Evaluating Model Physics in the Unified Forecast System (UFS): An Exercise of Using Common Community Physics Package (CCPP) Single-Column Model under the Hierarchical Testing Framework

Weiwei Li[1], Dan D'Amico[1X], Lulin Xue[1], Ligia Bernardet[2], Grant Firl[1], Judy Henderson[2], Jimy Dudhia[1], Michael Ek[1], Michelle Harrold[1], and Xia Sun[2,3]

1. National Center for Atmospheric Research (NCAR), and Developmental Testbed Center (DTC)
2. NOAA/Global Systems Laboratory (GSL), and Developmental Testbed Center (DTC)
3. University of Colorado/Cooperative Institute for Research in Environmental Sciences (CIRES), NOAA/Global Systems Laboratory (GSL), and Developmental Testbed Center (DTC)

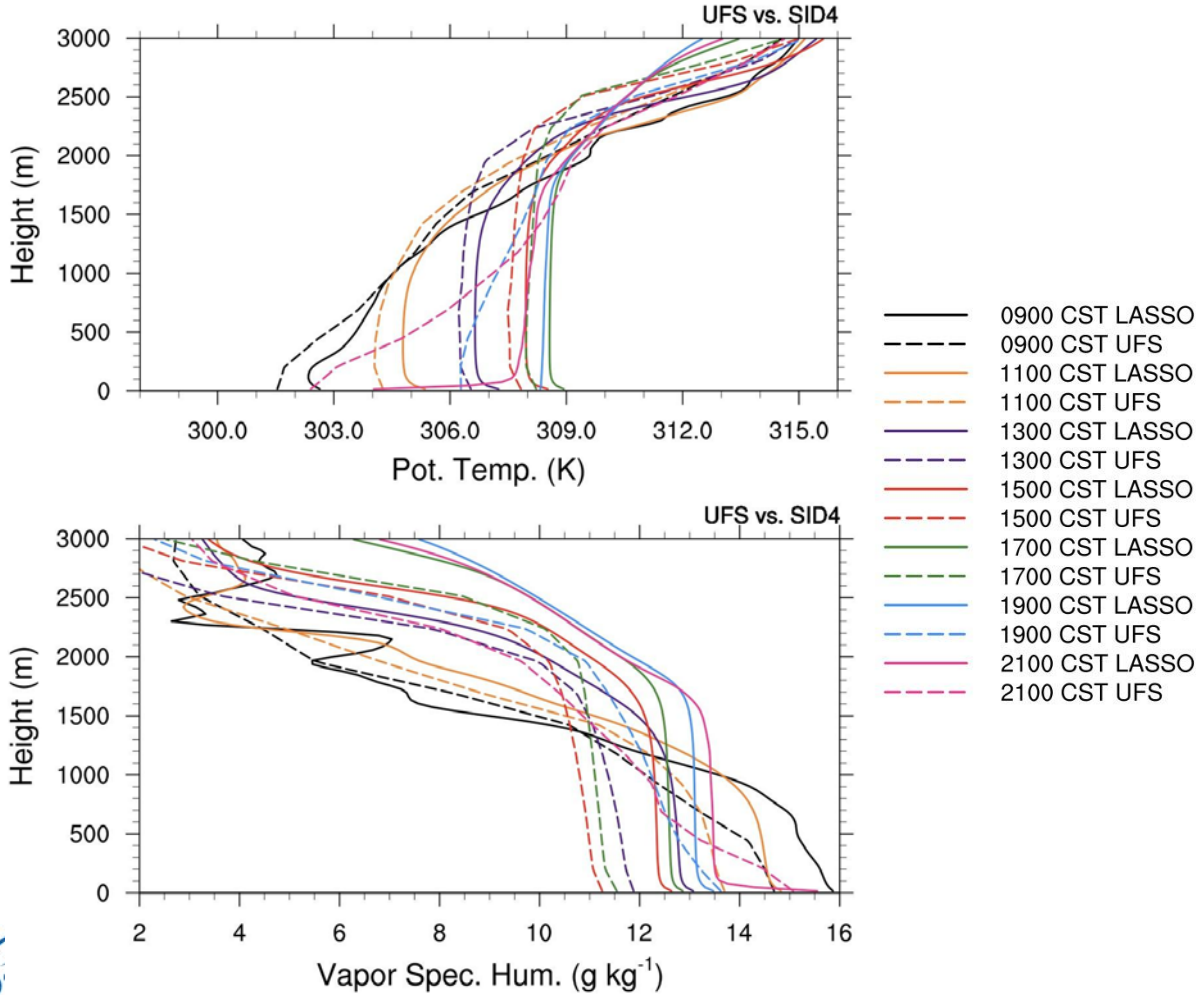
X. Presenting Author (damico@ucar.edu)

