# Model Meets Reality (MMR): A Cross-Comparison of DP-SCREAM and WRF Against ARM Observations

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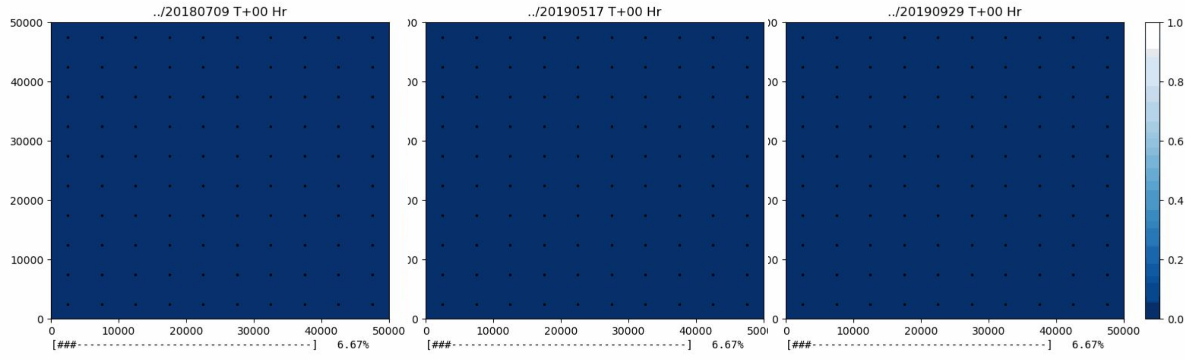


# Introduction

## ➢ Overview

- A comparison of DP-SCREAM and WRF models against ARM observations to evaluate low-cloud representation and the evolution of the Boundary Layer at SGP site C1

## ➢ Models & Observations

- *DP-SCREAM (3km res) :* global cloud resolving model
- *WRF/LASSO (100m res):* high-resolution LES framework
- *ARM Observations:* ARSCL and Radiosonde Equipment

## ➢ Cases

- *Case 1:* July 9, 2018
- *Case 2:* May 17, 2019
- *Case 3:* September 29, 2019

## ➢ Goal

- Which model compares better to ARM User Facility observations?
- How do differences in model resolution and parametrization impact overall low-cloud representation?

# Evolution of Potential Temperature Height Profiles Over Each Case

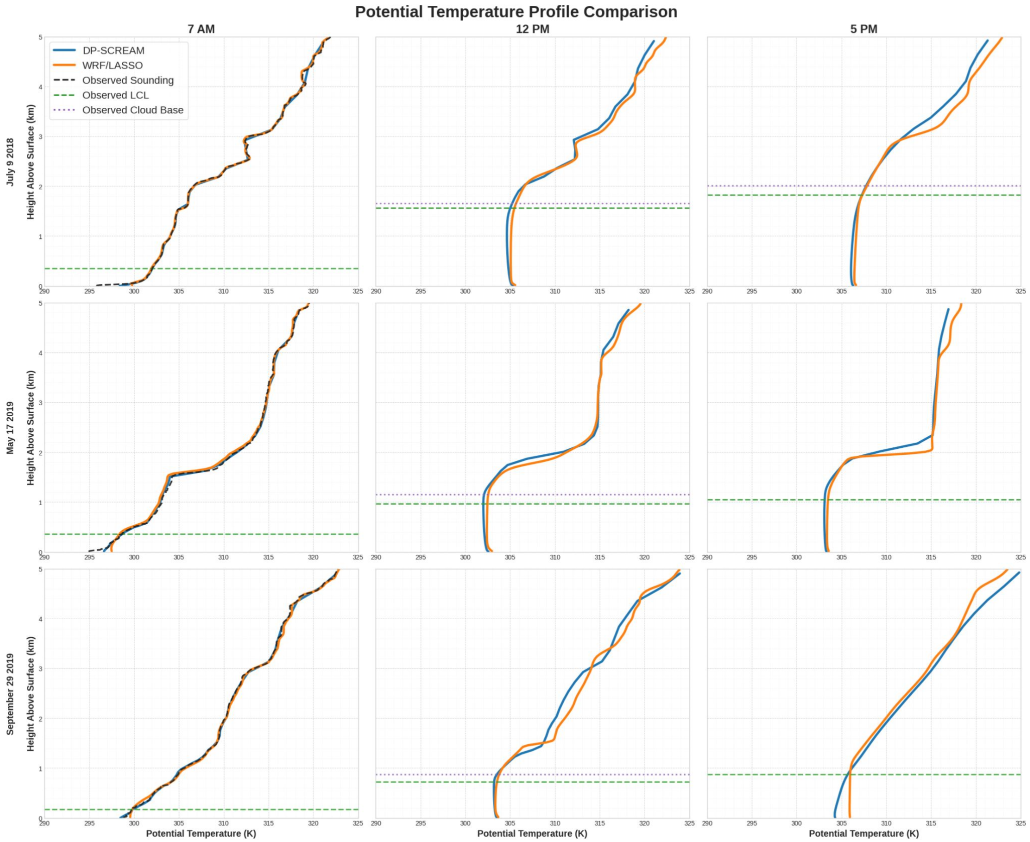
- Afternoon divergence highlights sensitivity to turbulence and mixing physics

- May case has strong afternoon mixing

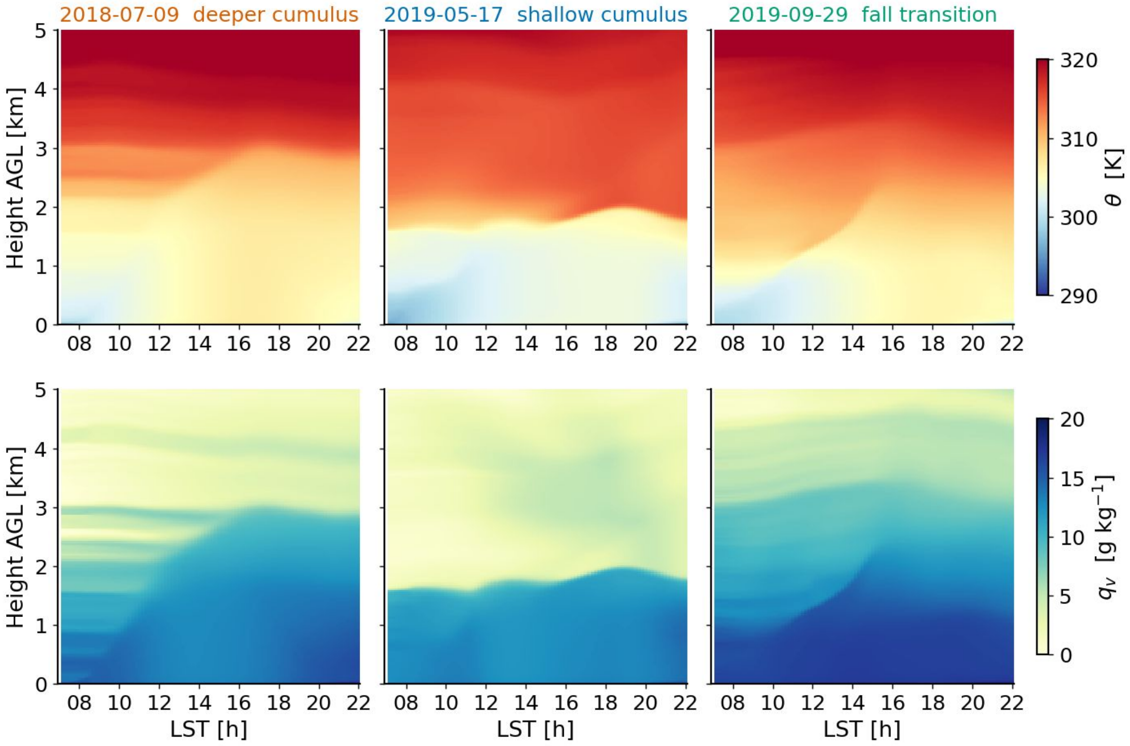
- LCL & cloud base connect to low-cloud formation (in relation to thermal cond.)
- BL evo influences formation timing and height

