# Comparison of Observed and Simulated Thermospheric Winds at Low Latitudes

communication: khadka@njit.edu

## Introduction

Measurements and understandings of thermospheric wind dynamics can support to address many scientific questions regarding geospace phenomena, e.g., equatorial spread-F, HR radio disruption, spacecraft drag, auroral zone heating, gravity, tidal and planetary waves, ULF wave heating, the impact of particle precipitation, etc., that severely impact our space-based modern technologies. This poster aims to evaluate the accuracy of few simulated (LLIONS, CTIPe, HWM-14) wind results and observed (SOFDI) equatorial thermospheric winds in Peru, where we have deployed a Fabry-Perot Interferometers (FPIs) system.

### •SOFDI Observation:

Second-generation, Optimized, Fabry-Perot Doppler Imager (SOFDI), a triple-etalon Fabry-Perot interferometer, is the relocatable FPI system which is currently deployed and operating near the geomagnetic equatorial latitude in Huancayo, Peru (Geo:12.1˚S, 75.3˚W; Mag: 1.9˚N), and utilized the OI 630-nm emission for 24-hour thermospheric wind observations.

**SOFDI Wind Climatology**

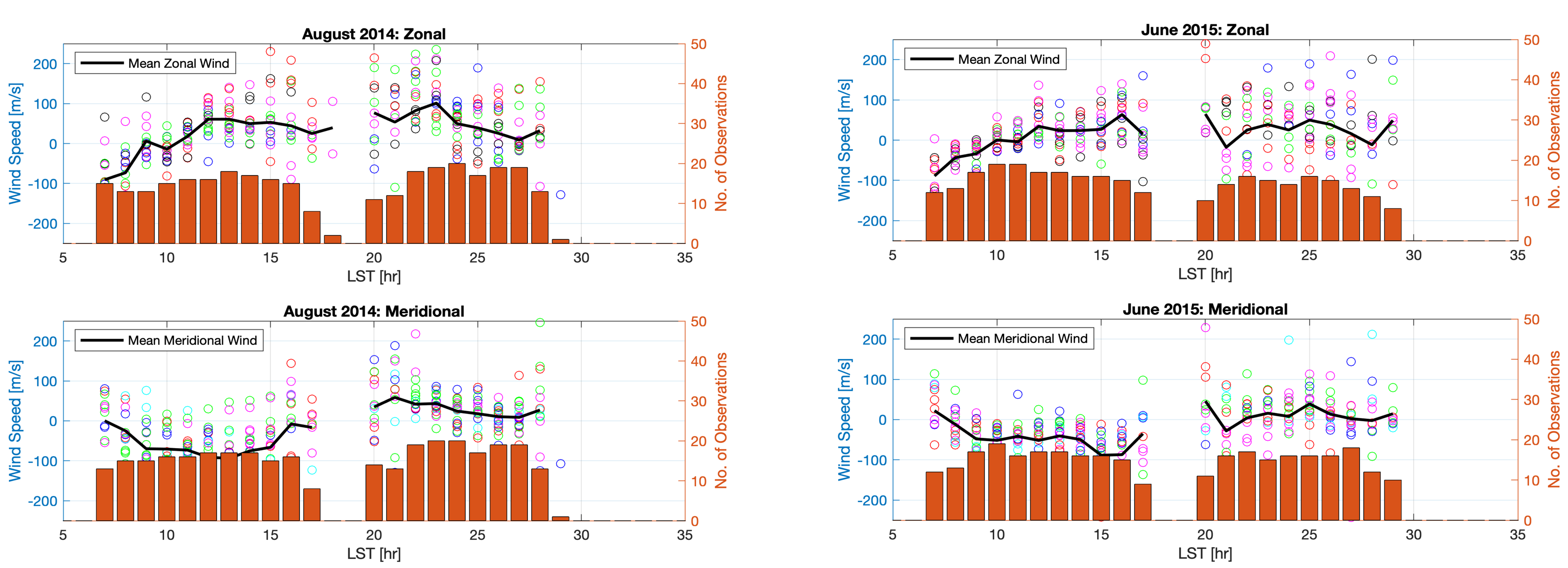


**Figure-1**
Left Panel: The zonal (top) and meridional (bottom) 630-nm winds measured by SOFDI placed into 1- hour time bins (colored circles) for August, 2014. The black curve represents the monthly mean wind. The red bar graphs showing the number of observations that are done in each hourly bin.
Right Panel: Same as left panel, but for June, 2015.

