Characteristics of Convective Cold Pools in CPEX

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Shuyi S. Chen

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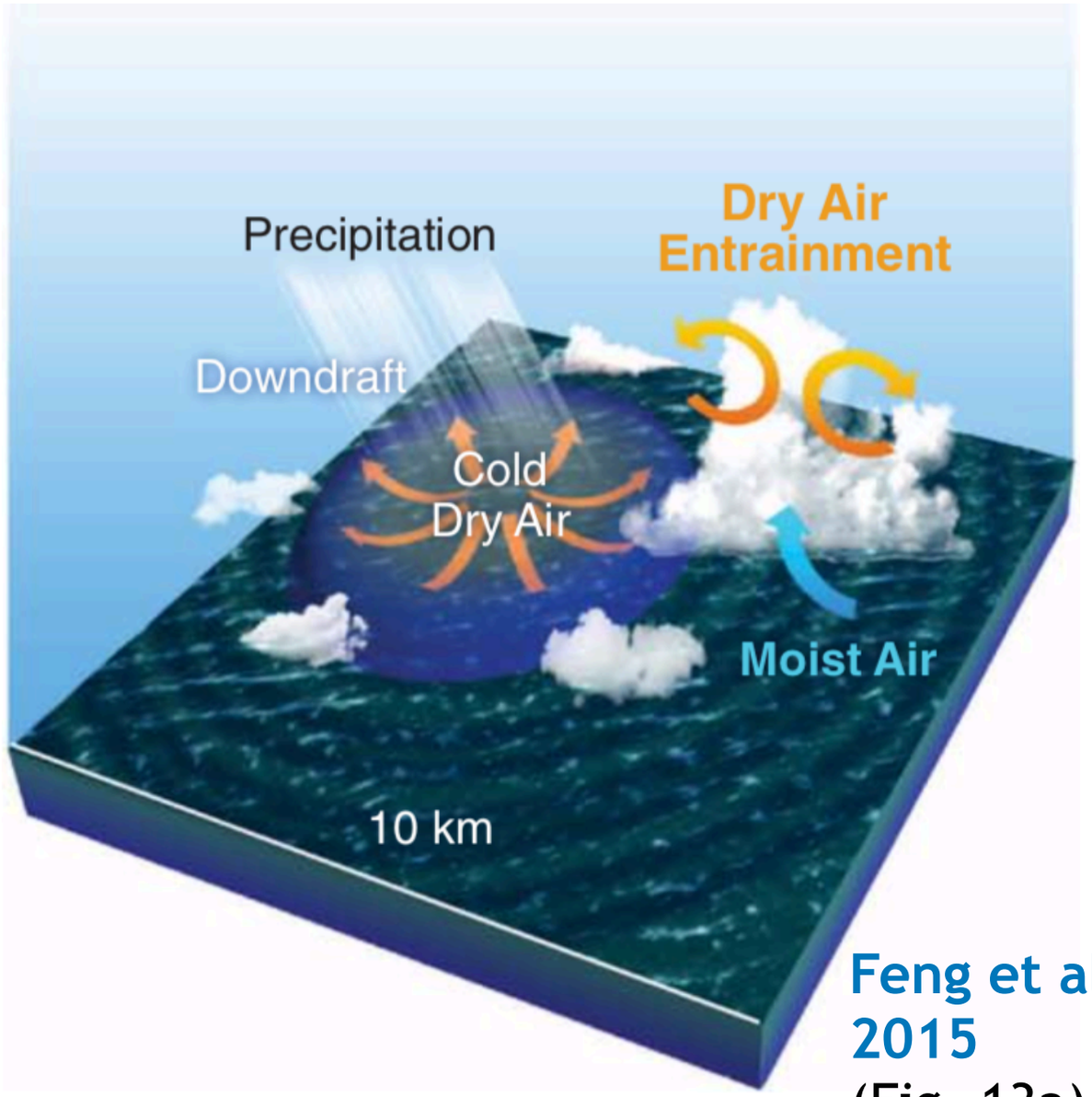
Introduction

Convective cold pools:

- Regions of evaporatively cooled air that has been transported to the surface through convective downdrafts.
- Represent a link in the multi-scale interactions among convective cloud systems, their large-scale environment, the atmospheric boundary layer, and the ocean.



Feng et al. 2015
(Fig. 13a)

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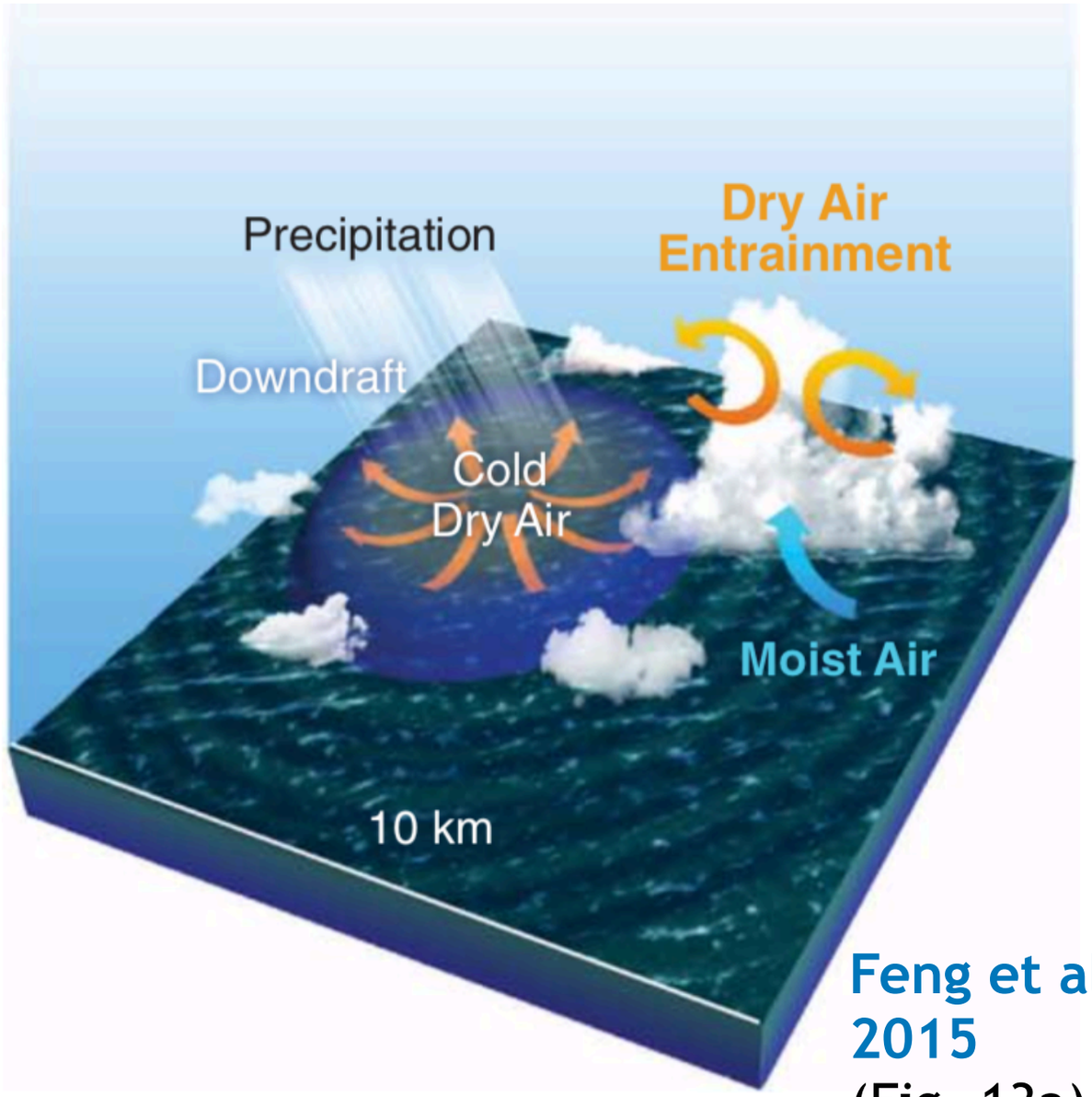
Objective:

- to investigate cold pool characteristics observed by CPEX dropsondes in the Gulf of Mexico, Caribbean and Atlantic.



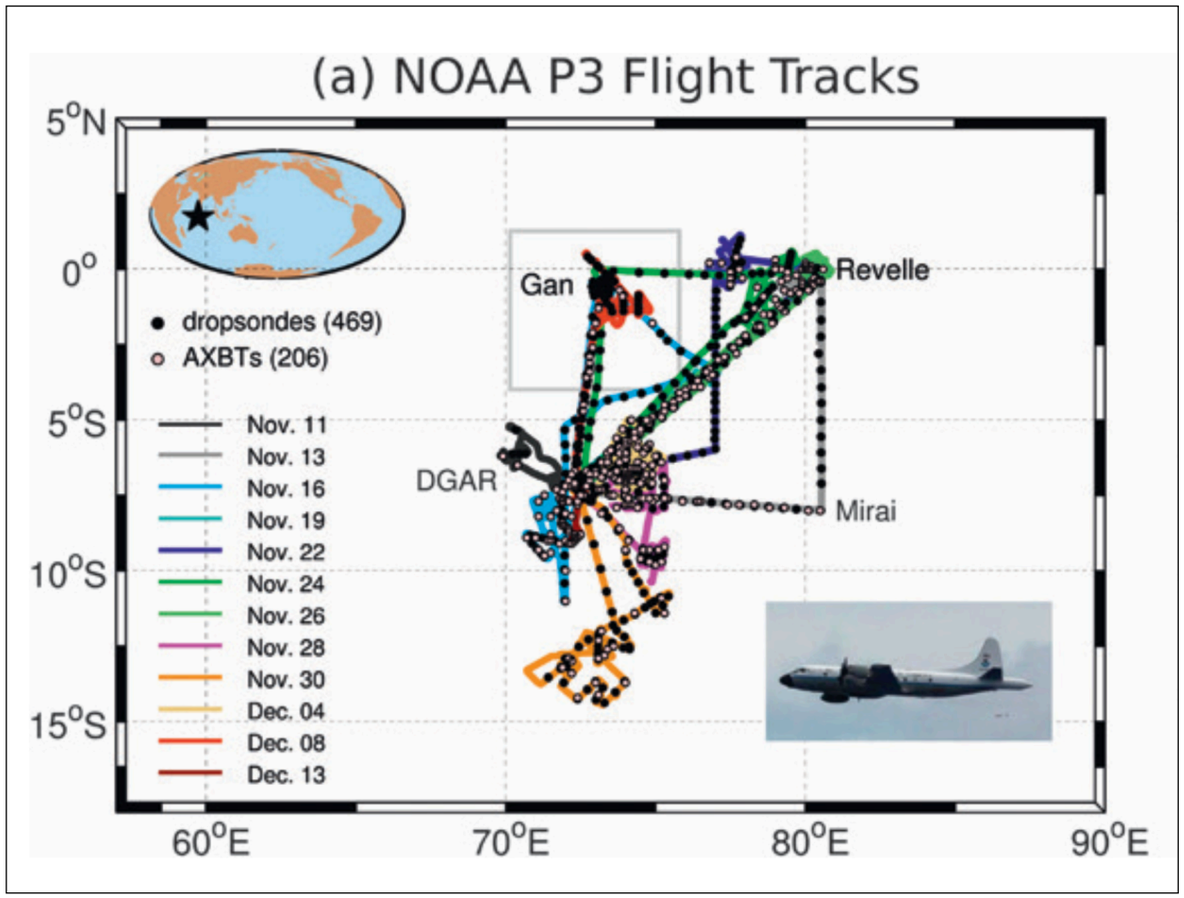
Feng et al. 2015
(Fig. 13a)

Motivation: DYNAMO field campaign

DYNAMO: Dynamics of the Madden-Julian Oscillation, central equatorial Indian Ocean, October 2011-March 2012.

NOAA P3 aircraft:

- 12 missions targeting large convective systems through all phases of the MJO.



Chen et al. 2016 (Fig. 1a)

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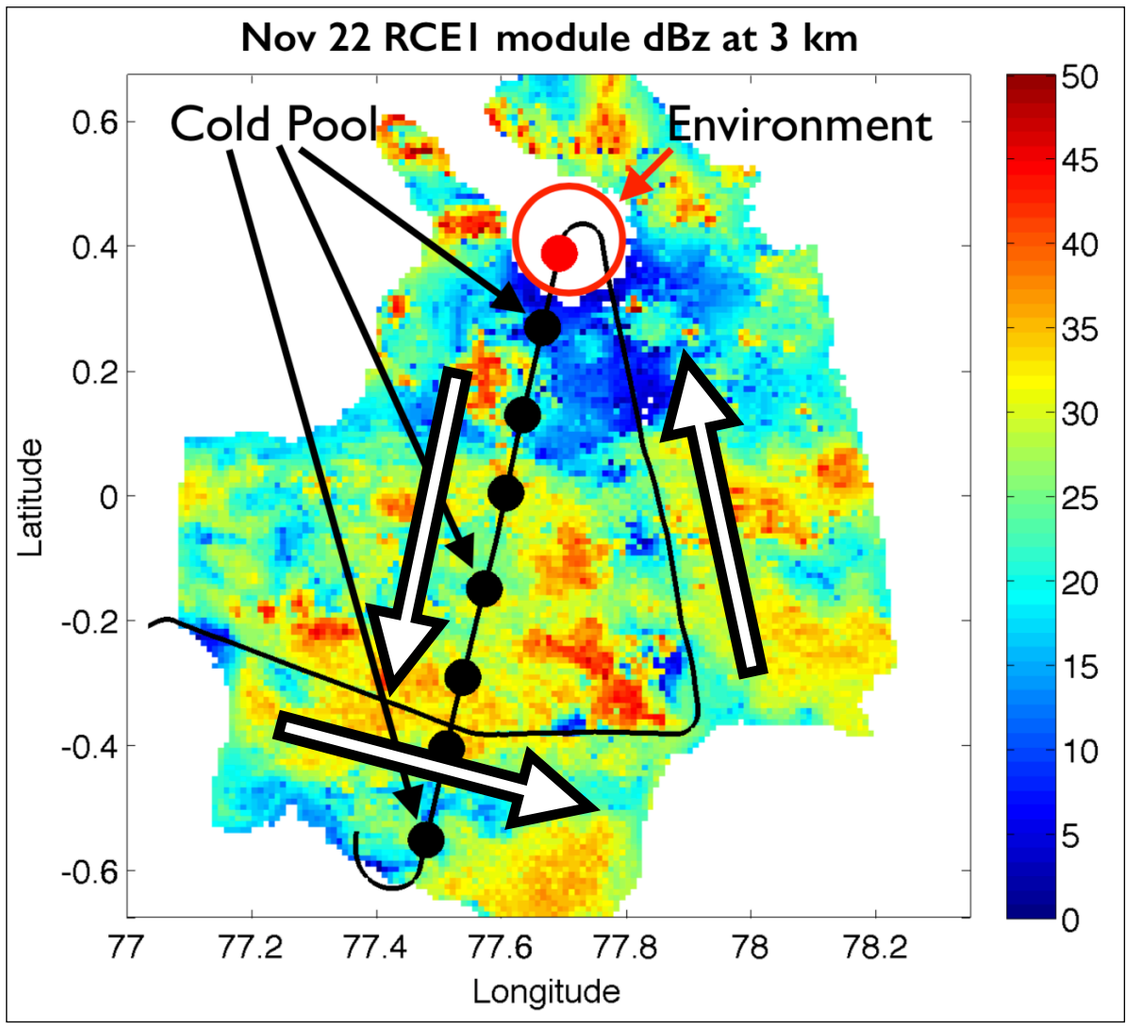

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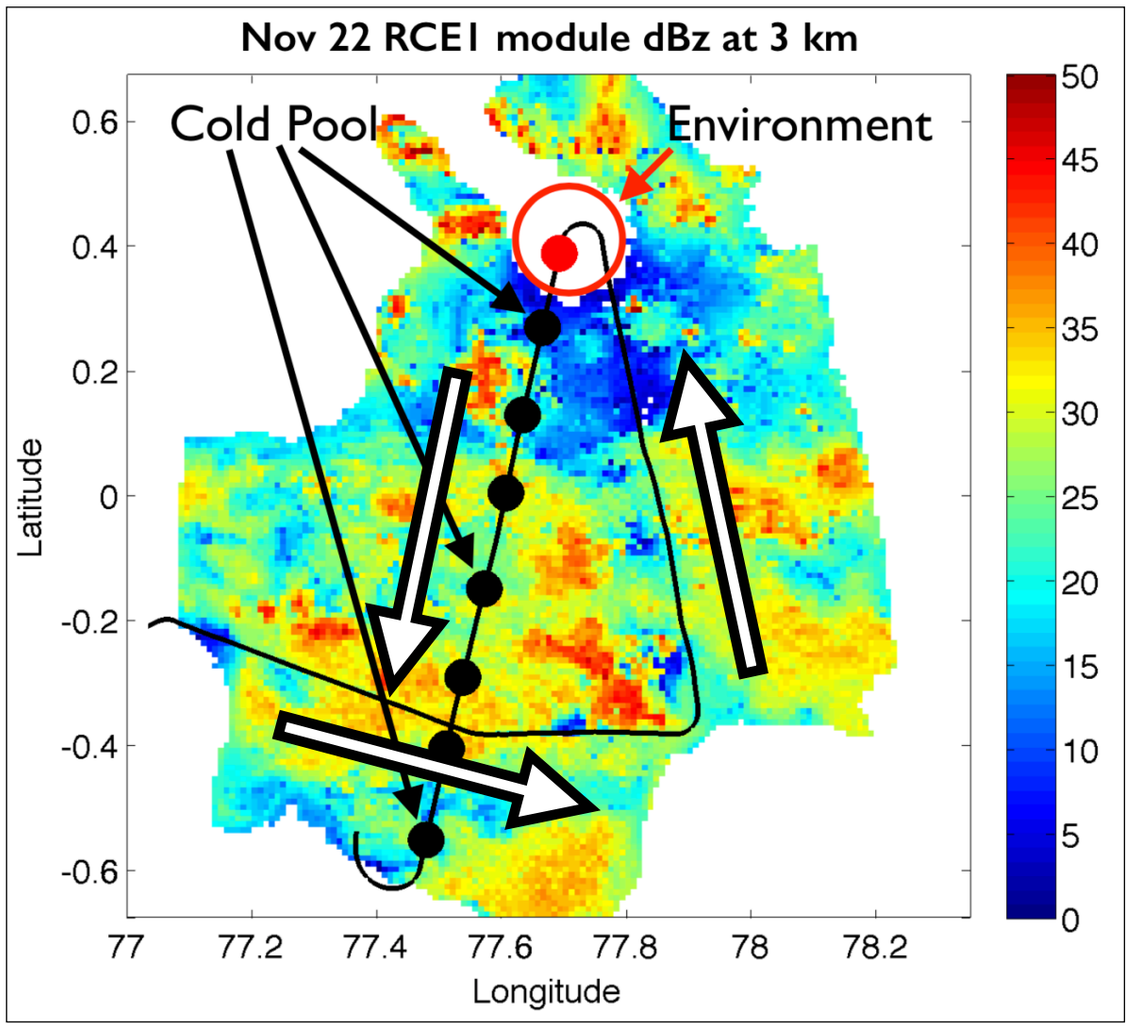
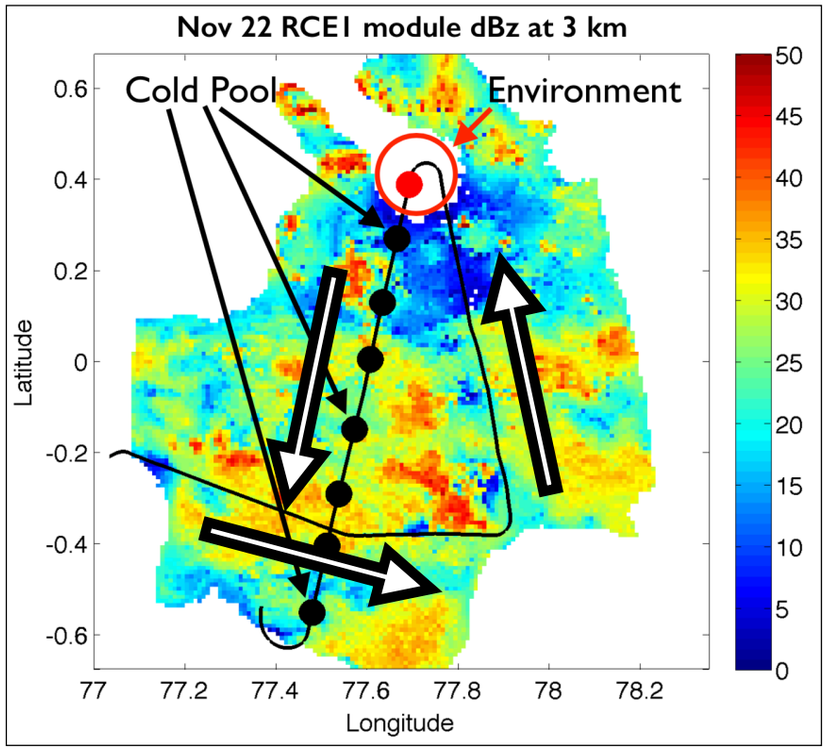
- 12 missions targeting large convective systems through all phases of the MJO.
- Targeted flight pattern to sample cold pools and their environment.
- Instruments: vertically-scanning Doppler radar, dropsondes, and AXBTs.



