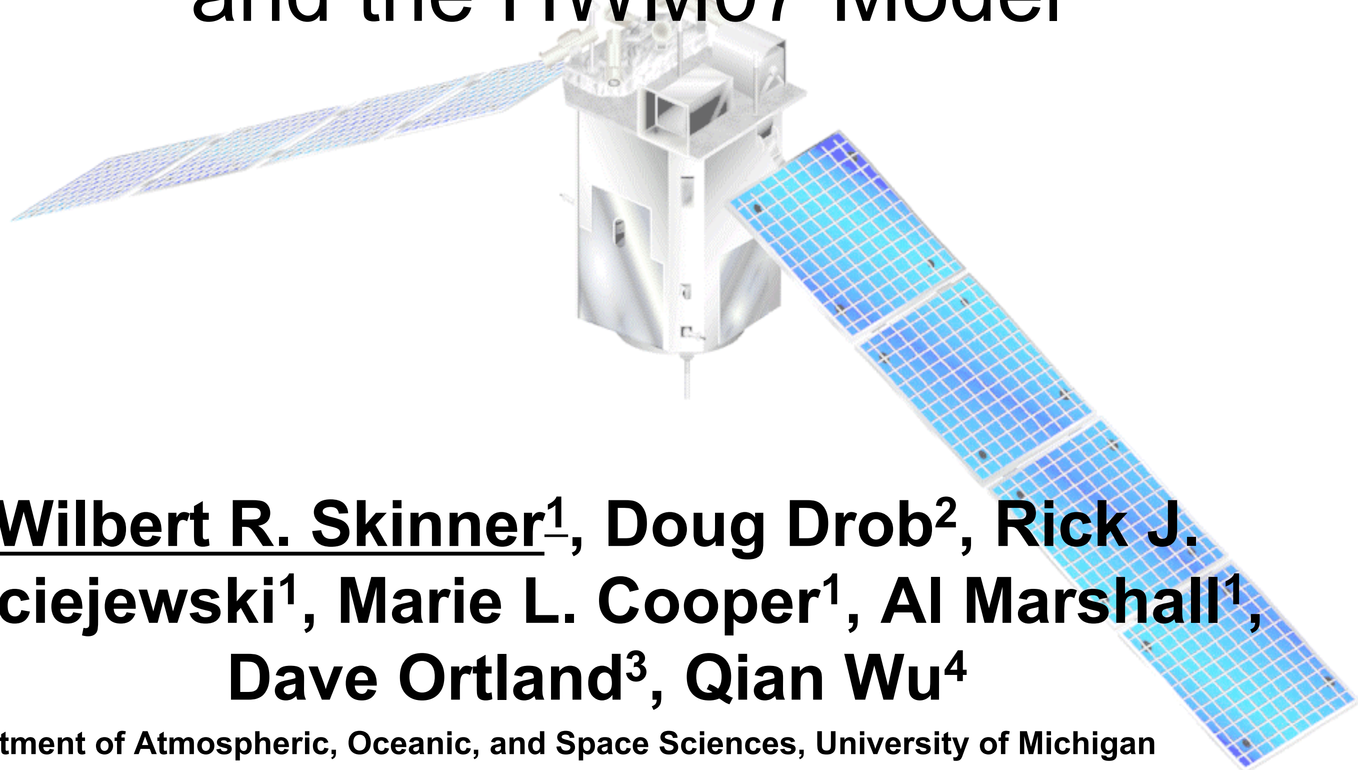
Comparison of TIDI Wind Observations and the HWM07 Model



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Introduction

- The Horizontal Wind Model 07 (HWM07) is a new empirical atmospheric wind model [see poster 1540]. A variety of ground and space-based data sources were included, but notably not data from the TIMED Doppler Interferometer (TIDI). TIDI has measured mesosphere, lower thermosphere winds since early 2002. This poster presents a comparison of the winds measured by TIDI and modeled by HWM07.

HWM07

The Horizontal Wind Model 07 (HWM07) is a provisional empirical model of horizontal winds in the troposphere, stratosphere, mesosphere, and thermosphere, and is intended to succeed HWM93 [Hedin et al., J. Atmos. Terr. Phys., vol. 58, 1421-1447, 1996]. In addition to the data used in HWM93, the model is based on extensive new ground-based and space-based wind measurements, including height profiles from NASA-UARS/WINDII, NASA-UARS/HRDI, measurements from ground-based optical and radar instruments obtained from the NSF-CEDAR database, and lower atmospheric NCEP data.

In the thermosphere, the model consists of two parts: a quiet-time portion, and a geomagnetically disturbed portion. The quiet-time part represents average wind conditions when ap <= 12. The disturbed part represents average perturbation winds for the specified ap input.

The quiet part is represented by vector spherical harmonics in geodetic latitude, geodetic longitude, and solar local time, up to wave number 8 in latitude, 2 in longitude, and 3 in local time. The seasonal dependence is represented by harmonic terms up to semiannual. The vertical structure is represented below 250 km by cubic B-splines with node spacing of 5 km below 110 km and higher nodes at 110, 117, 125, 135, 150, 200, and 250 km. Above 250 km, an exponential decay function with a scale height of 60 km is used; continuity up to the second derivative is imposed at 250 km.

The disturbance winds depend on magnetic latitude, magnetic local time, and Kp. The Quasi-Dipole magnetic coordinates described by Richmond [J Geomagn. Geoelectr., vol. 47, 191-212, 1995] are used for the magnetic coordinates; the code was obtained from the NSF-CEDAR database, and the interpolation grid was computed from IGRF at 250 km and epoch 1994.0 The magnetic latitude and magnetic local time dependence of the disturbance winds is represented by vector spherical harmonics up to wave number 10 in magnetic latitude and wave number 3 in magnetic local time. At mid and low latitudes, only latitudinal terms up to wave number 4 are used; the transition from low resolution at low latitudes to high resolution at high latitudes occurs at a pre-determined latitude that depends on local time and Kp. The transition is made with an exponential function with a width of 4 degrees. The Kp dependence is represented by cubic splines with nodes at 0, 2, 5, and 8. The Kp dependence is constrained to have zero slope at Kp=0 and Kp=8, and is constant above Kp=8.

MODEL LIMITATIONS

- The model currently contains no solar activity dependence.

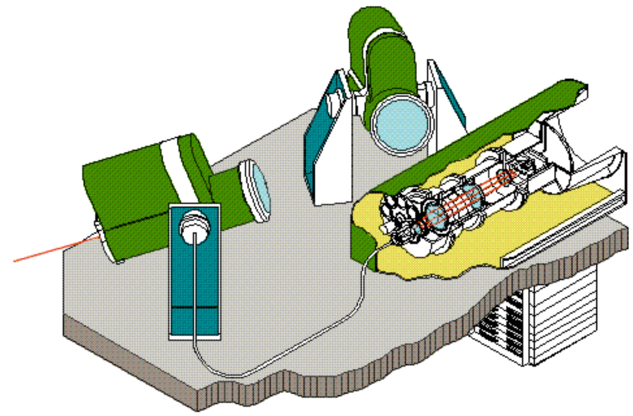
- The disturbed part depends only on magnetic latitude, magnetic local time, and Kp (via the ap argument), and represents average disturbance winds in the upper thermosphere (above 225 km). The disturbance winds are assumed to be constant with height, with a smooth artificial cutoff below 125 km.

