DOE ARM data products for land-related climate studies

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Acknowledgments
DOE ARM program, Stephen A. Klein, Yunyan Zhang, Hsi-Yen Ma, Thomas J. Phillips

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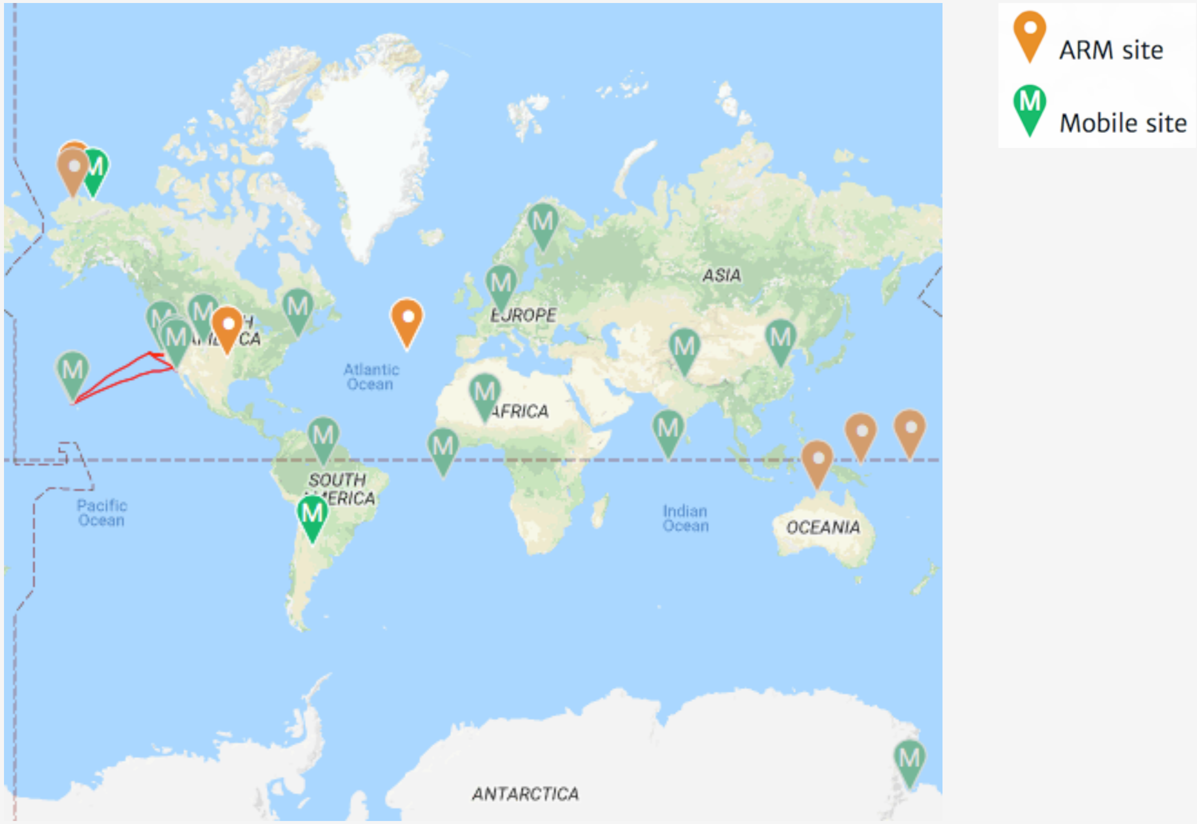
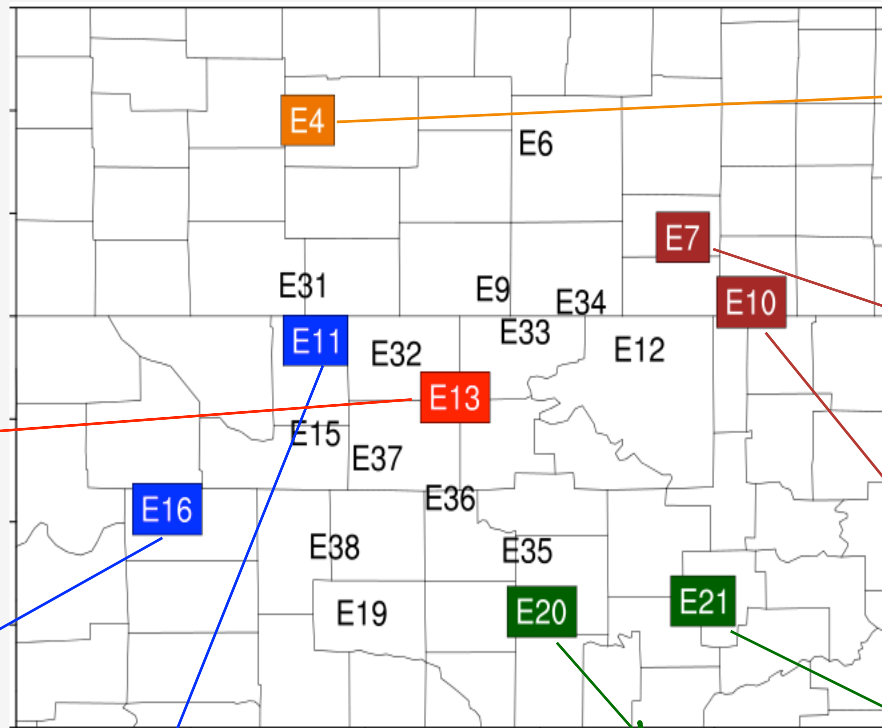
Atmospheric Radiation Measurement (ARM) user facility



- SGP: Lamont, Oklahoma, US, (1993 – present)
- NSA: Barrow, Alaska, US, (2013 – present)
- ENA: Graciosa Island, Azores, Portugal, (2013 – present)

ARM SGP - various types of surface/soil

~3.5°x3.5°



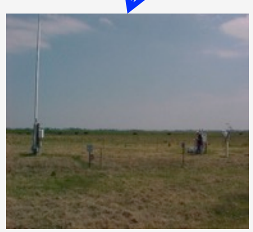
Pasture, wheat
Silty Clay
Loam

Rangeland
(ungrazed)
Cobbly-Loam

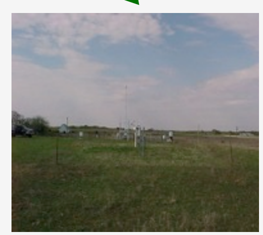
Pasture
Silt Loam

Alfalfa
Silt Loam

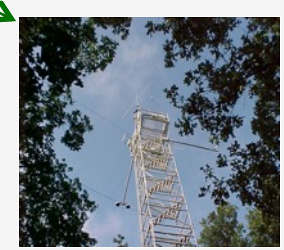
Wheat
Silt Loam



Alfalfa
Fine Sand



Pasture
Silt Loam



Forest
Stony-Fine
Sandy Loam

- Some sites (color) have co-located measurements to study LAC.
- Primarily grassland (42%) and cropland (43%) (Bagley et al., 2017)

