Soil Moisture and Surface Flux Observations

Robert Zamora[1], Allen White[1], Clark King[1]

[1]NOAA Earth System Research Laboratory Physical Sciences Division

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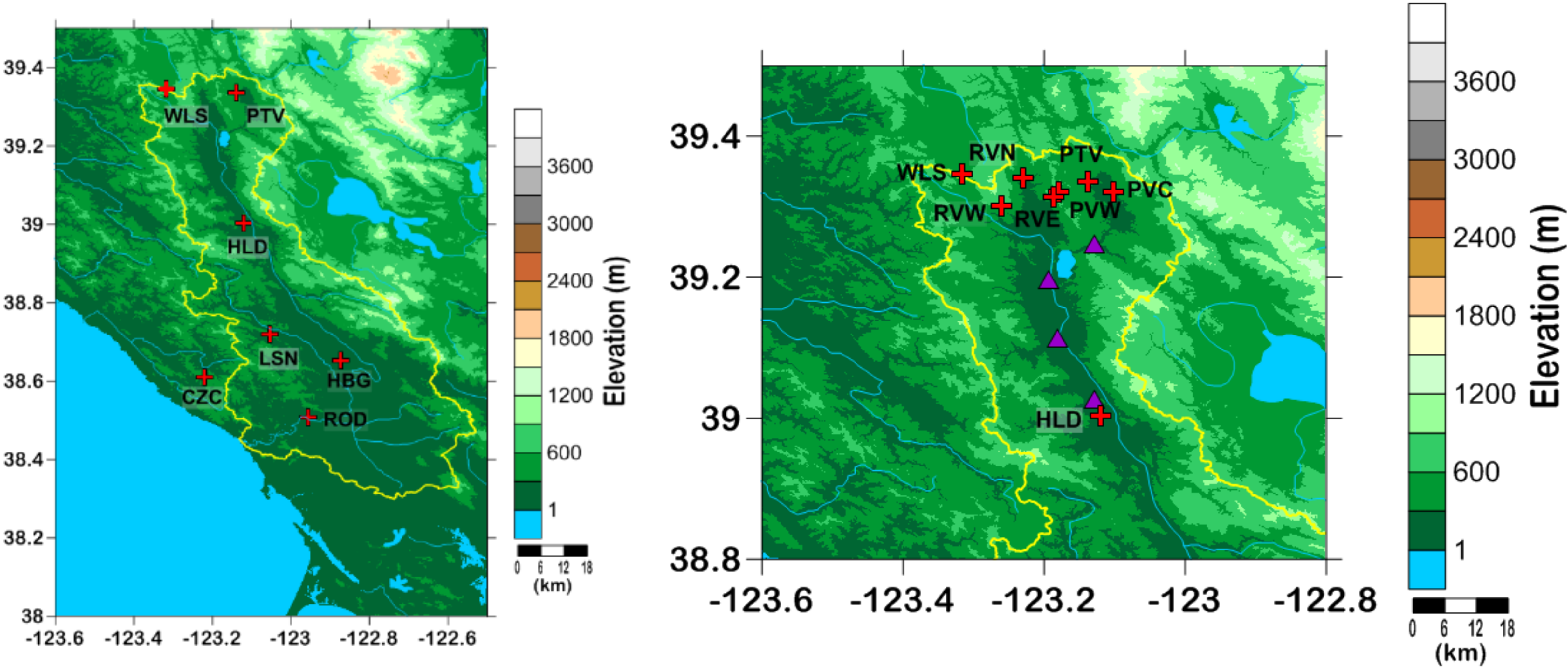
Overview

- A bit of history (From Air Quality to Hydrometeorology)
- The PSD soil moisture observing methodology
- A quick look at the PSD observations in Redwood and Potter Valley (histograms and available water capacity)
- National Water Model Intercomparison/Validation
- Surface Flux Observations

