

Implications of Soil Moisture on Modeled Land-Atmosphere Interactions over Heterogenous Terrain



MAC-MAQ 2019

G. Aaron Alexander¹

Xia Sun²

Justin Trousdell¹

Ian Faloon¹

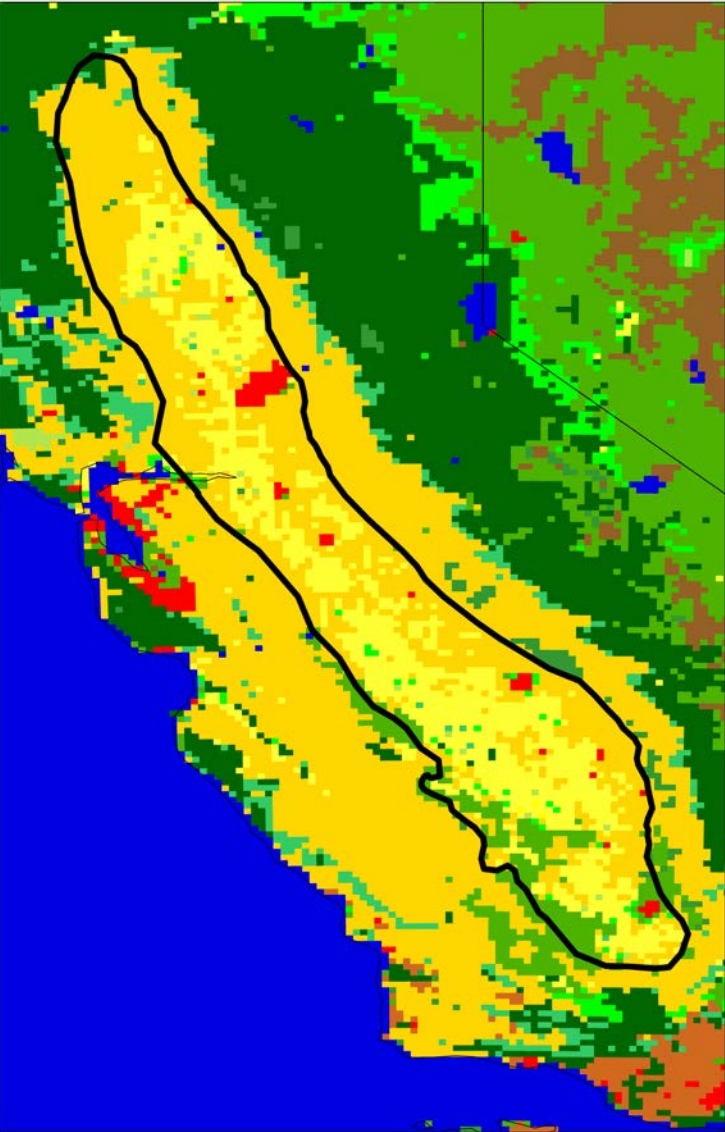
Heather A. Holmes²

Holly J. Oldroyd¹

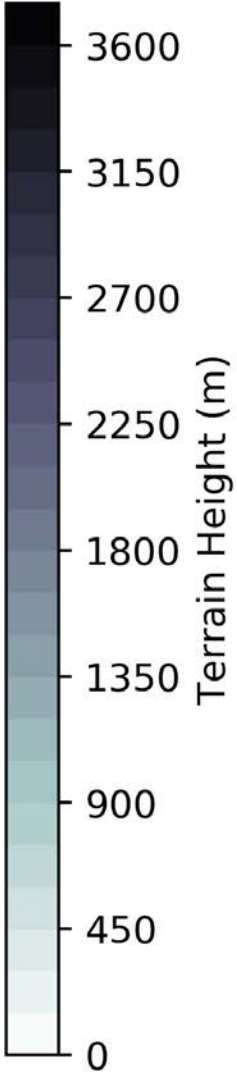
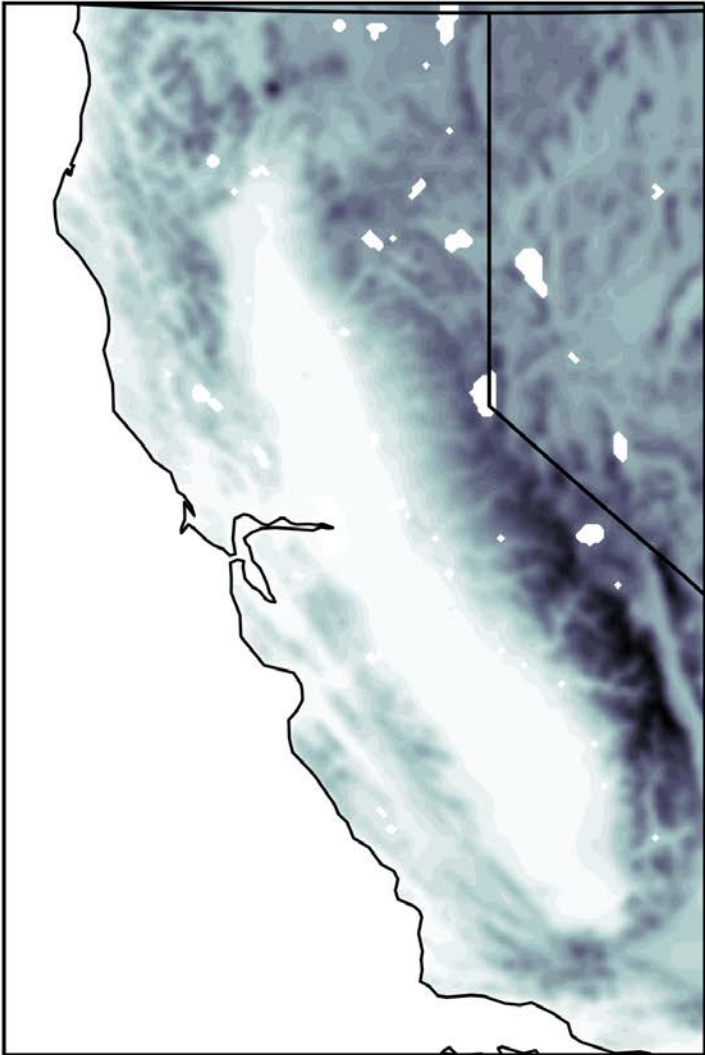
¹University of California, Davis

²University of Nevada, Reno

Challenges for Atmospheric Simulations in California



- Barren or Sparsely Vegetated
- Water Bodies
- Mixed Forest
- Evergreen Needleleaf
- Evergreen Broadleaf
- Deciduous Needleleaf Forest
- Deciduous Broadleaf Forest
- Savanna
- Mixed Shrubland/Grassland
- Shrubland
- Grassland
- Cropland/Woodland Mosaic
- Cropland/Grassland Mosaic
- Mixed Dryland/Irrigated Cropland
- Irrigated Cropland and Pasture
- Dryland Cropland and Pasture
- Urban and Built-up Land