HWM07 Data sources

Instrument	Location	Height (km)	Years	LT	Days	Data Points	Reference
Satellite							
AE-E NATEa	± 18.0° N	220 - 400	1975 - 1979	D,N	799	200,500	Spencer *et al.*, 1973
DE 2 WATSb	± 89.0° N	200 - 600	1981 - 1983	D,N	536	391,500	Spencer *et al.*, 1981
DE 2 FPIc	± 89.0° N	250	1981 - 1983	D,N	308	47,600	Hays *et al.*, 1981
UARS HRDI	± 72.0° N	50 - 115	1993 - 1994	D	834	30,100,000	Hays *et al.*, 1993
UARS WINDII 5577 Å	± 72.0° N	90 -300	1991 - 1996	D	949	24,672,000	Shepherd *et al.*, 1993
UARS WINDII 6300 Å	± 42.0° N	200 - 300	1991 - 1996	N	243	2,237,942	Shepherd *et al.*, 1993
Sounding Rocket							
Falling Sphere	8° S - 60° N	8 - 98	1969 - 1991	D,N	1,186	96,205	Schmidlin *et al.*, 1985
Rocketsonde	38° S - 77° N	2 - 90	1969 - 1991	D,N	5,082	843,000	Schmidlin *et al.*, 1986
TMA	31° S - 70° N	59 - 277	1956 - 1998	D,N	276	92,792	Larsen, 2002
Fabry-Perot Interferometer							
Arecibo	18.4° N, 66.8° W	250	1980 - 1999	N	473	14,198	Burnside and Tepley, 1989
Arequipa	16.2° S, 71.4° W	250	1983 - 2001	N	1048	32,238	Meriwether *et al.*, 1986
Arrival Heights	77.8° S, 116.7° E	250	2002 - 2005	N	535	54,214	Hernandez *et al.*, 1991
Halley Bay	75.5° S, 26.6° W	250	1988 - 1998	N	799	82,614	Crickmore *et al.*, 1991
Millstone Hill	42.6° N, 71.5° W	250	1989 - 2002	N	1,770	68,333	Sipler *et al.*, 1985
Mount John	44.0° S, 170.4° E	89, 96, 250	1991 - 1996	N	560	2,660	Hernandez *et al.*, 1991
Søndrestrøm	67.0° N, 51.0° W	250	1984 - 2004	N	1,223	69,734	Killeen *et al.*, 1995
South Poled	90.0° S	86, 250	1989 - 1999	N	1,091	163,044	Hernandez *et al.*, 1991
Svalbarde	78.2° N, 15.6° E	250	1980 - 1983	N	44	7,472	Smith and Sweeny, 1980
Thule	76.5° N, 68.4° W	250	1987 - 1989	N	172	21,500	Killeen *et al.*, 1995
Resolute Bay	74.7° N, 94.9° E	250	2003 - 2005	N	166	5,299	Wu *et al.*, 2004
Watson Lake	60.1° N, 128.6° W	250	1991 - 1992	N	135	28,000	Niciejewski *et al.*, 1996
Incoherent Scatter Radar							
Arecibo	18.3° N, 66.8° W	100 - 170	1974 - 1987	D	149	30,600	Harper, 1977
Chatanika	65.1° N, 147.4° W	90 - 130	1976 - 1982	D	97	38,721	Johnson *et al.*, 1987
EISCAT	69.6° N, 19.2° E	100 - 120	1985 - 1987	D	29	2,900	Williams and Virdi, 1989
Millstone Hill	42.6° N, 71.5° W	120 - 400	1983 - 1987	D,N	142	23,536	Salah and Holt, 1974
Søndrestrøm	67.0° N, 50.9° W	150 - 400	1983 - 1987	D,N	146	19,600	Wickwar *et al.*, 1984
St. Santinf	44.6° N, 2.2° E	90 - 165	1973 - 1985	D	256	18,382	Amaynec, 1974
Medium Frequency Radar							
Adelaide	34.5° S, 138.5° E	60 - 98	2001 - 2004	D,N	834	481,634	Vincent and Lesicar, 1991
Bribe Island	28.0° S, 153.0° W	60 - 98	1995	D,N	280	184,176	Reid, 1987
Davis	68.6° S, 78.0° E	50 - 100	2001 - 2004	D,N	730	526,160	Vincent and Lesicar, 1991
Poker Flat	65.1° N, 147.5° W	44 - 108	1979 -1985	D,N	1857	2,746,684	Murayama *et al.*, 2000
Wakkanai	45.4° N, 141.8° E	50 - 108	1998 - 2003	D,N	1538	1,874,672	Murayama *et al.*, 2000
Yamagawa	31.2° N, 130.6° E	60 - 98	1998 - 2003	D,N	1593	1,040,042	Murayama *et al.*, 2000
Wind and Temperature Lidar							
Ft. Collins	40.6° N, 105.1° W	75 - 115	2002 - 2002	D,N	244	93,288	She *et al.*, 2004
Numerical Weather Prediction Analysis							
NOAA GFS Analysis	Global	0 - 35	2002 - 2007	D,N	1520	–	Kalnay *et al.*, 1990
NASA GEOS4 Analysis	Global	0 - 55	2002 - 2007	D,N	1520	–	Bloom *et al.*, 2005

TIDI

The Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics (TIMED) Doppler Interferometer (TIDI) is a Fabry-Perot interferometer designed to investigate the dynamics of the earth's mesosphere and lower thermosphere-ionosphere (MLTI) from an altitude of 60 to 120 km as part of the TIMED mission. TIDI is a limb viewer and observes emissions from OI at 557.7 nm and rotational lines in the O_2(0-0) Atmospheric band at 762 nm to determine the Doppler shift and hence the wind. Some of the key TIDI parameters are shown below.