DYNAMO Methodology

Identify cold pool and environment profiles.



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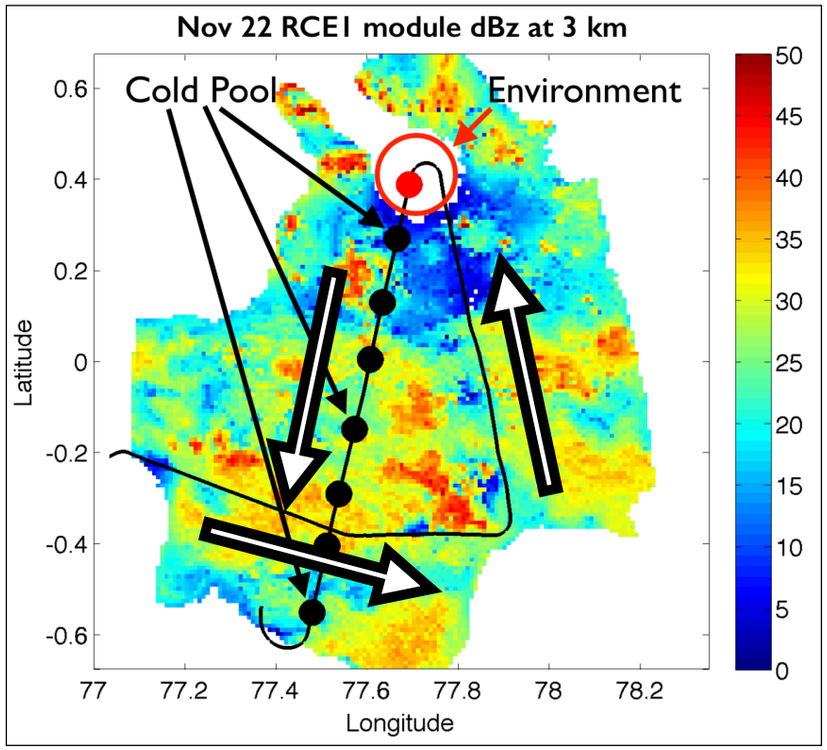
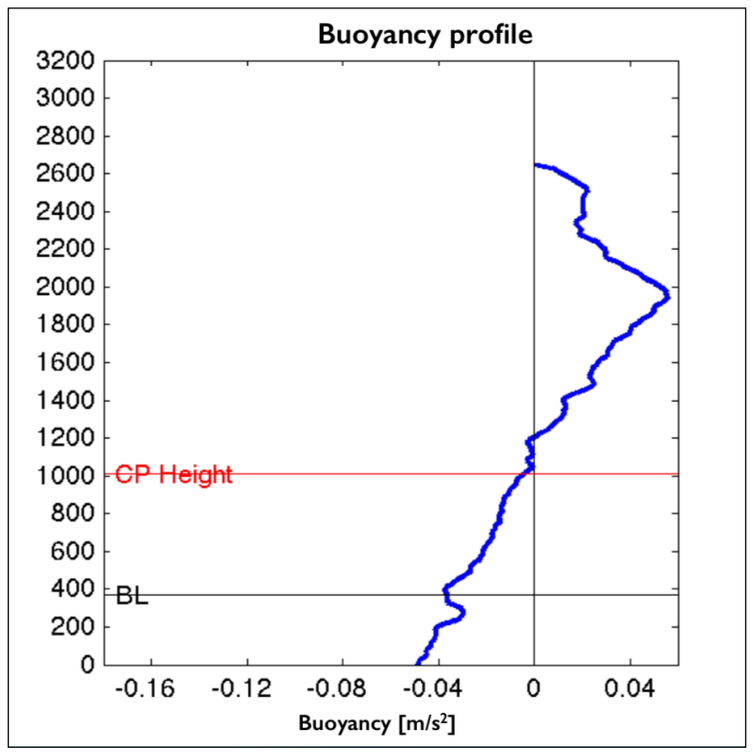


Each environment-cold pool pair is used to calculate buoyancy.

$$B = g\left(\frac{\theta_{cp} - \overline{\theta}}{\overline{\theta}} + 0.61(q_{v_{cp}} - \overline{q_v})\right)$$



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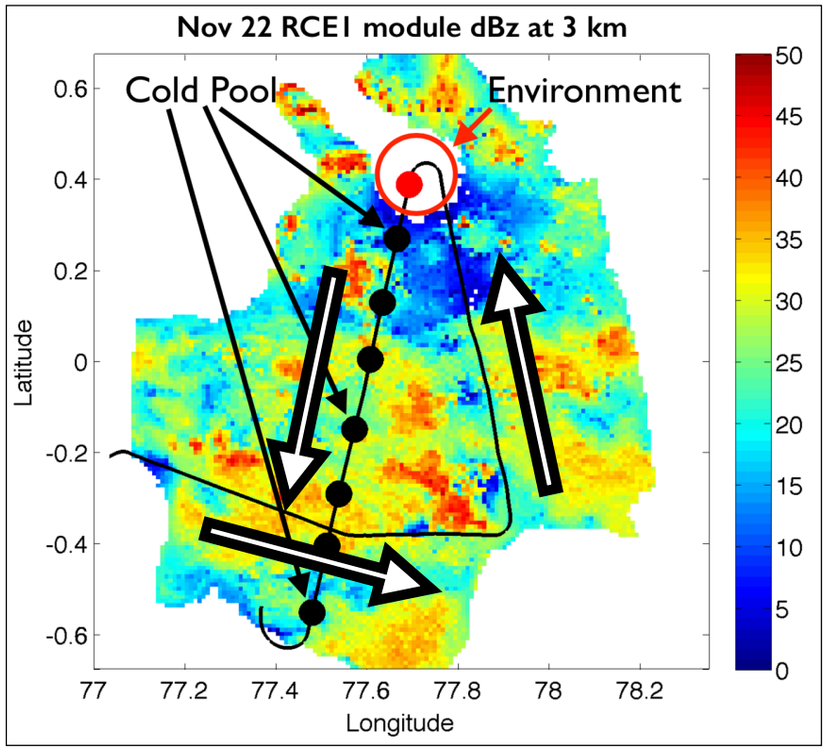

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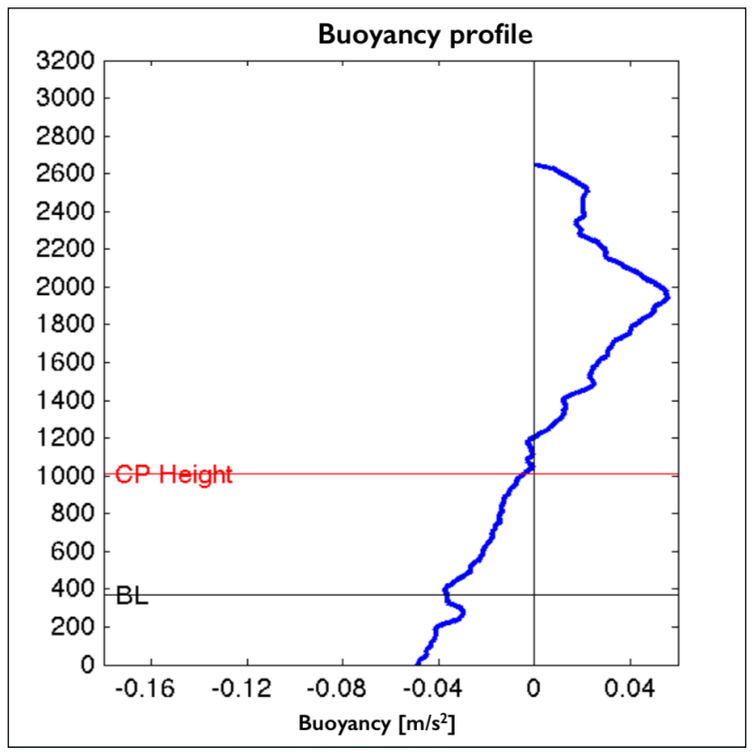


Infer environment and cold pool properties:

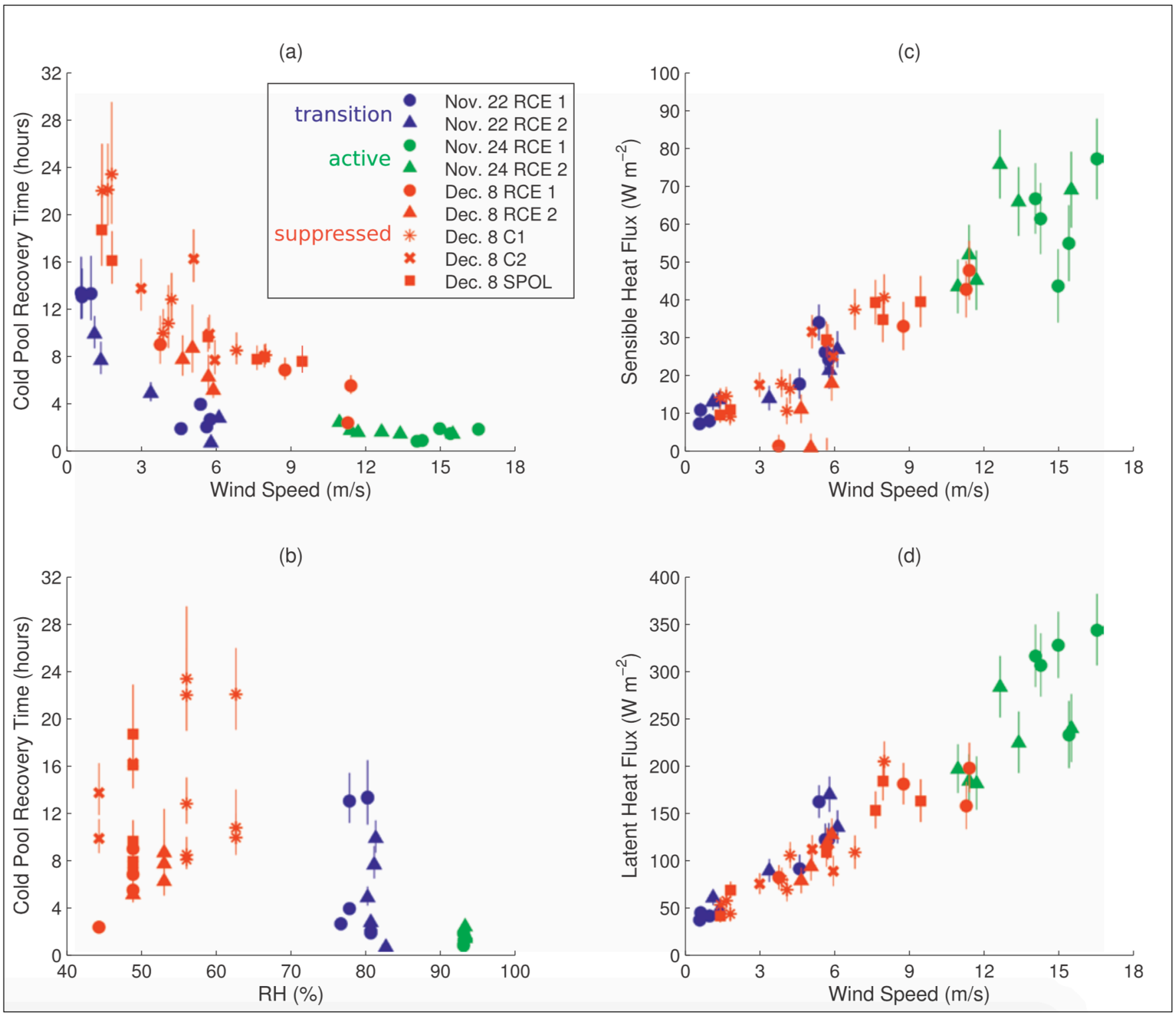
- BL height
- cold pool height (Tompkins 2001)
- cold pool intensity (Bryan et al. 2005)

$$C^2 = -\frac{1}{\overline{\rho}_{\mathrm{sfc}}}\int_0^{\mathrm{CPH}} (B\overline{\rho})dz$$

- cold pool recovery time (Jorgensen et al. 1997)

$$t_r = \mathrm{BLH}\left(\frac{\Delta_z\overline{\theta}\Delta_t\langle\overline{q_v}\rangle - \Delta_z\overline{q_v}\Delta_t\langle\overline{\theta}\rangle}{\overline{LH}_{\mathrm{sfc}}\Delta_z\overline{\theta} - \overline{SH}_{\mathrm{sfc}}\Delta_z\overline{q_v}}\right)$$

DYNAMO Results



ACTIVE MJO

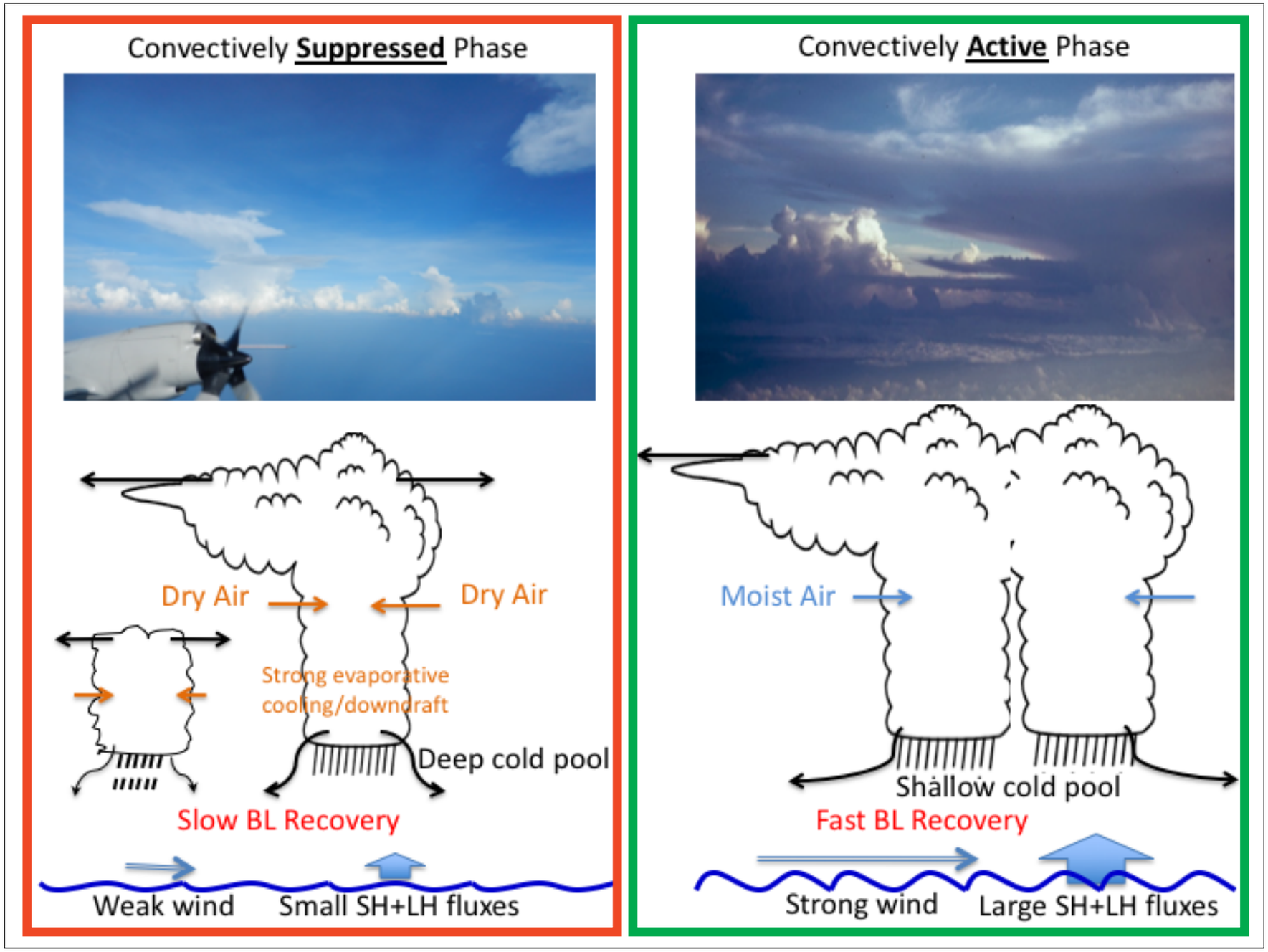
- Moist environment,
- Strong surface winds,
- High air-sea fluxes,
- Short recovery time.

SUPPRESSED MJO

- Drier environment,
- Deep cold pools,
- Longer recovery times.

