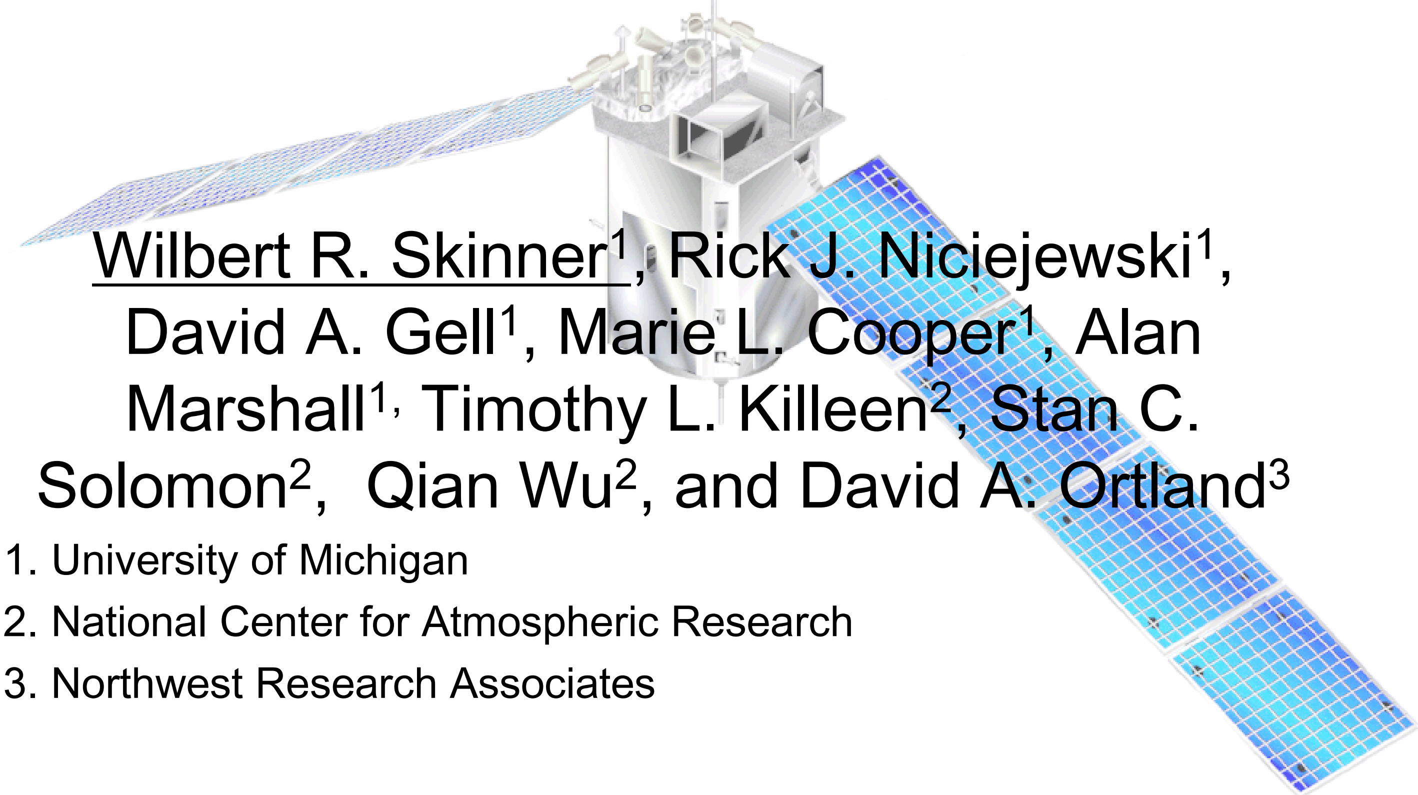
# Mesosphere and Lower Thermosphere Winds from space: A decade and a half of observations