UFS with LASSO and SCM

- UFS
  - 11 June 2016 – C768 (~13 km) with 64 vertical levels
  - UFS Medium Range Weather Application
- LASSO
  - Large Eddy Simulations over the ARM Southern Great Plains site near Lamont, OK
  - 11 June 2016 selected because of high total cloud skill score
  - 226 vertical levels
  - LES simulations with a super site, used as “truth” in our investigation
- CCPP SCM
  - Input for LASSO used to drive SCM experiments (MSDA atmosphere, VARANAL surface)
  - 64 vertical levels
- Bias identified with SCM can mainly be attributed to GFSv16beta suite of physical parameterizations

scale-aware (sa)	**LASSO (WRF LES)**	**UFS w/ GFSv16beta**	**SCM w/ GFSv16beta (CTRL)**	**SCM w/ GFSv16beta (TEST1)**	**SCM w/ GFSv16beta (TEST2)**
Radiation	RRTMG (sw+lw)	RRTMG (sw+lw)	RRTMG (sw+lw)	RRTMG (sw+lw)	RRTMG (sw+lw)
Microphysics	Thompson	GFDL Cloud MP	GFDL Cloud MP	GFDL Cloud MP	GFDL Cloud MP
PBL or Turbulence	1.5-order turbulent TKE approach	TKE-based Moist EDMF + free atmospheric turbulence scheme (sa)	TKE-based Moist EDMF + free atmospheric turbulence scheme (sa)	TKE-based Moist EDMF + free atmospheric turbulence scheme (sa)	MYNN in CCPPv4
Shallow convection	N/A	SAS Mass-Flux	SAS Mass-Flux	SAS Mass-Flux	SAS Mass-Flux
Deep convection	N/A	SAS Mass-Flux	SAS Mass-Flux	SAS Mass-Flux	SAS Mass-Flux
Land surface model	Surface fluxes prescribed with VARANAL	Noah LSM	Surface heat fluxes prescribed with UFS	Surface heat fluxes prescribed with VARANAL	Surface heat fluxes prescribed with VARANAL
Large-scale forcing	MSDA	N/A	MSDA	MSDA	MSDA

