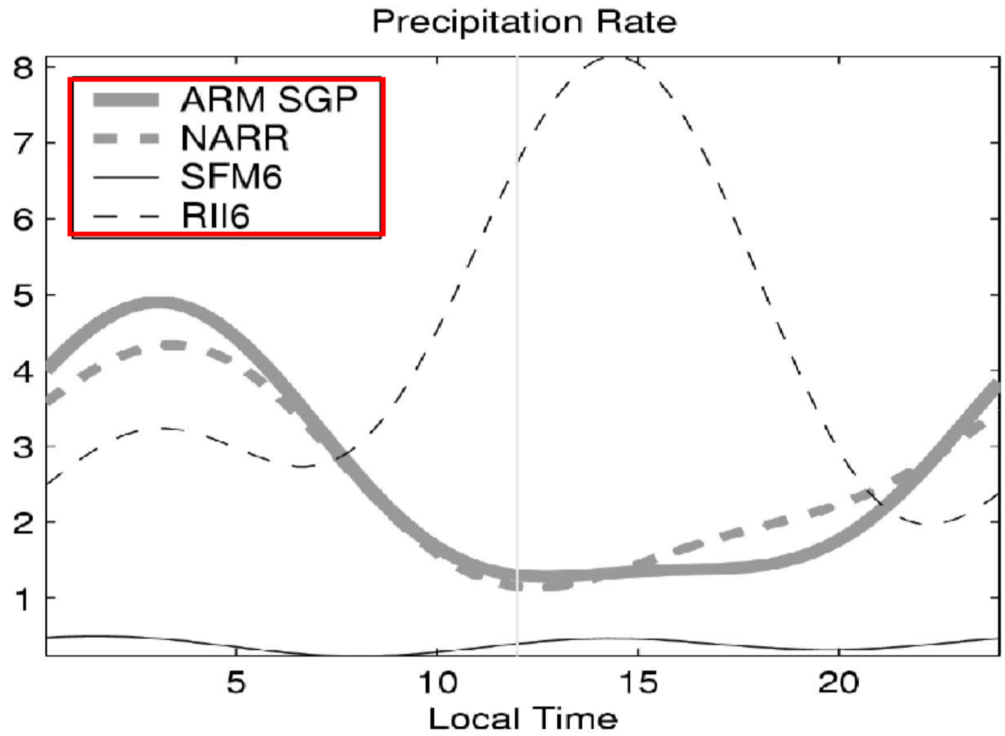
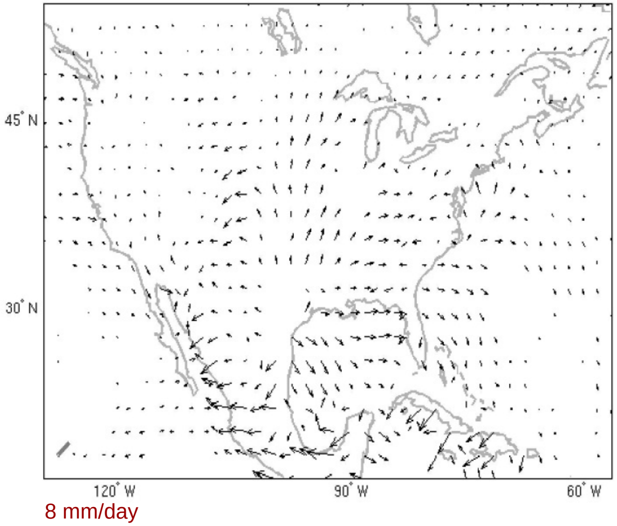
Ruane and Roads, 2007a

- Simulated diurnal cycle of precipitation at ARM SGP site shows wide variation
  - NARR assimilated precipitation matches observation
  - RII6 shows strong afternoon peak
  - SFM6 has low amplitude

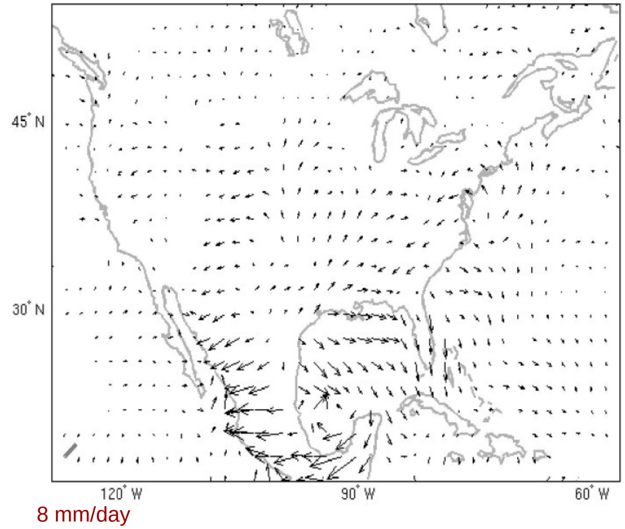


Ruane and Roads, 2007a

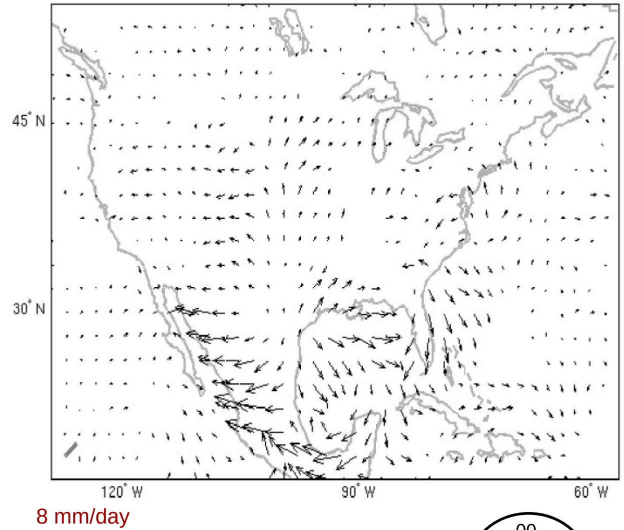
NARR Vapor Convergence

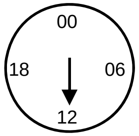


SFM6 Vapor Convergence



RII6 Vapor Convergence

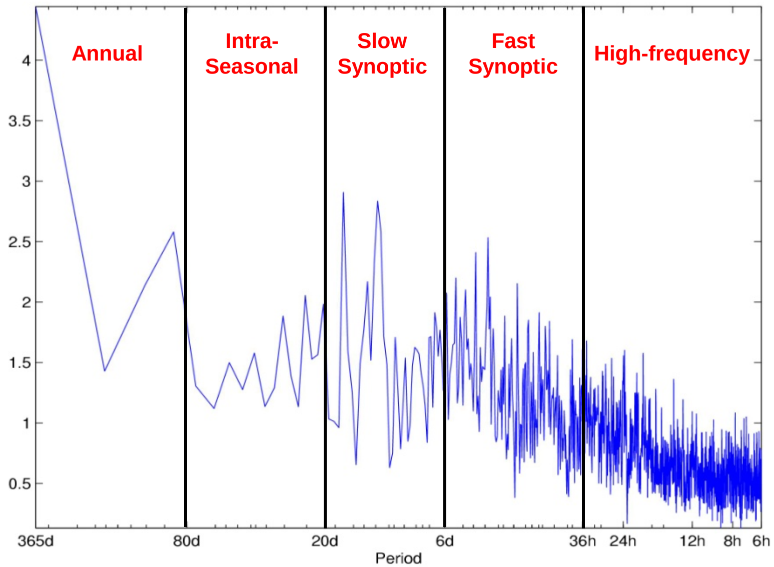




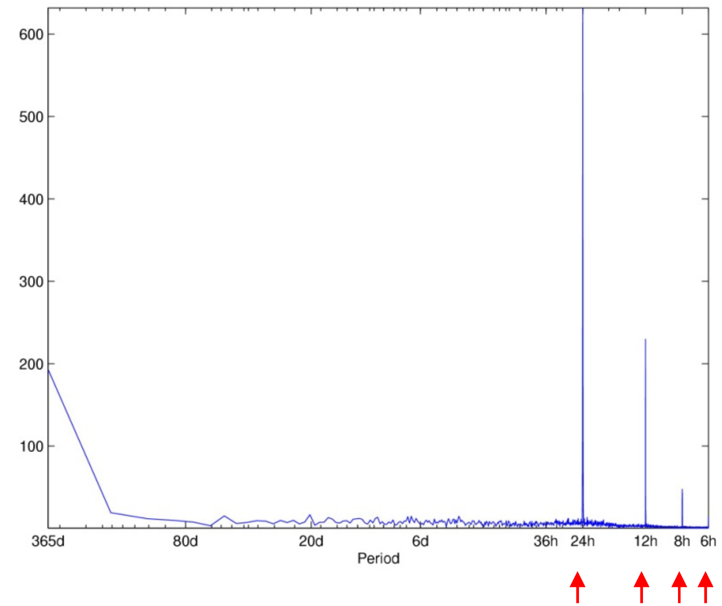
- Diurnal cycle in atmospheric water vapor convergence matches assimilated precipitation pattern
  - True in NARR and global analyses
  - Precipitation parameterizations appear to be too dominant
    - Arakawa-Schubert based parameterizations prematurely initiate convection

