Evaluation of pressure extracted from NCEP and CMC global numerical weather prediction models against in-situ and GPT pressure

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1. Introduction

The following summarizes an investigation into the performance of various numerical weather prediction (NWP) models with respect to measured pressure. An earlier investigation by Urquhart et al (2011) demonstrated that ray traced hydrostatic zenith delays from NCEP's Re-Analysis I (NCEP) dataset proved to exhibit higher variability when compared to those from the Canadian Meteorological Centre's (CMC) Global Deterministic Prediction System (GDPS) and the European Centre for Medium Range Weather Forecasting (ECMWF). This investigation expands on the original by analyzing the variation of the zenith hydrostatic delay (as ray traced through the NWP) and the extracted pressure at the surface for 35 IGS reference stations for the entire year of 2010.

Two NWP's were selected: NCEP's Re-Analysis I since it forms the basis for the UNB-VMF1 service; and CMC's GDPS due to availability. Both models have global coverage. NCEP's grid resolution is 2.5° by 2.5°; CMC's (GDPS) is 0.6° by 0.6°. The location within the NWP is defined by the location of the IGS reference stations, defined by the IGS weekly solutions for the year 2010. The height was adjusted by the meteorological sensor offset as defined by IGS stations' log.

The stations were selected to provide an even distribution across the globe. However, station selection was restricted to the availability of meteorological data (which were selected from a pool of data available on the CDDIS server). Stations that were at high, mid, and close to equatorial latitudes were selected as well as stations that were close to sea level and located at high elevations (Figure 1).

The investigation is based on the following comparisons:

1. <u>Extracted Pressure from the NWP (NCEP and CMC (GDPS)) compared to measured pressure from the site</u>. Here the pressure is extracted from the NWP first by linearly interpolating the logarithm of the pressure vertically at each of the grid nodes surrounding the point of interest to obtain the pressure at the station's elevation. To obtain the final surface pressure, the pressure at each of the grid nodes surrounding the point of interest is then linearly interpolated two-dimensionally. The pressure from the IGS meteorological RINEX file was then subtracted from the resulting extracted NWP pressure.
2. <u>Raytraced hydrostatic zenith delay compared to the Saastamoinen hydrostatic zenith computed from the measured site pressure</u>. In this case, the hydrostatic zenith delay is ray-traced through the NWP using the algorithms developed by Nievinski (2009). The Saastamoinen hydrostatic delay computed with the measured surface pressure from the IGS meteorological RINEX file was then subtracted from the ray-traced hydrostatic zenith delay.

2. Results and discussion

A second order polynomial was fitted to the difference between the pressure extracted from the NWP and the IGS pressure datasets (Δp_{nwp}). The resulting function (Δp_{fit}) was then used to evaluate the pressure differences standard deviation σ (treating the quantities as equally weighted):

$$\sigma = \left[\frac{1}{n-2}\sum_{i=1}^{n}(\Delta p_{nwp} - \Delta p_{fit})^2\right]^{\frac{1}{2}}$$

A similar evaluation was made was made for hydrostatic zenith delay in which case the quantity assessed was the difference between the raytraced and the Saatamoinen hydrostatic zenith delay (playing the role of (Δp_{nwp}) in the equation).

Figure 2 illustrates the resulting standard deviations using NCEP's Re-Analysis I dataset and Figure 3 illustrates the resulting standard deviations using CMC's GDPS dataset. Dataset from NCEP exhibits a latitude dependent effect. Variation with the dataset from the CMC is more uniform across the globe. The same trend hold true for the difference in the zenith hydrostatic delay (not shown).

