



Summary of Hurricane Outflow Jet Structure Derived from Global Hawk Dropsonde Observations during HS3



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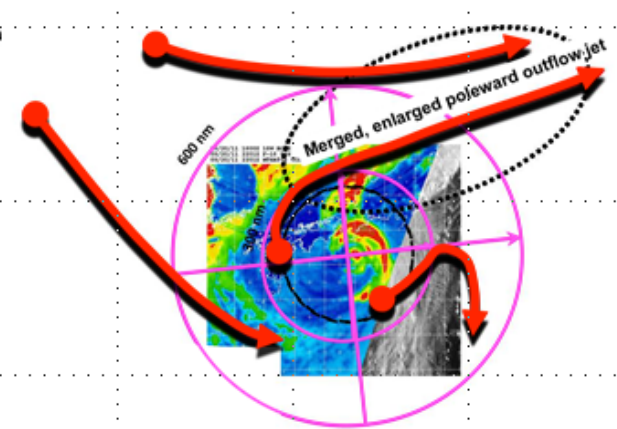
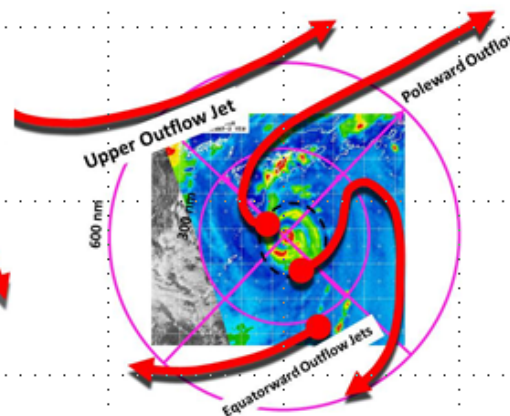
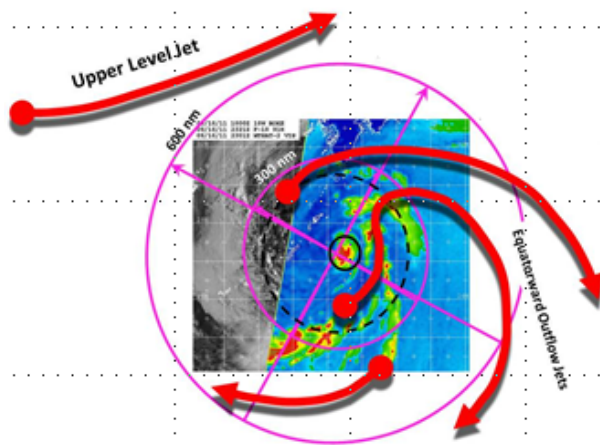
Objectives

- Measure outflow layer jets and inner core 'roots':
 - pattern,
 - strength,
 - structure and
 - orientation
- Relate to:
 - Hurricane intensity change and size: V_{max} , P_{min} , R_{max}
 - Boundary layer and inner-core structure
- Provide input for *BALANCED* initialization of TC models

HYPOTHESIS

TC Life Cycle, including Rapid Intensification (RI) and Rapid Decay (RD), is associated with environmentally-forced and inner-core convectively-forced outflow jet evolution:

- I. TC development- Single Equatorward-directed Jet
- II. Intensification and RI: Dual Equatorward and Poleward Jets
- III. Mature & decay (ET): Primarily, single Poleward-directed Jet

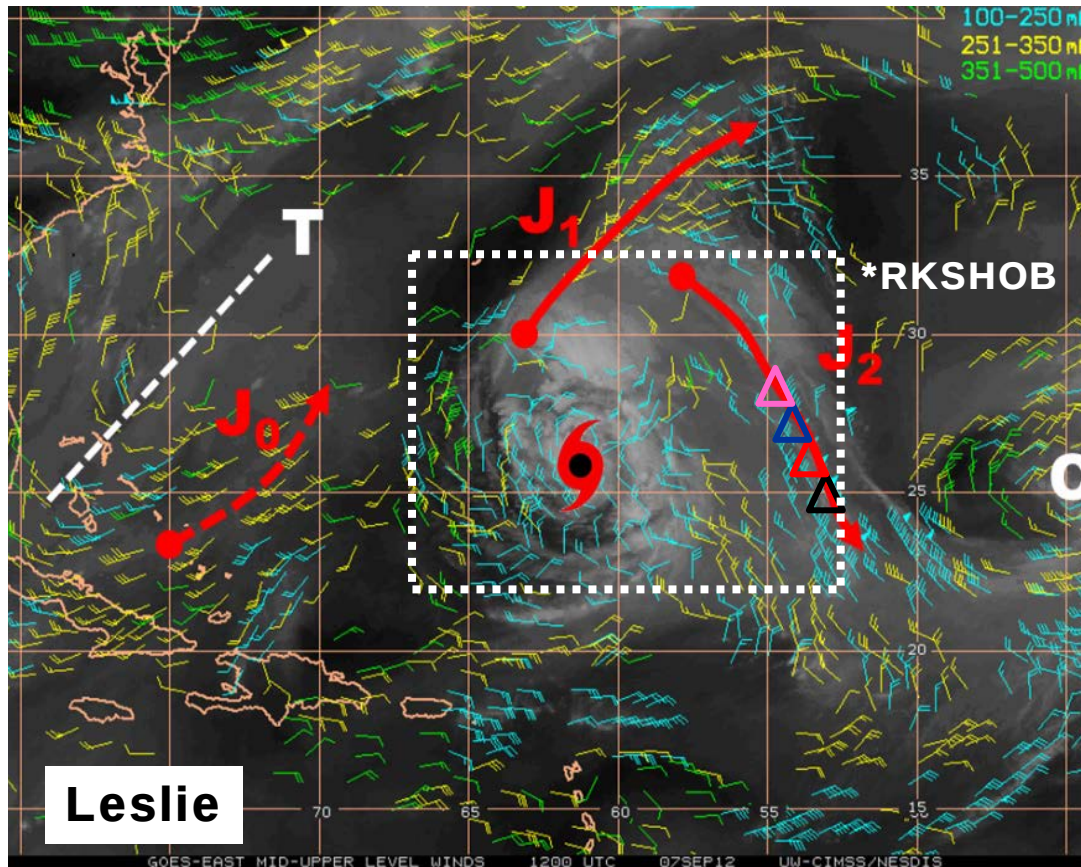




Outflow Studies Best Cases

- **Leslie, 7Sept, 2012:**
 - Outflow Jet forced by Environment
- **Nadine, 14-15 Sept, 2012:**
 - Outflow Jet 'Roots': associated with 'inner-core' supercell convection
- **Pre-Gabrielle, 4-5 Sept, 2013**
 - Outflow Jet rapid onset: associated with convective 'burst' diurnal cycle
- **Edouard, 14-15 Sept; 16-17 Sept, 2014**
 - Transition from single poleward to dual poleward/ equatorward outflow jets during mini-RI (40 kt/ 12hr SATCON; 25 kt/ 12hr BT, SFMR) subsequent to convective 'bursts'
 - Genesis/ intensification on 11-12 Sept; ET on 19-20 Sept
- **Gonzalo, 15-17 Oct, 2014**
 - Transition from single poleward to dual poleward/ equatorward outflow jets during mini-RI (16 Oct)