Ruane and Roads, 2007b

Darwin, Australia, Precipitation



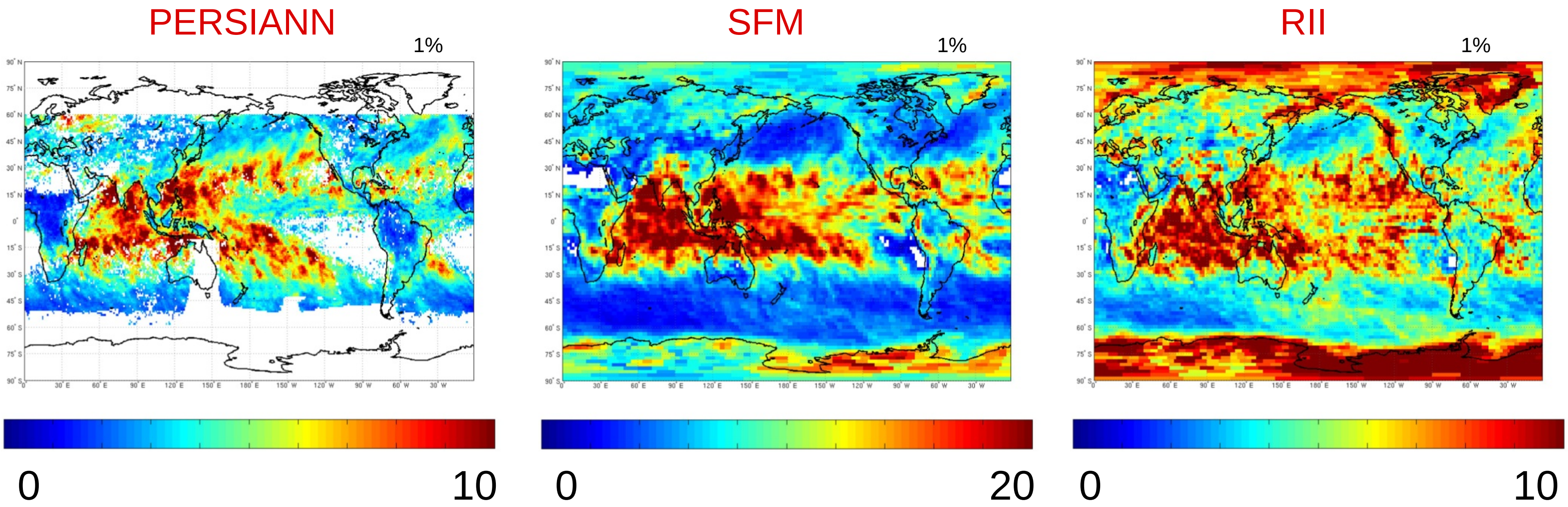
Darwin, Australia, Surface SW Radiation



- Performed fast-Fourier transform on three annual 3-hourly time series
  - Corresponds to the end of the Coordinated Enhanced Observing Period (2002-2004)
  - Compared data between two global reanalyses and three high-resolution precipitation products (TRMM 3B-42, PERSIANN, and 2003-2005 CMORPH)
  - Divided spectral variance density into 6 comprehensive variance categories
    - Annual (80d – 1y), Intraseasonal (20d-80d), Slow Synoptic (6d-20d), Fast Synoptic (36h – 6d), High-frequency (6h – 36h), and Diurnal (as determined by response to radiation)

Ruane and Roads, 2007b

Intraseasonal (20-80 days) variance

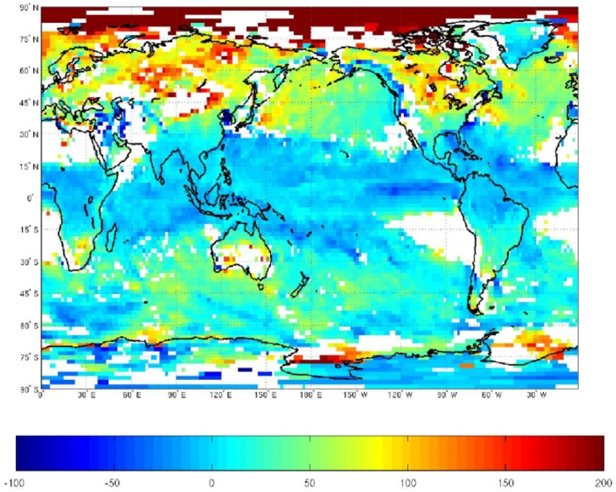


- Convective parameterizations have mixed results in intraseasonal frequency
  - Relaxed Arakawa-Schubert scheme produces ~double the low-frequency variances over the tropics (at the expense of high-frequency variance)
  - SFM also misses the dynamic excitation of the Rossby wave trains
  - Many features captured well by reanalyses (e.g. monsoons, ITCZ, Hadley circulation)

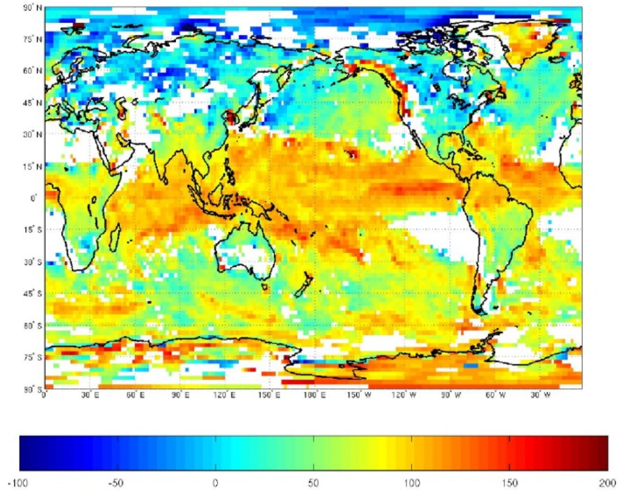
Ruane and Roads 2008a,b and continuing work

- Evaluation of the dominant balances and exchanges of the atmospheric water cycle in the NCEP/DOE Reanalysis-2

Annual Covariance of Evaporation with Precipitation



Annual Covariance of Vapor Flux Convergence with Precipitation

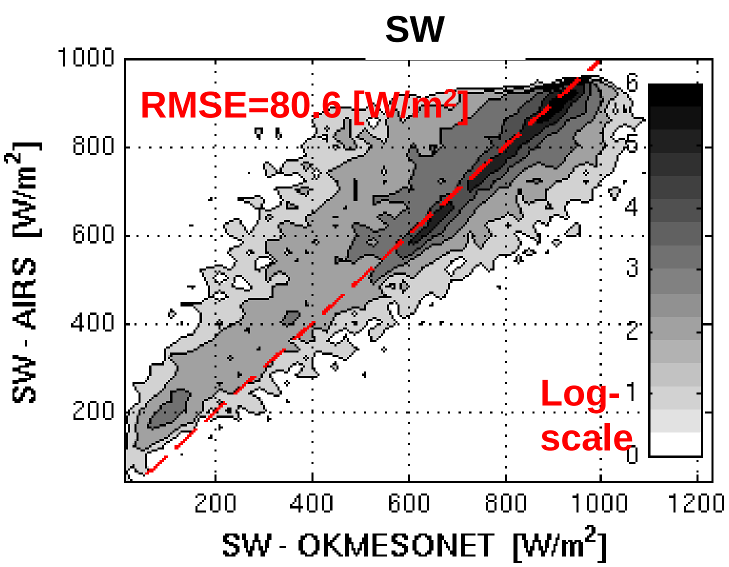


- Examinations of the temporal variability of the water cycle’s sensitivity to pairings of land-surface schemes and convective parameterizations

Science Issue:

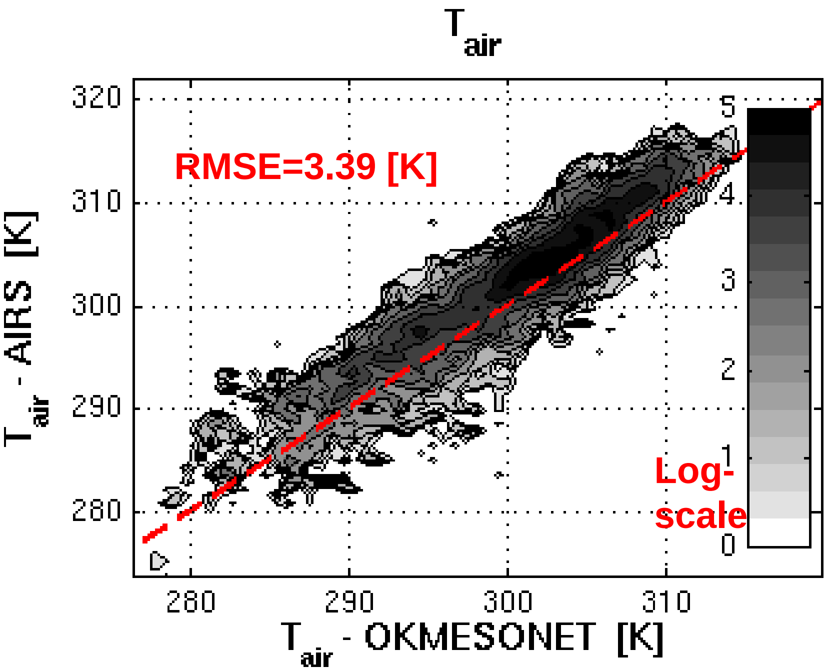
Validating Remote Sensing Products for Global ET Estimates

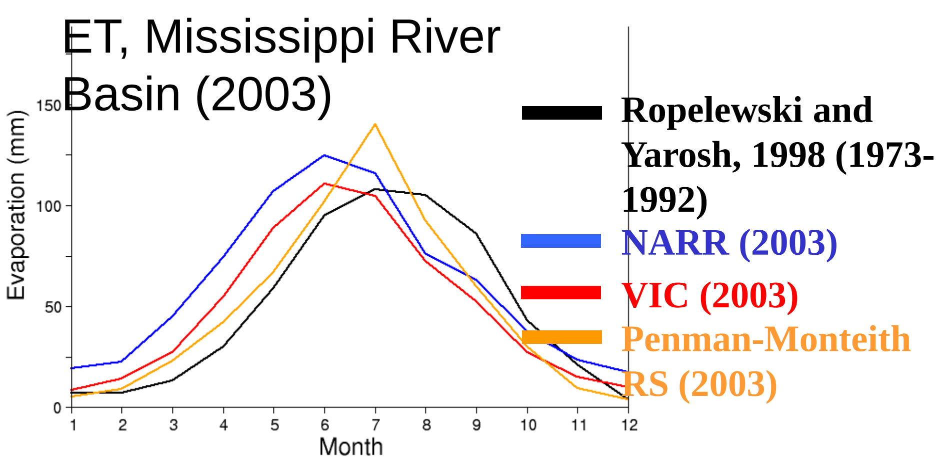
Land Surface Hydrology Group @ Princeton University



Approach:

Inter-comparison of RS products with in-situ observations and regional land surface models to quantify errors in a global RS-ET product.





Land Surface Hydrology Group @ Princeton University

Science Issue:

Evaluating Land-Atmosphere Coupling Through Remote Sensing Observations

Approach:

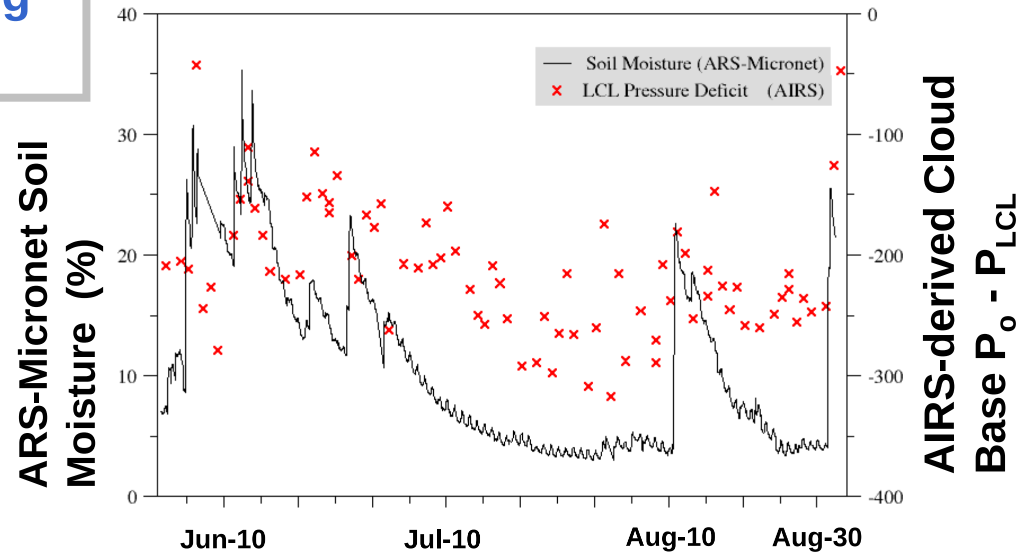
Quantify coupling in terms of observational diagnostics set forth by the work of Betts et al. (2004, 2007) and Findell and Eltahir (2003), using observational products from remote sensing

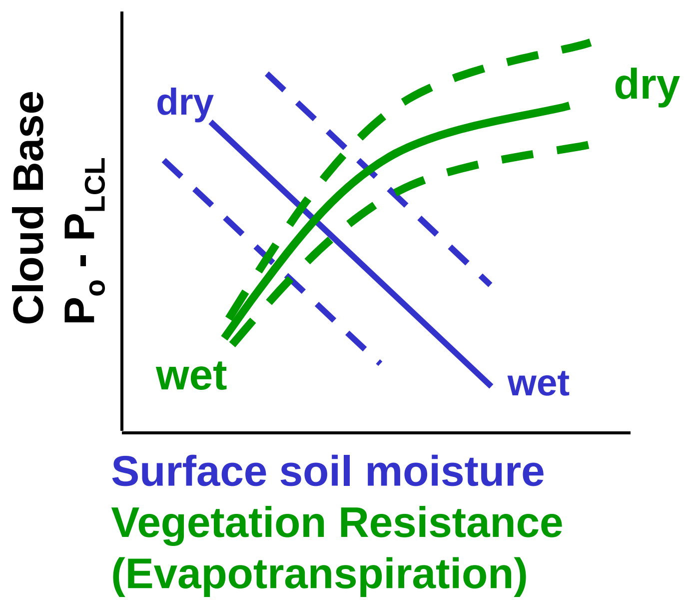
Remote Sensing Data:

NASA Aqua AIRS (RH,Ts), AMSR-E (X-band soil moisture)

Other Data:

Princeton RS-ET, in-situ observations from the Oklahoma Mesonet, West Texas Mesonet and WMO Radiosonde Network





Recent Scientific Achievements

- WEBS in Europe (EMC)
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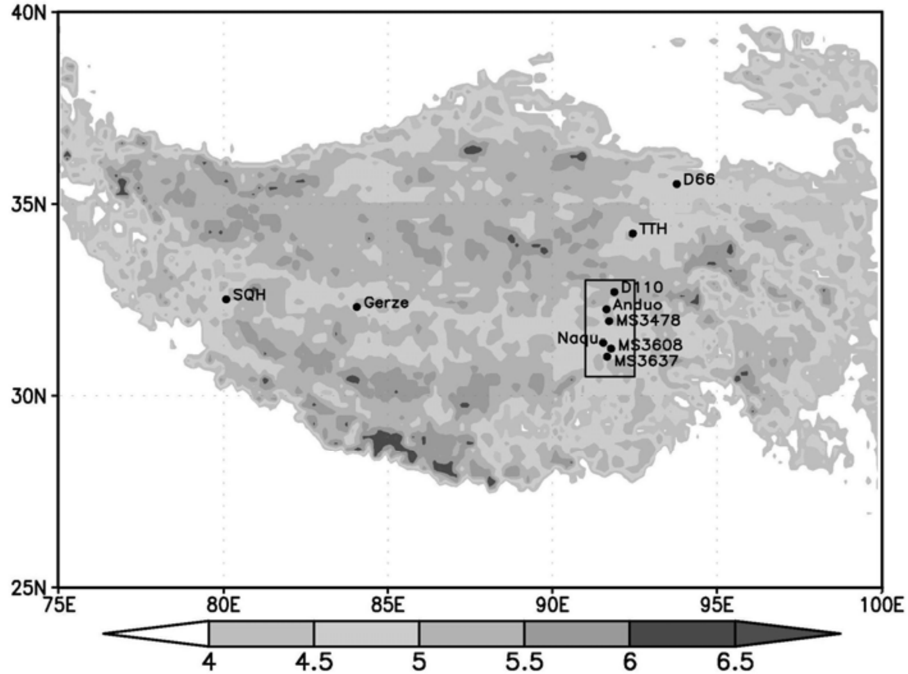
- **WEBS in Tibet (ITP, UT)**