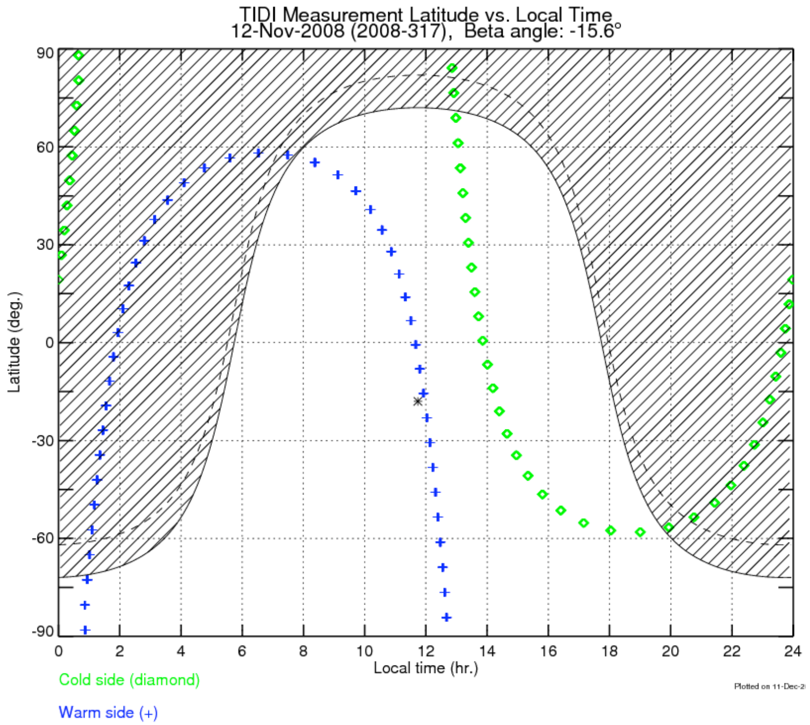


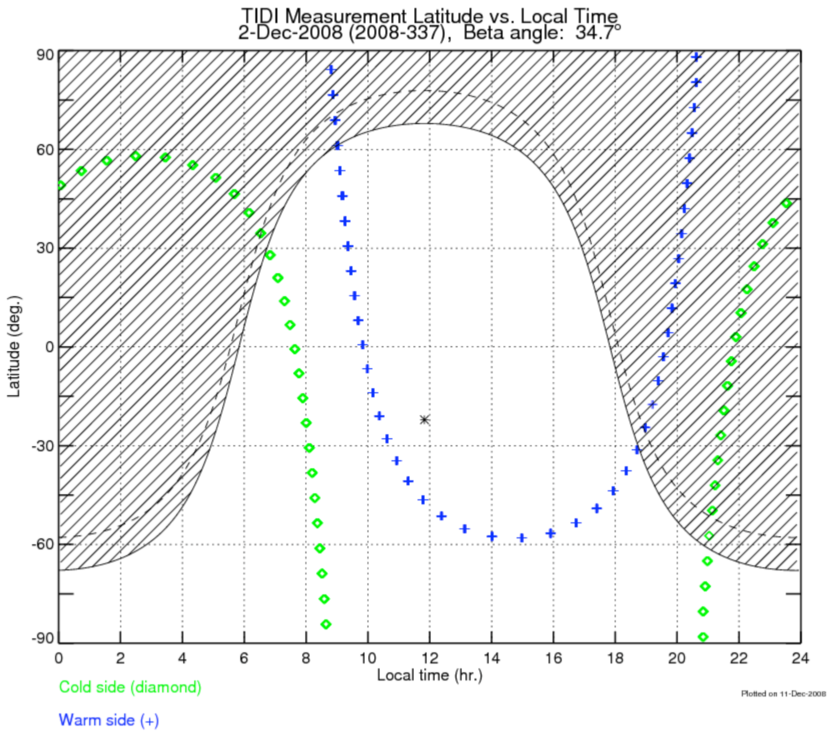
TIDI layout showing two of the four telescopes, the fiber optic connecting the telescopes and profiler and the electronics box.

TIDI parameters

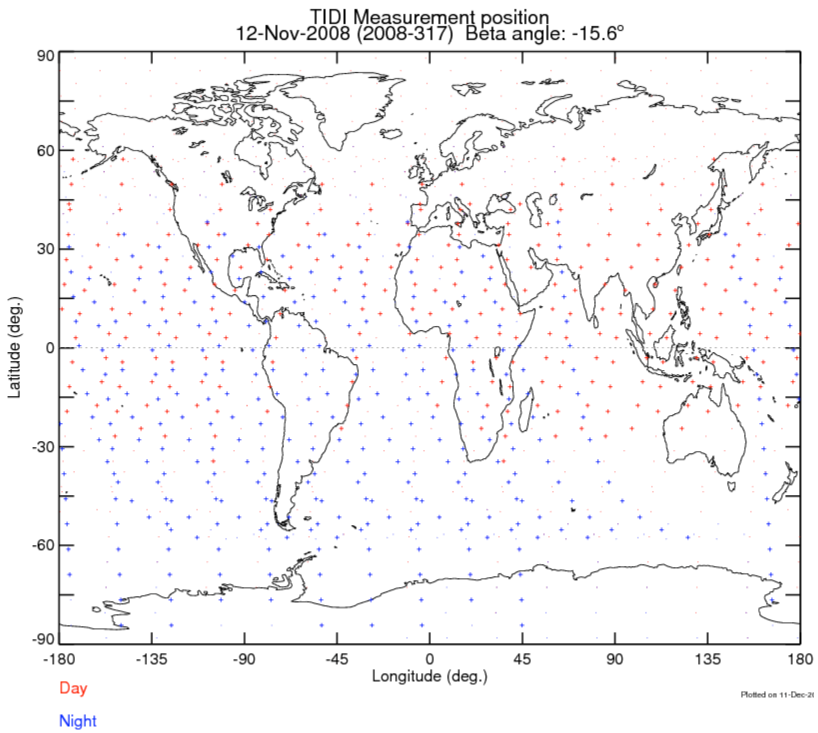
Spacecraft altitude	625 km
Orbital inclination	74.1°
Time to precess 24 hours of local time	120 days (yaw every 60 days)
Altitude Resolution	2 km
Spectral Range	550 - 900 nm
Gap thickness	2.2 cm
CCD	SITe ST-005AB
CCD size	2000 x 800 (1000 x 400 quadrant used)
Pixel size	15 x 15 microns
Number of telescopes	4 (45°, 135°, 225°, 315° to flight direction)
Aperture	7.5 cm
Field of view	0.05° (vertical) x 2° (horizontal)
Latitude coverage	-90° to 57° (south viewing) and -57° to 90° (north viewing)
Emissions observed	O_2 Atmospheric A band, $O(^1D)$ red line, $O(^1S)$ green line

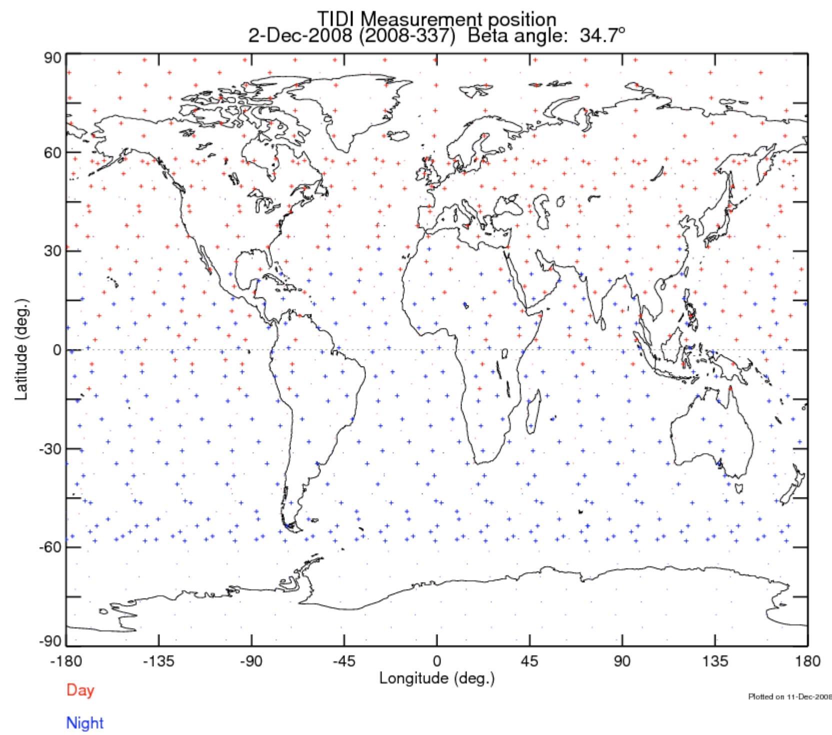
Single day local time coverage for TIDI measurements.





