ECGVM MEMO aen3

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To: ECGVM Workshop
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Subject: Sensitivity of height to pressure error and to height of pressure sensor

1. Objective

Provide sensitivity of height estimate to error in a priori pressure for minimum observed elevations of 5°. For site at sea level, what is the sensitivity of the height estimate to error in the height of the pressure sensor?

2. Sensitivity to error in a priori zenith hydrostatic delay

ΔP = pressure error (hPa)

ΔZHD = zenith hydrostatic delay error (mm)

= 2.776 * ΔP (from Saastamoinen)

The error in a priori zenith hydrostatic delay is mapped to the elevation of observation and becomes a contribution to the pre-fit residual. If the partial derivative for estimating the atmosphere delay were the hydrostatic mapping function, this error would be corrected perfectly. However, when the atmosphere delay correction is estimated using the wet mapping function as the partial derivative, there is an error given by the difference in mapping functions times the ZHD error.

$\Delta\tau(\varepsilon) = \Delta ZHD * (mfw(\varepsilon) - mfh(\varepsilon))$

From tests by MacMillan and Ma and by Boehm and Schuh, and from simulations and tests by Niell, delay errors of this type map into errors in the height approximately as -1/3 of the delay error at the lowest elevation angle. The range of the coefficient is -0.2 to -0.4 and depends on the number density of observed elevations. MacMillan and Ma and Boehm and Schuh find the value closer to -0.2 for 5°. The relative SNR and any elevation-dependent weighting factor, such as $1/\cos^2(\varepsilon)$ as used by GPS, will affect the effective lowest elevation.

For the purposes of this note I will use -1/3 and a minimum elevation of 5° for the initial estimate. Therefore the height error is

$\Delta ht = -1/3 * \Delta\tau(\varepsilon)$

$= -1/3 * 2.776 * \Delta P * (mfw(\varepsilon) - mfh(\varepsilon)) = -0.9 * (10.7-10.1) * \Delta P$

$\Delta ht/\Delta P \approx$ -0.7 mm/hPa

The vertical gradient of pressure is approximately -1/8 hPa/m of height change, so the sensitivity of estimated height to location of the pressure sensor is

$\Delta ht/\Delta ht\_of\_Psensor \approx$ -0.09 mm/meter or $\approx$ -0.1 mm/meter

3. Conclusion

To maintain a height accuracy of 1 mm, the contribution to the height uncertainty from the pressure measurement should be less than 0.2 mm. Therefore the height of the pressure sensor relative to the intersection of axes of the antenna should be known to better than 2 meters.