Evaluation of the boundary layer temperature and moisture fields in the Hurricane Weather Research and Forecast (HWRF) system

Evan Kalina[1,2,3], Evelyn Grell[1,3,4], Mrinal Biswas[3,5], Georg Grell[2], Kathryn Newman[3,5], Joseph Cione[4,6], Kelly Ryan[6,7], Ligia Bernardet[1,2,3], Laurie Carson[3,5], Jim Frimel[2,3,8], Bin Liu[9], Zhan Zhang[9], and the Coyote UAS Team

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[1]CU/CIRES [2]NOAA ESRL/GSD [3]DTC

[4]NOAA ESRL/PSD [5]NCAR

[6]NOAA AOML/HRD [7]UM/CIMAS [8]CSU/CIRA

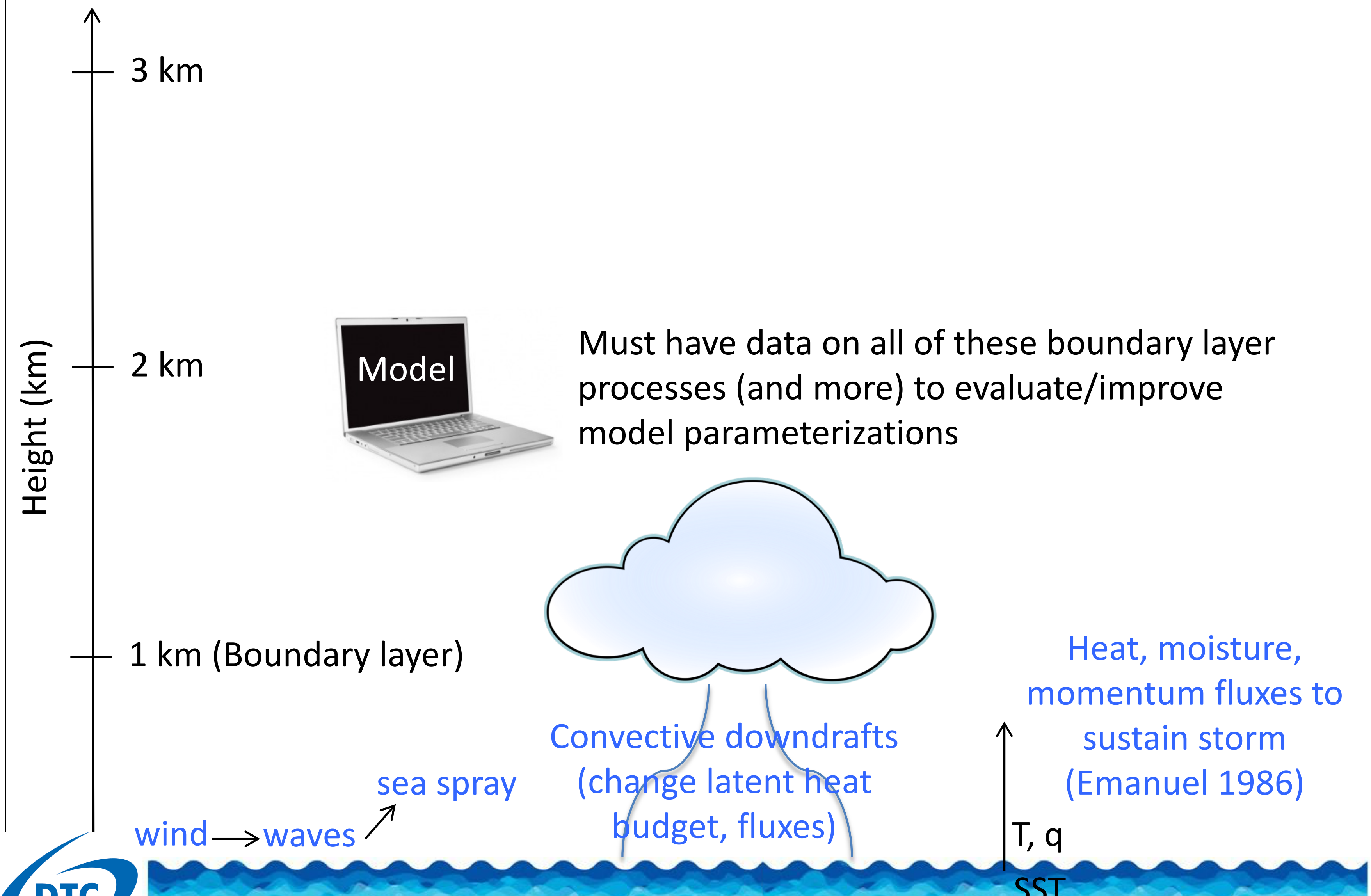
[9]NOAA NCEP/EMC and IMSG

Developmental Testbed Center

Outline

- Why are UAS data from hurricanes useful for model evaluation?
- How can these data be used effectively?
- Do the data agree with conventional observations (e.g., dropsondes)?
- Are model biases present in boundary layer temperature and moisture fields in the Hurricane Weather Research and Forecast system (HWRF)?
- Are these biases sensitive to the cumulus parameterization?

Boundary layer processes are complex and nonlinear



During CBLAST, the NOAA P-3 collected BL measurements

Height (km)