TIDI single day geographical coverage





Method:

1. **TIDI V10 [current version] VECTOR files (L3) from late 2003 until 2008 are used.**
2. **HWM07 is sampled at the same locations [time, altitude, latitude, longitude, (local time determined from time and longitude)]**
3. **Data are separated into warm and cold side observations**
4. **Date are binned into 5 degree latitude bins, 1 hour local time, 2.5 km altitude per yaw cycle.**
5. **Various slices are compared.**

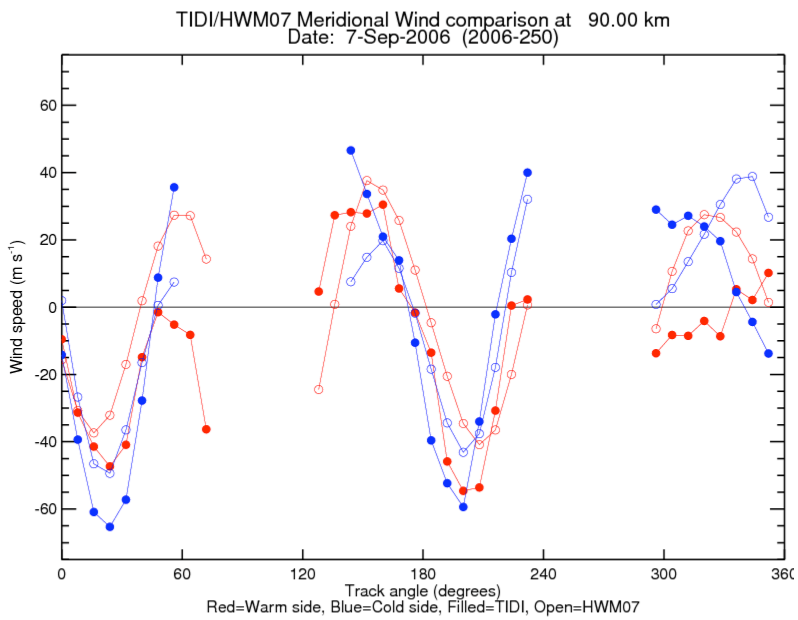
TIMED yaw dates

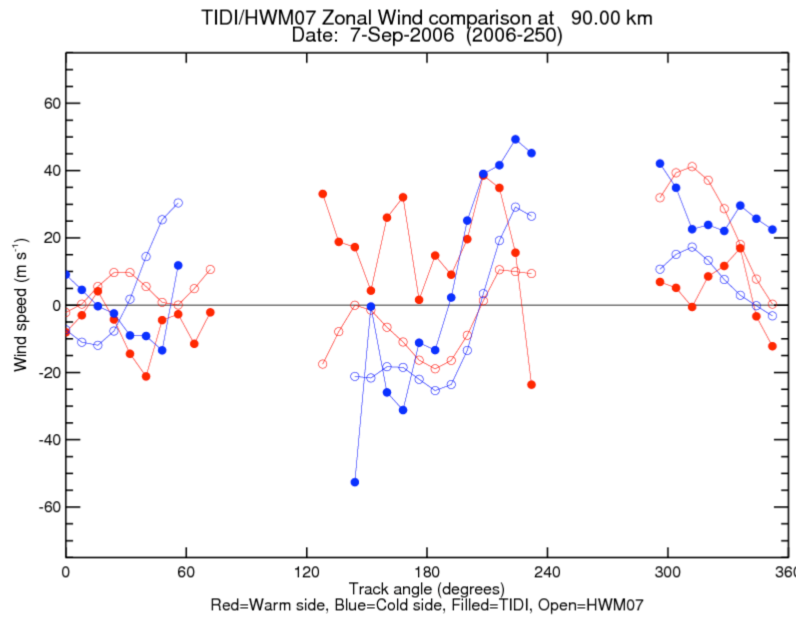
(Day 15=15 January, 78=19 March, 142=22 May,
197=16 July, 262=19 September, 325=21 November)

Start Date	End Date	Flight Direction
2001-341	2001-355	Backward
2001-355	2002-015	Forward
2002-015	2002-078	Backward
2002-078	2002-142	Forward
2002-142	2002-197	Backward
2002-197	2002-262	Forward
2002-262	2002-325	Backward
2002-325	2003-015	Forward
2003-015	2003-078	Backward
2003-078	2003-142	Forward
2003-142	2003-198	Backward
2003-198	2003-262	Forward
2003-262	2003-325	Backward
2003-325	2004-015	Forward
2004-015	2004-078	Backward
2004-078	2004-142	Forward
2004-142	2004-197	Backward
2004-197	2004-263	Forward
2004-263	2004-324	Backward
2004-324	2005-014	Forward
2005-014	2005-077	Backward
2005-077	2005-140	Forward

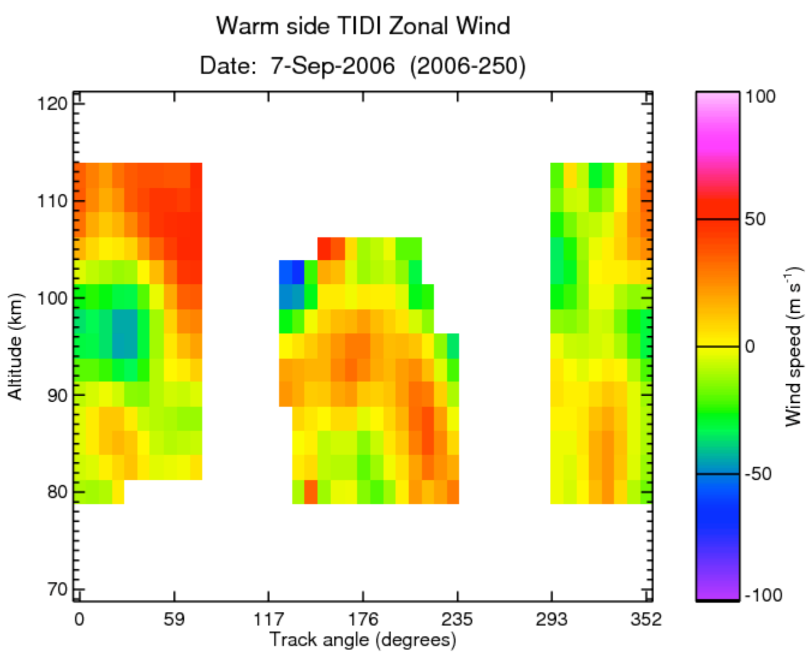
Start Date	End Date	Flight Direction
2005-140	2005-196	Backward
2005-196	2005-261	Forward
2005-261	2005-323	Backward
2005-323	2006-013	Forward
2006-013	2006-076	Backward
2006-076	2006-139	Forward
2006-139	2006-195	Backward
2006-195	2006-261	Forward
2006-261	2006-324	Backward
2006-324	2007-012	Forward
2007-012	2007-075	Backward
2007-075	2007-140	Forward
2007-140	2007-196	Backward
2007-196	2007-260	Forward
2007-260	2007-323	Backward
2007-323	2008-012	Forward
2008-012	2008-075	Backward
2008-075	2008-140	Forward
2008-140	2008-195	Backward
2008-195	2008-259	Forward
2008-259	2008-322	Backward
2008-322		Forward