- Results can show how model physics impacts cloud realism

- These small-scale processes can influence larger biases

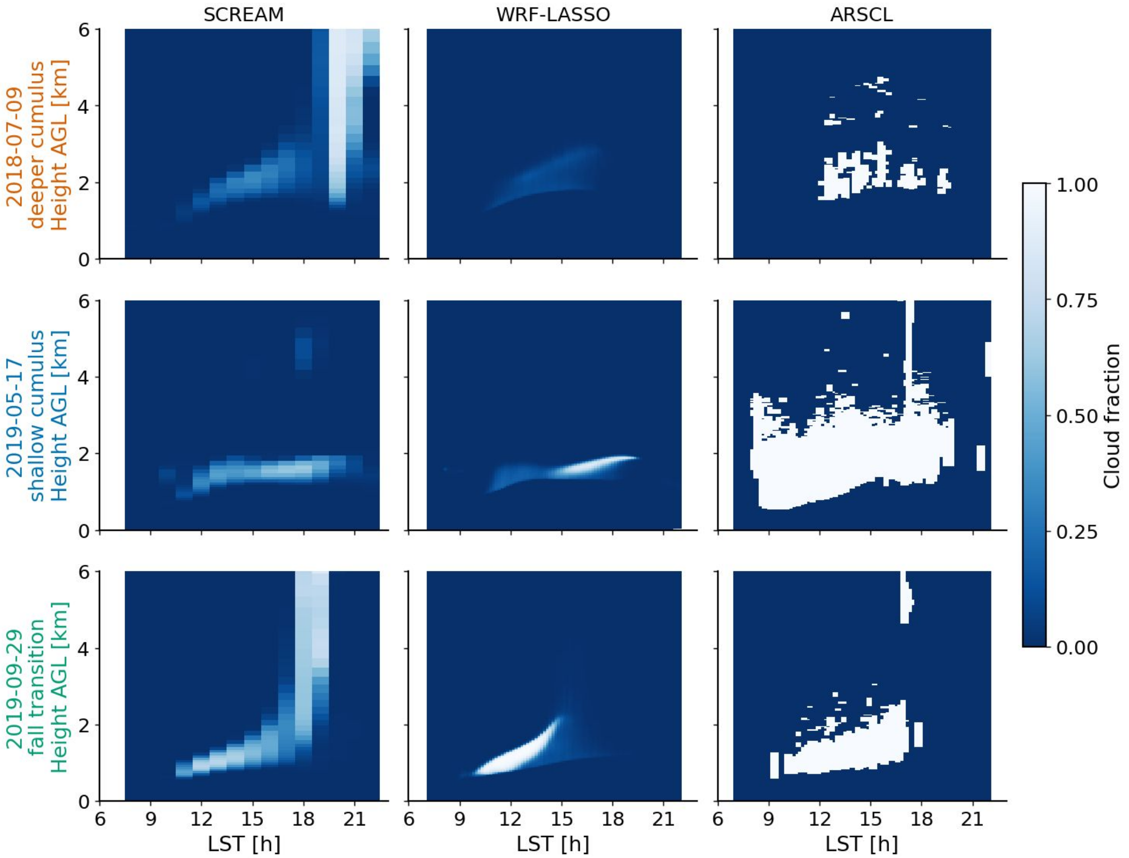


# Boundary-Layer Thermodynamic Structure During Low-Cloud Evolution (WRF)

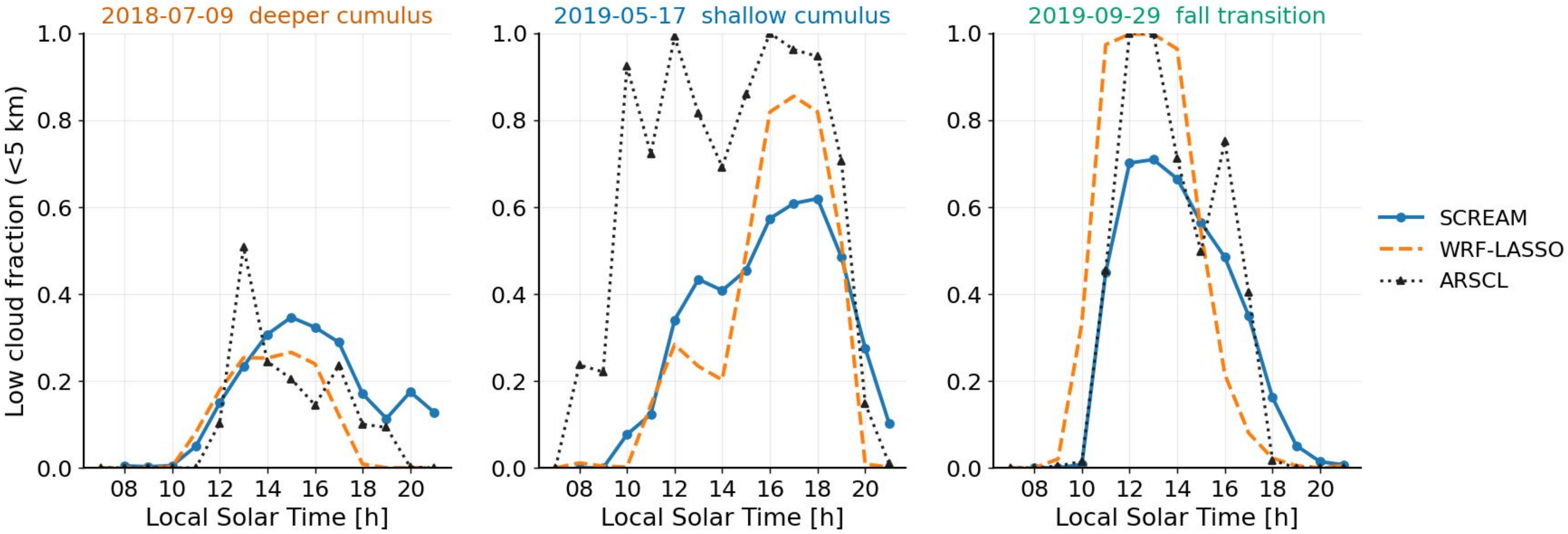



- Moisture is concentrated below ~2 km within the shallow-cloud layer
- Potential temperature increases with height, indicating stable stratification above the boundary layer
- RH/LCL potentially control the low-cloud prediction bias

# Cloud Fraction (all cases) SCREAM/WRF/ARSCL

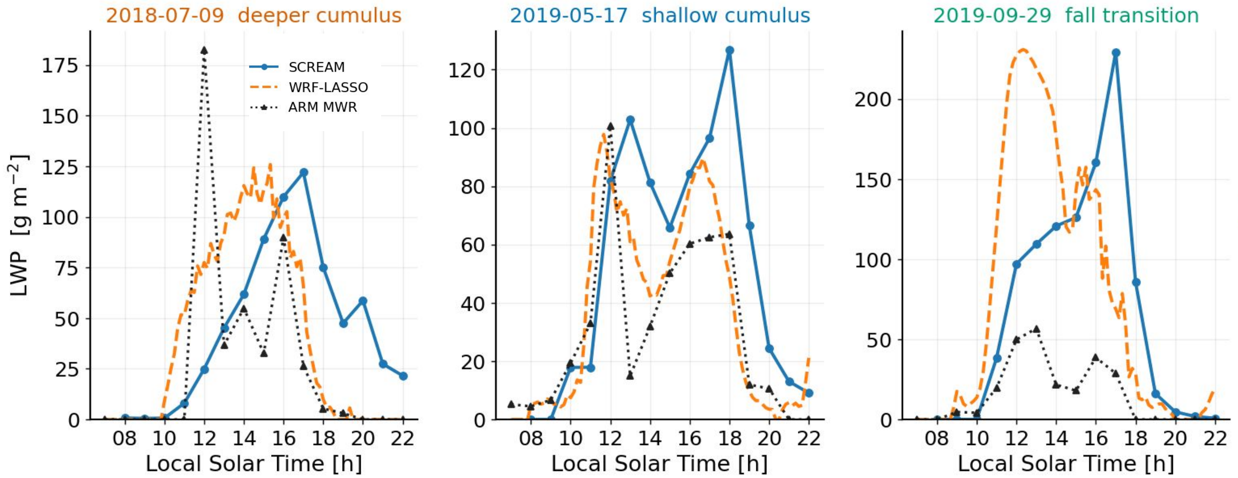


# Model and Observation Comparison




Models behaved differently on each day.

# Liquid Water Path (LWP)



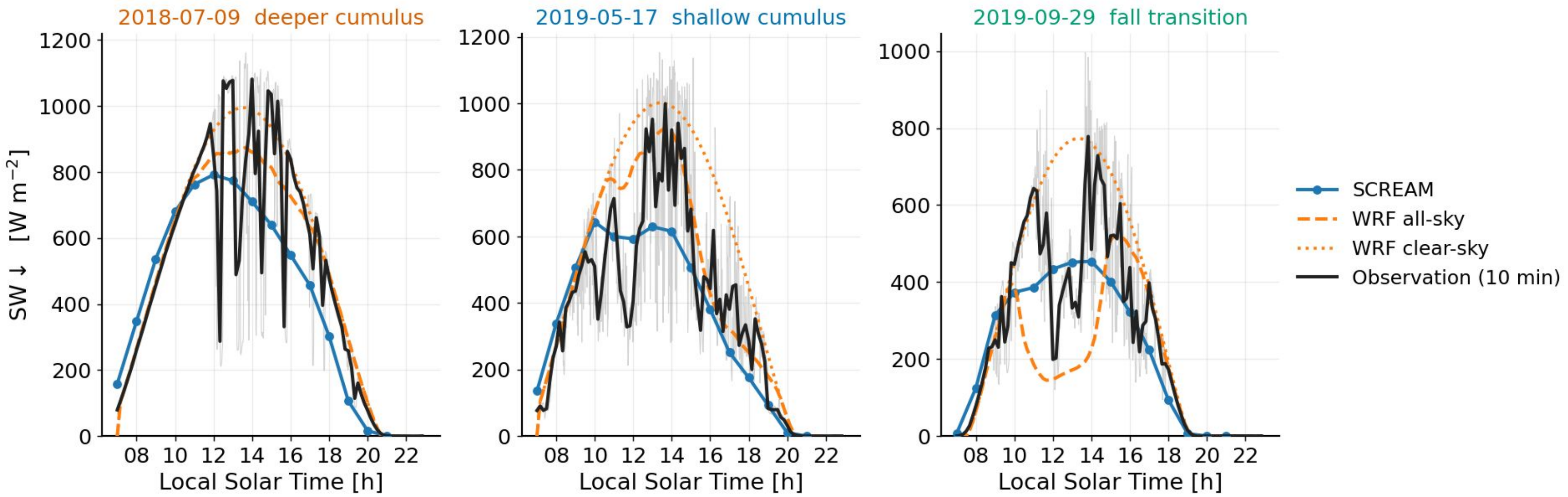

- **DP-SCREAM** tends to produce more persistent afternoon cloud liquid water.
- **LASSO** often initiates clouds earlier.
- Both models generally **overestimate** LWP and miss some of the strong short-timescale variability.

