Assimilating high-density flight-level data from operational reconnaissance aircraft at reduced spatial density in NAVDAS-AR

P201

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HDOB—High Density High Accuracy Data

HDOB or High Density/High Accuracy data are flight level data from hurricane reconnaissance aircraft, primarily USAF WC-130Js and NOAA P-3s. These reports include:

- 30 sec average pressure, geopotential height, temperature, dewpoint temperature, wind speed, and wind direction
- Maximum 10 sec average flight level wind speed
- Maximum 10 sec average surface wind speed from the Stepped Frequency Microwave Radiometer (SFMR)
- Rain rate estimated from the SFMR
- Location and meteorological variable QC flags

(Details of format at http://www.nhc.noaa.gov/abouthdobs_2007.shtml)

NAVDAS Pre-processing

- HDOB data are read into the NAVDAS-AR conventional data pre-processor, rejecting data flagged bad.
- Dewpoint temperatures, which are defined using saturation over water regardless of temperature, are adjusted for the NOGAPS "Smithsonian method" definition, which is a blend of saturation over water and saturation over ice as a function of temperature. Negative dewpoint depressions are rejected.
- NOGAPS 3, 6, and 9 hr forecast ("background") fields are interpolated in time and space to the observations.
- The HDOB data are then subjected to the NRL aircraft data QC system, which checks for duplicates, invalid data, constant values, gross errors, and track errors.

Is it sufficient to process HDOB data in the same way as other aircraft data (with the addition of humidity processing), or is specialized processing needed?

Acknowledgements

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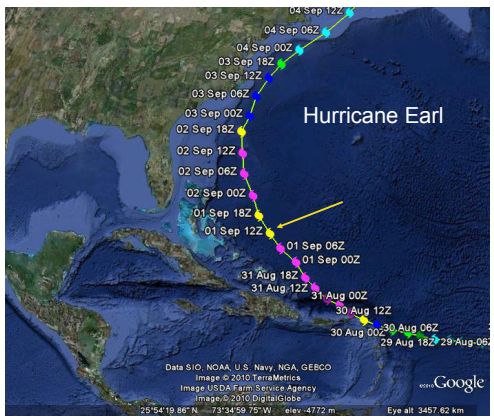
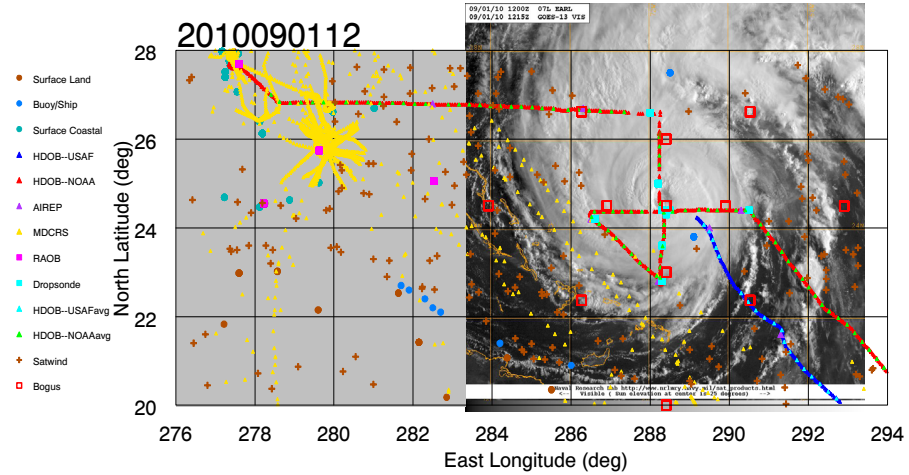
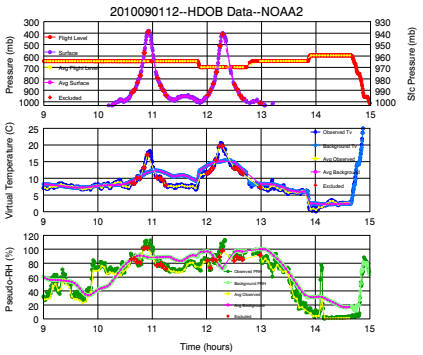
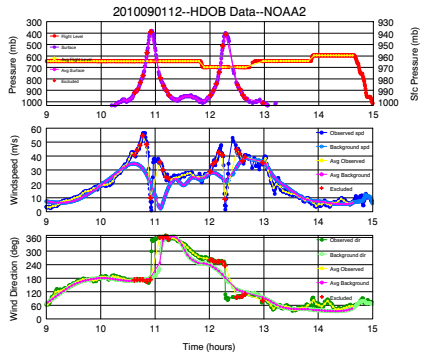
Comparison of HDOB Data with NOGAPS

- The test dataset presented here is from Hurricane Earl on 1 September 2010 for the period 0900 to 1500 UTC, the six-hour data assimilation window for 1200 UTC. The 1200 UTC position of the hurricane is indicated on the track map with a yellow arrow. Data in the vicinity of the hurricane during this six-hour period are superimposed on a 1215 UTC visible satellite image.
- There were two Air Force flights and one NOAA flight during this period that provided HDOB data. With the exception of one buoy and a few satwinds, these flights provide the only conventional data in the immediate vicinity of the hurricane as well as its eastern and northern flanks. Commercial aircraft flights skirt the southwestern flank of the hurricane and form clusters around the southern Florida airports. Data from the NOAA flight, which did a center fix near 12Z, are shown in the time-series plots.
- The background values in these graphs are from the operational post-time run of NOGAPS, which uses a data cut-off of eight hours past the analysis time. The model was run using 42 levels and a horizontal resolution of T319, approximately 41km. Data assimilation was performed using the operational 4DVAR NAVDAS-AR, which did not use the HDOB data.
- The overall agreement between the observed and background temperatures is remarkably good, with the exception of the much warmer observed temperatures in the core of the hurricane.
- Pseudo-relative humidity (PRH), the humidity variable used in NAVDAS-AR, is defined as the ratio of the observed mixing ratio to the saturation mixing ratio determined from the model background temperature. The observed PRH values in the core of the hurricane that exceed 100% are an artifact of the colder-than-observed background temperatures at these locations.
- Wind speeds and directions also agree well away from the storm center. NOGAPS is unable to resolve the details of the windspeed profile in the eyewall and eye and also shows a small displacement of the center in the flight's first pass.









Specialized Processing for HDOB Data Prior to Assimilation

- The 30 sec spacing between obs translates into a spacing of approximately 5 km, which is too dense for use in NOGAPS with its resolution of 41 km. As a comparison, operational aircraft data from commercial jets commonly have either a 3 min spacing of approximately 45 km or a 1 min spacing of 15 km.

The example shows how averaging six observations to yield 2.5 min or approximately 25 km spacing retains the character of the time series at a more manageable resolution.

- The data inside the core of the hurricane should not be assimilated, since NOGAPS is incapable of depicting the strong gradients shown in the data. Instead, the NOGAPS "bogus" derived from the center fix should be allowed to determine the characteristics of the storm core. The problem becomes defining the limits of the hurricane core. As a first attempt, the along-track pressure gradient is estimated as the difference between successive average values of estimated surface pressure.

Excluding values with along-track surface pressure differences greater than 3 mb excludes the warm temperatures in the core of the hurricane along with the PRH values exceeding 100% and the strong winds in the hurricane eye-wall.

- The thresholds need to be examined for weaker hurricanes to see if adjustments are necessary. Pending the results of full data assimilation tests, the HDOB data should be ready for operational use by next hurricane season.