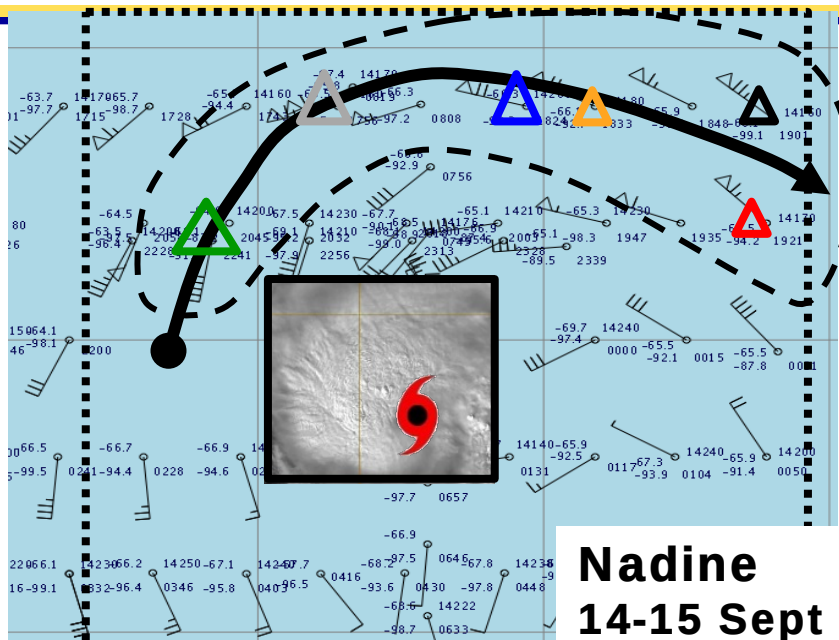
Leslie (7 Sept, 2012) Outflow Jet



***RKSHOB:**
Roger K Smith
Honorary
Outflow
Boundary

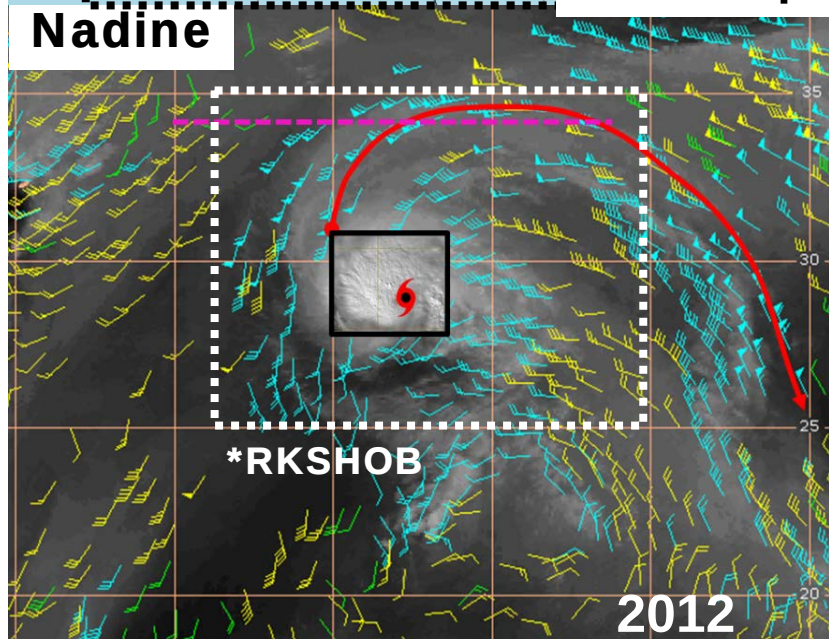
Outflow jet (J_1 & J_2) configuration established
in response to environmental features:

- Mid-Atlantic trough (TUTT), T
- Subtropical Jet, J_0
- Upper cold low, C



**Nadine
14-15 Sept**

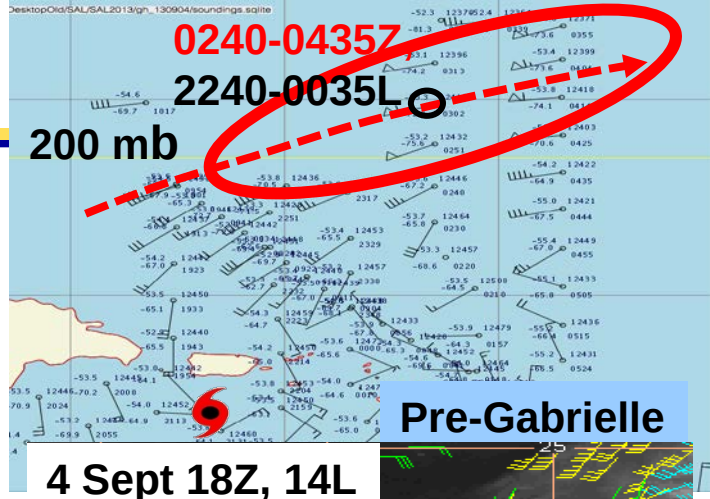
Nadine



***RKSHOB**

2012

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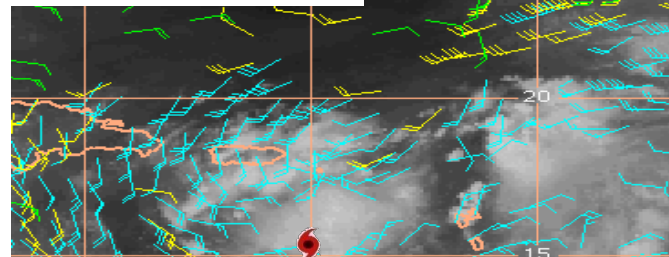
0240-0435Z

2240-0035L

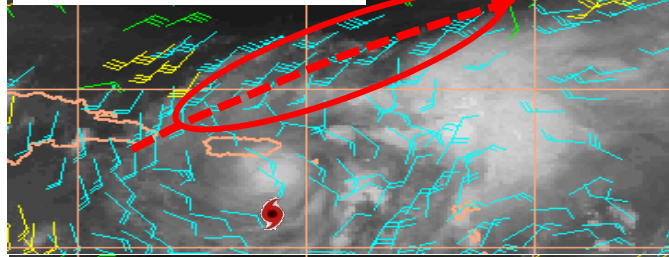
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Pre-Gabrielle

