Developmental Testbed Center:
Core support activities & HWRF testing and evaluation

Kathryn Newman & Evan Kalina

DTC team: Mrinal Biswas, Evelyn Grell, Jim Frimel, Laurie Carson

Acknowledgements:

M. Iacono & J. Henderson (AER), G. Grell (NOAA/ESRL/GSD),

NOAA/EMC Hurricane Team, NOAA/AOML/HRD

HFIP telecon: 2018 September 5

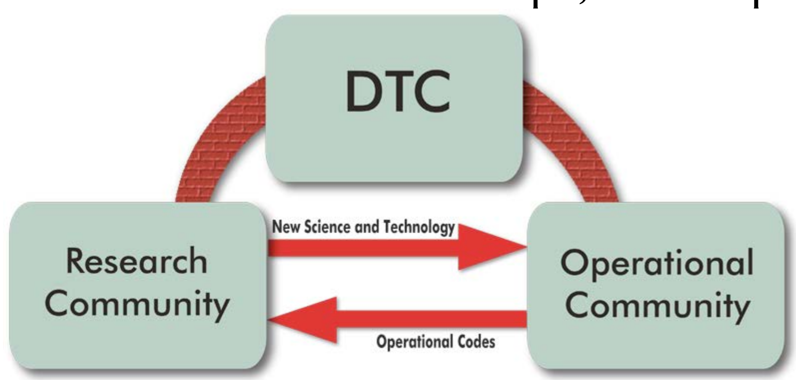
Part I: Core support & R2O activities

Kathryn Newman

NCAR/RAL

What is the DTC?

- **Collaboration between NOAA/ESRL and NCAR**
- **Purpose**: Facilitate the interaction and transition of NWP technology between research & operations
  - **O2R**: Support operational NWP systems to the community
  - **R2O**:
    - Partner with developers to get innovations into centralized code
    - Perform diagnostics on and test and evaluate promising NWP innovations for possible operational implementation
  - **Interaction between R & O**: Workshops, visitor program, newsletter



DTC is jointly sponsored by NOAA, Air Force, NSF, and NCAR

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DTC strategies to promote HWRF O2R2O

1. **Code management**
   - *Create and sustain a framework for NCEP and the research community to collaborate and keep HWRF code unified*
2. **User and developer support**
   - *Support the community in using and providing improvements for HWRF*
3. **Visitor program**
   - *Funds the research community to partner with DTC in R2O*
4. **Independent testing & evaluation**
   - *Test and evaluate innovations for potential operational implementation*

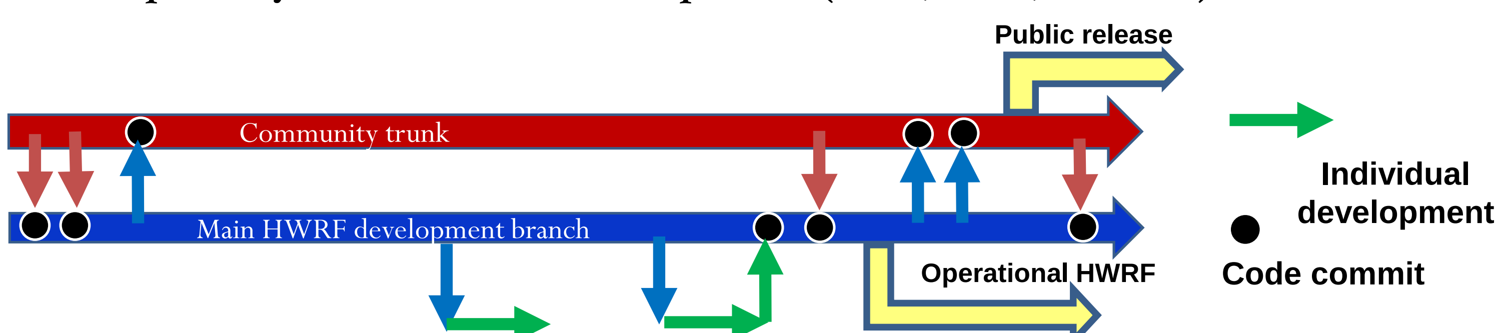
Provides tools/infrastructure, support and opportunities for developers to transition research innovations into operations

Code management

Need repository access? DTC arranges access to repositories for all HWRF components

- **Centralized HWRF repository**
  - SVN & Git repositories house all HWRF components
  - Automated build for entire system, end-to-end python scripts, tools for automation (Rocoto workflow manager), source for components
  - Maintain integrity of code, supports integration of code into trunk
  - Ensures developers have access to the latest code developments
  - Unified scripts are fully supported by DTC

Code repository for each HWRF component (WRF, WPS, GSI etc.)



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User & developer support

Single helpdesk: **hwrf-help@ucar.edu**

- Users work with stable yearly release with known capabilities
  - Code downloads, datasets, extensive documentation, online tutorial
  - HWRFv4.0 (consistent with 2018 operational HWRF) release underway … target end of Sept
- Developers work with latest experimental code in repository
  - Primary goal to facilitate R2O

www.dtcenter.org/HurrWRF/users
www.dtcenter.org/HurrWRF/developers

HWRF developers website

ABOUT | TESTING & EVALUATION | COMMUNITY CODES | VISITOR PROGRAM | NEWS | EVENTS

DTC Developmental Testbed Center

HURRICANE WRF DEVELOPERS PAGE

- Developers Home
- Code Management ▶
- Getting Started ▶
- Using the Code ▶
- Computing Resources
- Docs and Support ▶
  - Support for Developers
  - FAQ
  - Known Issues
- Contributed Code
- HWRF Users Site

HWRF Developers Page

Welcome to the DTC HWRF developers page. The source for information concerning the developmental code for HWRF.

Most HWRF users should obtain the HWRF code through the official releases available from the Community HWRF users website. The official code releases contain stable, well-tested and documented code. Datasets, tutorials, test cases, and a help desk are available for the official releases from the Community HWRF users website. Each official code release matches the operational configuration of that year.

…elopment in collaboration with NOAA (with the intention of contributing code back to the HWRF …d to use the latest experimental HWRF code, access to the HWRF code repository may be necessary. …date for accessing the HWRF code repository, please contact **hwrf-help@ucar.edu** with the subject line ***"HWRF Code Repository"***.

This website provides an overview of the HWRF Code Repository, how to request repository access, information about code management and how to contribute code back to HWRF, details on how to check out, build and update your code, and information on forecast skill. To start, navigate to the tab on the left entitled **Getting Started**, and select **Obtaining Repository Access**. If you have already been granted repository access, skip to the next tab entitled **Repository Structure**.

http://www.dtcenter.org/HurrWRF/developers

HWRF *contrib* repository

A repository serving as a hub for developers to exchange peer-supported code

Available utilities

- WBDump - Provides a mechanism to dump a WRF binary file. Download here.
- WBPlot - Plots a single variable or the difference between two variables contained in a WRF binary file. Download here.
- POMTC_matlab - Matlab scripts for plotting POM-TC output Download here.
- HYCOM-HWRF - Matlab scripts for plotting HYCOM-HWRF output Download here.
- Sat_verif - Scripts for GOES satellite verification Download here.

Developers share code related to HWRF (verification, obs processing, etc.), DTC distributes it to the community, Developers maintain and provide as much/little support as they wish

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Communication

- HWRF Developers Committee
  - Membership: 2 from DTC, 2 from EMC
  - All developers welcome to biweekly meetings
  - Forum for discussion, plans, and updates for development, including testing, evaluation, and technical aspects
- Mailing list for exchanging information about development, annoucements
  - hwrf_developers@rap.ucar.edu
  - All those with HWRF repository access are members

DTC Visitor Program

- Supports visitors to work w/ the DTC to test new forecasting & verification techniques, models & model components for NWP
  - PI project – up to 2 months support
  - Graduate student project - up to 1 year
- Announcement of opportunity: https://dtcenter.org/visitor-program/announcement-opportunity
- Contact knewman@ucar.edu, Evan.Kalina@noaa.gov - or other DTC staff member for more information!

https://dtcenter.org/visitors

Accepting proposals now!