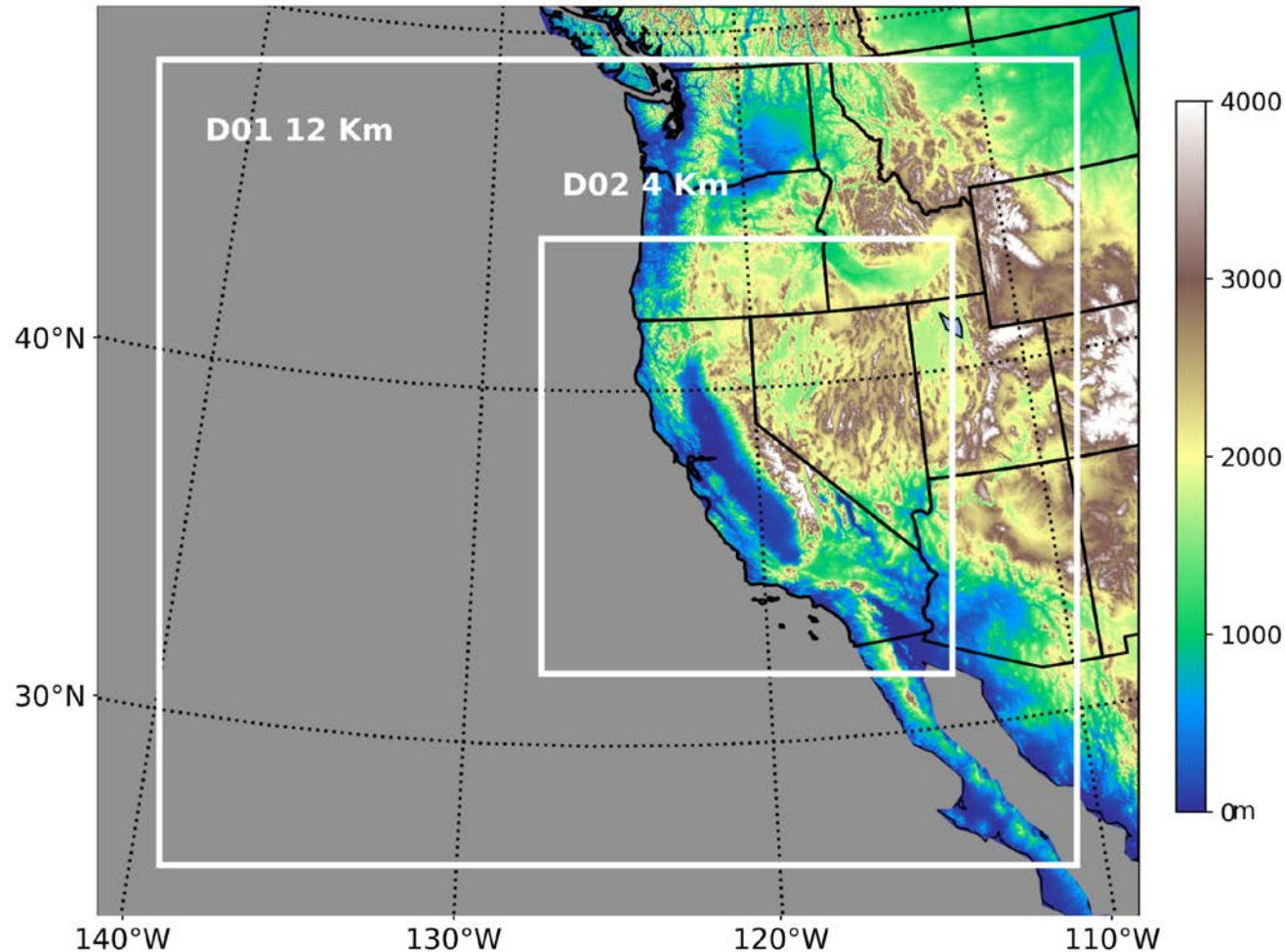




Research Questions

- ① How is the soil moisture within the Central Valley represented in Numerical Weather Prediction Models?
- ② How does soil moisture affect:
 - Near-surface Meteorology
 - Surface Turbulent Fluxes
 - Boundary Layer Height
- ③ What is the sensitivity of different soil moisture treatments in Numerical Weather Prediction models within the Central Valley?

Weather Research and Forecasting (WRF) Model V 3.8.1



Model Specifications:

- 24 July 2016 – 8 Aug 2016
 - First 24 hours spin-up
- North American Regional Reanalysis (NARR) Inputs
- USGS 28 Category Land Use
- Observational Nudging in Outer Domain