Radiation evaluation

- Surface radiation is sensitive to elevation, and therefore Tibet represents an extreme.
- Evaluation of radiation against Tibet data → test the universality of an algorithm

Evaluate satellite estimates of surface radiation against Tibet data

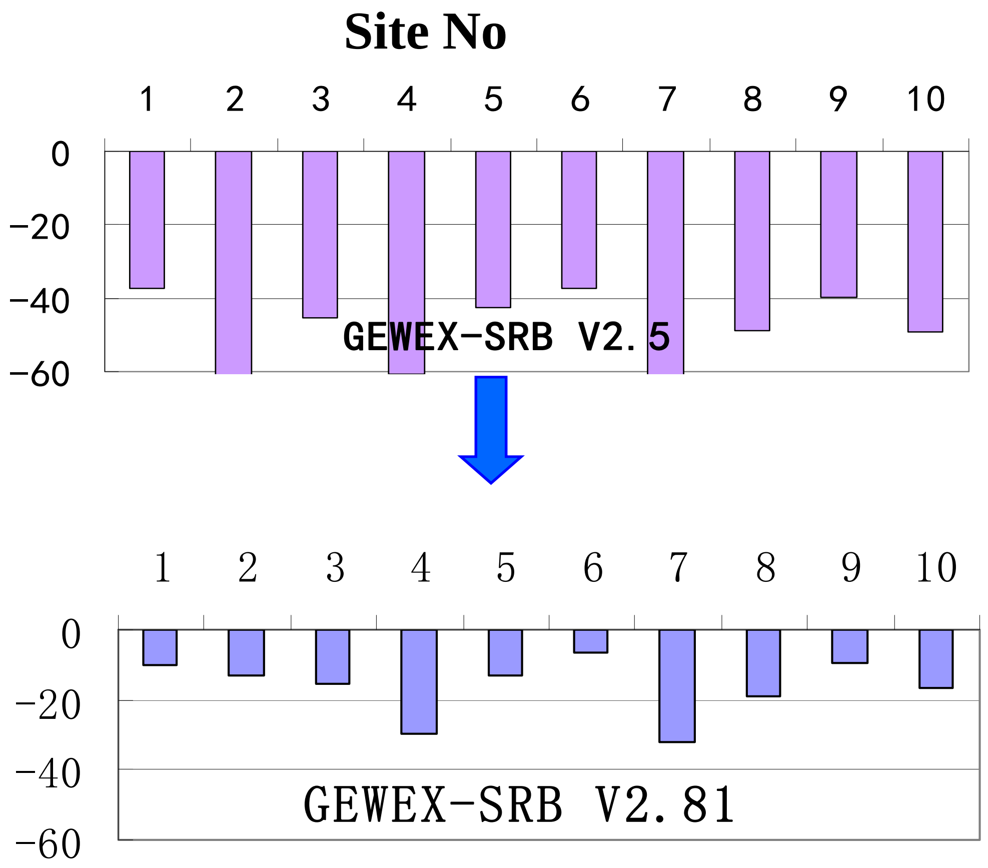


Satellite estimates	dx	dt
GEWEX-SRB V2.5	1.0 deg.	3 hr
GEWEX-SRB V2.81	1.0 deg.	3 hr
ISCCP-FD	2.5 deg.	3 hr
UMD-SRB	0.125 deg.	1 hr

GEWEX-SRB v2.5 SW did not account for altitudinal effects, which resulted in errors of 20%

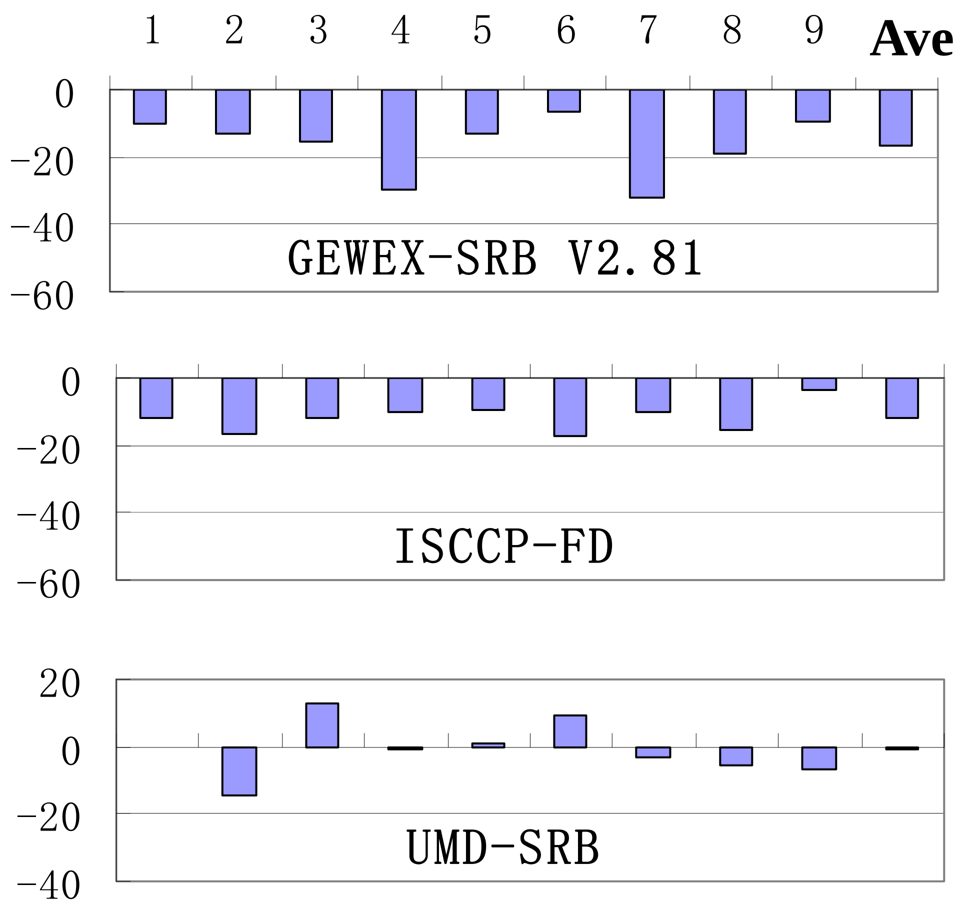
GEWEX-SRB V2.5
Biases: 50Wm^{-2} or 20%

GEWEX-SRB V2.81
Biases: 17Wm^{-2} or 7%



(Yang et al., 2006 GRL)