History

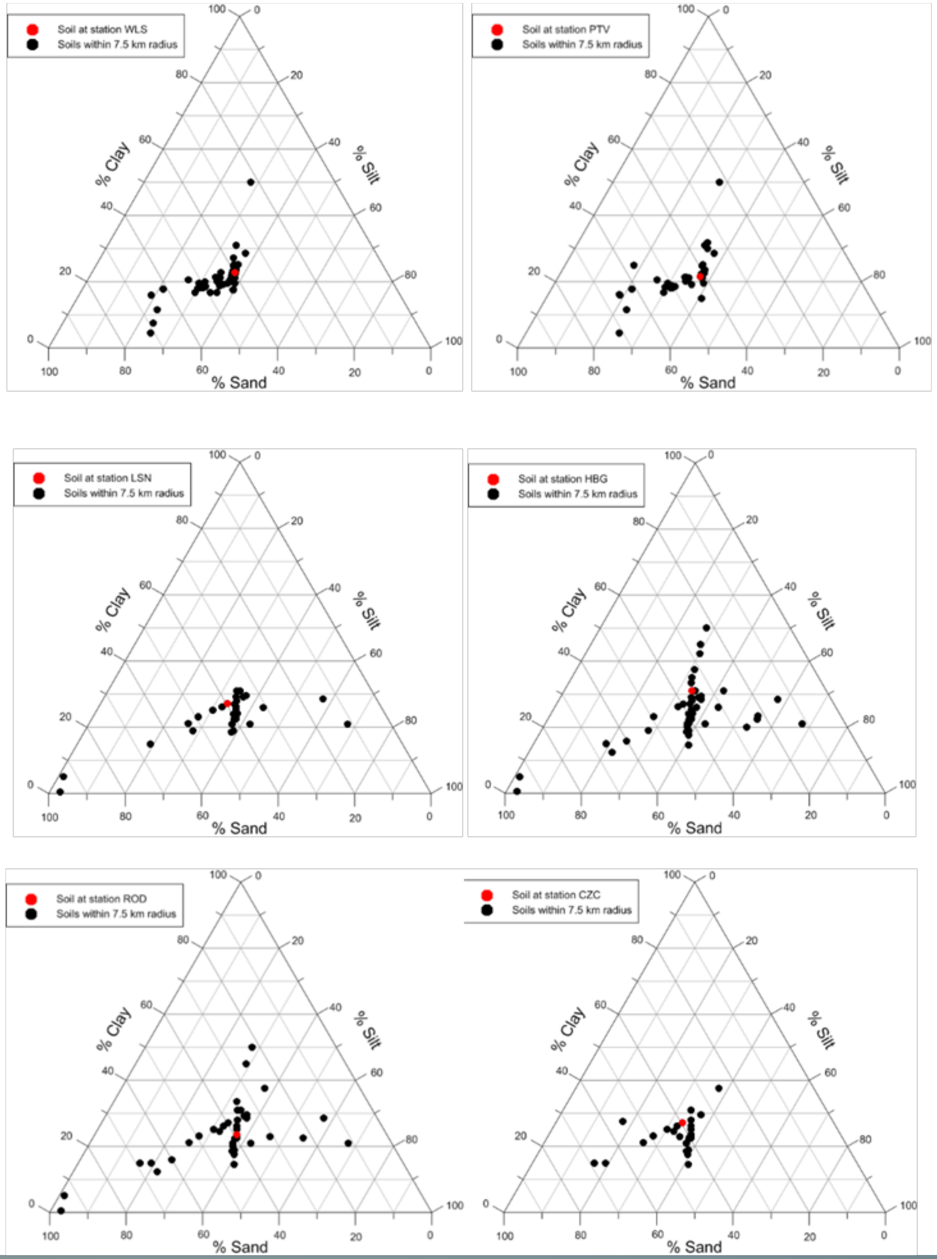
- Original soil moisture observations supported California air quality meteorological surface energy balance model validation (1999)
- Legacy sites established at Cazadero (CZD), Rio Nido (ROD), and Healdsburg (HBG) (2003)
- North Fork of the American River, CA 5 sites (2004)
- Cazadero and Healdsburg augmentation to six and four level soil pits (2008)
- Babocomari River, Arizona (Tributary of the San Pedro) instrumented 4 sites (2008) sponsored by NOAA Office of Water Prediction (OWP)
- California Department of Water Resources sponsored two level sites installed at Lake Sonoma (LSN), Willits (WLS), Potter Valley (PTV), Hopland (HLD) (2010)
- Sonoma County Water Agency sponsored six level sites installed at Potter Valley West (PVW), Potter Valley Central (PVC), Redwood Valley North (RVN), Redwood Valley East (RVE), Redwood Valley West (RVW), Middletown, (MDT), and Santa Rosa (STR) (2016)
- Completed the addition of 50 cm probe depths at the Russian DWR sites (July 2018)