Chen et al. 2016 (Fig. 14)

DYNAMO Results



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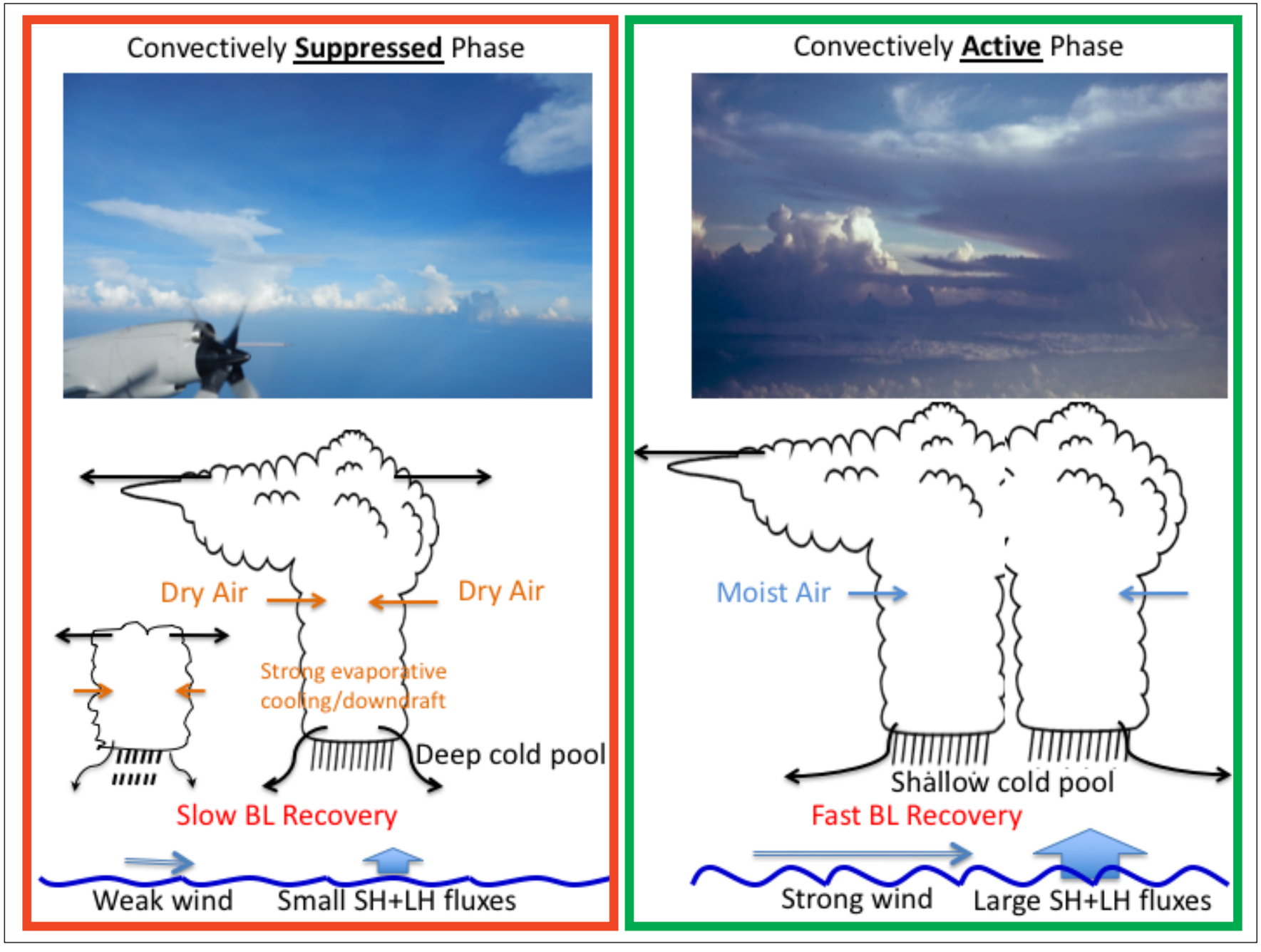
Expectations for CPEX?



Gulf of Mexico

- Larger convective systems
- Environment similar to active MJO?

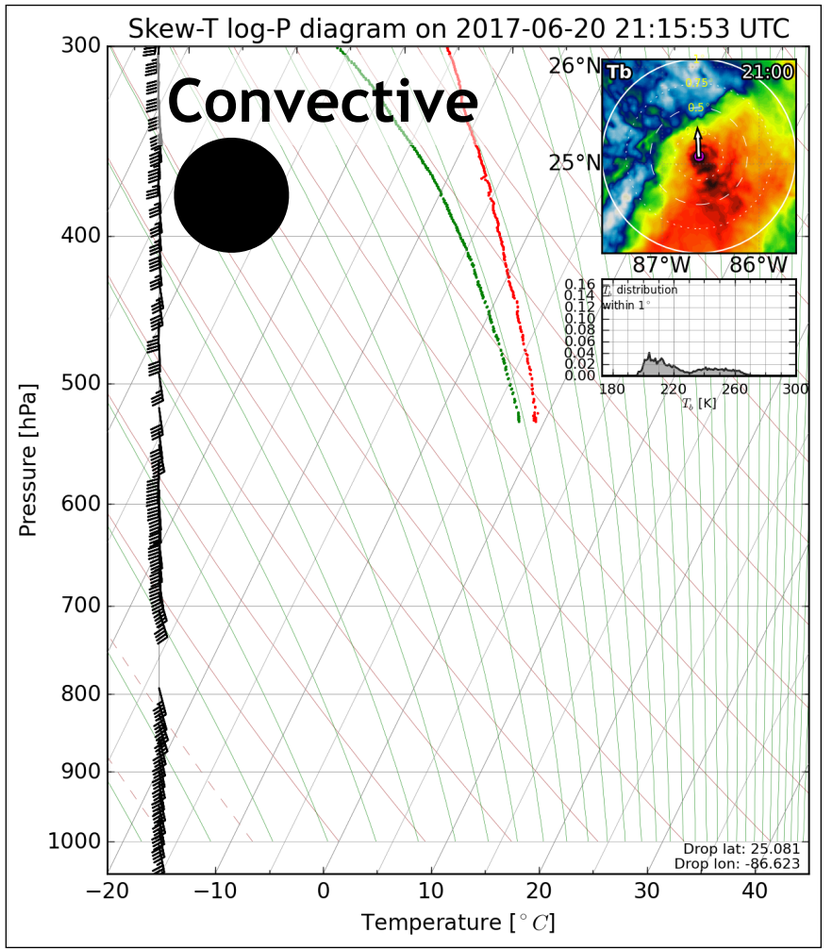
West Atlantic / Caribbean

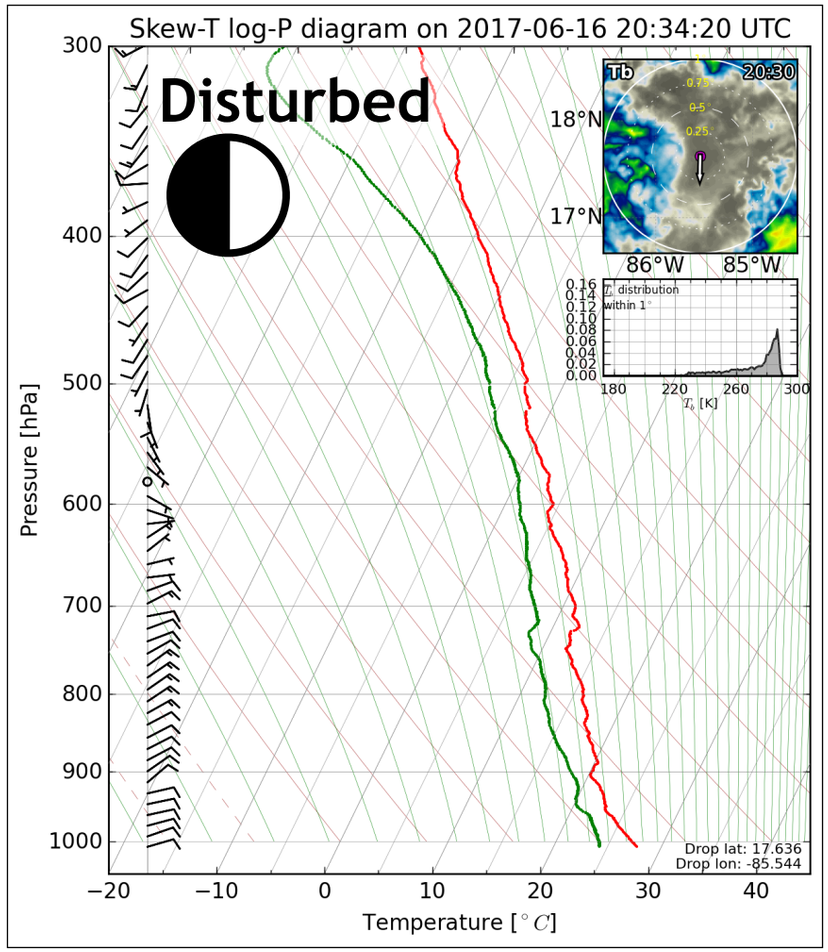
- Trade-winds,
- Isolated convection,
- Environment similar to suppressed MJO?

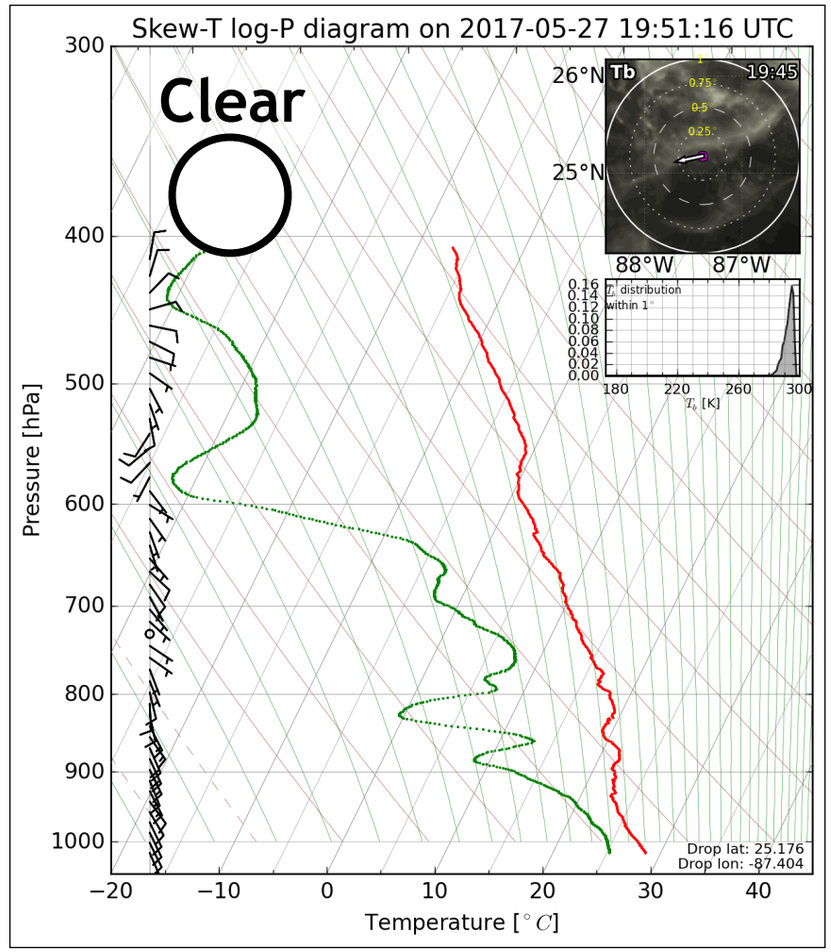
CPEX Methodology

No Doppler radar data to identify convective systems → no clear separation between environment and convection.

- GOES-16 IR brightness temperature is used to classify dropsondes as convective, disturbed, or clear.







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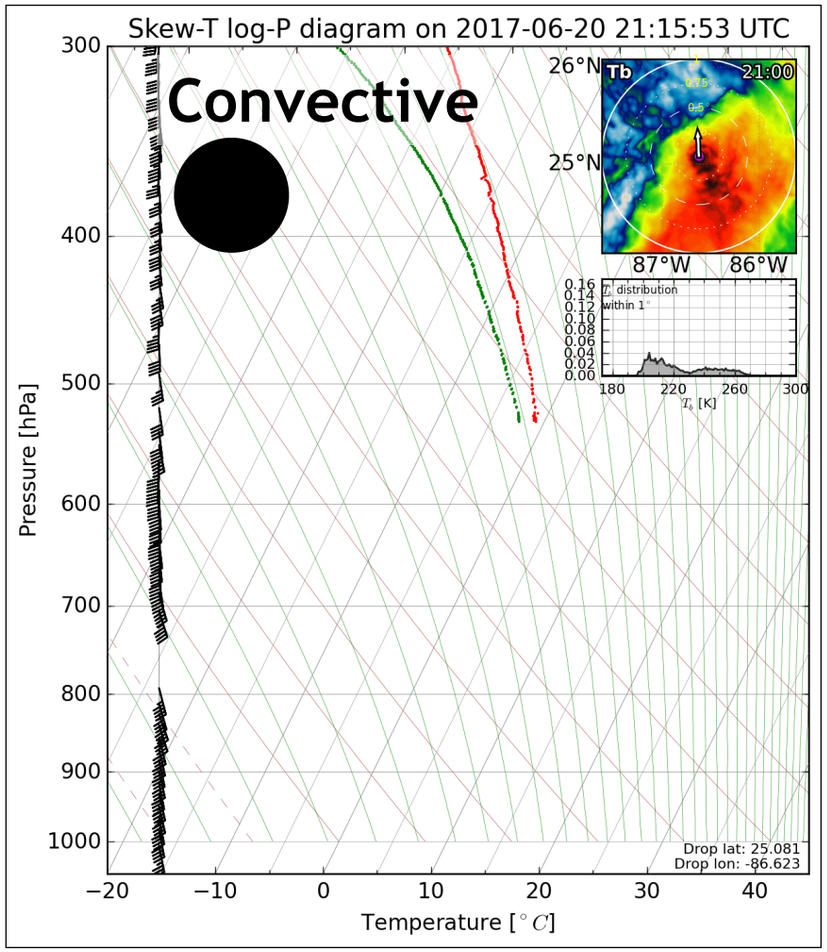
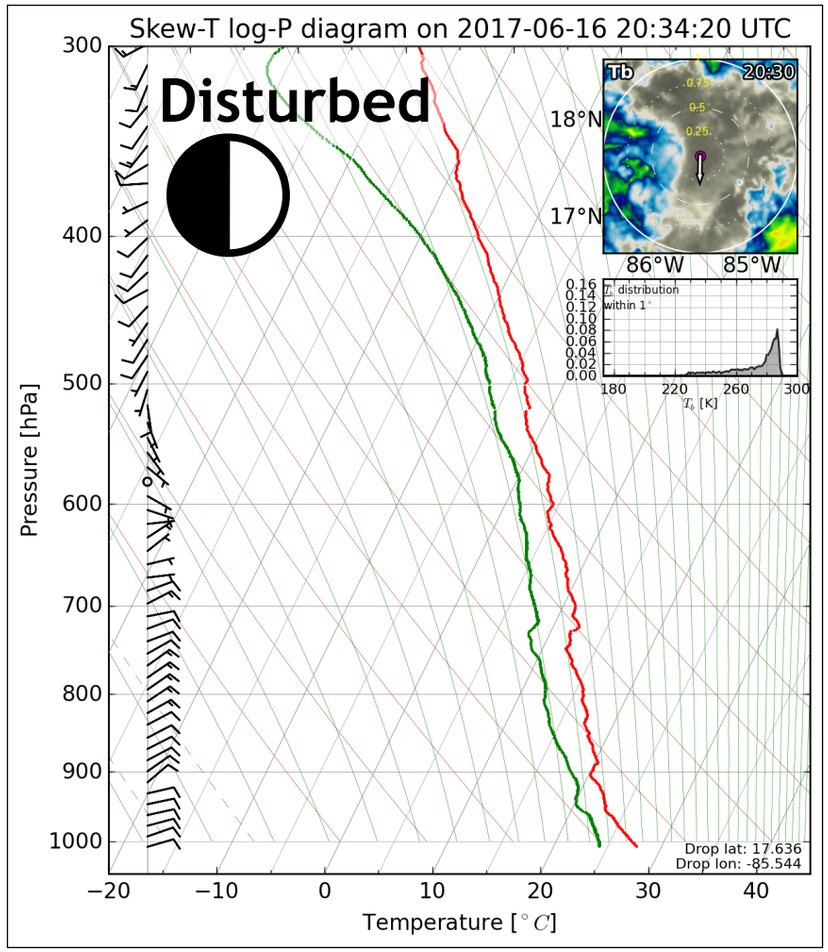
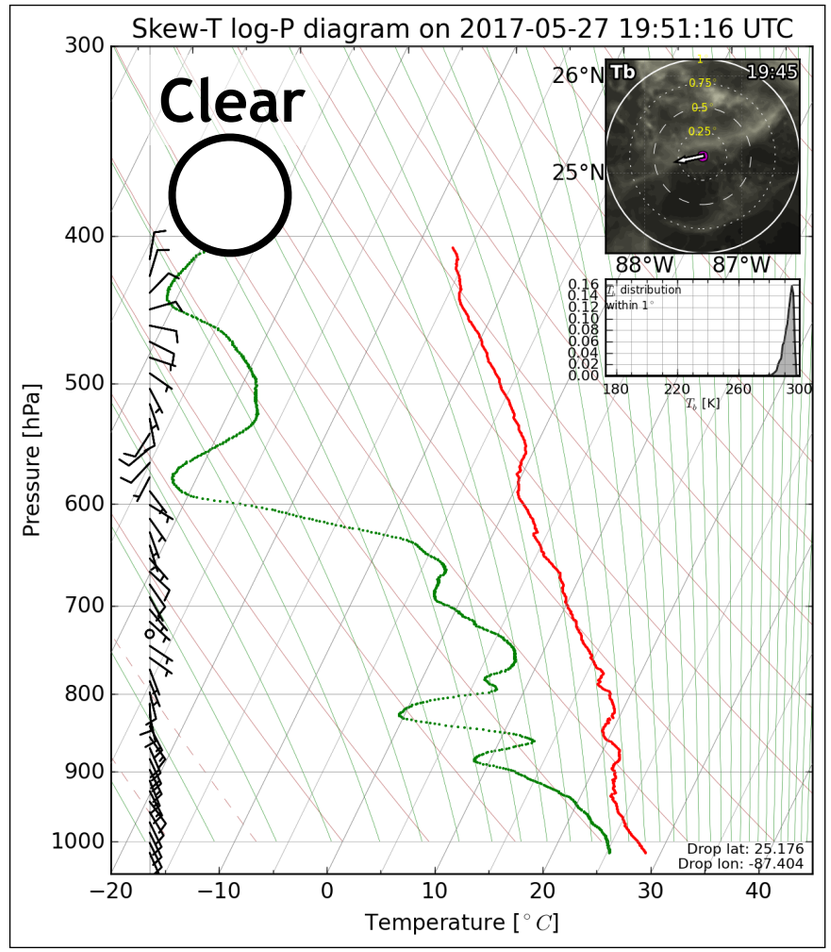


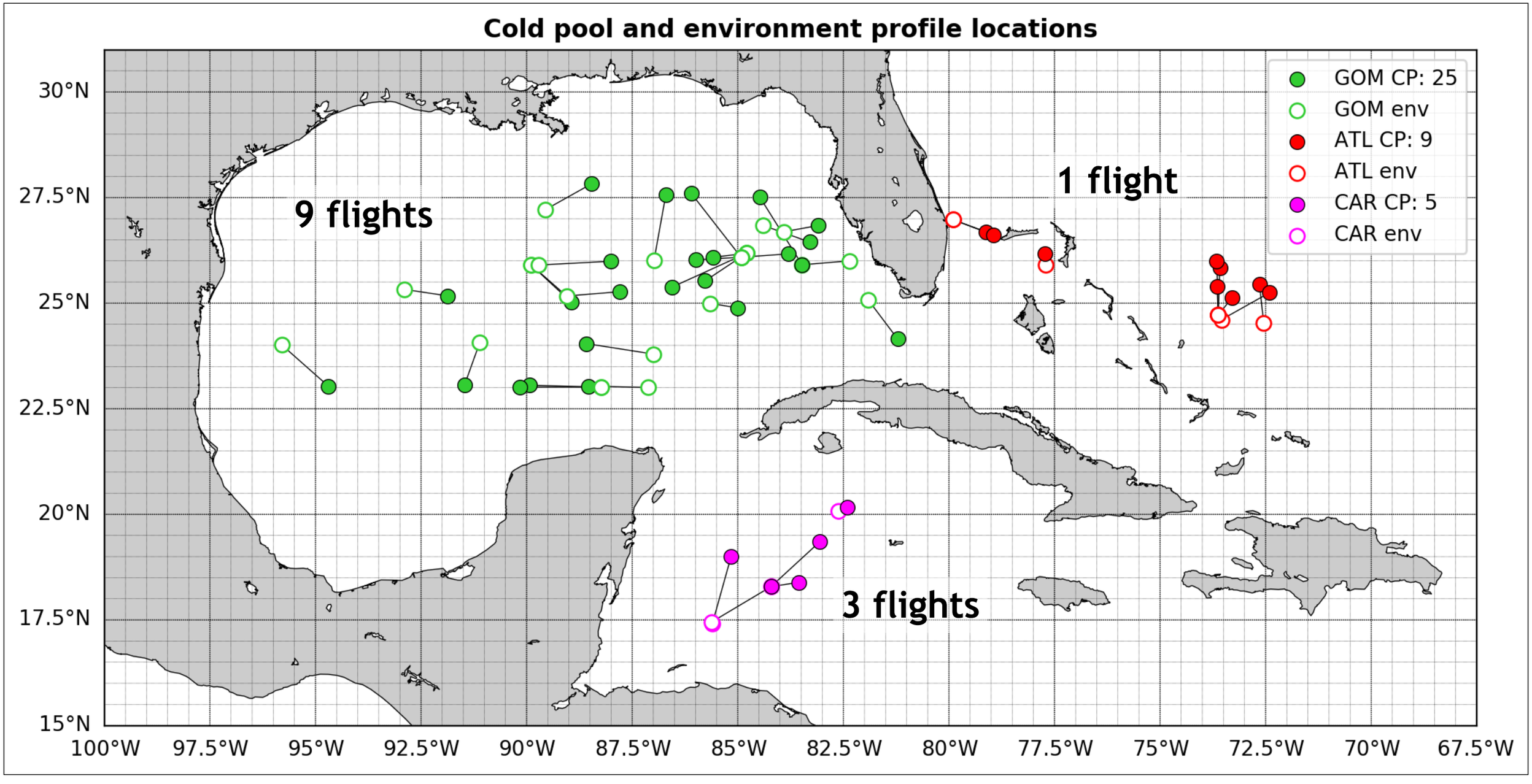




- Each cold pool profile is paired to a single environment.
- Cold pool characteristics: BL height, CP height, CP intensity.