http://www.dtcenter.org/visitors

DTC Visitor Program

DTC Visitor Program – Recent hurricane-related work		
Michael Iacono & John Henderson	AER	Testing Revisions to RRTMG Cloud Radiative Transfer and Performance in HWRF (2016)
Dev Niyogi & Subashini Subramanian	Purdue Univ	Developing Landfall Capability in Idealized HWRF for Assessing the Impact of Land Surface on Tropical Cyclone Evolution (2016)
Robert Fovell	SUNY-Albany	Impact of Planetary Boundary Layer Assumptions on HWRF Forecast Skill (2016)
Shaowu Bao	Coastal Carolina Univ	Evaluation of the microphysics scheme in HWRF 2016 version with remote-sensing data (2016)
Ting-Chi Wu	Colorado State Univ	Evaluation of the Newly Developed Observation Operators for Assimilating Satellite Cloud Precipitation Observations in GSI within HWRF system (2017)
Michael Iacono & John Henderson	AER	Testing Variations of Exponential-Random Cloud Overlap with RRTMG in HWRF (2017)
Jun Zhang	U. Miami and HRD	Evaluating the Impact of Model Physics on HWRF Forecasts of Tropical Cyclone Rapid Intensification (2017)

Research funded via DTC visitor program successfully contributing to HWRF development, HFIP goals

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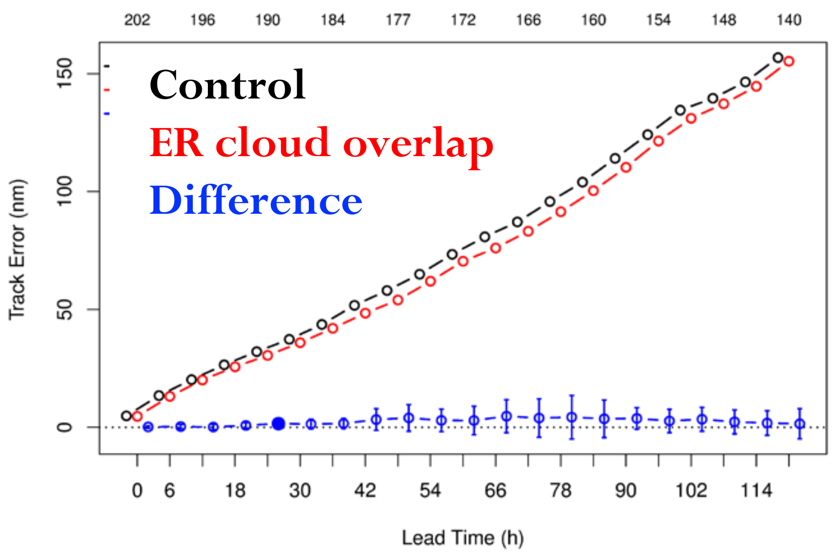
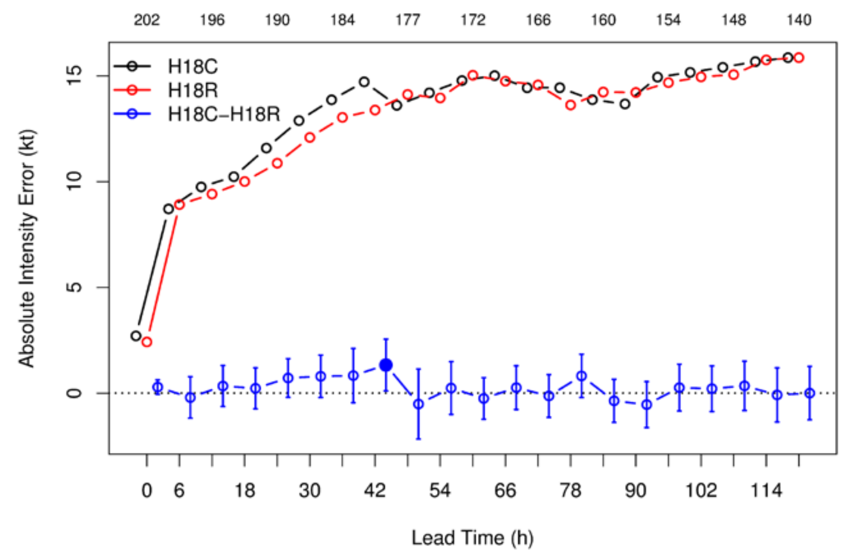
T&E: Alternate Cloud Overlap methodology

M. Iacono, J. Henderson (AER)

Mean Track Error



Mean Absolute Intensity Error

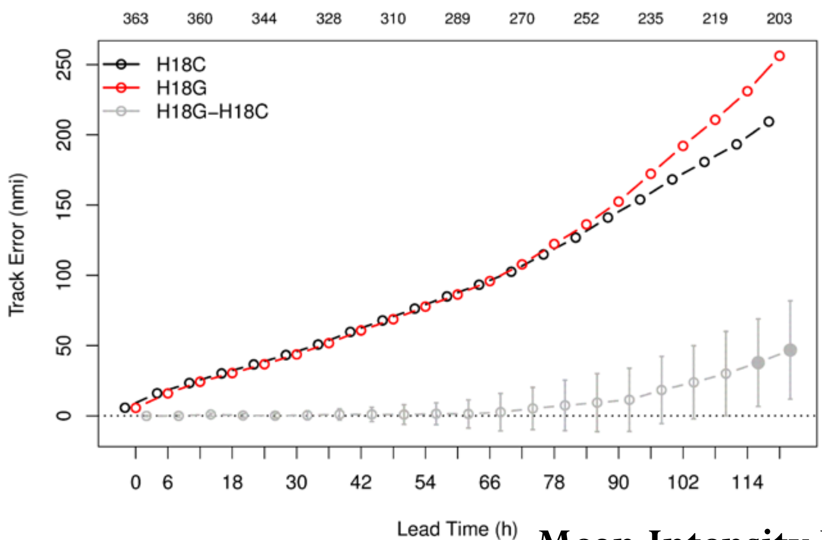


- Examined the effect of replacing the default maximum-random (MR) cloud overlap assumption with an exponential cloud overlap method within the RRTMG
- Tested during pre-implementation period – accepted for 2018 operational HWRF
- Follow-up project implementing exponential-random cloud overlap underway

GF SASAS Difference

T&E: Grell-Freitas cumulus

Mean Track Error



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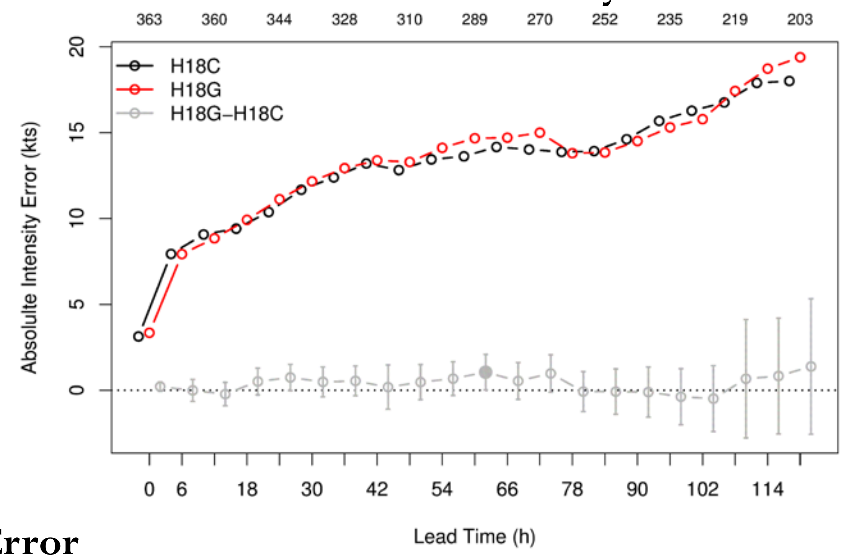
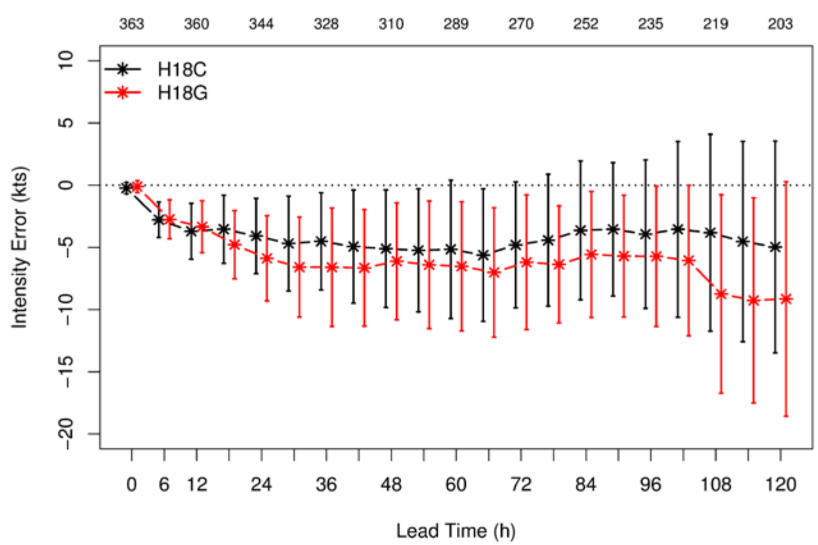