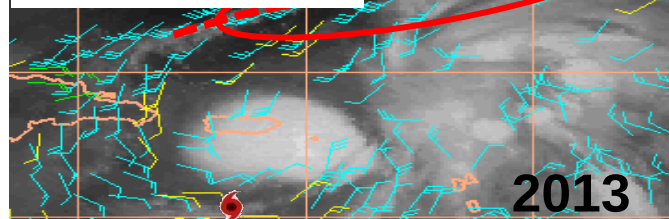
4 Sept 18Z, 14L



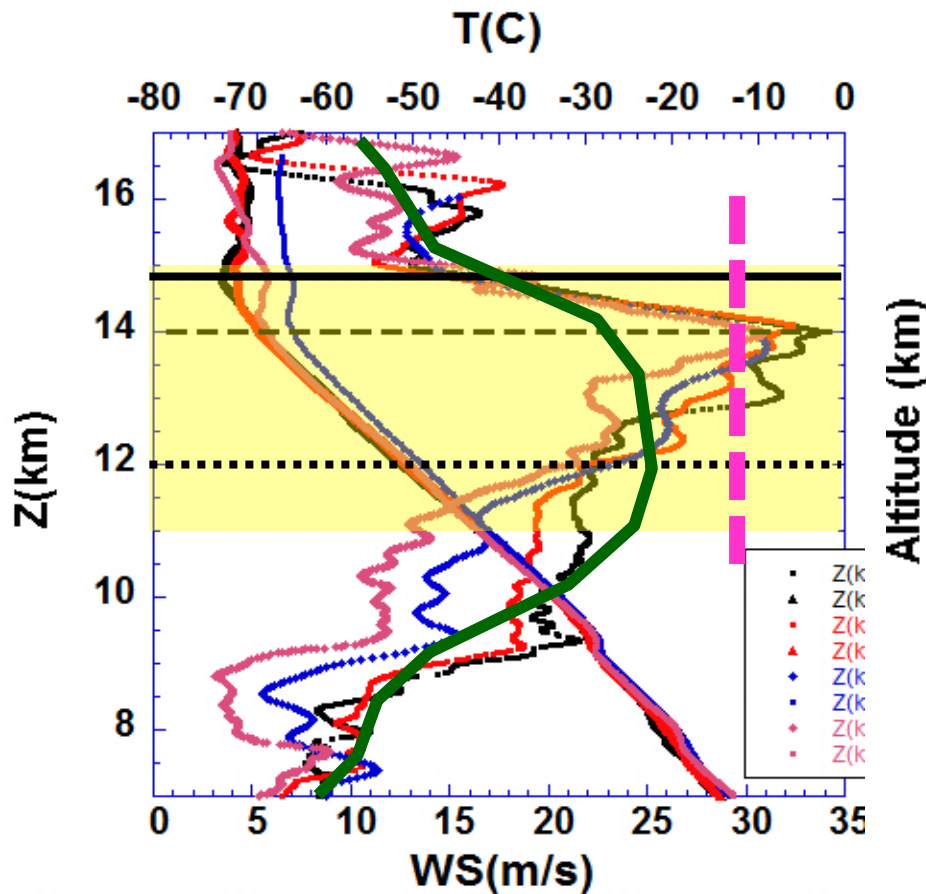
5 Sept 00Z, 20L



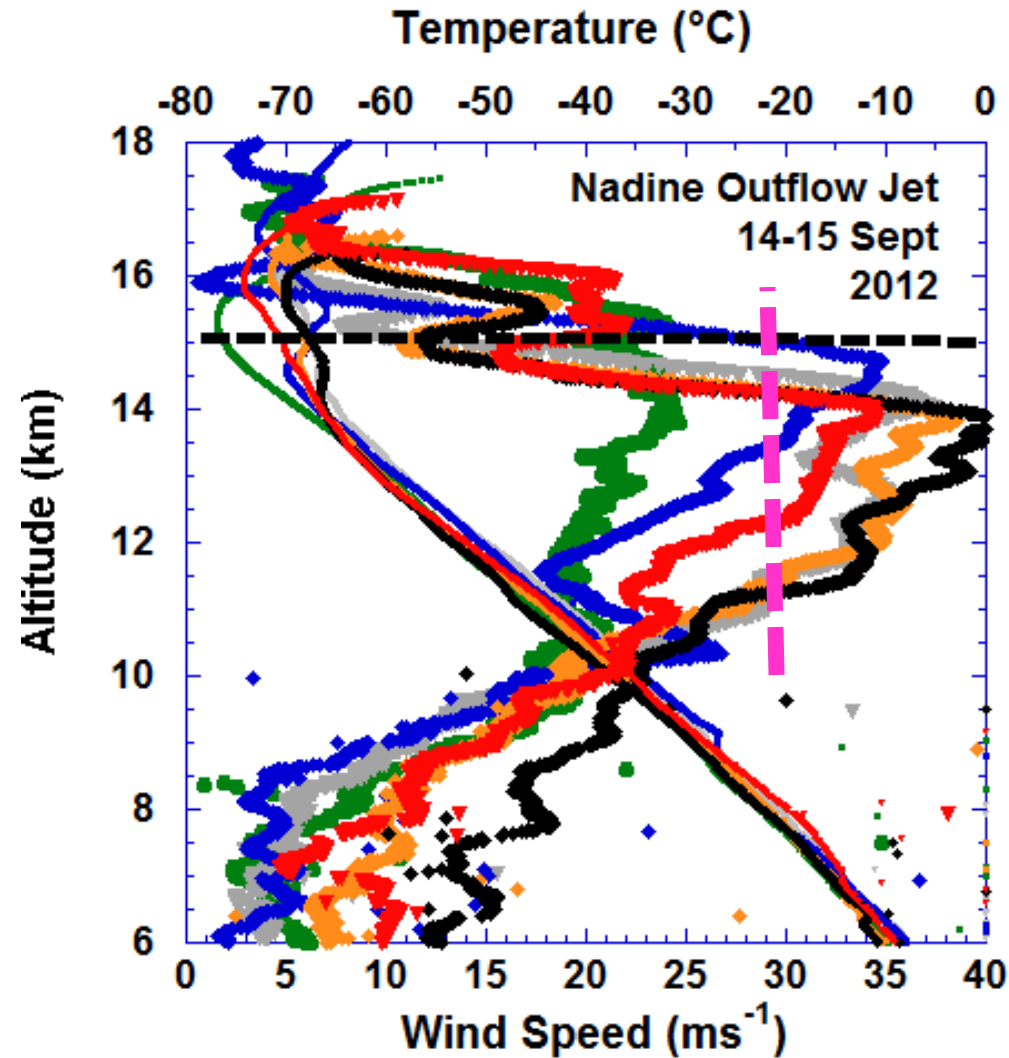
5 Sept 06Z, 02L



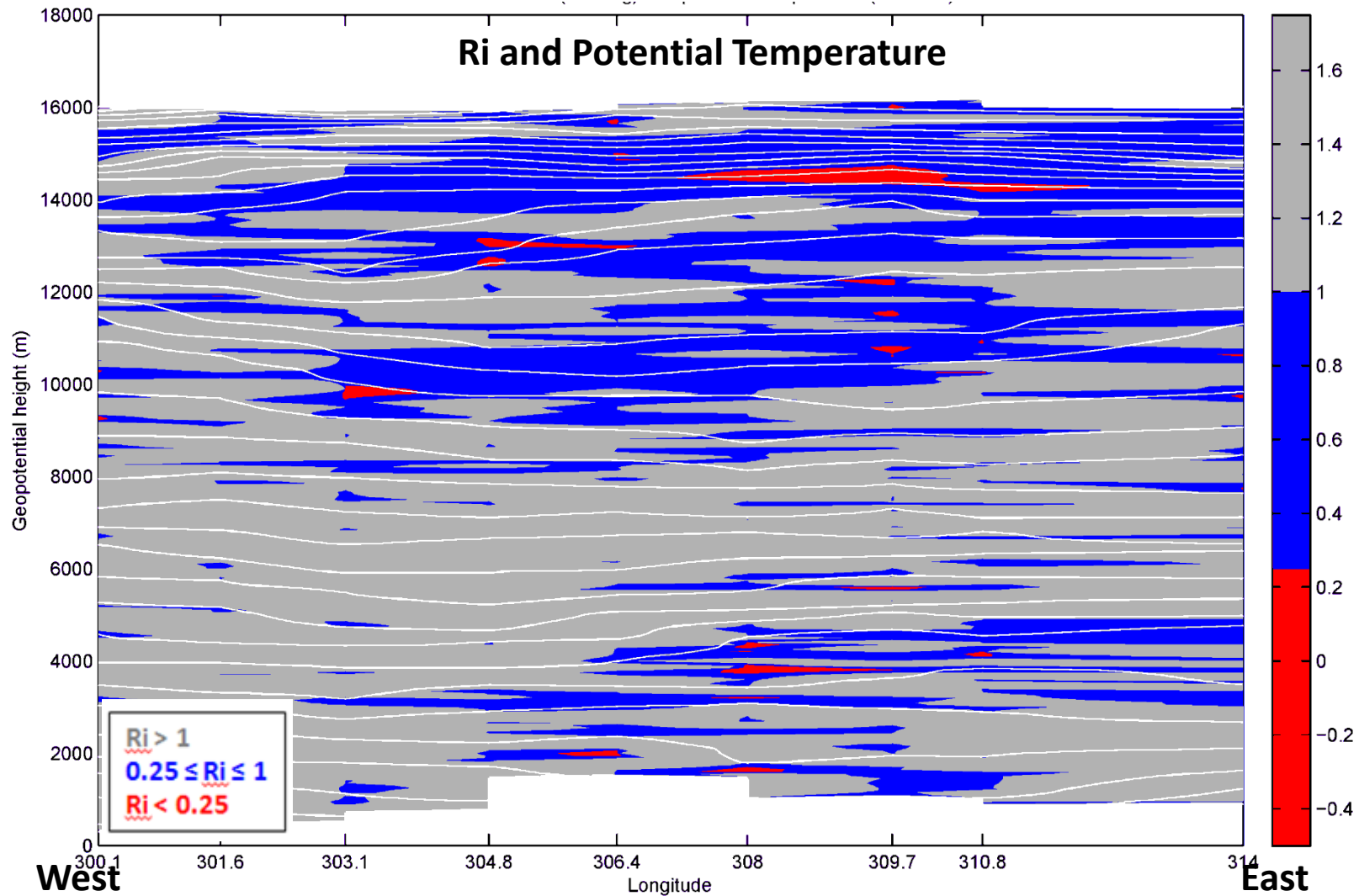
2013