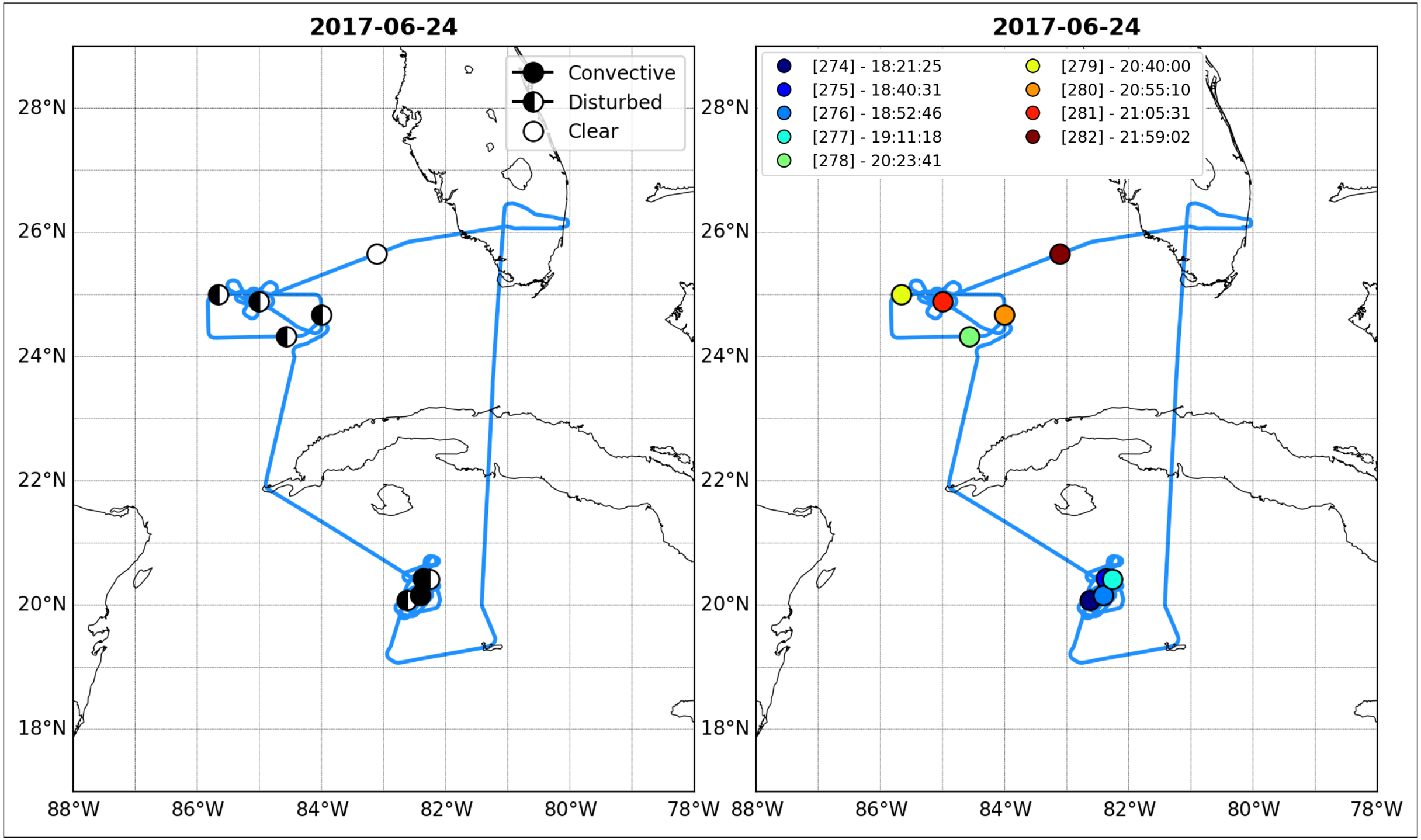
CPEX Cold Pool Overview

- 39 cold pool & environment pairs over 12 flights



Example: Isolated Convection

- June 24 - Caribbean



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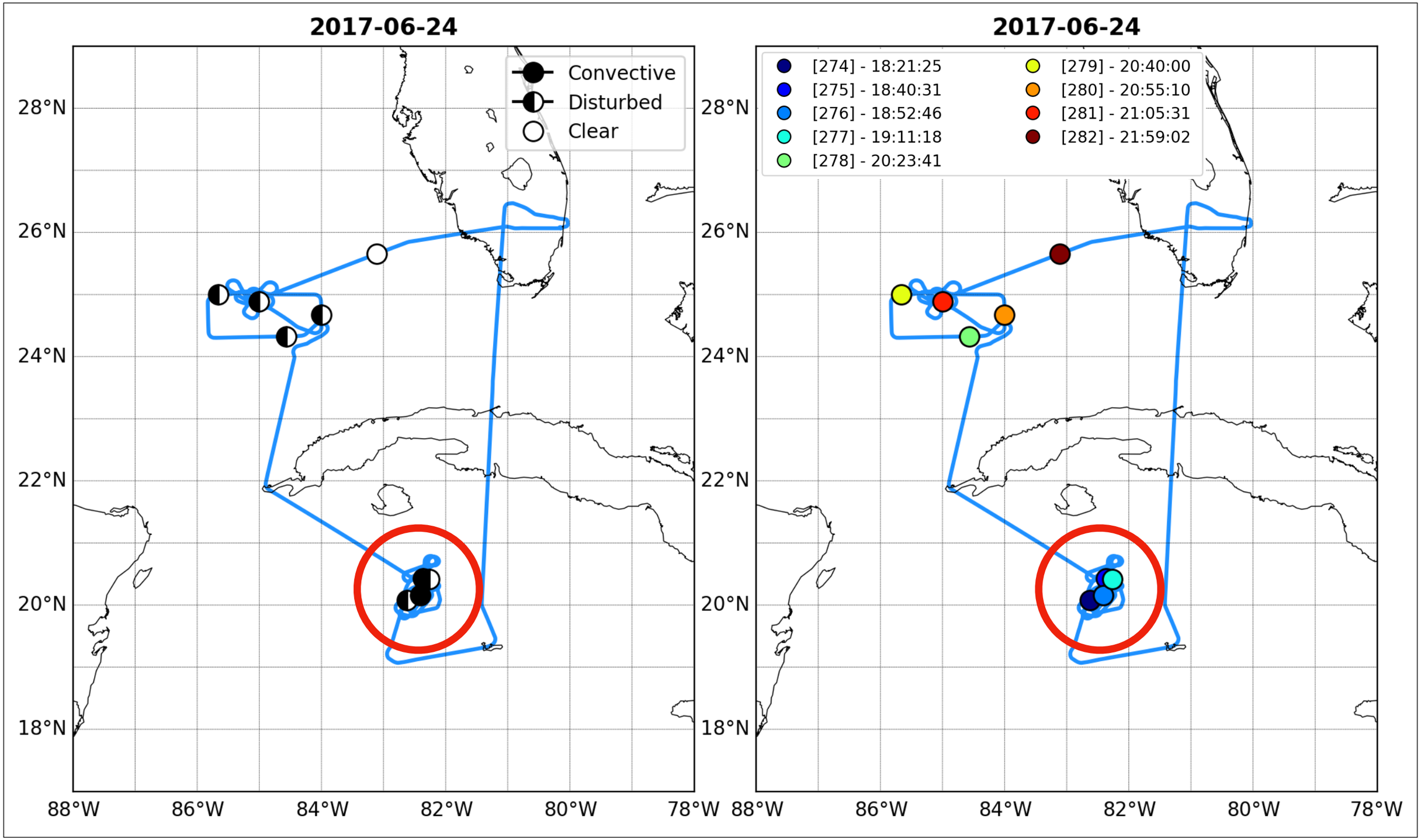

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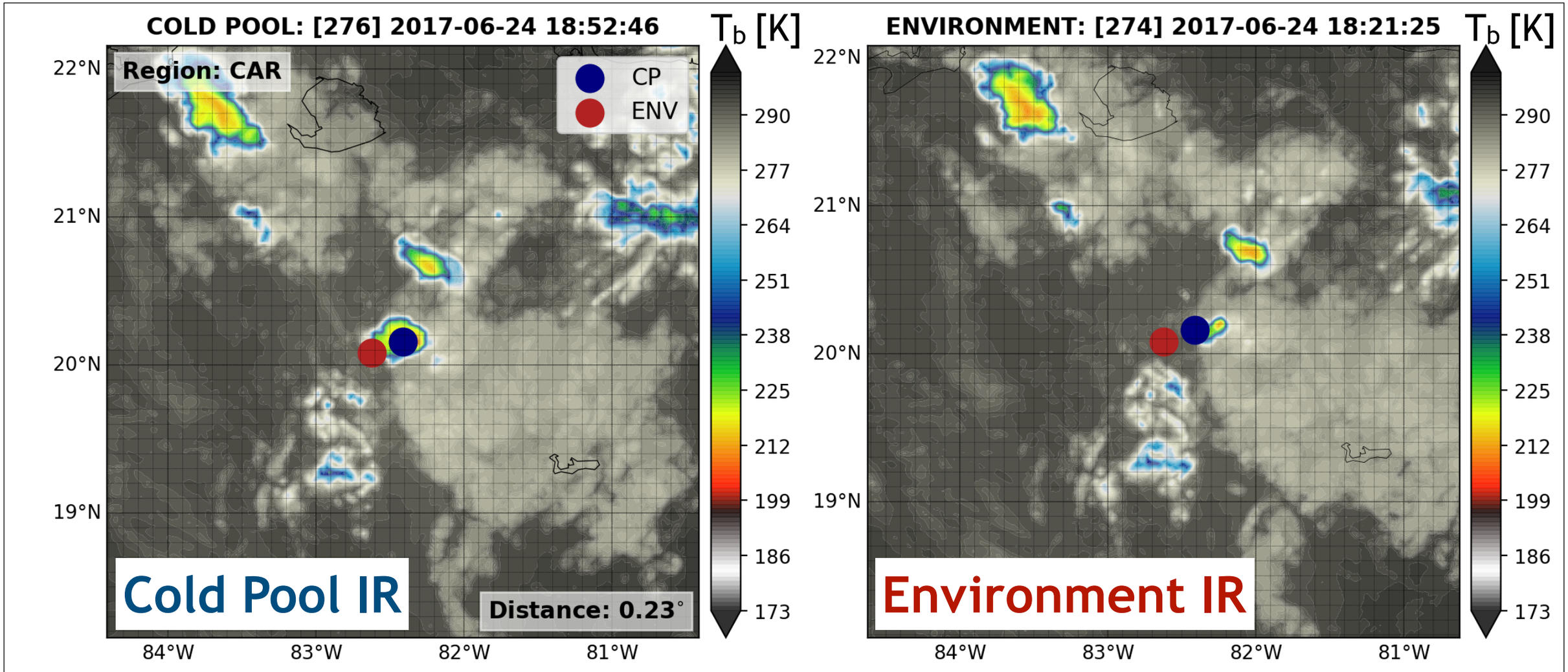
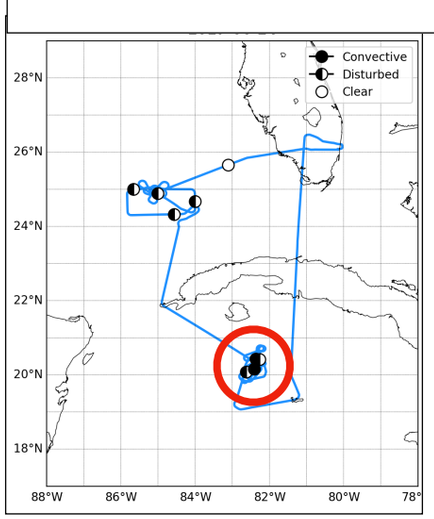
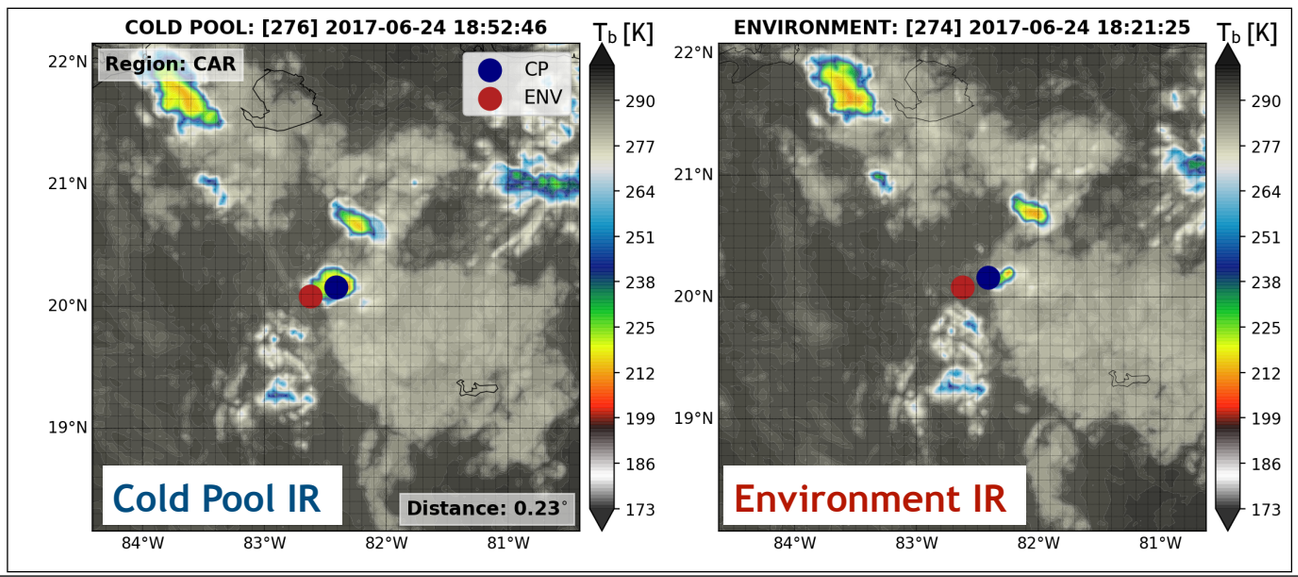
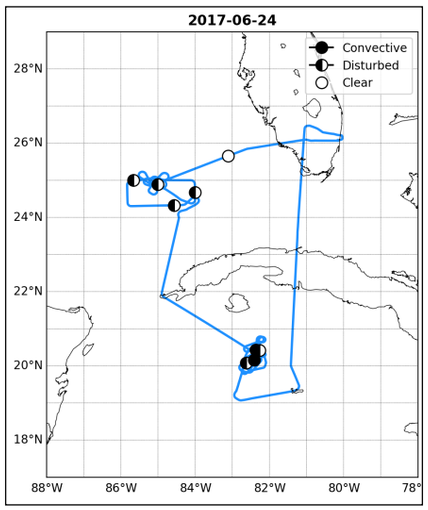