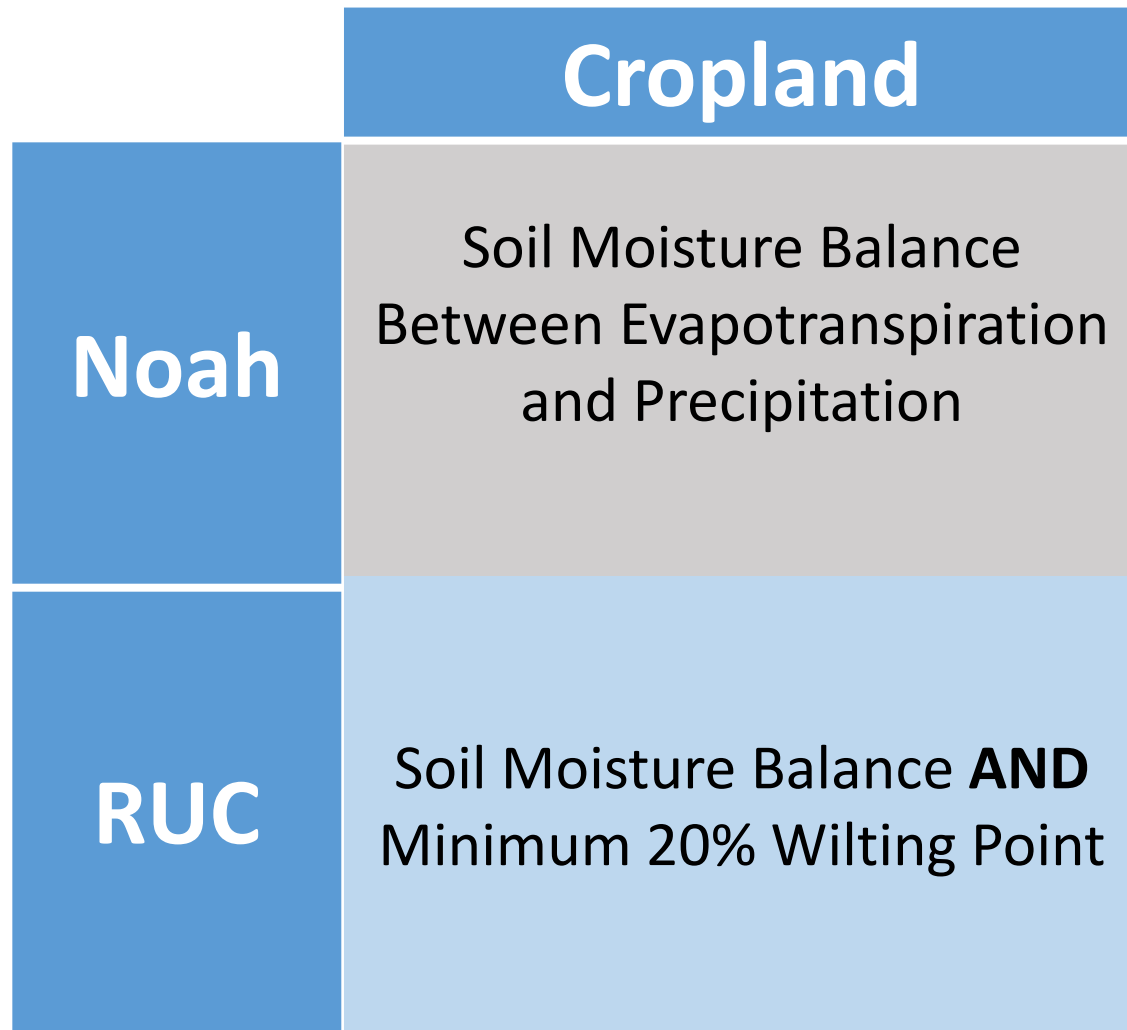
Weather Research and Forecasting (WRF) Model V 3.8.1

Run Number	1	2	3	4
PBL Scheme	YSU	YSU	MYNN	MYNN
LSM Model	RUC	Noah	RUC	Noah

Other Physics Options:

- MM5 Surface Scheme
- RRTMG Longwave
- RRTMG Shortwave
- Morrison Double Moment Microphysics
- Kain-Fritsch Cumulus

WRF Land Surface Model Treatment of Cropland



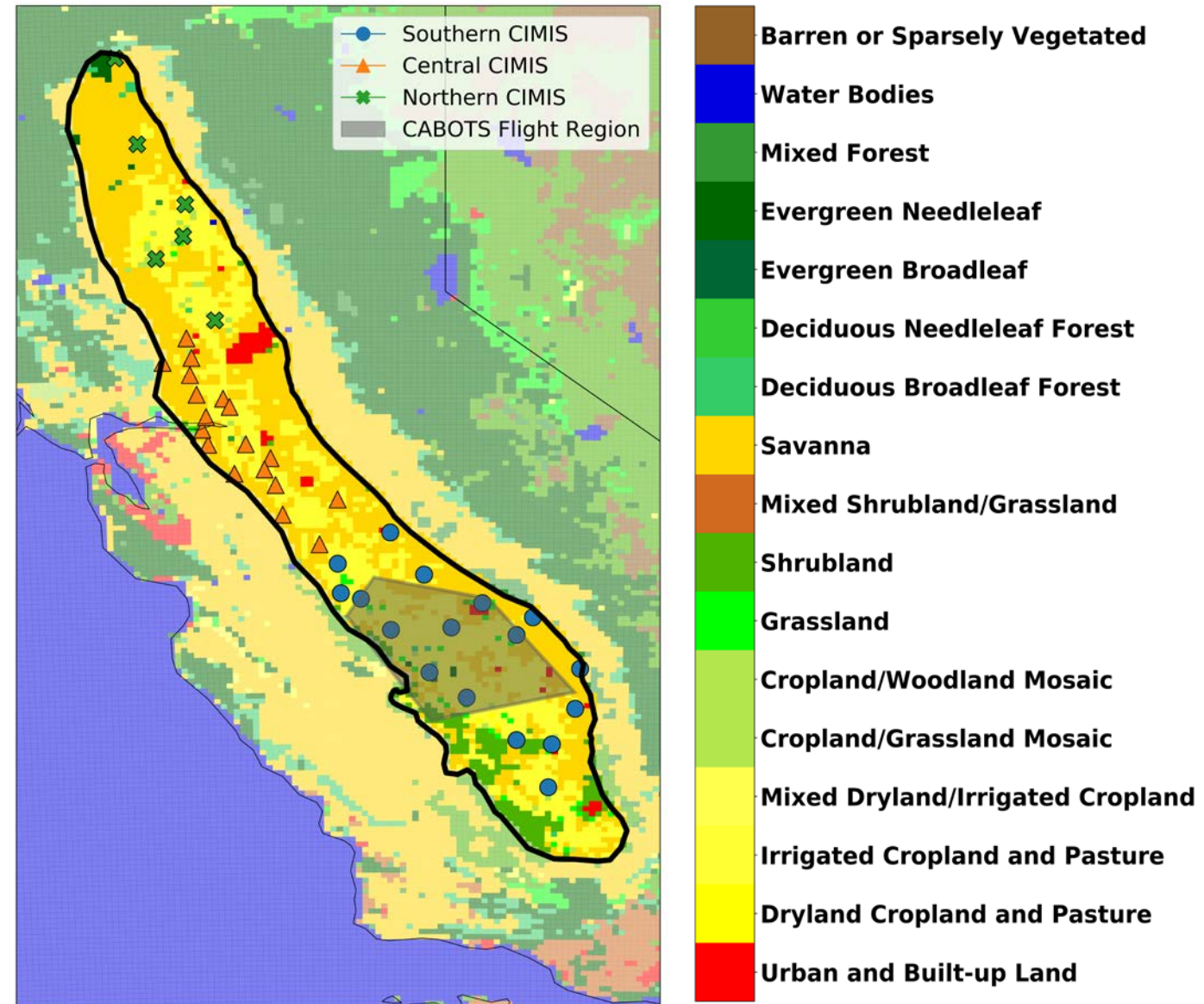
LSM Precipitation Inputs:

- Dew Point Condensation
- Drip from Canopy onto Bare Soil
- Precipitation:
 - Not expected during California CV Summertime

Observations:

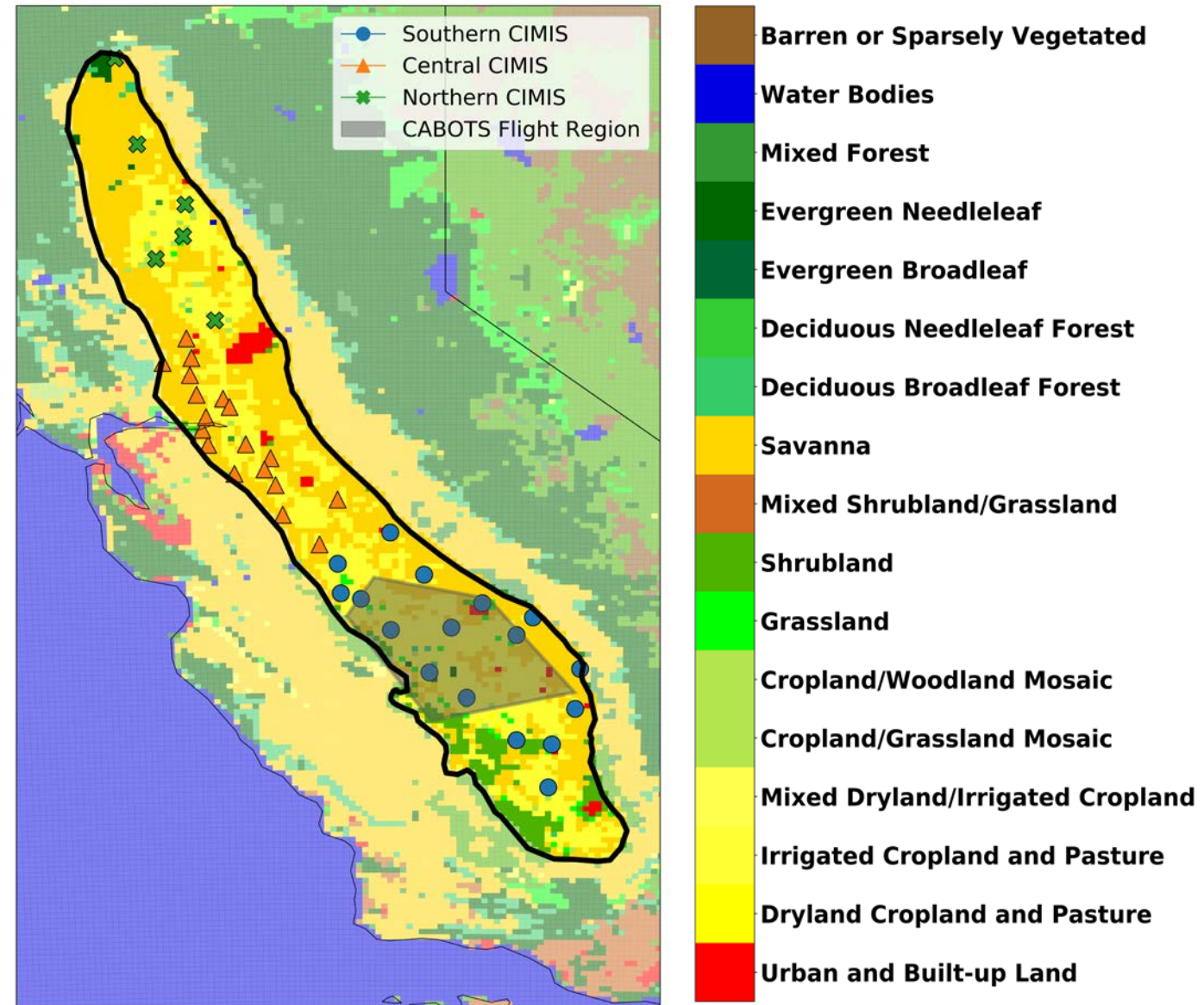
California Irrigation Management Information System (CIMIS) Stations:

- 41 Stations:
 - Hourly T_2 , RH_2 , WS_2 , Incoming Solar Radiation
- Categorized through:
 - K-means clustering based on spatial & meteorological correlations



Observations: California Baseline Ozone Transport Study Flights (CABOTS):

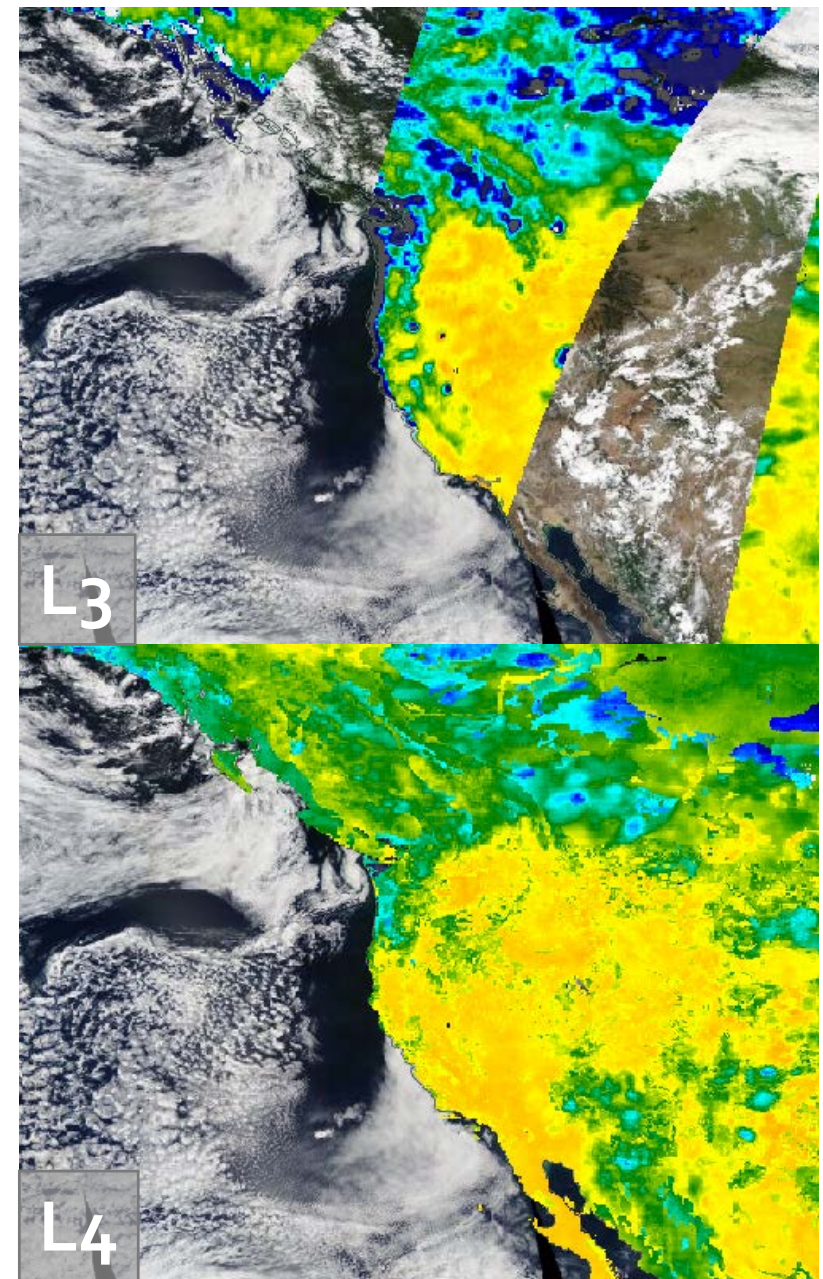
- 6 flights:
 - 26 – 29 July & 04 – 07 August 2016
- Representative afternoon (11am - 4pm) values of:
 - Planetary Boundary Layer Heights
 - Surface Latent Heat fluxes