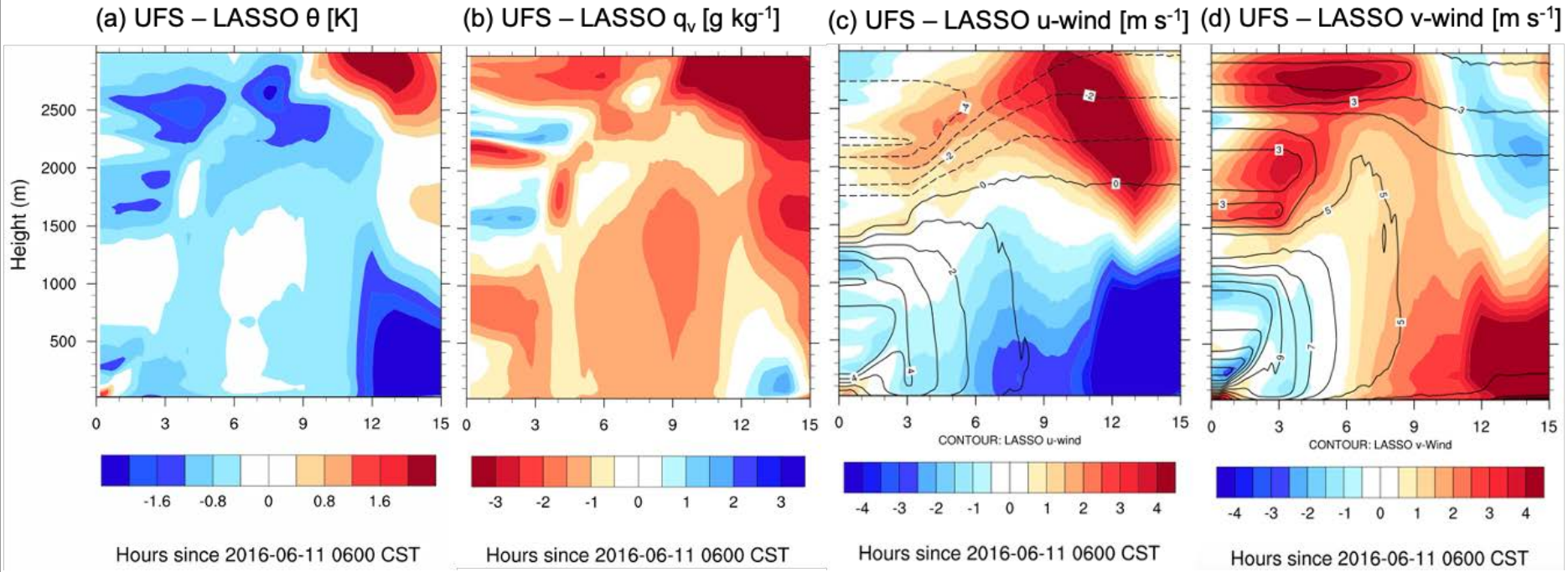
Part I. Evaluating UFS against LASSO



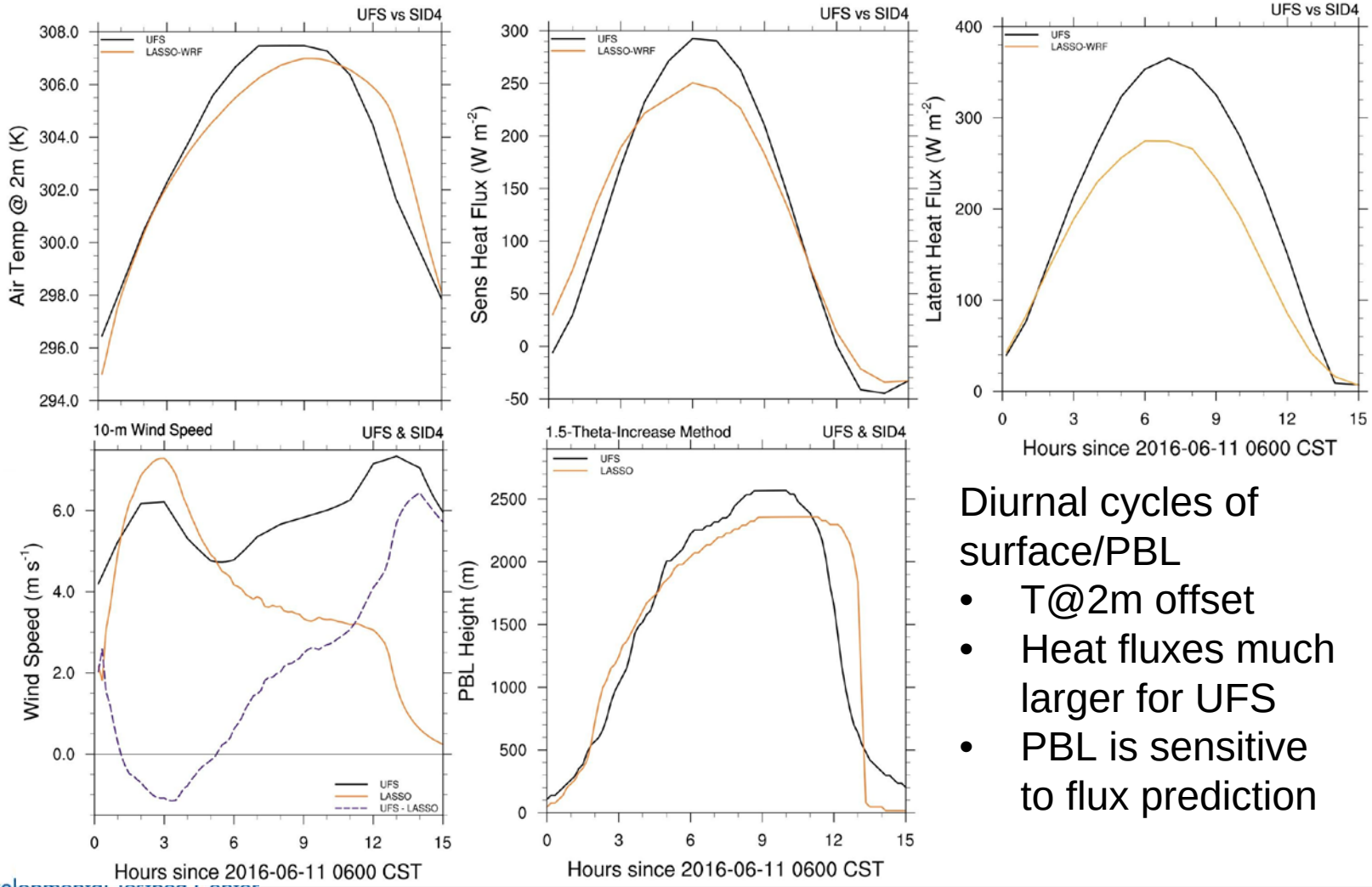
Vertical profiles of PBL thermodynamics

- UFS PBL is notably cooler and drier throughout the simulation