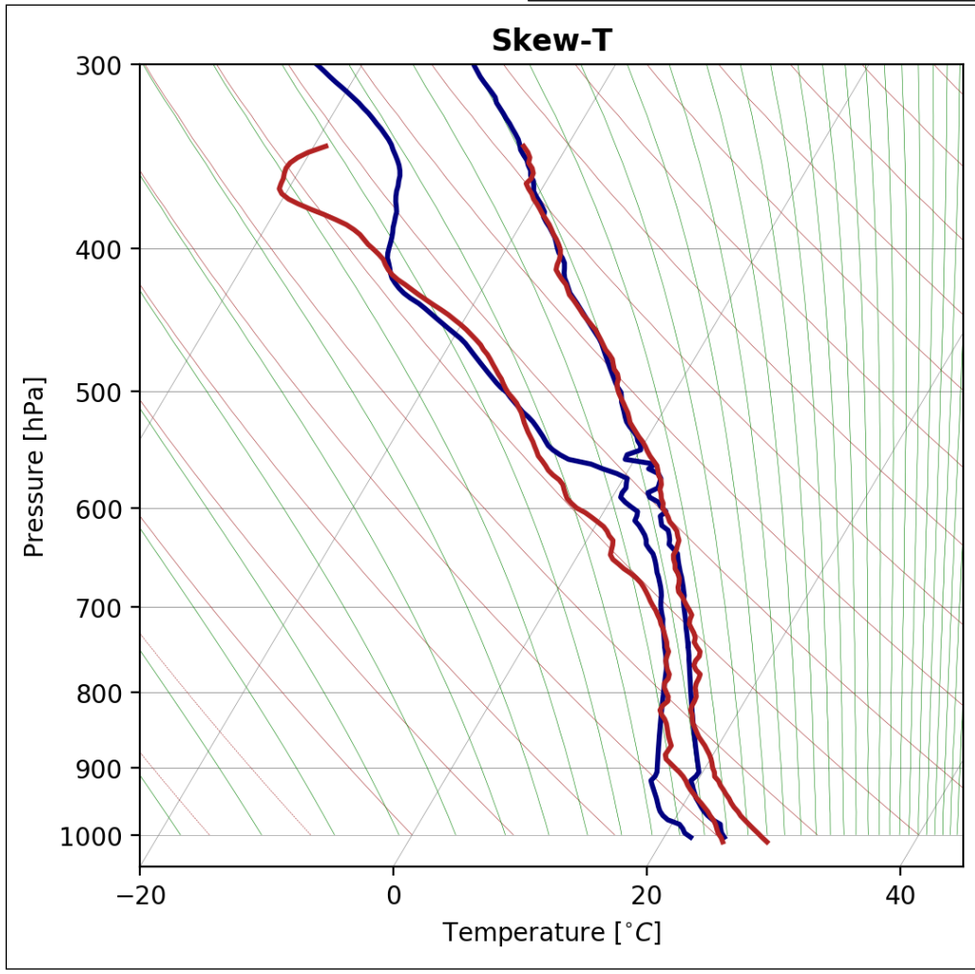


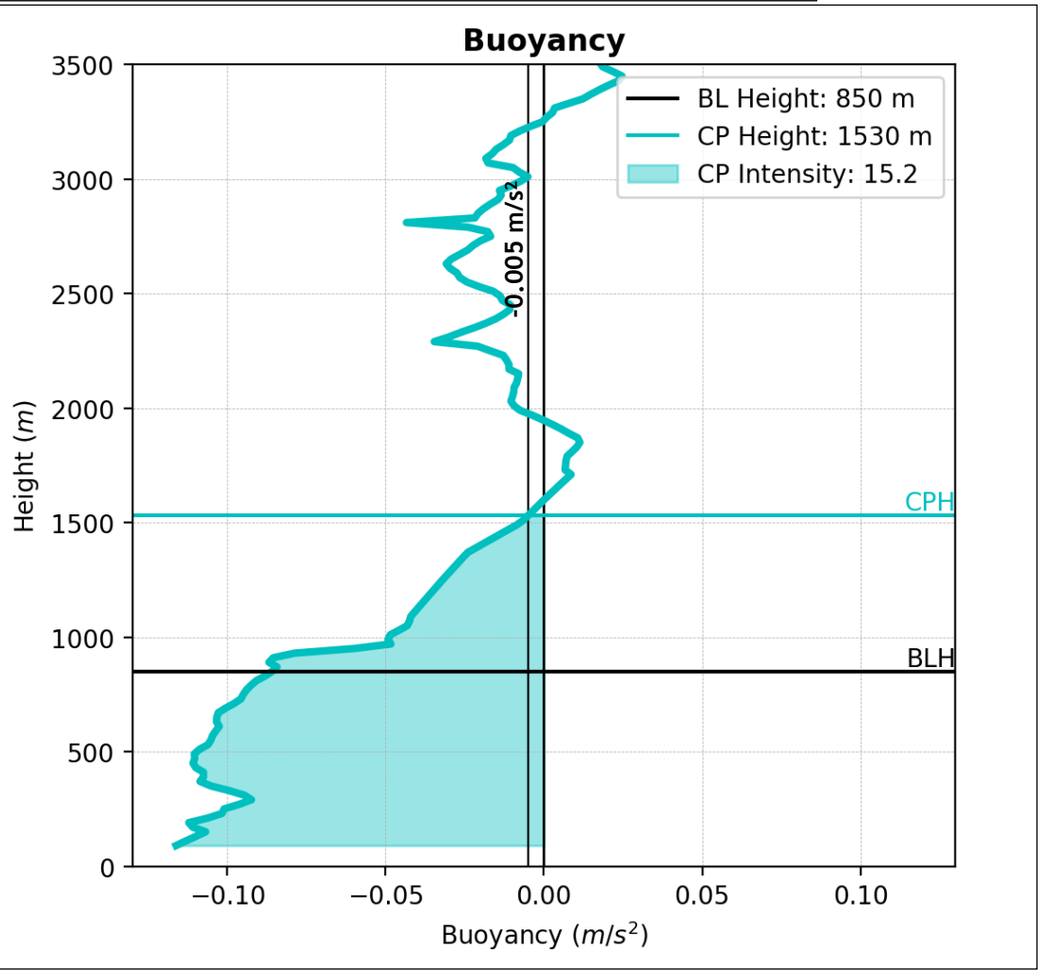
Example: Isolated Convection

- June 24 - Caribbean
- BL height: 850 m
- CP height: 1530 m
- CP intensity: 15.2 m/s



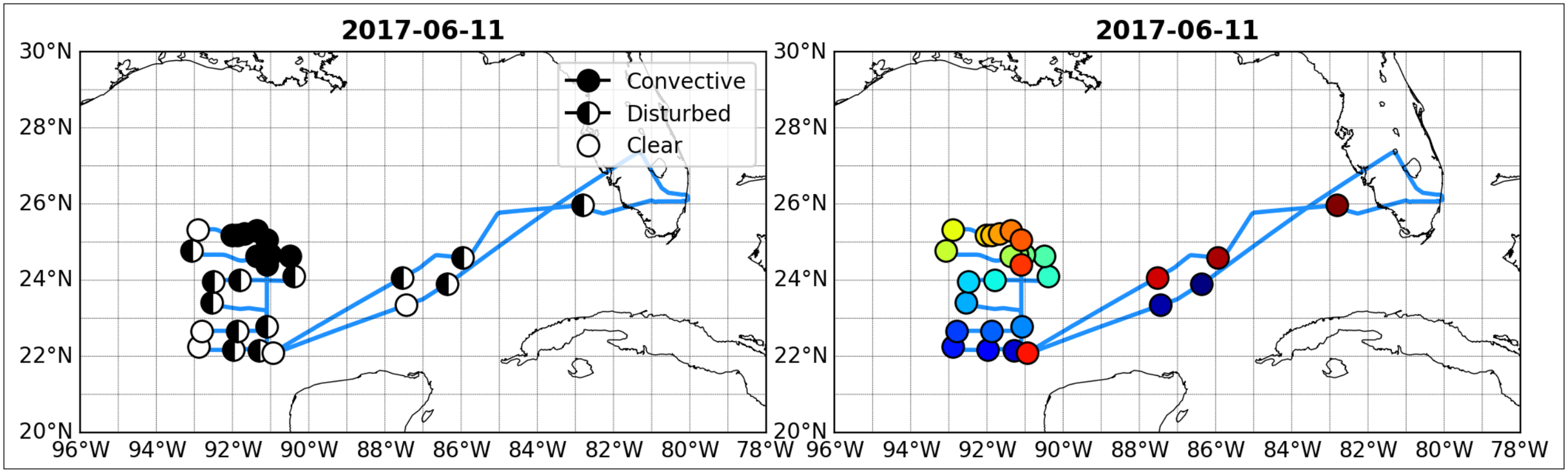


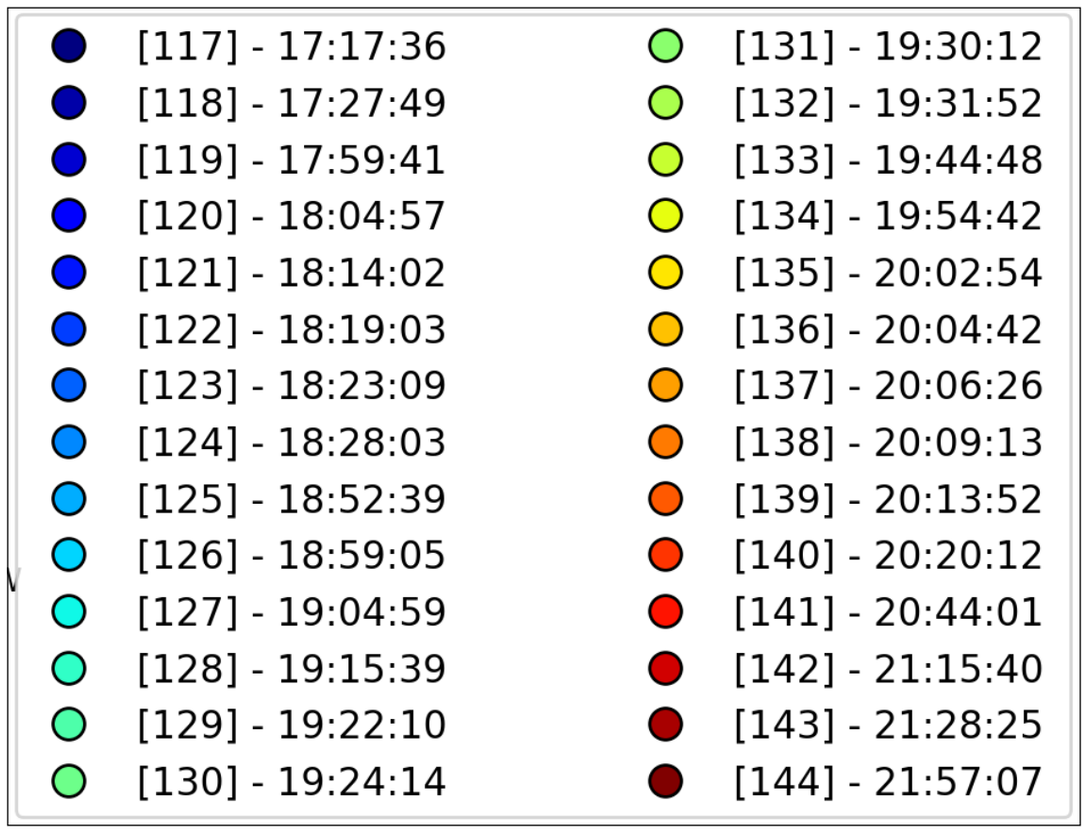




Example: Organized Convection

- June 11 - Gulf of Mexico





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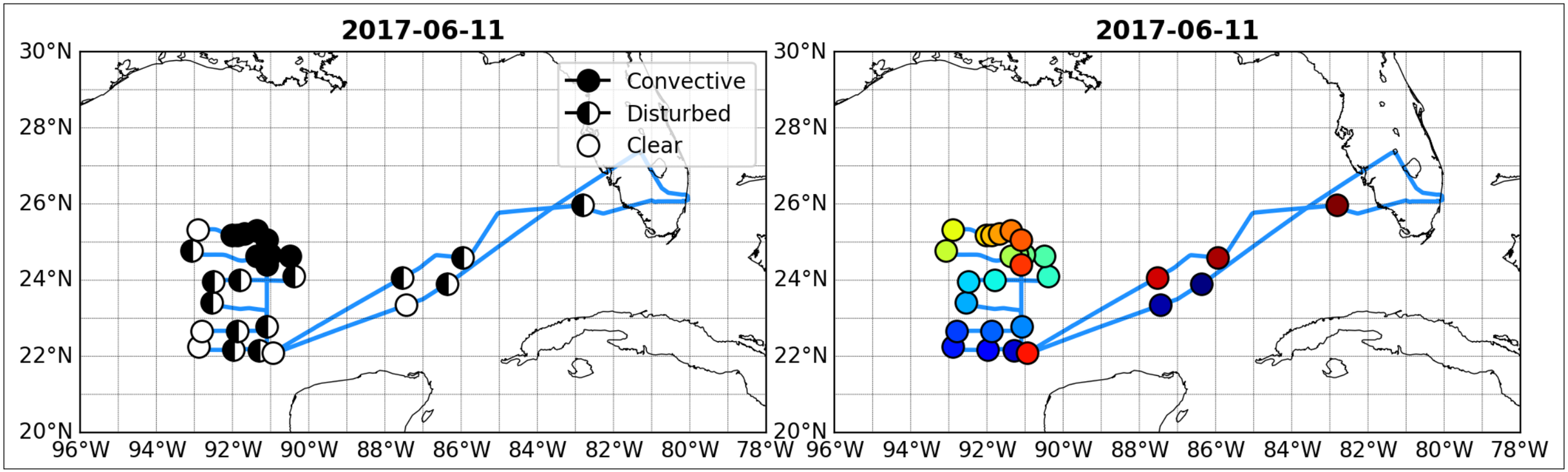

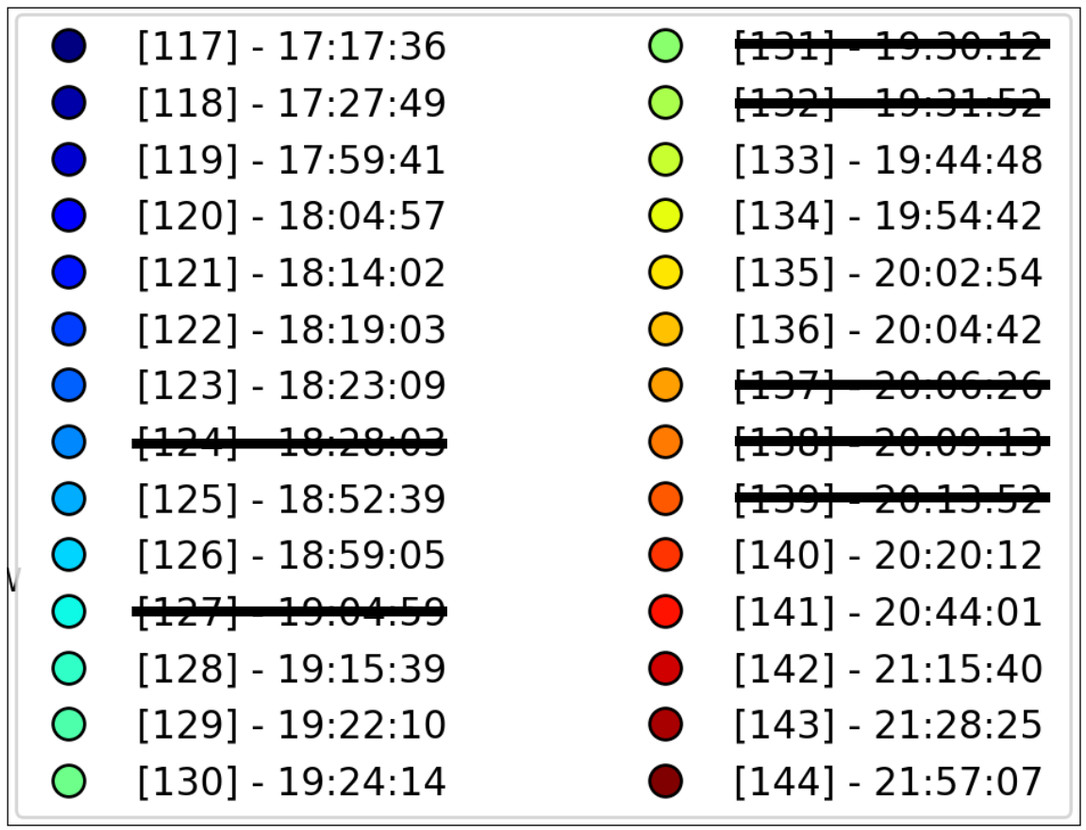

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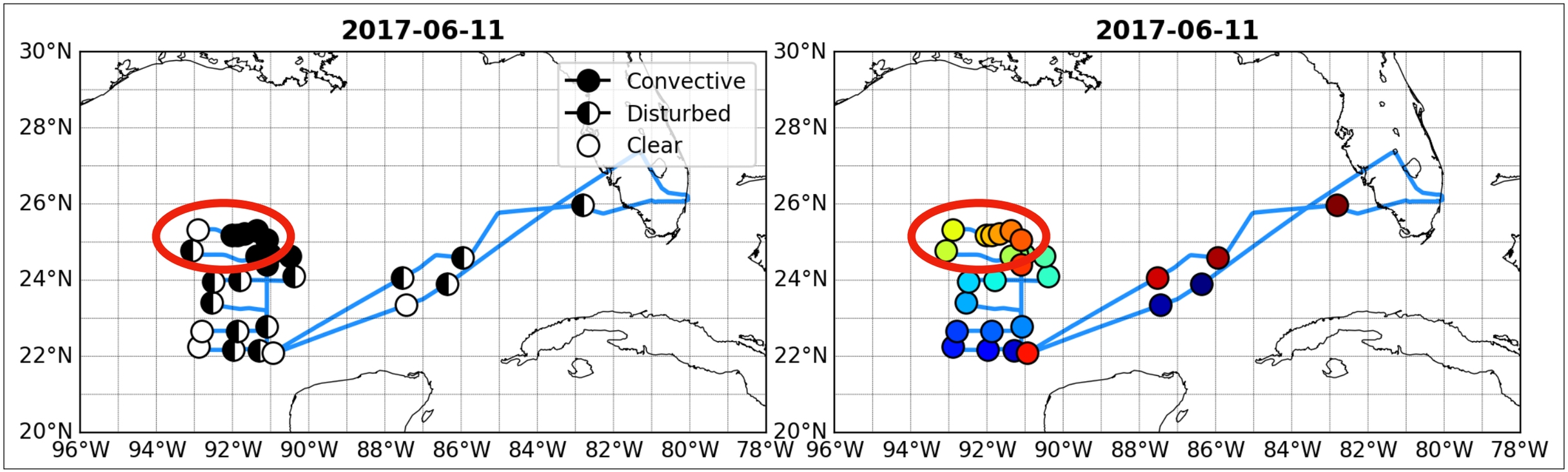