(http://www.arm.gov/sites/sgp/geoinfo) (http://www.xdc.arm.gov/data_viewers/sgp_surfchar/soil_and_land_links.html#top)

ARM 2-D datasets

- ARMBESTNS (DOE/LLNL), ARMBE2DGRID (DOE/LLNL), RADFLUXANAL (DOE/PNNL), VISST (NASA/Langley)

Variables	Datastream	Site N (2011)
U, V, T, q, precip	MET	9
Radiation fluxes	QCRAD, RADFLUX	21
Latent & sensible heat flux	BAEBBR, ECOR	8, 5
Soil moisture/T	SWATS, EBBR	12
Cloud fraction	VISST (GOES)	0.5^o x 0.5^o

- Soil Water and Temperature System (SWATS)
  - Vertical profiles, 8 layers up to 175 cm below surface

Long-standing climate model biases related to LAC

GEOPHYSICAL RESEARCH LETTERS, VOL. 33, L18805, doi:10.1029/2006GL027567, 2006

2006

Diagnosis of the summertime warm and dry bias over the U.S. Southern Great Plains in the GFDL climate model using a weather forecasting approach

Stephen A. Klein,[1] Xianan Jiang,[2] Jim Boyle,[1] Sergey Ma

Journal of Geophysical Research: Atmospheres

2018

RESEARCH ARTICLE

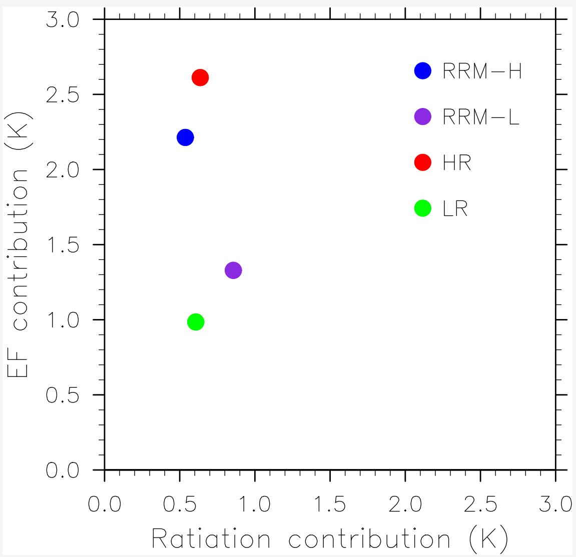
10.1002/2017JD027194

CAUSES: On the Role of Surface Energy Budget Errors to the Warm Surface Air Temperature Error Over the Central United States

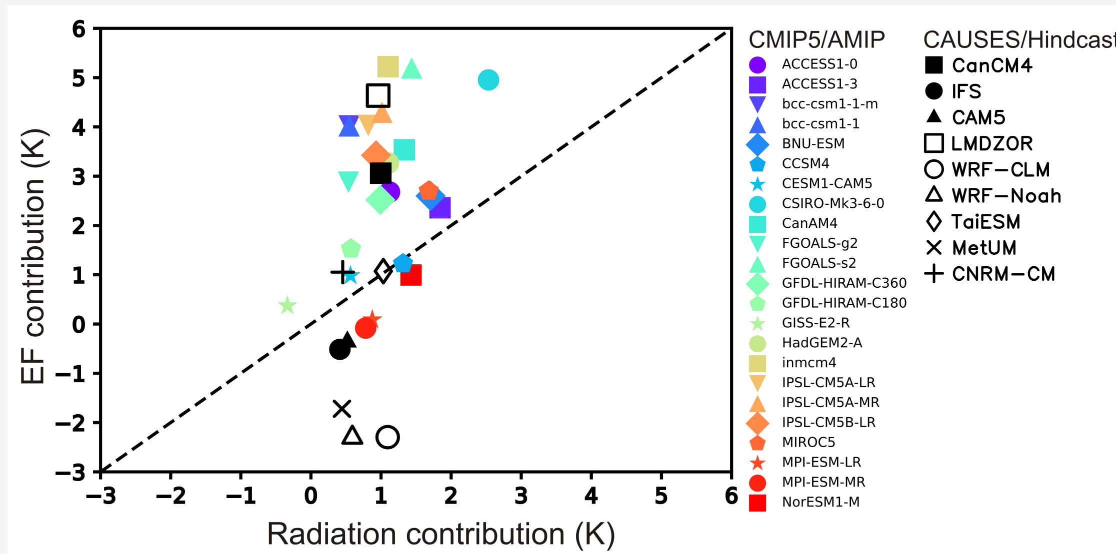
Key Points:

- Biases in the net shortwave

DOE E3SM V1



CMIP5



- T_{2m} biases relative to ARMBE2DGRID data at SGP
- Larger contribution from EF (land) than radiation (atm) for most climate models.

Warm season LAC at SGP: observations & model evaluations

Journal of Geophysical Research: Atmospheres 2014

RESEARCH ARTICLE
10.1002/2013JD020492

Land-atmosphere coupling manifested in warm-season observations on the U.S. southern great plains

Thomas J. Phillips[1] and Stephen A. Klein[1]

Key Points:
- Statistically significant SGP land-atmosphere interactions occur
- Atmospheric forcings predominate

Journal of Geophysical Research: Atmospheres 2017

RESEARCH ARTICLE
10.1002/2017JD027141

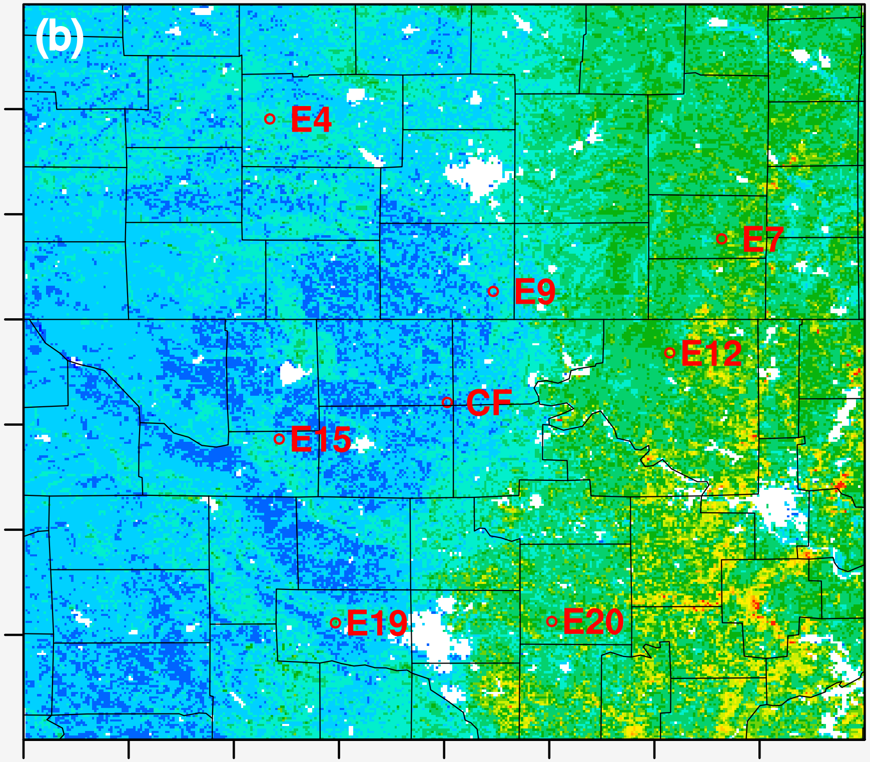
Using ARM Observations to Evaluate Climate Model Simulations of Land-Atmosphere Coupling on the U.S. Southern Great Plains