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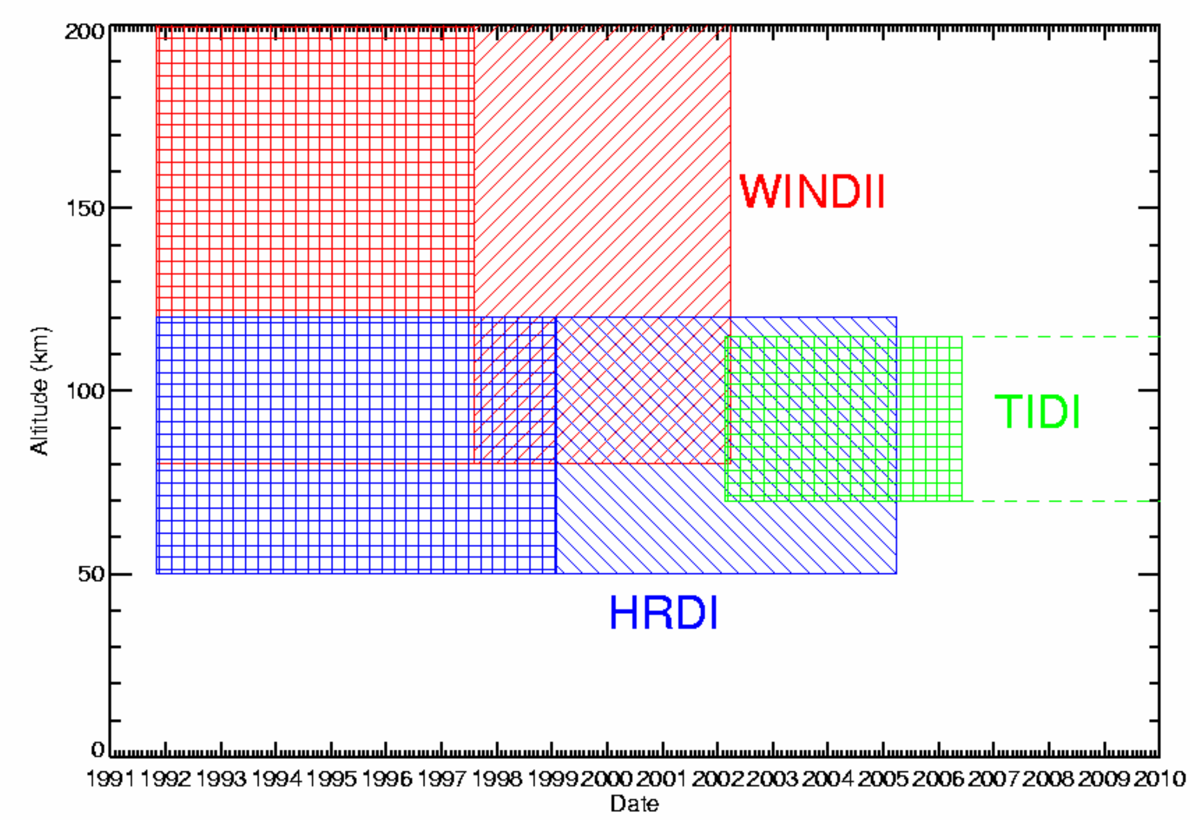
# Talk Outline

- Brief discussion of the data
- Wind Variations since 1991
- Diurnal tide variability

# Wind sensor comparison

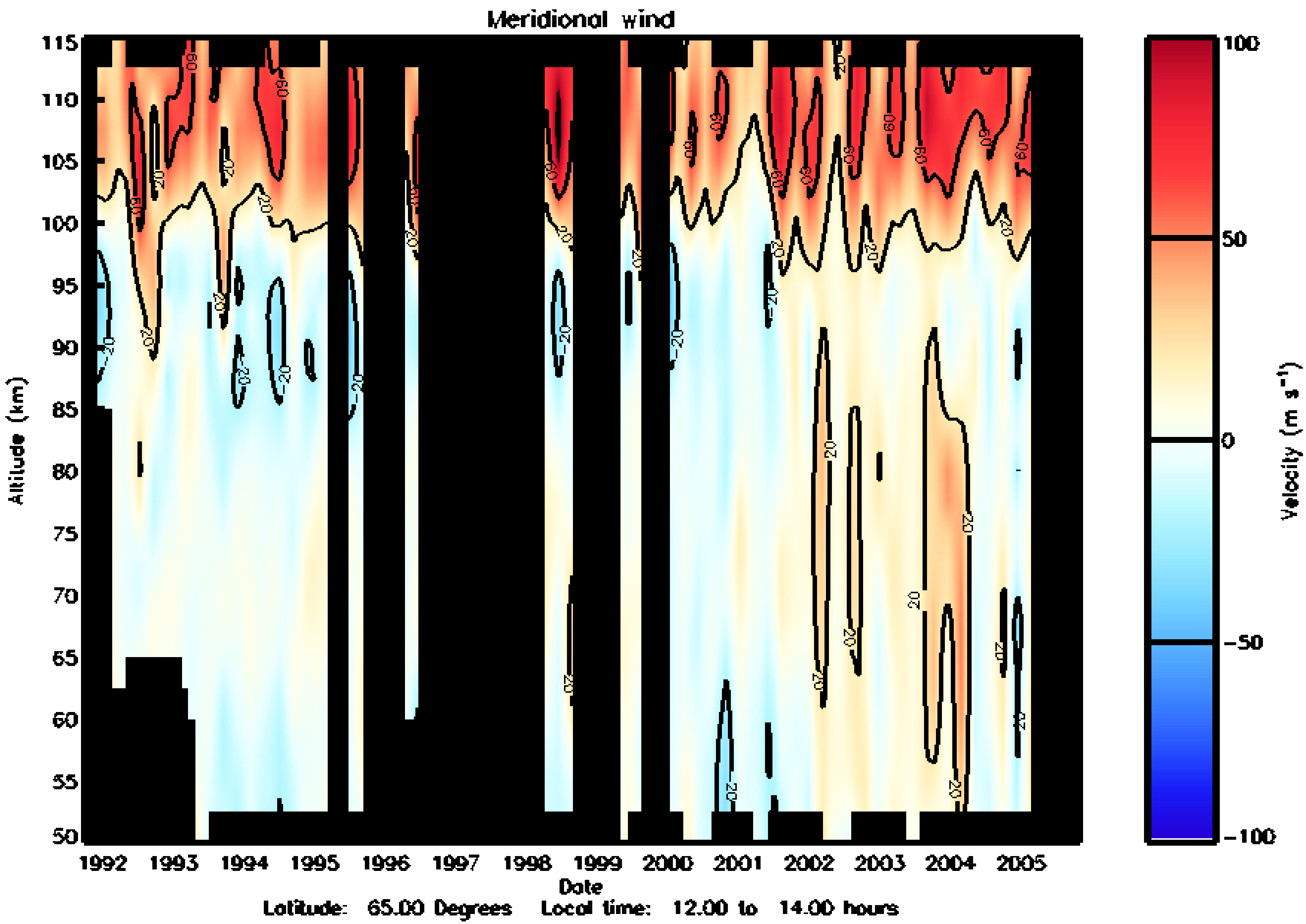
| Feature | TIMED/TIDI | UARS/HRDI | UARS/WINDII |
|---|---|---|---|
| Type of instrument | Single Fabry-Perot interferometer with 4 fixed azimuth telescopes | Triple Fabry-Perot interferometer with 1 fully gimbaled telescope | Field widened Michelson with 2 fixed azimuths (cold side) |
| Primary emissions observed | $O_2$ (0-0) Atmospheric band rotational lines | $O_2$ (0-0) Atmospheric band rotational lines | $O(^1S)$ green line |
| Launch | December, 2001 | September, 1991 | September, 1991 |
| Operational period | February 2002 - present | November 1991 – March 2005 | November 1991 – February 2002 |
| Spacecraft altitude | 625 km | 585 km | 585 km |
| Inclination | 74 degrees | 57 degrees | 57 degrees |
| Precession rate | 3 degrees/day 120 days/360 degrees | 5 degrees/day 72 days/360 degrees | 5 degrees/day 72 days/360 degrees |
| Latitude range observed | ±90 degrees | ±74 degrees | ±74 degrees |