Errors in new satellite estimates

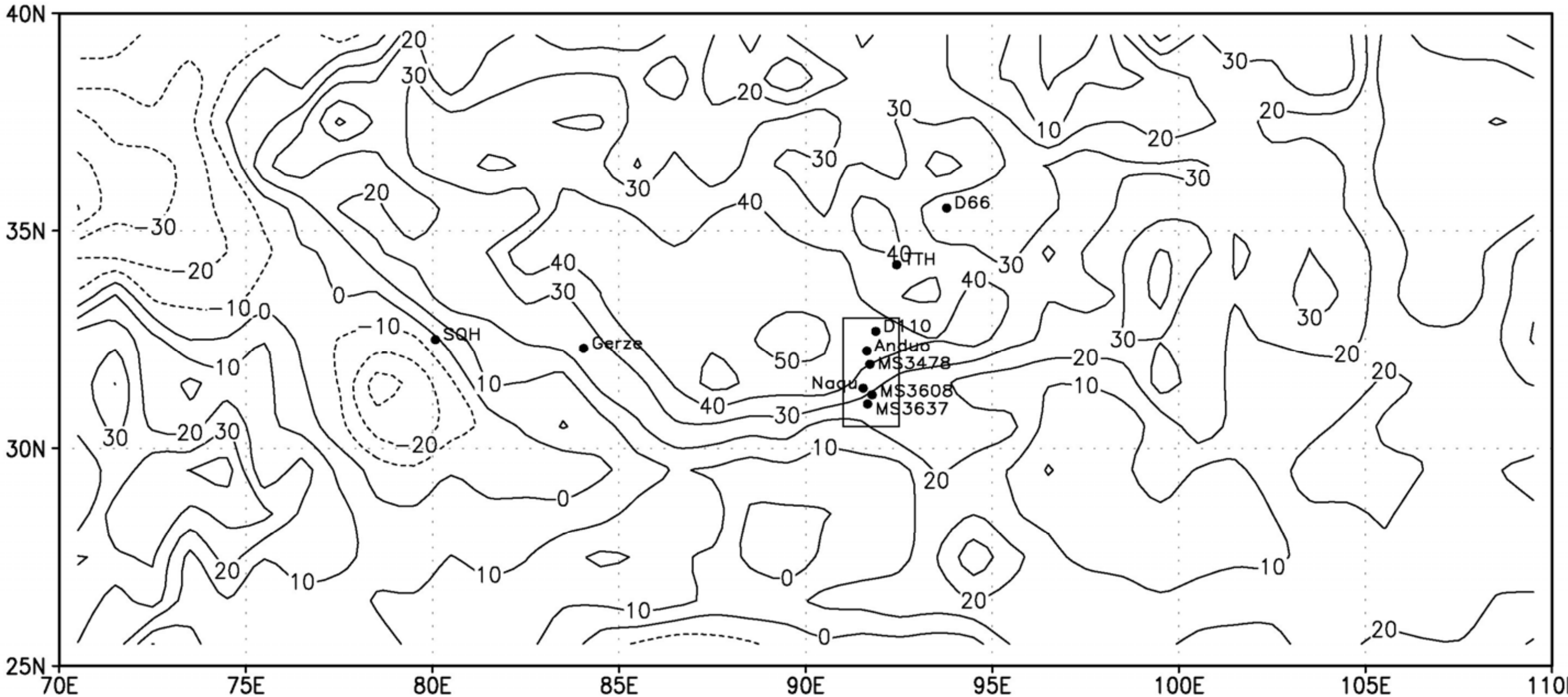


	dx	dt
17Wm^{-2} (GEWEX-SRB V2.81)	1.0 deg.	3 hr
12Wm^{-2} (ISCCP-FD)	2.5 deg.	3 hr
Small biases (UMD-SRB)	0.125 deg.	1 hr

High-res. product does better agree with obs.

(Yang et al., 2008 JGR)

Uncertainty in Clear-sky SW radiation (ISCCP-GEWEX)



Important to check input aerosol and water vapor data!

(Yang et al., 2008 JGR)

Climatology and trend of sensible heat flux on Tibet

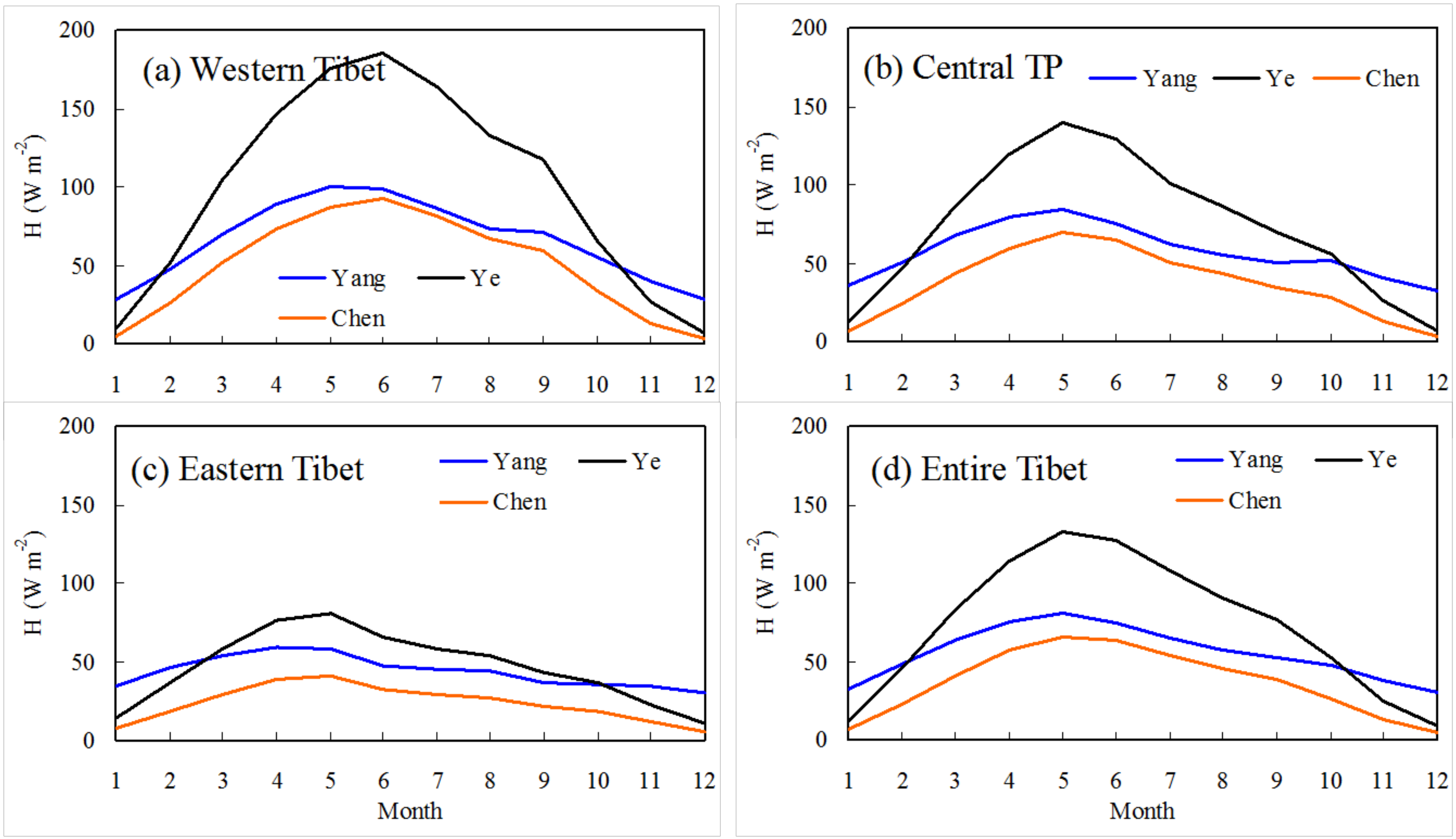
- Empirical method

$$\overline{H} = \rho c_p \overline{C_H}\,\overline{u}(\overline{T_g} - \overline{T_a})$$