3 km

2 km

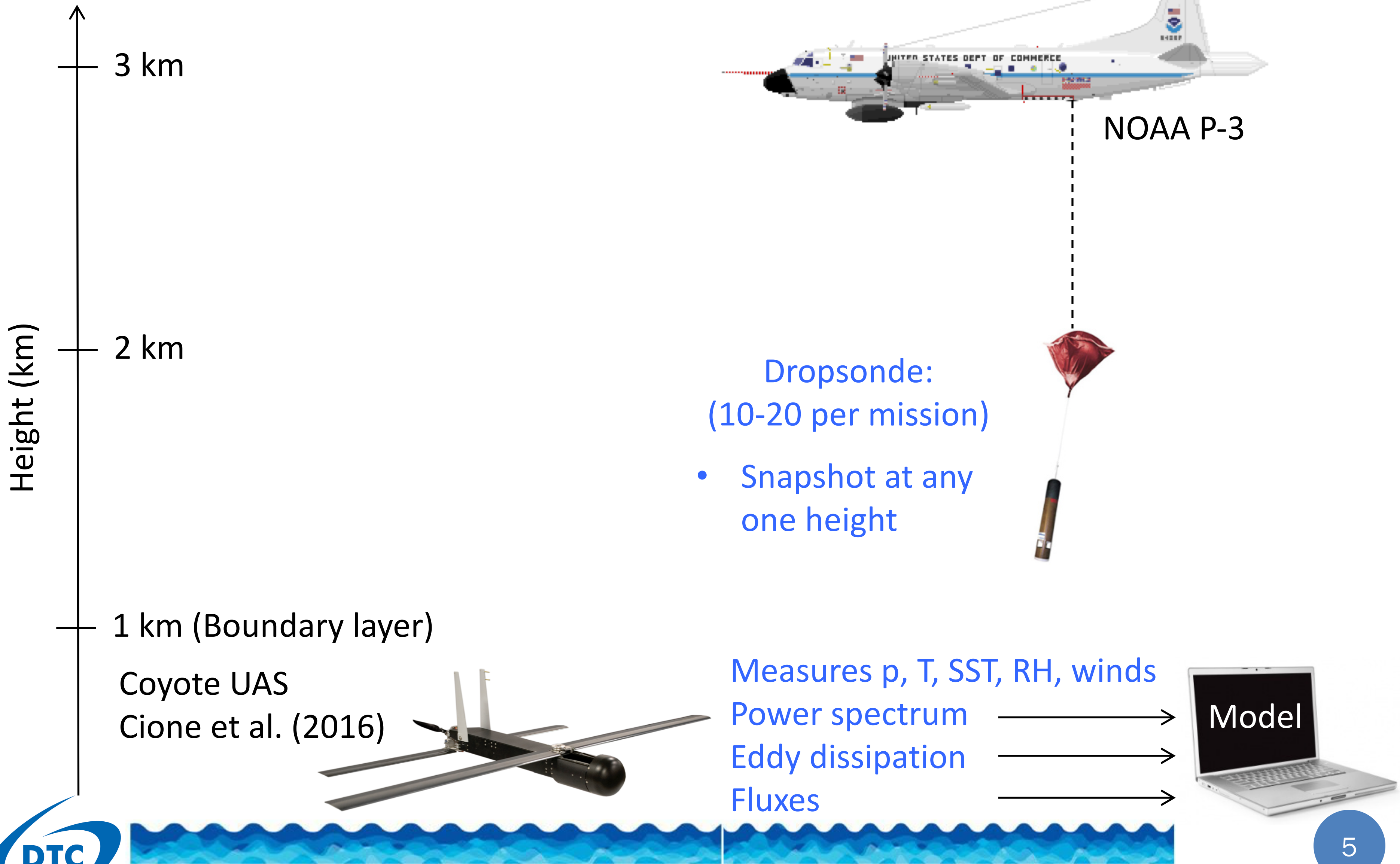
1 km (Boundary layer)

The Coupled Boundary Layer Air-Sea Transfer (CBLAST) experiment (French et al. 2007)

- P-3 flew as low as 70 m in 2 storms
  - 18-30 m s^{-1} wind speeds
- Underscored need to fly even lower (Andreas et al. 2012)

NOAA P-3

Today, the NOAA P-3 flies at 3 km. How do we obtain additional BL measurements?