# Space based MLT wind measurement systems

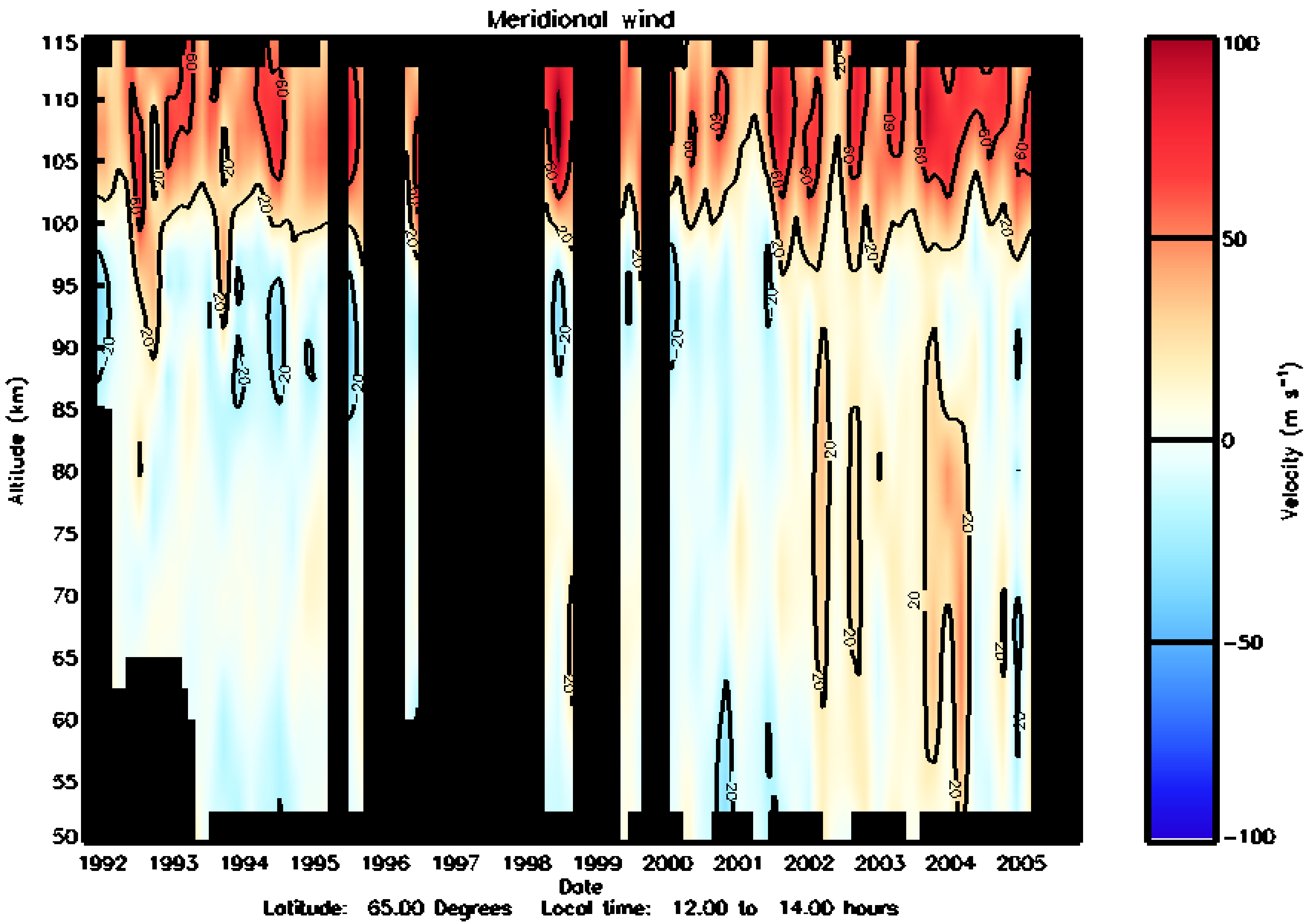


# Data binning

- Data is binned into a four dimensional grid
  - Time. All data in a yaw cycle (36 days for UARS, 60 days for TIMED). This provides complete local time coverage using both ascending and descending nodes.
  - 5 degrees in latitude.
  - 1 hour local time.
  - 2.5 km in altitude.



Meridional wind
Altitude (km)
115
110
105
100
95
90
85
80
75
70
65
60
55
50
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Date
Latitude: 65.00 Degrees Local time: 12.00 to 14.00 hours
Velocity (m s$^{-1}$)
100
50
0
−50
−100