**Suggest ongoing challenges in representing boundary-layer moisture evolution, entrainment, and cloud lifecycle processes [1-4].**

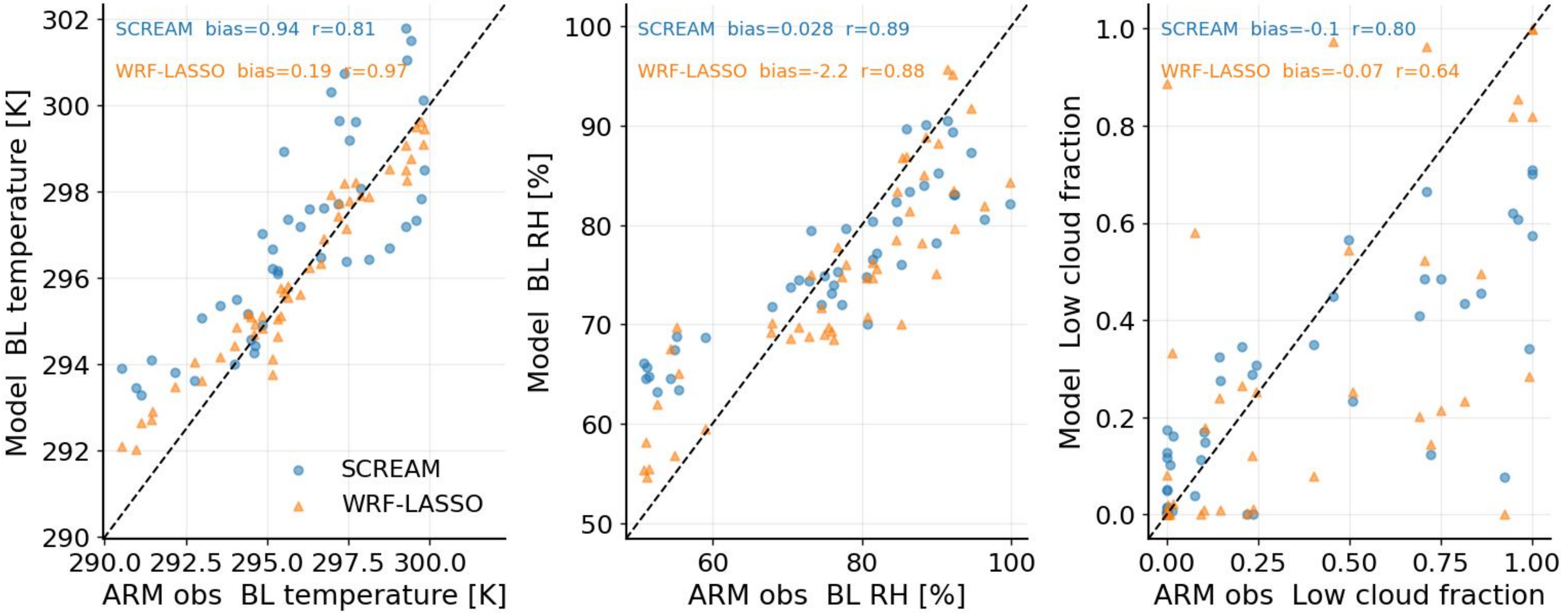

1. Qiu et al. **2026**, Understanding the causes of satellite–model discrepancies in aerosol–cloud interactions using near-LES simulations of marine boundary layer clouds. *Atmospheric Chemistry and Physics*, *26*(3), 1769-1794.
2. Peng et al. **2024**, Improvingstratocumulus cloud amounts in a 200-m resolution multi-scale modeling framework through tuning of its interior physics. Journal of Advances in Modeling Earth Systems, 16, e2023MS003632
3. Zhang et al. **2023**, Surface-atmosphere decoupling prolongs cloud lifetime under warm advection due to reduced entrainment drying. Geophysical Research Letters, 50, e2022GL101663
4. Del Genio **2012,** Representing the sensitivity of convective cloud systems to tropospheric humidity in general circulation models. *Surveys in Geophysics*, *33*(3), 637-656.

# Downwelling Shortwave Radiation

During partial cloud fraction times, both DP-SCREAM and WRF miss the highest observed values due to their 1D radiative transfer schemes.