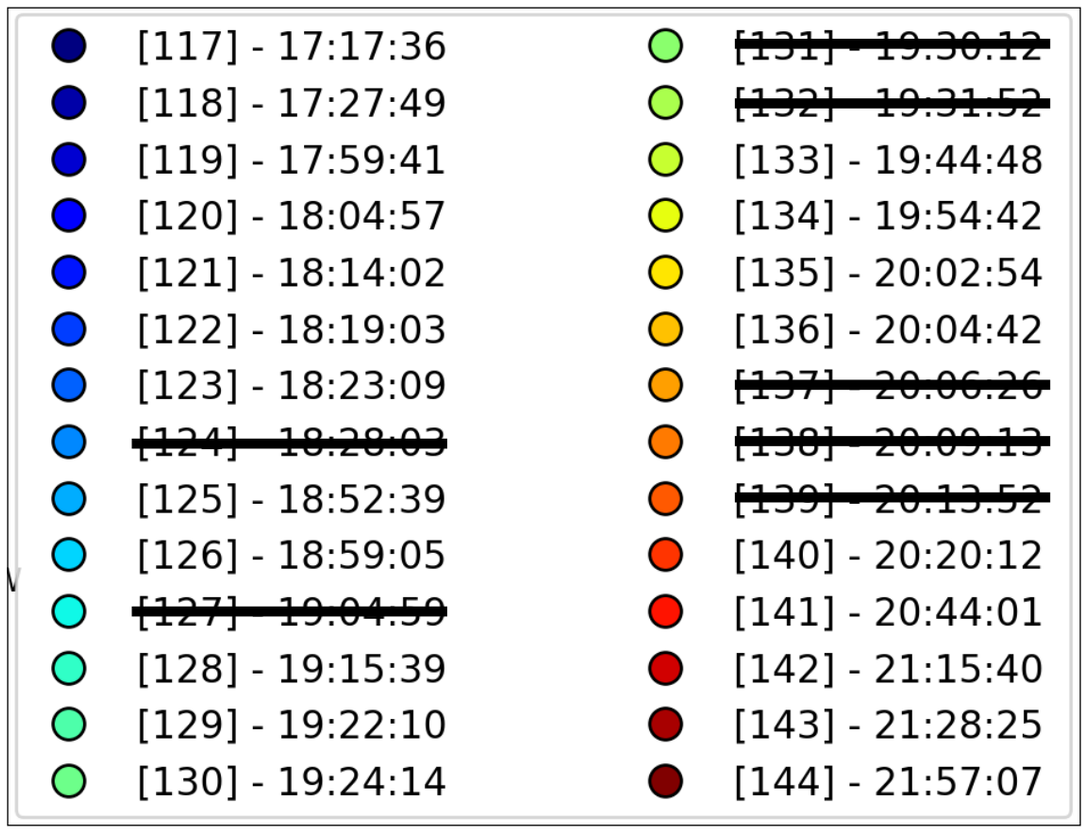

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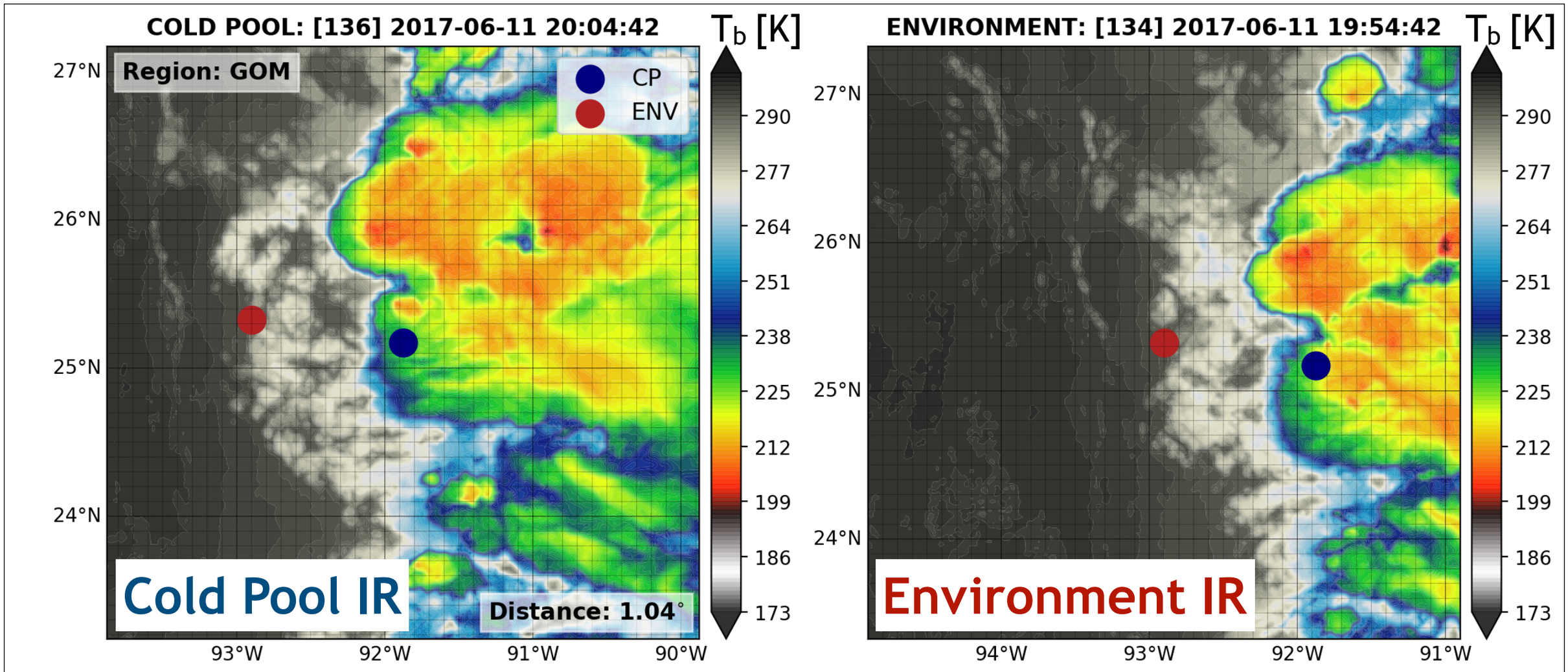
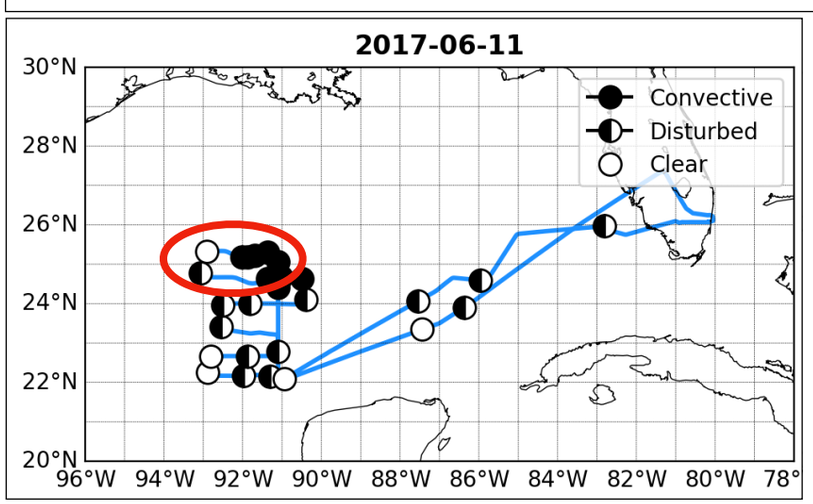
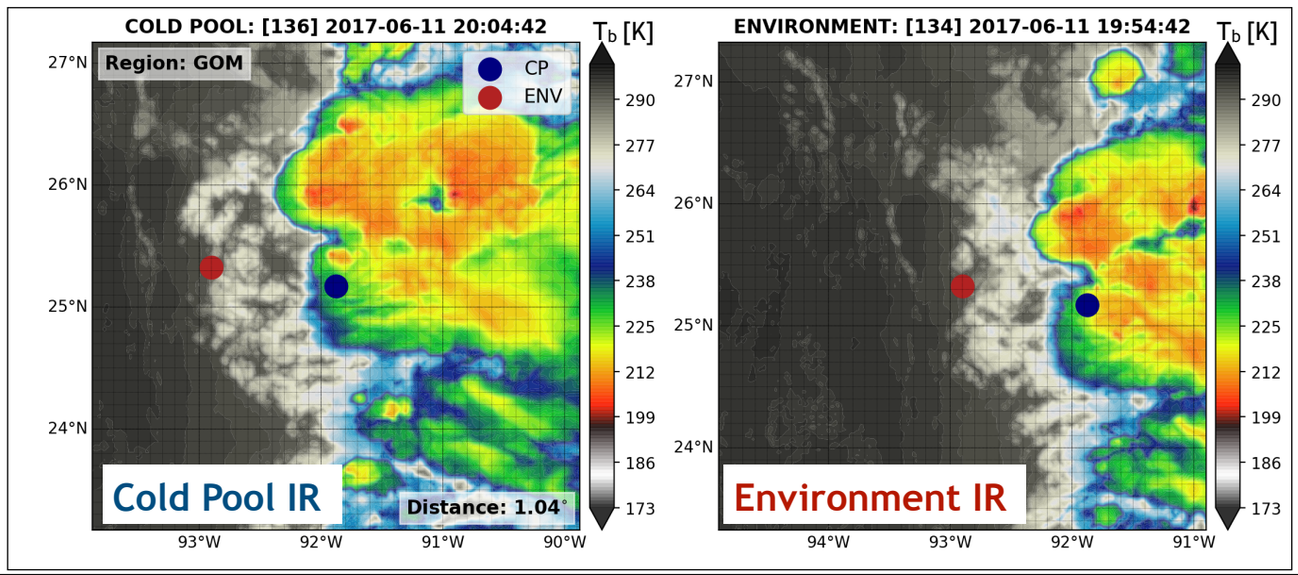
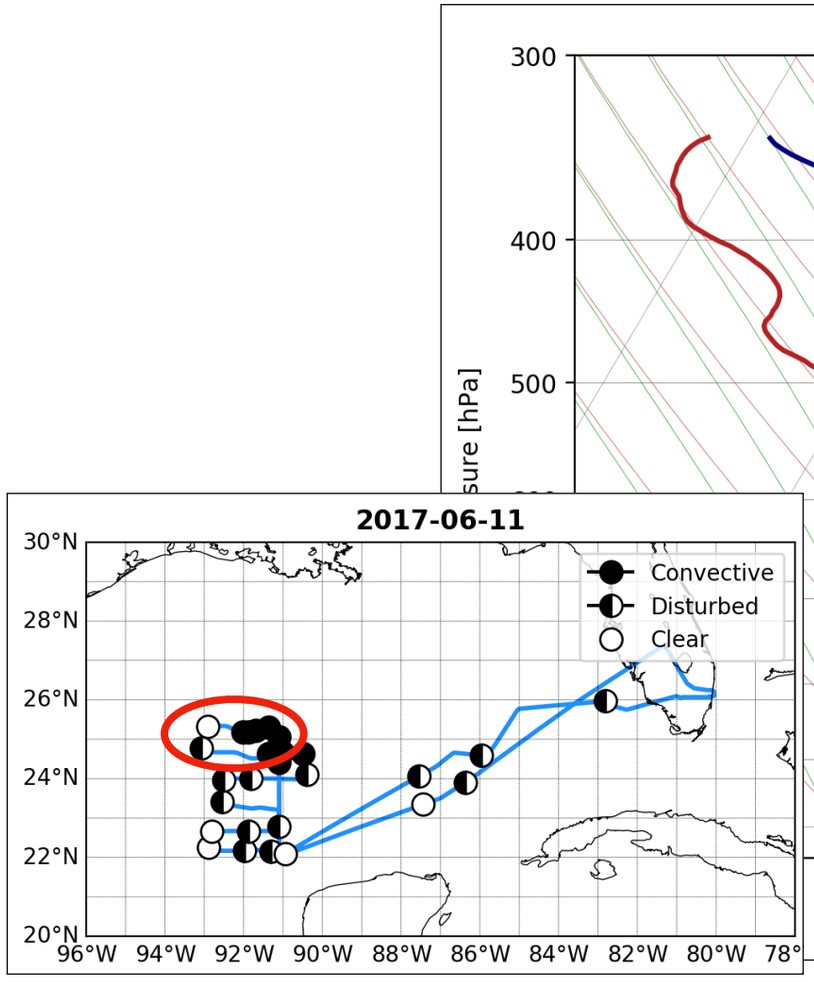


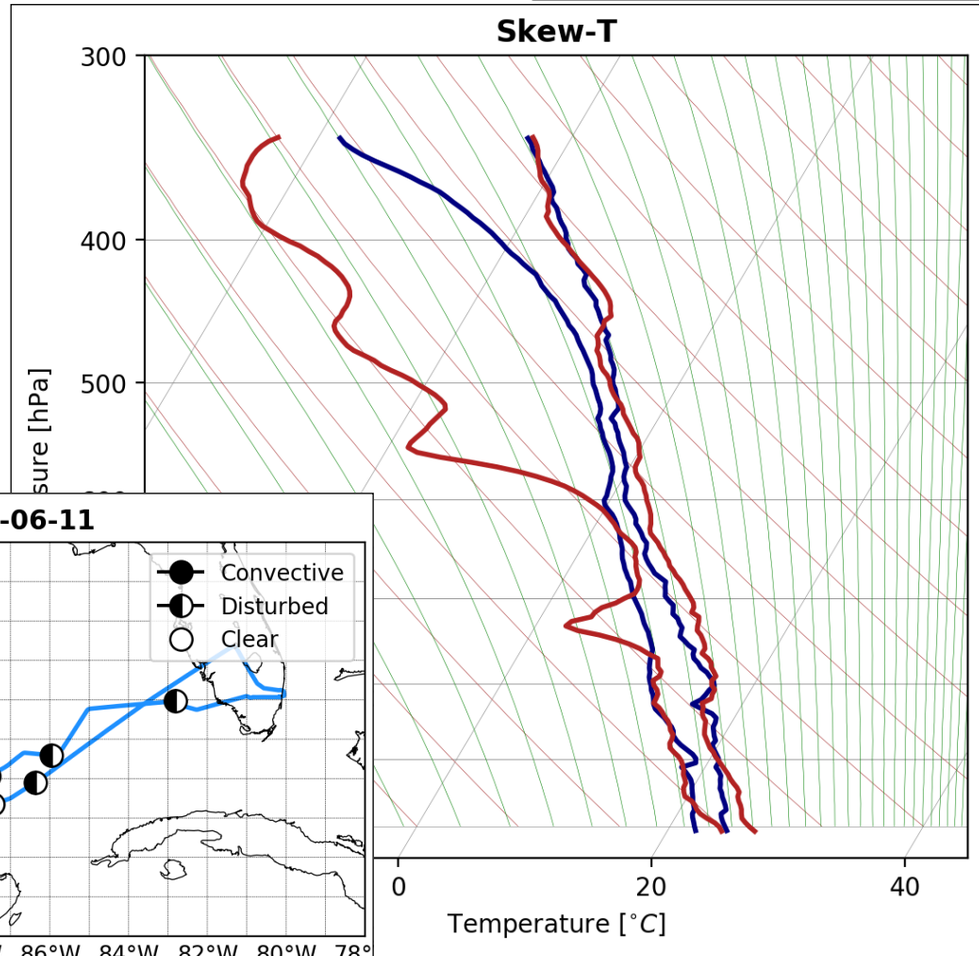


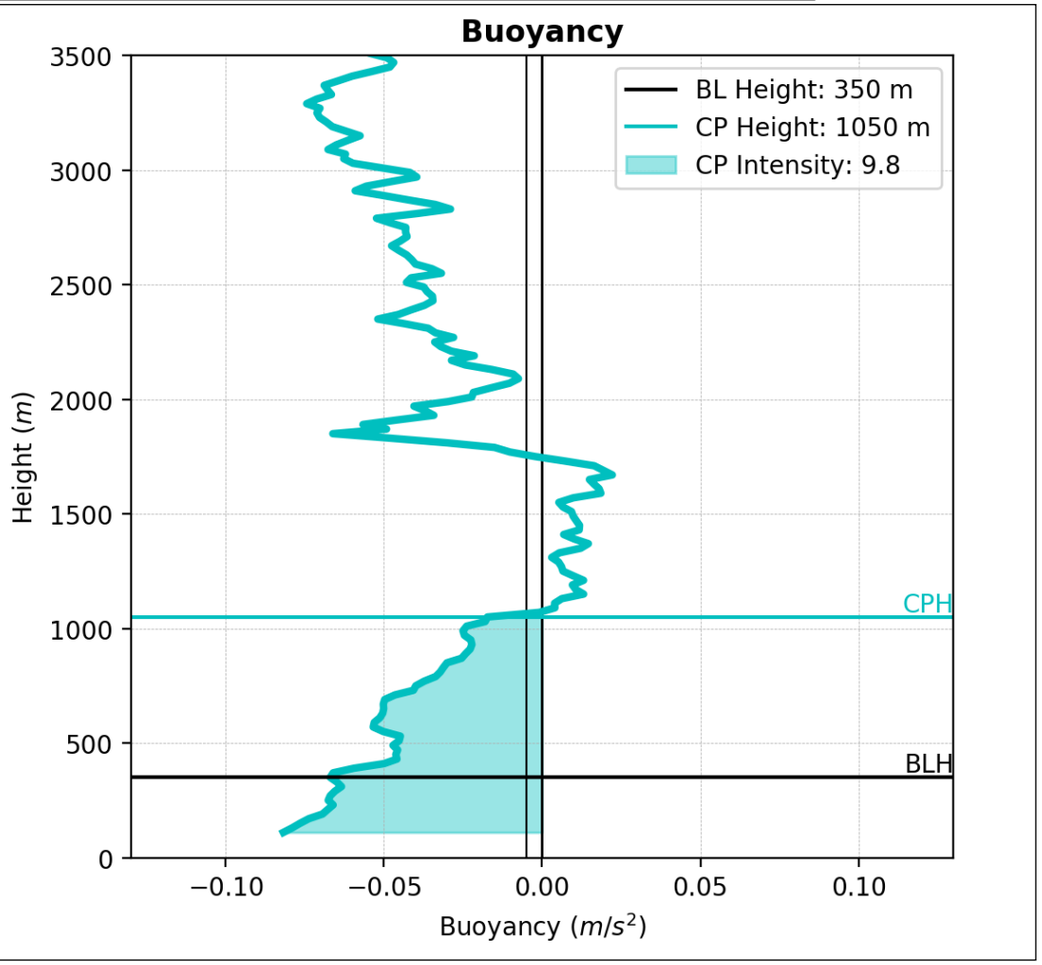
Example: Organized Convection

- June 11 - Gulf of Mexico
- BL height: 350 m
- CP height: 1050 m
- CP intensity: 9.8 m/s