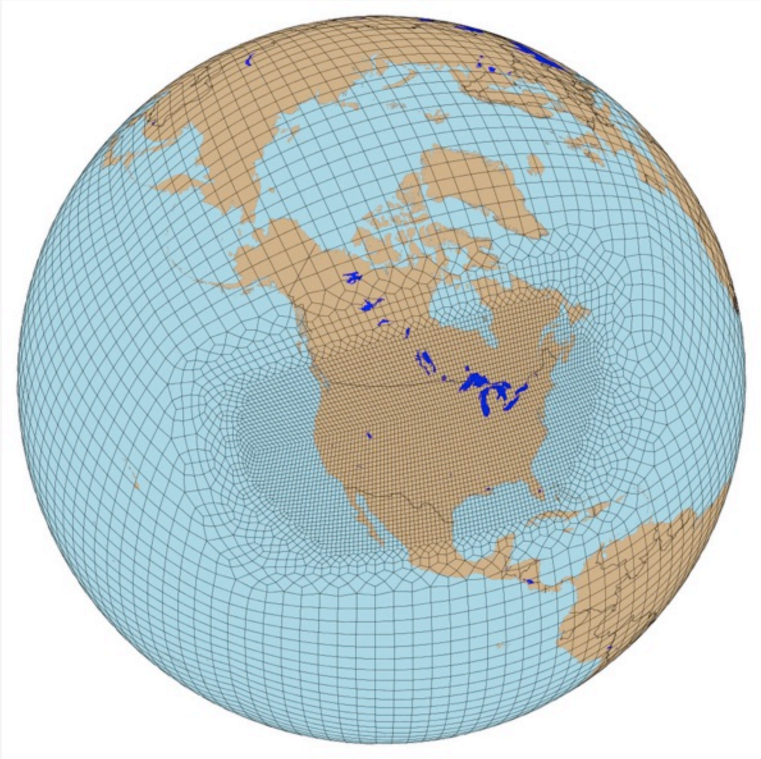
Thomas J. Phillips[1], Stephen A. Klein[1], Hsi-Yen Ma[1], Qi Tang[1], Shaocheng Xie[1], Ian N. Williams[2], Joseph A. Santanello[3], David R. Cook[4], and Margaret S. Torn[2]

Key Points:
- ARM observational data are used to estimate the terrestrial component of land-atmosphere coupling strength in the U.S. SGP region

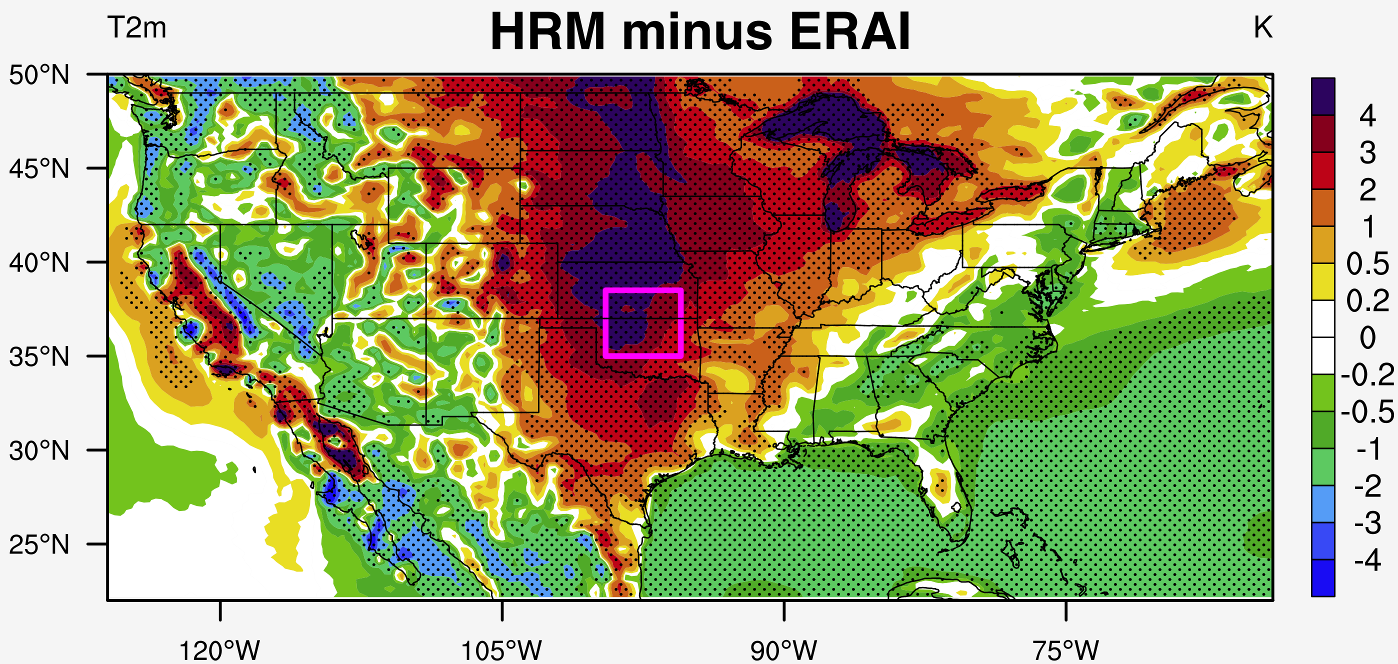
- Modest LAC between EF and SM is found at SGP CF.
- Atmospheric forcings predominate over land feedbacks
- Both free-running and constrained climate model simulations of regional atmospheric coupling with SM are too strong compared to observations
- Simulated coupling of local vegetation leaf area with surface evaporative fraction is weaker than the observational estimate