Mean Intensity Error



Storms:
Fred, Fiona, Hermine, Harvey, Irma, Kate, Jose, Nicole, Maria, Nate, Ophelia

Degradation in track forecasts for GF configuration at longest lead times

Neutral intensity errors differences between the GF and SASAS

Negative intensity bias present in both configurations

Summary

- DTC facilities access to HWRF code for users and developers
- Resources, websites, and documentation are available
- Critical for developers to follow code management best practices to make code available for operational testing
- DTC can be a resource for testing potential developments before operational implementation

- We are here to help! Please contact us if you would like more information on the development process

Part II: HWRF model evaluation using Coyote UAS and Dropsonde data

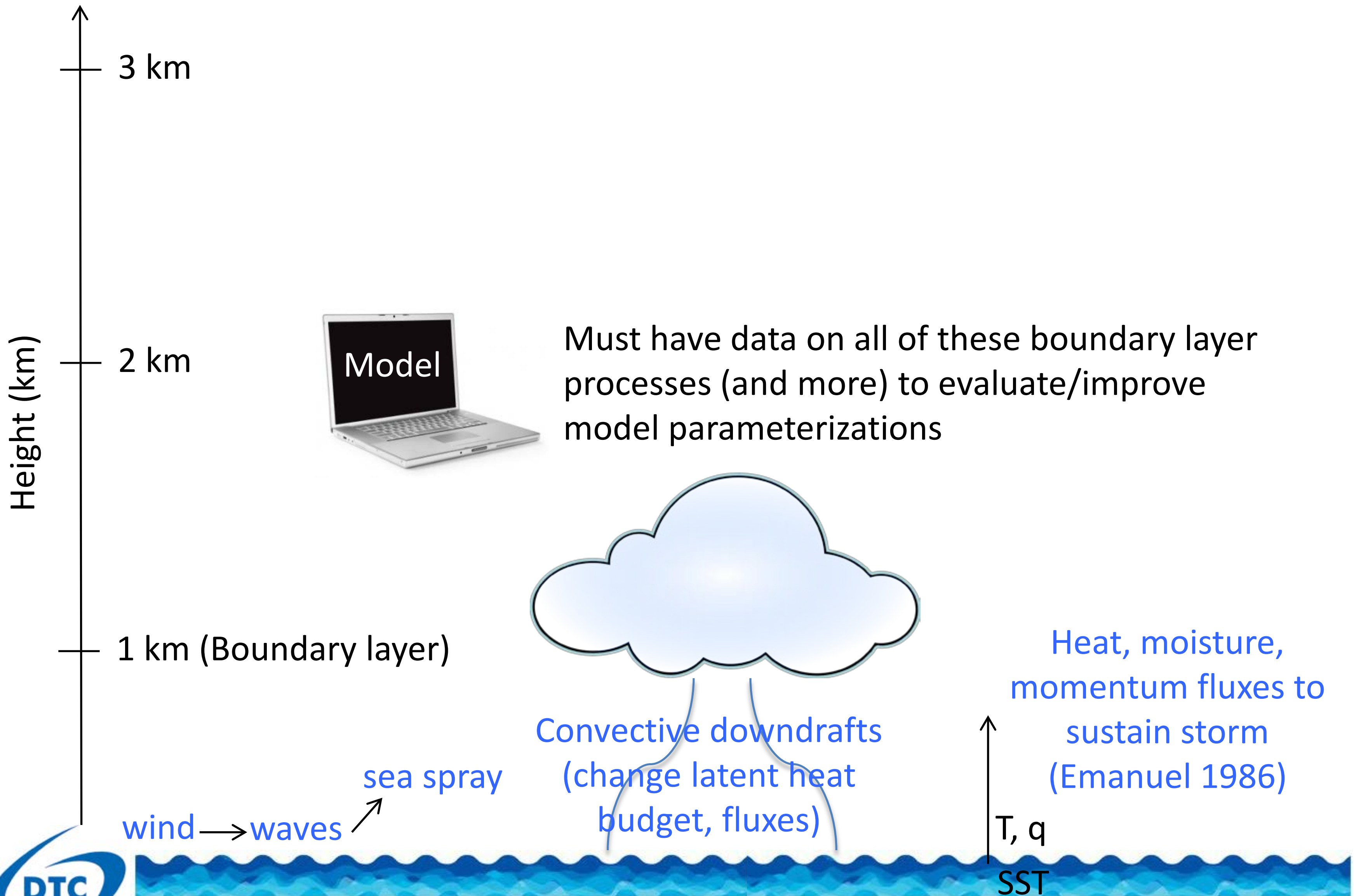
Evan Kalina

CIRES at NOAA/ESRL/GSD

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

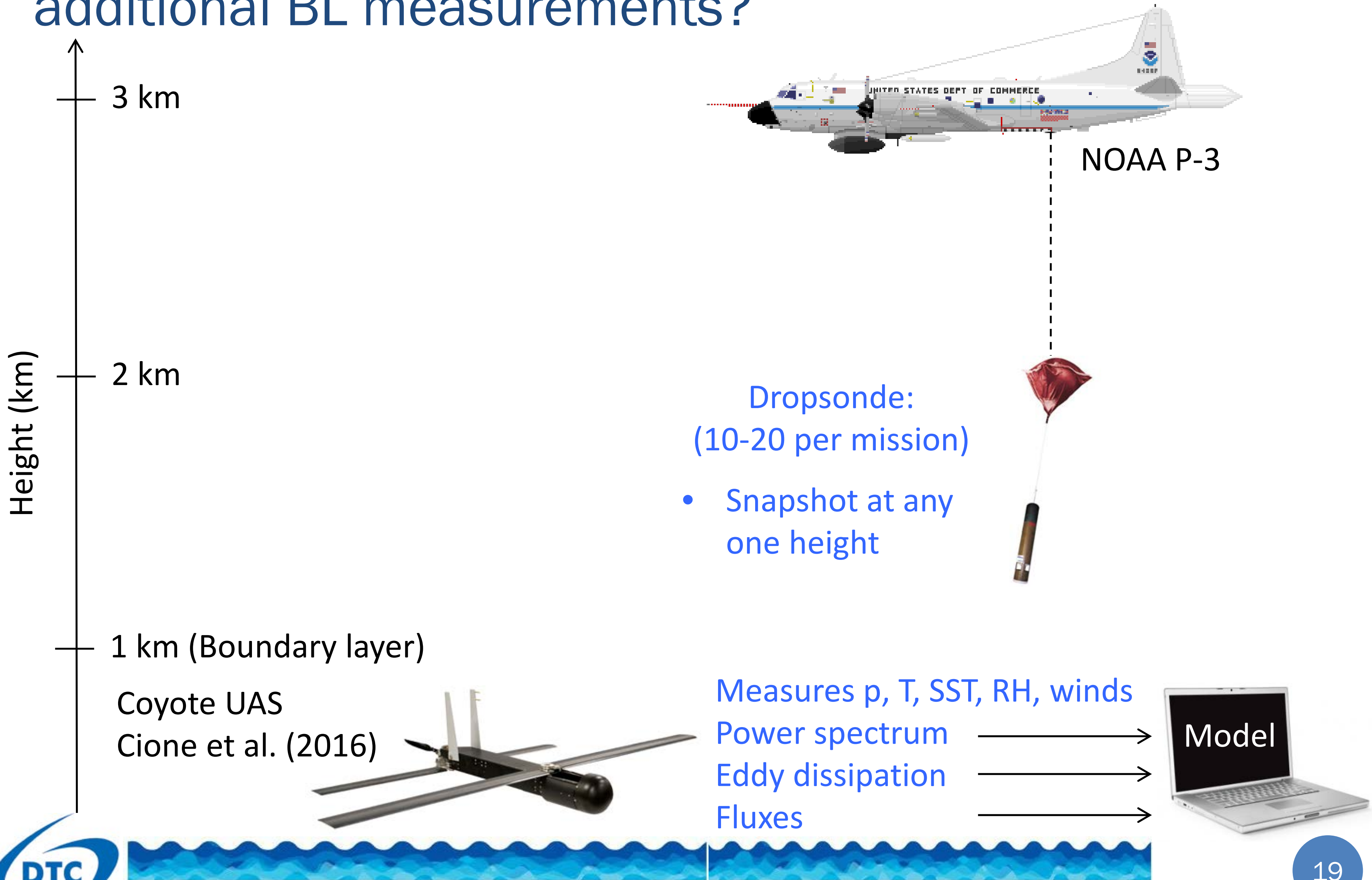
1 km (Boundary layer)