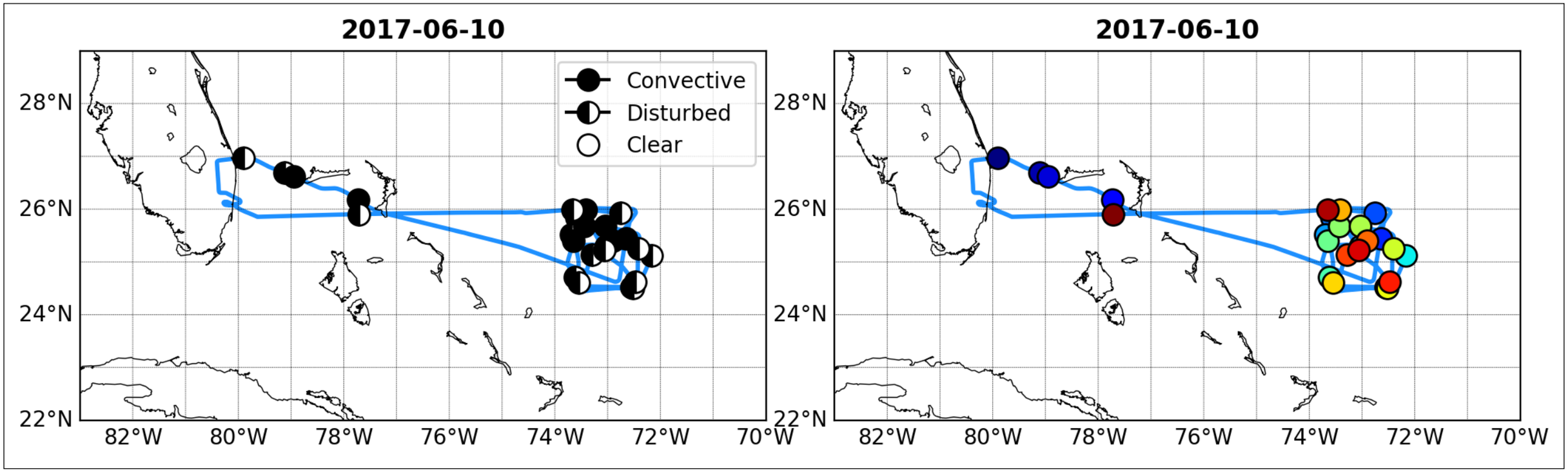


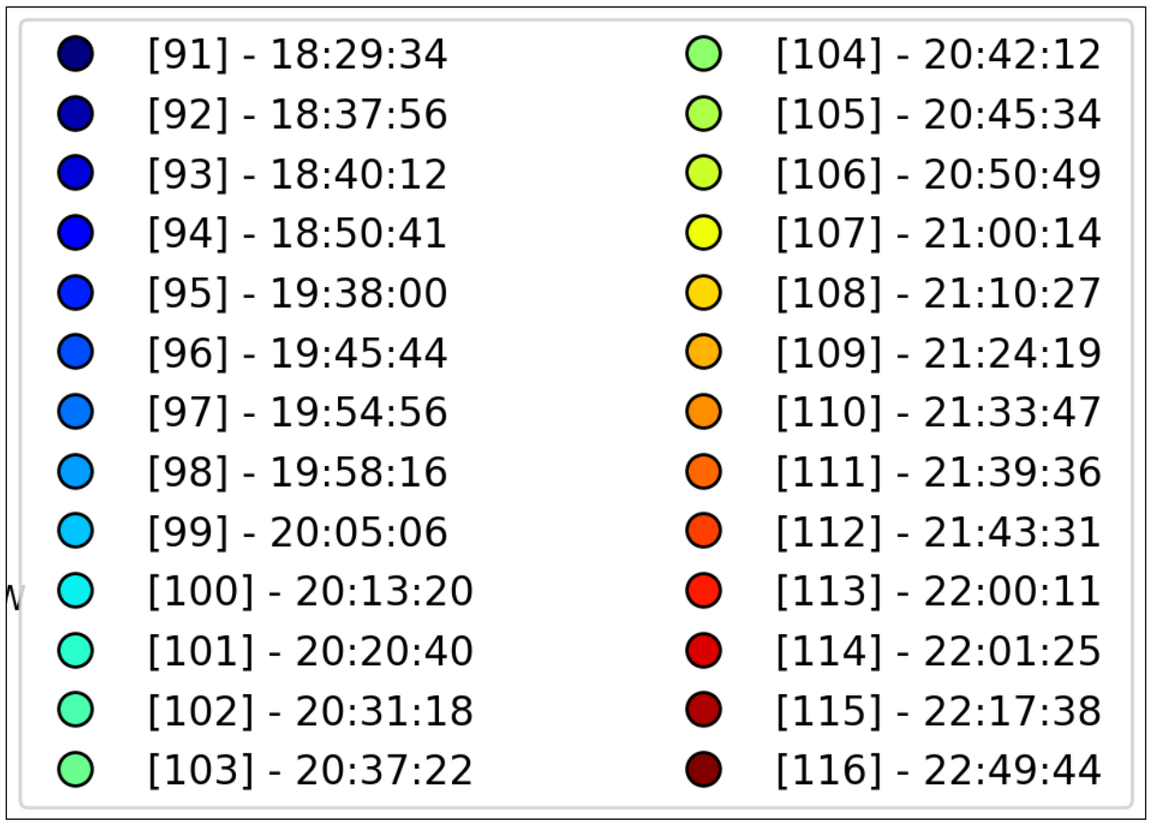




Example: Isolated Prefrontal

- June 10 - Atlantic





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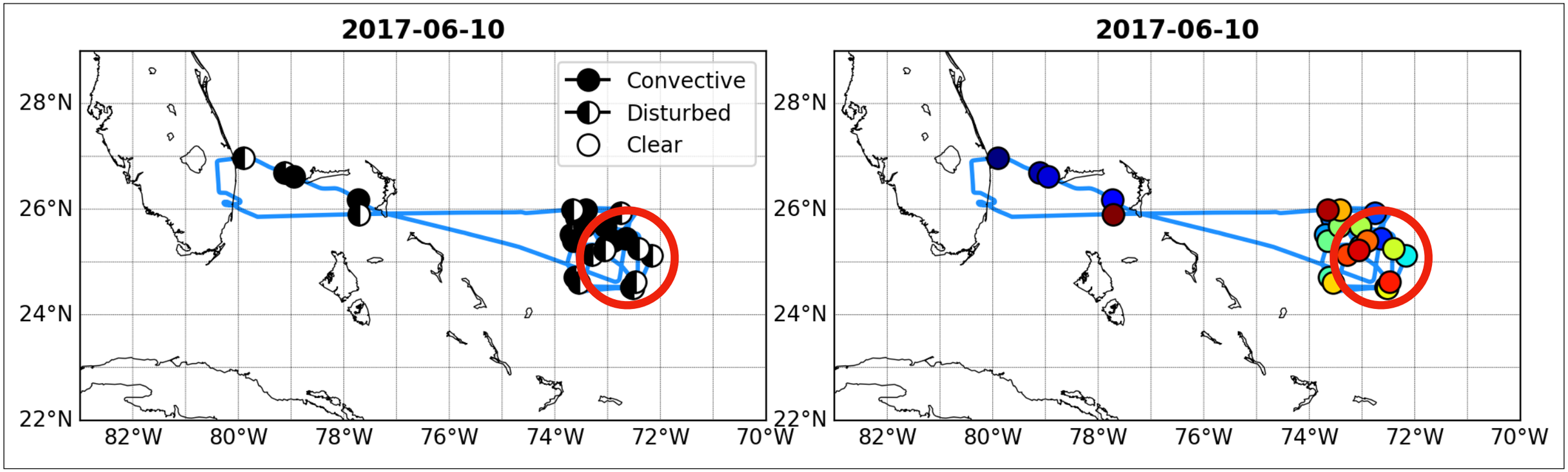

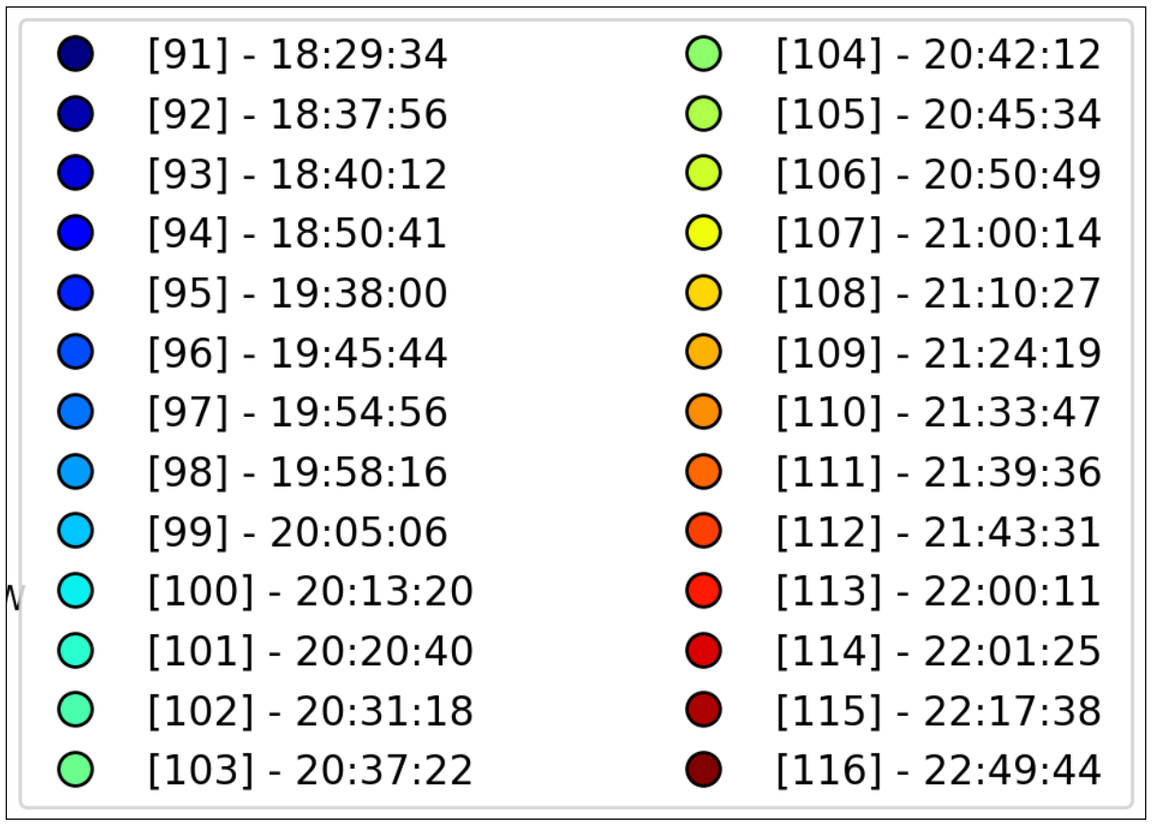

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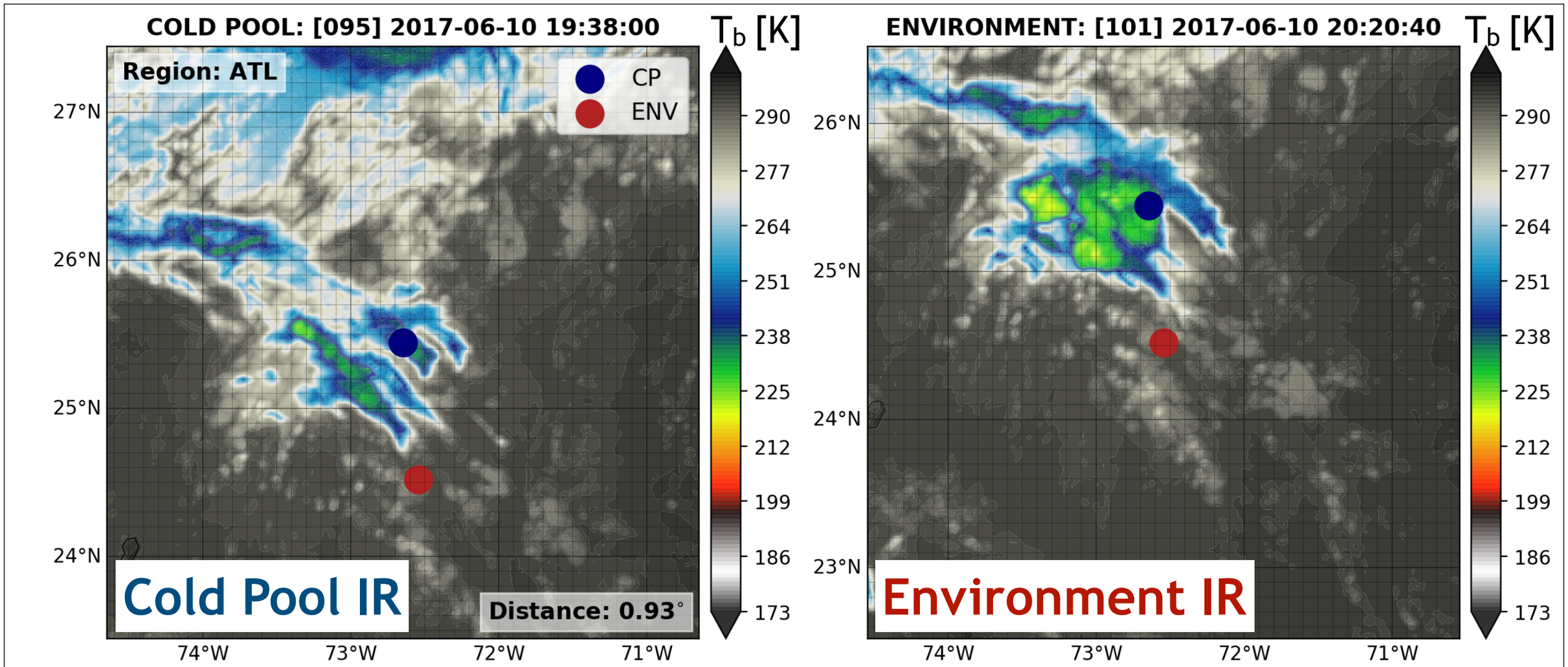
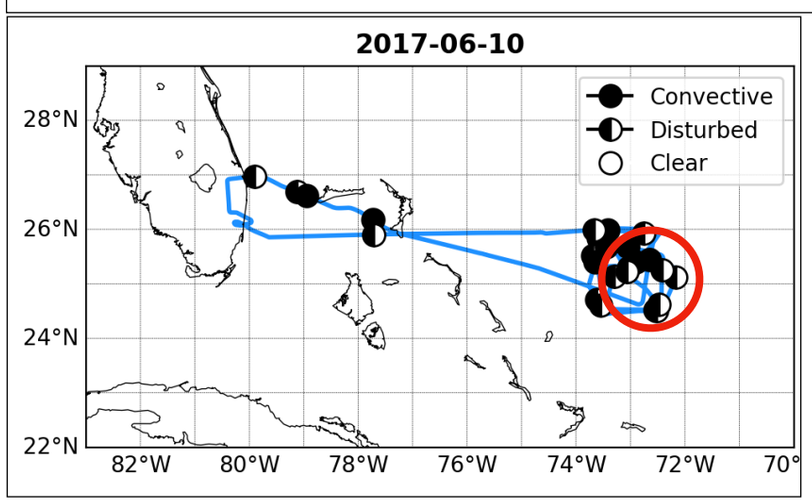
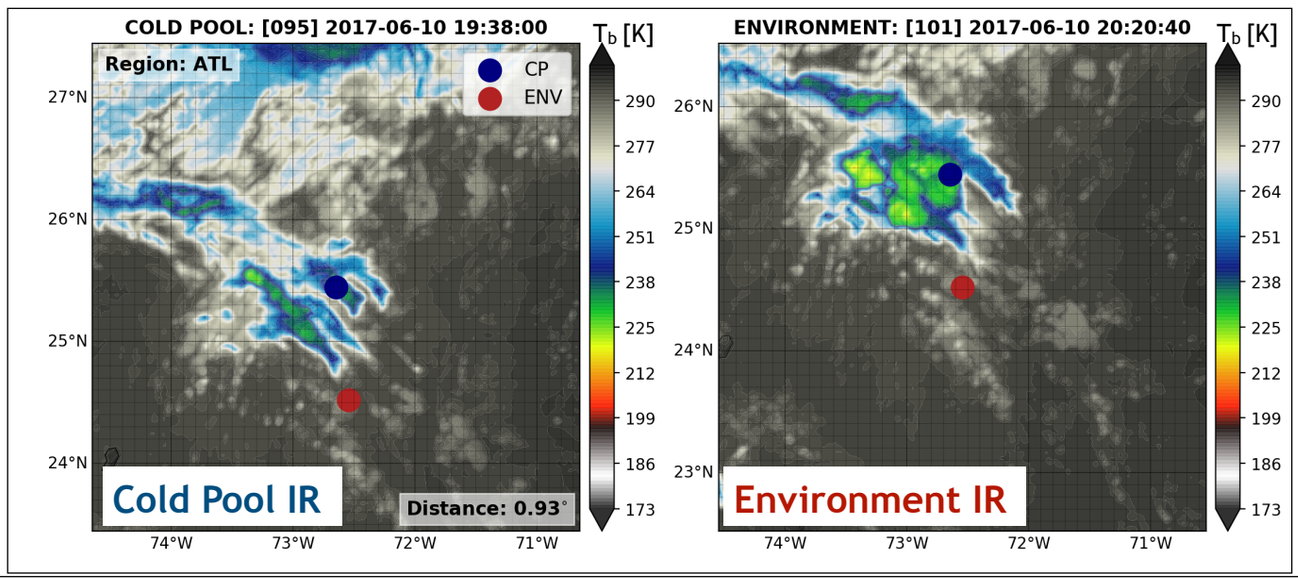
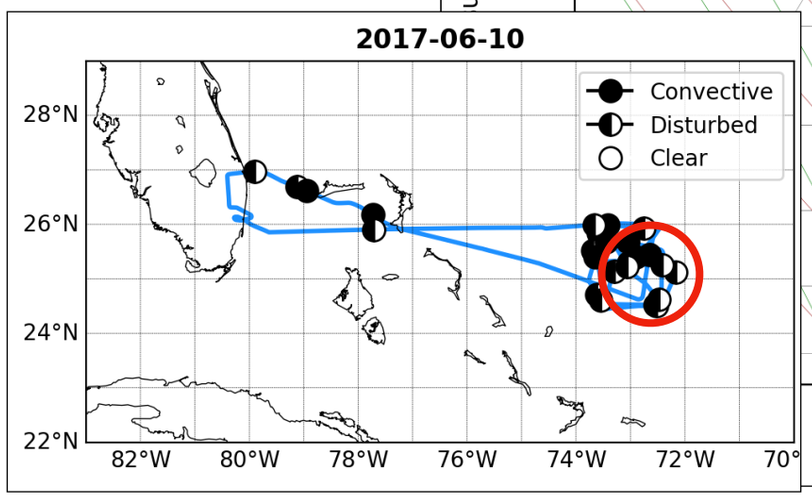


