LONG TERM OBSERVATIONS OF THE LOW LATITUDE (1,1) DIURNAL MIGRATING TIDE FROM WINDII, HRDI AND TIDI

R. Niciejewski, W. Skinner, D. Gell, M. Cooper, A. Marshall, University of Michigan, Ann Arbor, MI
T. Killeen, Q. Wu, S. Solomon, High Altitude Observatory, Boulder, Colorado
D. Ortland, Northwest Research Associates
D. Drob, J. Emmert, Naval Research Laboratory, Washington DC
G. Shepherd, S. Zhang, B. Solheim, York University, Toronto, Canada

ABSTRACT

The dominant feature in the global scale wind field in the low latitude mesosphere and lower thermosphere (MLT) region is the solar diurnal migrating tide, classically represented by the (1,1) Hough function. The meridional component of the horizontal neutral wind vector is relatively stable in this region making it possible to estimate the daily (1,1) amplitude and phase. Observations of the MLT winds have been performed from satellite platforms by HRDI and WINDII (UARS) and by TIDI (TIMED) since September 1991 providing a unique and continuous global perspective of the classical (1,1) tide for 15 years.

CONTACT INFORMATION

Rick Niciejewski
Space Physics Research Laboratory
The University of Michigan
Ann Arbor, MI 48109-2143
(voice) 734-647-3445
(fax) 734-936-0503

http://www-personal.umich.edu/~niciejew
email: niciejew@umich.edu

TIDI Observations

TIDI measures the horizontal neutral wind with a precision approaching 5 m/s for individual limb observations on a daily synoptic basis. The data sets are of similar quality to those obtained from HRDI and provide better global as well as complete diurnal coverage [*Niciejewski et al.,* 2006]. The same diagnostic is employed with TIDI and HRDI [O_2 (0,0) Atmospheric band emission] compared with WINDII [OI (5577Å)].

The dominant signal in the MLT wind is the classical (1,1) Hough mode component best seen at low latitudes during equinox. The amplitude of the diurnal tide was initially extracted from HRDI observations by *Hays et al.* [1994] by fitting the meridional component of the low latitude MLT winds on a daily basis with a simple representation of the migrating diurnal tide. This poster presents a 15 year trend of the (1,1) Hough mode component based on all available TIDI, HRDI, and WINDII observations.

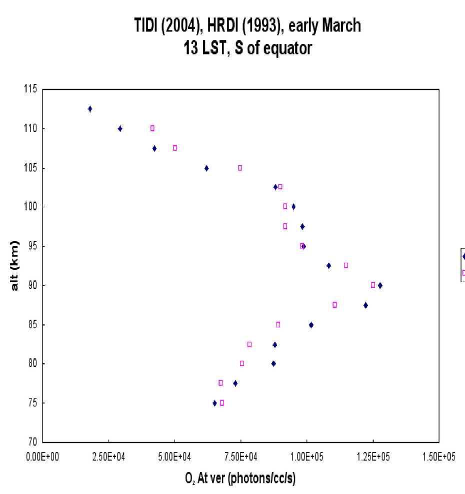

Figure 1. O_2 (0,0) Atmospheric band observed at similar geophysical conditions by both HRDI and TIDI.