### • LLIONS Model:

Low-Latitude IONospheric Sector (LLIONS) model is originally inspired by the Low-latitude ionosphere model (LOWLAT) [*Anderson, 1973*], and mainly based on the low-latitude portion of the Ionospheric Forecast Model [*Schunk et al., 1997*]. Here, neutral winds are estimated using a physics-based inverse-modeling approach on the LLIONS model, which utilizes vertical drift measured from Jicamarca Incoherent Scatter Radar (ISR) as one of the inputs in this analysis.

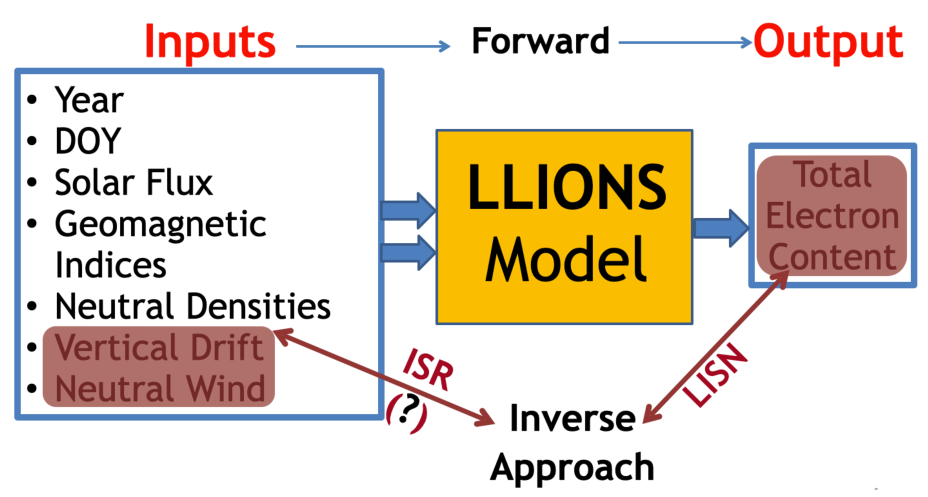


**Figure-2**
Block diagram illustrating the inverse-modeling approach where LLIONS modeled and Global Positioning System (GPS) measured total electron content (TEC) data from the Low-Latitude Ionospheric Sensor Network (LISN) are compared to derive winds.

### • HWM-14:

The horizontal wind model 2014 (HWM-14), an empirical model, is used here to calculate the meridional and zonal components of the horizontal neutral wind at equatorial thermosphere for 250 km altitude.

### • CTIPe Model:

The Coupled Thermosphere Ionosphere Plasmasphere Electrodynamics (CTIPe) model is a non-linear, coupled thermosphere-ionosphere-plasmasphere physically based numerical code that includes a self-consistent electrodynamics scheme for the computation of dynamo electric fields. Wind components are modeled for 250 km altitude range at equatorial latitude.