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 for additional data

NOAA P-3

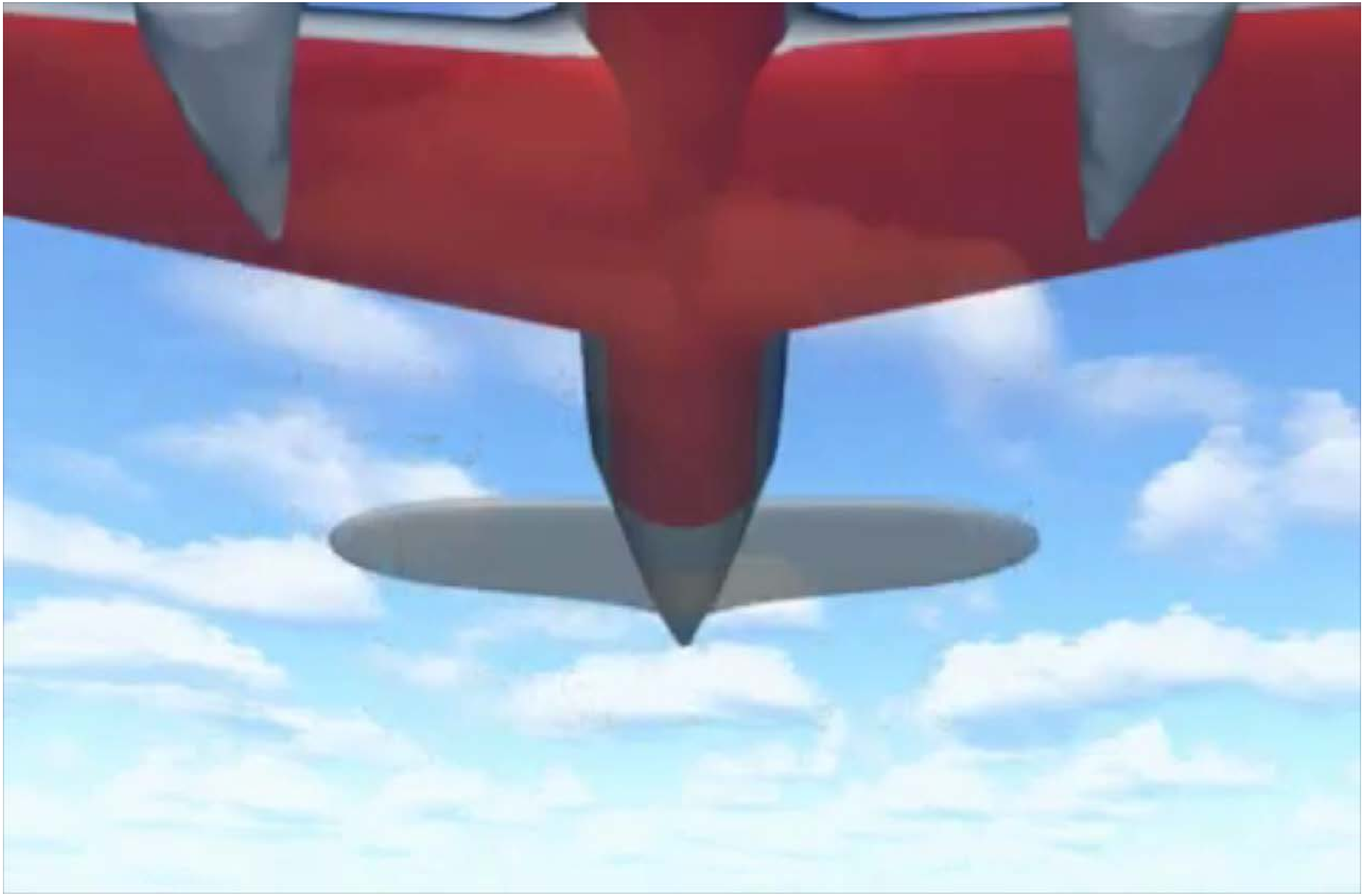
Today, the NOAA P-3 flies at 3 km. How do we obtain additional BL measurements?



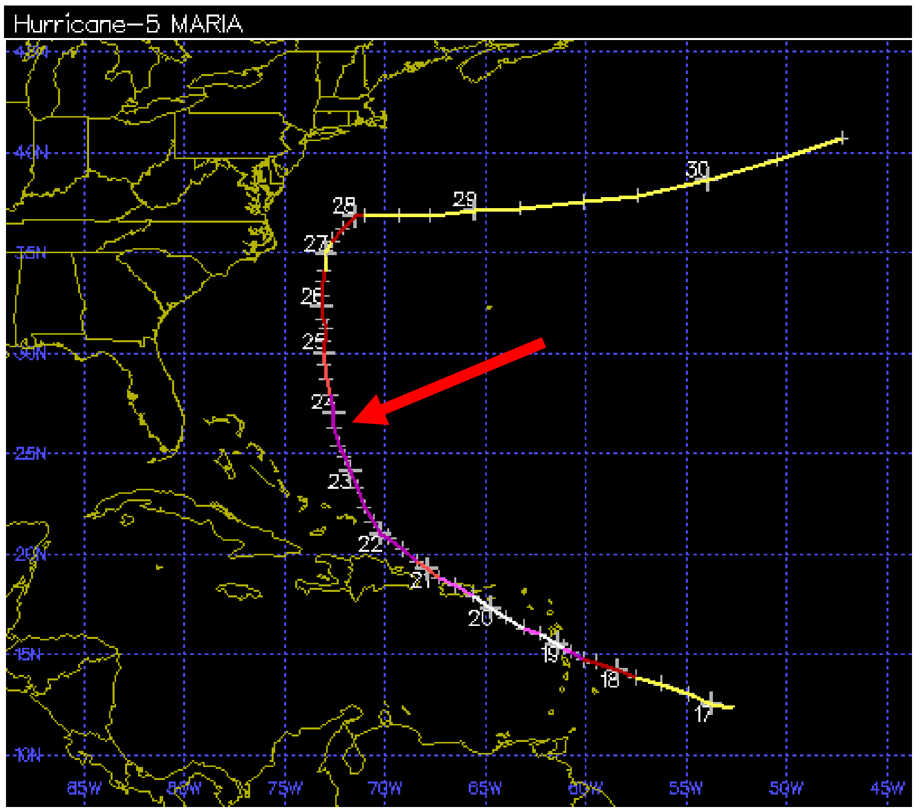
Coyote UAS: Fast facts

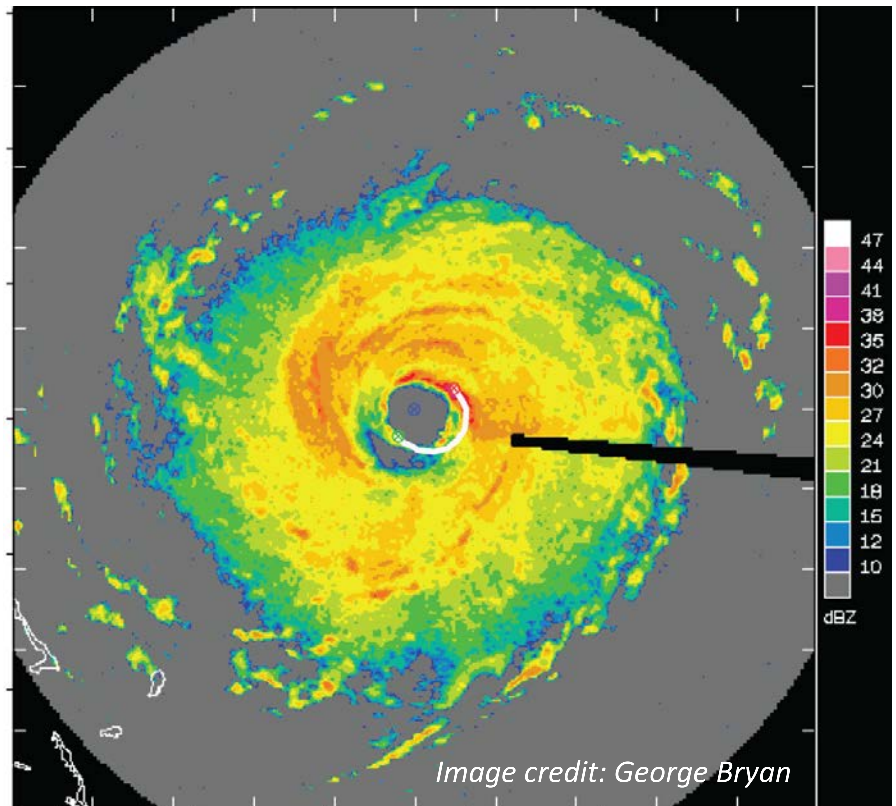
Dimensions	0.91 m length, 1.47 m wingspan
Mass	6 kg
Sensors	p, T, RH, winds (from GPS); all 1-3 Hz
Delivery	Air-deployable thru P-3 sonobuoy chute
Control	Piccolo autopilot; commands issued from P-3