Biases in UFS (vs LASSO)



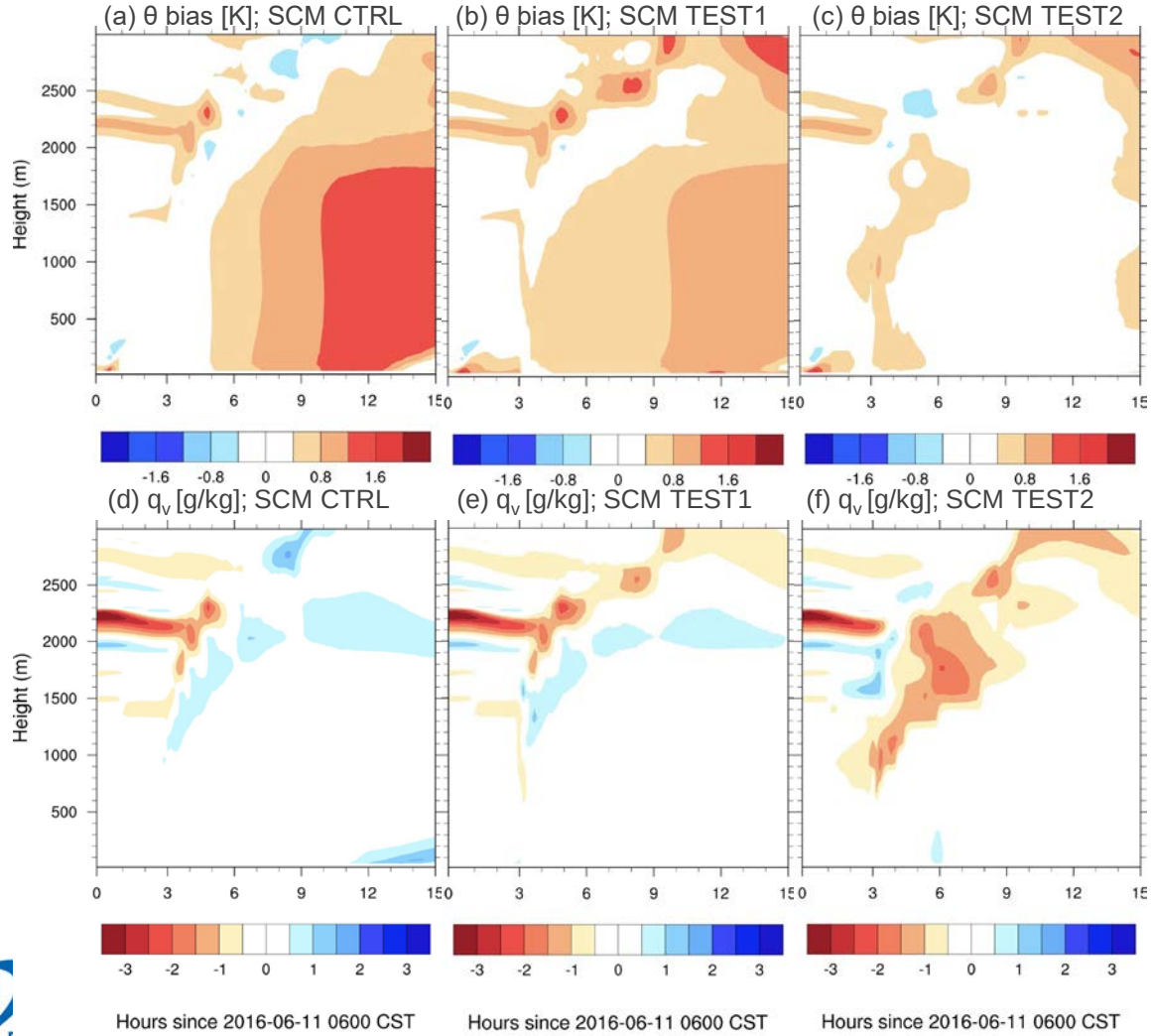
- Noted cold and dry bias
- Light LASSO winds, particularly near the end of the simulation
- Strong UFS westerlies aloft