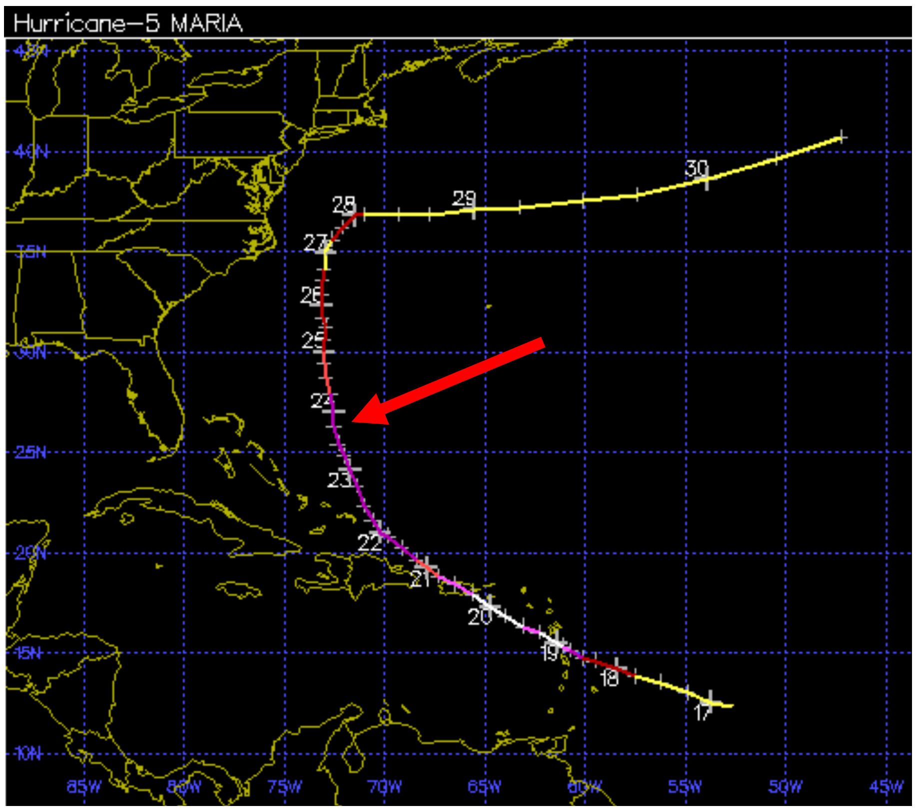


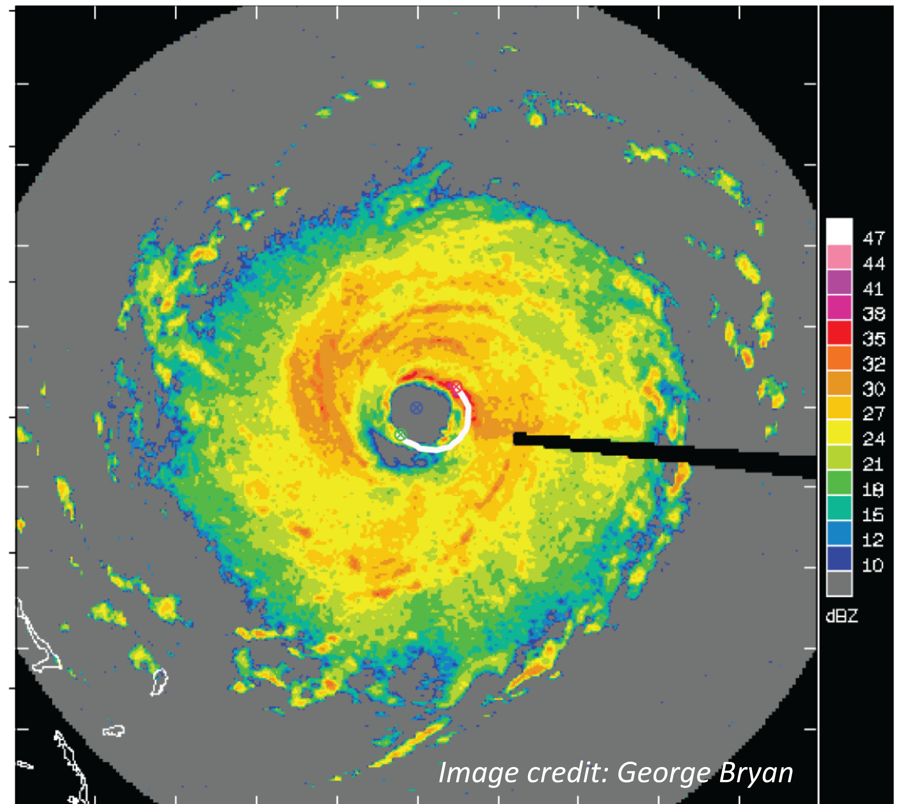
Coyote UAS: Fast facts

Dimensions	0.91 m length, 1.47 m wingspan
Mass	6 kg
Sensors	p, T, RH, winds (from GPS); all 1-3 Hz
Delivery	Air-deployable thru P-3 sonobuoy chute
Control	Piccolo autopilot; commands issued from P-3

Image credit: Raytheon

A Coyote UAS flight on 23 September 2017 sampled the eyewall of Hurricane Maria (100 kt, 952 mb)





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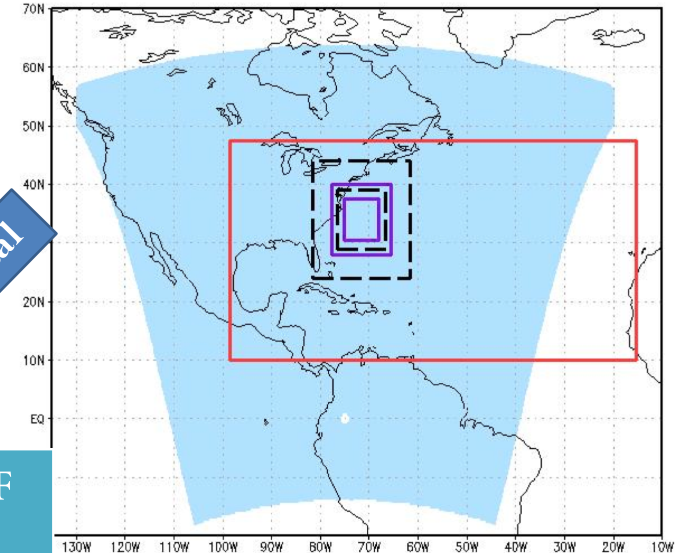
Compare UAS data to two HWRF configurations: H18C and H18G