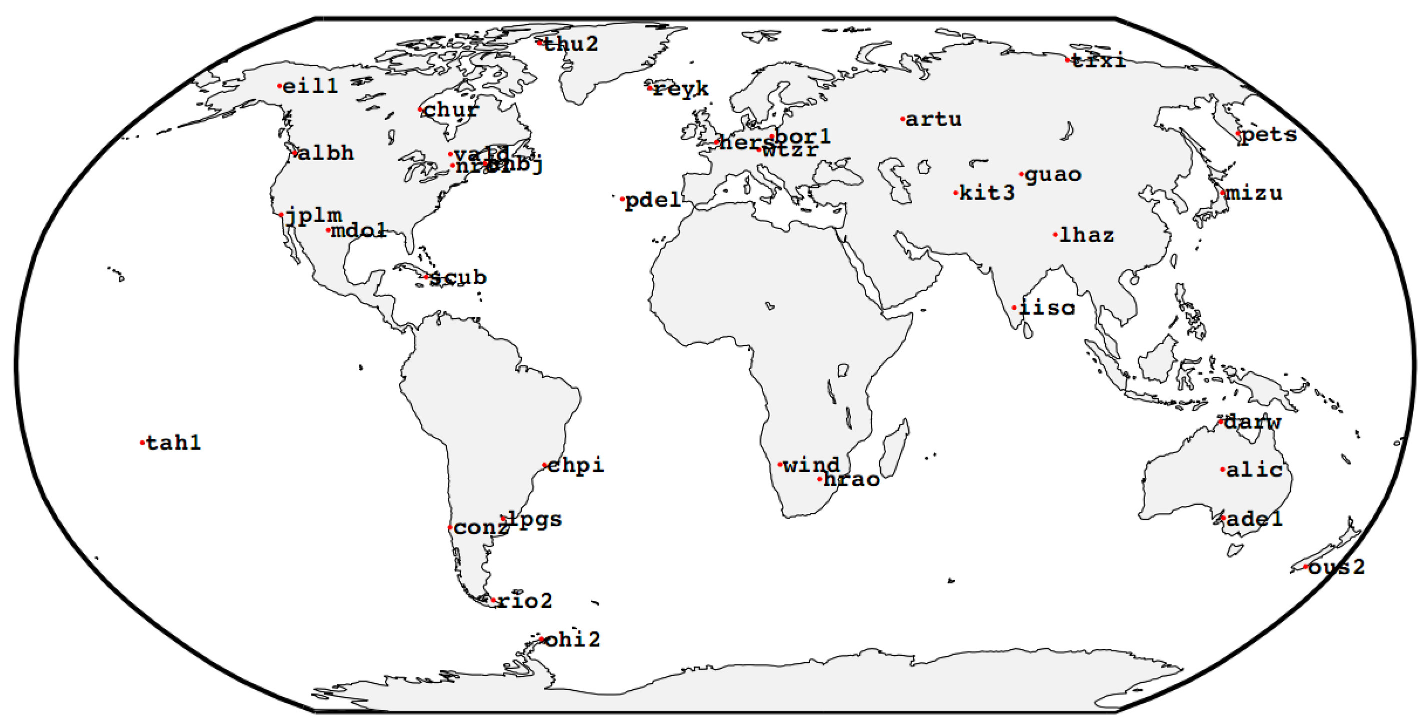

Fig.1: Location of the IGS stations

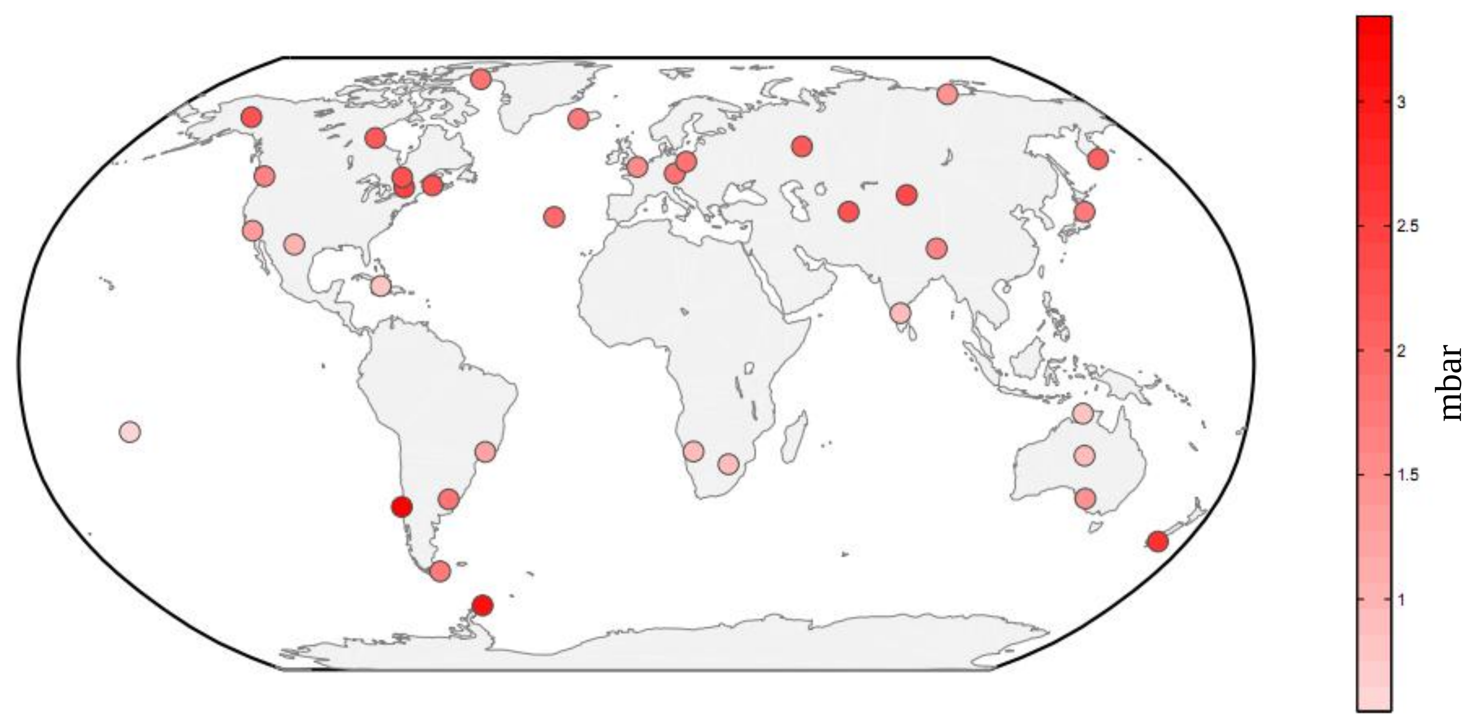

Fig.2: Standard deviation of difference between NCEP pressure and IGS site pressure over year 2010