- Micrometeorological method

Climatology of sensible heat flux on Tibet

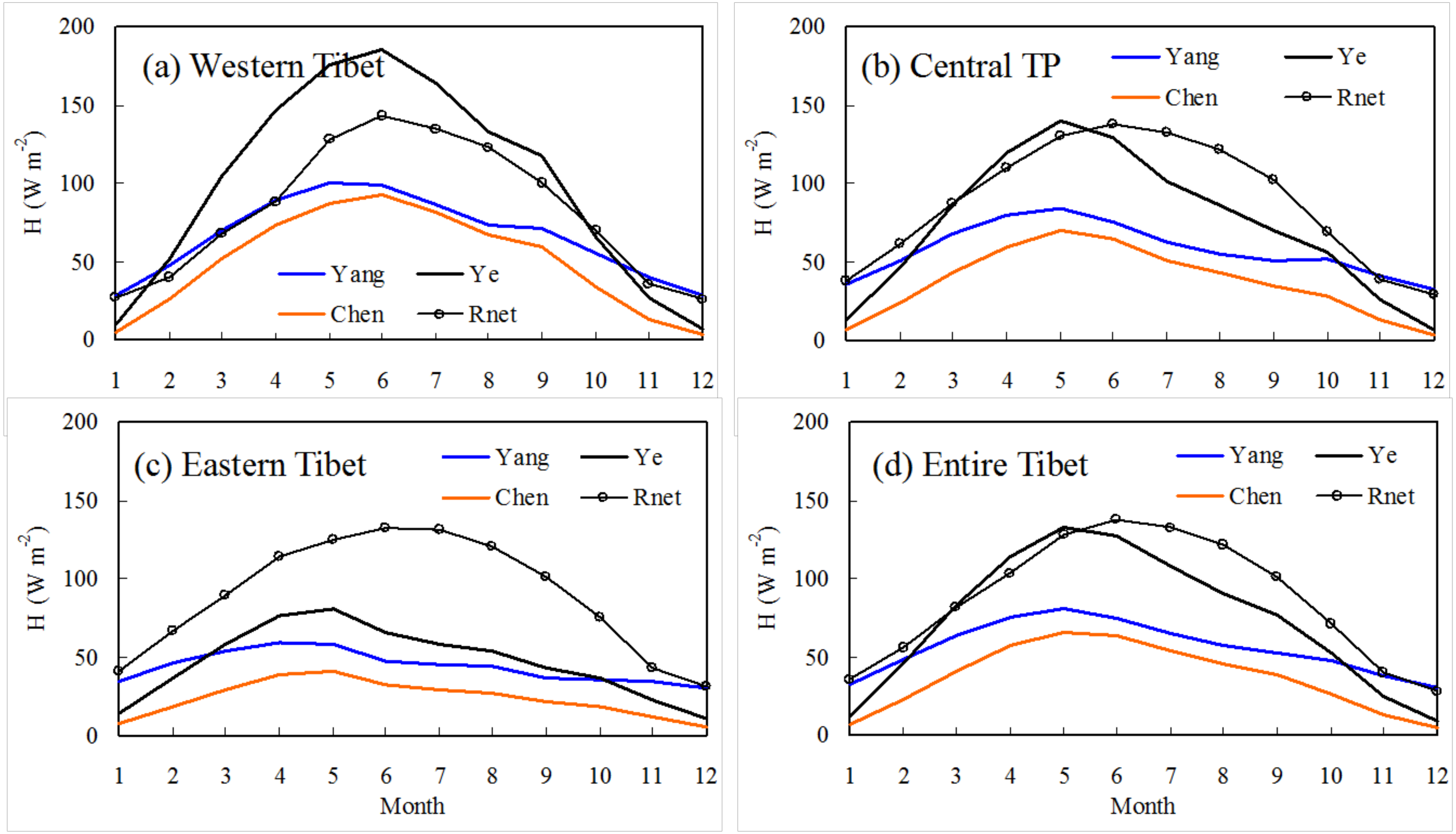
Results based on micrometeorological studies



Much different from previous studies, particularly in winter

Climatology of sensible heat flux on Tibet

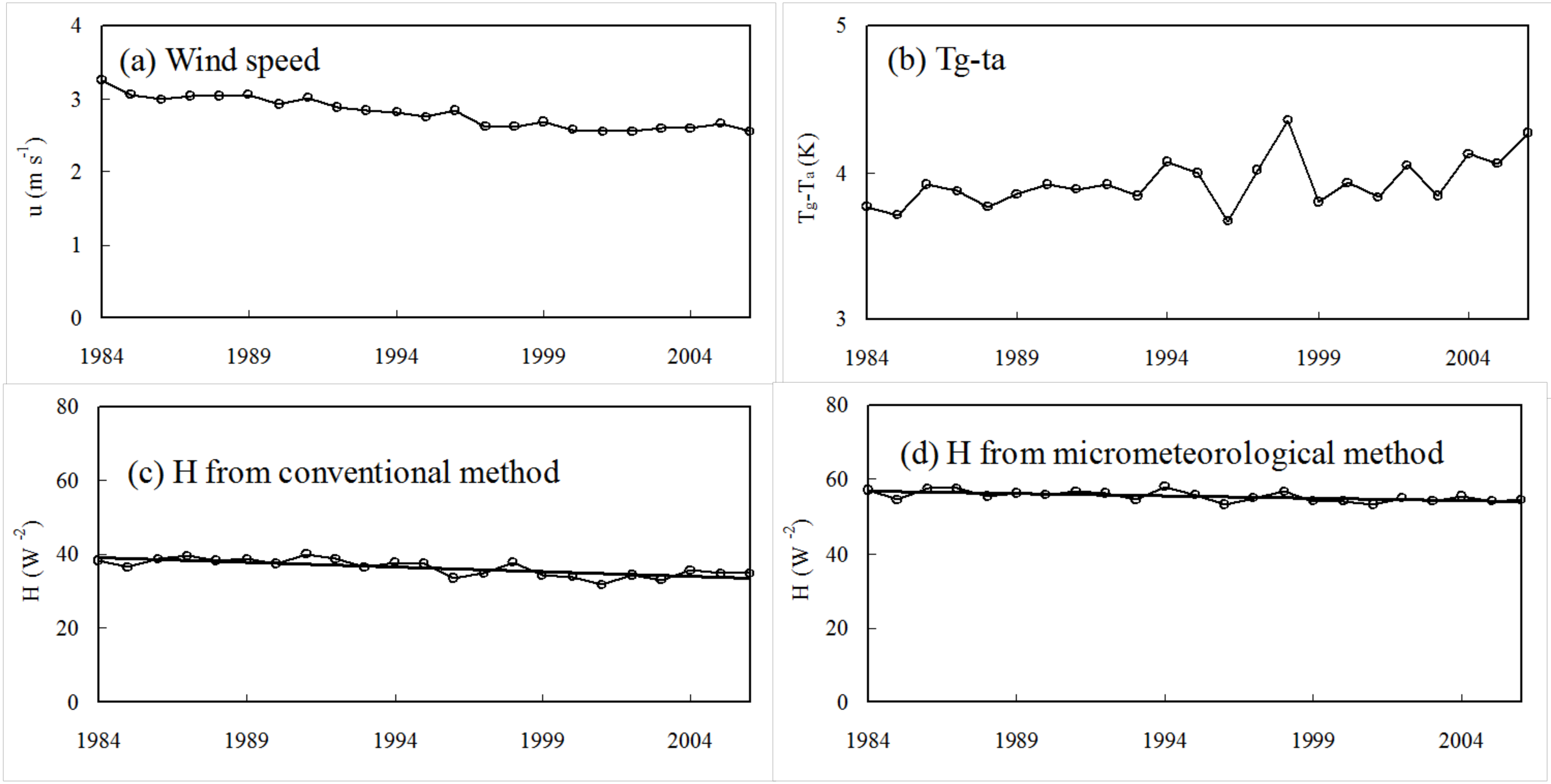
Results based on micrometeorological studies



Much different from previous studies, particularly in winter

Trend of sensible heat flux on the entire Tibet

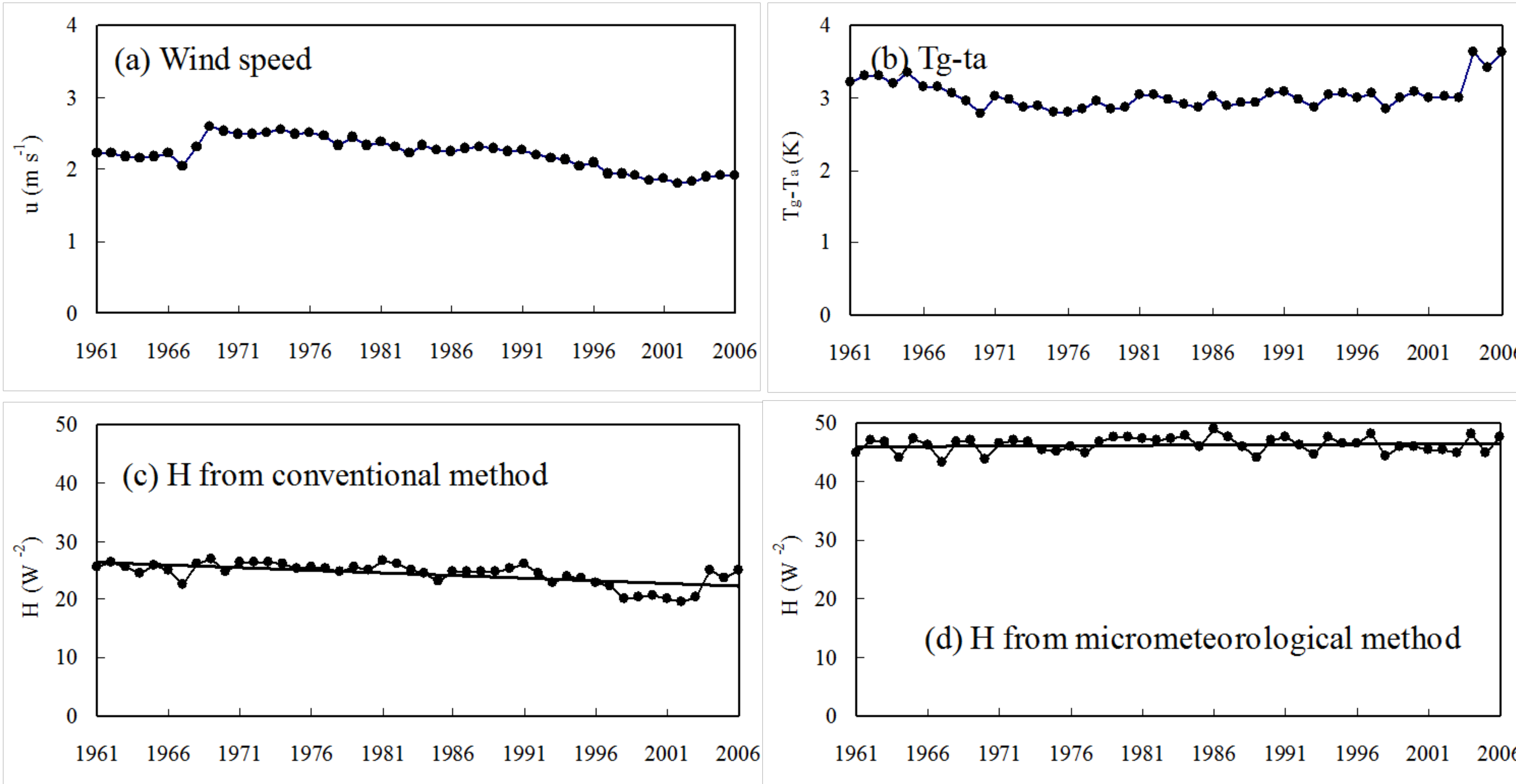
Results based on micrometeorological studies