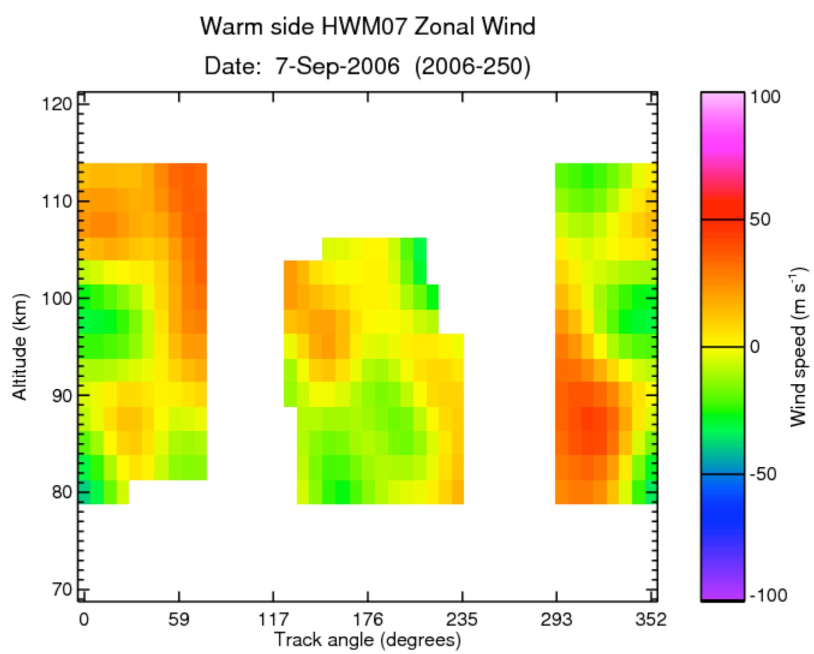
TIDI and HWM07 winds as a function of spacecraft track angle for 7 September 2006 at 90 km