Observations:

SMAP Satellite Returns:

- L₃ 9 Km Grid Surface Soil Moisture:
 - Daily composites of upper 5cm soil moisture returns
- L₄ 9 Km Grid Surface Soil Moisture:
 - Global model from NASA GEOS-5 Catchment Land Surface Model
- Temporally averaged over WRF simulation period (15 days) for comparison



Source: NASA Worldview SMAP

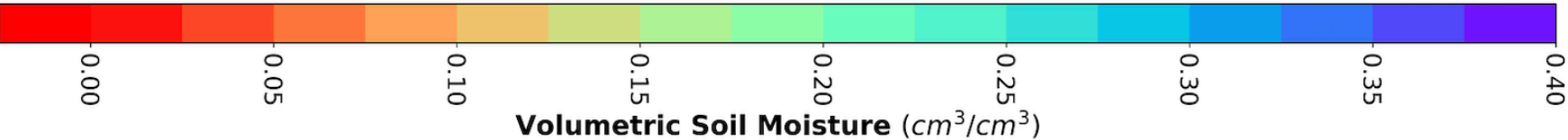
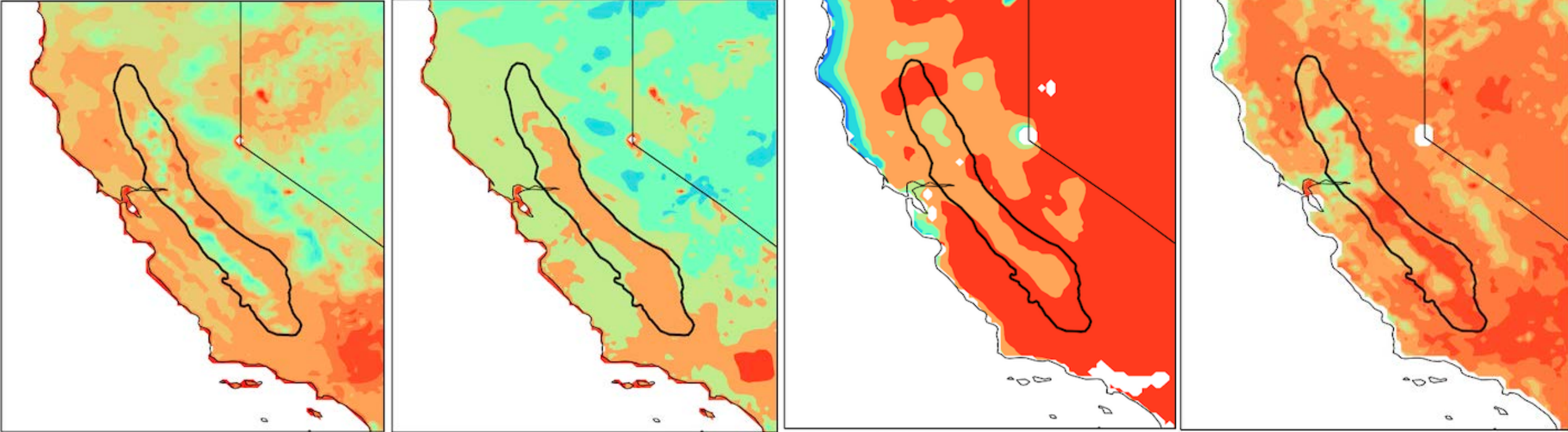
Results – Soil Moisture

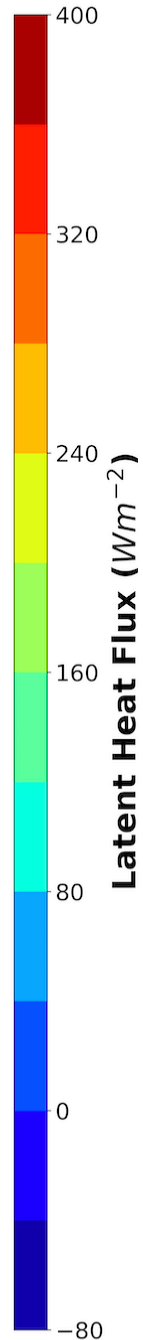
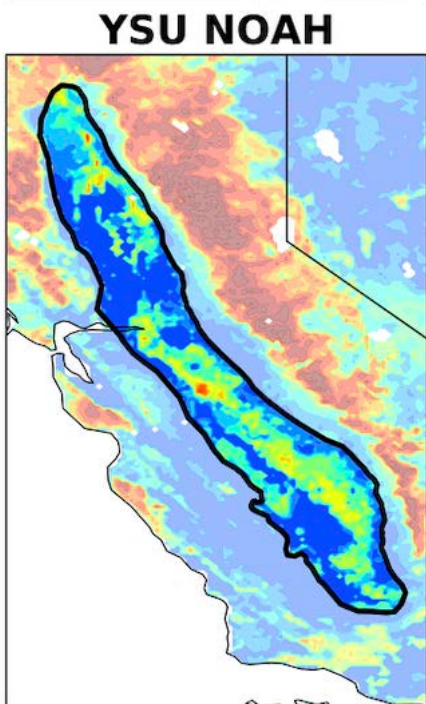
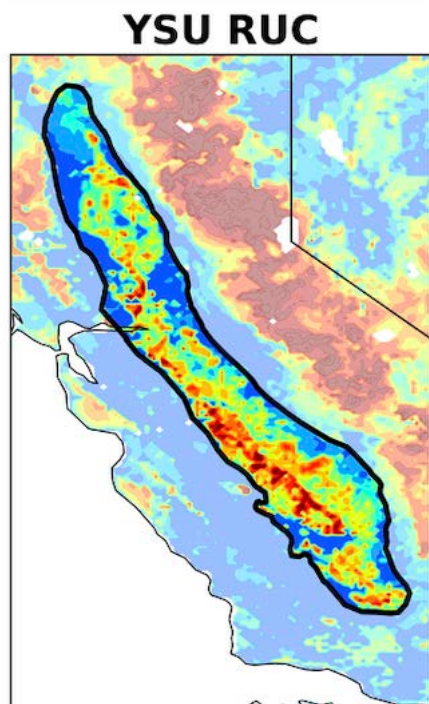
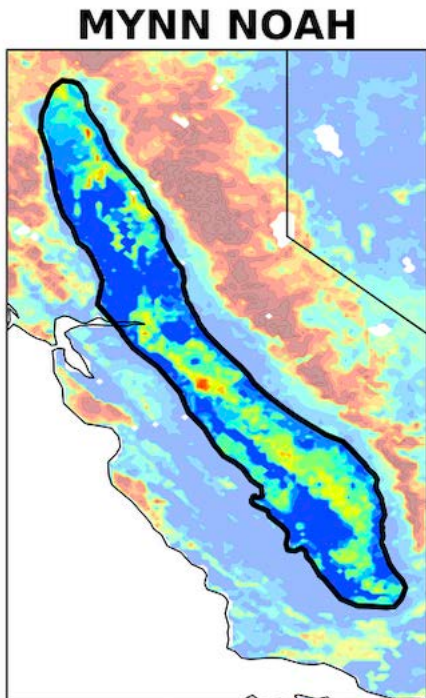
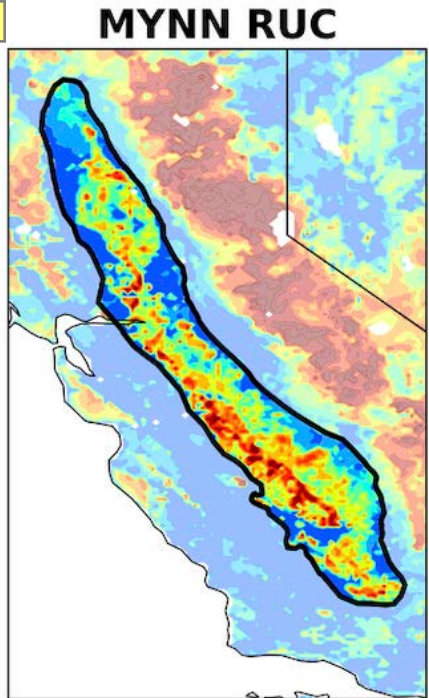
RUC

