The International Beacon Satellite Symposium *BSS2010*
P. Doherty, M. Hernández-Pajares, J.M. Juan, J. Sanz and A. Aragon-Angel (Eds)
Campus Nord UPC, Barcelona, 2010

DETERMINING SELF-CONSISTENT PLASMA DRIFTS AND NEUTRAL WINDS DRIVING THE LOW-LATITUDE IONOSPHERE FROM LISN MODEL AND DATA INVERSION

J. VINCENT ECCLES*, ERHAN KUDEKIN† AND ERHAN KUDEKI°

*Space Environment Corporation
Providence, Utah 84332 USA

†CSL Coordinated Science Lab, University of Illinois at Urbana Champaign

°Institute for Scientifique Rester, Boston Collge
Chestnut Hill, Massachusetts 02467 USA

Key words: Ionosphere, low-latitude, multi-instrument, models.

Abstract. The Low-Latitude Ionospheric Sensor Networ he single longitude of 290 E. The regional ionosphere provides reasonable results with just the standard wind model and electric field model for the conditions of January 2008 (Figure). The sector results are from the heavy field line meridion. The top panel of the Figure shows the comparison of the observed Vertical TEC and the modeled TEC values before local sunset (2100UT / 16:20LT). The use of tidal models often provides a good estimate of winds but the longitudinal distribution of the winds still needs to be adjusted in the southern hemisphere. k (LISN) has provided a ground-based GPS-TEC network to provide TEC measurements from GPS monitors across the South American continent. We combine a low-latitude ionospheric model with an electric field model and the LISN data to generate a self-consistent determination of the important drivers of low-latitude ionospheric structure. Specifically, the neutral winds and cross-field plasma drifts will be self-consistently determined and optimally chosen by the LISN data. The methods of obtaining optimal self-consistent winds and electric fields are to be described and demonstrated. Bayesian model comparison using the data to provide the Bayesian factors. The selection of neutral winds generates the background electric fields self-consistently. The neutral winds are selected through combinations of tides and F region neutral wind representations. The tuning of the ionosphere model to the monthly average was required due to the conditions of the current extreme solar minimum of 2008 and 2009. The ionization model underlying the ionosphere model required adjustment to ensures that the model reproduces the monthly average TEC observations using the average vertical plasma drift. Comparisons of the vertical plasma drift with the average observations of the Jicamarca Radar of vertical drift are done to provide confidence that the day to day merging of model and data

will be provide good weather variations about the mean climatology.

1 INTRODUCTION

We use the GPS TEC data from the Low-Latitude Ionospheric Sensor Network (LISN) help select the neutral winds that drive the low-latitude electric fields and ionosphere. The determination provides self-consistent electric fields and ionospheric structure associated with the underlying neutral winds. The data are used to provide Bayesian factors to weight each member of an ensemble of ionosphere-electric field results with different neutral winds drivers. The meridonal neutral wind will directly influence the TEC distribution along a magnetic field sector. Both the zonal and meridonal neutral winds will determine the electric fields and the resulting plasma drifts. The vertical plasma drifts also directly influence the TEC observations. There remains an uncertainty of the zonal neutral winds that the TEC observations will not be sensitive to. The primary selection of the neutral winds will be based on tide that have a consistent zonal and meridonal phase relationship. The uncertainty of the full neutral wind field can be reduced in zonal plasma drift information provided by the Jicamarca IS Radar. The methods of the data-model inversion to obtain the neutral wind field and associated plasma field drifts are presented in Section 2. Section 3 gives the results of the inversion.

2 INVERSION DATA-MODEL METHODS

The GPS TEC data is reduced data by Cesar Valladares GPS TEC analysis routines, which applies the station and satellite biases and provides both line-of-sight and vertical TEC values for all ground stations and GPS satellite pairs. We only use the observations near the magnetic field line sector that crosses the equator at 290° longitude. LISN data from January 2008 are used in the study.

The models are the Low-Latitude Ionosphere Sector Model or LLIONS code which solves of the electron density and ion constituents in this single magnetic field-line sector. The model is a physics/chemistry based ionosphere model. The MSIS 90 model atmosphere is used for the neutral constituents1. The F region neutral wind is constructed using a combination of the 2007 Horizontal Wind Model2, which has works well for solar minimum conditions, and a tidal wind model based on 1 diurnal mode and 2 semi-diurnal modes. The tide mode magnitude and phase is adjusted for different ensemble members of model runs. The F region wind model (HWM07) is adjusted through a factor and an offset. The electric fields (plasma drifts) are calculated through the simple electric field model of Eccles [1998] which provides a quick and accurate estimate of the vertical and zonal plasma drifts near the dip equator at F region heights. The ionosphere mode is permitted to response to these self- consistent electric fields and neutral winds.

The ensemble members are generated around the average values of the winds that generate the best average ionosphere and electric fields for the month of January 2008.

A number of runs were performed to search the space for reasonable values of the tide magnitudes and phases. Each ensemble result is assigned a Bayesian Factor based on the root-mean-square difference from the observed TEC values and the modeled TEC values along the magnetic sector at each 15 minute time step. These Bayesian Factors are used to determine the optimal set of tides and wind factors for that time step.

The average observations of vertical and zonal plasma drifts obtained from Jicamarca Radar are compared against the plasma drifts determined from the optimization methods.