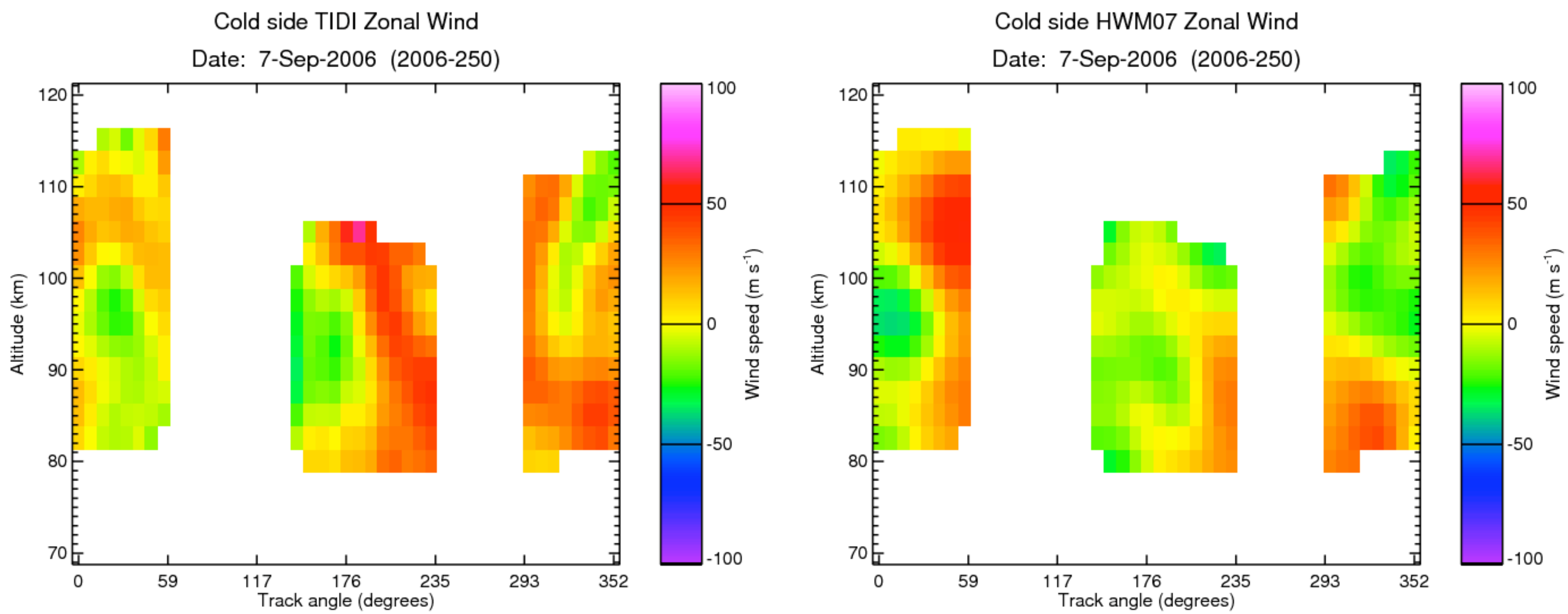


Zonal wind comparison along spacecraft track angle on 7 September 2006

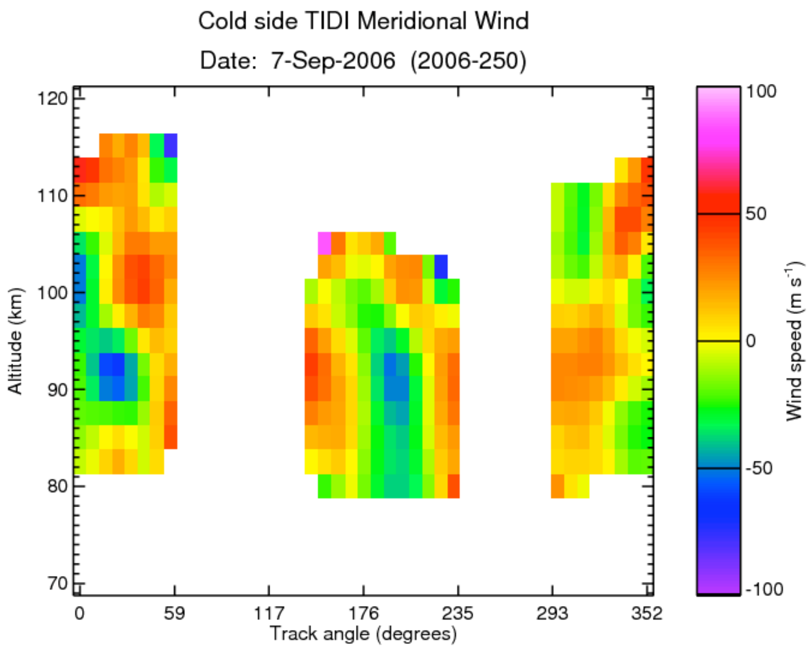


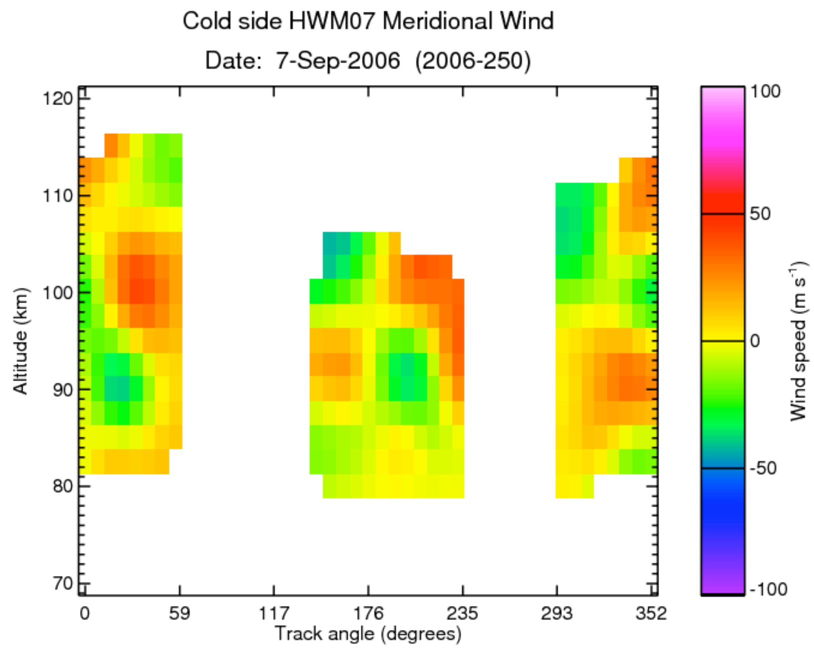


Zonal wind comparison along spacecraft track angle on 7 September 2006

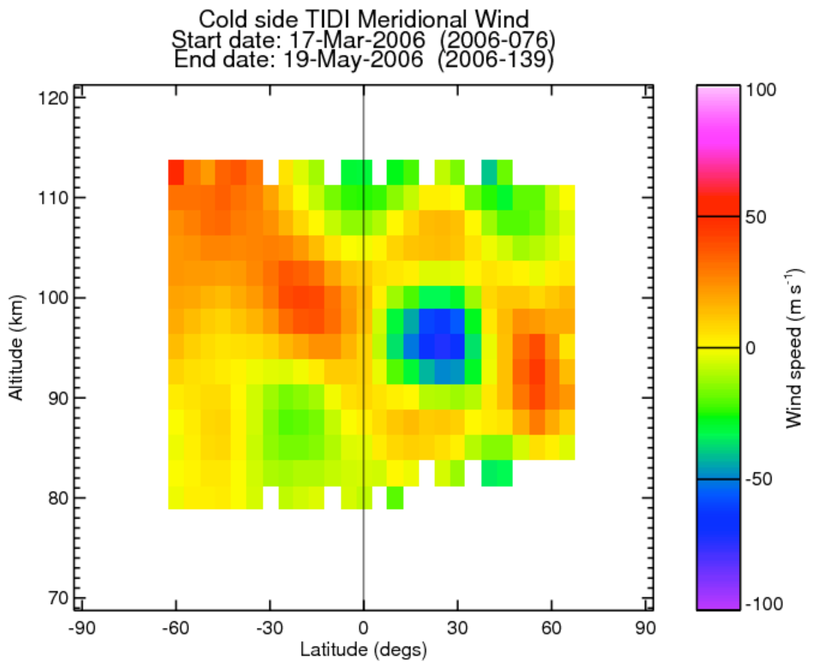


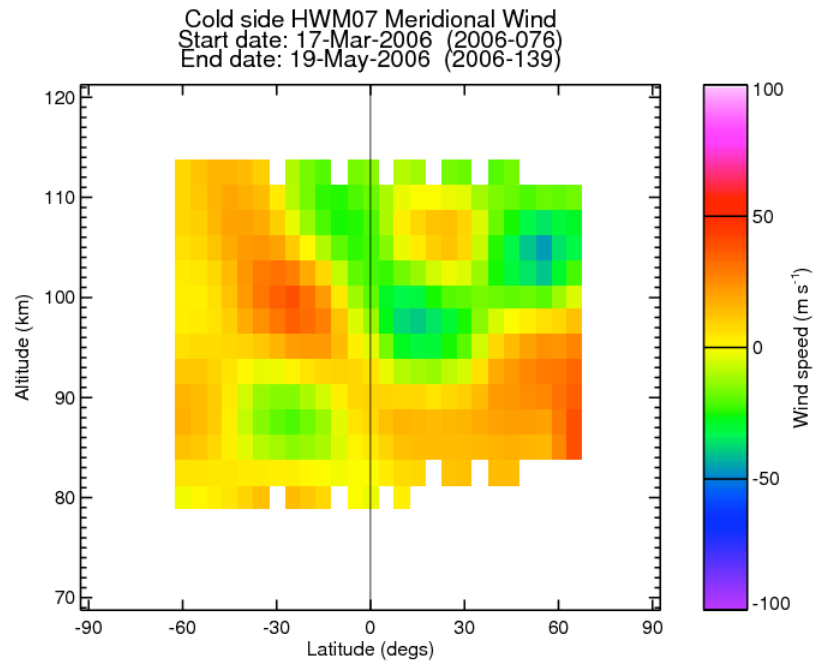
Meridional wind comparison along spacecraft track angle on 7 September 2006