Baseline

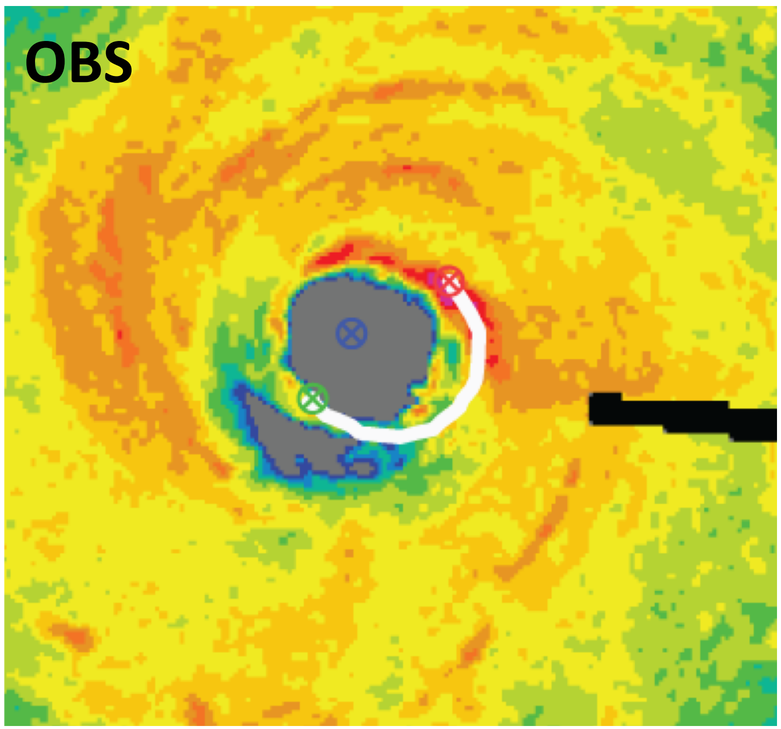
Experimental

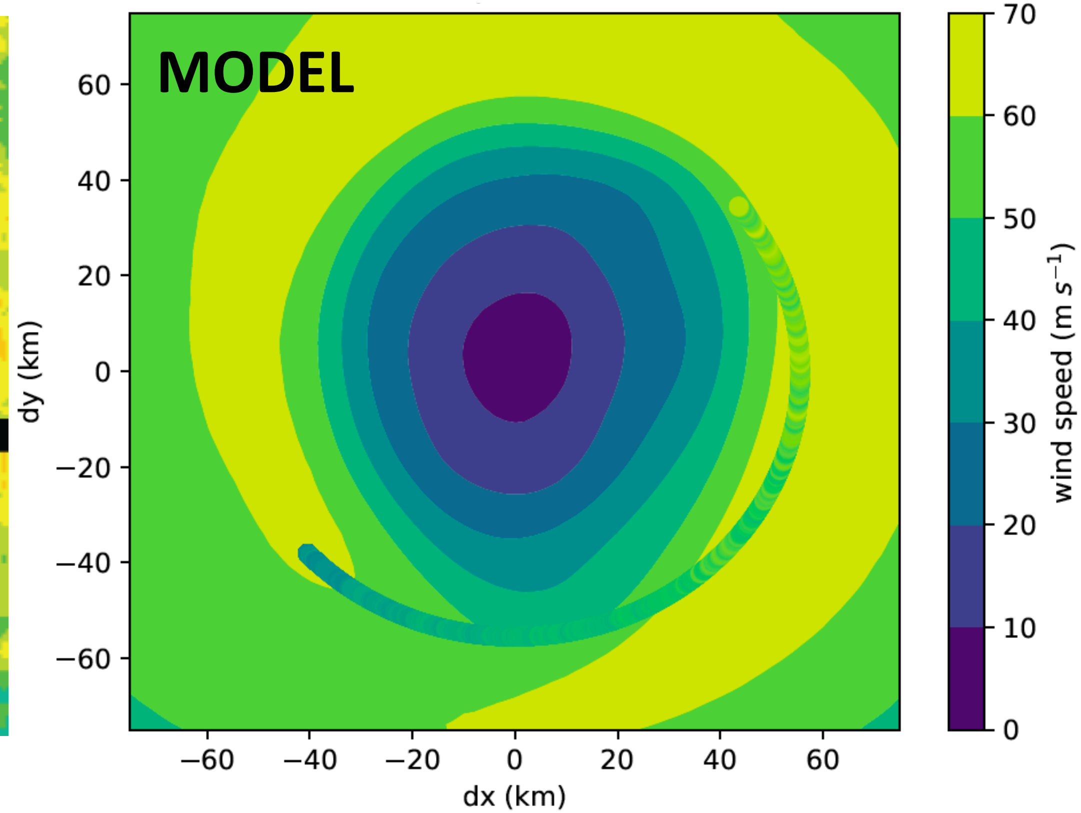
	HWRF with SASAS (H18C)	HWRF with GF (H18G)
Cumulus	Scale Aware SAS	**Grell-Freitas**
Microphysics	Ferrier-Aligo	Ferrier-Aligo
Surface layer	HWRF	HWRF
Land surface	Noah LSM	Noah LSM
PBL	GFS Hybrid EDMF	GFS Hybrid EDMF
Radiation	RRTMG	RRTMG

- Horizontal grid spacing: 18, 6, 2 km
- Inner nests move to follow storm
- Domain location varies from run to run depending on storm location