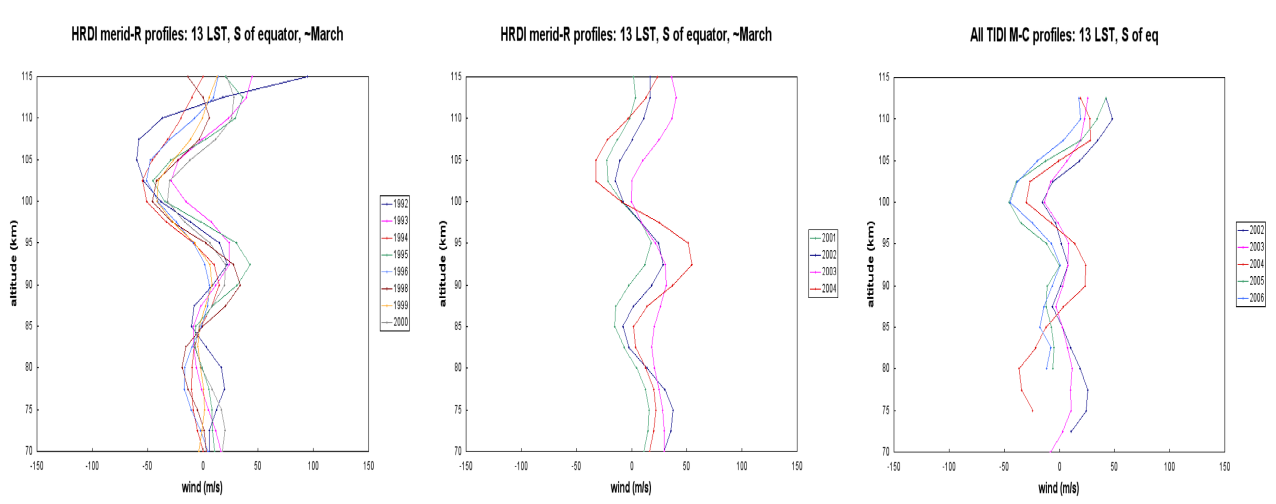

Figure 2. (left) HRDI meridional wind profiles for the altitude range 70 – 115 km, for March of the year listed in the legend (1992-2000). All winds obtained during the local solar time window 13 – 14 hr LST and the latitude range 0 – 7.5°S are shown. These profiles correspond to the period in the mission when attitude knowledge of UARS was obtained from on-board star trackers. (middle) Same, but attitude obtained from a constrained engineering model based on airglow climatology for the years 2001-2004. (right) TIDI meridional wind profiles for the same temporal and spatial grid points as those of the HRDI profiles for the years 2002-2006.

References

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Hays, P. B., D. L. Wu, and the HRDI science team, Observations of the diurnal tide from space, *J. Atmos. Sci., 51*, 3077, 1994.

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Hough Mode Fit

The solar diurnal tide is easily discerned in the neutral wind during equinox. The meridional component is symmetric about the equator with a vertical wavelength of ~23 km in the MLT. Peak winds near 100 m/s occur at ±20 degrees latitude between 90 and 100 km altitude. Averaged measurements are well described by the classical (1,1) Hough mode component [*Hays et al.,* 1994; *Burrage et al.,* 1995] suggesting a simple means to estimate the strength of the diurnal migrating tide on a daily basis. Further analysis provides a measure of the semi-annual variation of the diurnal tide.

A simple statistical model based on the latitudinal and altitudinal description of the (1,1) Hough mode may be constructed from yaw cycle averages during equinox. Measured winds, v_{ik}, may be fit as

$$v_{ik} = f(z_k) * H(lat_i) * \{ A \cos [2\pi(z_k/23 + t_i/24)] + B \sin [2\pi(z_k/23 + t_i/24)]\},$$

where $f(z_k)$ and $H(lat_i)$ are shown below.

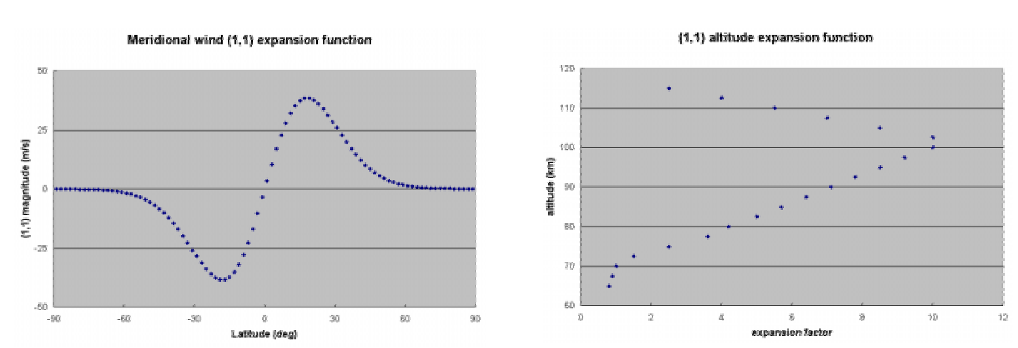

Figure 4. (left) Latitudinal profile of the meridional wind for (1,1) Hough mode fitting. (right) Altitudinal profile.