Image credit: Raytheon

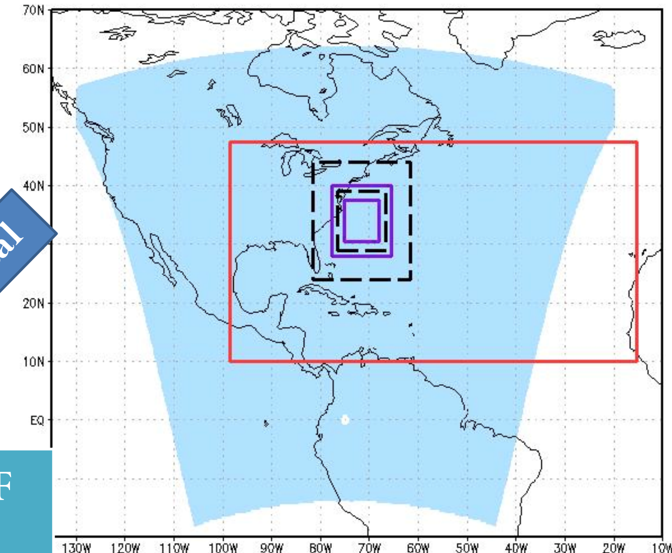


A Coyote UAS flight on 23 September 2017 sampled the eyewall of Hurricane Maria (100 kt, 952 mb)





Compare UAS data to two HWRF configurations: H18C and H18G



Baseline

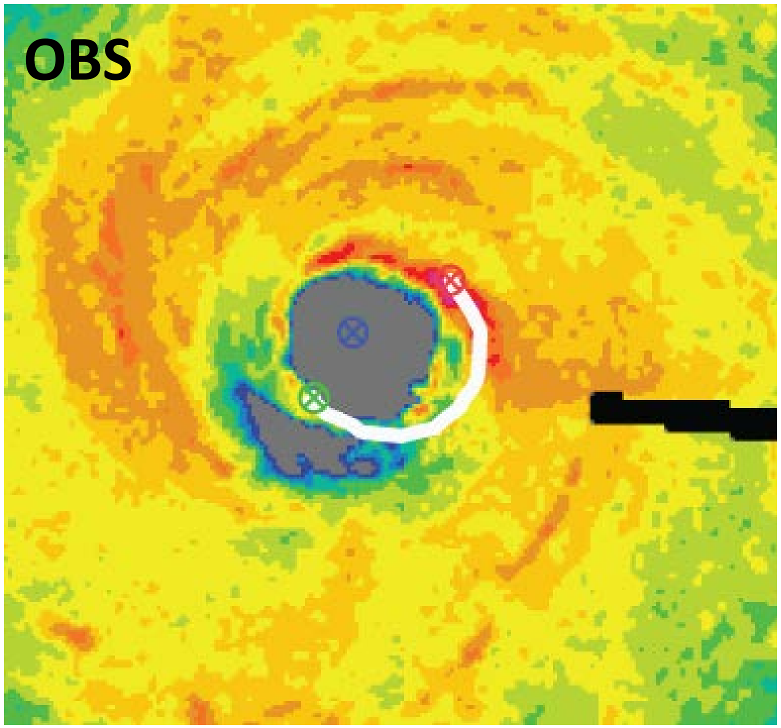
Experimental

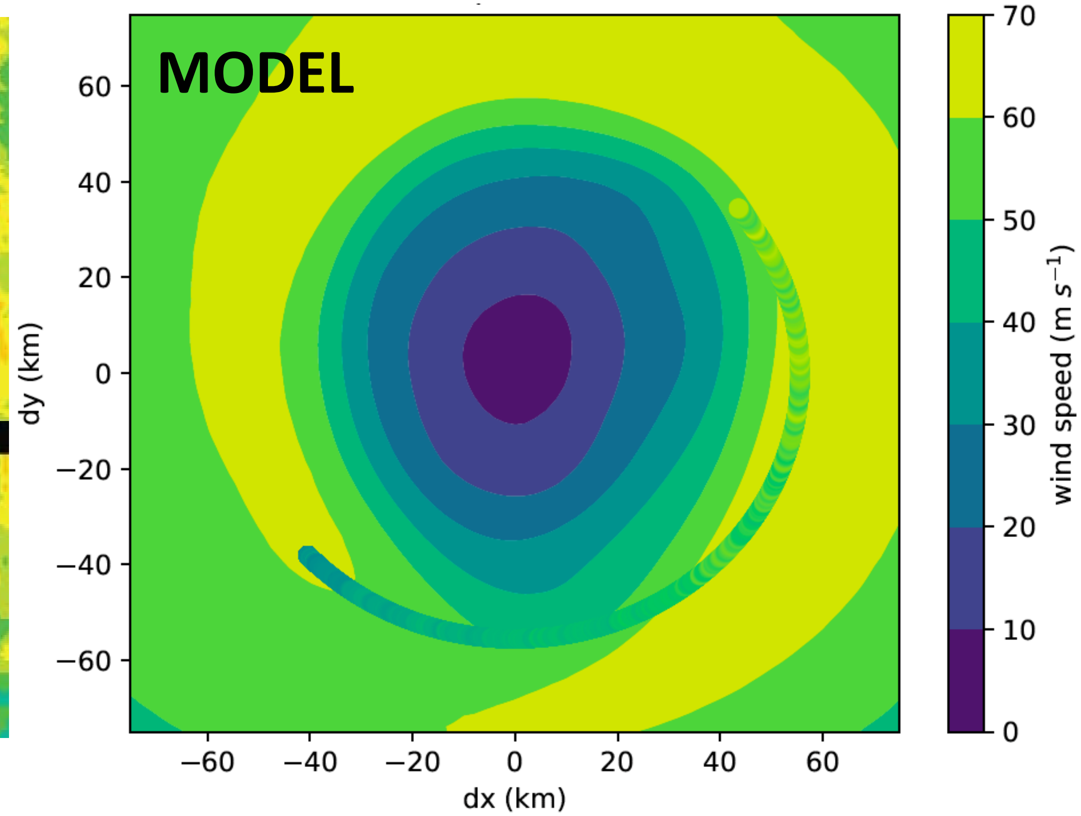
	HWRF with SASAS (H18C)	HWRF with GF (H18G)
Cumulus	Scale Aware SAS	**GF**
Microphysics	Ferrier-Aligo	Ferrier-Aligo
Surface layer	HWRF	HWRF
Land surface	Noah LSM	Noah LSM
PBL	GFS Hybrid EDMF	GFS Hybrid EDMF
Radiation	RRTMG	RRTMG