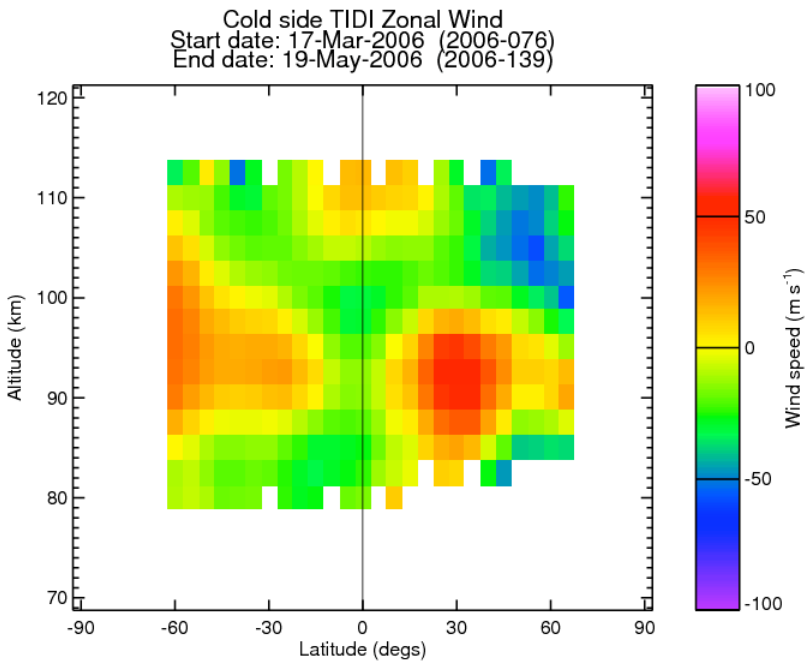


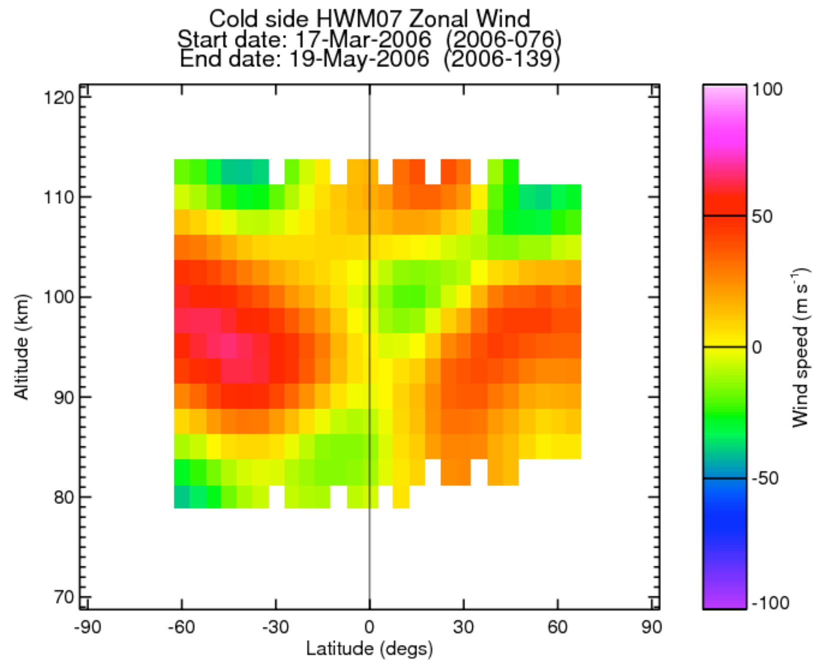
Comparison of binned zonal winds as a function of altitude for the yaw period extending from17 March to 19 May 2006 and 17 hours local time



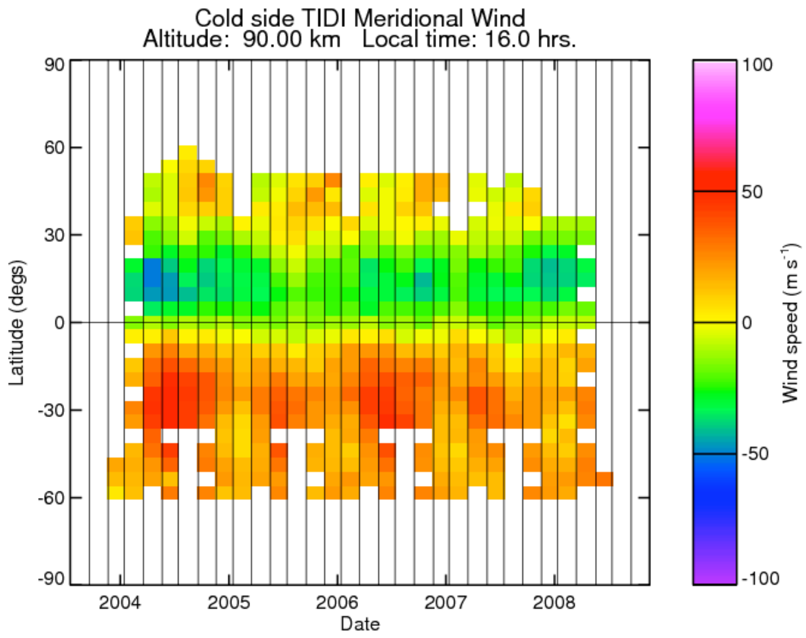


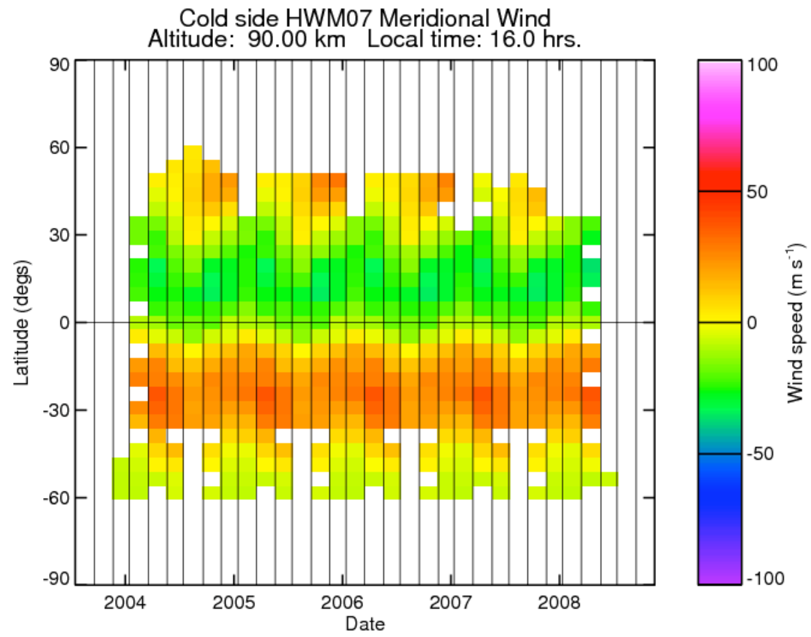
Comparison of binned zonal winds as a function of altitude for the yaw period extending from17 March to 19 May 2006 and 7 hours local time



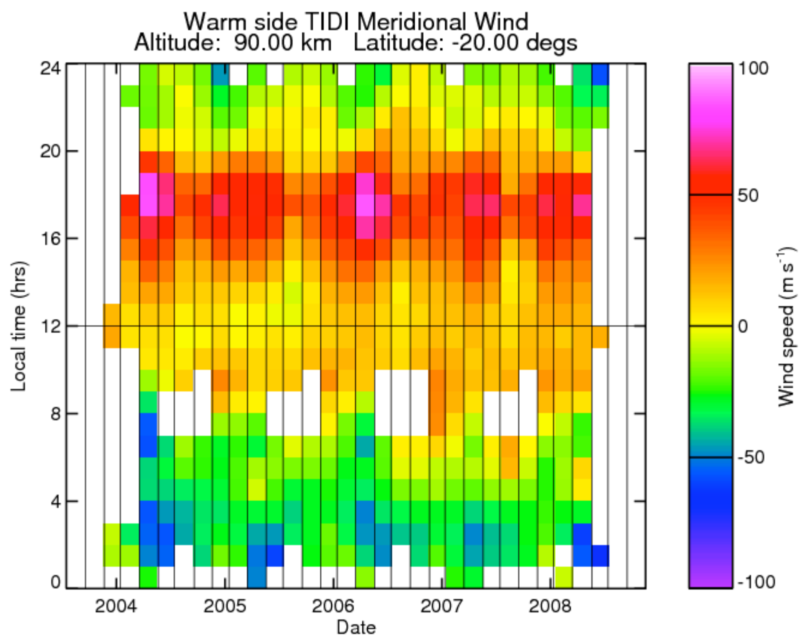


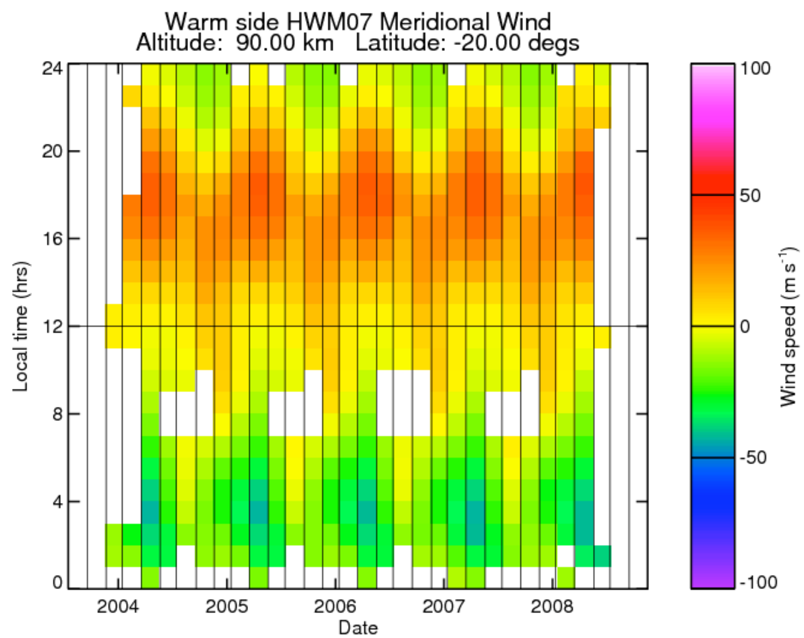
Comparison of meridional winds at 90 km and 16 hrs. local time from 2004 to 2008



