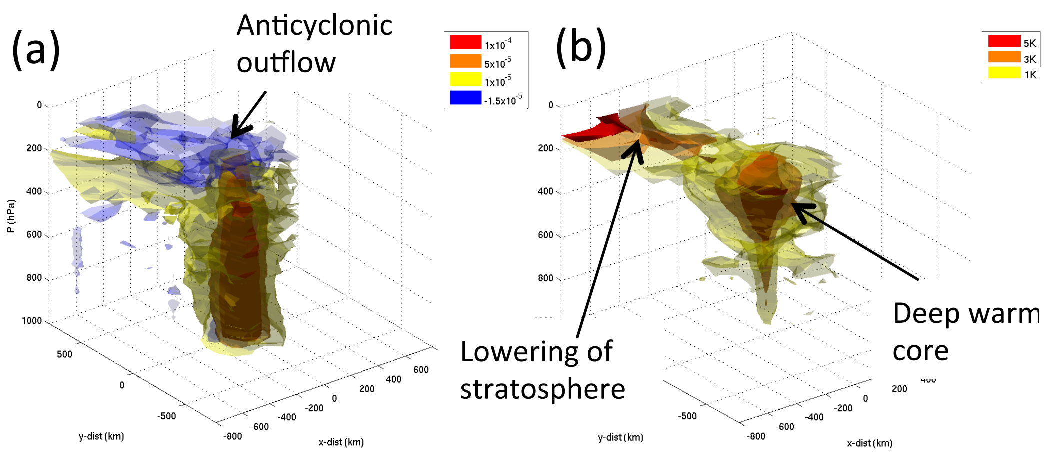
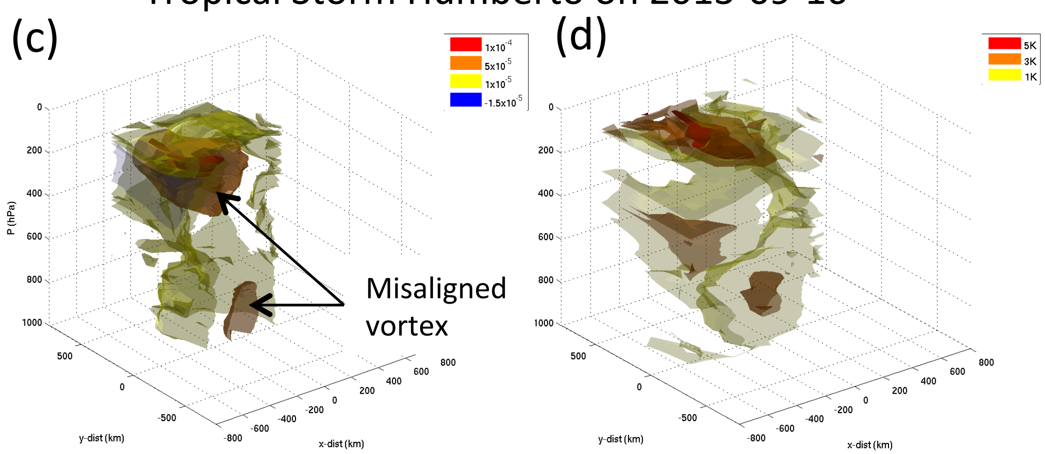
Tropical cyclone outflow and structure as revealed by high-resolution HS3 dropsonde data

3-dimensional structure

Hurricane Edouard on 2014-09-14

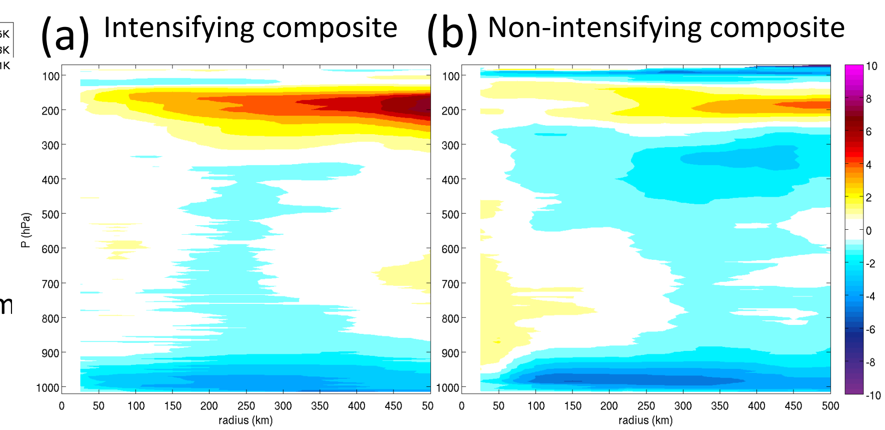


Tropical Storm Humberto on 2013-09-16



Relative vorticity *Potential temperature anomaly*

Cross sections of azimuthally-averaged radial wind



- Difference in strength and vertical alignment of vorticity structure and warm core well captured by the HS3 dropsondes
- Intensifying TCs found to be, in general, associated with stronger radial outflow than non-intensifying TCs, regardless of present storm intensity
- Radial outflow found to vary much more sharply in the vertical than the tangential wind component of the upper-level anticyclone, often accompanied by one or more inflow layers immediately above or below the primary outflow channel

From Komaromi and Doyle (2016)

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Data sources: Dropsonde data from the HS3 field campaign from 2012-2014. Data are interpolated to a 25 km grid in 5 hPa increments using a triangulation-based natural neighbor method. Storm motion and dropsonde drift are accounted for. Data spanning 16 research missions investigating 6 different tropical cyclones (TCs) are included, with comparisons made between hurricane strength versus sub-hurricane strength TCs and intensifying versus weakening TCs.

Technical Description of Figures:
Left (4-panel): Relative vorticity (a,c) and θ-anomaly (b,d) in three dimensions for Hurricane Edouard on 2014-09-14 (a,b) and Tropical Storm Humberto on 2013-09-16 (c,d). The analysis for Edouard depicts a vertically-aligned column of vertical vorticity beneath a well-developed upper-level anticyclone, associated with a deep upper-level warm core. In contrast, the analysis of Humberto depicts a misaligned vortex associated with detached upper and low-level warm cores, with a cold anomaly at middle levels.

Top right (2 panel): Composite radius-pressure cross sections of azimuthally-averaged radial wind for (a) intensifying and (b) non-intensifying and weakening TCs. For both subsets of data, radial outflow continues to strengthen with radius out to 500km; however, magnitudes are much greater for intensifying systems (note that data beyond 500km is not plotted as dropsondes becomes more limited and more asymmetric about the TC at further radii). This finding is consistent with the fact that strengthening TCs sampled during HS3 are associated with, on average, stronger upper-level divergence than weakening TCs, regardless of current intensity. However, weakening TCs are associated with comparable or even slightly stronger low-level inflow. As high values of inertial stability (I) resist radial motion, radial outflow is found to originate (aka the “outflow roots” region) in a region of more modest values of 1-2x10^{-4} s^{-1} for I (not shown).

Scientific significance, societal relevance, relation to future missions: The Global Hawk AV-6 has provided an unprecedented dataset of upper-level winds and temperature data in the TC outflow region. Many fundamental questions about the significance of outflow remain, such as whether outflow is passive (simply a response to TC size and intensity changes) or active (changes in strength or structure of outflow have an impact on the TC size and intensity). Fully exploring these data, in conjunction with high-resolution modeling efforts, will improve our understanding of the TC secondary circulation.