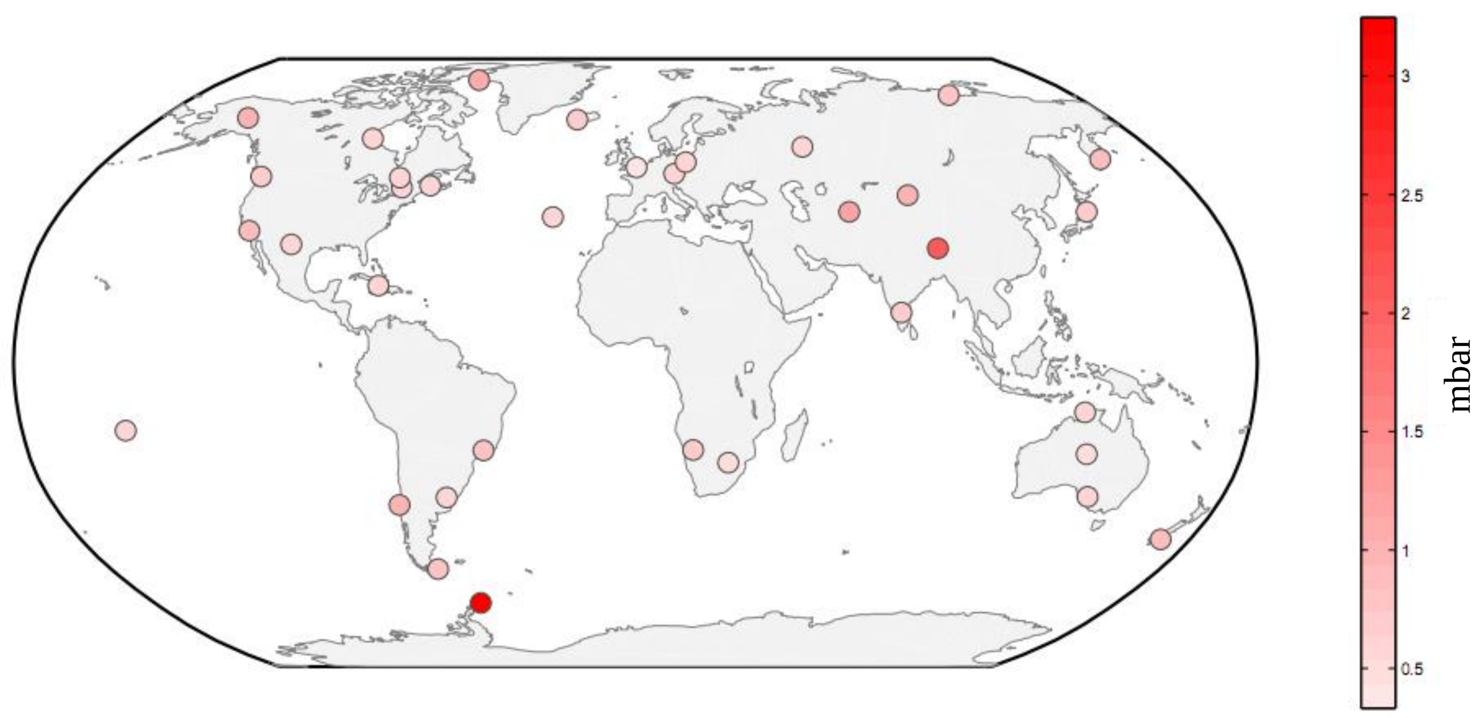

Fig.3: Standard deviation of difference between CMC pressure and IGS site pressure over year 2010