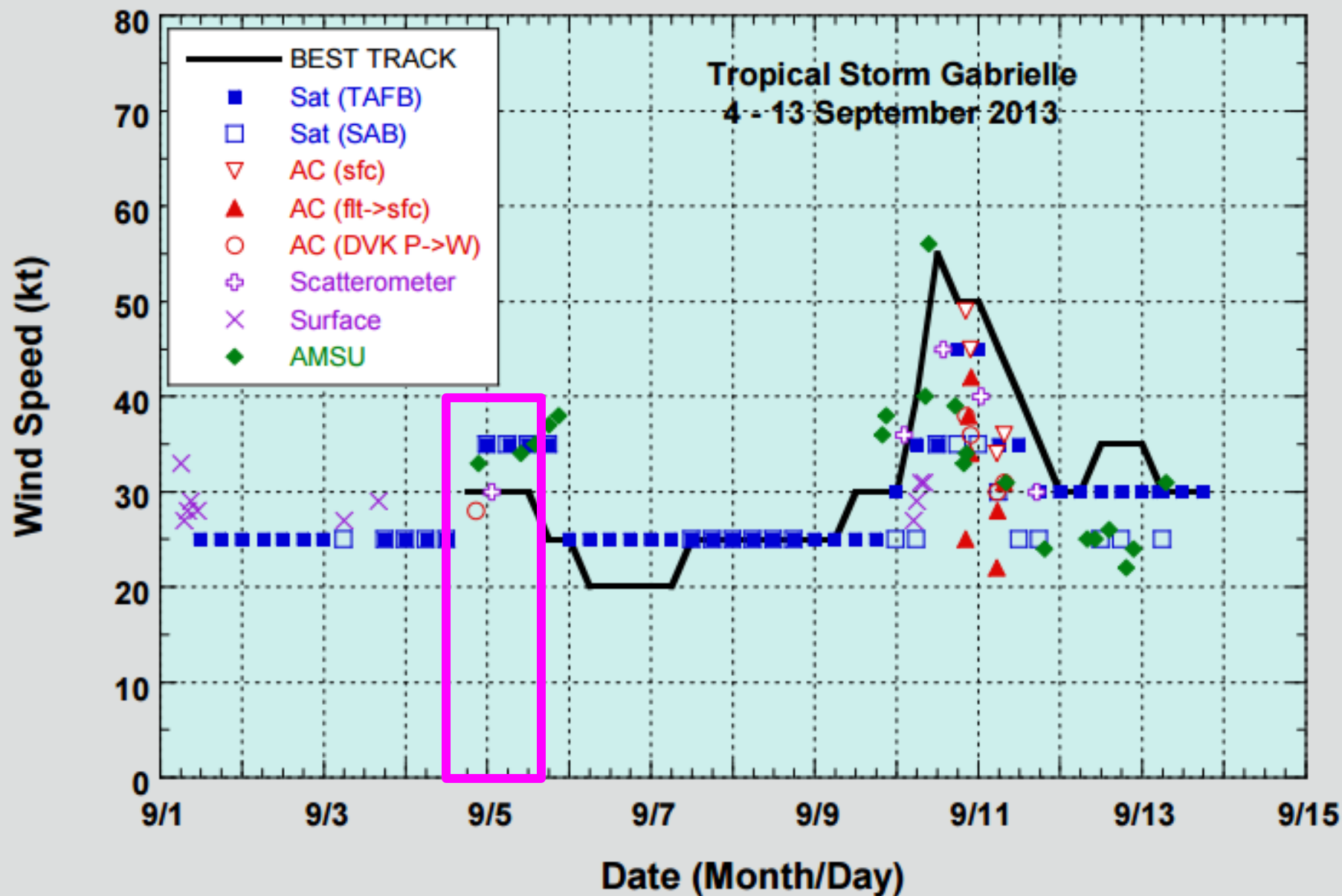
Leslie, 2012



Nadine, 2012



- Sharp shear zone just above tropopause and below outflow. (Jon Moskaitis)
- $Ri < 1/4$ particularly above the outflow jet (less frequently below jet).