Meridional wind
Altitude (km)
115
110
105
100
95
90
85
80
75
70
65
60
55
50
1992
1993
1994
1995
1996
1997
1998
1999
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Latitude: 65.00 Degrees Local time: 12.00 to 14.00 hours
Velocity (m s$^{-1}$)
100
50
0
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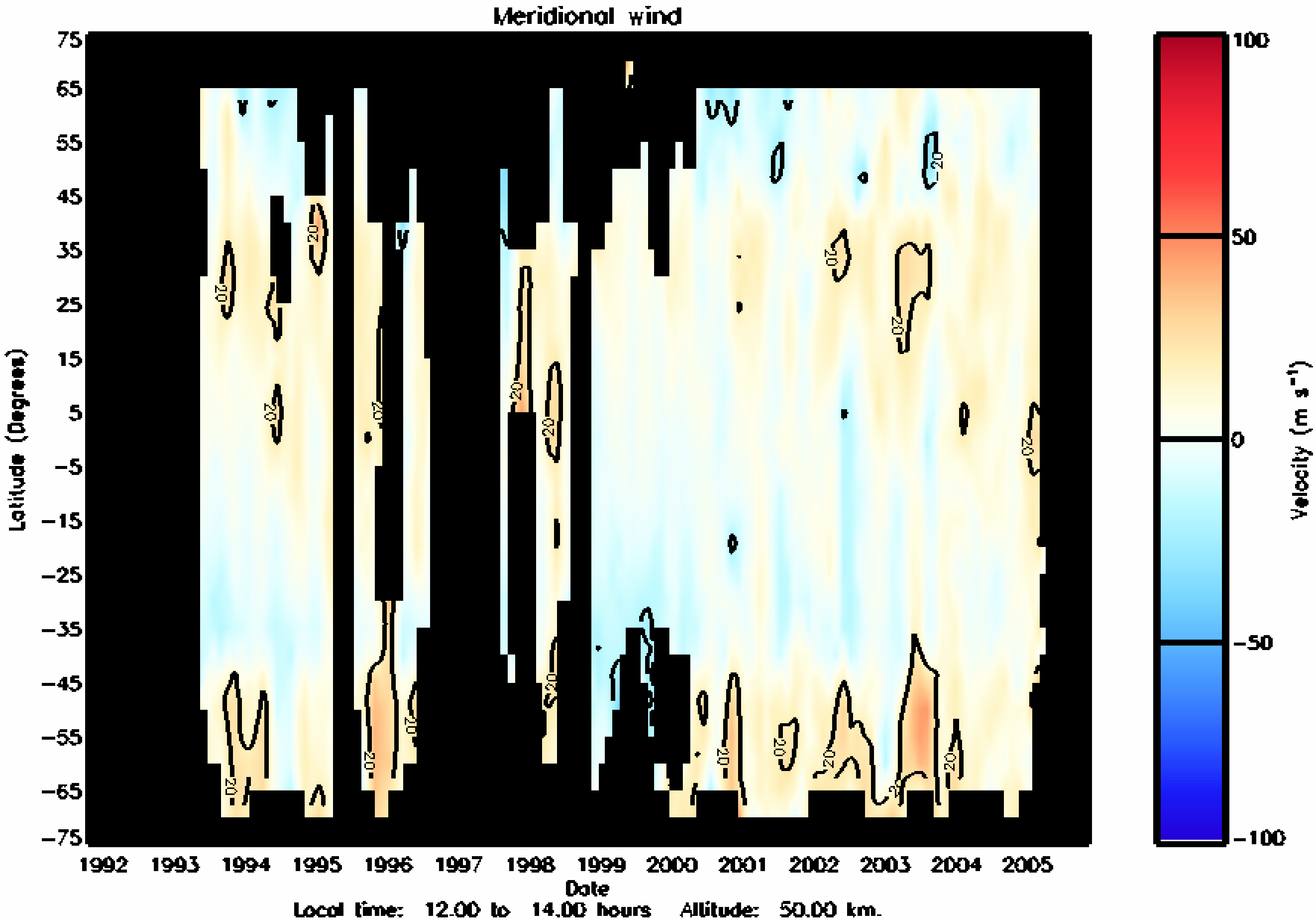
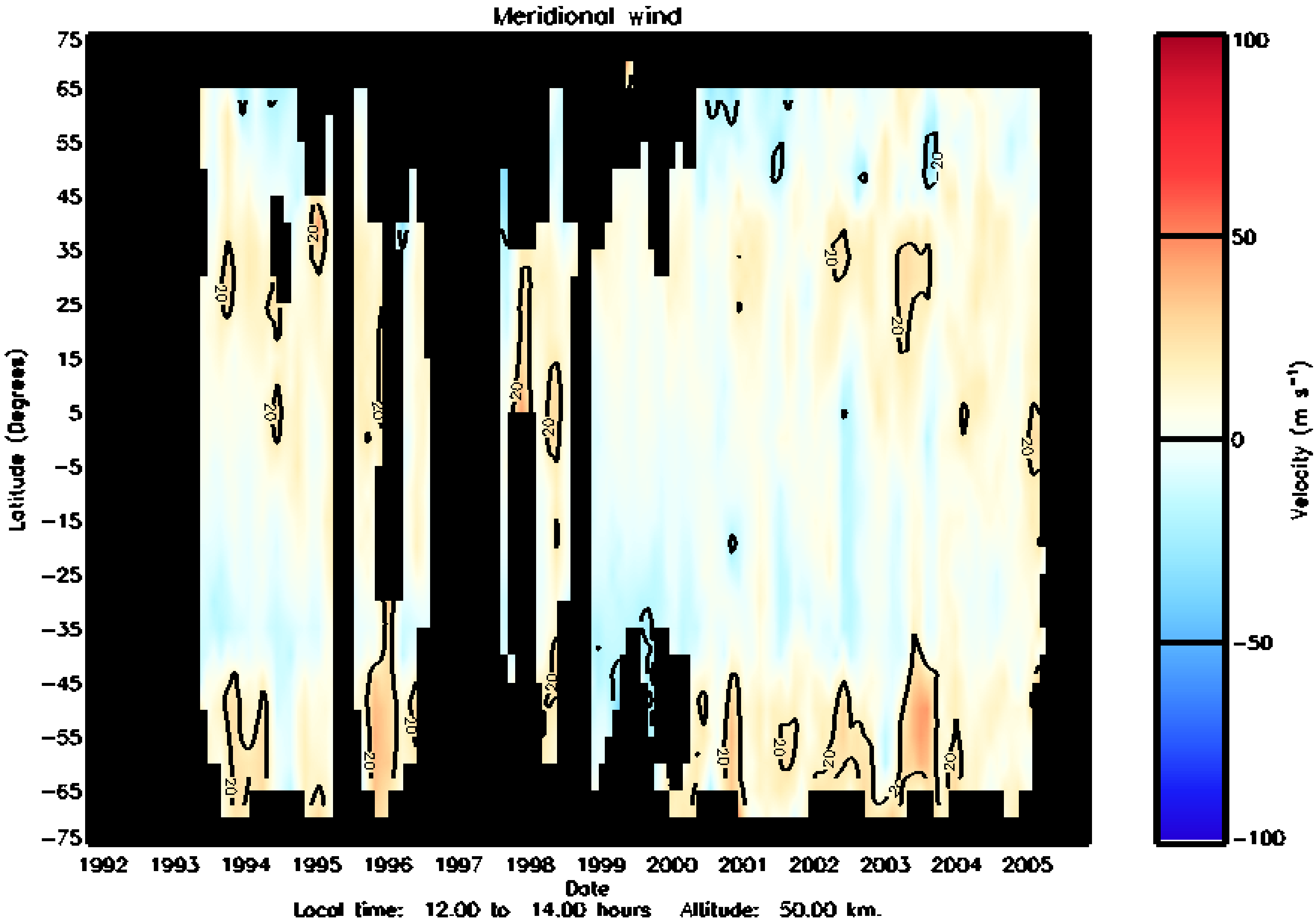
−100