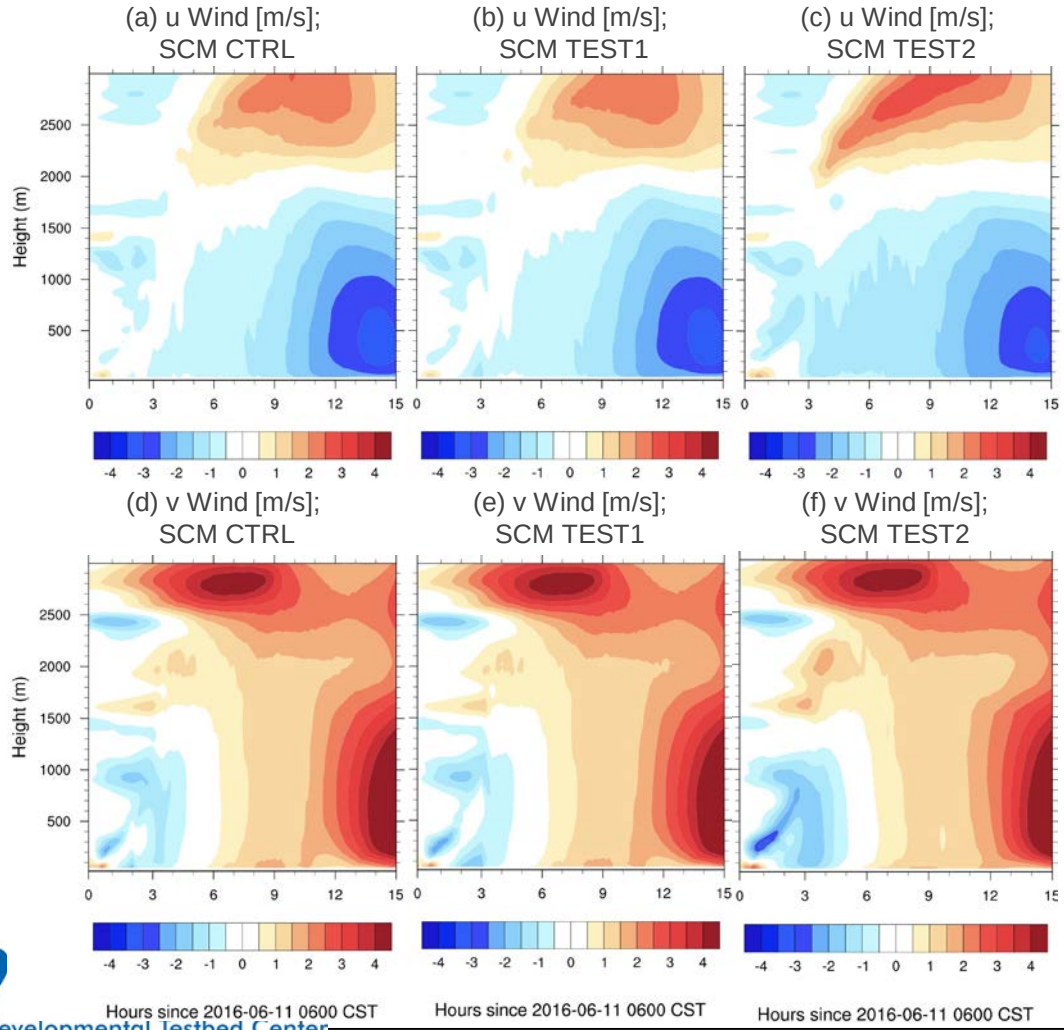
Diurnal cycles of surface/PBL

- T@2m offset
- Heat fluxes much larger for UFS
- PBL is sensitive to flux prediction

