Automatic Airborne Doppler Wind Analysis aboard the NOAA WP-3D Aircraft

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JHT Project: Real-Time Dissemination of Hurricane Winds Determined from Airborne DopplerRadar Data (Project officially ended 30 June 2005)

Goals:

- **To demonstrate capability to automatically quality control airborne Doppler data well enough that they may be assimilated in "real-time", and also used to produce analyses of the hurricane core winds--*demonstrated in 2004***
- **To demonstrate capability to produce three-dimensional wind analyses in real time on the aircraft--*demonstrated in 2004***
- **To demonstrate capability to transmit the analyses to the NHC/TPC--*demonstrated in 2005***
- **To demonstrate transmission of the quality-controlled Doppler radial-velocity data to EMC for assimilation into HWRF--*real time quality control has been done but transmission presently severely limited by bandwidth***

Development Required for JHT Project

- **Automated Quality Control of Raw Doppler Data (completed)**
- **Software to generate batch job files (completed, although present implementation requires too much human input)**
- **Software to generate output files that can be transmitted off the aircraft by SATCOM to TPC (completed) and EMC (not completed)**
- **Path to TPC (completed) and EMC (not yet completed)**

Automatic quality control

- **Remove data with high velocity spectral width**
- **Remove reflection of main- and side-lobes by sea surface**
- **Remove isolated speckles which can fool the automatic Doppler unfolding process**
- **Use single ray "Bargen-Brown" automatic unfolding**
- **Use a full sweep de-aliasing method developed at HRD**
- **Produce a wavenumber 0 and 1 analysis of wind velocity**
- **Use low-wavenumber analysis to improve "Bargen-Brown" and sweep dealiasing**

Products produced on aircraft

- **Three-dimensional wind field centered on storm center domain: (44 x 44 x 37), resolution: (3-5 km x 3-5 km x .5 km) variables: horizontal and vertical wind velocity, radar reflectivity**
- **Radial-vertical cross-sections of wind along the average azimuth flown outward from the storm center domain: (59 x 121), resolution (1.5 km radial, 150 m vertical) variables: tangential, radial, vertical, and total wind speed**
- **Trimmed set of quality-controlled Doppler radial-velocity measurements**

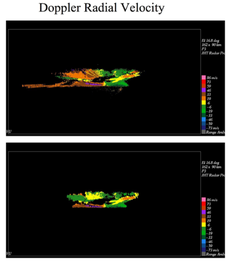
Products transmitted from aircraft via SATCOM in 2005

- **u- and v-components of wind at 0.5- and 1.0-km levels (1640 and 3280 ft) sent in knots as 4 gzipped ASCII text files (4-5 km horizontal resolution)**
- **Inbound and outbound vertical-radial profiles of total wind speed (1.5 km radial resolution, .15 km vertical resolution, out to 88 km)**

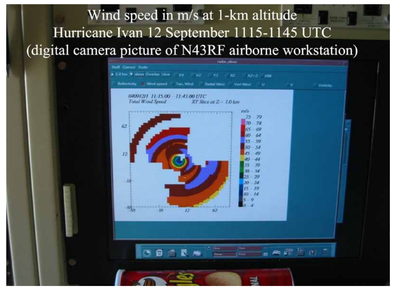
Doppler Radial Velocity

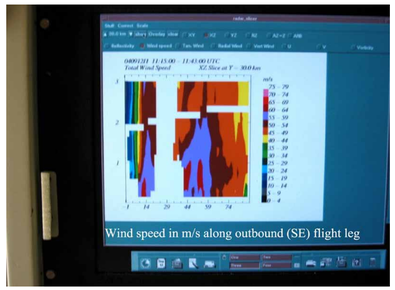
Before Quality Control

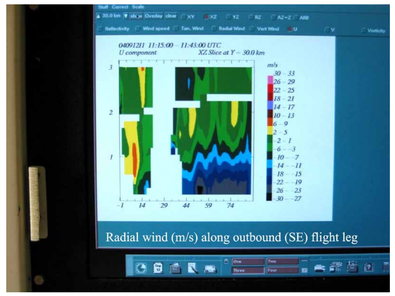
After Quality Control



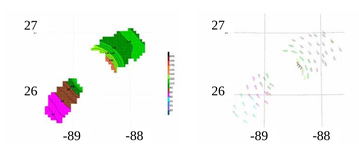
Hurricane Humberto
232855 UTC
23 Sep 2001



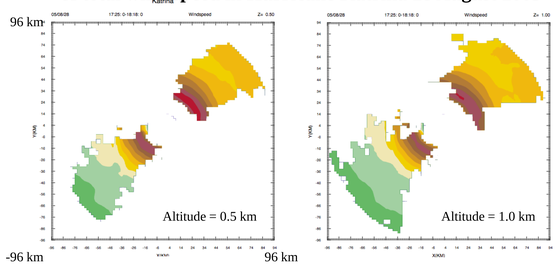




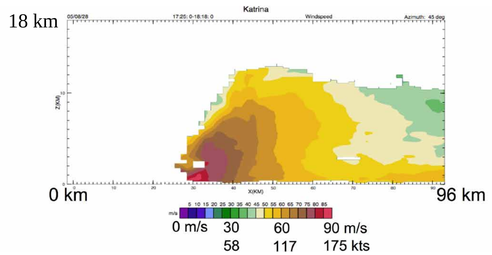
Real-time 1600-ft analysis of Hurricane Katrina Wind
1725 - 1818 UTC, 28August 2005
wind in knots as seen within N-AWIPS graphics overlays