NOAH

SMAP L3

SMAP L4





	MYNN NOAH	MYNN RUC	YSU NOAH	YSU RUC	AIRPLANE OBS
2016-07-27	124.2	246.9	123.6	249.7	197.0
2016-07-28	123.9	254.4	123.7	256.2	312.0
2016-07-29	117.7	253.5	117.7	255.4	243.0
2016-08-04	103.4	211.2	103.7	207.1	94.0
2016-08-05	101.6	202.7	101.3	200.9	151.0

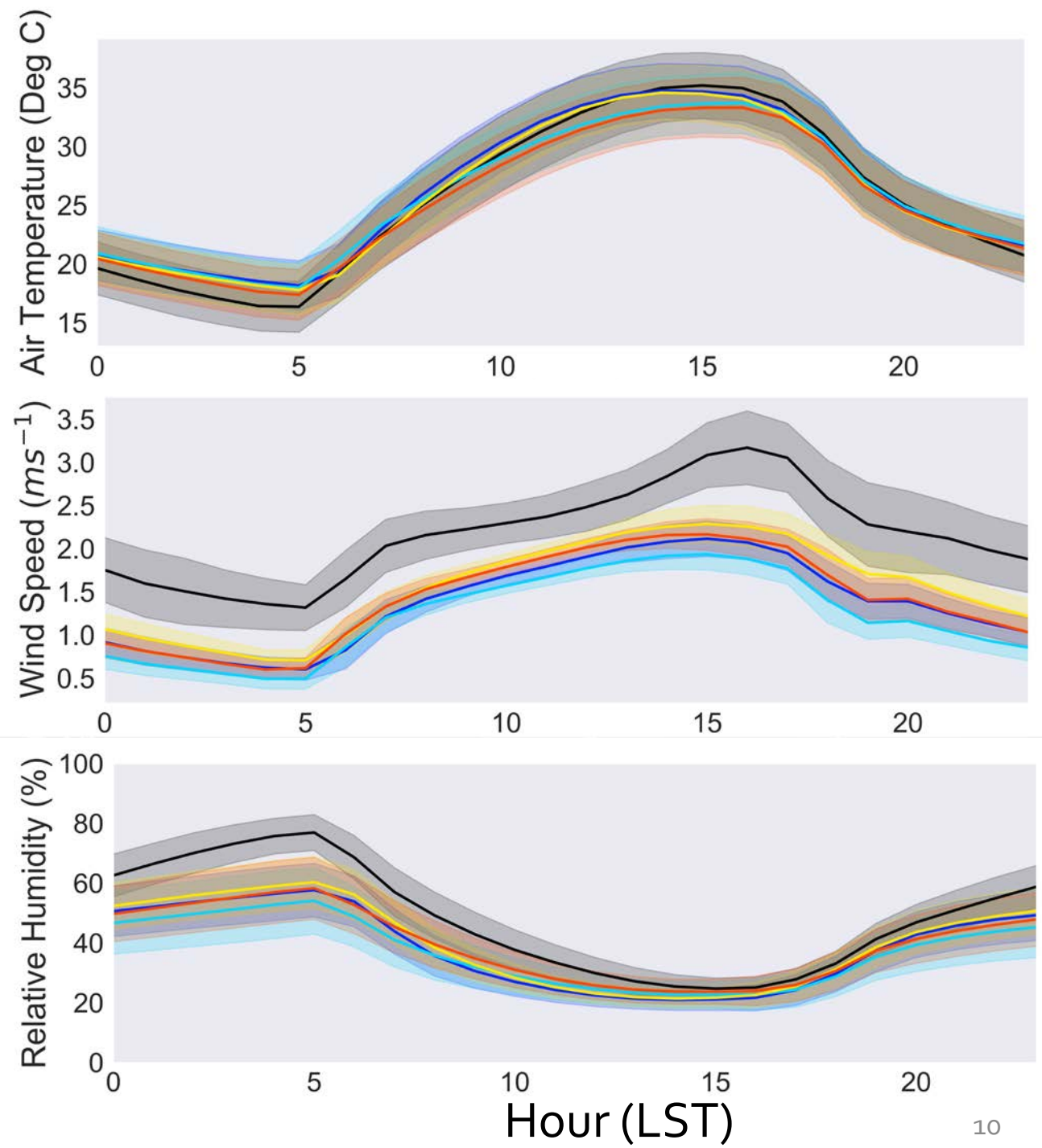
Latent Heat Flux (Wm^{-2})