Sensible heat does not have a significant trend though the Asian monsoon became weak in recent decades

Trend of sensible heat flux on East+Central Tibet

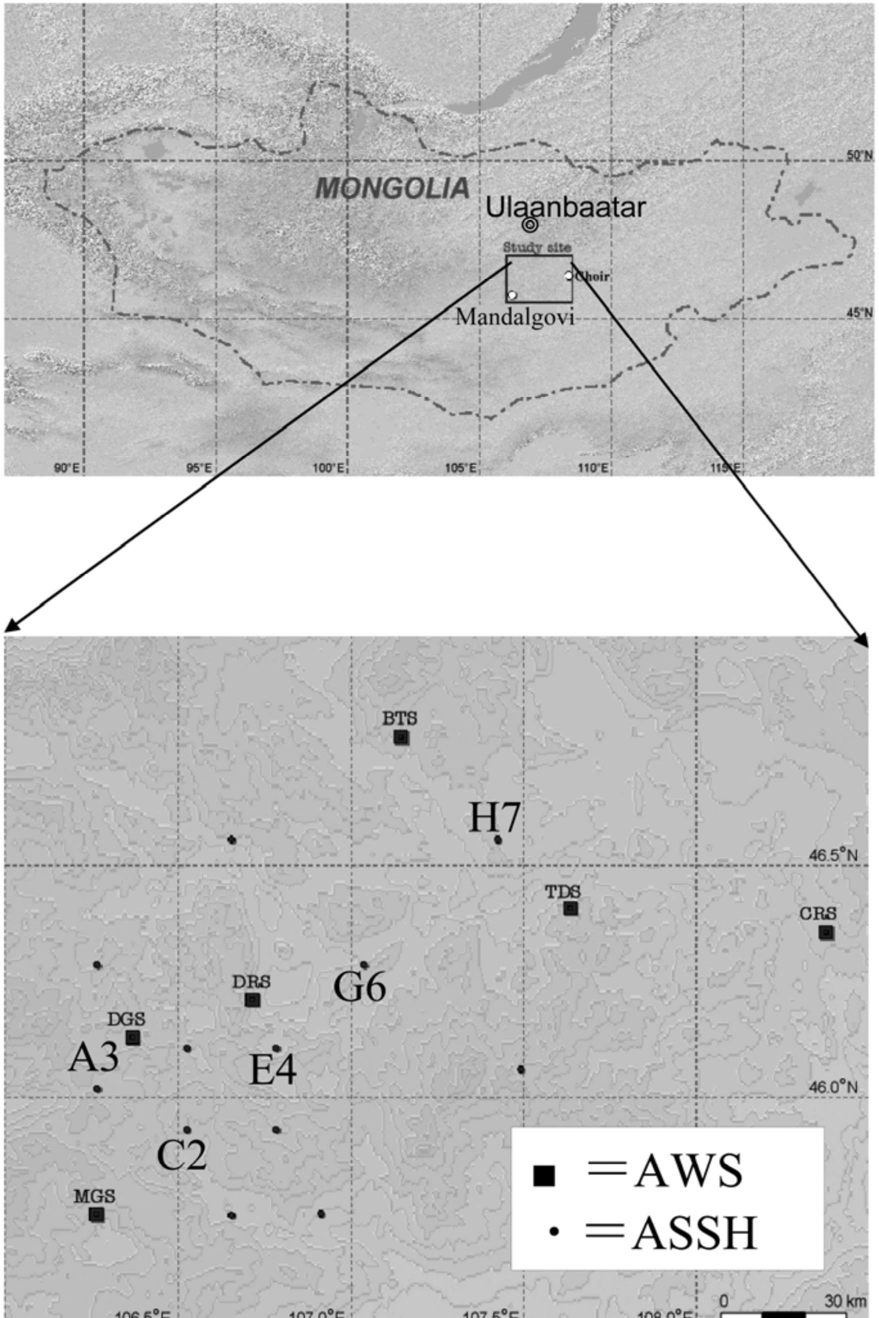
Results based on micrometeorological studies



Sensible heat does not have a significant trend though the Asian monsoon became weak in recent decades

LDAS-UT

Validation of soil moisture at a regional scale



AWS

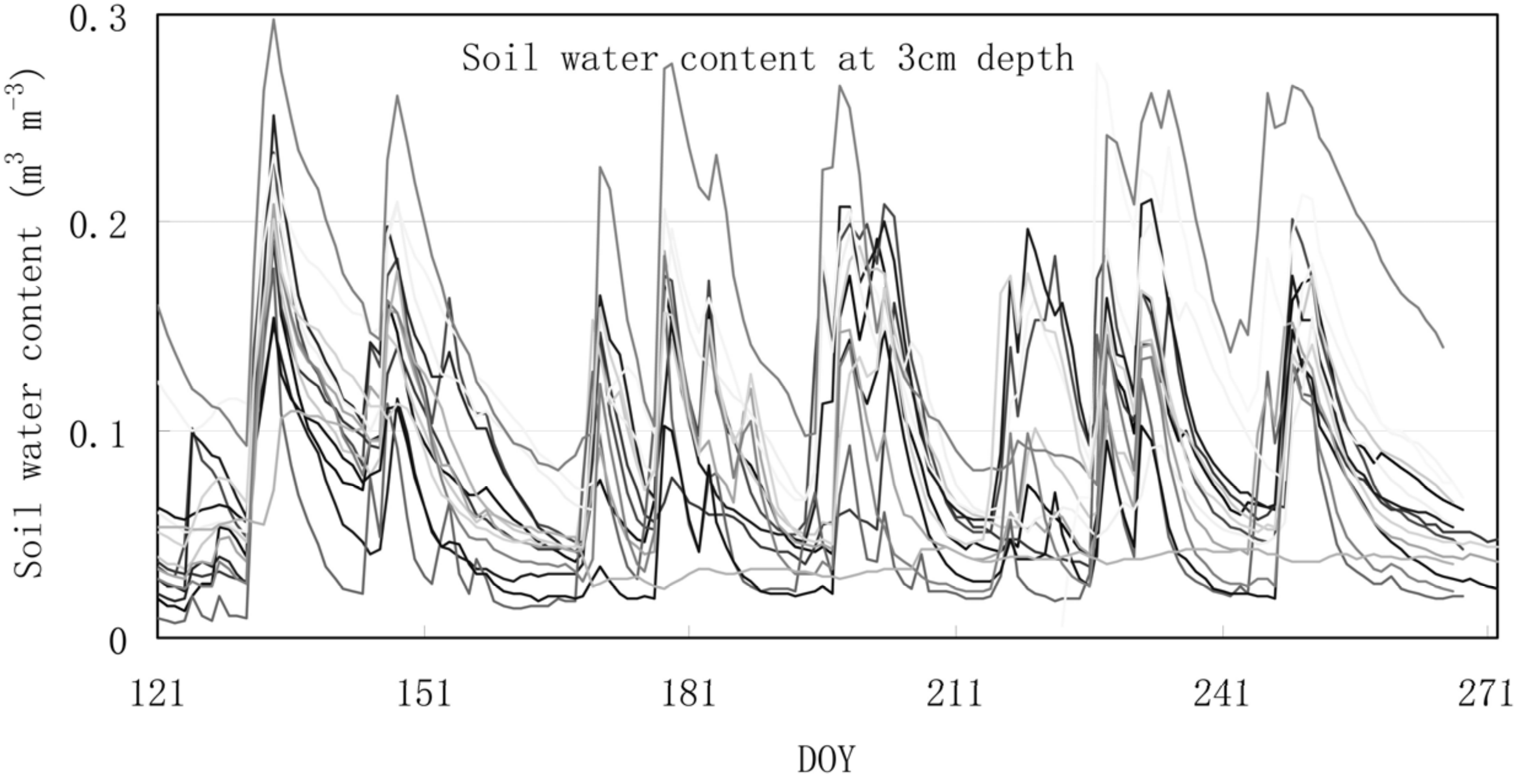
No.	Site code	Lat. (N)	Lon. (E)	Alt. (m)
1	MGS	45° 44'34.9"	106° 15'52.2"	1393
2	DRS	46° 12'31.2"	106° 42'53.0"	1297
3	DGS	46° 07'38.3"	106° 22'06.8"	1409
4	BTS	46° 46'35.4"	107° 08'32.2"	1371
5	TDS	46° 24'22.4"	107° 38'03.5"	1365
6	CRS	46° 21'08.0"	108° 22'30.5"	1287