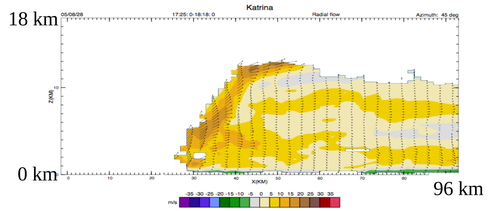
Three-dimensional cartesian analysis of total wind speed in Hurricane Katrina 28 August 2005

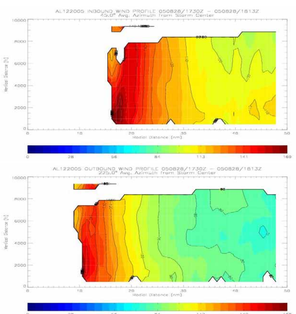


Radius-height cross-section of total wind speed Hurricane Katrina 1725-1818 UTC 28 August 2005



Radius-height cross-section of radial wind speed Hurricane Katrina 1725-1818 UTC 28 August 2005



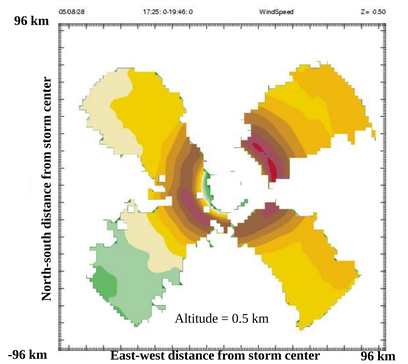


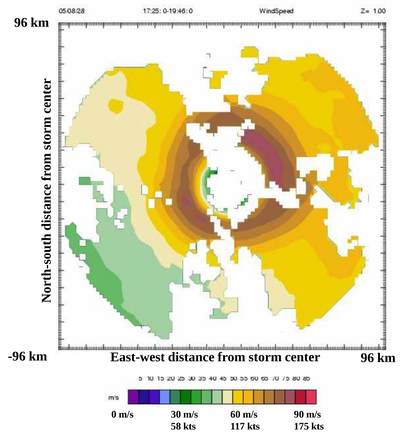
Inbound radial cross-section

Outbound radial cross-sectior

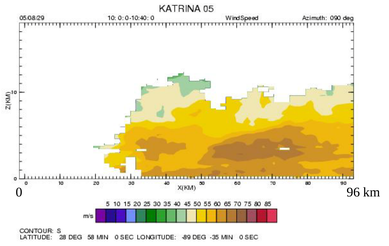
Real-time vertical cross-sections of wind speed (knots) in NAWIPS Environment Same analysis time as that to the left and above

Three-dimensional cartesian wind-speed analysis from combining first and second pass through Hurricane Katrina on 28 August

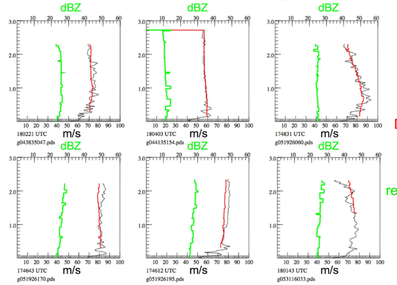




Radius-height cross section just before Katrina Landfall (29 Aug 2005) showing elevated wind speed maximum



Sonde - Doppler total-wind-speed intercomparison
Hurricane Katrina 28 August 2005



Comparison for all drops on 28 August 2005 by NOAA 43 with real time airborne Doppler analysis (0.5 - 1.0 km layer)
note--nearly all drops are eyewall (wind max) drops where wind variability is high

- **Radial wind mean difference (sonde – Doppler): 6.7 m/s, 13.0 kts**
- **Tangential wind mean difference (sonde – Doppler): 1.5 m/s, 2.9 kts**
- **Wind speed mean difference (sonde – Doppler): 0.4 m/s, -0.8 kts**
- **Radial wind RMS difference: 13.6 m/s, 26.4 kts**
- **Tangential wind RMS difference: 7.5 m/s, 14.6 kts**
- **Wind speed RMS difference: 6.4 m/s, 12.4 kts**

Comparison of all NOAA drops in 2004 with automatic quick-look airborne Doppler analyses
note--nearly all drops are eyewall (wind max) drops where wind variability is high

- **Radial wind mean difference (sonde – Doppler): 1.4 m/s, 2.7 kts**
- **Tangential wind mean difference (sonde – Doppler): 0.2 m/s, 0.4 kts**
- **Wind speed mean difference (sonde – Doppler): 0.8 m/s, 1.6 kts**
- **Radial wind RMS difference: 7.3 mm/s, 14.2 kts**
- **Tangential wind RMS difference: 6.0 m/s, 11.7 kts**
- **Wind speed RMS difference: 6.2 m/s, 12.1 kts**

Future Work

- **Automatically determine systematic errors in antenna pointing angle**
- **Automatically determine navigational coordinates for analysis (with some help from operator)**
- **Extend analysis beyond ~100 km from storm center--make it work more effectively with no well defined center (disturbances and depressions)**
- **With faster link in future--run analysis software from the ground or on the ground**
- **Assimilation testing in HWRF (begun at NCEP/EMC)**
- **Make software work in the G-IV linux environment as well**