- 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

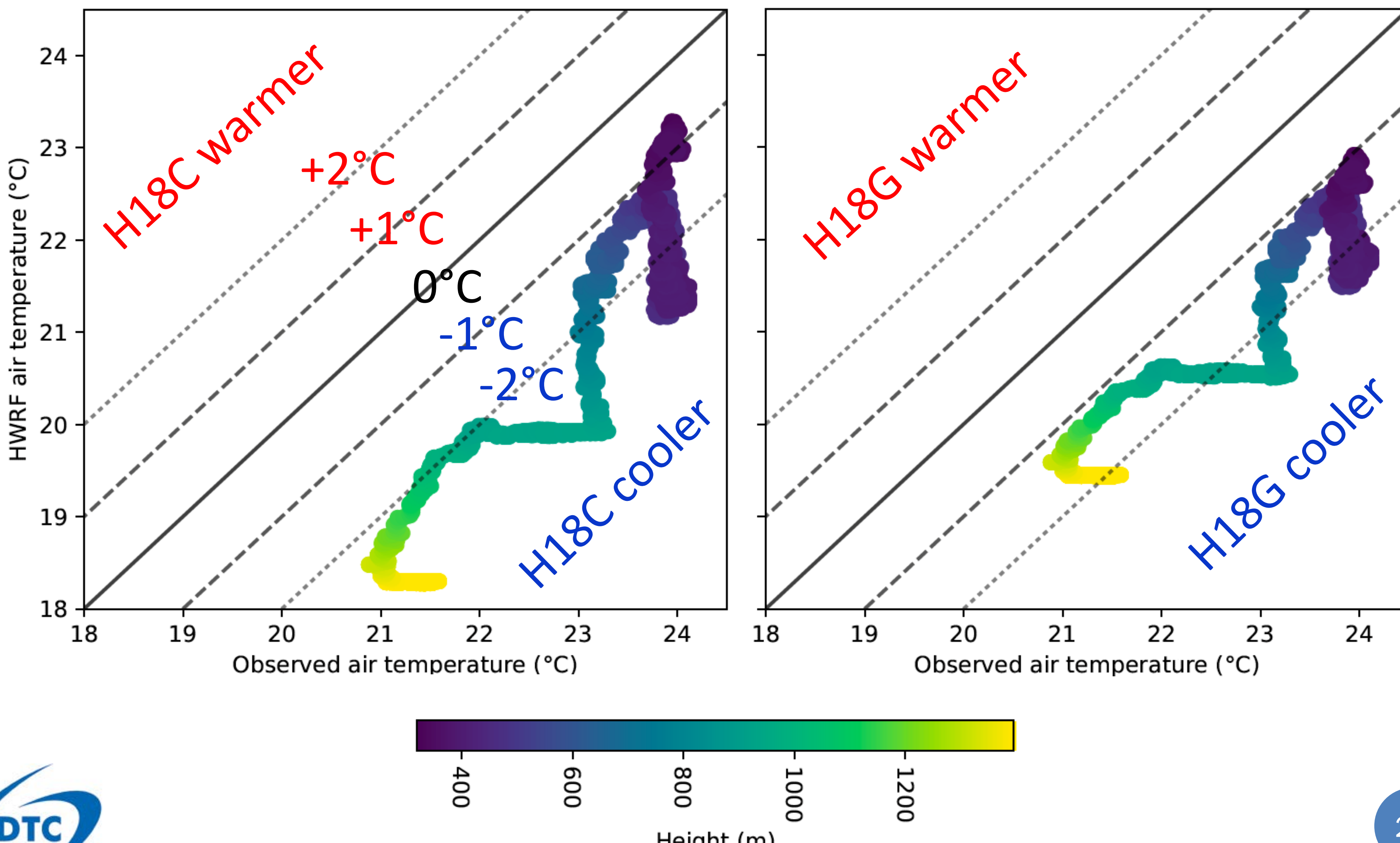
H18G considered by EMC for operational implementation this year

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).





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



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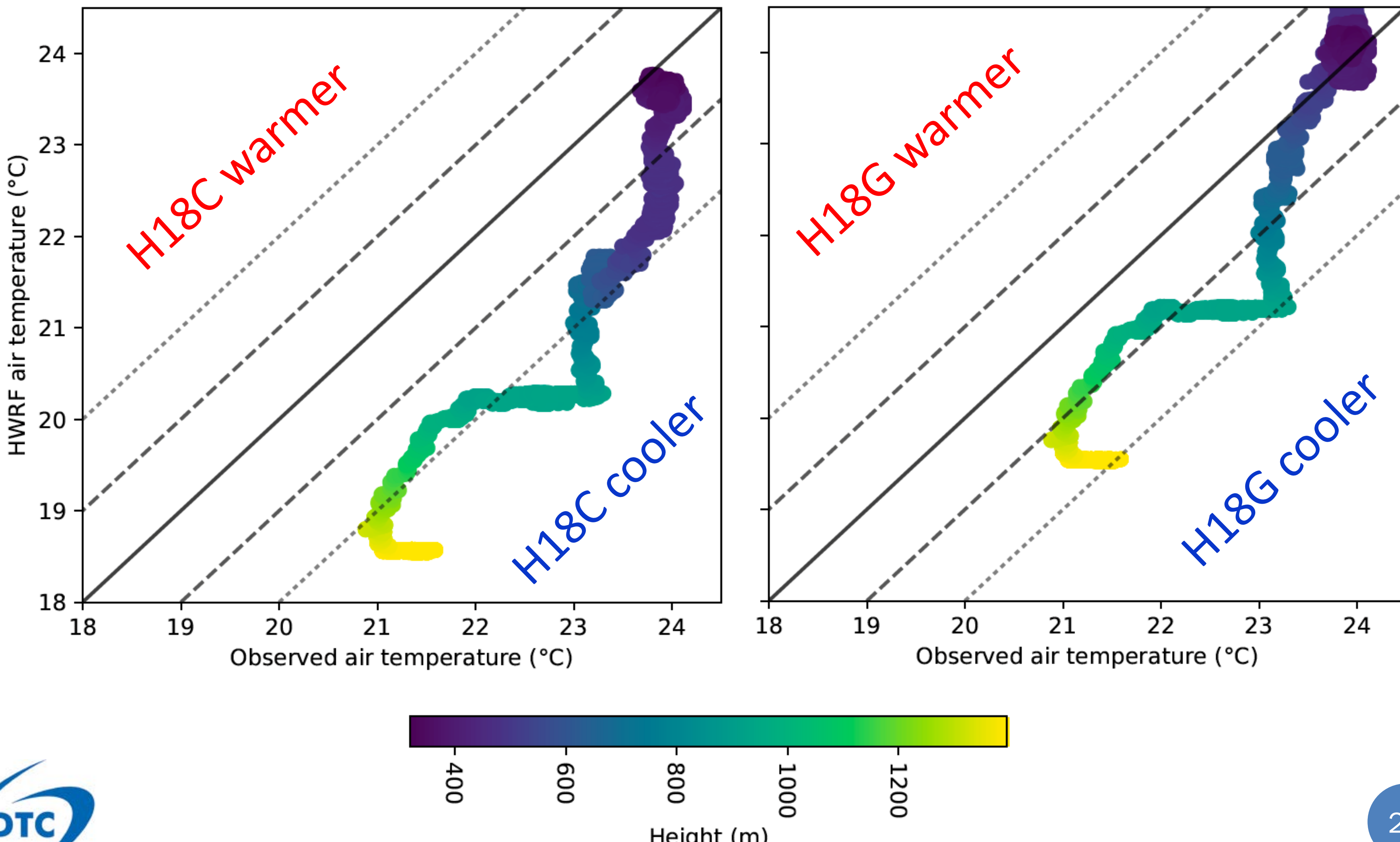
At forecast hour 72, the cool bias is reduced in H18G by ~1°C



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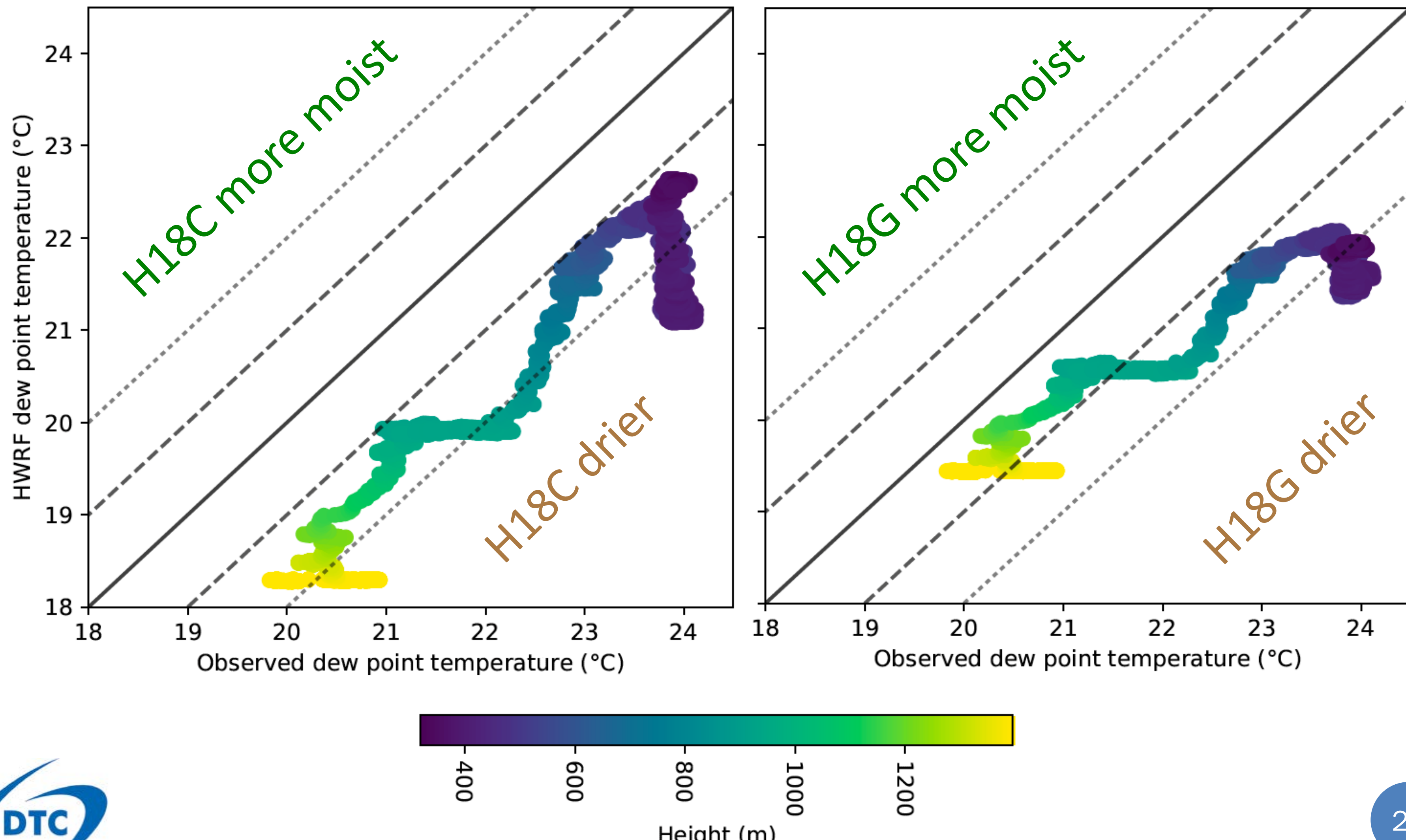
At the initial time, dry bias of 1.5–2°C in both configurations