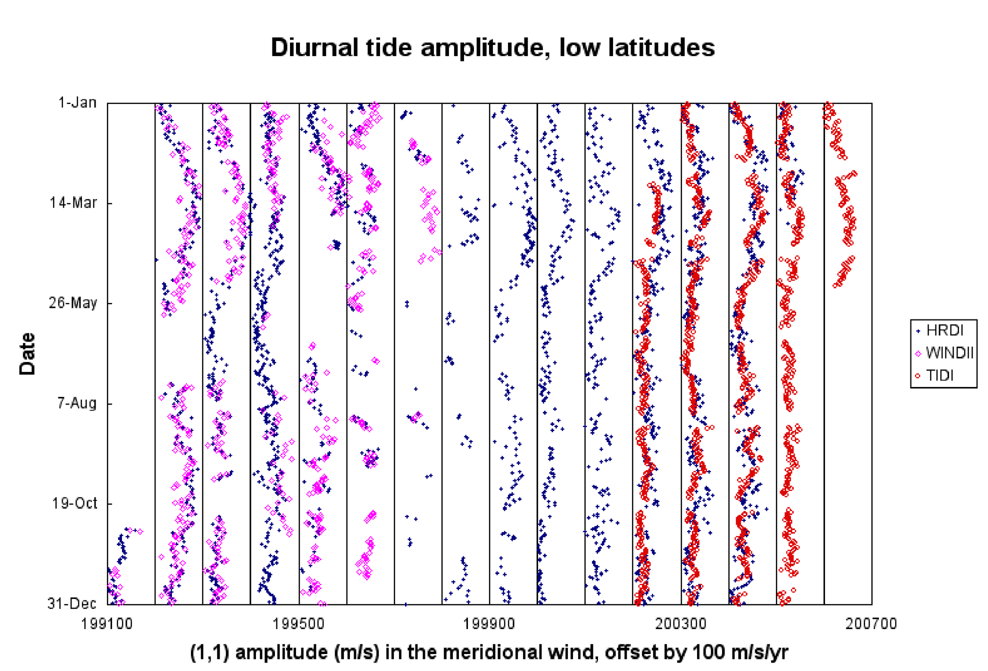

Figure 5. Diurnal tide amplitude as determined with daily Hough (1,1) mode fits to low latitude meridional wind profiles in the mesosphere and lower thermosphere for HRDI (1991 – 2005), WINDII (1991 – 1997), and TIDI (2002 – 2006). The velocity grid spacing is 100 m/s with zero diurnal tide amplitude shown for each year at the appropriate abscissa.

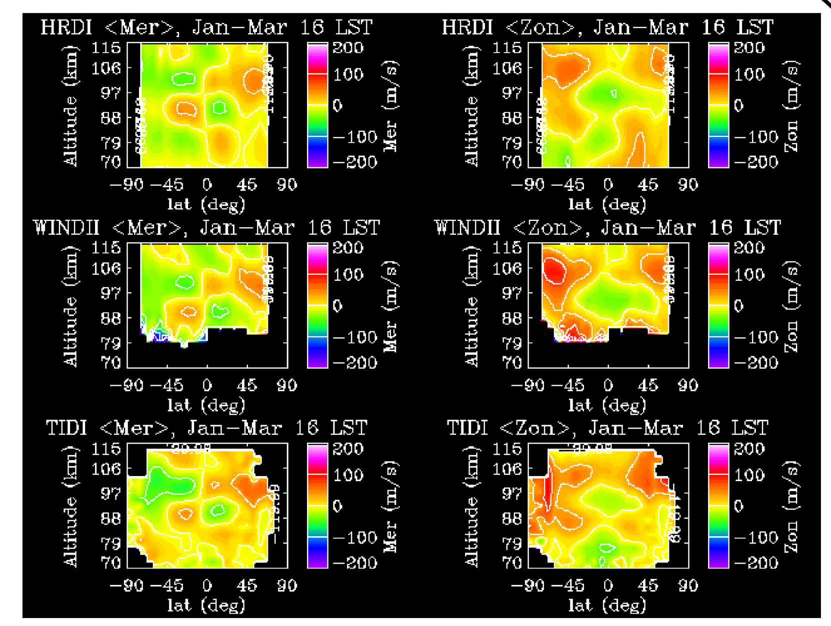

Figure 3. Multiple year average of the neutral wind components for the mid-January to mid-March TIDI yaw cycle for HRDI (top), WINDII (middle), and TIDI (bottom) at 16 hr LST.