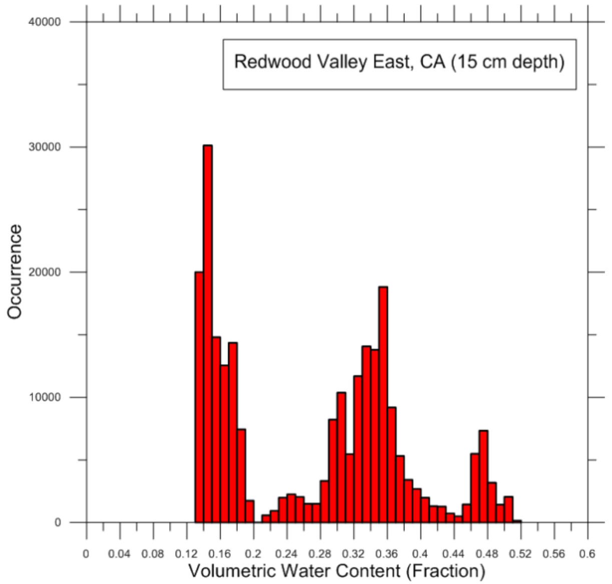

39.4
39.2
39
38.8
38.6
38.4
38.2
38
-123.6
-123.4
-123.2
-123
-122.8
-122.6
WLS
PTV
HLD
LSN
HBG
CZC
ROD
3600
3000
2400
1800
1200
600
1
Elevation (m)
0 6 12 18
(km)
RVN
PTV
WLS
PVC
RVW
RVE
PVW
HLD
39.4
39.2
39
38.8
-123.6
-123.4
-123.2
-123
-122.8
3600
3000
2400
1800
1200
600
1
Elevation (m)
0 6 12 18
(km)