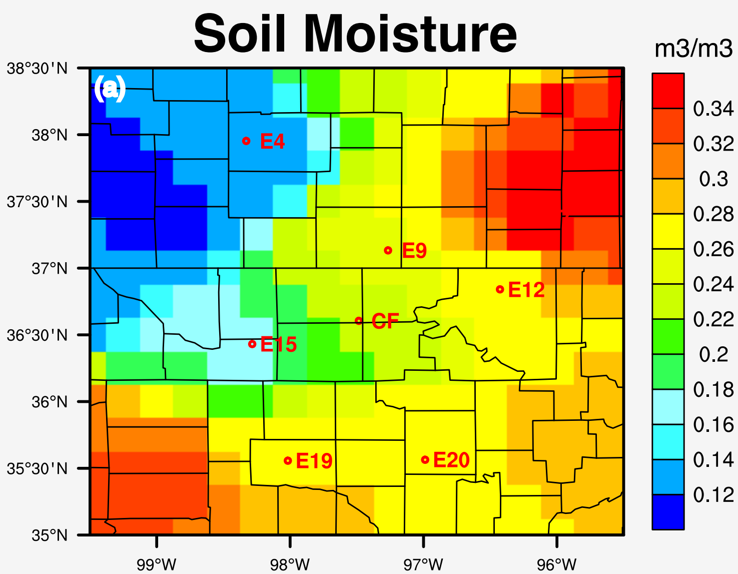
Heterogeneity in LAC, same land cover & instruments

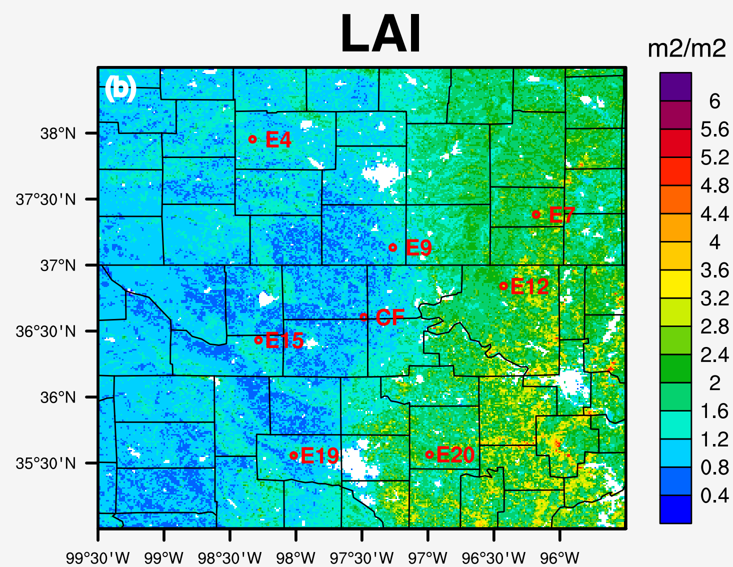




- Energy balance Bowen ratio (EBBR) systems
- Grassland
- Availability of long-term, co-located measurements


T2m
HRM minus ERAI
K
50°N
45°N
40°N
35°N
30°N
25°N
120°W
105°W
90°W
75°W
4
3
2
1
0.5
0.2
0
-0.2
-0.5
-1
-2
-3
-4


Soil Moisture
m3/m3
(a)
E4
E9
E12
CF
E15
E19
E20
38°30'N
38°N
37°30'N
37°N
36°30'N
36°N
35°30'N
35°N
99°W
98°W
97°W
96°W
0.34
0.32
0.3
0.28
0.26
0.24
0.22
0.2
0.18
0.16
0.14
0.12

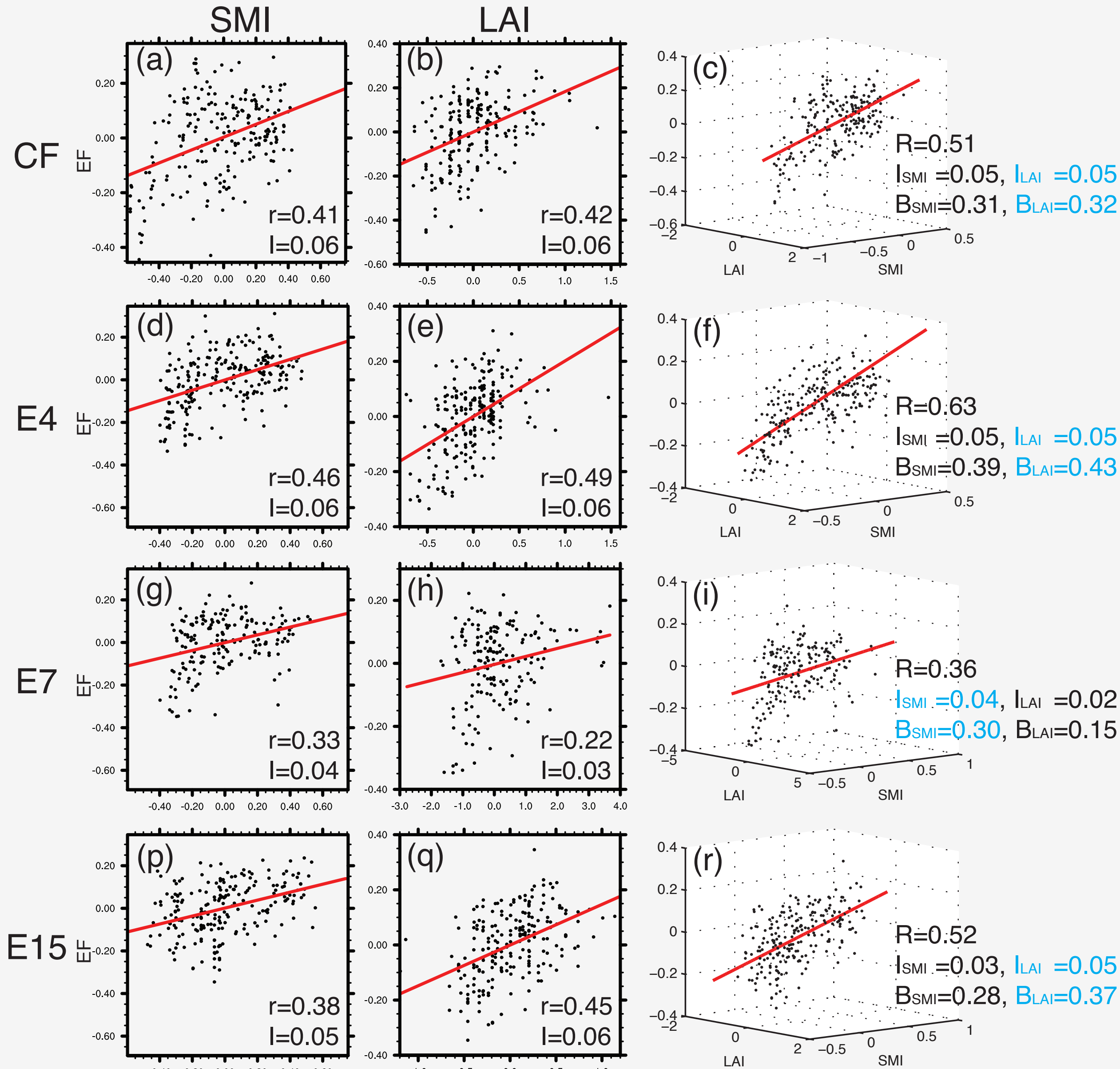

LAI
m2/m2
(b)
E4
E7
E9
E12
CF
E15
E19
E20
38°N
37°30'N
37°N
36°30'N
36°N
35°30'N
99°30'W
99°W
98°30'W
98°W
97°30'W
97°W
96°30'W
96°W
6
5.6
5.2
4.8
4.4
4
3.6
3.2
2.8
2.4
2
1.6
1.2
0.8
0.4