## Comparisons and Consequences of Meridional Winds

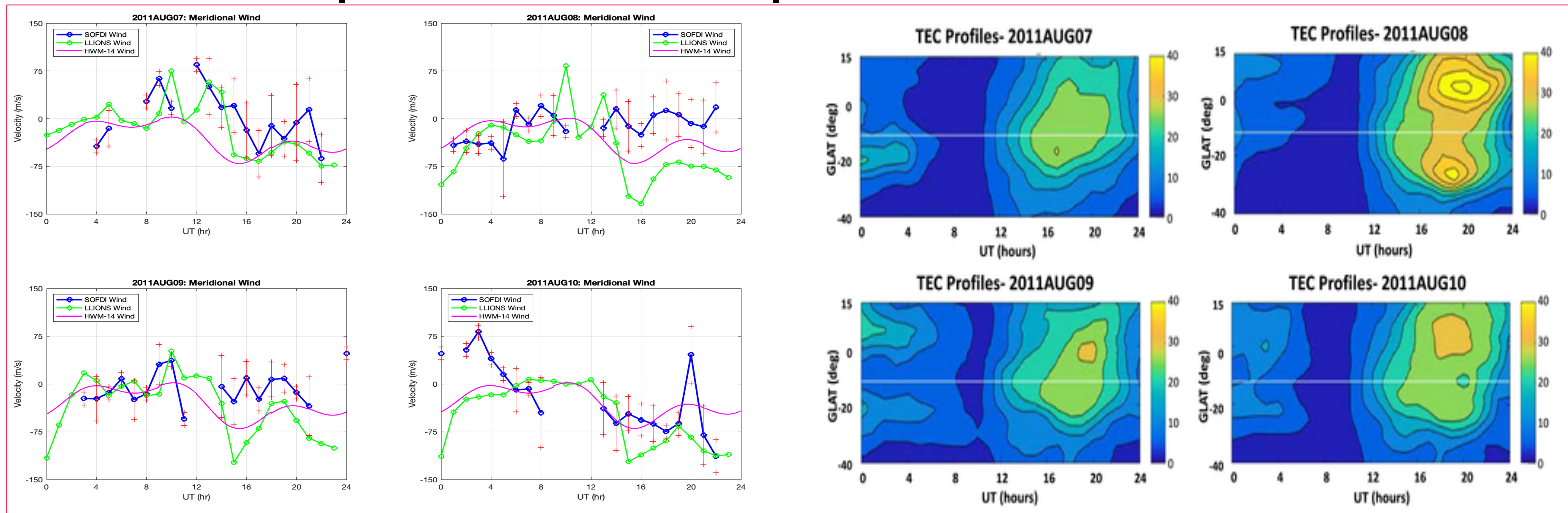


**Figure-3**
Left 4 Panels: The blue (green & magenta) curve with circles is the observed (simulated) meridional wind velocity by SOFDI (LLIONS & HWM-14), and the vertical red lines represent the error bars of the measured wind as a function of Universal time (UT) for 4 days (07, 08, 09, and 10 August 2011). The simulated results show reasonably good agreement within the error range of measurements by SOFDI at the geomagnetic equator for similar conditions.
Right 4 Panels: Contour plots of total electron content (TEC) distribution corresponding to left panel days. The white horizontal line represents the location of the geomagnetic equatorial line. GLAT, geographic latitude. The equatorial ionization anomaly (EIA) corresponding to weak meridional wind velocities are the most symmetric.

[Adapted from Khadka, *et al.*, 2018]