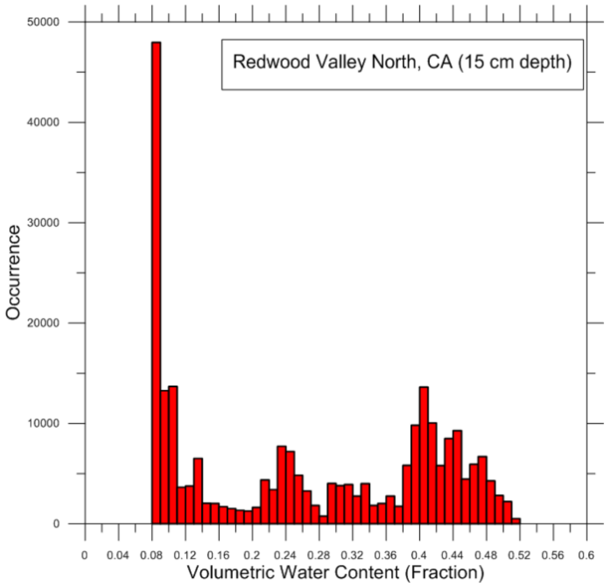
Observing Strategy

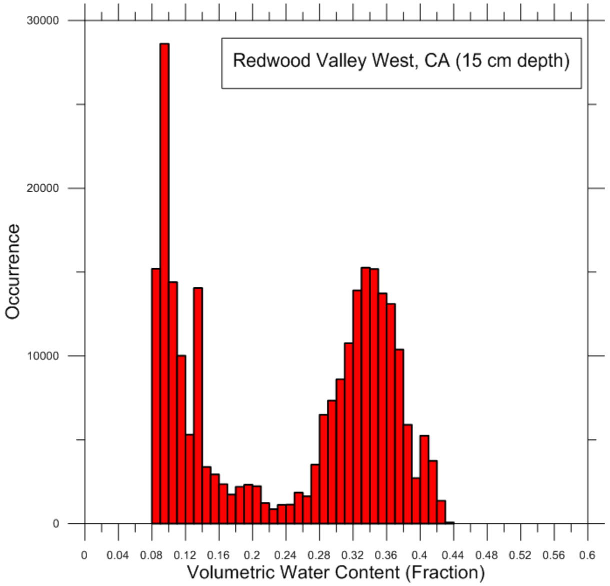
- Our Hydrometeorological Testbed HMT (HMT) observing strategy allows us to address fast infiltration (minutes) to climatological time scales.
- Sample soil temperature and CSI 616 soil moisture probes 1 or 2 Hz, average to 1 or 2 minutes (same as meteorological variables).
- Standard USDA SCAN depths (5, 10, 20, 50, and 100 cm) plus HMT 15 cm legacy depth. Deepest probes depend on depth to first restrictive layer.
- Gravimetric re-calibration when soil electrical conductivity exceeds (1.0 dS/m) (WLS)
- Avoids the issues now facing the establishment of a National Soil Moisture Network

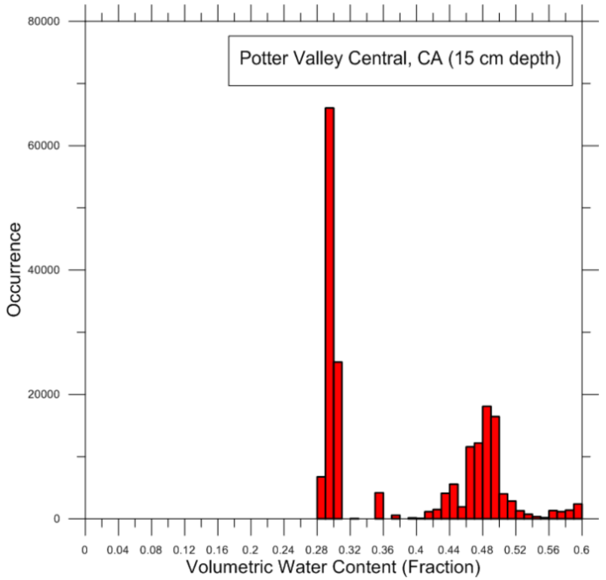
Note: Volumetric Water Content is reported as a fraction. So 0.15 VWC (fraction) is 15% VWC.

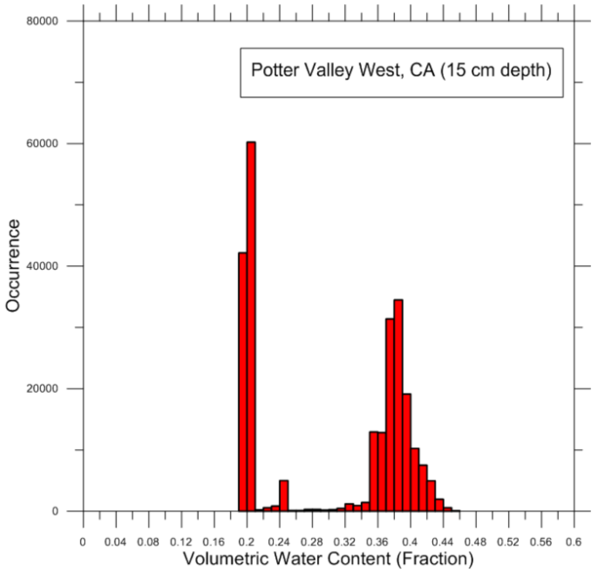

Soil at station WLS
Soils within 7.5 km radius
Soil at station PTV
Soils within 7.5 km radius
Soil at station LSN
Soils within 7.5 km radius
Soil at station HBG
Soils within 7.5 km radius
Soil at station ROD
Soils within 7.5 km radius
Soil at station CZC
Soils within 7.5 km radius
% Clay
% Silt
% Sand