Land-Atmosphere Coupling (LAC) metrics

- Single-variable regression
  - r(EF, SMI), r(EF, LAI)
  - Sensitivity index: $I = b^*\sigma_x$ (Dirmeyer 2011)
- Multiple-variable regression
  - $EF = b(0) + b(1)^*SMI + b(2)^*LAI$
  - R(EF; SMI, LAI)
  - Standardized regression coefficients: $B_i = b_i^*\sigma_{xi}/\sigma_y$

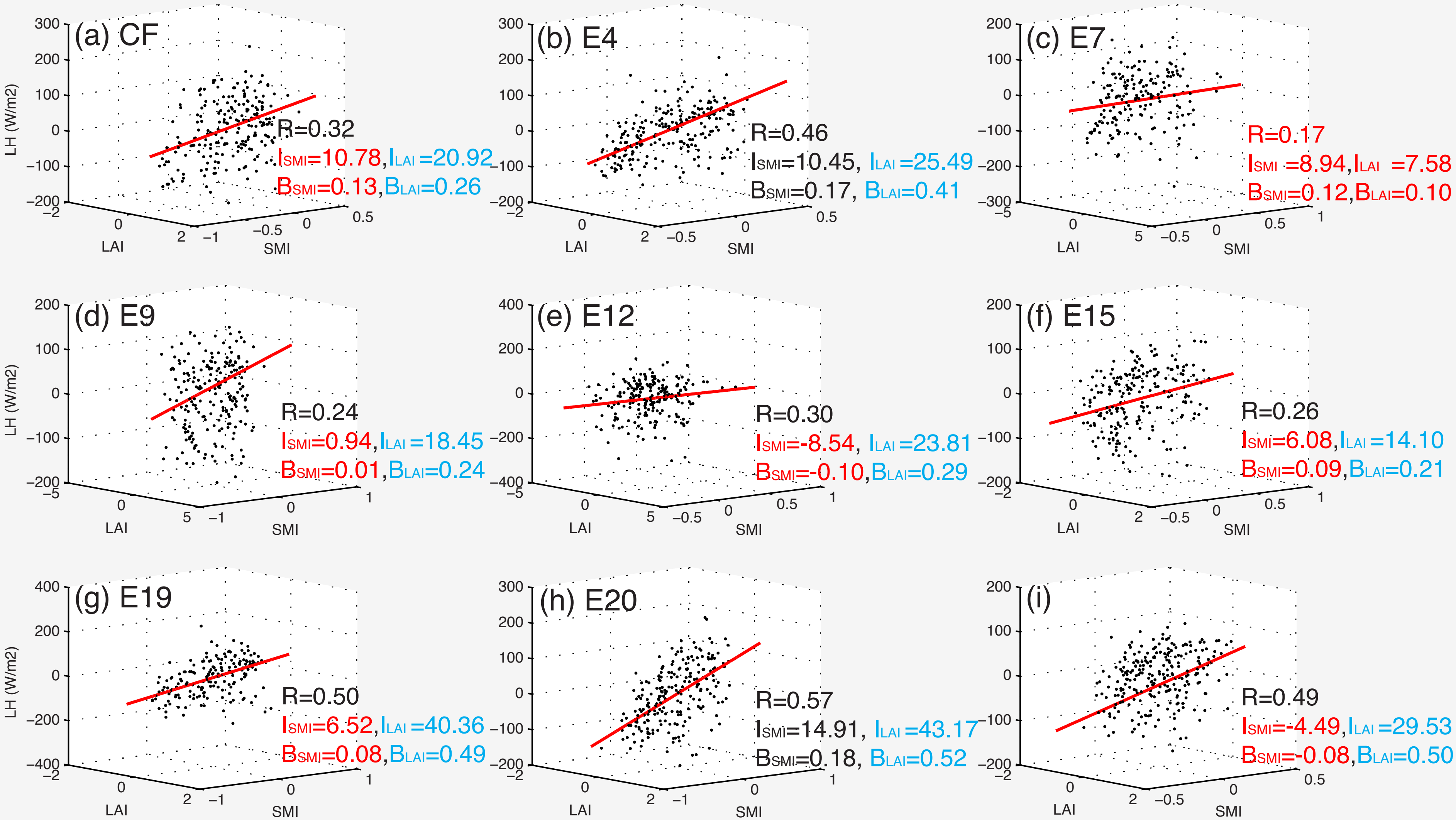
Tang et al., 2018

Soil moisture vs. vegetation controls on EF



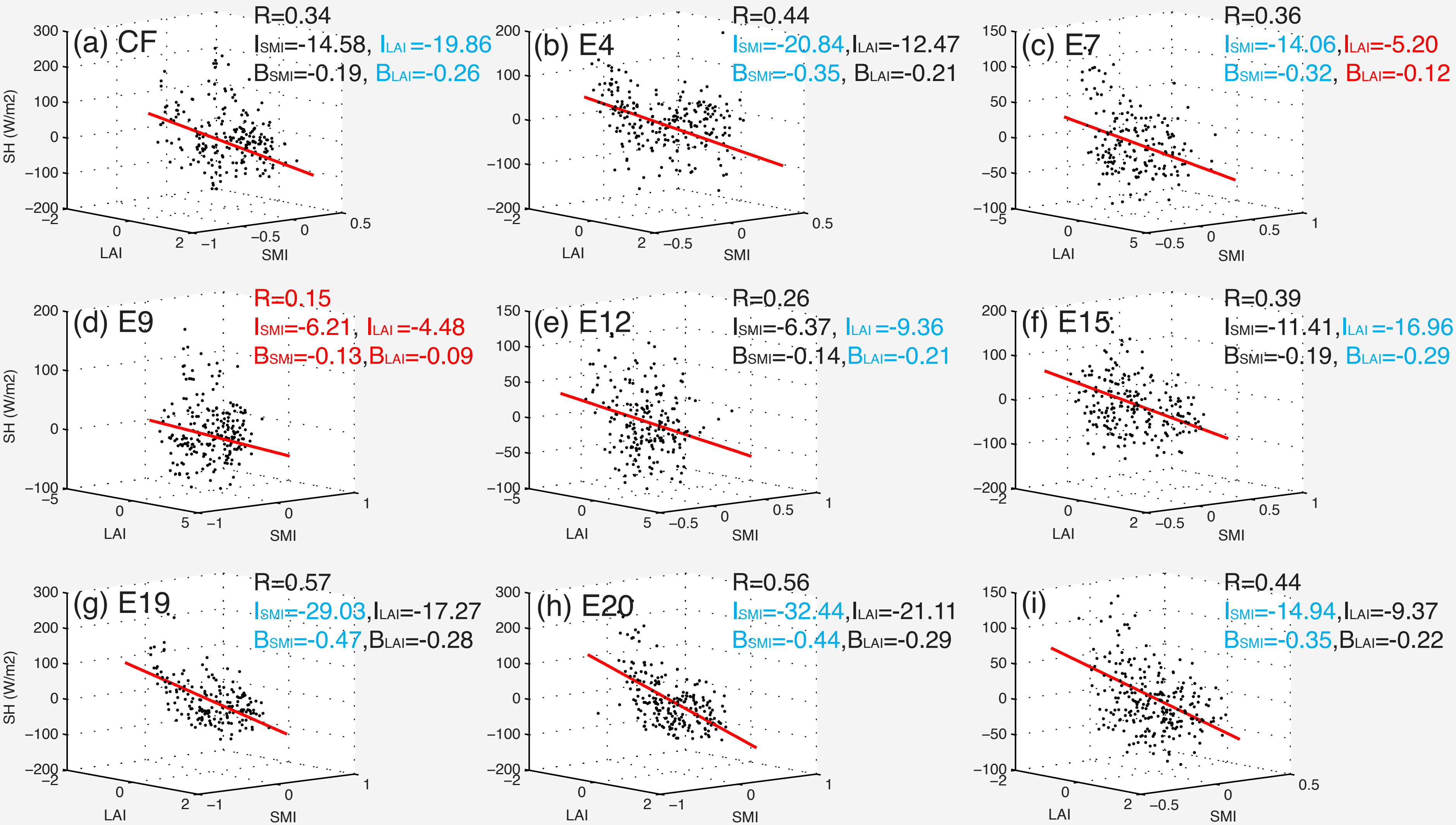
Tang et al., 2018

Soil moisture vs. vegetation controls on LH



Tang et al., 2018

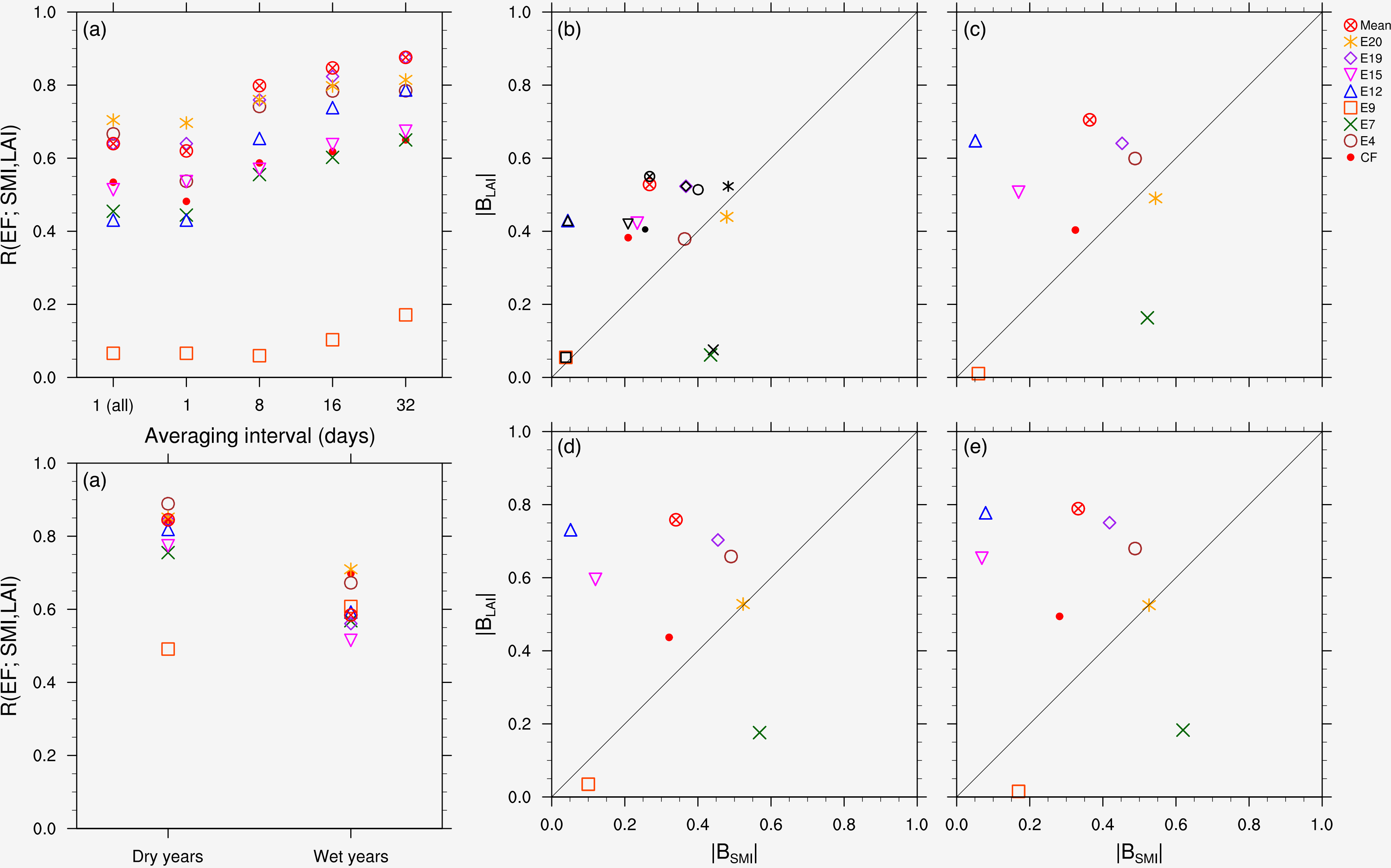
Soil moisture vs. vegetation controls on SH