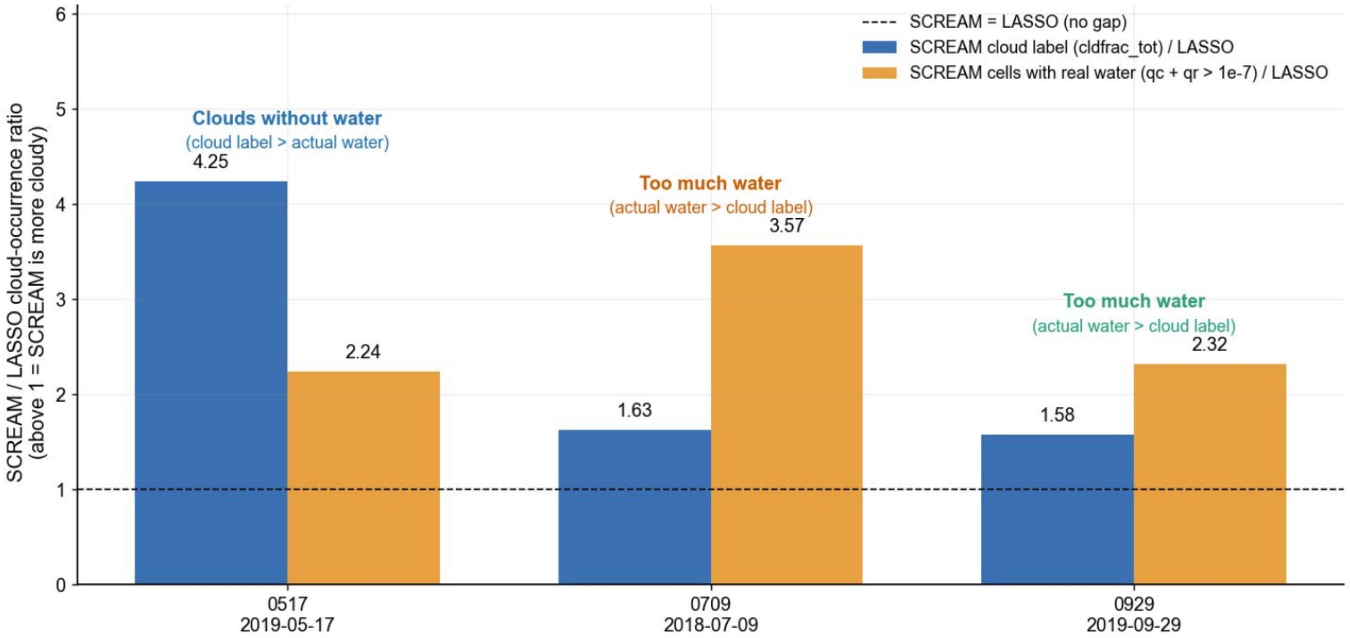


# Scatter Plot of DP-SCREAM / LASSO Simulation and Observation



# Possible Explanation for Higher Cloud Fraction in SCREAM

For full-column, SCREAM is cloudier all three days but for different reasons

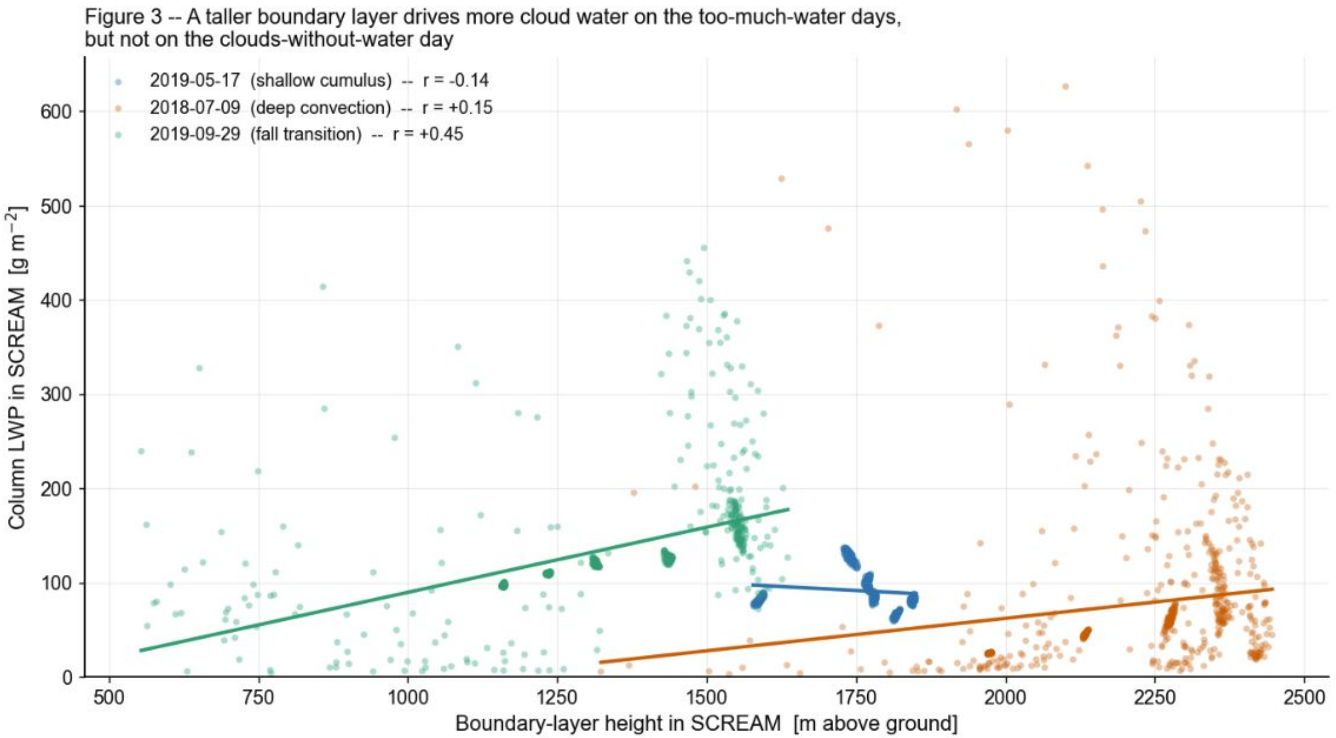



Different diagnosis:

- May 17: weak-condensate cloud labels
- Jul 9 / Sep 29: condensate-supported cloud excess

# Possible Explanation for Higher Cloud Fraction in SCREAM



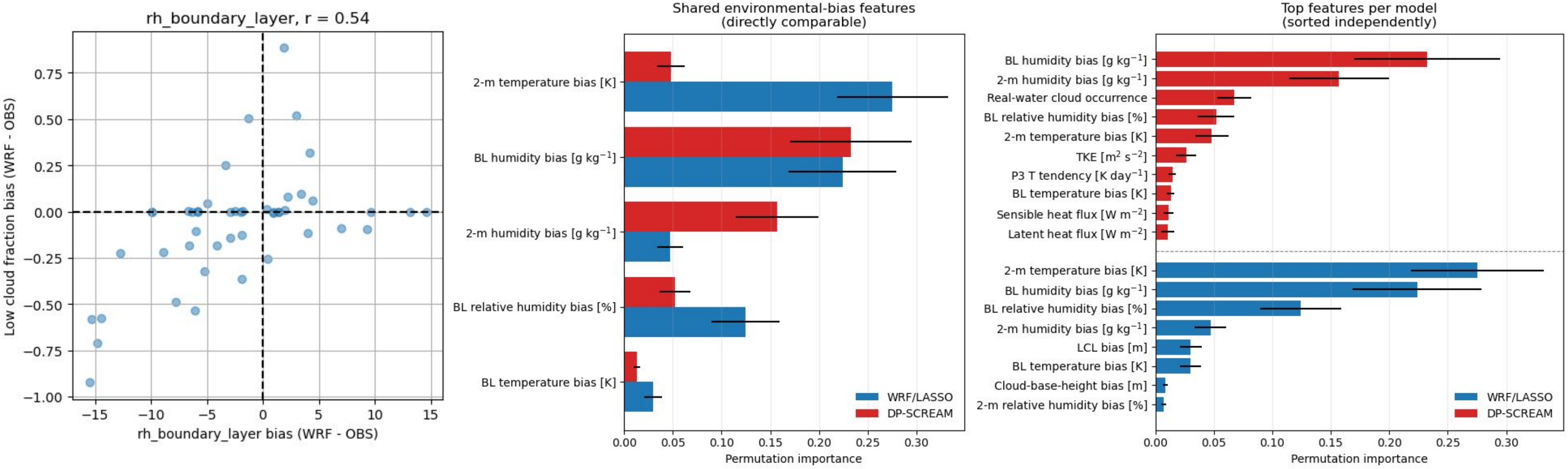



PBLH–LWP relationship:

- May 17: weak/negative
- Jul 9: weak positive
- Sep 29: clearer positive

Take-home: Boundary-layer growth is associated with cloud water in Jul 9 / Sep 29, but not in May 17.

# Preliminary ML Results




- This ML analysis identifies variables that are most strongly associated with cloud-fraction bias. Random Forest learns statistical relationships between environmental/process factors and cloud-fraction bias
- Humidity matters in both model!

# Conclusions and Future Work

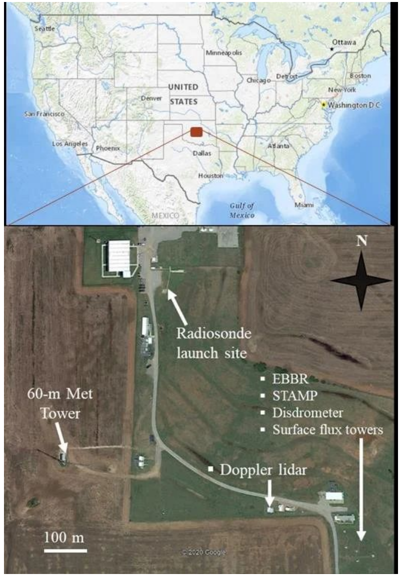
## Conclusions
- WRF’s representation of low-level clouds generally aligns more closely with ARM observations
- DP-SCREAM frequently overestimates LWP, especially during afternoon BL growth
- Biases in observed downwelling shortwave radiation are mainly due to cloud representation in the models

## Limitations
- Only 3 case studies were analyzed, meaning there is limited statistical information
- Large difference in model resolution (3km vs 100m) complicates direct comparison
- Observational datasets include uncertainty and spatial sampling limits

## Future Work
- Expand analysis to wider variety of ARM shallow-cloud cases
- Analyze additional variables (vertical velocity, turbulence, etc.)
- Run DP-SCREAM at 100 m resolution to directly compare how different physics representations impact cloud process