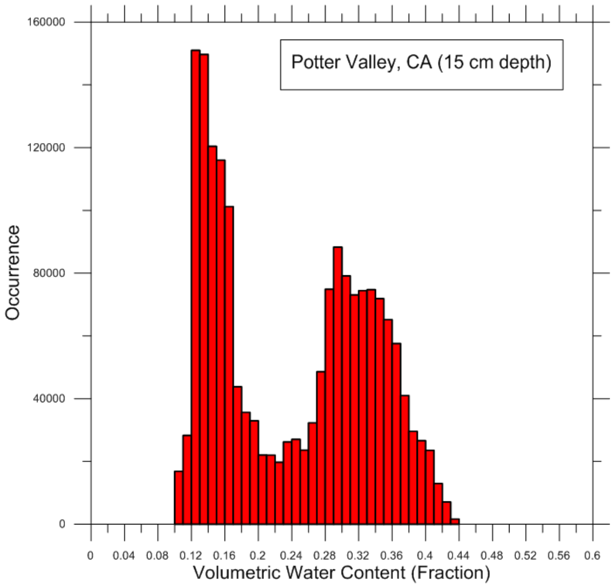

Redwood Valley East, CA (15 cm depth)
Occurrence
0
10000
20000
30000
40000
0 0.04 0.08 0.12 0.16 0.2 0.24 0.28 0.32 0.36 0.4 0.44 0.48 0.52 0.56 0.6
Volumetric Water Content (Fraction)


Redwood Valley North, CA (15 cm depth)
Occurrence
0
10000
20000
30000
40000
50000
0 0.04 0.08 0.12 0.16 0.2 0.24 0.28 0.32 0.36 0.4 0.44 0.48 0.52 0.56 0.6
Volumetric Water Content (Fraction)


Redwood Valley West, CA (15 cm depth)
Occurrence
0
10000
20000
30000
0 0.04 0.08 0.12 0.16 0.2 0.24 0.28 0.32 0.36 0.4 0.44 0.48 0.52 0.56 0.6
Volumetric Water Content (Fraction)


Potter Valley Central, CA (15 cm depth)
Occurrence
0
20000
40000
60000
80000
0 0.04 0.08 0.12 0.16 0.2 0.24 0.28 0.32 0.36 0.4 0.44 0.48 0.52 0.56 0.6
Volumetric Water Content (Fraction)


Potter Valley West, CA (15 cm depth)
Occurrence
0
20000
40000
60000
80000
0 0.04 0.08 0.12 0.16 0.2 0.24 0.28 0.32 0.36 0.4 0.44 0.48 0.52 0.56 0.6
Volumetric Water Content (Fraction)


Potter Valley, CA (15 cm depth)
Occurrence
0
40000
80000
120000
160000
0 0.04 0.08 0.12 0.16 0.2 0.24 0.28 0.32 0.36 0.4 0.44 0.48 0.52 0.56 0.6
Volumetric Water Content (Fraction)

Available Water Content (15 cm depth)

Site	Soil Dry*	Field Capacity	AWC
PTV	0.14	0.47	0.32
PVC	0.19	0.59	0.39
PVW	0.11	0.54	0.43
RVE	0.01	0.51	0.50
RVN	0.08	0.59	0.50
RVW	0.08	0.43	0.35

- Soil Dry are the driest values observed during the period of record. Meteorological processes can continue to extract water from the soil long after the oats have wilted.

