Sandy Supplemental Grant Recipient Quarterly Progress Report

25 April 2014

Quality Control and Impact Assessment of Aircraft Observations in the GDAS/GFS
NA13NWS4830022

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Major Accomplishments or Changes

1. Trip to NCWCP

   B. Hoover visited NCWCP during the week of 24 February 2014. This was the first of several planned trips to meet and collaborate with NCEP scientists involved with the assimilation of aircraft data. Meetings and discussions were arranged with Andrew Collard, John Derber, Stephen Lord, James Jung.

2. Analysis of Innovations

   Innovation Dataset

   Temperature and moisture observations (q_o,T_o) from MDCRS are collected from 183 analysis profiles between 09 September – 25 October 2012 from a GFS control run on Badger/S4, totaling 823,560 observations between 1030 – 100 hPa. These observations have only been subject to quality control taking place before placement of observations in the prepbufr file (i.e. NRLACQC). A 4-dimensional interpolation of the background temperature and moisture is provided within the GSI (q_b,T_b), and the observations are passed through to the routine output statistics files. As of this time, no moisture observations are being assimilated, although the temperature observations are being assimilated.

   Each MDCRS moisture observation is paired with the MDCRS temperature observation at the same location and time, if it exists. From these pairs, a relative humidity is computed:

$$RH = 100 * q / q_s \; ; q_s = \left(\left(1.004 * 6.112 * 0.622 \right) / P \right) \exp\left(\left(17.502 * T \right) / \left(240.97 + T \right) \right)$$

   where P is the pressure and T is the temperature. A relative humidity is computed for both the observed temperature and moisture as well as that produced by the interpolated background. Innovations are defined as the difference between the observed value and the interpolated background value: $q_{inv}=q_o-q_b$; $T_{inv}=T_o-T_b$; $RH_{inv}=RH_o-RH_b$.

   Innovation Profiles

   Innovations were binned in 31 evenly-spaced pressure levels between the surface and 200 hPa, above which there are too few observations for reasonable analysis. Most bins contain between 20,000 – 30,000 observations. In each bin, a mean innovation was computed, as well as the standard deviation of the innovation. These are used to construct vertical profiles of the temperature, moisture, and relative humidity innovations imposed by MDCRS observations. (Fig. 1). While the mean innovations are near-zero throughout the troposphere, the standard deviation from the mean makes it clear that significant innovations to *RH* are imposed throughout – innovations of 10% or more are routine. The largest moisture innovations are imposed at low levels and decay to near-zero at 200 hPa; temperature innovations are largest near the surface as well, but significant innovations exist at upper levels as well, with standard deviations of 1 K common above the boundary layer.

The very small values of q_{inv} at upper-levels, combined with larger T_{inv} and RH_{inv} values, would at first glance indicate that the relative humidity innovations from MDCRS observations above ~500 hPa are driven primarily by temperature innovations, not moisture, whereas RH_{inv} at lower levels is driven by both. This assumption appears to conflict with a simple linear regression analysis, described below.