- 75 vertical levels; top at 10 hPa

H18G considered by EMC for operational implementation this year

A Coyote was "flown" around the eyewall within the HWRF inner nest for a series of forecast cycles. Each cycle was evaluated at the valid time of the Coyote flight (~18 UTC).





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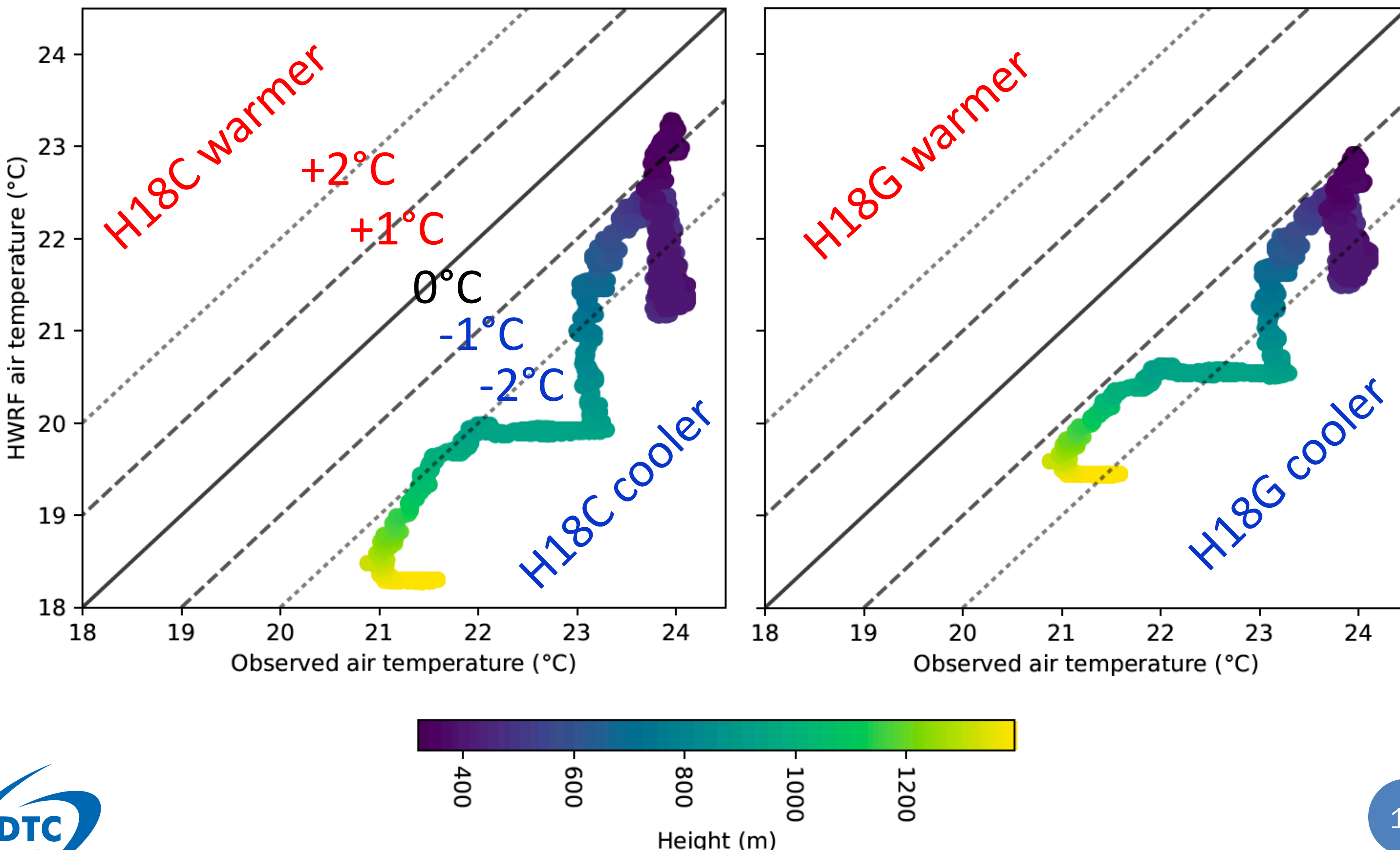
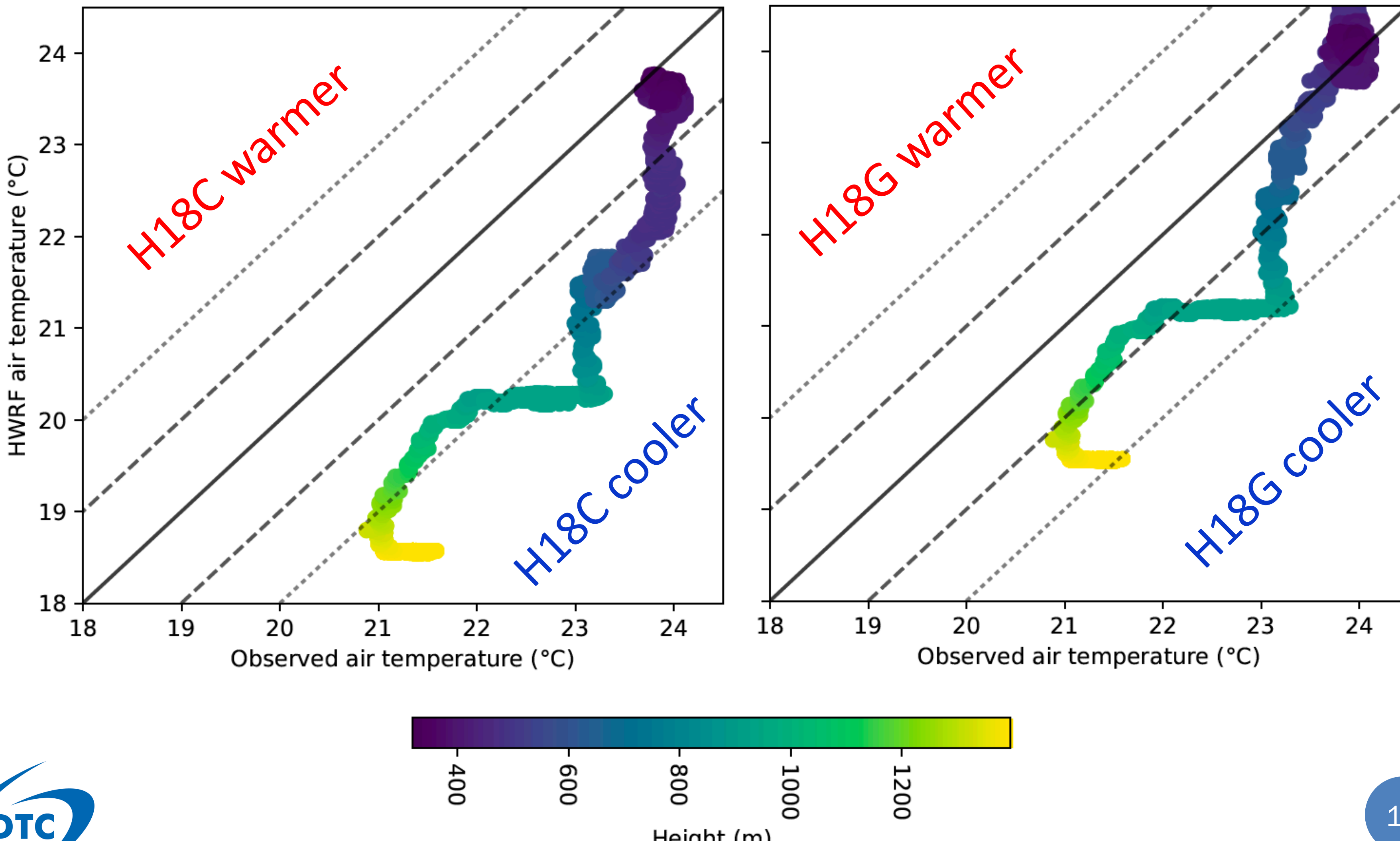
At the initial time, cool bias of 1.5–2°C in both configurations

