SOME RESULTS ON GPS-NNSS TEC COMPARISON

L CIRAOLO¹ and P SPALLA¹

Availability of three years of TEC versus latitude, obtained from NNSS differential doppler measurements, enables to give a contribution to the study of TEC of the upper part of the ionosphere.

Keywords: GPS; GPS-NNS TEC differences; NNSS; plasmaspheric content

1. Basic considerations on GPS and NNSS data analysis

- For both GPS and NNSS: Equation of observation: \( d = k \cdot \text{TEC} + \beta \).

Observed Differential Phase and/or Group Delays, \( d \); total electron content, TEC; bias or offset, \( \beta \).

Extra problems for phase: inherent ambiguity, cycle slips.

- Model: Vertical total electron content (VEC): \( \text{TEC}(P-S) = \text{VEC}(P_{\text{iono}}) \sec \chi \).

Ionosphere: slab of infinitesimal width at 400 km height.

Solution of \( d = \text{VEC} \cdot \sec \chi + \beta \) enables estimation of VEC.

- NNSS analysis: One station: assuming VEC quasi-linear function of \( P_{\text{iono}}, \Phi \).

\( \text{VEC}(\Phi) = (d - \beta) \cos \chi, \Delta \text{VEC} = \Delta(d \cos \chi) - \beta \Delta(\cos \chi) \).

LSQ solution for intercept \( \Delta \text{VEC} \) and slope \( \beta \).

Two stations: assuming that observations relative to the same ionospheric point have the same VEC (neglecting the longitude displacement)

\[
(d(t_1) - \beta_1) \cos \chi_1 = (d(t_2) - \beta_2) \cos \chi_2
\]

LSQ solution for \( \beta_1 \) and \( \beta_2 \).

Final product: VEC at every degree of latitude along the track of \( P_{\text{iono}} \).

- GPS analysis: Assumptions for VEC over the station: a) dependence on time and longitude only through the Local Time; b) linear dependence on latitude.

Given a time \( t_s \) at the station, observations from satellite \( i \) and \( j \) at the same LT are paired in order to give the same VEC, giving the equations of condition:

\[
[d(t_1) - \beta_i] \cos \chi_i - m(t_s) \cdot (\Phi_i - \Phi_s) = [d(t_j) - \beta_j] \cos \chi_j - m(t_s) \cdot (\Phi_j - \Phi_s).
\]

LSQ solution for biases \( \beta's \) and latitude slopes \( m(t_s) \) smoothed over 20 minutes.

Final product: VEC and latitude slope daily curves at each 10th minute, satellite plus receiver biases (group) or phase offsets (phase).

¹Istituto di Ricerca sulle Onde Elettromagnetiche "Nello Carrara", Firenze, Italy
2. The comparison method

NNSS provides TEC evaluations and their accurate latitudinal dependence sparse in time; GPS provides continuous TEC evaluations.

The comparison proceeds as follows, as described in Fig. 1:

- the NNSS TEC value at the latitude of the GPS station (Matera) is interpolated from the latitudinal curve,

- this NNSS TEC value is tagged with the epoch of the closest approach, instead of with the actual time of crossing the parallel of the GPS station,

- these NNSS TEC values are plotted on the GPS TEC daily curves displaced in time according to the difference in longitude between the ionospheric point of the NNSS measurement and that of the GPS station. This accounts for the local time dependence of the ionosphere, in accordance with the above assumptions.

A typical example for a given day is shown in Fig. 2, in which the continuous line is the GPS TEC daily curve and the single points are NNSS TEC’s. The results of about 3 years of daily curves of GPS TEC and about 42000 NNSS TEC passes (from only one station during 1994 and mainly from two stations during 1995 and 1996) are available and can be compared. This analysis follows a similar one carried out on two years (1994–95) observations and constitutes its improvement (Ciraolo and Spalla 1997).

Fig. 1. The geometry of GPS and NNSS observations