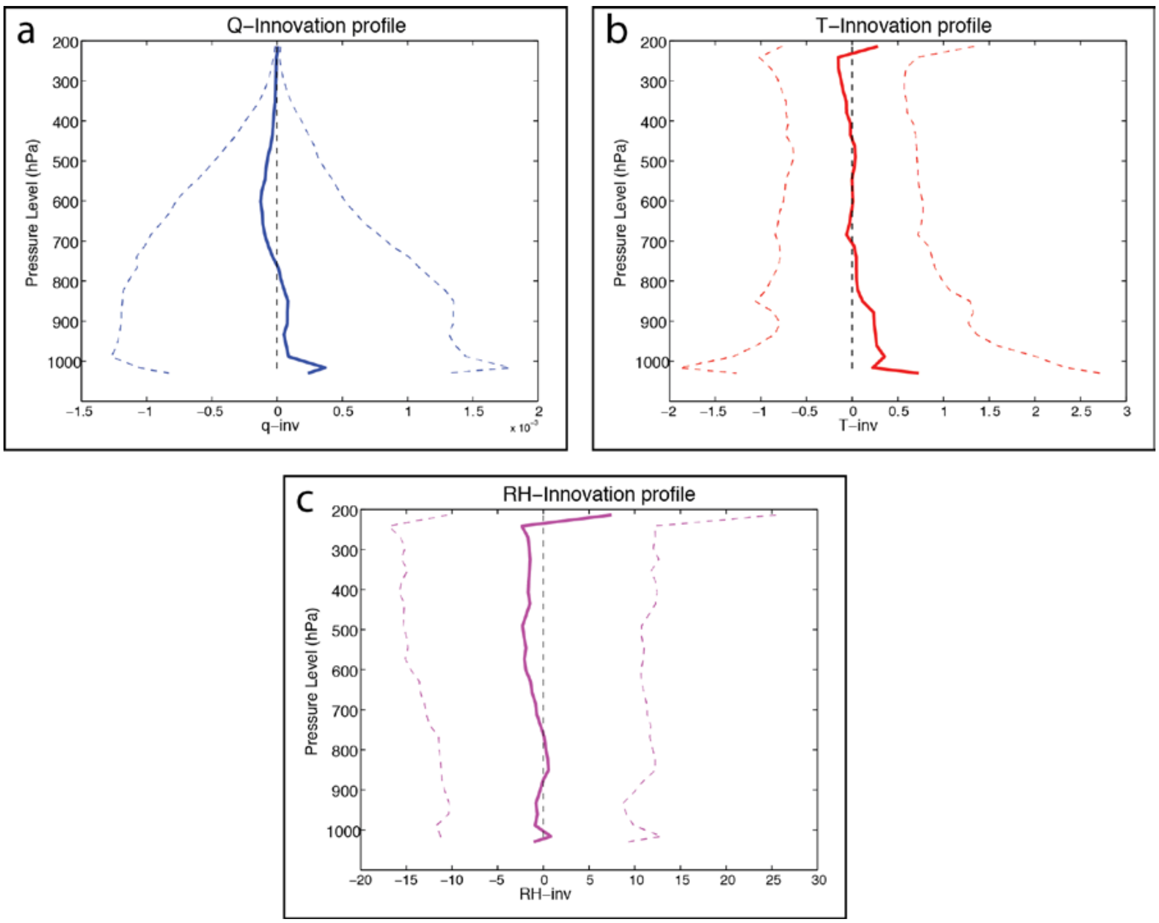

Figure 1: **Profiles of (a) q_{inv}, (b) T_{inv}, and (c) RH_{inv}. Mean profiles are bold; one standard deviation in both directions from the mean is indicated by the dashed line. A black dashed line also indicates the location of the zero-line.**

<u>Regression of RH_{inv} onto q_{inv}, T_{inv}</u>

To better understand how q_{inv} and T_{inv} drive RH_{inv} throughout the troposphere, a linear regression of the predictand (RH_{inv}) onto these predictors was performed separately for each bin. The predictand and each predictor are first normalized, by having their mean removed and then scaled by their standard deviation. The linear regression computes an estimate of normalized RH_{inv} based on a mean value (consistently vanishingly small, and therefore considered zero), normalized q_{inv}, and normalized T_{inv}. The resulting regression coefficients represent how many standard deviations of q_{inv} or T_{inv} are required to move RH_{inv} by a standard deviation. The larger the regression coefficient, the more variation in RH_{inv} can be explained by that predictor.

Regression coefficients are computed for each pressure-bin and plotted as profiles (Fig. 2). The correlation between RH_{inv} and the regression-estimate is also plotted – the correlation is between 0.91-0.95 throughout the profile, indicating excellent agreement between the predictand and the predictors.

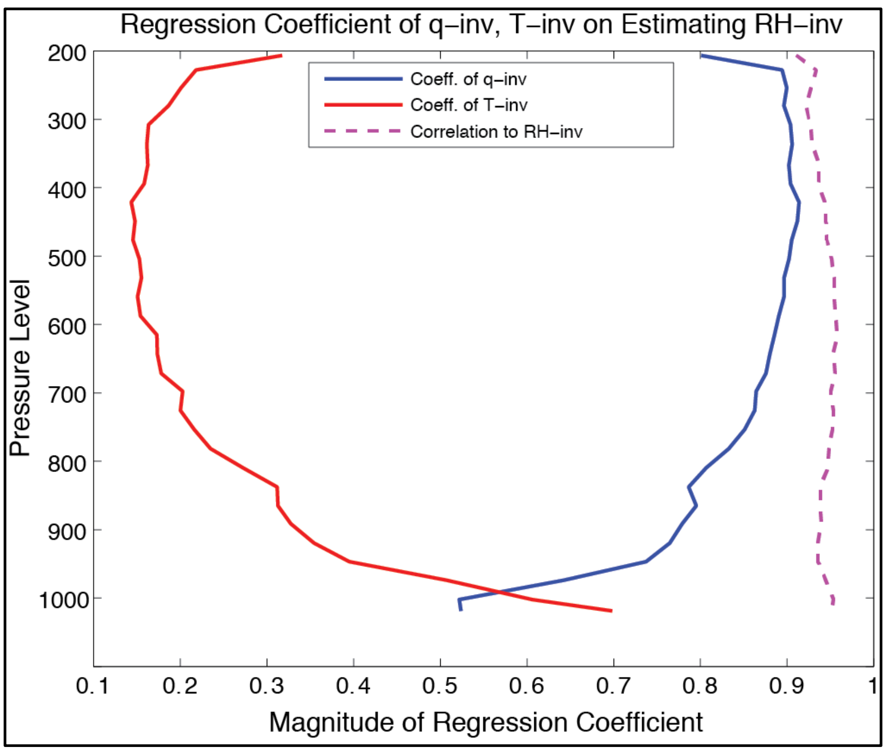

Figure 2: Absolute value of regression coefficient of q_{inv} (blue) and T_{inv} (red) on predicting RH_{inv}, as a function of pressure-level. The correlation between the regression and RH_{inv} is provided by the dashed magenta line.

The regression analysis indicates that between 900 – 250 hPa, RH_{inv} is almost entirely predicted by q_{inv}, while outside of this layer both q_{inv} and T_{inv} play a significant role, especially near the surface. This seems to indicate that even when q_{inv} is near zero in the upper troposphere, it is still the primary driver of RH_{inv} at these levels. This may pose a challenge to assimilating moisture observations at these upper levels – since the relative humidity is highly sensitive to even very small moisture innovations at these levels, this may require more stringent quality control of moisture observations.

Resolved Issues and/or Risks

1. Researchers access to restricted data

Restricted Data Access Request was made through EMC sponsor and approved.

2. Researchers allocation of CPU time and disk space on computing cluster
   NCEP computer 'Zeus' has been chosen as system for running experiments. CPU time and disk space have been approved.

New Issues and/or Risks

1. Limited computing resources do not permit running the (current) Eulerian formulation of the model at the standard T574 resolution. Researchers are currently investigating options for running the model at reduced T254 resolution, and waiting for the soon-to-be-released Lagrangian formulation that will permit a T670 resolution with current resources. Both options require optimizing parameters and developing scripts to run the model at non-standard resolution.
2. On-site access for a non-federal employee (contractor) at NCWCP is highly restricted, and researchers are investigating options to get a NOAA contractor badge to make future visits to NCWCP more efficient.