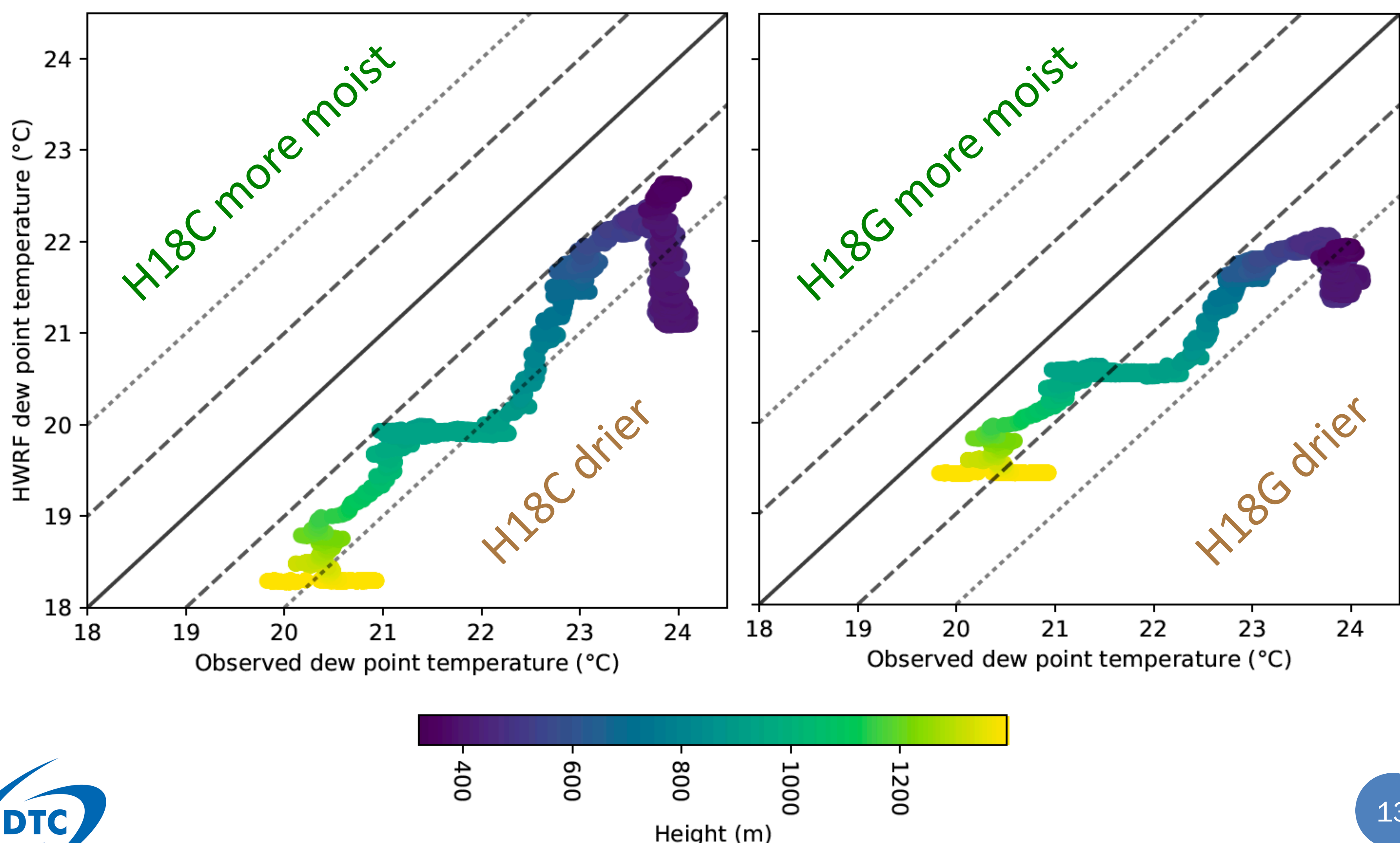


At forecast hour 72, the cool bias is reduced in H18G by ~1°C

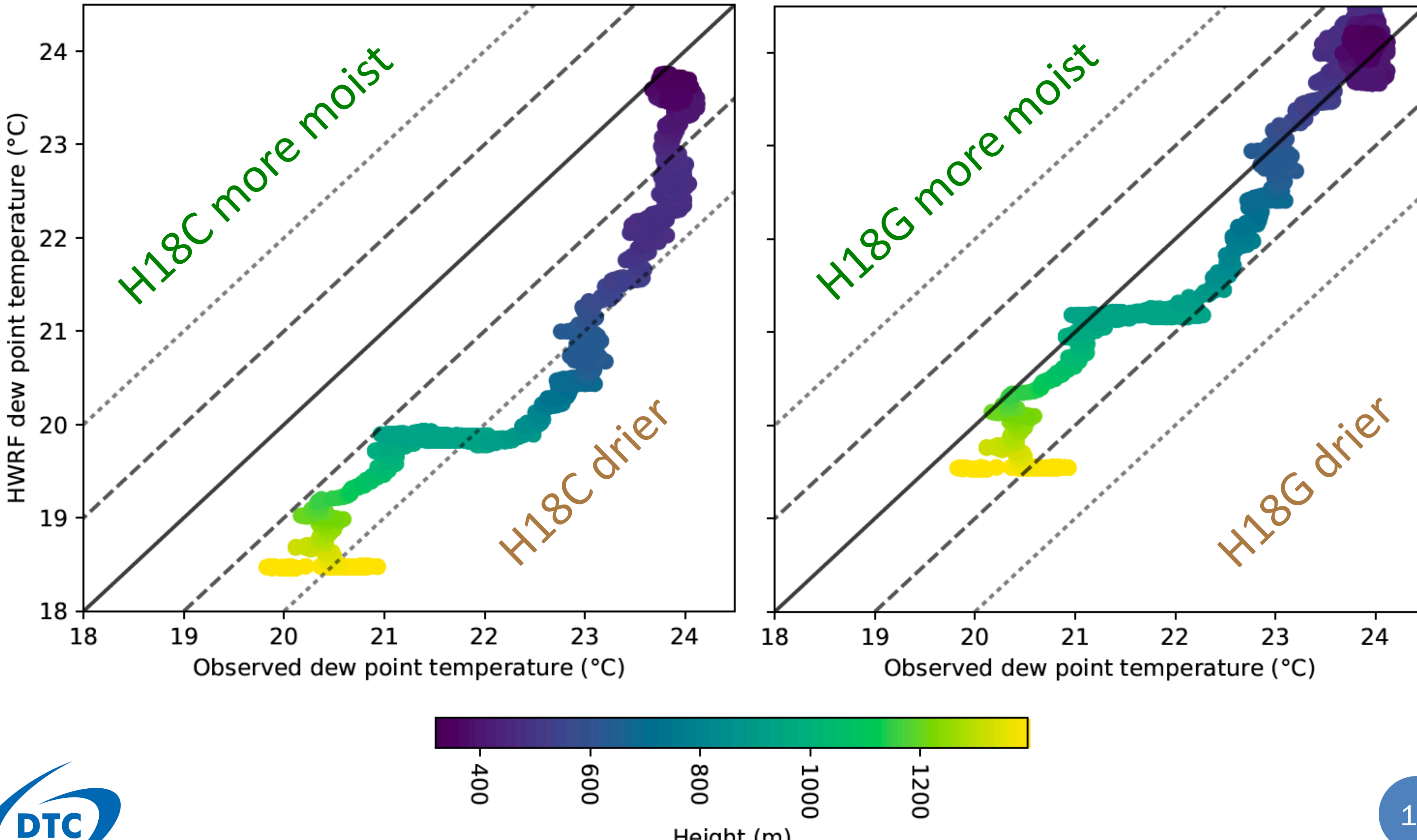


Developmental Testbed Center

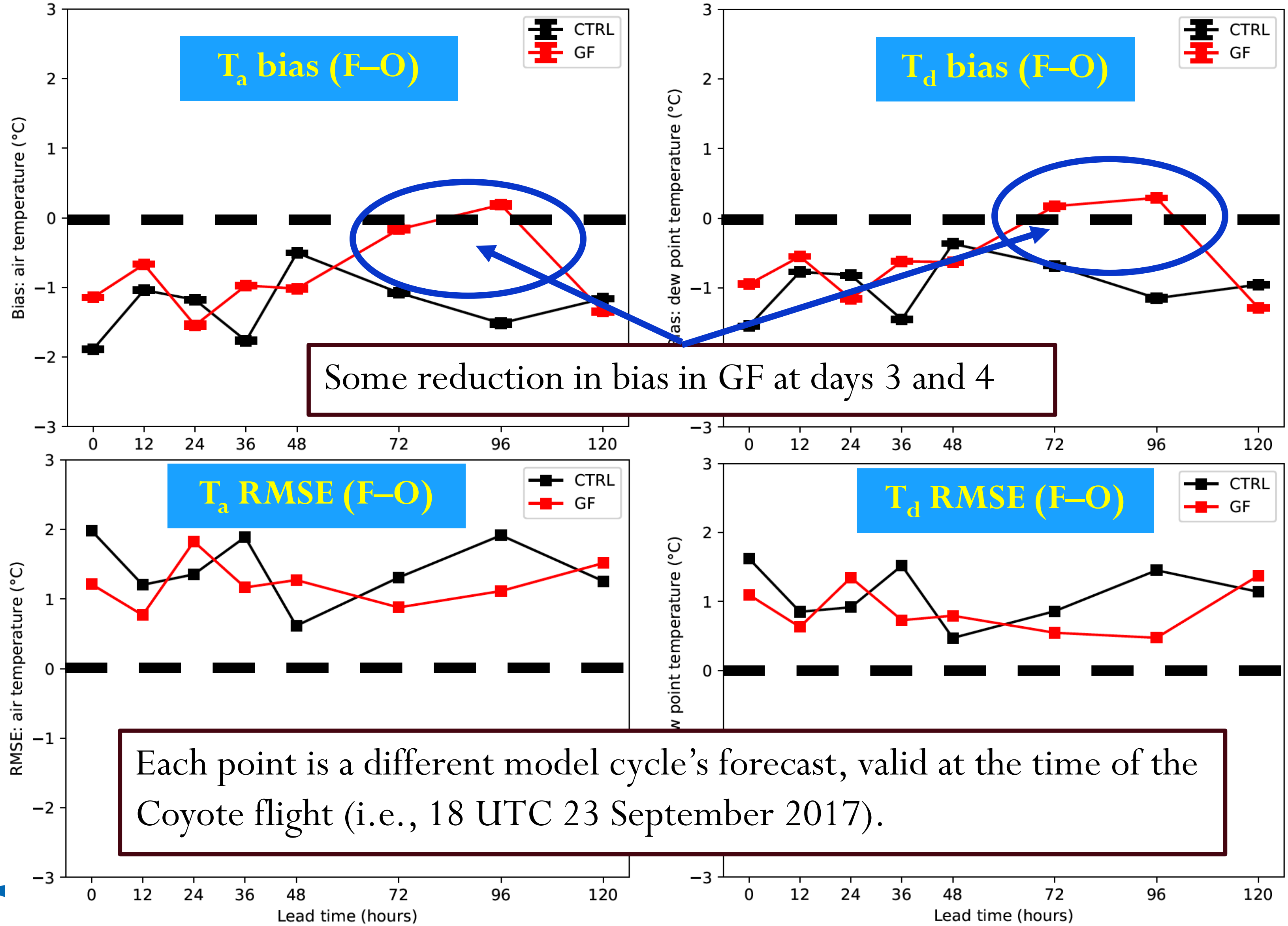
At the initial time, dry bias of 1.5–2°C in both configurations