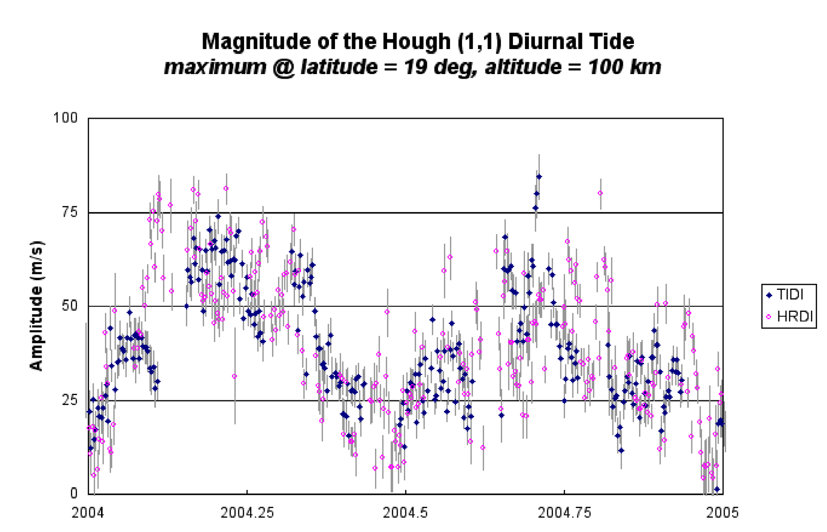

Figure 6. Solar diurnal tide amplitude for 2004 determined separately for TIDI (solid) and HRDI (open) with error bars determined from the Hough mode fit. Though the two satellites seldom viewed a common volume element, the correspondence between the two fits indicates the dominance of the diurnal migrating tide at low latitudes when wind data are averaged over a 24-hour period. A clear semi-annual signature is evident in the time trend.

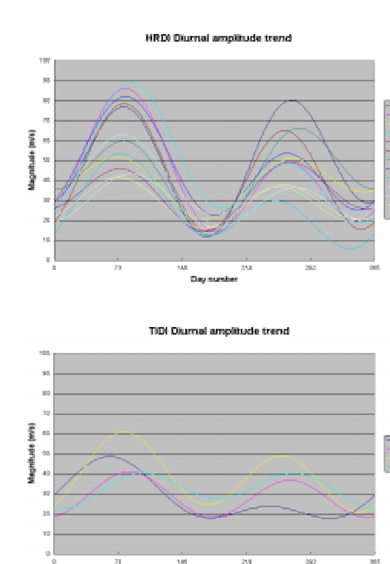

Figure 7. Summary of (1,1) Hough mode fits for the entire HRDI (top) and TIDI (bottom) missions. The yearly behavior was determined from fitting the tide amplitudes with sinusoids representing the semi-annual and annual terms, plus a mean offset.

Inter-annual variations

The solar diurnal tide in the MLT is dominant during equinox and weak during solstice, and follows a semi-annual variation. It is of interest to fit the diurnal tide amplitude on an annual basis to compare trends from different years. Since the semi-annual variation is clear, a fit with a 6 month and a 12 month amplitude and phase along with a mean term may be applied to each year. The results show

- the diurnal tide peaks within a few days of the March equinox, but has greater scatter around the September equinox date
- the magnitude of the semi-annual amplitude is between 10 and 30 m/s
- the magnitude of the annual amplitude is scattered and between ~0 and 20 m/s
- the magnitude of the mean term decreases from 50 m/s to 30 m/s between 1992 and 2005
- independent fits between HRDI and WINDII, and HRDI and TIDI most often show similar values within fit error bars

The simple model employed in the fitting excludes longer term variations which may be present.