Pre-Gabrielle AMV Diurnal Outflow Pattern

**Pre- Gabrielle
2013**
4 Sept 18Z, 14L

4 Sept 21Z, 17L

5 Sept 00Z, 4/20L

5 Sept 03Z, 4/23L

5 Sept 06Z, 02L

5 Sept 09Z, 05L

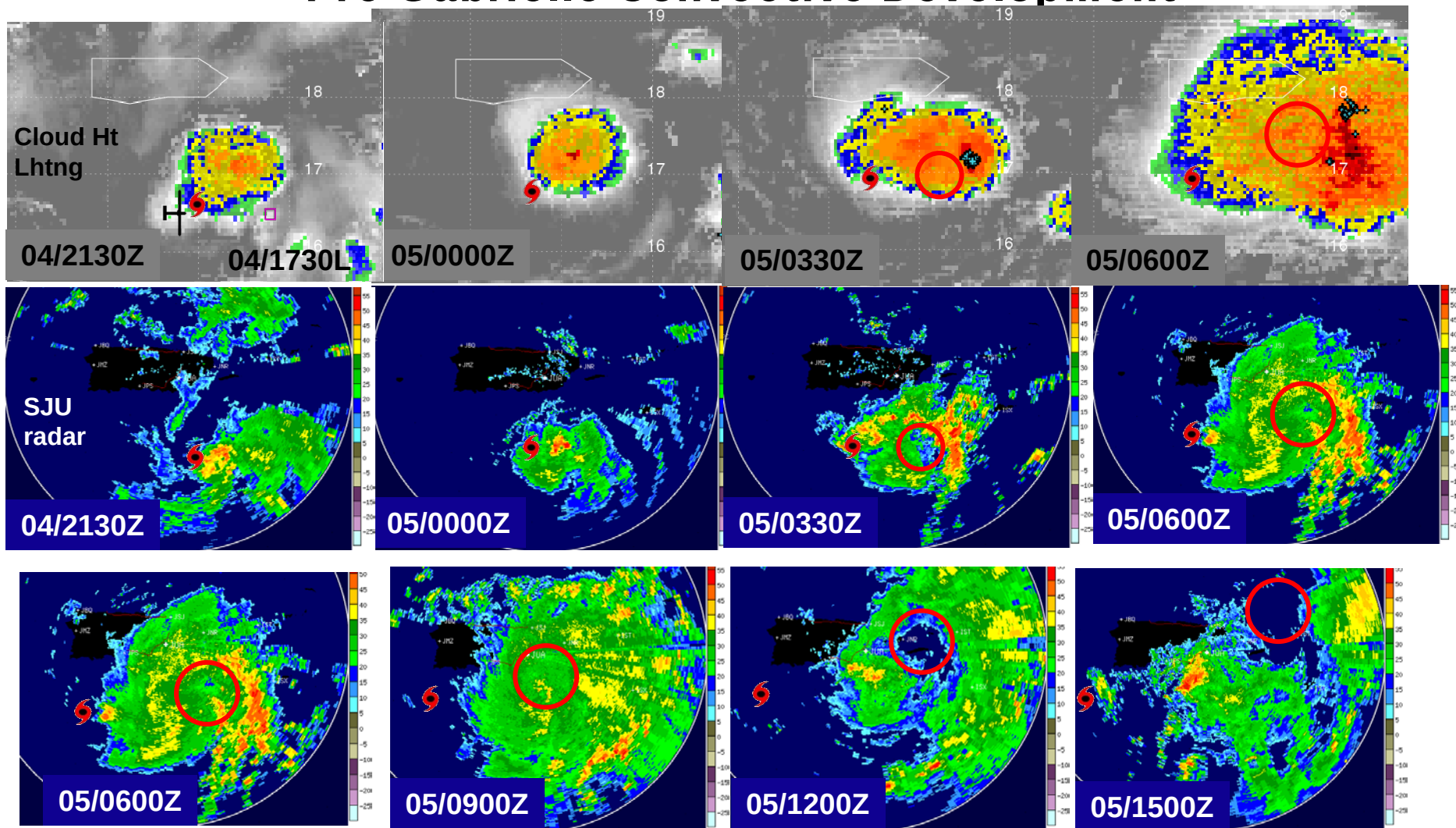
5 Sept 12Z, 08L

5 Sept 15Z, 11L

5 Sept 18Z, 14L



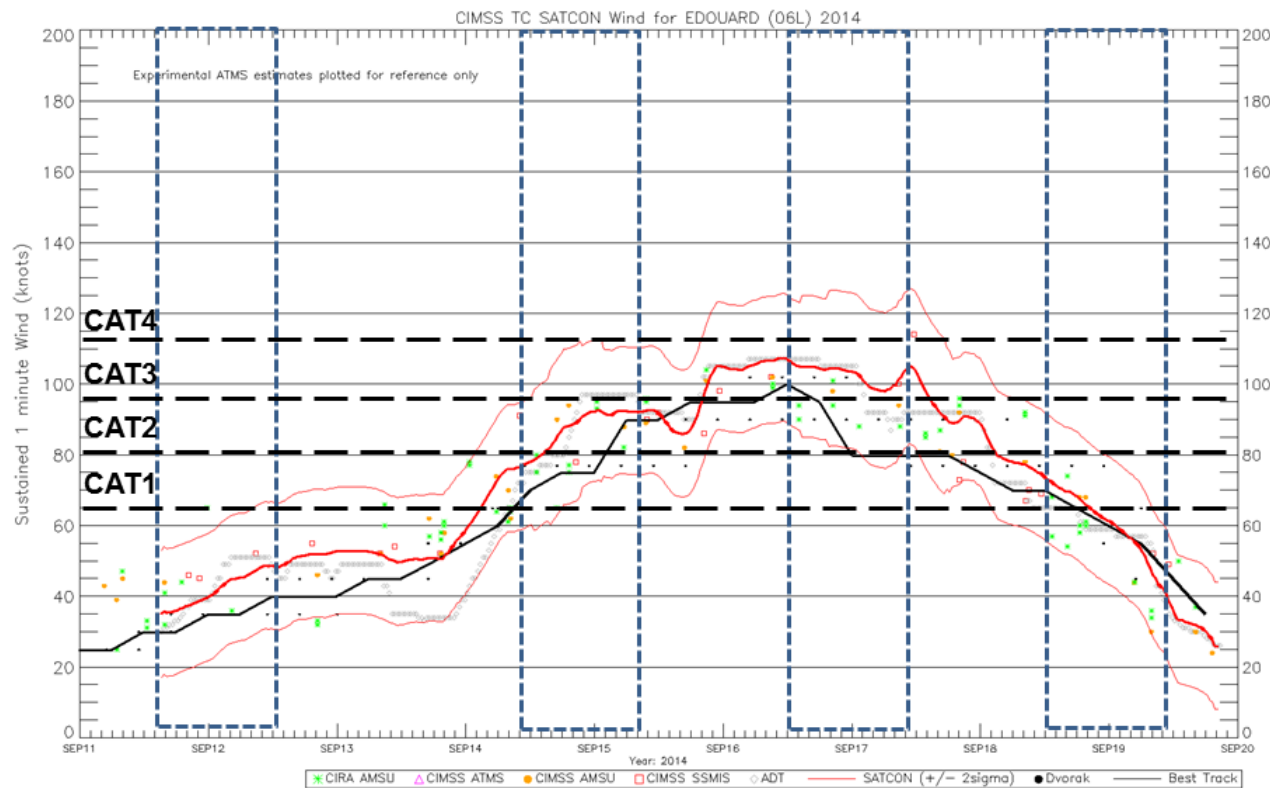
Pre-Gabrielle Convective Development



Pre-Gabrielle 2013

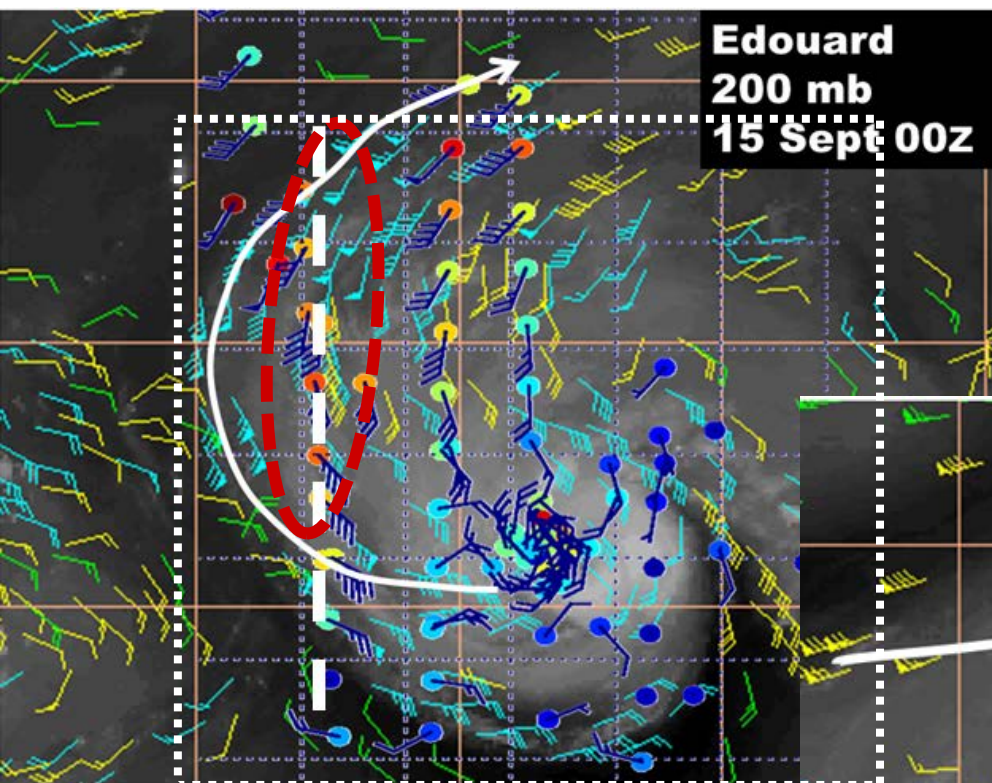