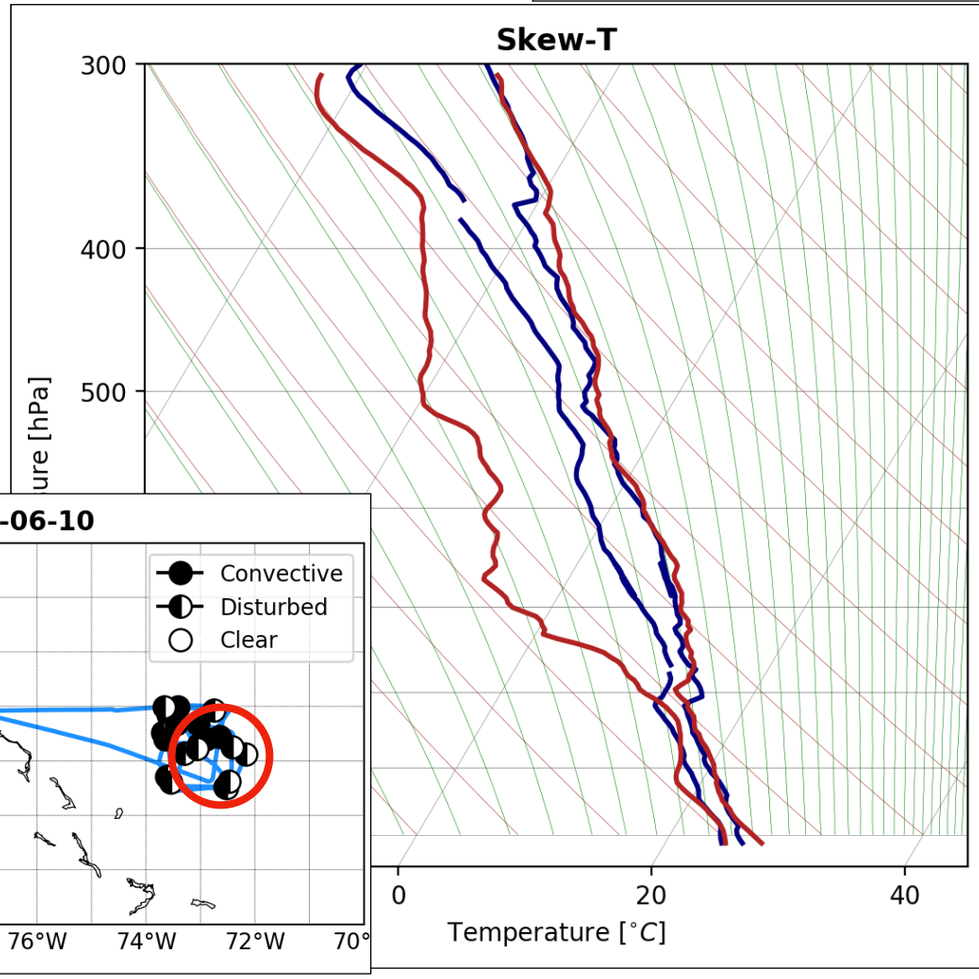


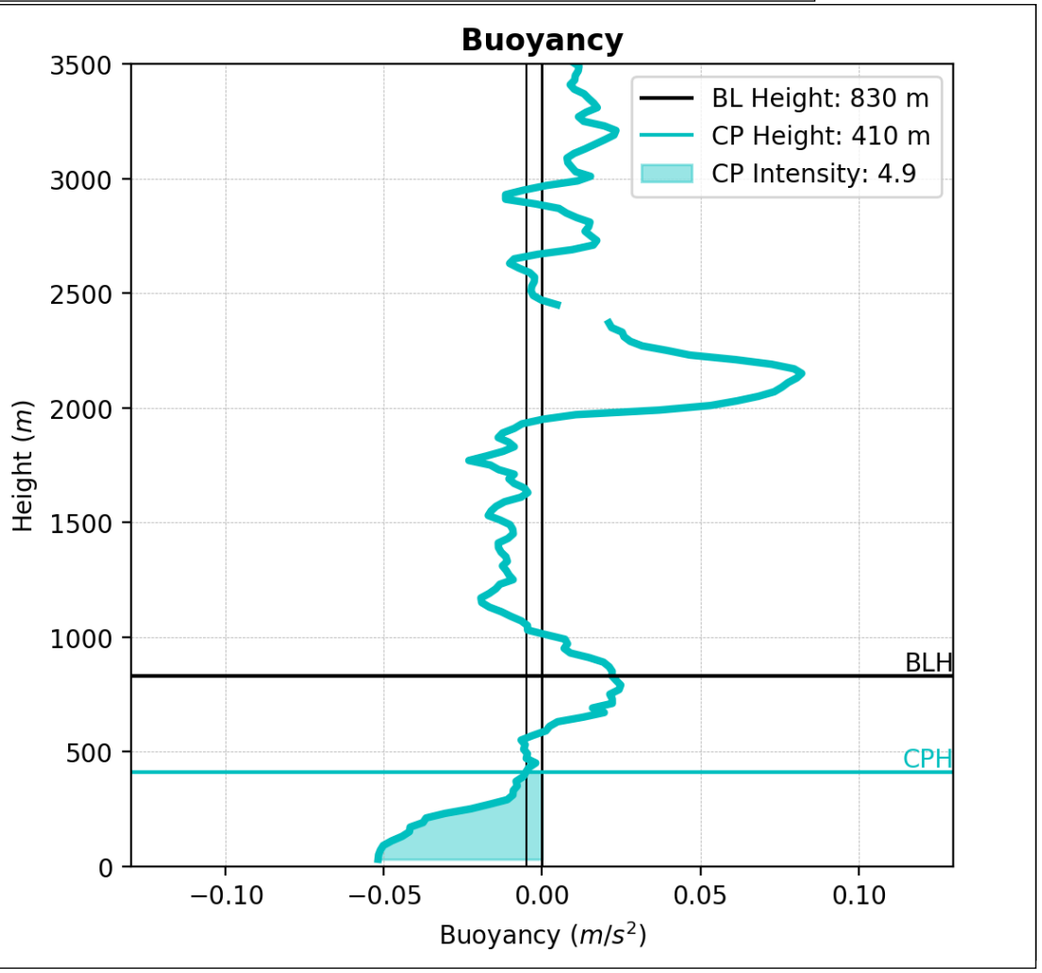
Example: Isolated Prefrontal

- June 10 - Atlantic
- BL height: 830 m
- CP height: 410 m
- CP intensity: 4.9 m/s









CPEX Cold Pool Summary

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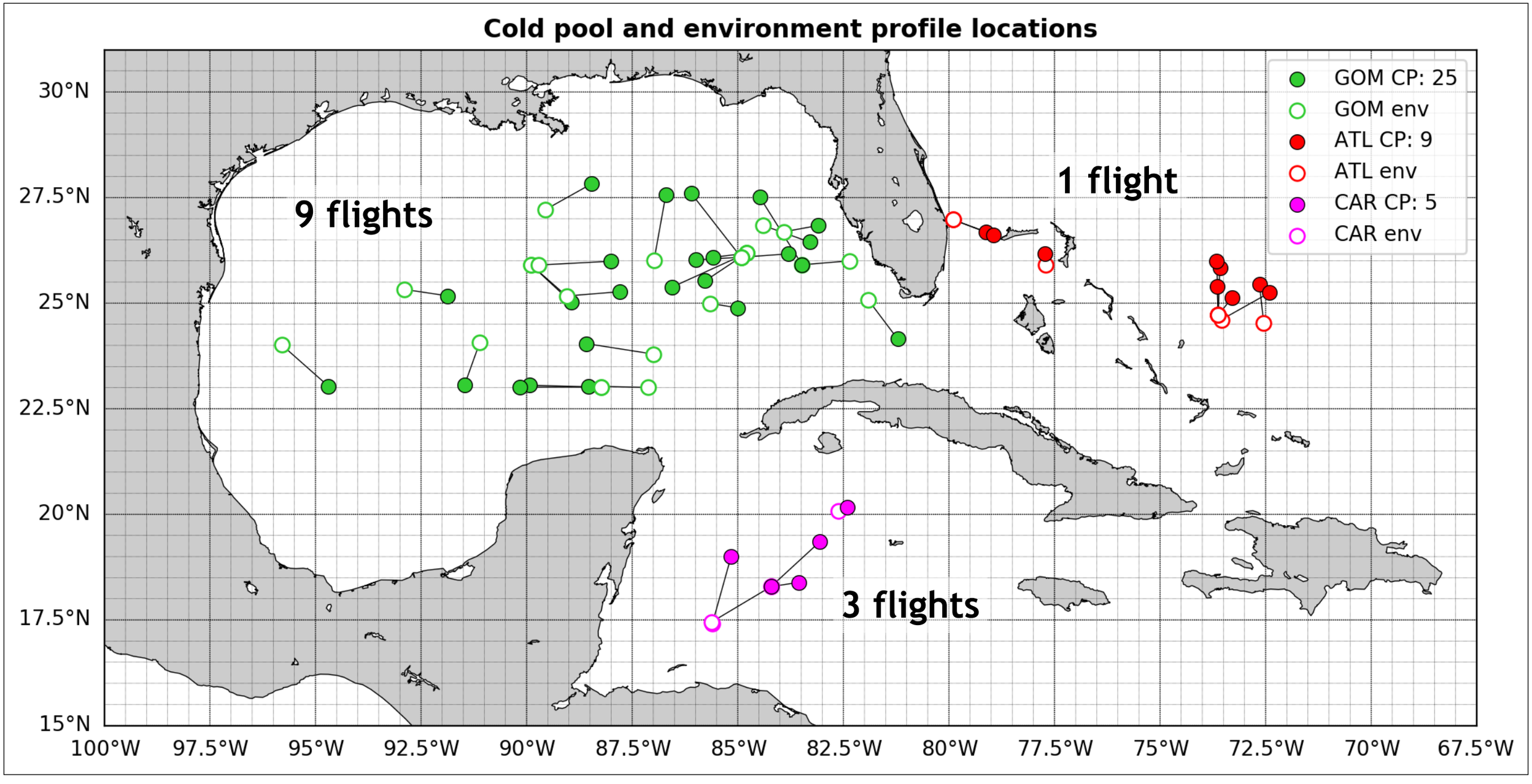
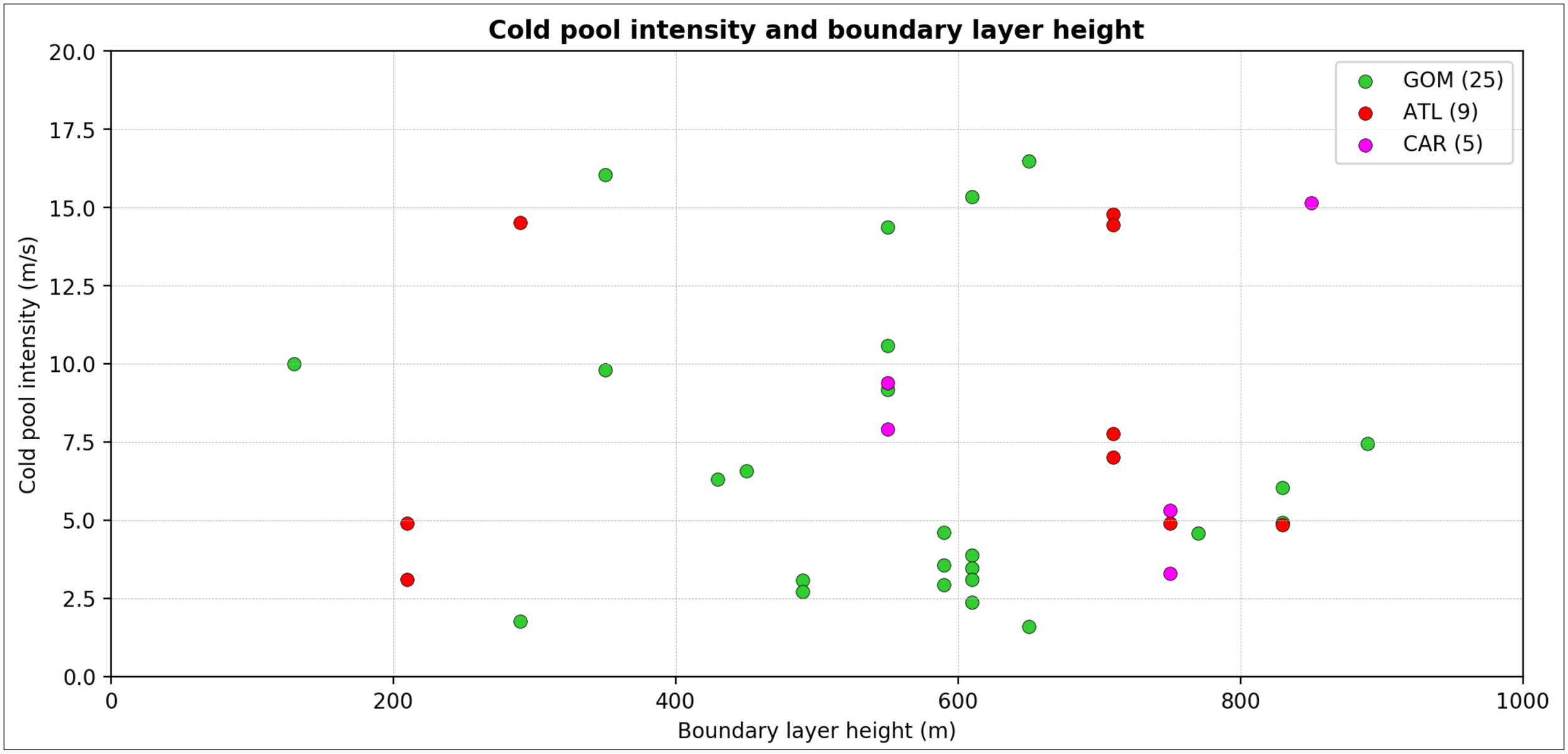
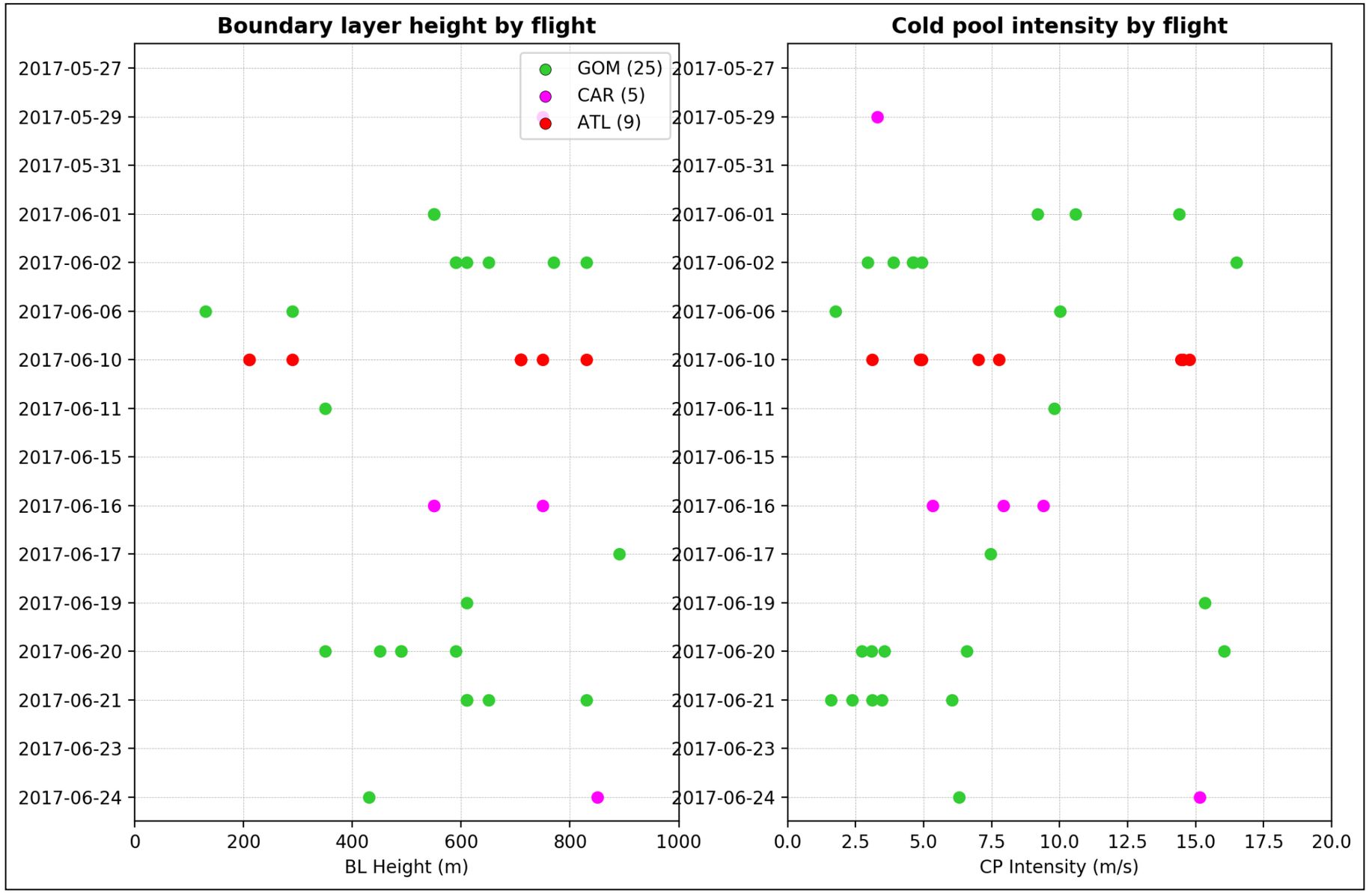


CPEX Cold Pool Summary



- **GOM** sampled organized convection (mesoscale & TS Cindy). Associated boundary layers are relatively shallow (560 m), and cold pools less intense (6.8 m/s).
- **ATL** and **CAR** sampled more isolated convection. We find deeper boundary layers (620 m) and more intense cold pools (8.4 m/s).

CPEX Cold Pool Summary



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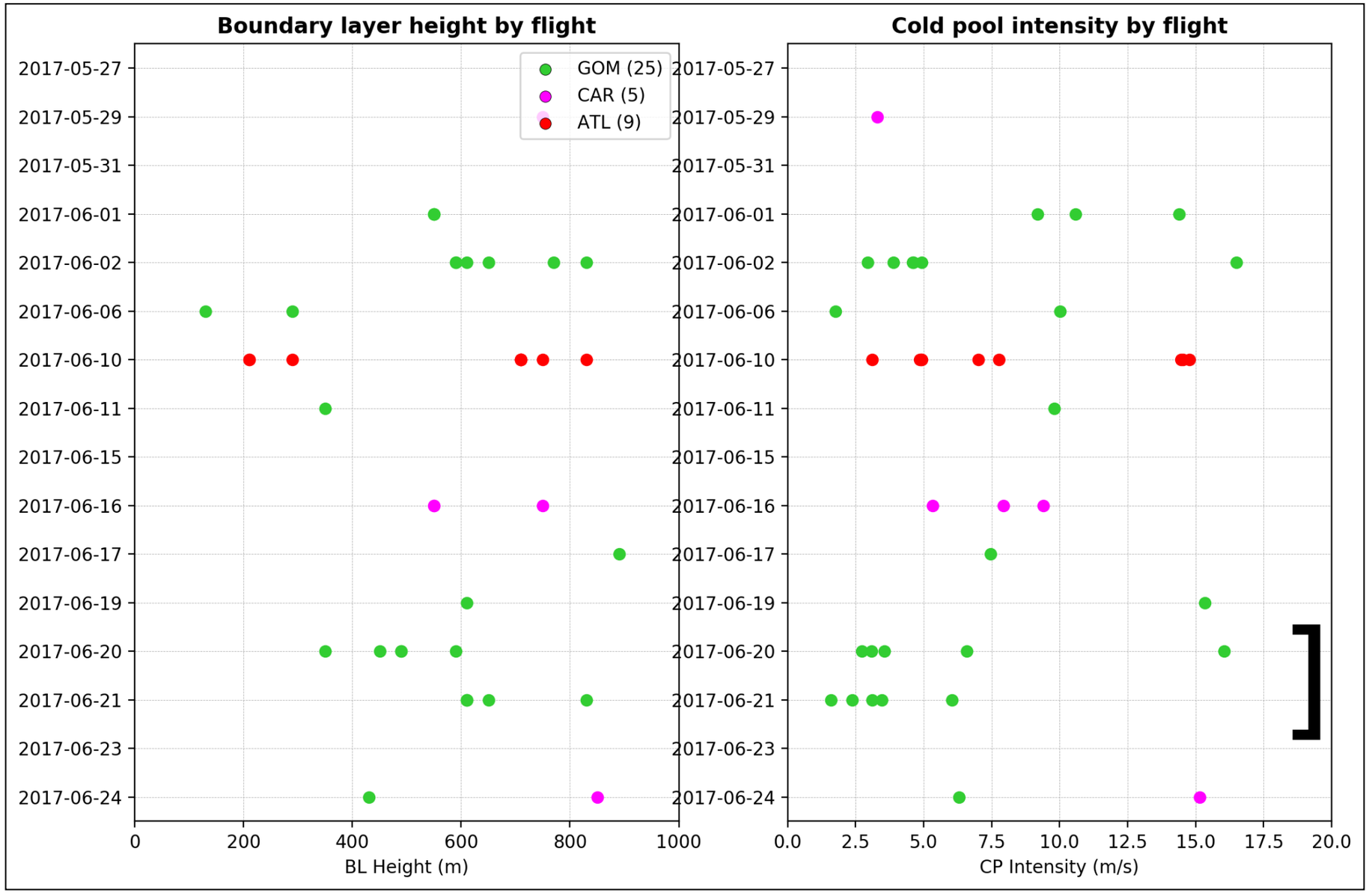

TS Cindy

- GOM sampled organized convection (mesoscale & TS Cindy). Associated boundary layers are relatively shallow (560 m), and cold pools less intense (6.8 m/s).
- ATL and CAR sampled more isolated convection. We find deeper boundary layers (620 m) and more intense cold pools (8.4 m/s).

Summary

General boundary layer height and cold pool intensity results match what we found in DYNAMO:

- In **large-scale, organized convection**, we find shallower boundary layers, and less intense cold pools.
- In more **isolated convection**, we find deeper boundary layers and more intense cold pools.

There are very few samples of cold pools from the convective core due to sensor malfunction.

We want to further quantify the cold pool recovery time as we did in DYNAMO, but we need SST measurements to compute air-sea fluxes. SST from dropsondes is not necessarily reliable.