At forecast hour 72, the dry bias is still present in H18C, but not in H18G



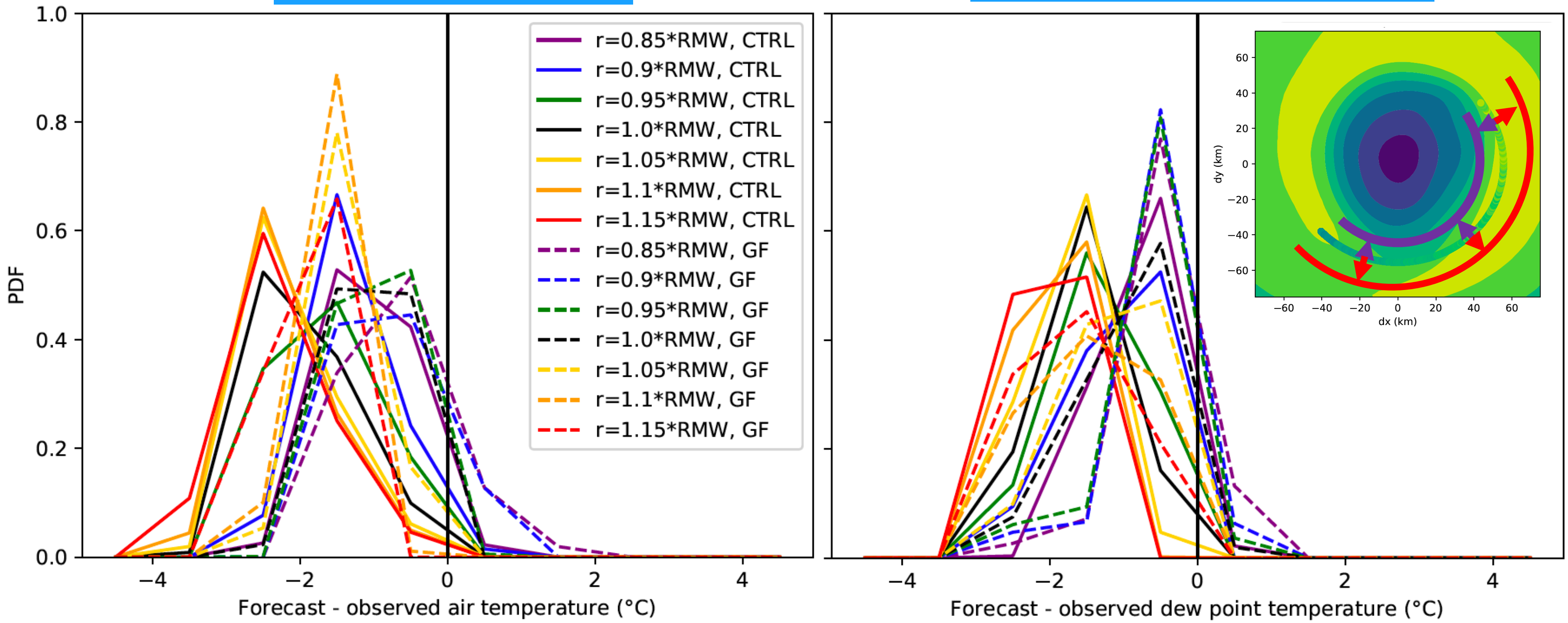
H18G improvements are uneven across forecast cycles



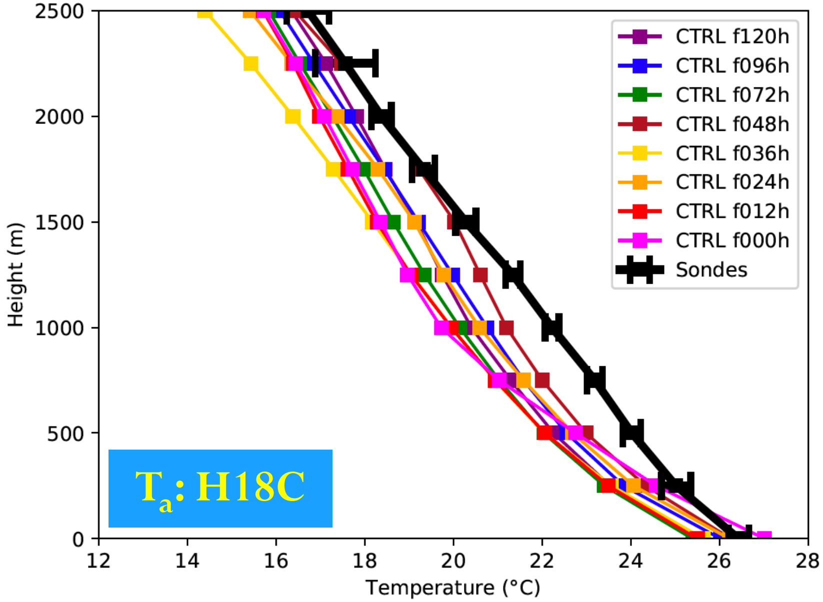
Small changes in the radial location of the simulated Coyote flight do not change results