3 RESULTS

The ionosphere model runs for the South American region but the ensemble runs focus on he single longitude of 290°. The regional ionosphere provides reasonable results with just the standard wind model and electric field model for the conditions of January 2008 (Figure). The sector results are from the heavy field line meridion. The top panel of the Figure shows the comparison of the observed Vertical TEC and the modeled TEC values before local sunset (2100UT / 16:20LT). The use of tidal models often provides a good estimate of winds but the longitudinal distribution of the winds still needs to be adjusted in the southern hemisphere.

4 CONCLUSIONS

The Bayesian Factors determined from the RMS difference of the data and the model provide a stable basis for inverting the data model comparison into an optimal choice of neutral winds.

There are differences in the observed TEC and modeled TEC due to the lack of a wide enough basis set of neutral wind variations.

REFERENCES

[1] Hedin, A. E., Extension of the MSIS thermosphere model into the middle and lower atmosphere, *J.Geophys. Res*, 96, 1159-1172 (1991).

[2] Drob, D. P. et al., An empirical model of the Earths horizontal wind fields: HWM07, J. Geophys. Res., 113, A12304, doi:10.1029/2008JA013668 (2008).

[3] Eccles, J. V., A Simple Model of Low-Latitude Electric Fields, *J. Geophys. Res. 103*

, p26699,(1998).

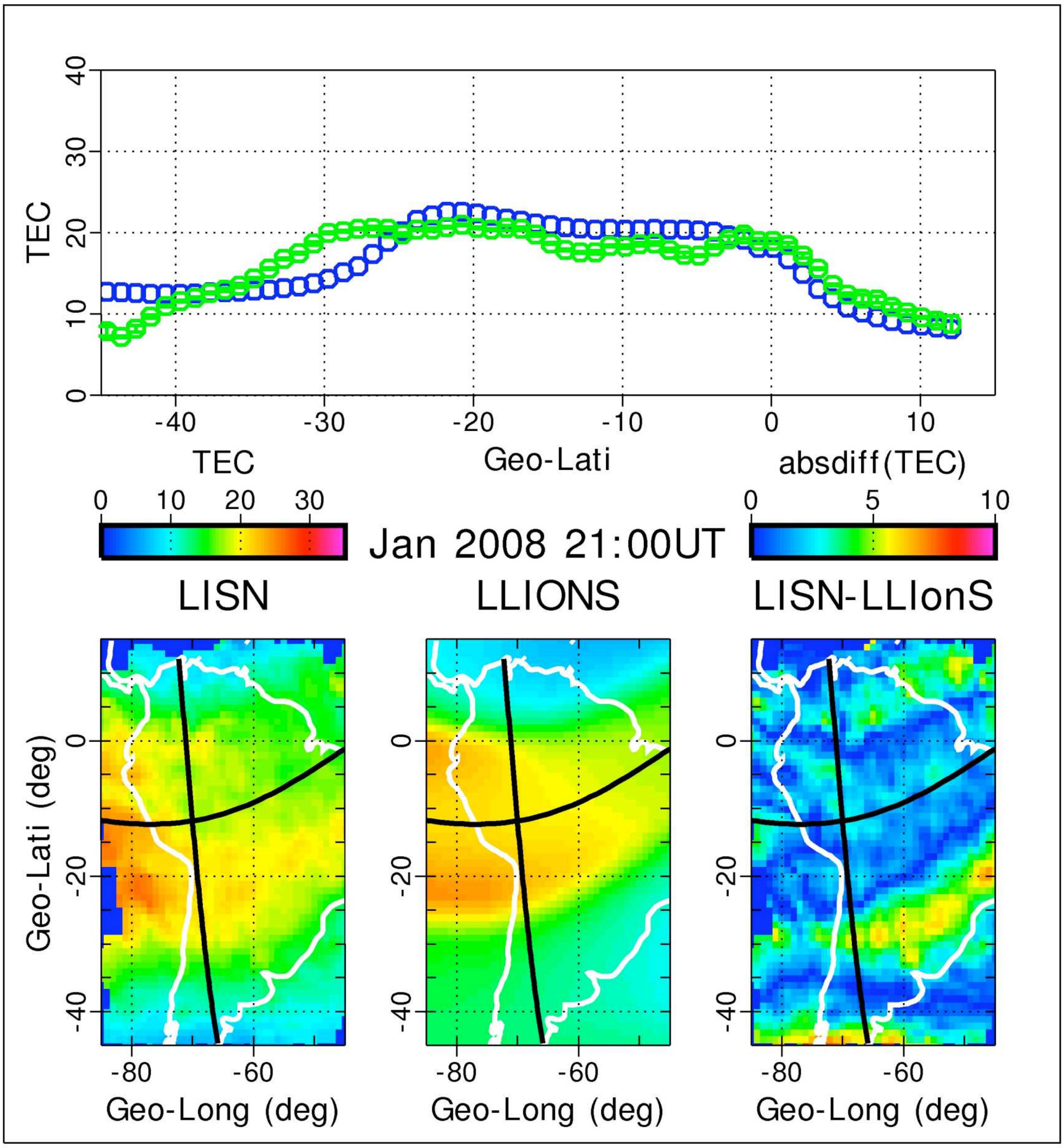

Figure 1: The TEC comparison between the model and the LISN data for the January 2008.