Meridional wind
Latitude (Degrees)
75
65
55
45
35
25
15
5
−5
−15
−25
−35
−45
−55
−65
−75
1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
Date
Local time: 12.00 to 14.00 hours Altitude: 50.00 km.
Velocity (m s$^{-1}$)
100
50
0
−50
−100
20



Meridional wind
Latitude (Degrees)
75
65
55
45
35
25
15
5
-5
-15
-25
-35
-45
-55
-65
-75
1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
Date
Local time: 12.00 to 14.00 hours Altitude: 50.00 km.
Velocity (m s$^{-1}$)
100
50
0
-50
-100

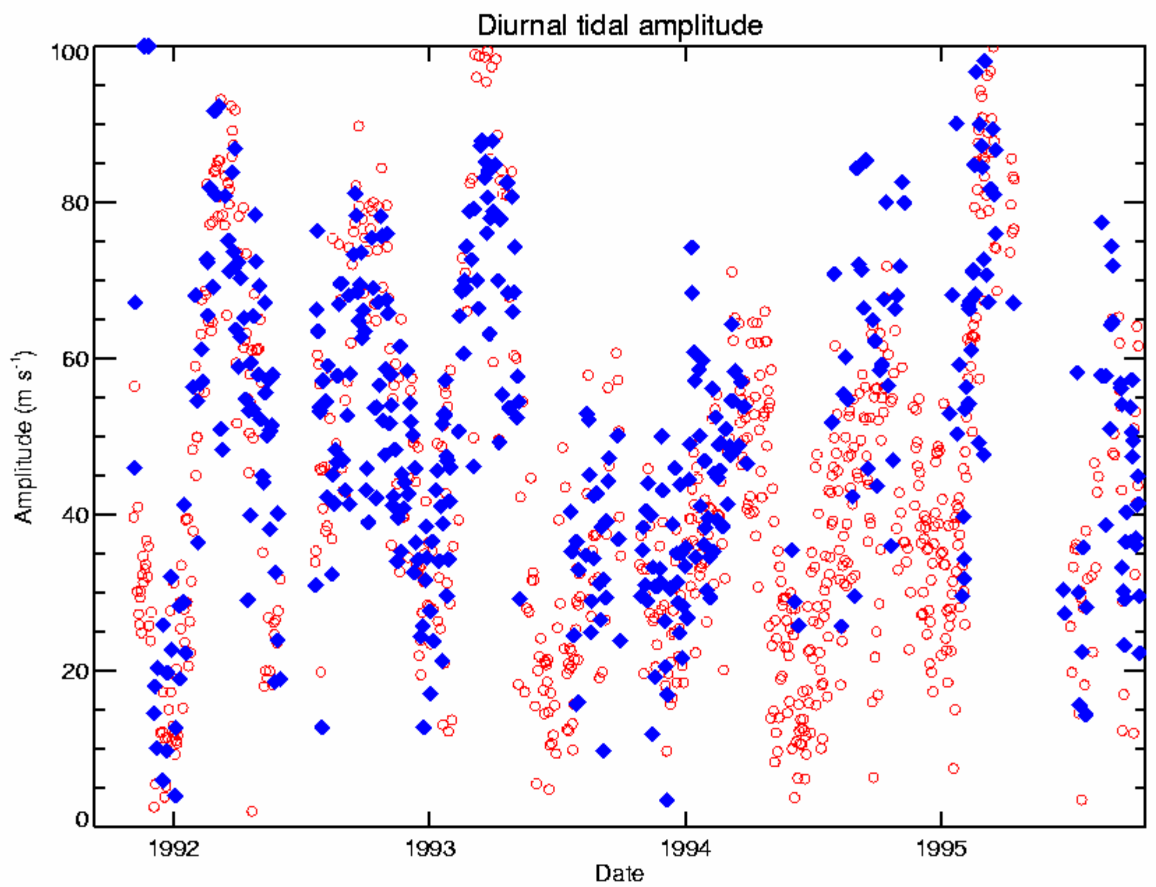
# Daily tide fitting

The daily diurnal tide amplitude is determined by

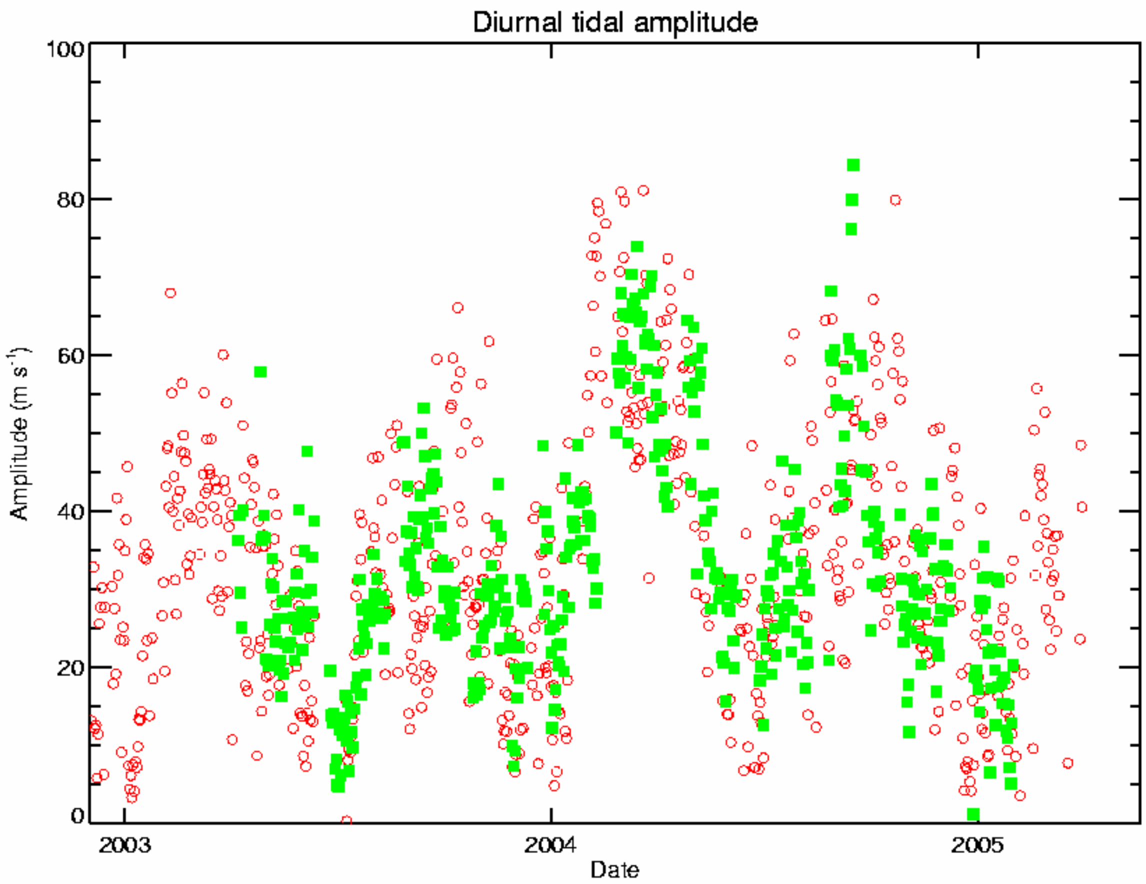
$$A(t, z, \lambda, t_{lt}) = B(t)\xi(z)H(\lambda)\cos\left(2\pi\left[\frac{z - z_{ref}}{z_W} - \frac{t_{lt}}{24}\right]\right)$$

B is the daily amplitude, ξ is the growth function, H is Hough function. B is reported at 20 degrees latitude and 90 km

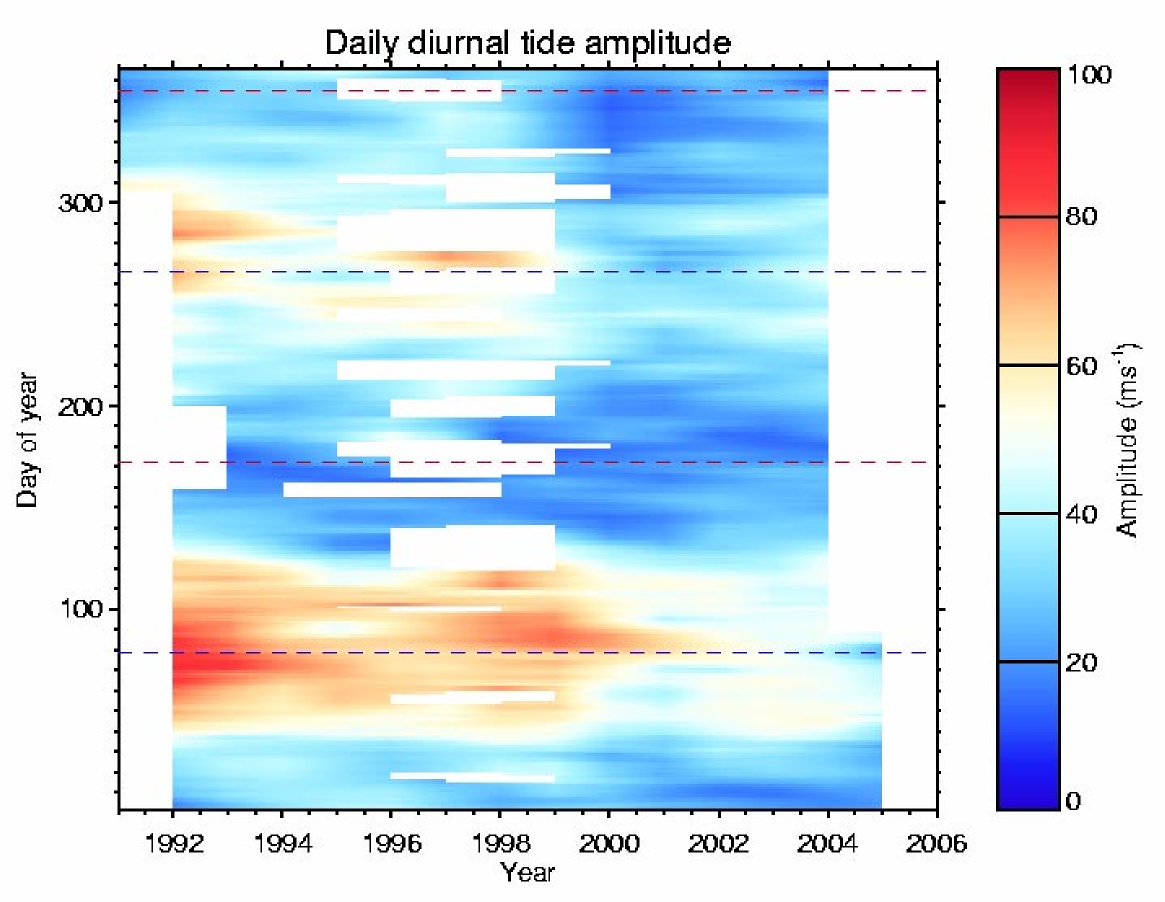
# Daily Diurnal Tide estimate (HRDI = red, WINDII=blue)