Hydrological Model Configurations

NOAA NWS Research Distributed Hydrologic Model (HL-RDHM)

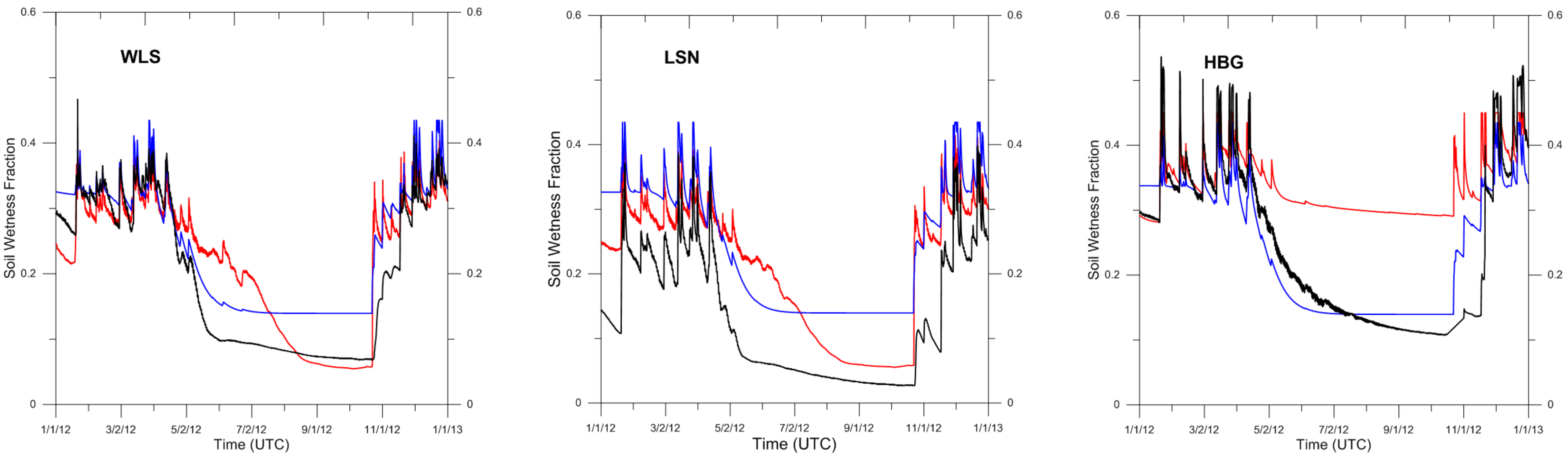
- Sacramento Model Heat Transfer version (Koren el al. 2007)
- HRAP 4-km grid, OWP routing
- OWP a-priori parameters (Out of the box)
- NWS California Nevada River Forecast Center Stage IV
- 6-h time step
- Simulation period: 1 January 2012 – December 2012

NOAA NWS National Water Model (NWM)

- NWM version 1.2
- Noah MP LSM 1-km grid, 250 m routing
- NCAR a-priori parameters (Out of the box)
- NLDAS and Stage IV Forcing
- 1-h LSM time step
- Simulation period: 1 January 2012 – December 2012