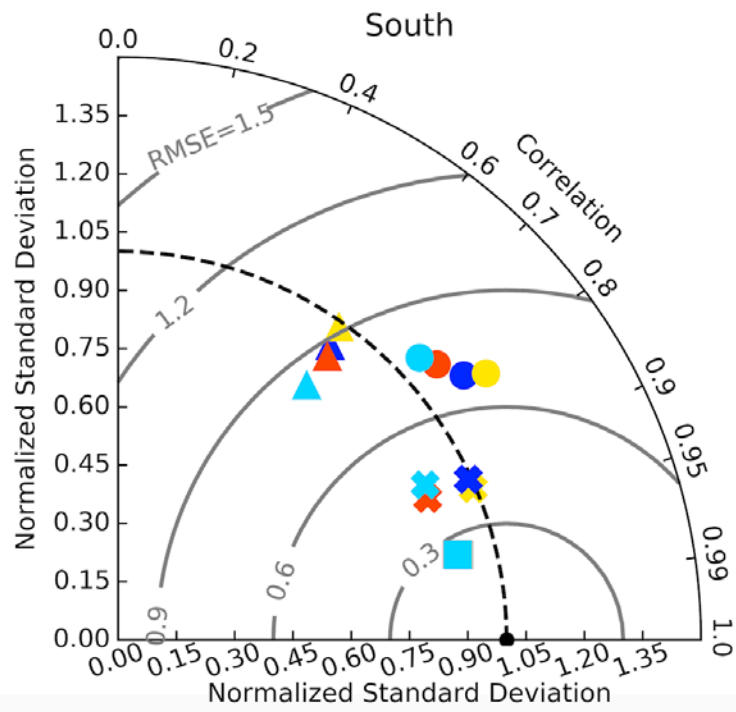
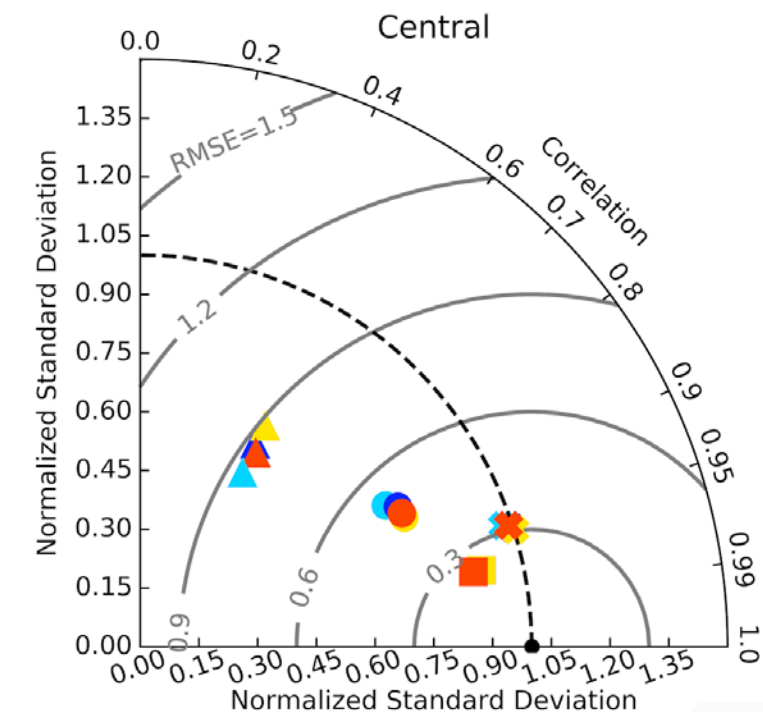
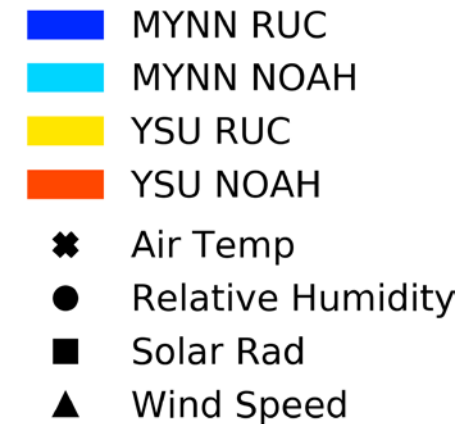
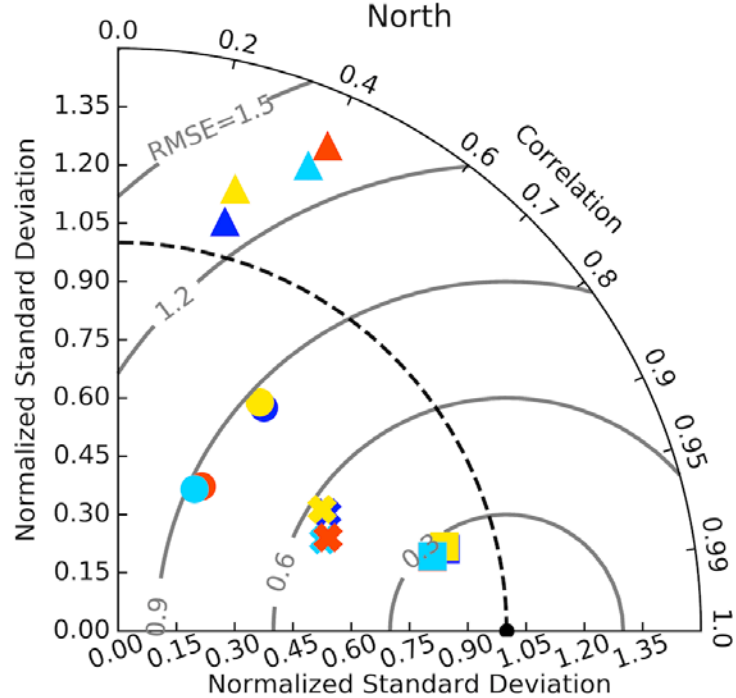
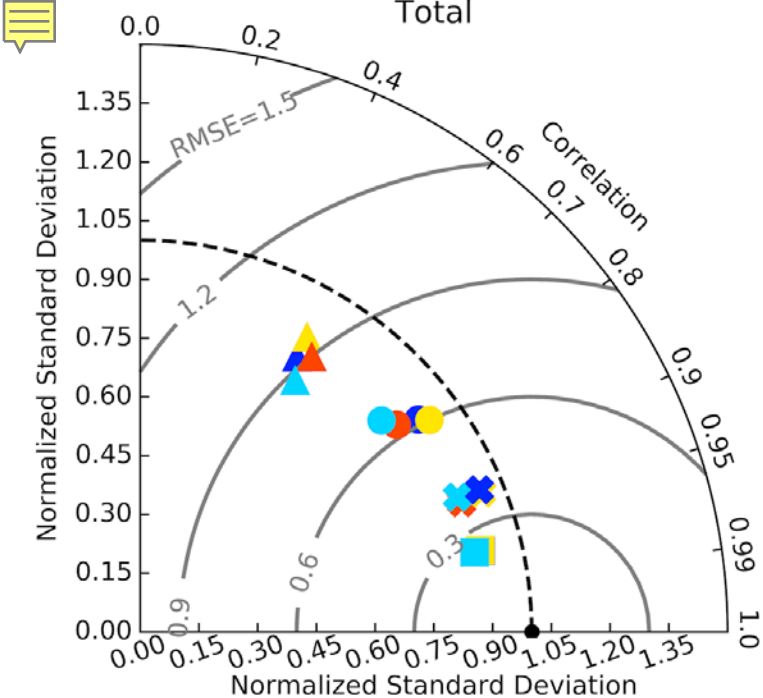
- WRF Latent Heat Flux values in table correspond to afternoon averages in flight domain
- **Increased Latent Heat Flux** in RUC model (more soil moisture), **corresponding** to observations from flights in Southern CV