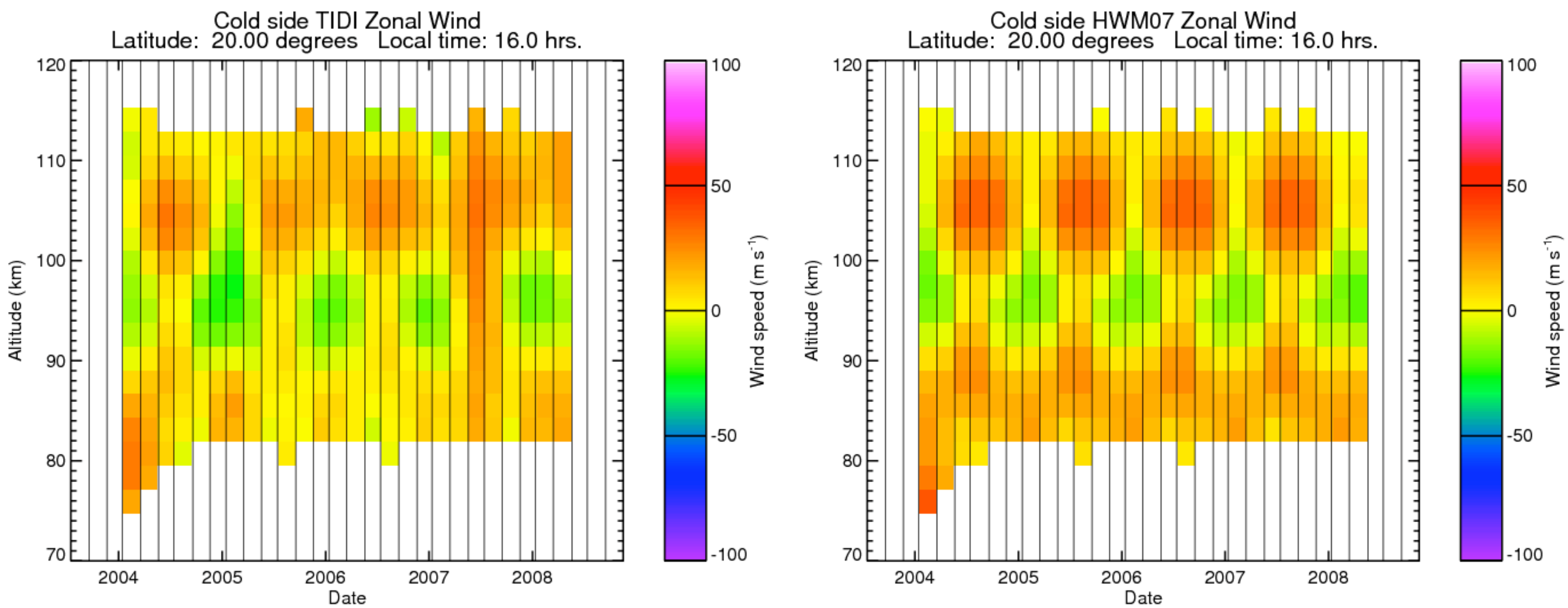


Comparison of meridional winds at 90 km and -20 degrees latitude from 2004 to 2008



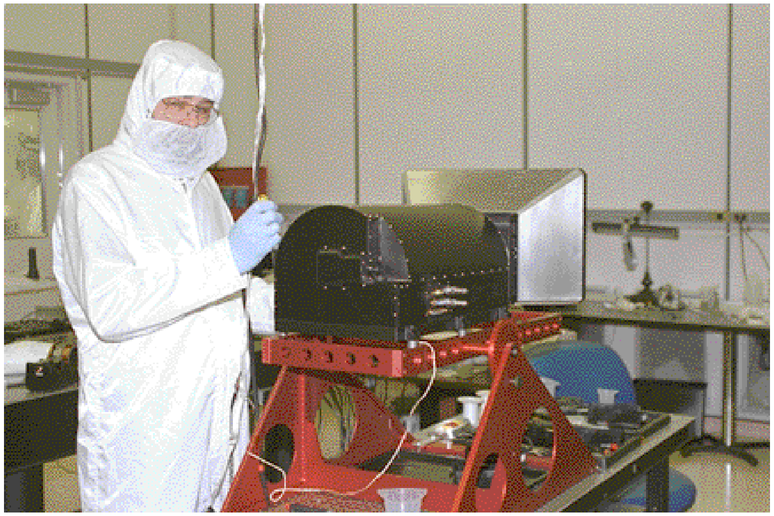


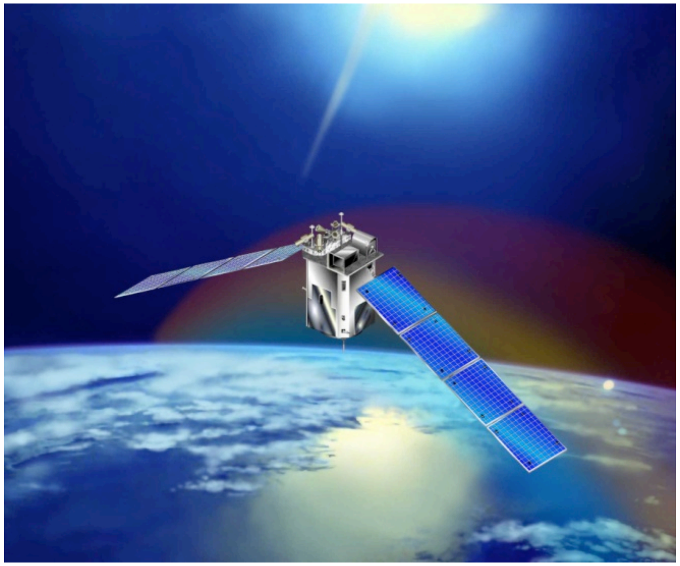
Comparison of meridional winds at 16 hrs local time and -20 degrees latitude from 2004 to 2008



Conclusion

- This poster compared two <u>independent</u> sources of MLT wind: TIDI and HWM07
- TIDI wind measurements and HWM07 model results show good qualitative agreement.
- Possible sources of quantitative differences:
  - Natural atmospheric variation
  - Problems with TIDI data retrieval
    - Interpretation made difficult by light lead and ice on optics
  - Limitations of model
    - e.g. there is no forcing from below (e.g. QBO)





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