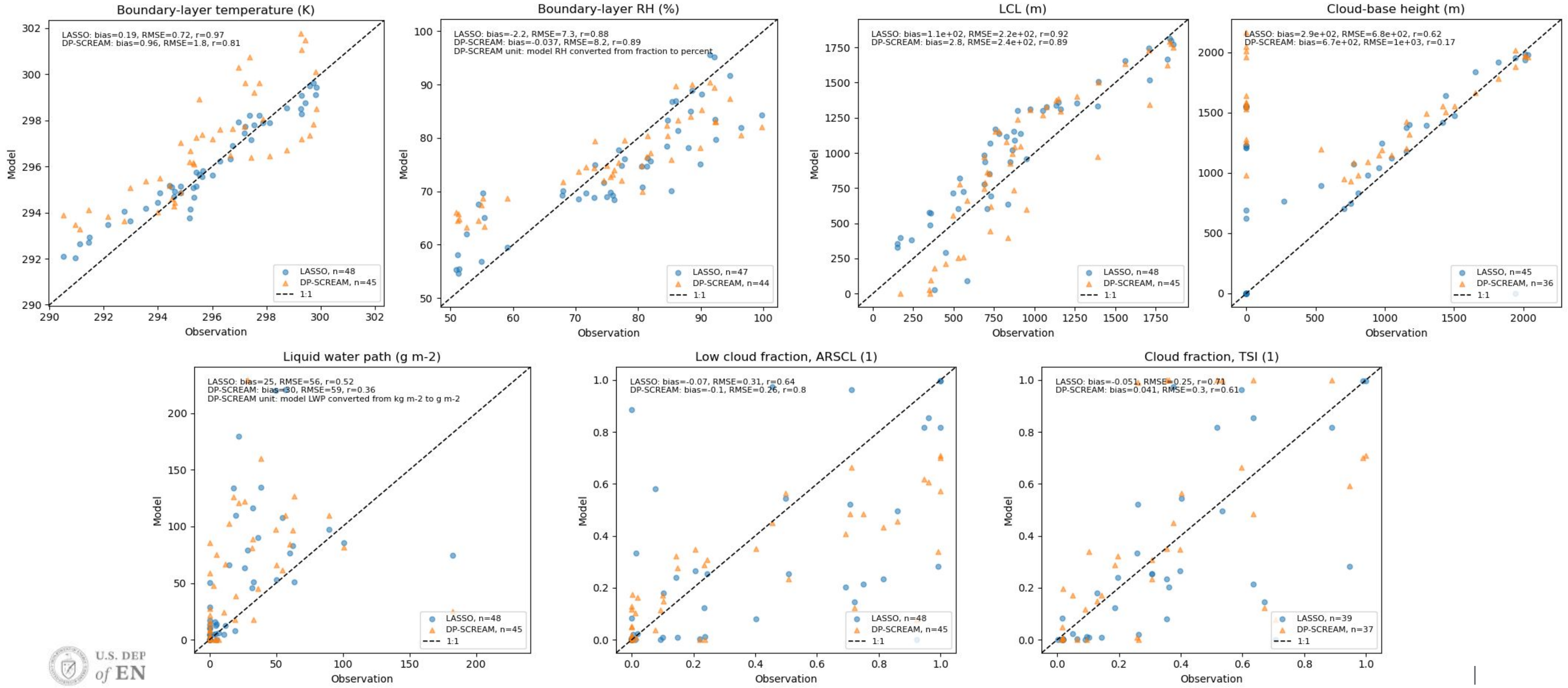
# Thank You

***Github Repository Link***



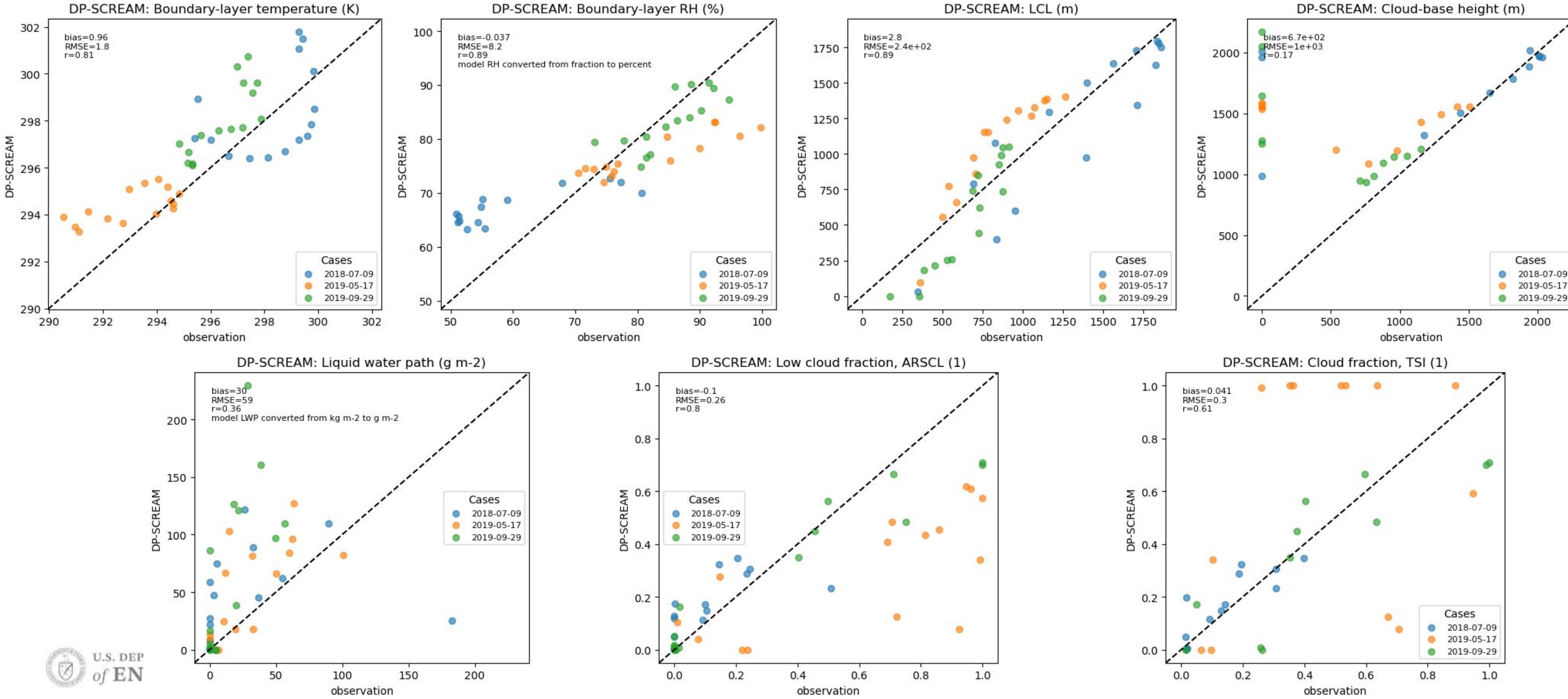

Thanks to all the instructors, mentors, and organizers!!