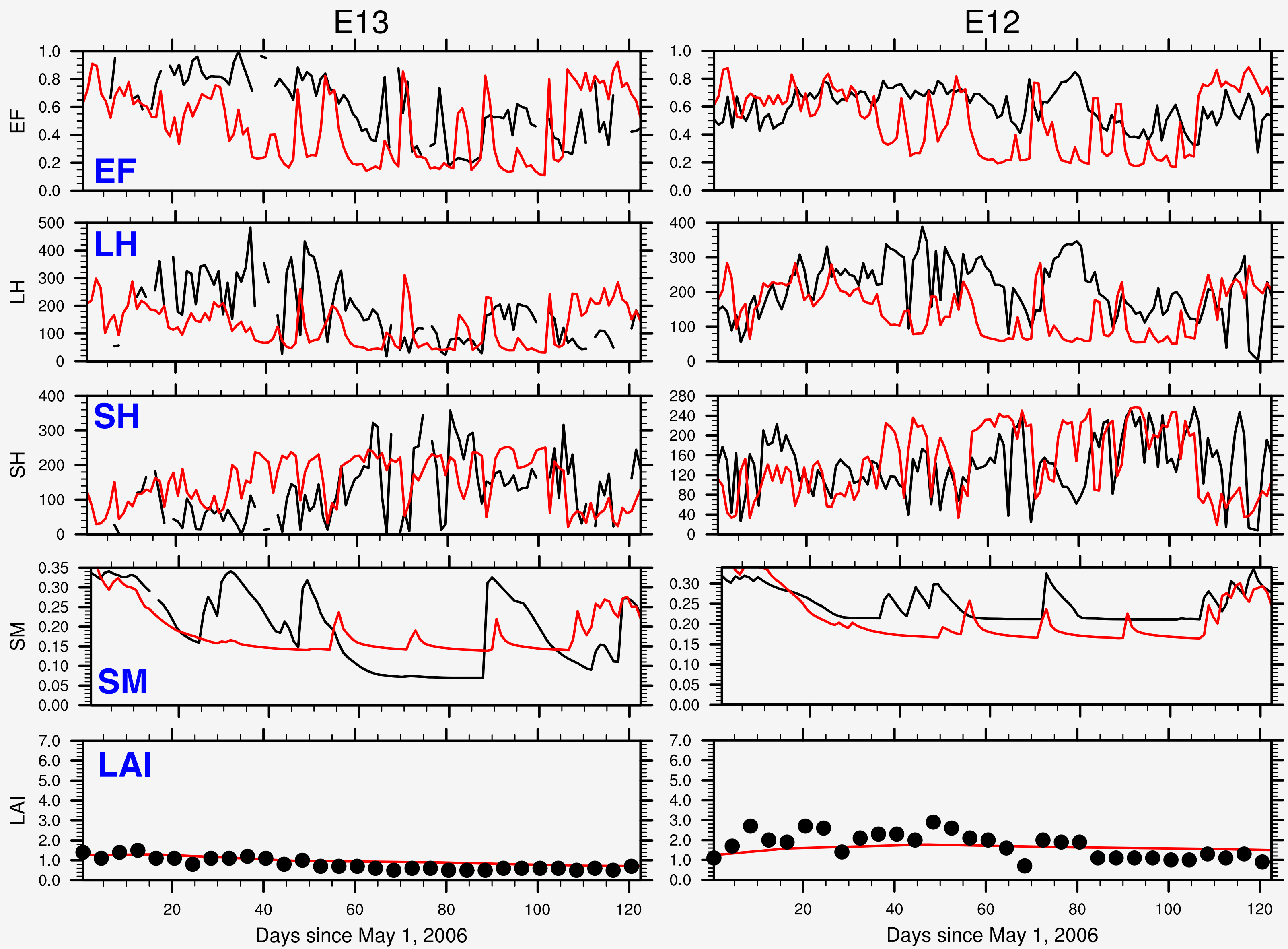
Tang et al., 2018

Large heterogeneity over same surf. type

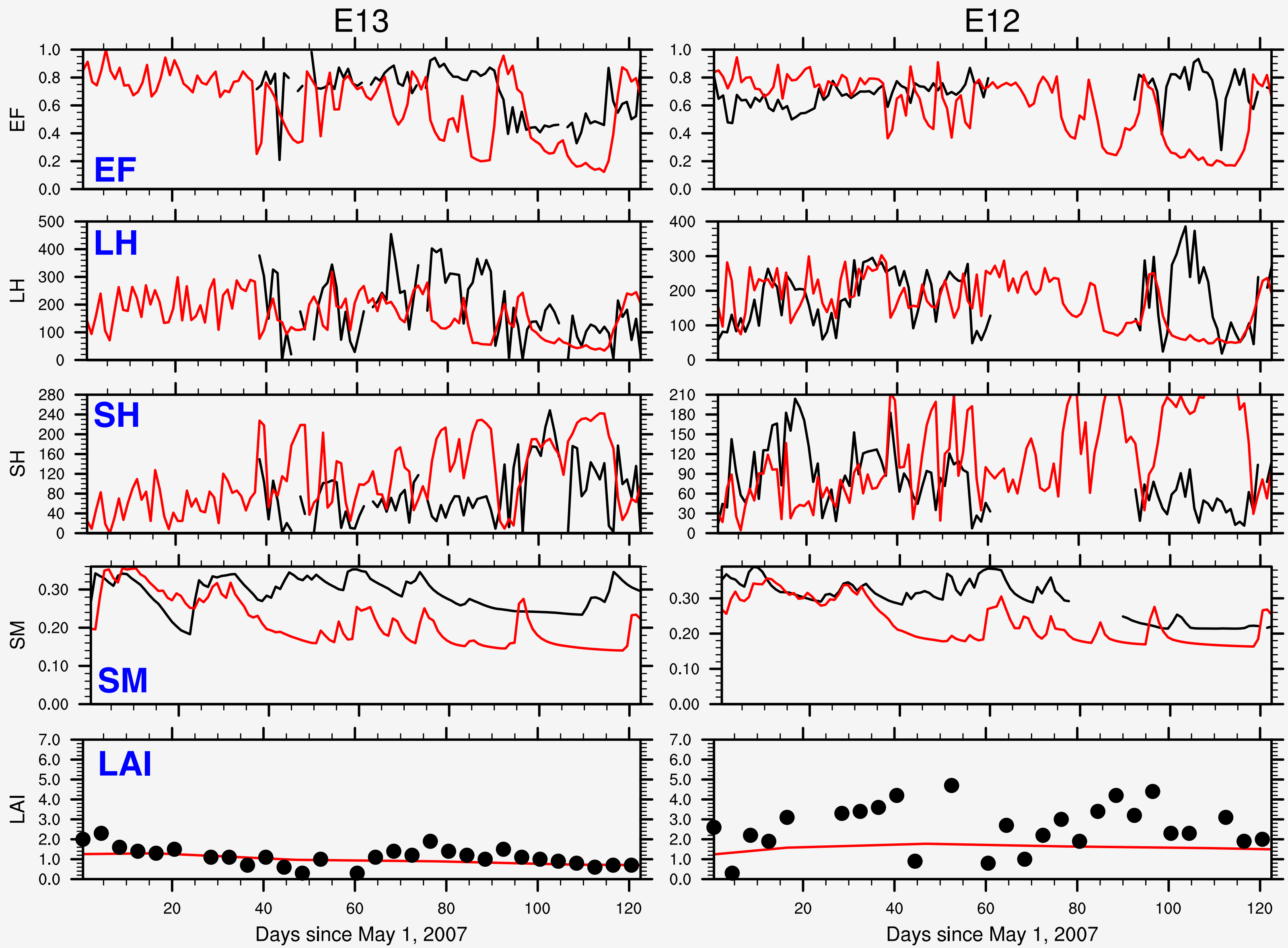
Tang et al., 2018



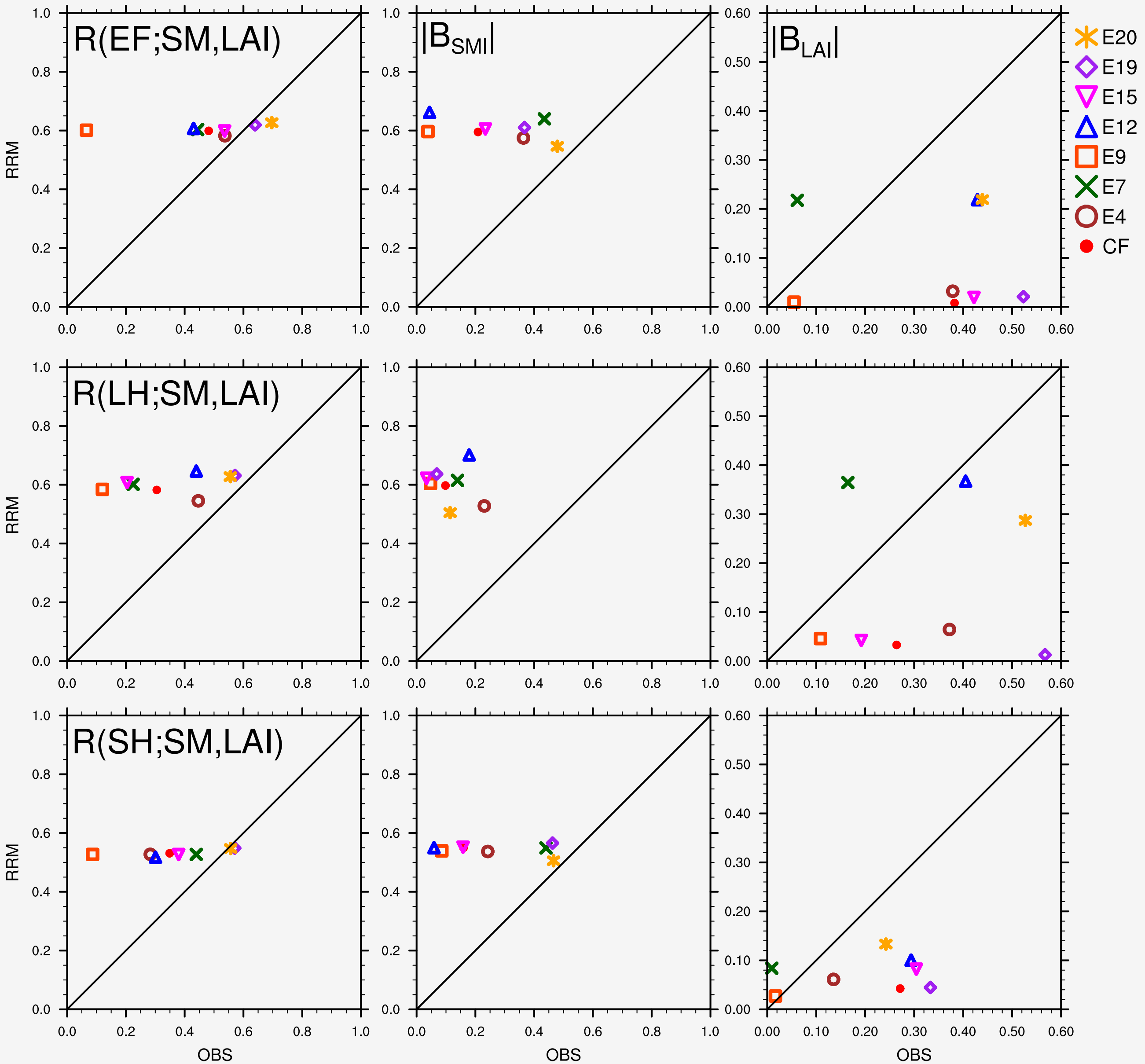
RRM vs. OBS, dry 2006, daily mean



RRM vs. OBS, wet 2007, daily mean



RRM vs. OBS LAC



Summary

- ARM collects long-term, co-located ground measurements (including soil T & moisture) for climate studies.
- ARM data can be critical for studying land surface processes in S2S prediction.
  - SGP, Mobile facilities
- Climate model biases are identified with ARM data.
- DOE LLNL group can also contribute Energy Exascale Earth System Model (E3SM) simulations.
  - Regional refined model (RRM)
- Help interpret results in comparison with ARM data

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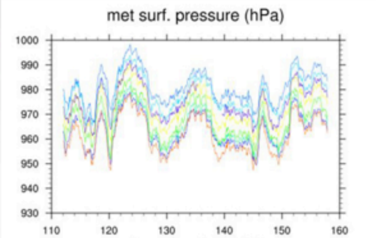
ARMBESTNS

TECHNICAL REPORT | BROWSE DATA

ARMBESTNS: STATION-BASED SURFACE PRODUCTS

The ARM Best Estimate Station-based Surface (ARMBESTNS) data set merges together key surface measurements from the Southern Great Plains (SGP) sites. It is a twin data product of the ARM Best Estimate 2-dimensional Gridded Surface (ARMBE2DGRID) data set. Unlike the 2DGRID data set, the STNS data are reported at the original site locations and show the original information, except for the interpolation over time. Therefore, users have the flexibility to process the data with the approach most suitable for their applications.

Information about the input data, quality-control (QC) method, and output format of this data set is in the data documentation found with the data. The data are currently available for the year 2011 and will be extended to longer periods.