ASSH

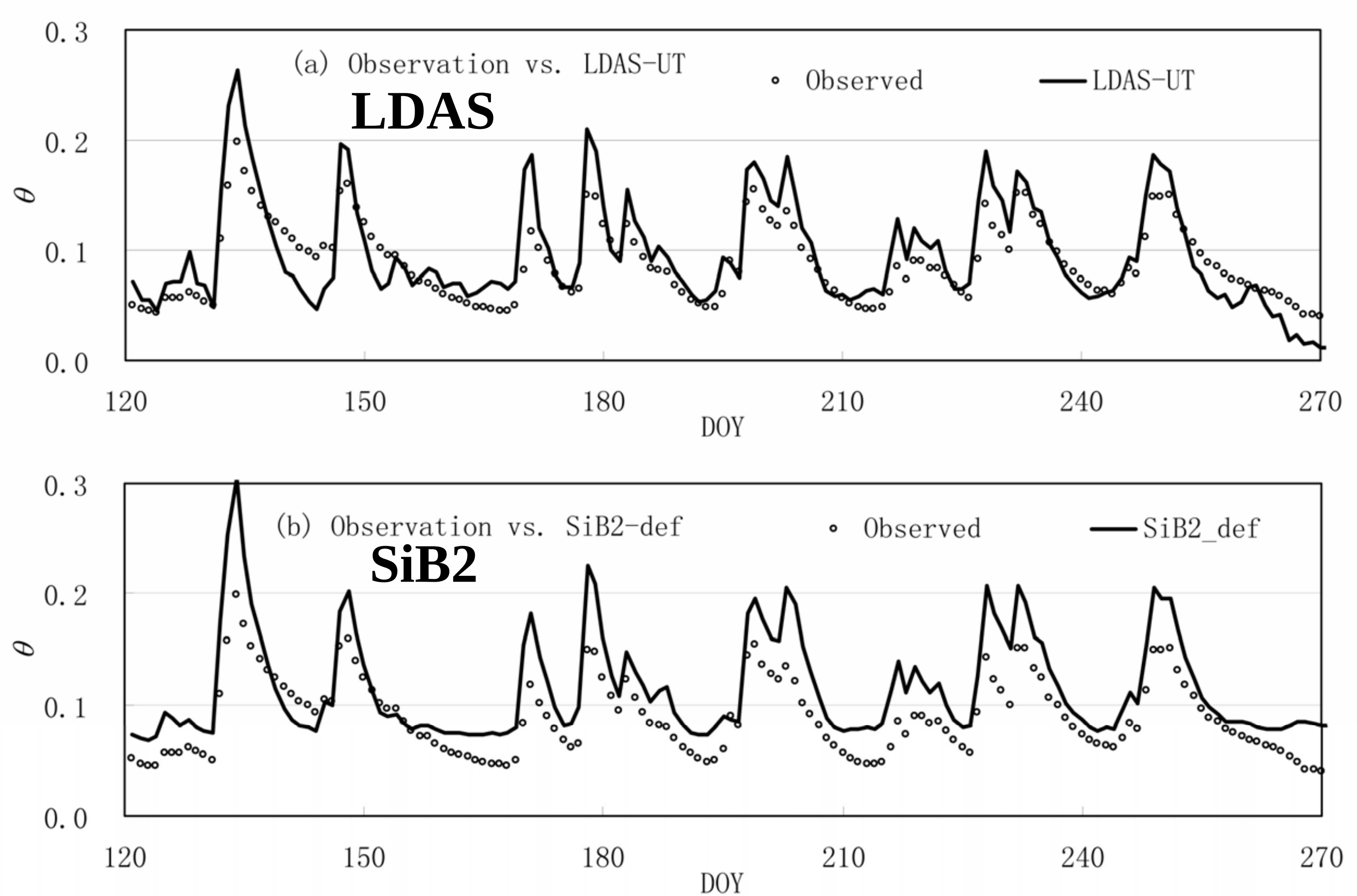
No.	Site code	Lat. (N)	Lon. (E)	Alt. (m)
1	E2	45° 55'22.5"	106° 46'47.2"	1422
2	A3	46° 00'46.2"	106° 15'52.1"	1502
3	E4	46° 06'10.0"	106° 46'47.2"	1318
4	G6	46° 16'57.6"	107° 02'13.1"	1350
5	GUS	46° 03'14.2"	107° 29'20.3"	1472
6	H7	46° 33'08.9"	107° 25'22.0"	1383
7	D0	45° 44'23.4"	106° 39'05.5"	1342
8	F0	45° 44'34.9"	106° 54'30.2"	1332
9	A6	46° 16'57.6"	106° 15'52.1"	1407
10	C2	45° 55'22.5"	106° 31'21.2"	1422
11	C4	46° 06'10.0"	106° 31'21.2"	1383
12	D7	46° 33'08.9"	106° 39'04.2"	1357

There were 6 Automatic Weather Stations (AWS), 12 Automatic Stations for Soil Hydrology (ASSH). Data at two AWS (TDS, CRS) were not archived in CEOP.

Observed soil moisture at 16 stations



Comparison with site-mean soil moisture



Contribution to GEWEX roadmap

- Objective 1
  - Evaluate satellite products of precipitation and surface radiation and pproduce multi-year water and energy budget data sets by integrating in situ data, model, satellite data
- Objective 2
  - Understanding water and energy budgets in regional hydroclimate hotspots and their relationships with extreme events
- Objective 3
  - Identify model deficiencies in simulating diurnal, seasonal, and inter-annual water and energy budget;
- Objective 4
  - Recommend high-quality model output and satellite products for hydro-meteorological applications

Accomplishments toward CEOP and WCRP plans

- Established land data assimilation system and validated its ability in estimating soil moisture and surface energy budget

- WRF simulates precipitation well in southern Europe (EMC: Could WRF be a good candidate to be combined with satellite-derived estimates to build a more accurate sub-daily precipitation product over Europe?)

- Described biases and uncertainties of satellite products of precipitation and radiation

Data Contributions and Requirements

- Produce energy and water budgets
  - For hydroclimate hotspots
  - For extreme events

- Required high-quality satellite data
  - Radiation
  - Precipitation
  - Collaborate with SAS, Extreme, Cold region

Issues and Plans (1–3 Years)

Plan

- Continue the evaluation of remote sensing products and model output for water and energy budgets;
- Continue hydroclimate studies in Tibet, including producing soil moisture and analyzing atmospheric heating;
- 2010: Joint International Workshop on CEOP/WEBS and Tibet Energy and Water Cycle, Lhasa, China.

Issues

- Who will continue analyses of water and energy cycles in models and identify model deficiencies in this aspect;
- No Interactions between WEBS and SAS, Extreme events, as well as Cold region.

Lhasa Branch of Institute of Tibetan Plateau Research (ITP), Chinese Academy of Sciences (CAS)