# EXTRA

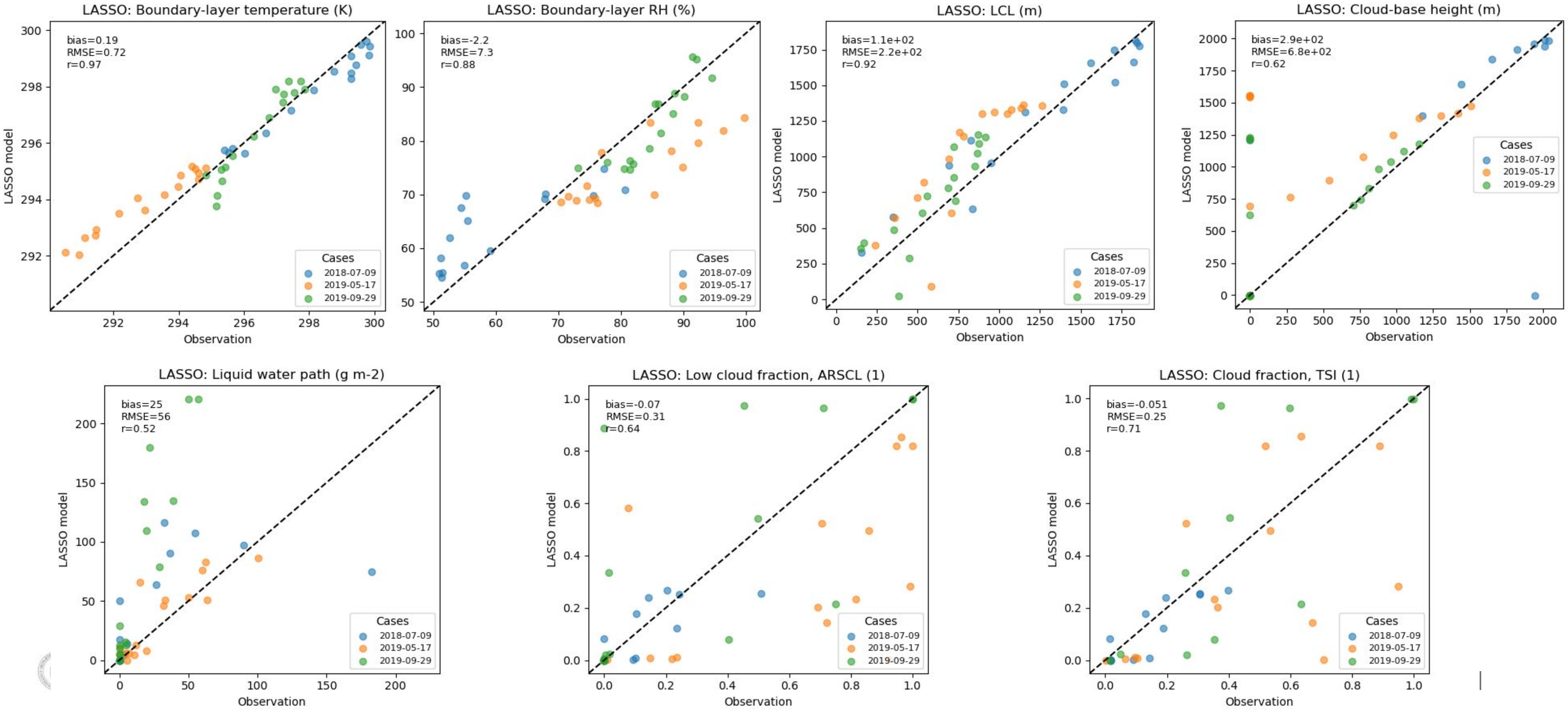


Boundary-layer temperature (K)
LASSO: bias=0.19, RMSE=0.72, r=0.97
DP-SCREAM: bias=0.96, RMSE=1.8, r=0.81
LASSO, n=48
DP-SCREAM, n=45
1:1
Boundary-layer RH (%)
LASSO: bias=-2.2, RMSE=7.3, r=0.88
DP-SCREAM: bias=-0.037, RMSE=8.2, r=0.89
DP-SCREAM unit: model RH converted from fraction to percent
LASSO, n=47
DP-SCREAM, n=44
1:1
LCL (m)
LASSO: bias=1.1e+02, RMSE=2.2e+02, r=0.92
DP-SCREAM: bias=2.8, RMSE=2.4e+02, r=0.89
LASSO, n=48
DP-SCREAM, n=45
1:1
Cloud-base height (m)
LASSO: bias=2.9e+02, RMSE=6.8e+02, r=0.62
DP-SCREAM: bias=6.7e+02, RMSE=1e+03, r=0.17
LASSO, n=45
DP-SCREAM, n=36
1:1
Liquid water path (g m-2)
LASSO: bias=25, RMSE=56, r=0.52
DP-SCREAM: bias=30, RMSE=59, r=0.36
DP-SCREAM unit: model LWP converted from kg m-2 to g m-2
LASSO, n=48
DP-SCREAM, n=45
1:1
Low cloud fraction, ARSCL (1)
LASSO: bias=-0.07, RMSE=0.31, r=0.64
DP-SCREAM: bias=-0.1, RMSE=0.26, r=0.8
LASSO, n=48
DP-SCREAM, n=45
1:1
Cloud fraction, TSI (1)
LASSO: bias=-0.051, RMSE=0.25, r=0.71
DP-SCREAM: bias=0.041, RMSE=0.3, r=0.61
LASSO, n=39
DP-SCREAM, n=37
1:1
Model
Observation

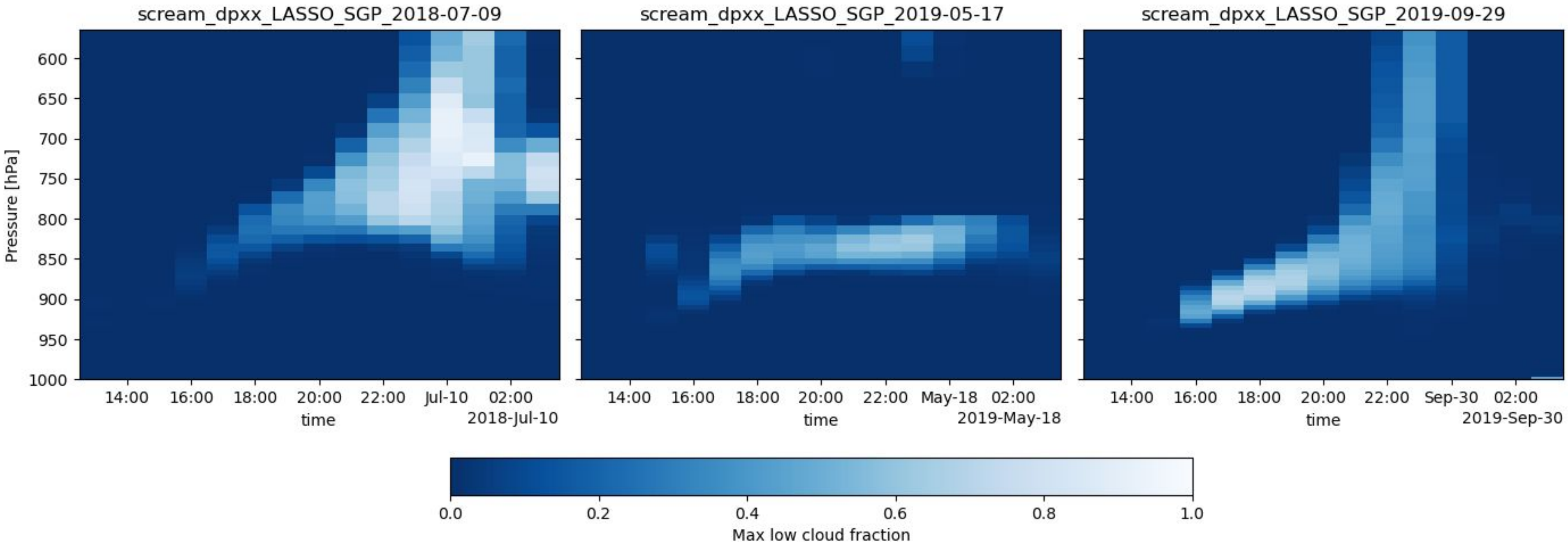
# Scatter plot of DP-SCREAM simulation and observation



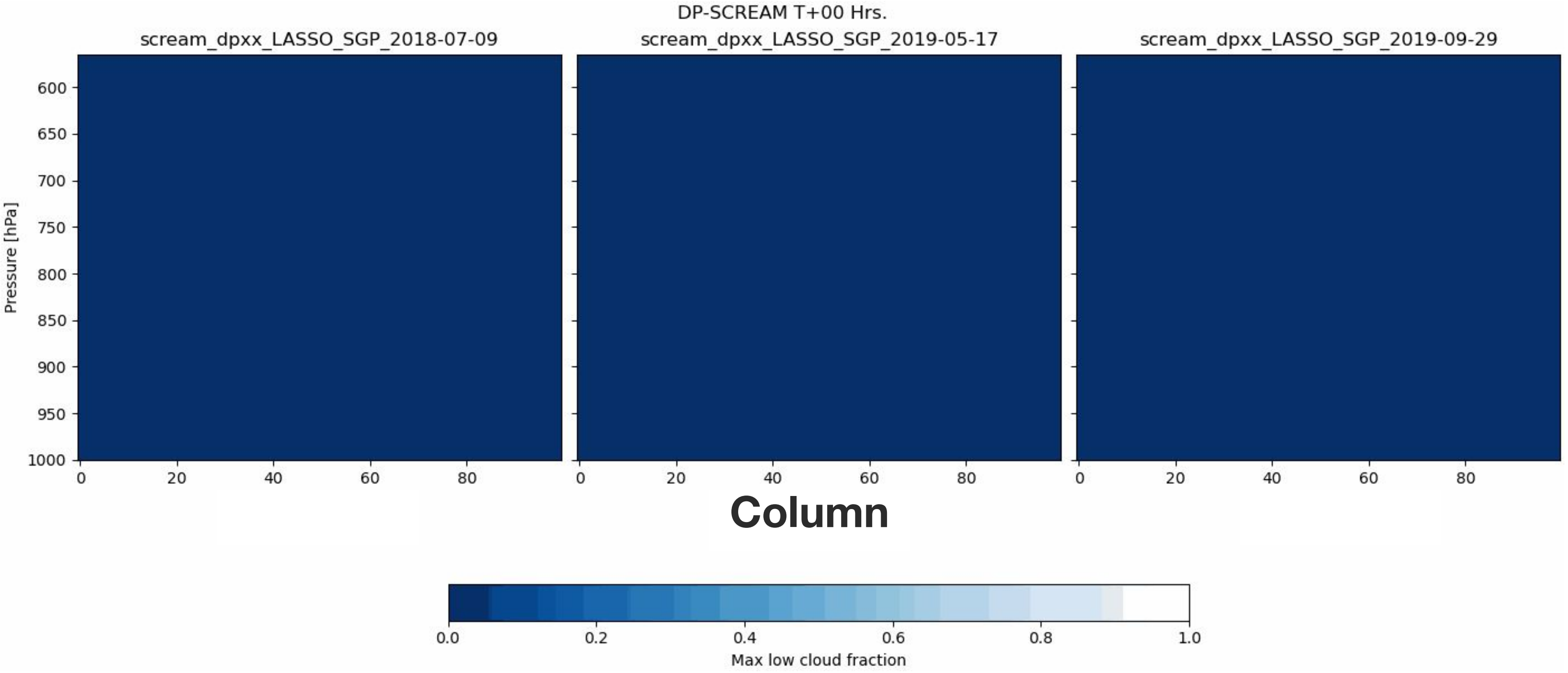
# Scatter plot of LASSO simulation and observation



