Status on variational correction of aircraft temperature bias at NCEP

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Aircraft data constitute one of the major sources of temperature observations, however, various studies have noted that aircraft temperature data have a generally warm bias relative to radiosonde data around 200 hPa. In this study, variational aircraft temperature bias correction is incorporated into the Gridpoint Statistical Interpolation (GSI) data assimilation system at the National Centers for Environmental Prediction (NCEP) (Zhu et al. 2015). Since each individual aircraft can have a different aircraft temperature bias, tail-number dependent bias correction is applied to the NUS-AMDAR and MDCRS data, but bias correction is applied indiscriminately without regard to tail number to all NCEP AIREP+ class data because of the lack of tail number information. A list of acronyms of instrument systems for aircraft data is provided in Table 1.

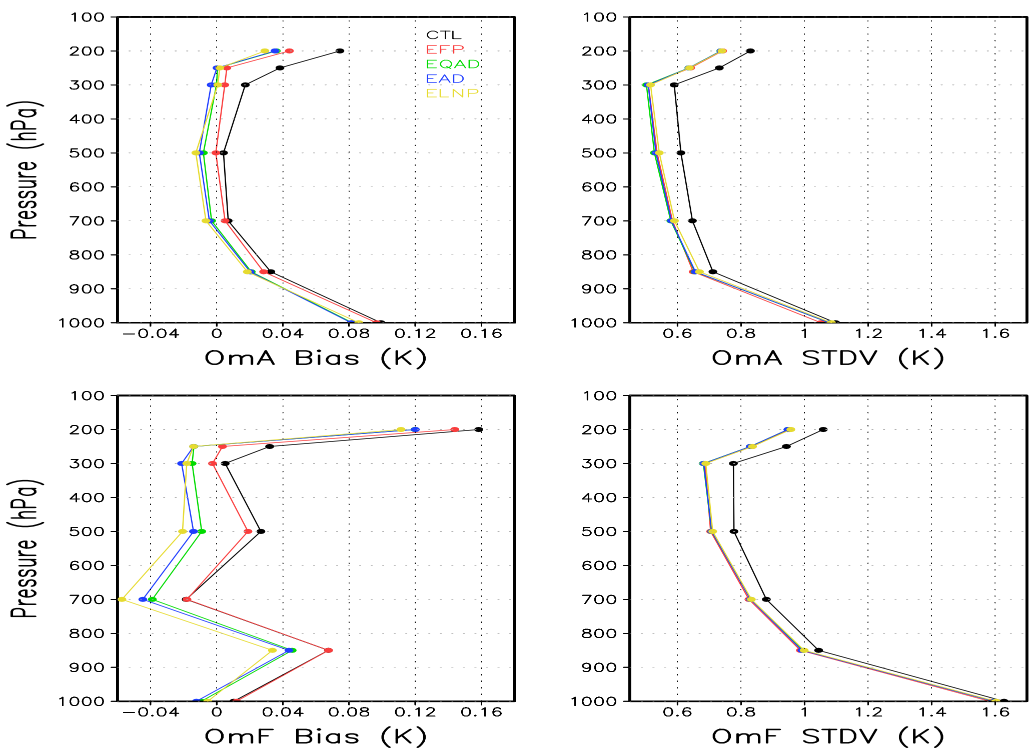

Figure 1. The biases (left panels) and standard deviations (right panels) of the OmA (upper panels) and OmF (lower panels) fits to the aircraft temperature data in experiments CTL (black line), EFP (using flight phase bias model, red line), EQAD (using quadratic aircraft ascent/descent rate bias model, green line), EAD (using aircraft ascent/descent rate bias model, blue line), and ELNP (using log-pressure bias model, yellow line) over the entire globe.

In this study, several choices of bias models are investigated in the experiments. The bias predictors use one of the following: phase of flight information; a quadratic function (i.e., three coefficients) of aircraft ascent/descent rate; separate ascending and descending linear functions of aircraft ascent/descent rate (Isaksen et al. 2012); or observation pressure information. The biases (left panels) and standard deviations (right panels) of the OmA (upper panels) and OmF (lower panels) fits to the aircraft temperature data over the entire globe are presented in Fig. 1 for the control and bias correction experiments. It is also seen that aircraft temperature bias correction cools down the atmosphere at around 200 hPa in the Northern Hemisphere, especially over the northern Atlantic Ocean and in the areas to the south-east of Australia; and improves the OmF fit to radiosonde at upper levels without degrading the fit at lower levels (Fig. 2). The improvement of the fits to GPSRO data is also observed at upper levels. Overall, the bias models using aircraft ascent/descent rate