Surface pressure is shown in hPa from different SGP surface meteorological sites (color-coded) from ARMBESTNS data set for the Midlatitude Continental Convective Clouds Experiment (MC3E).

capabilities/vaps/armbe2dgrid

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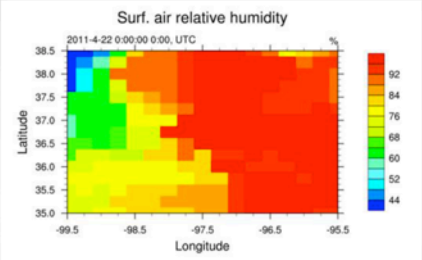
ARMBE2DGRID

TECHNICAL REPORT | BROWSE DATA

ARMBE2DGRID: 2D GRIDDED SURFACE DATA SET

The ARM Best Estimate 2-dimensional Gridded Surface (ARMBE2DGRID) data set merges together key surface measurements at the Southern Great Plains (SGP) sites and interpolates the data to a regular 2D grid to facilitate data application. Data from the original site locations can be found in the ARM Best Estimate Station-based Surface (ARMBESTNS) data set. The data are currently available for the year 2011 and will be extended to longer periods.



Surface air relative humidity is shown in percent from the ARMBE2DGRID data product on 2011-04-22 0:00:00 UTC.

lysis (RADFLUXANAL)

s of the Madden Julian Oscillation for Mode

oad Data]

» **Colorado: The Storm Peak Lab Cloud Property Validation Experiment (STORMVEX)** [Download Data]
Steamboat Springs CO, USA; Mobile Facility, 2010.11.15 - 2011.04.25

» **Colorado: The Storm Peak Lab Cloud Property Validation Experiment (STORMVEX)** [Download Data]
Steamboat Springs CO, USA; Mobile Facility, 2010.11.15 - 2011.04.25

» **IRSI Inter-Comparison Study** [Download Data]
Southern Great Plains, 2007.08.27 - 2007.09.23

www.arm.gov