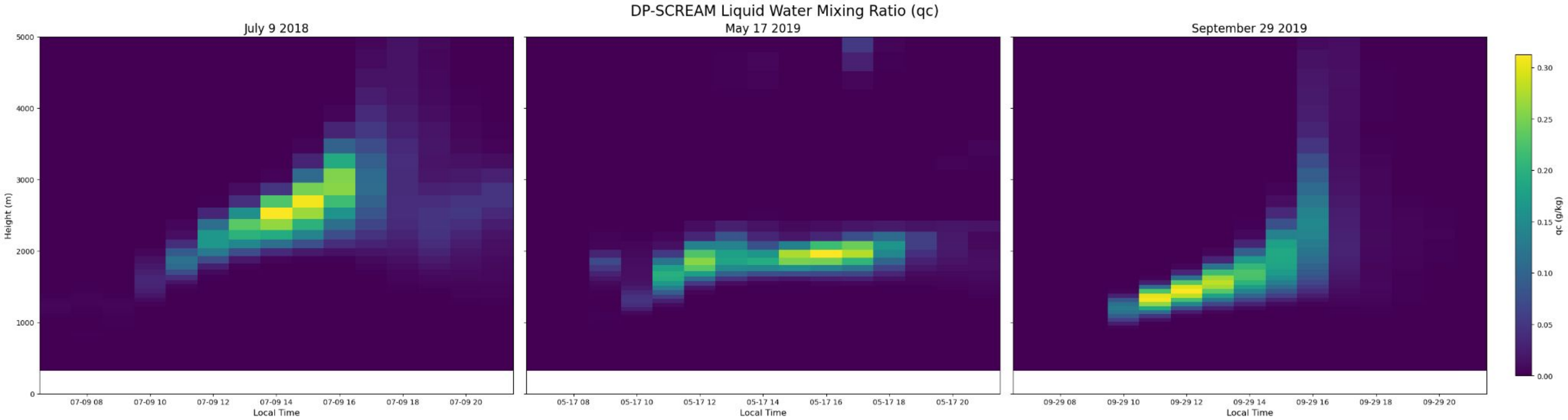
# Low Cloud Fraction (<5km) from DP-SCREAM



# DP-SCREAM Low Cloud Fraction (<5km) Time Series

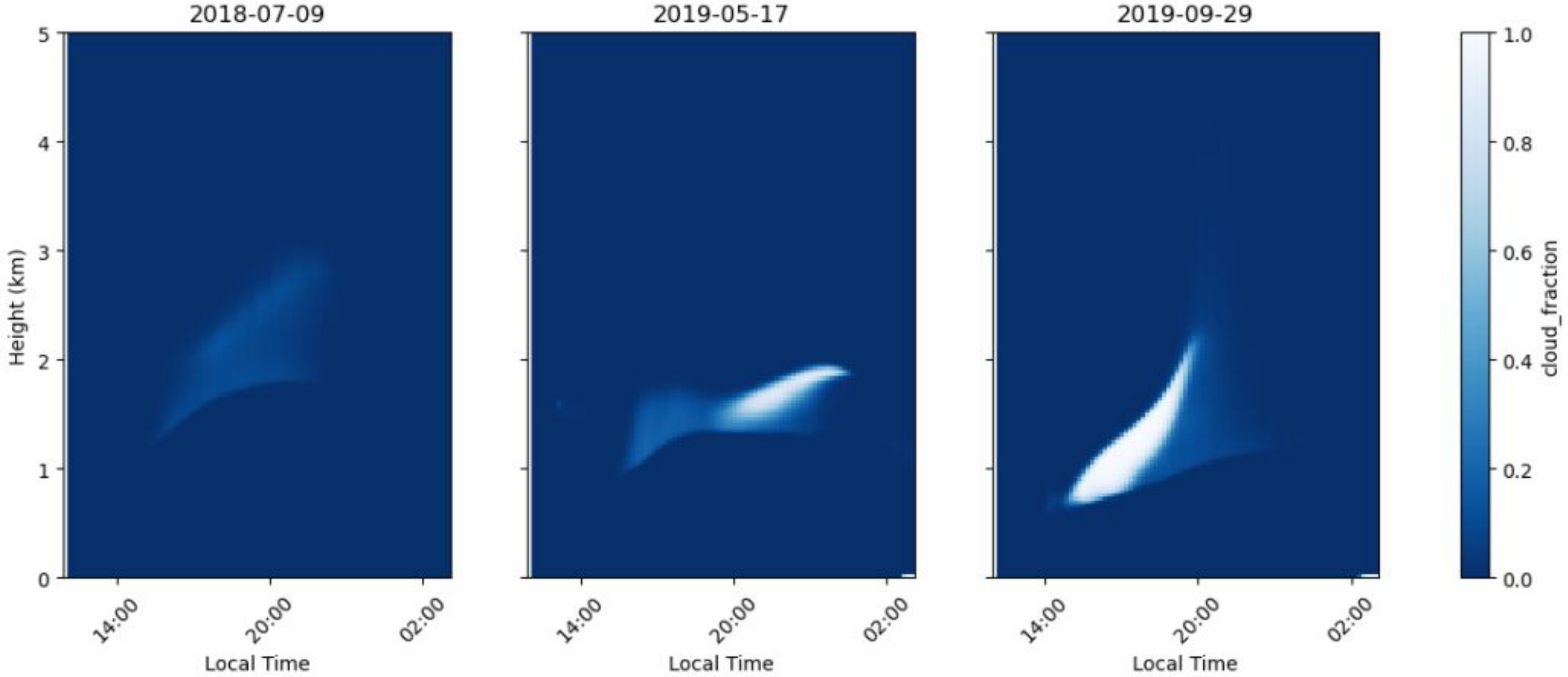


# SCREAM Liquid Water Mixing Ratio (qc)

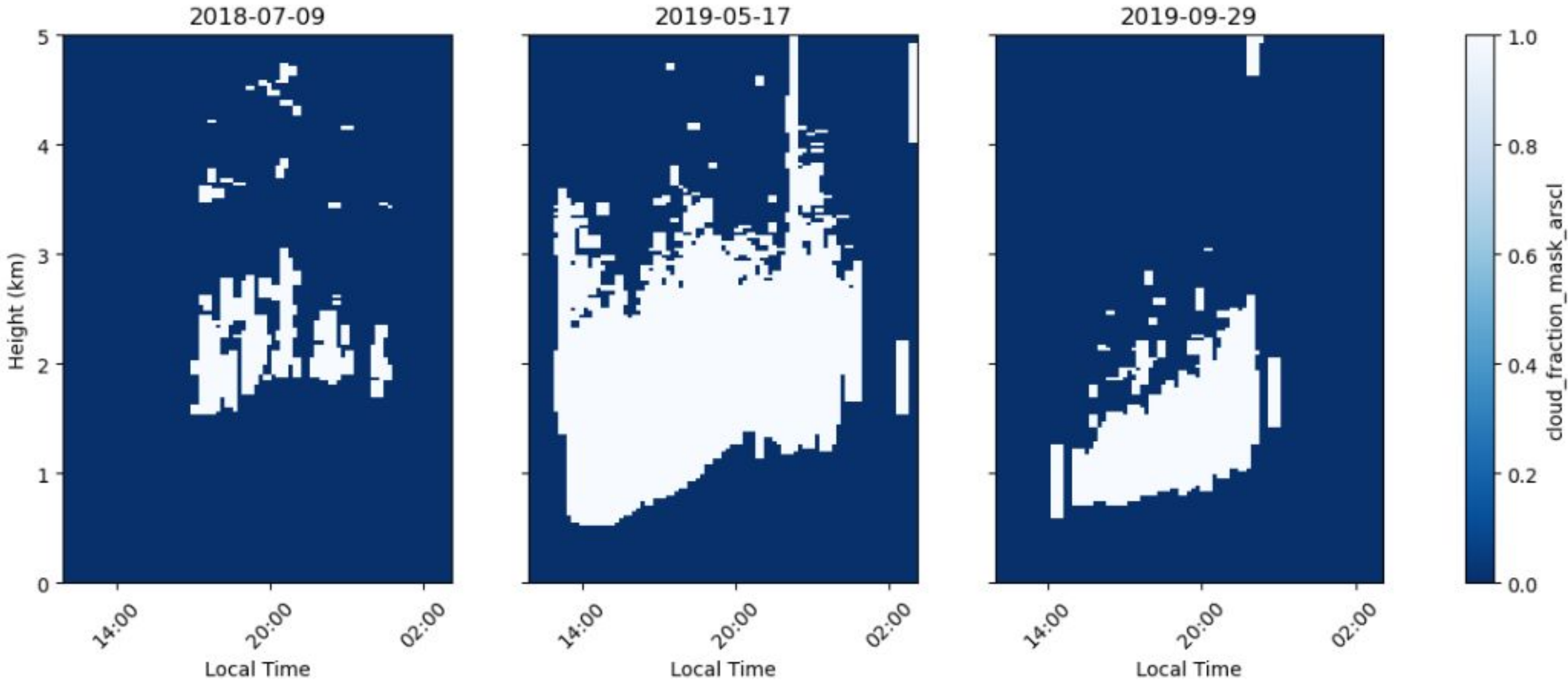



(luke)