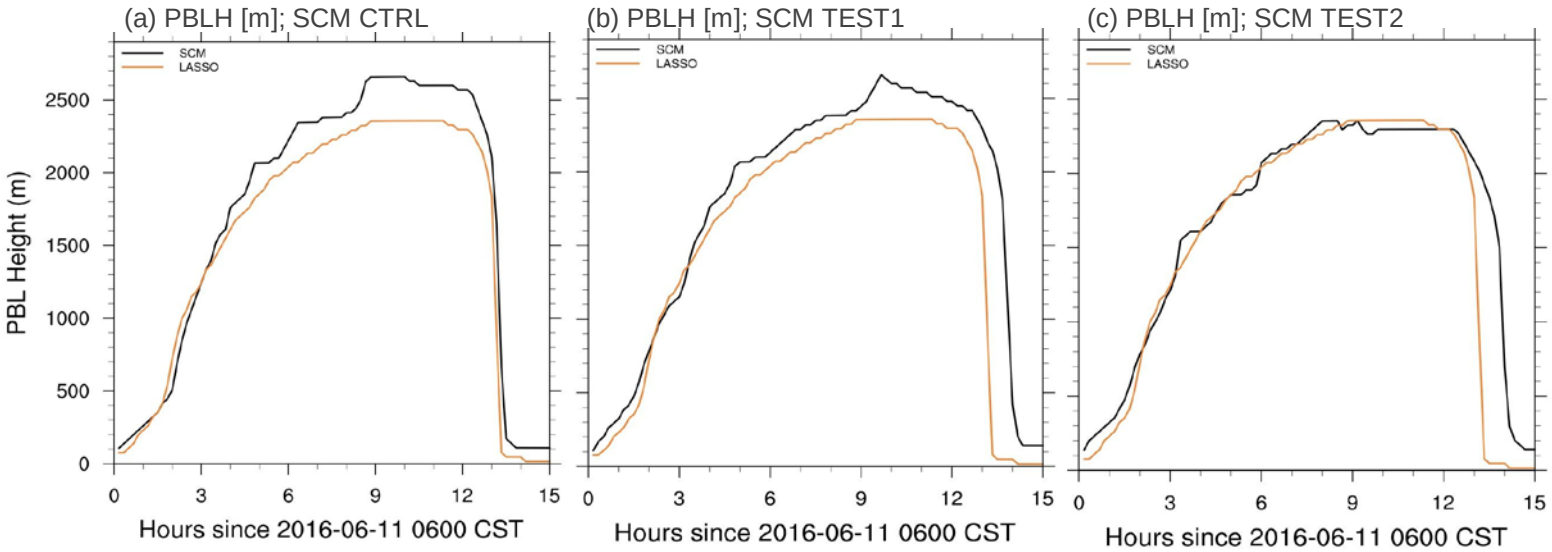
Part II. SCM Tests vs. LASSO



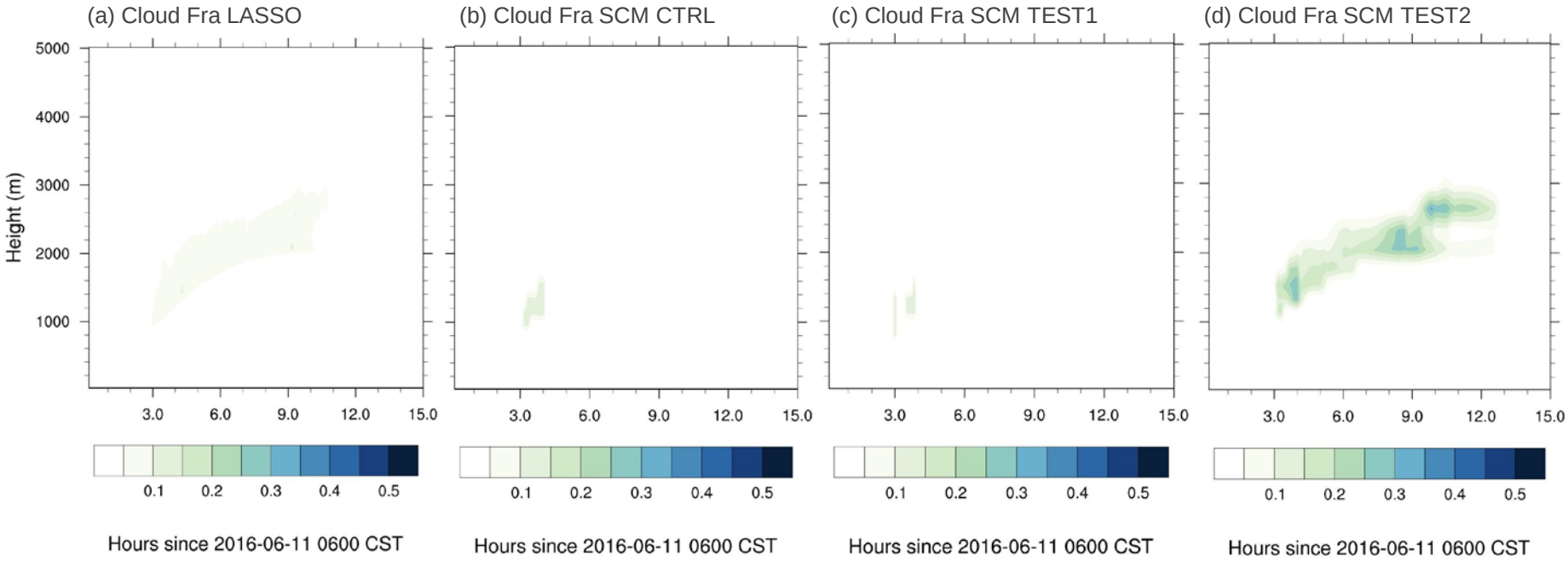
- Observation -constrained sfc fluxes help alleviate the warm bias within the PBL, while overpredicts dry bias near the PBL tops
- MYNN largely reduces the warm bias, however, enhances the dry bias near the PBL top (above 1000 m during day time)



- Overmixing is a distinct issue in the later hours for S-N winds (v-component) for all surface forcings
- Overmixing of S -N and W-E wind components is a presence near the top of and above the PBL, particularly around midday



- CTRL and TEST1 both feature deeper afternoon PBLs
- TEST2 (w/MYNN PBL scheme) simulates a fairly similar PBL to LASSO



MYNN has a somewhat better handle on clouds, although all SCM experiments struggle with clouds

Summary

Biases in UFS: cold and dry PBL, and greater wind speed within lower PBL in the afternoon and evening

SCM helps explain:

1. Salient cold and dry biases in the GFSv16beta mostly due to the large -scale advection, which may shed light into the longstanding cold bias issue over the CONUS
2. In spite of the bias due to LS advection, GFSv16beta physics suite actually generates a warmer PBL , which results from both the land surface and PBL schemes
3. GFSv16beta also has a lack of PBL clouds, which implies PBL and radiation schemes are not communicating well. SAS convection could also play a role.