Edouard 2014 Global Hawk UAV AVAPS Minisondes Synoptic Forcing



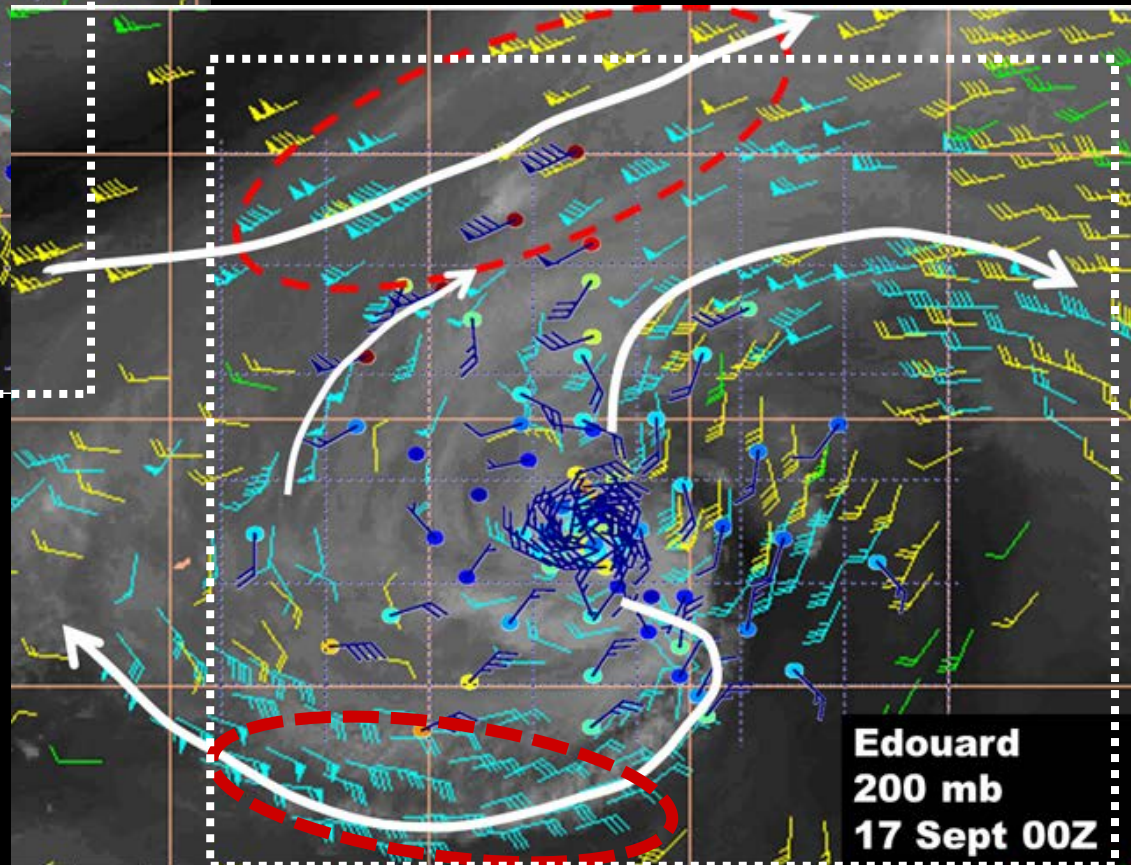


Revolutionary Research... Relevant Results



Edouard
200 mb
15 Sept 00z

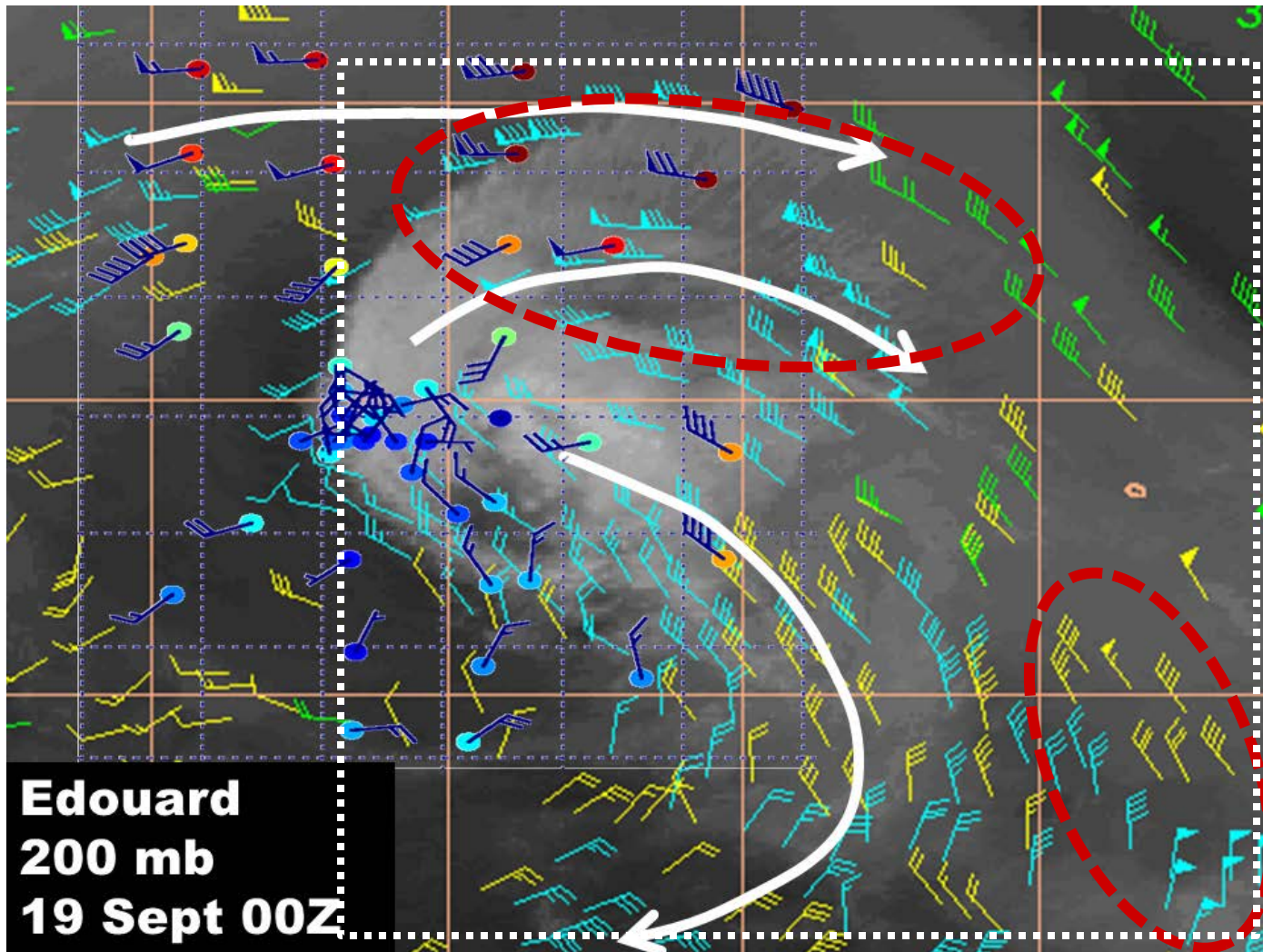
Phase I



Phase II

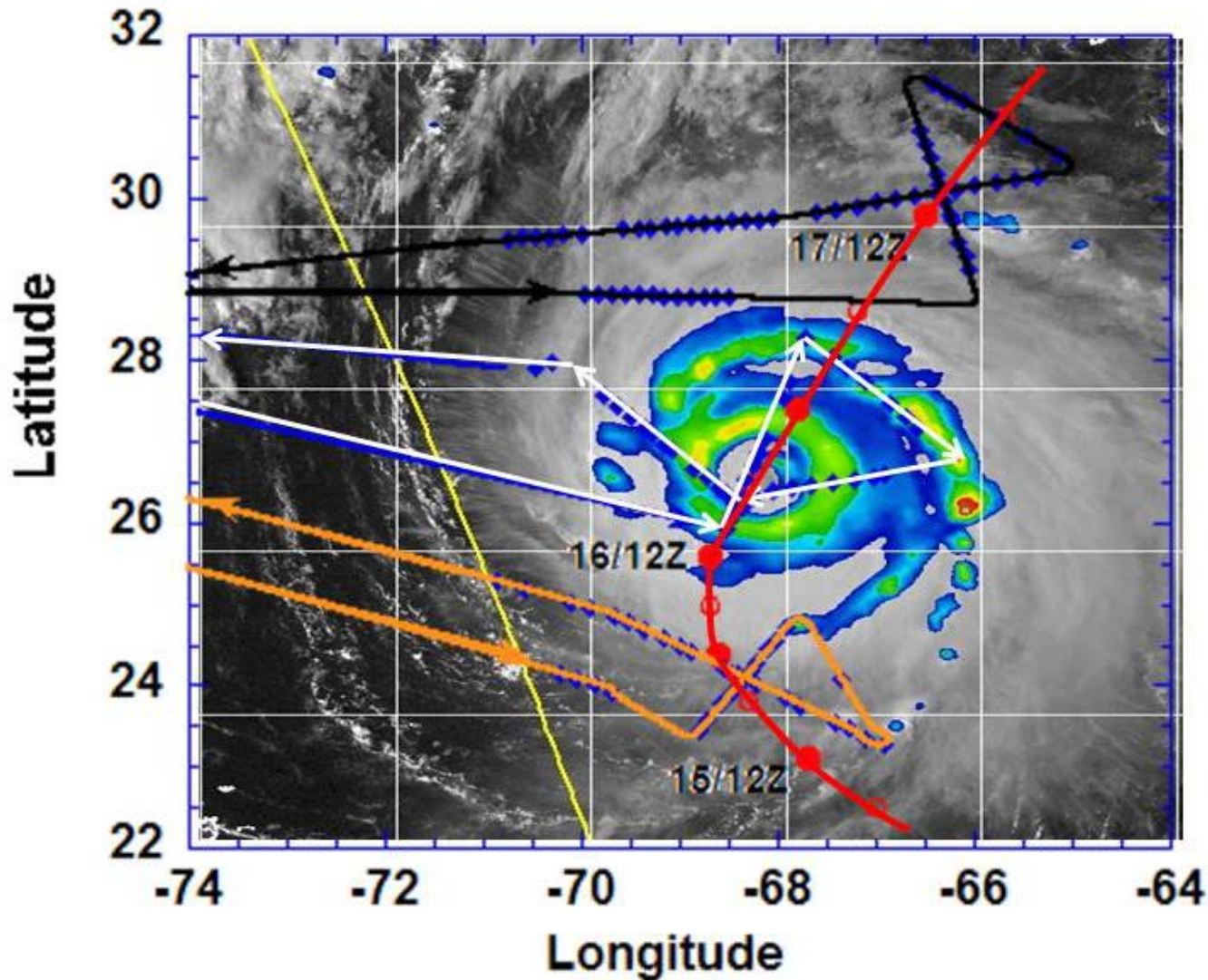
Edouard
200 mb
17 Sept 00z

(Sonde plots courtesy Scott Braun, NASA Goddard)
(Rapid-Scan AMVs courtesy CIMMS)