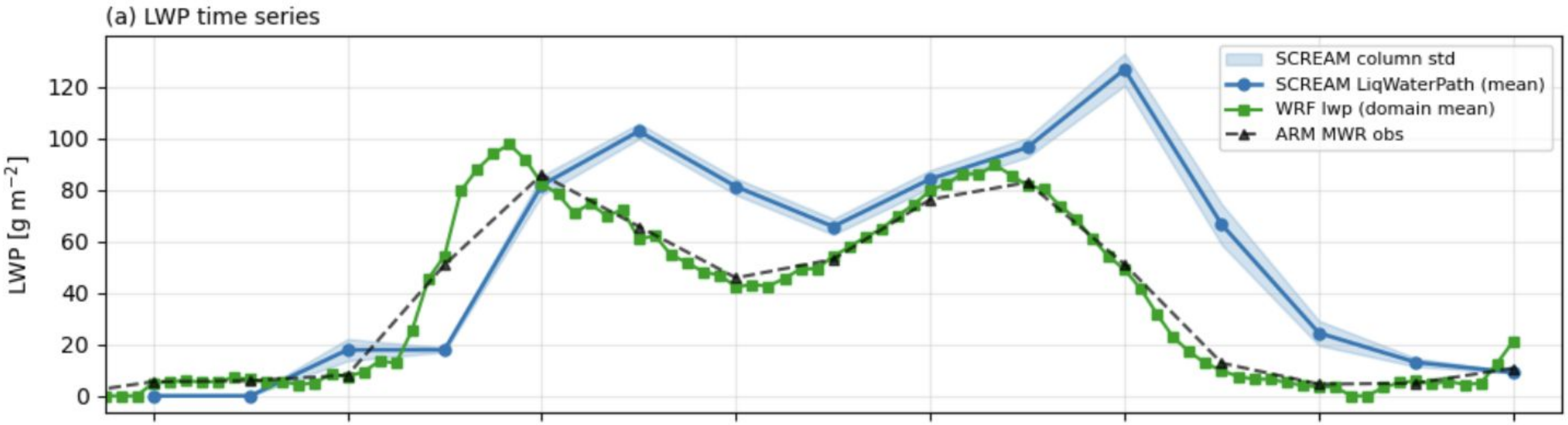
# Vertical Cloud Fraction (<5km) from LASSO



# Vertical Cloud Fraction (<5km) from Observation

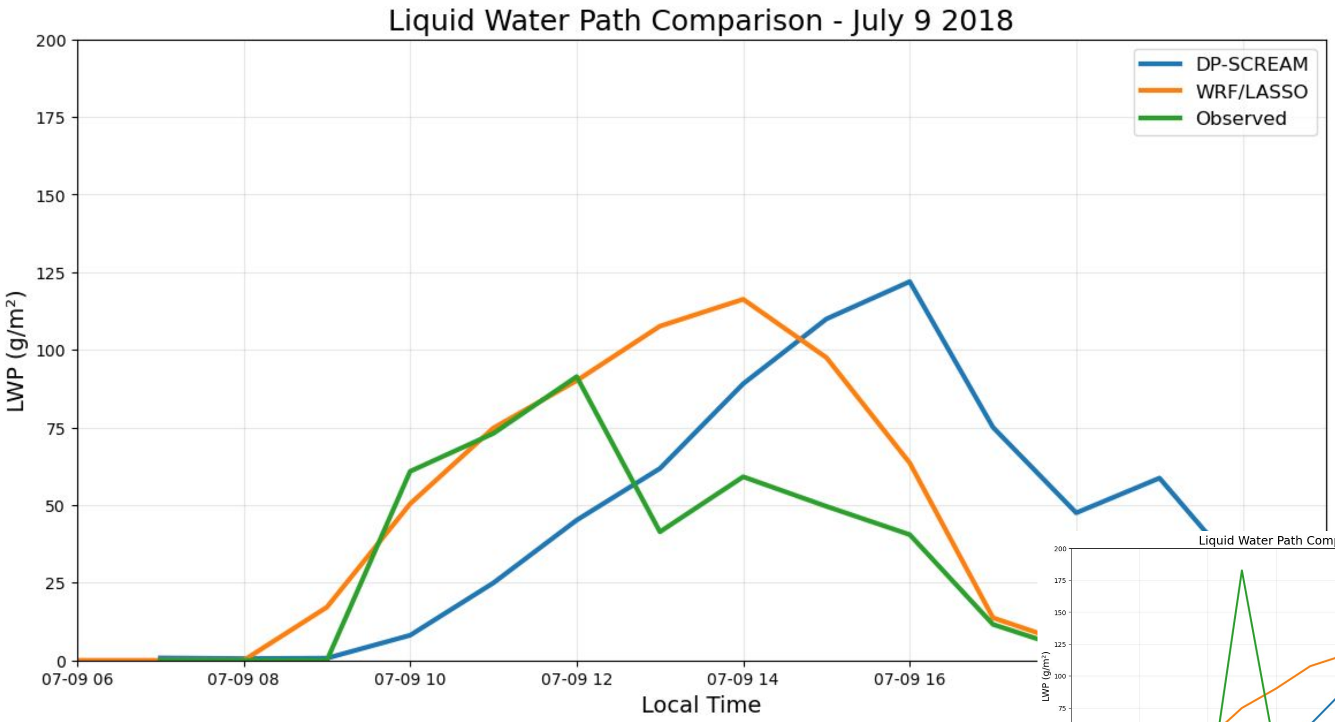


# LWP time series (0517 only)

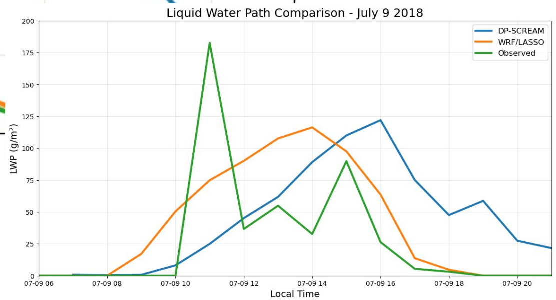



WRF has better agreement in LWP compared to observation. (not so right, I checked other two cases, the conclusion is not robust)

# LWP 0709



Liquid Water Path Comparison - July 9 2018
DP-SCREAM
WRF/LASSO
Observed
LWP (g/m²)
200
175
150
125
100
75
50
25
0
07-09 06
07-09 08
07-09 10
07-09 12
07-09 14
07-09 16
Local Time

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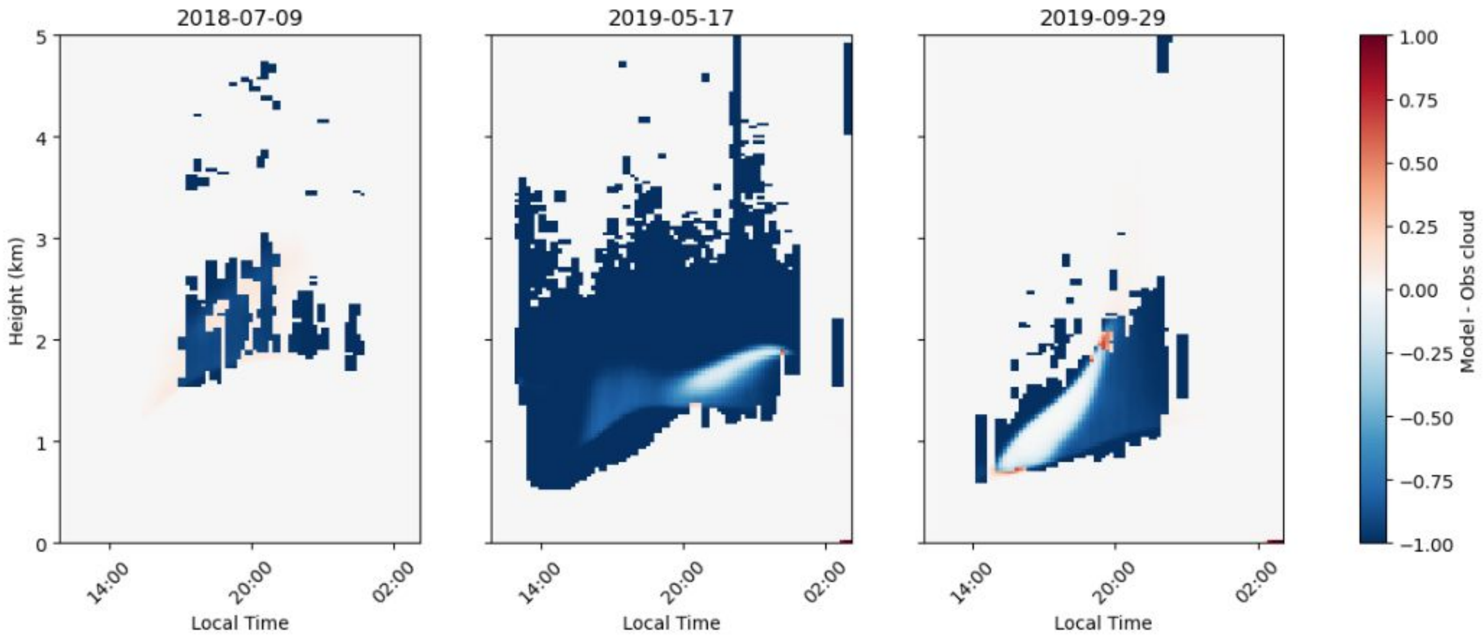
07-09 08
07-09 10
07-09 12
07-09 14
07-09 16
07-09 18
07-09 20
Local Time

# Diff between WRF and Observation




Overestimation are comparatively localized near cloud edges

# QCRAD vs DPSREAM Surface Radiation Analysis