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: Vmax, Pmin, Rmax
  - 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

Phase I

Phase II

Phase III
Outflow Studies Best Cases

- **Leslie, 7 Sept, 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

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

a) Mid-Atlantic trough (TUTT), $T$

b) Subtropical Jet, $J_0$

c) Upper cold low, $C$

*RKSHOB: Roger K Smith
Honorary Outflow Boundary
5-7 May, 2015  Moffett Field, CA

2015 HS3 Science Meeting
NASA Ames Research Park

Pre-Gabrielle
4 Sept 18Z, 14L
5 Sept 00Z, 20L
5 Sept 06Z, 02L

Nadine
14-15 Sept

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2012
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
Edouard 2014
Global Hawk UAV
AVAPS Minisondes
Synoptic Forcing

CIMSS TC SATCON Wind for EDOUARD (06L) 2014

Sustained 1 minute Wind (knots)

CAT4
CAT3
CAT2
CAT1

Year: 2014

- CIRA AMSU
- CIMSS AMSU
- CIMSS SSMS
- AAT
- SATCON (+/- 1ktsmo)
- Inward
- Test Track
Phase I

Phase II

Edouard 200 mb 15 Sept 00Z

Edouard 200 mb 17 Sept 00Z

(Sonde plots courtesy Scott Braun, NASA Goddard)
(Rapid-Scan AMVs courtesy CIMMS)
Gonzalo 2014
WB-57F
HDSS/ XDD sondes
Convective Forcing

![Graph showing sustained 1 minute wind in knots over a period from OCT12 to OCT20, with categories CAT4, CAT3, CAT2, CAT1 indicated.](image)
Gonzalo
17 Oct 12Z
Phase II
Outflow WIND Profiles:
Different profiles in different storms
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.