## Winds from SOFDI, HWM-14, and CTIPe Model

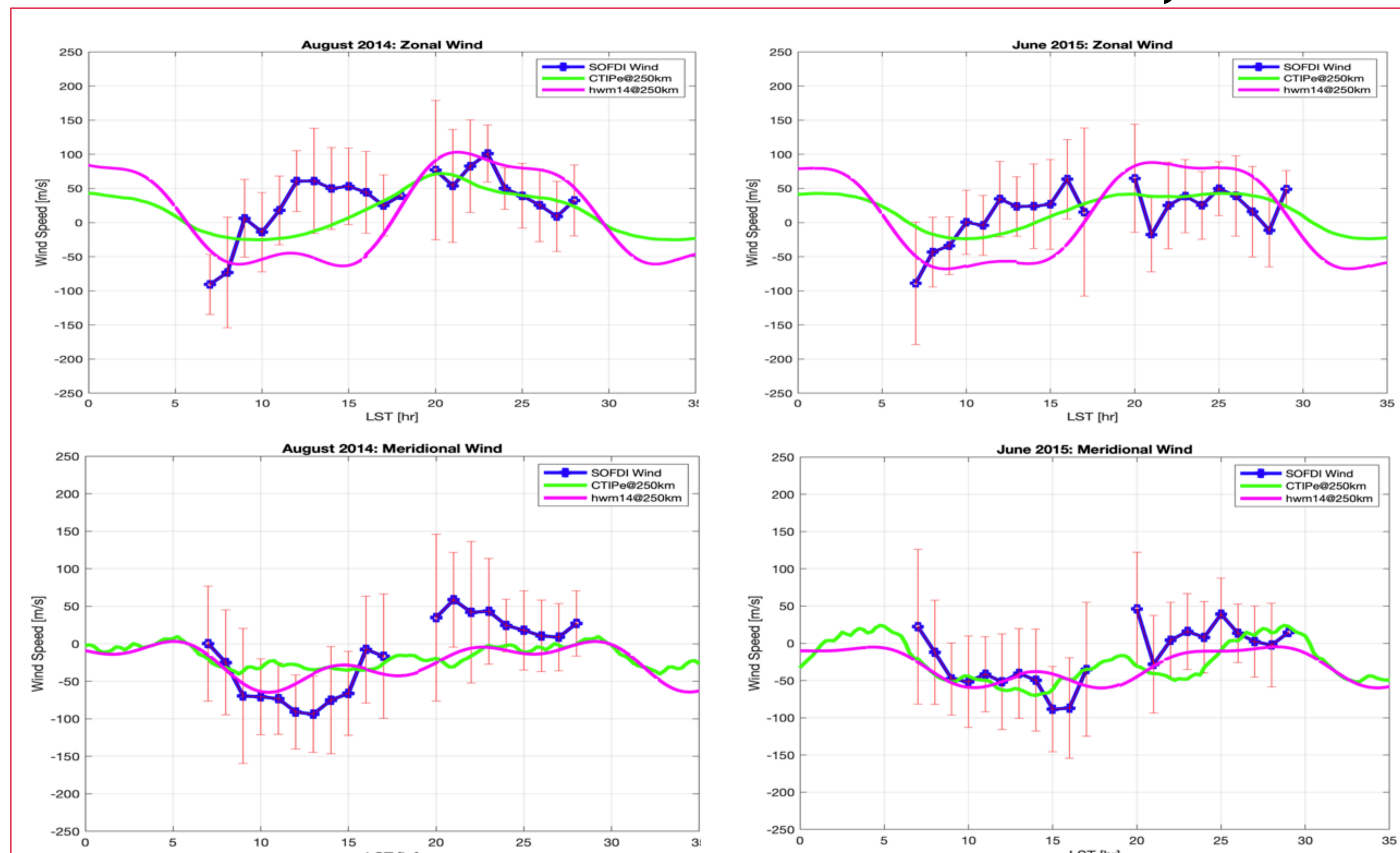


**Figure-4**
The blue (green & magenta) curve with circles is the observed (simulated) zonal and meridional monthly averaged wind components into 1- hour time bins by SOFDI (CTIPe & HWM-14), and the vertical red lines represent the error bars of the observed wind for August, 2014 and June, 2015. The simulated results show reasonably good agreement within the error range of measurements by SOFDI at the geomagnetic equator.

**TAKEAWAY**

The measured and simulated meridional winds obtained from the SOFDI instrument, CTIPe, and HWM-14 model respectively match climatology. Zonal winds are likewise consistent, EXCEPT for the daytime portion. The SOFDI zonal winds matched better with CTIPe model results than that of the HWM-14 model in the daytime portion. The deviation of measured winds from modeled climatological averages might be due to lower atmospheric waves dripping up in the thermosphere or/and change in emission layer heights. Also, redefining the quality of the input data (forcing), the accuracy of the physics-based model results could be improved.

## Summary

- The ground-based observed SOFDI wind data system can be used as a benchmark for validating/ improving various thermospheric neutral wind models and also be used as inputs or boundary conditions for physics-based models of the upper atmosphere.
- The overall agreement between the observed and simulated wind results is very good. The measured SOFDI meridional winds correspond well to simulated (LLIONS, CTIPe, and HWM-14) wind results, EXCEPT for the daytime eastward winds seen in the 630-nm emission.
- The daytime SOFDI zonal winds matched better with CTIPe results than that of other models. For instance, by increasing the model spatial resolution, including prompt penetration electric fields from an empirical model, improving the lower boundary conditions, implementing the International Geomagnetic Reference Field (IGRF) might overcome the above discrepancies between observed and simulated results. Some of these works are in progress now.
- The meridional neutral wind plays a very significant role in the development of the EIA asymmetry by transporting the plasma up the field lines. Precise observation of the meridional wind contributes to forecasting fluctuations in the upper atmosphere, including the thermosphere.

**Sovit Khadka[1], Andrew Gerrard[1], Mariangel Fedrizzi[2,3], and John Meriwether[1]**
[1]New Jersey Institute of Technology, Newark, NJ, USA, [2]University of Colorado, Boulder, CO, USA, and [3]Space Weather Prediction Center, NOAA, Boulder, CO, USA