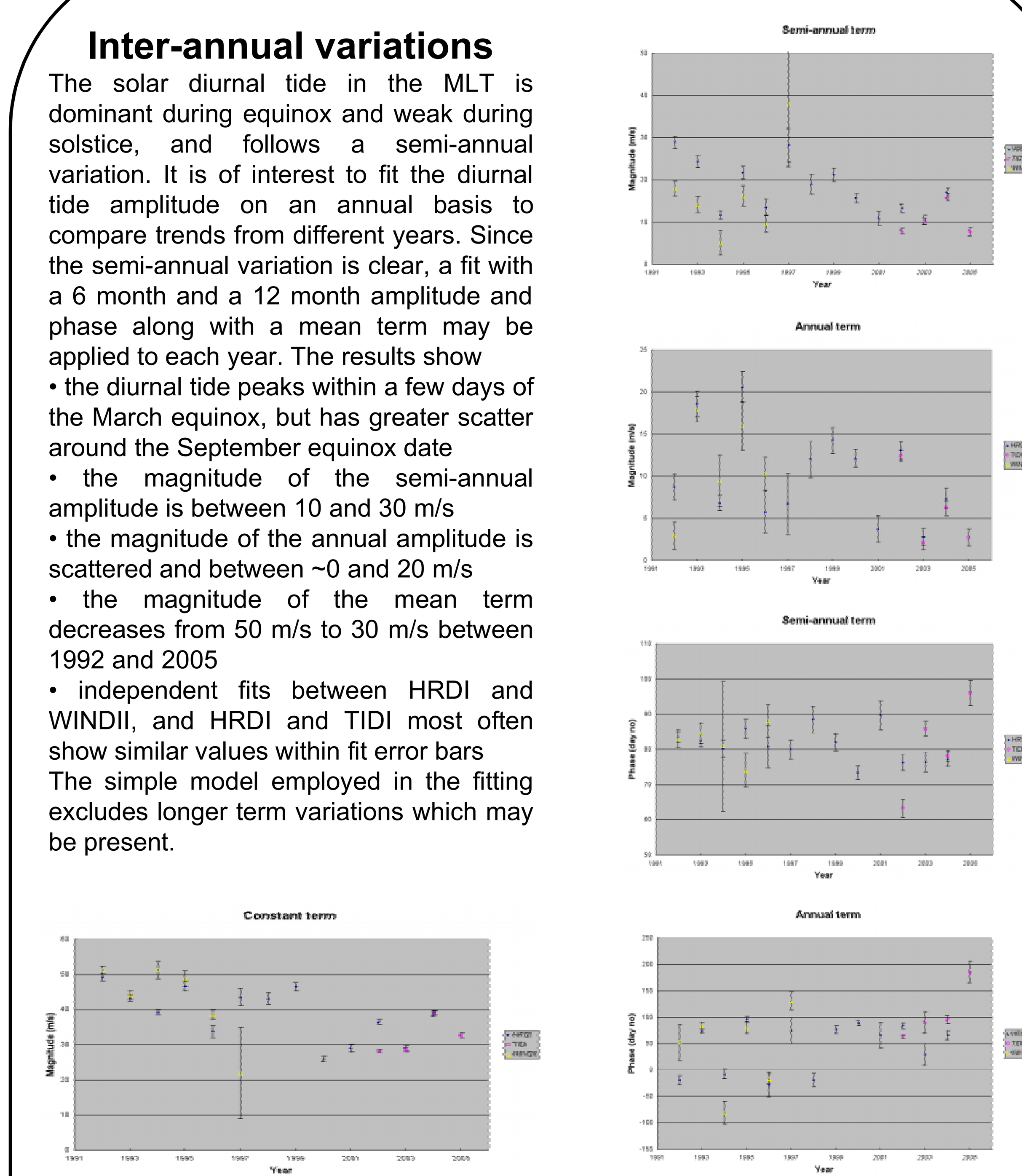

Figure 8. Individual components from a term analysis of the entire satellite MLT wind database. HRDI results are available for 1992 to 2004, WINDII from 1992 to 1997, and TIDI from 2002 to 2005. The mean offset diurnal wind is shown on the left. The amplitudes of the semi-annual and annual terms are shown in the top right, while the phase, as a function of day number, are shown bottom right. The fit was performed by giving equal weight to each diurnal tide amplitude result in the preceding (1,1) Hough mode analysis. Data gaps exist, eg. preceding the March equinox 2002 for TIDI, which tend to skew the simple term analysis.

Conclusions

1. TIDI neutral wind observations are of comparable quality to HRDI and WINDII on an individual basis. Much better is the global and temporal coverage of TIDI wind measurements when compared with UARS.
2. The solar diurnal tide is a stable feature of the low latitude MLT during equinox. There are differences in the strength of the tidal amplitude between March and September
3. A strong semi-annual periodicity is evident in the long term solar diurnal tide. An annual periodicity is at least required to fit yearly tide data sets.
4. Inter-annual variability of the solar diurnal tide is evident in the combined 15 year wind data set. Multiple year periodicities are suggested in the long term trends, and are likely related to the ~27 month QBO or other lower atmospheric oscillations. Further synoptic observations of the MLT, to at least 2010, will improve our understanding of the basic state of the MLT region.