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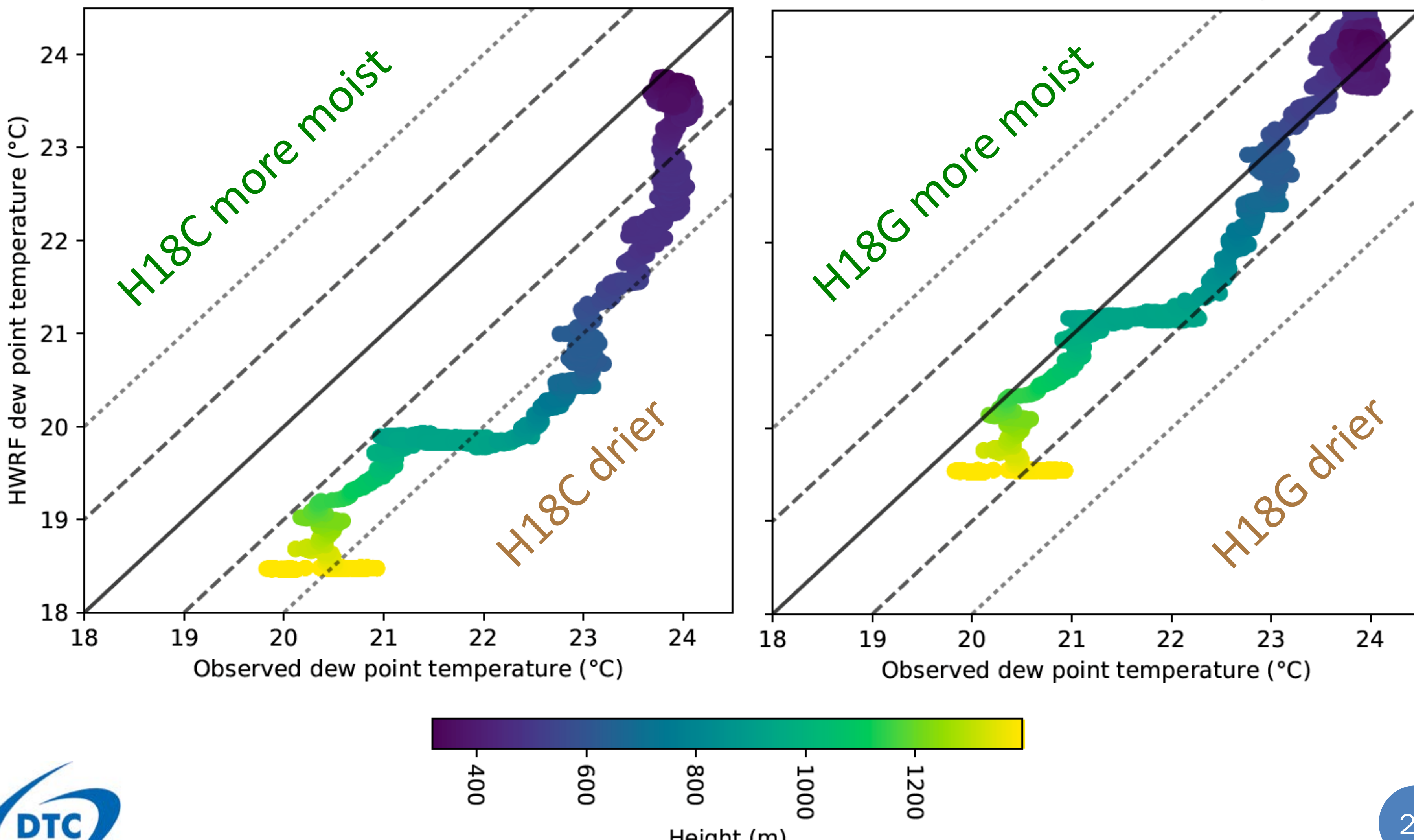
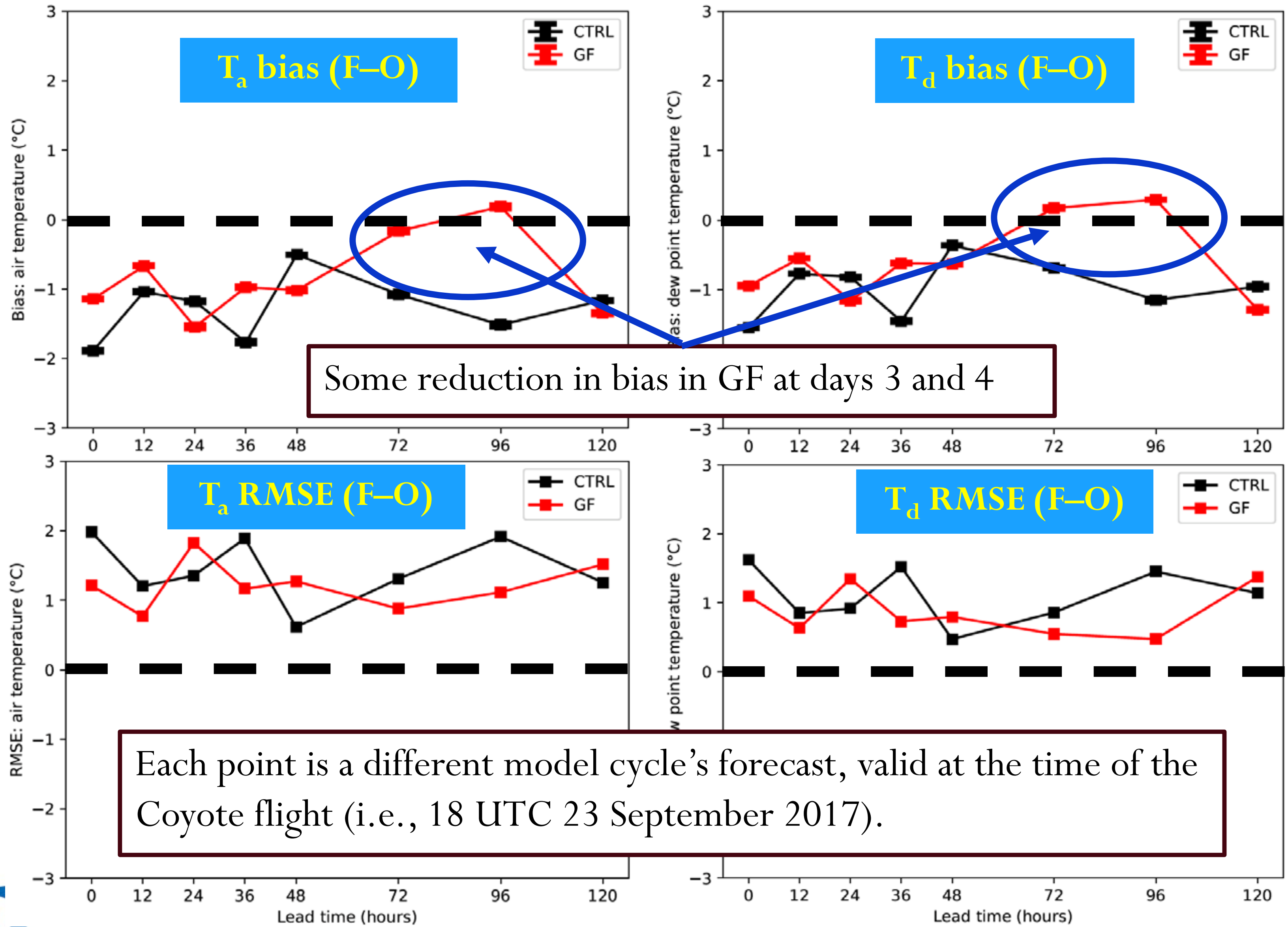
At forecast hour 72, the dry bias is still present in H18C, but not in H18G