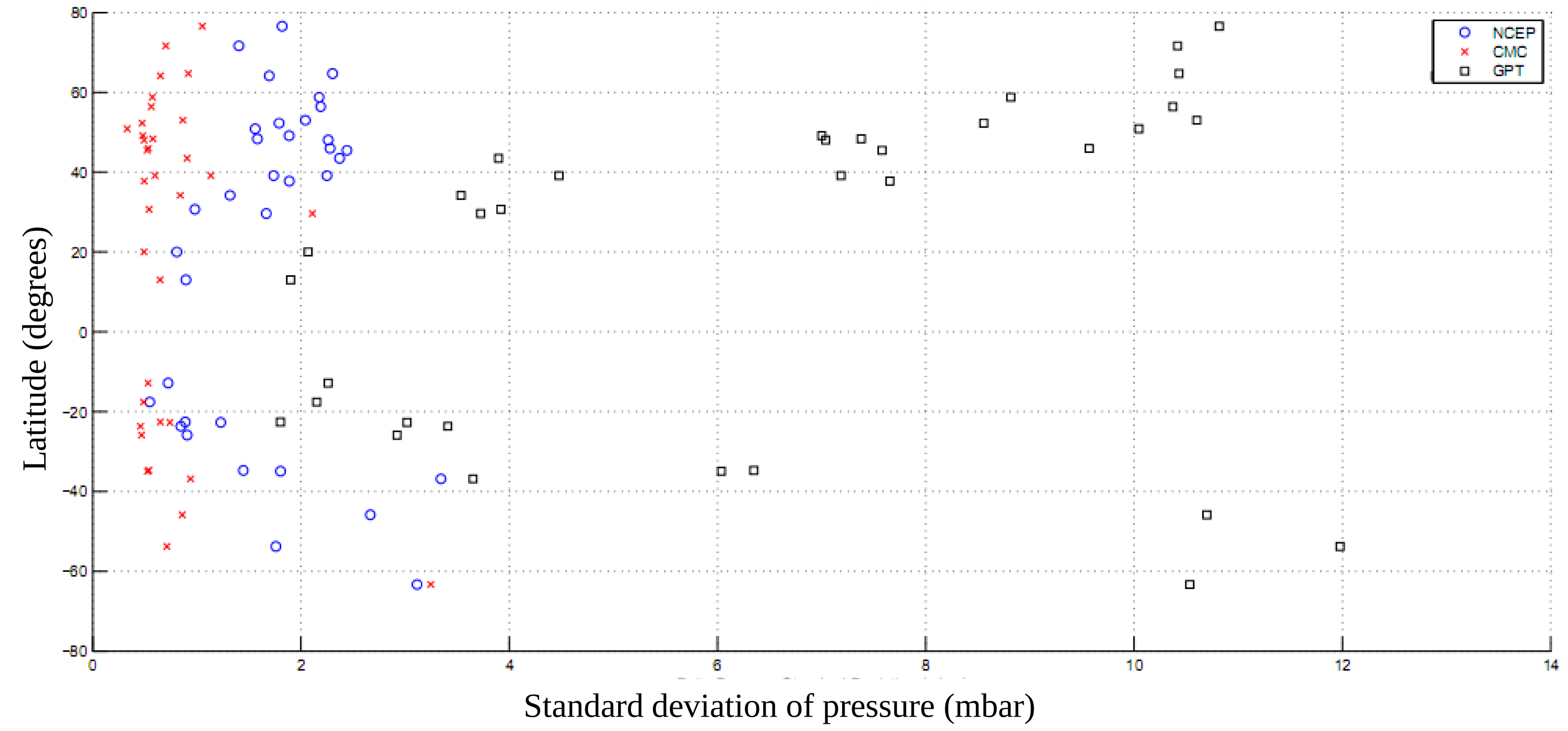

Fig.4: Standard deviation **of the d**ifference between CMC,NCEP and GPT pressure with IGS site pressure over year 2010, in latitude

Figure 4 plots the standard deviation of the difference in pressure with respect to latitude. Figure 4 illustrates that the results from the CMC (red ×) show no strong correlation with latitude, but the results using NCEP's Re-Analysis I data set (blue circles) show a small trend with respect to latitude. As the station is nearer to the equator, it appears that the variation in the difference in extracted pressure to site pressure is reduced. Results coming from the comparison with GPT (black squares) show a much bigger trend with latitude.

Not only are the results using CMC's dataset more uniform, but the magnitude of the variation is smaller than that of the results using NCEP's Re-Analysis I. A global mean of all standard deviations (35 stations) for the difference in pressure was determined to be 1.723 mbar with an associated standard deviation of 0.673 mbar for the NCEP dataset and 0.7622 mbar with a standard deviation of 0.532 mbar for the CMC dataset. For the difference in hydrostatic zenith delay, the global mean of all standard deviations for all stations was determined to be 4.03 mm with a standard deviation of 1.58 mm for the NCEP dataset and 1.83 mm with a standard deviation of 1.18 mm for the CMC dataset.

3. Acknowledgements

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References:

Urquhart, L. M.Santos, F.Nievinski, J.Bohm (2011). "**Generation and Assessment of VMF1-Type Grids using North-American Numerical Weather Models**." presented at XXV IUGG General Assembly, Melbourne, Australia, June 28th – July 7th, 2011.

Nievinski, F. G. (2009). **Ray-tracing Options to Mitigate the Neutral Atmosphere Delay in GPS**. M.Sc.E. thesis, University of New Brunswick, Dept. of Geodesy and Geomatics Engineering, Fredericton, N.B., Canada, May, 232 pp., Technical Report 262, http://gge.unb.ca/Pubs/TR262.pdf .