Average Near Surface Diurnal Patterns in CV

- 2 Meter Air Temperature overpredicts minimums and underpredicts maximum temperatures
- 2 Meter Wind Speed is biased low in simulations
- 2 Meter Relative Humidity low throughout all simulations





- Models with **higher soil moisture (RUC)** perform slightly better in simulating of near surface meteorology
- All simulations capture standard deviation in the **South CV**, but lacks correspondence in **North & Central**

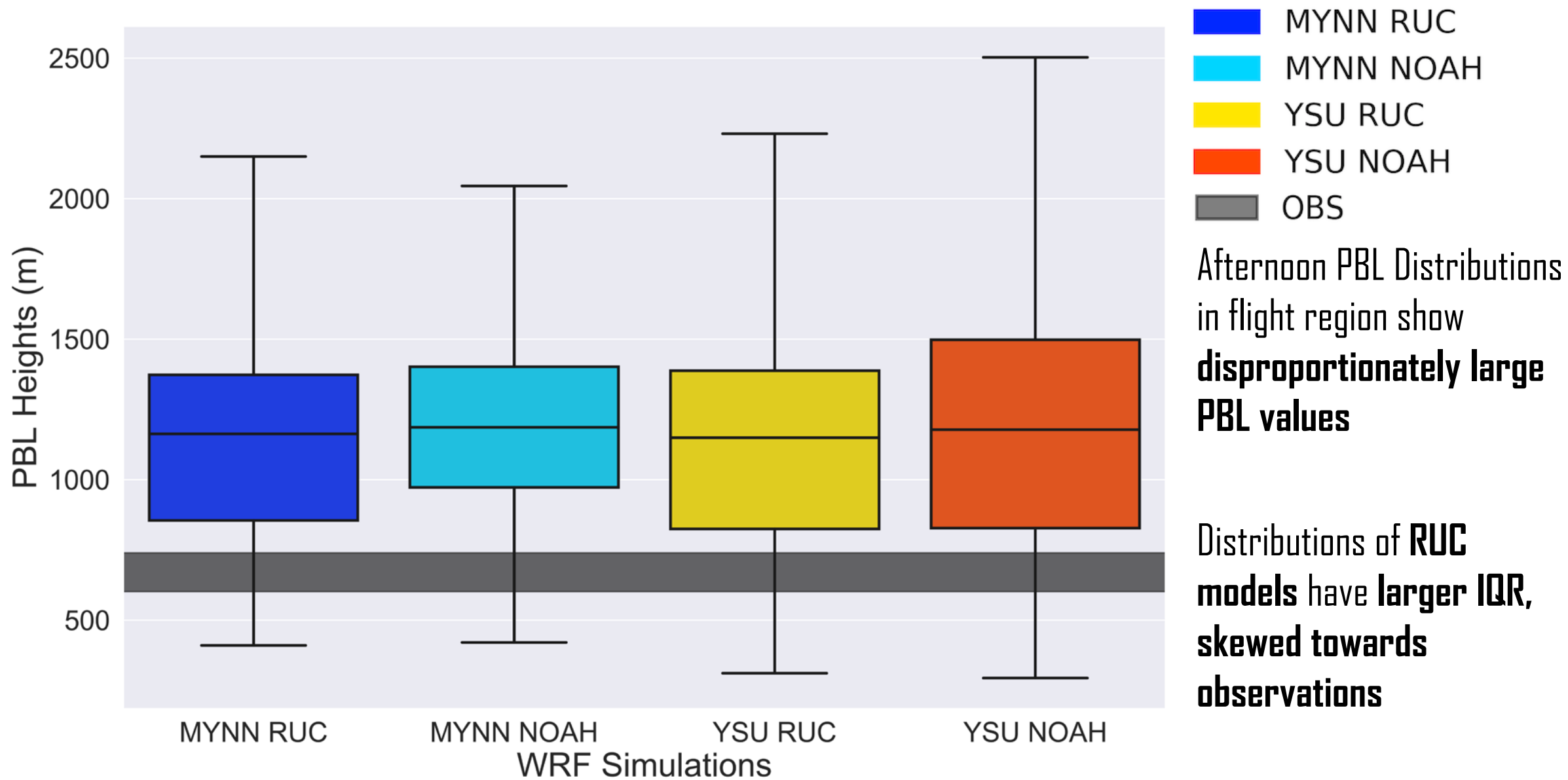
Planetary Boundary Layer Height

	MYNN NOAH	MYNN RUC	YSU NOAH	YSU RUC	AIRPLANE OBS
2016-07-27	1186	800	1245	819	541
2016-07-28	1021	771	1034	760	512
2016-07-29	1105	789	1111	782	492
2016-08-04	1285	964	1183	876	645
2016-08-05	1096	902	1054	860	511
2016-08-06	1151	1003	1126	942	547

PBL Height (m)

*WRF PBL values correspond to afternoon averages in flight domain

Planetary Boundary Layer Height





Conclusions

- ① Parameterization of soil moisture has a direct impact as a boundary condition within the CV
 - RUC attempts to account for irrigation within the CV
 - Noah uses standard balance equations

Without accounting for irrigative soil moisture:

- ②
 - Surface flux partitioning allocates more energy to sensible heat
 - Boundary Layer Heights distributions are skewed to larger values
 - Surface Meteorology is relative humidity and wind speeds are biased low in the CV

- ③ Near surface meteorology and boundary layer properties are higher sensitive to different LSM treatments of soil moisture, less so to PBL schemes in the CV



Questions?

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