H18G improvements are uneven across forecast cycles



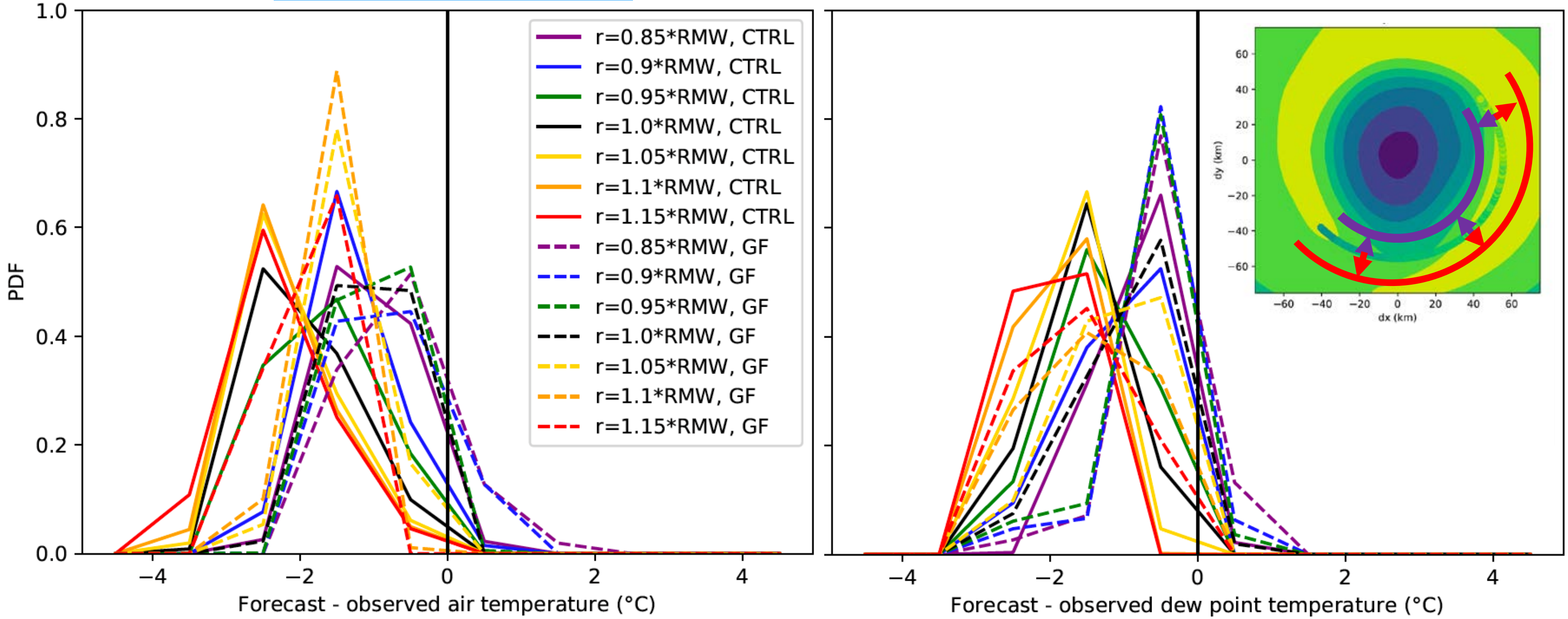
Some reduction in bias in GF at days 3 and 4

Each point is a different model cycle's forecast, valid at the time of the Coyote flight (i.e., 18 UTC 23 September 2017).

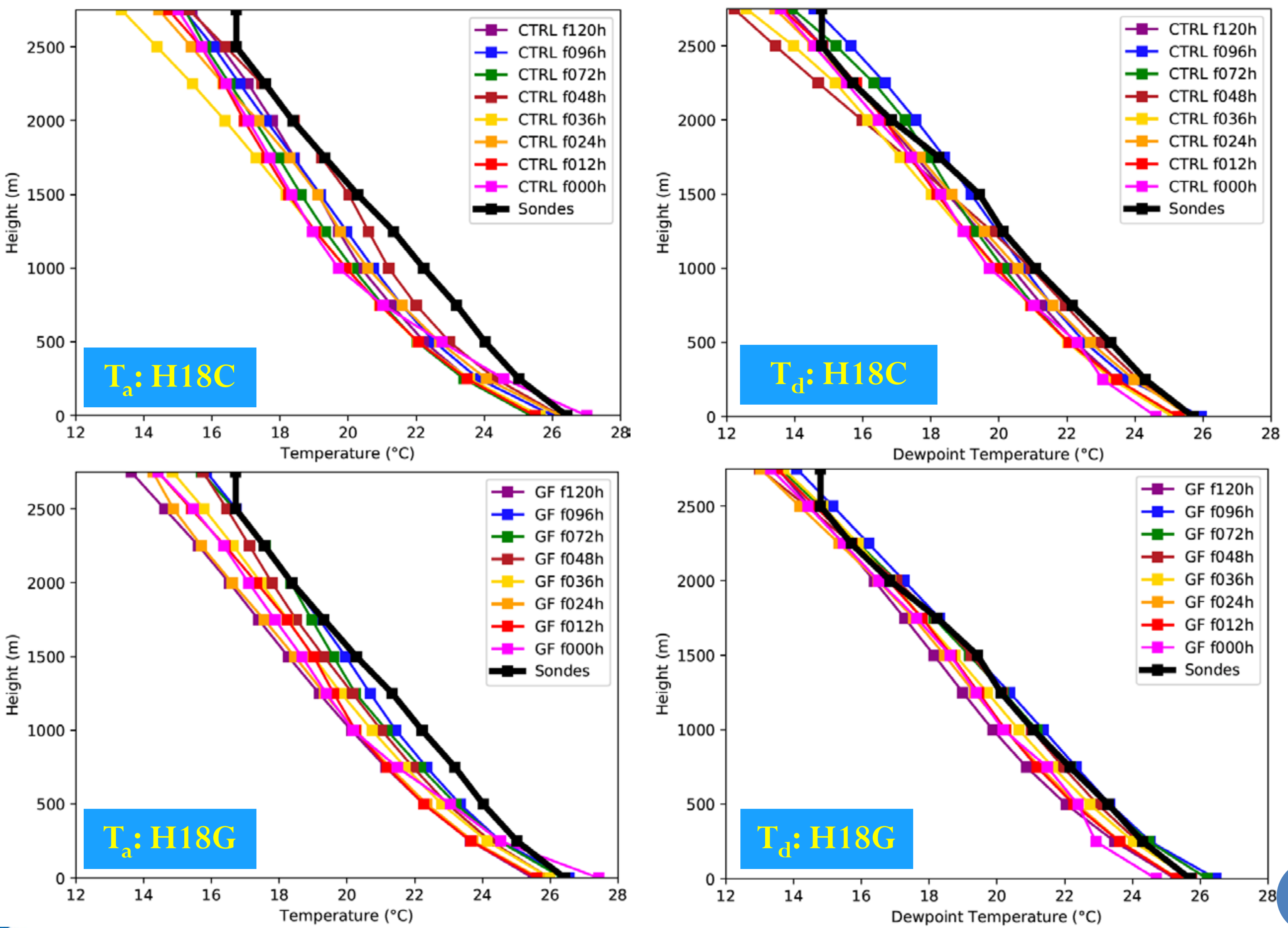
Small changes in the radial location of the simulated Coyote flight do not change results

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

Thank you!

- Questions?

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Resources:

http://www.dtcenter.org/HurrWRF/users
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