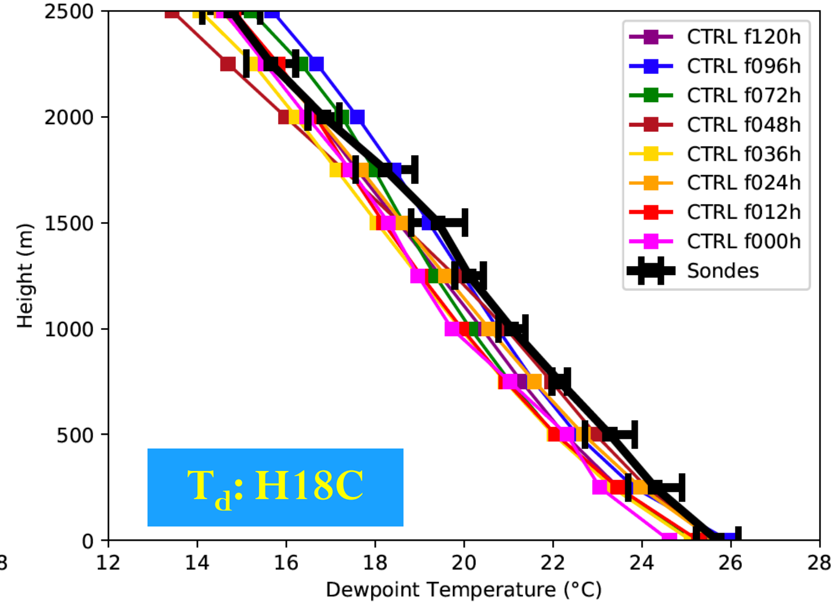
Air temperature Initialization

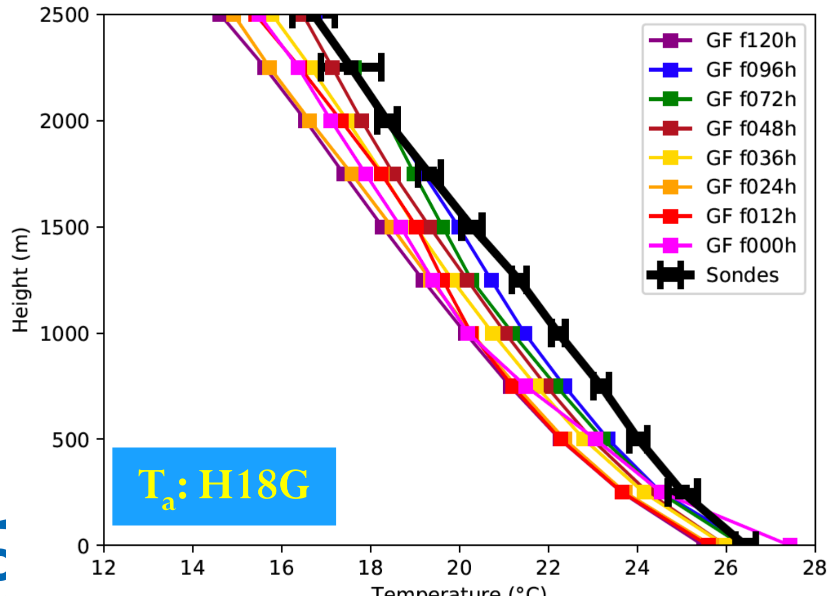
Dewpoint temperature Initialization

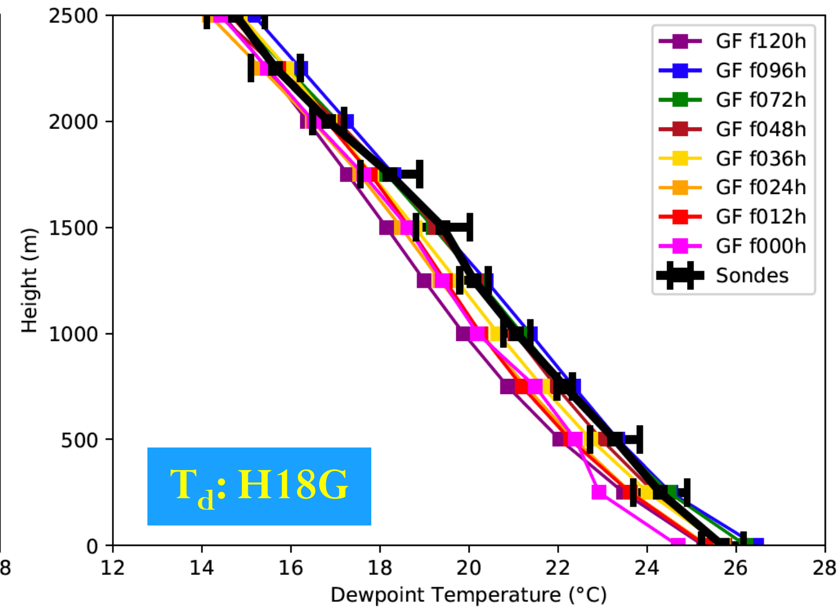


Dropsondes confirm 1–2°C cool, dry bias in eyewall









Conclusions

- Why are UAS data from hurricanes useful for model evaluation?
  - Accurate data collected at altitudes unsafe for crewed aircraft
- How can these data be used effectively?
  - Map obs to R/RMW space and compare to model
  - Consider sensitivity to simulated flight trajectory
- Do the data agree with conventional observations (e.g., dropsondes)?
  - Yes, dropsondes and Coyote UAS data are qualitatively similar
- Are model biases present in boundary layer temperature/moisture fields in HWRF?
  - Yes, 1–2°C cool, dry bias suggested by both Coyote and dropsondes
- Are these biases sensitive to the cumulus parameterization?
  - While running HWRF with the Grell-Freitas cumulus scheme lessens the bias at 3–4 day lead time, bias remains for other forecast cycles