Acronym	Description
ADS	Automatic Dependent Surveillance
AIREP	Aircraft Reports
AIREP+	Combined AIREP and coarse resolution ADS data at NCEP
AMDAR	Aircraft Meteorological Data Relay
GPSRO	Global Positioning System radio occultation
MDCRS	Automated aircraft data from U.S. aircraft
NUS-AMDAR	Automated aircraft data from outside the United States

Table 1. A list of acronyms of instrument systems for aircraft data.

outperform the others, and the quadratic ascent/descent rate bias model is slightly better than the ascent/descent rate bias model.

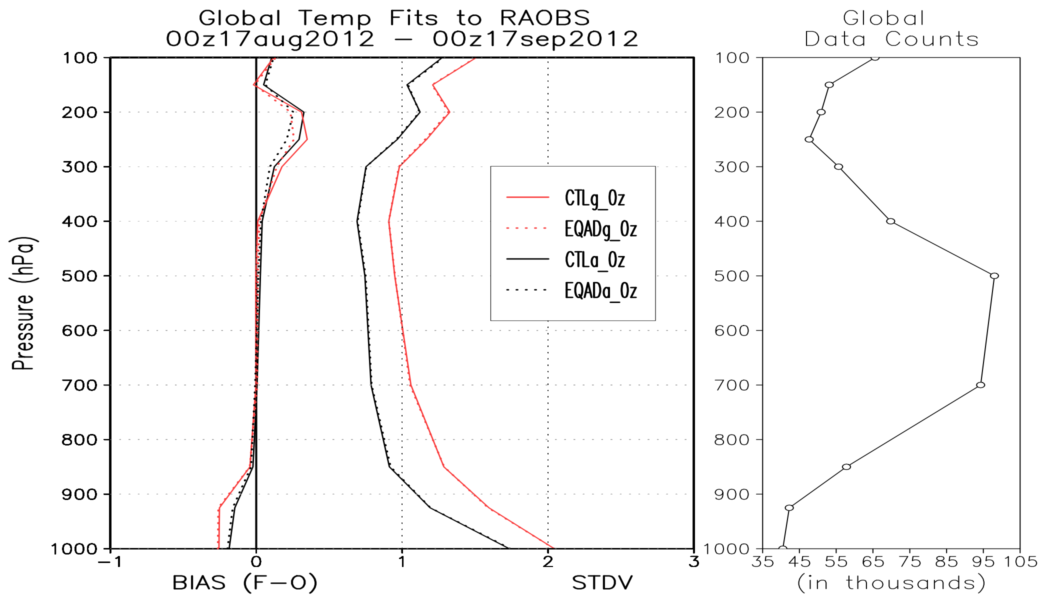

Figure 2. Bias and STDV of the fits of the first guess (red line) and the analysis (black line) to the radiosonde temperature data, i.e., First guess-minus-Observation and Analysis-minus-Observation, for experiments CTL (solid line) and EQAD (using quadratic aircraft ascent/descent rate bias model, dotted line) during the period from Aug. 17 to Sept. 17, 2012. CTLg_0Z and EQADg_0Z are the first guess fits and CTLa_0Z and EQADa_0Z are the analysis fits at 00Z.

Another issue examined in this study is the problem of too many aircraft not reporting time in seconds or too infrequently to be able to determine an accurate aircraft ascent/descent rate, which is used in the aircraft temperature bias correction as the bias predictor. In addition to the finite-difference method employed to estimate aircraft ascent/descent rate, a tensioned-splines (Tsplines) method is applied to obtain more continuously smooth aircraft ascent/descent rates and mitigate the missing time information (Purser et al. 2014). When compared to the finite difference method, it is seen that the experiment using the Tsplines ascent/descent rate as the bias predictor performs slightly better in terms of forecast fits to radiosonde data and wind forecast RMSVE in the Northern Hemisphere.

Currently the quadratic ascent/descent rate bias model with the Tsplines-based aircraft ascent/descent rate is being carefully tested in the NCEP parallel hybrid 4D Ensemble-Variational (4D_EnVar) data assimilation configuration for the next implementation. Future work includes more sophisticated bias models, which would include additional constant terms or dependence upon aircraft altitude/pressure in the quadratic ascent/descent rate bias model.

References

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