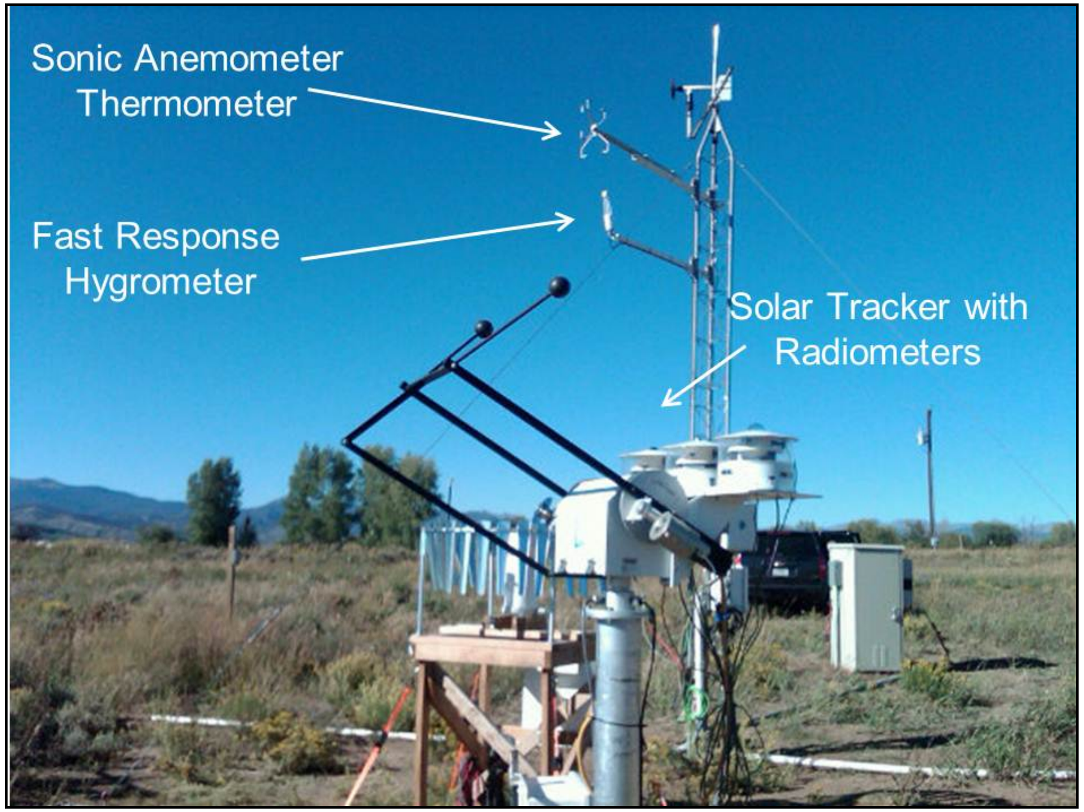
Observational Intercomparison

Higher clay content



Observed soil moisture (solid black), NWM simulated soil moisture (solid red), and HL-RDHM (solid blue) simulated soil moisture for the period 1 January, 2012 – 31 December 2012.

Surface Flux Observations



- Wind and Temperature: Fast response Applied Technology Incorporated Sonic Anemometer/Thermometers
- Water Vapor: Licor LI-7500 fast response gas analyzer
- Incoming direct beam solar radiation: Eppley Normal Incidence Pyroheliometer (Component Summation)
- Incoming diffuse solar radiation: Eppley Black and White Pyranometer
- Incoming IR radiation: Eppley Precision Pyrgeometer
- Outgoing solar radiation: Eppley Black and White Pyranometer
- Outgoing IR radiation: Eppley Precision Pyrgeometer
- Aerosol Optical Depth: Carter-Scott sun-photometer
- Ground Heat Flux: Radiation Energy Balance System soil heat flux plates
- Baseline Surface Radiation Protocols and Calibration (NOAA GMD collaboration)

Getting the Right Answer for the Right Reasons

Zamora, R. J., E. G. Dutton, M. Trainer, S. A. McKeen, J. M. Wilczak, and Y.-T. Hou, 2005: The accuracy of solar irradiance calculations used in mesoscale numerical weather prediction. *Mon. Wea. Rev.*, **133**, 783-792.

Zamora, R. J., F. M. Ralph, E. Clark, and T. Schneider, 2011: The NOAA hydrometeorology testbed soil moisture observing networks: Design instrumentation, and preliminary results. *J. Atmos. Ocean. Technol.*, **28**, 1129-1140.

Zamora, R. J., E. Clark, E. Rogers, M. B. Ek, and T. A. Lahmers, 2014: An examination of meteorological and soil moisture conditions in the Babocomari River Basin before the flood event of 23 July 2008. *J. Hydrometeor.*, **15,** 1, 243-260.

Thank You!