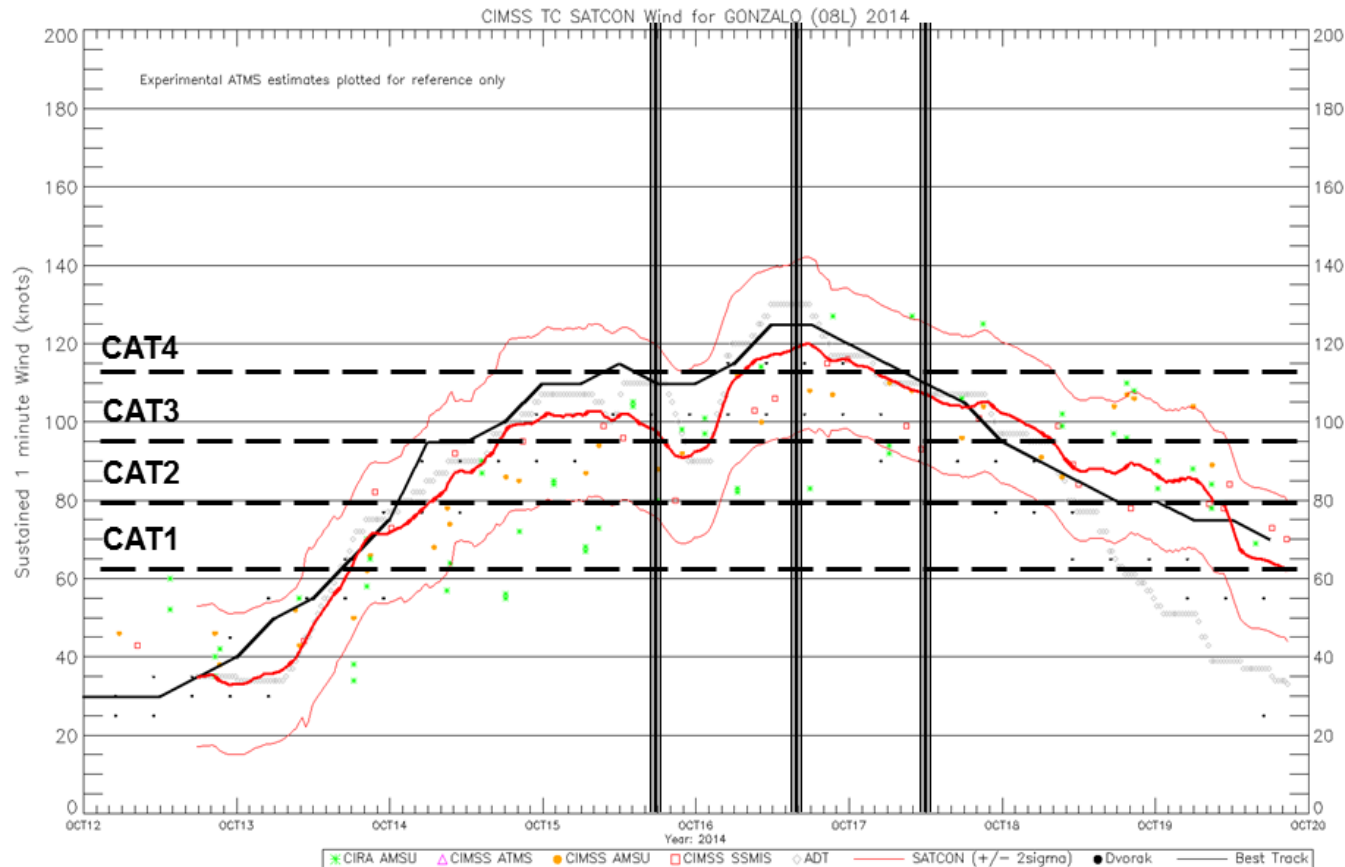
Phase III

Gonzalo Best Track WB-57 Track XDD Drops



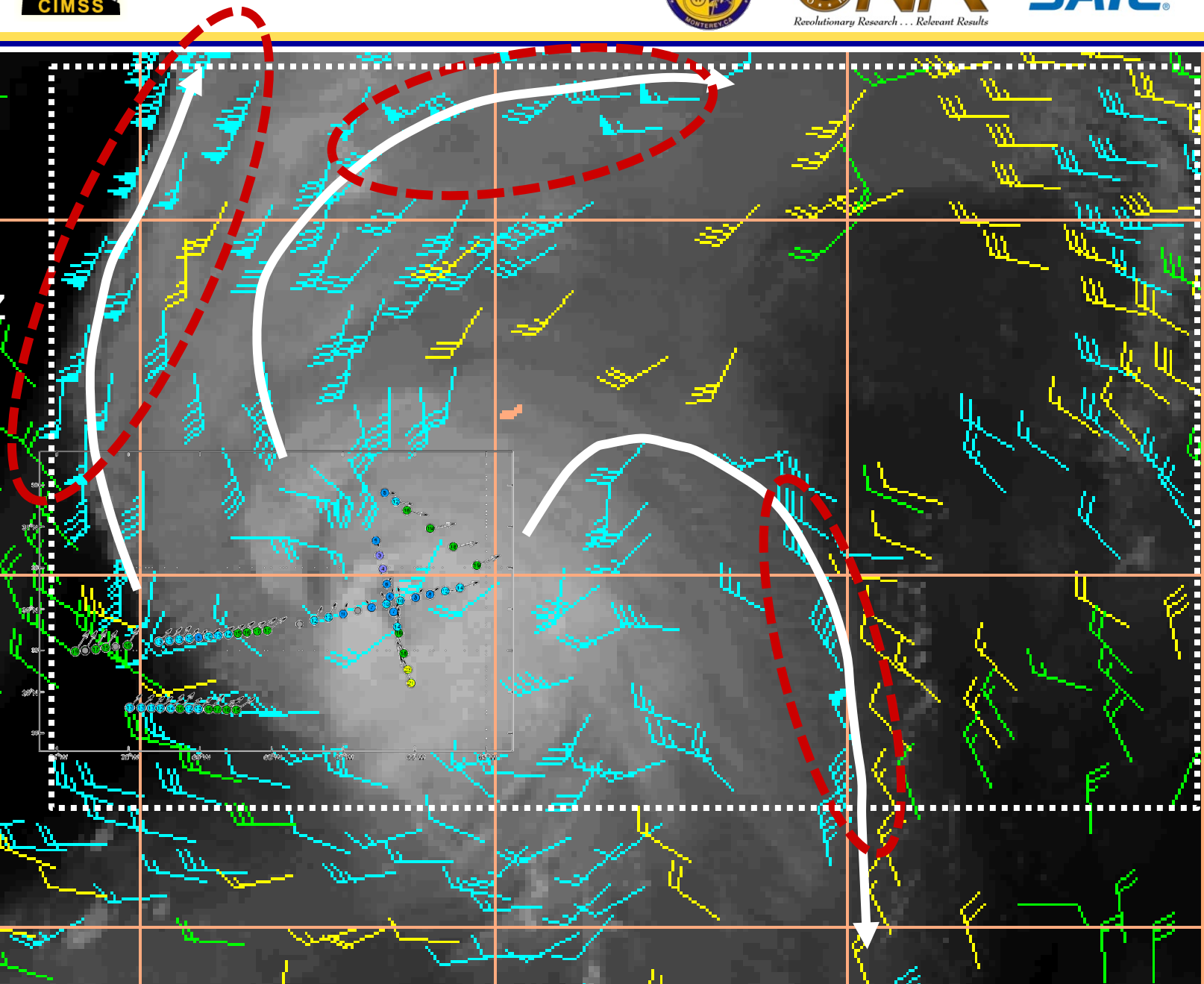


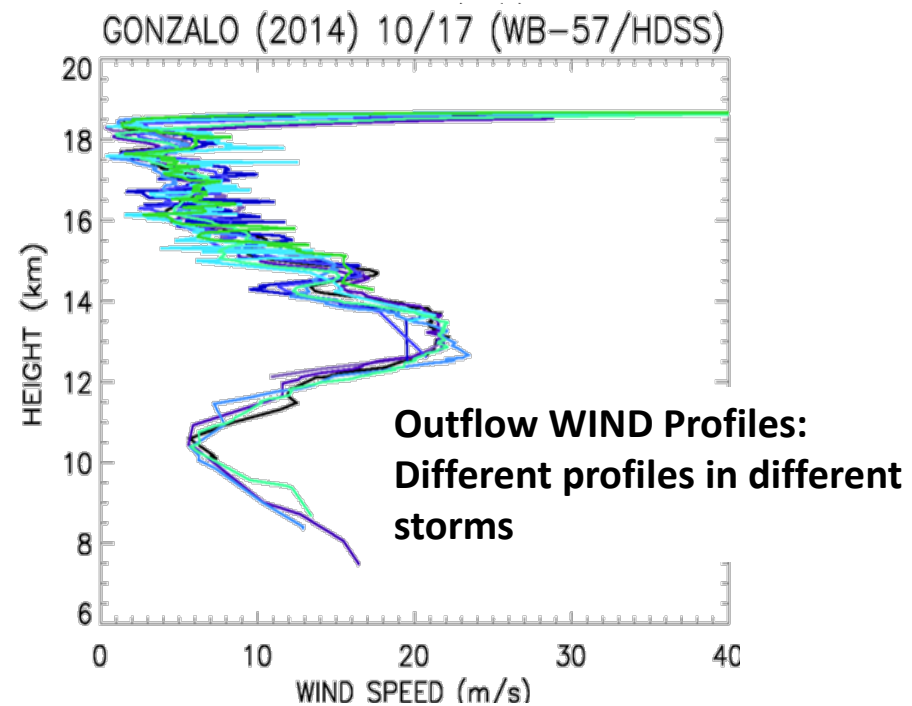
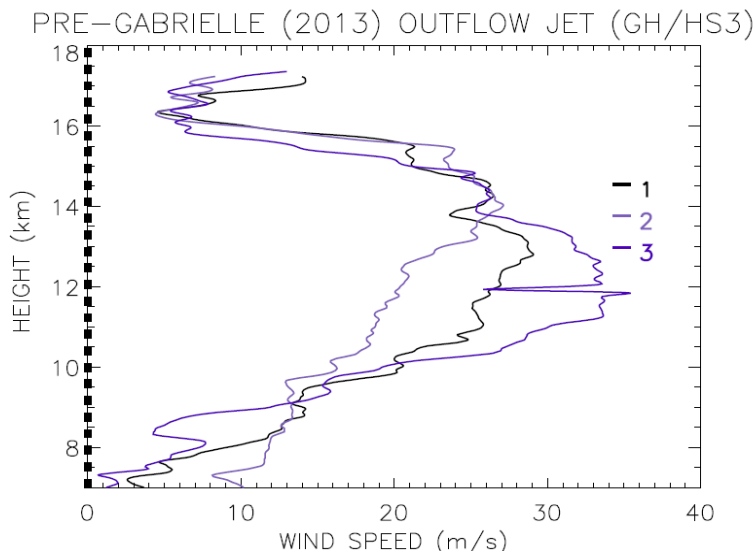
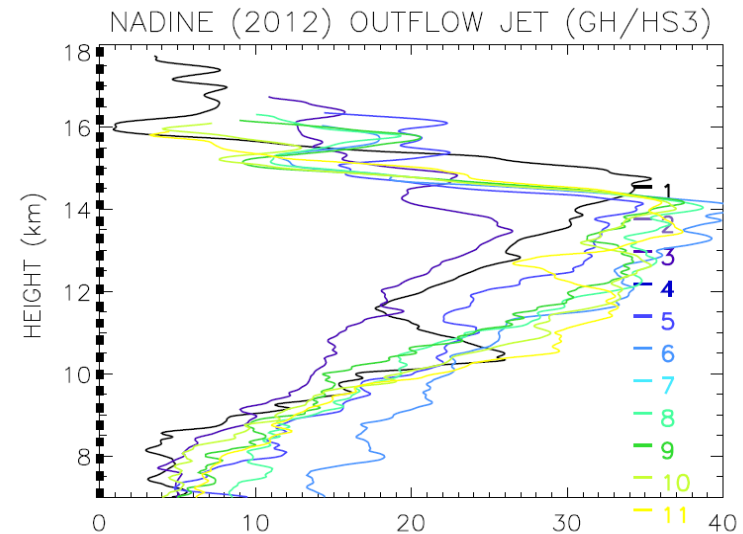
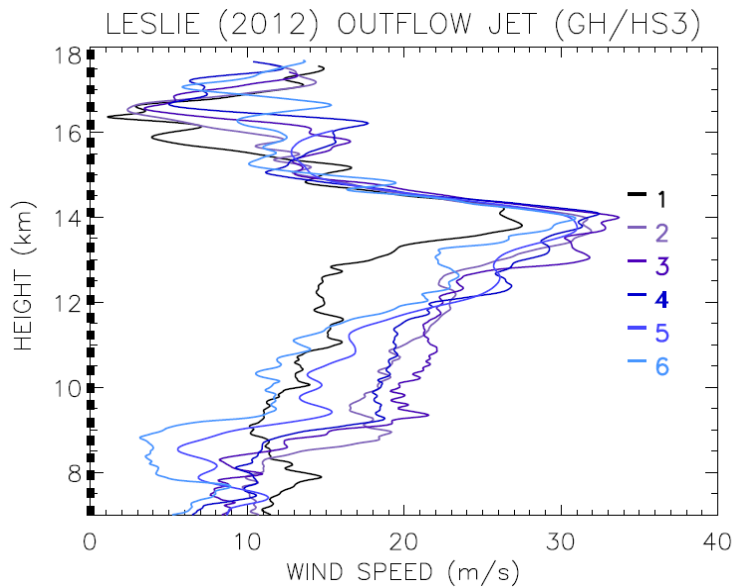
Gonzalo 2014 WB-57F HDSS/ XDD sondes Convective Forcing





Gonzalo
17 Oct 12Z
Phase II





Achievements and Key Findings



- ❑ Four TC outflow layers sampled 2012-14 HS3/ Global Hawk: Leslie, Nadine, Pre-Gabrielle, Edouard; One partial 2014 TCI/ WB-57: Gonzalo
- ❑ Outflow layer jets sometimes precede intense inner core convection
 - Some thin peripheral outflow jets appear to be forced by environmental features: Leslie
 - ✓ Subtropical jets
 - ✓ Upper cold lows
 - ✓ Tropical Upper Tropospheric Troughs (TUTTs)
 - Thick inner-core outflow jets associated with convective bursts: Nadine, Pre-Gabrielle, Edouard: enhanced outflow preconditions TC for future intensification or RI: dual outflow jet development
 - Dual poleward and equatorward jets associated with RI: Edouard, Gonzalo
- ❑ Here-to-for unknown outflow jet fine-structure may lead to instabilities which enhance outflow layer mixing not yet adequately modelled.
- ❑ Outflow jets appear to have diurnal modulation in response to burst.