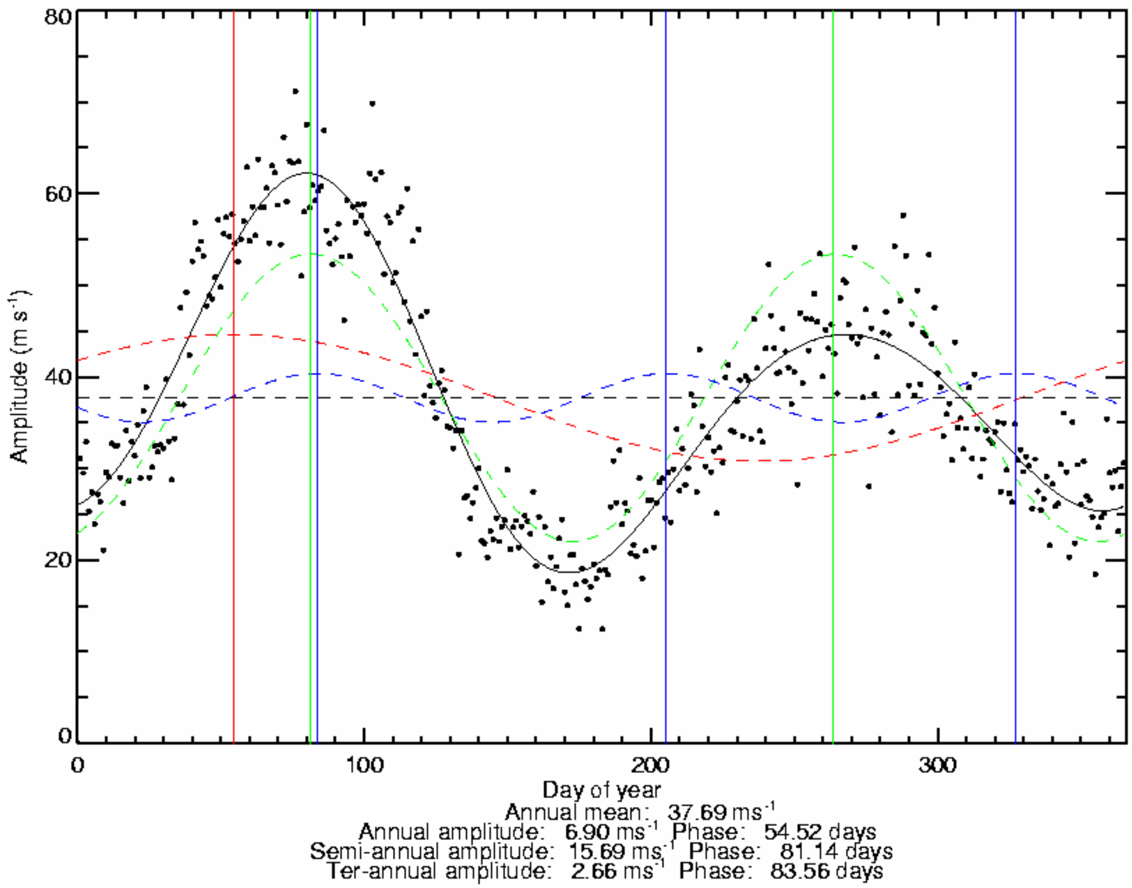
# Daily Diurnal Tide Estimate (HRDI=red, TIDI=green)



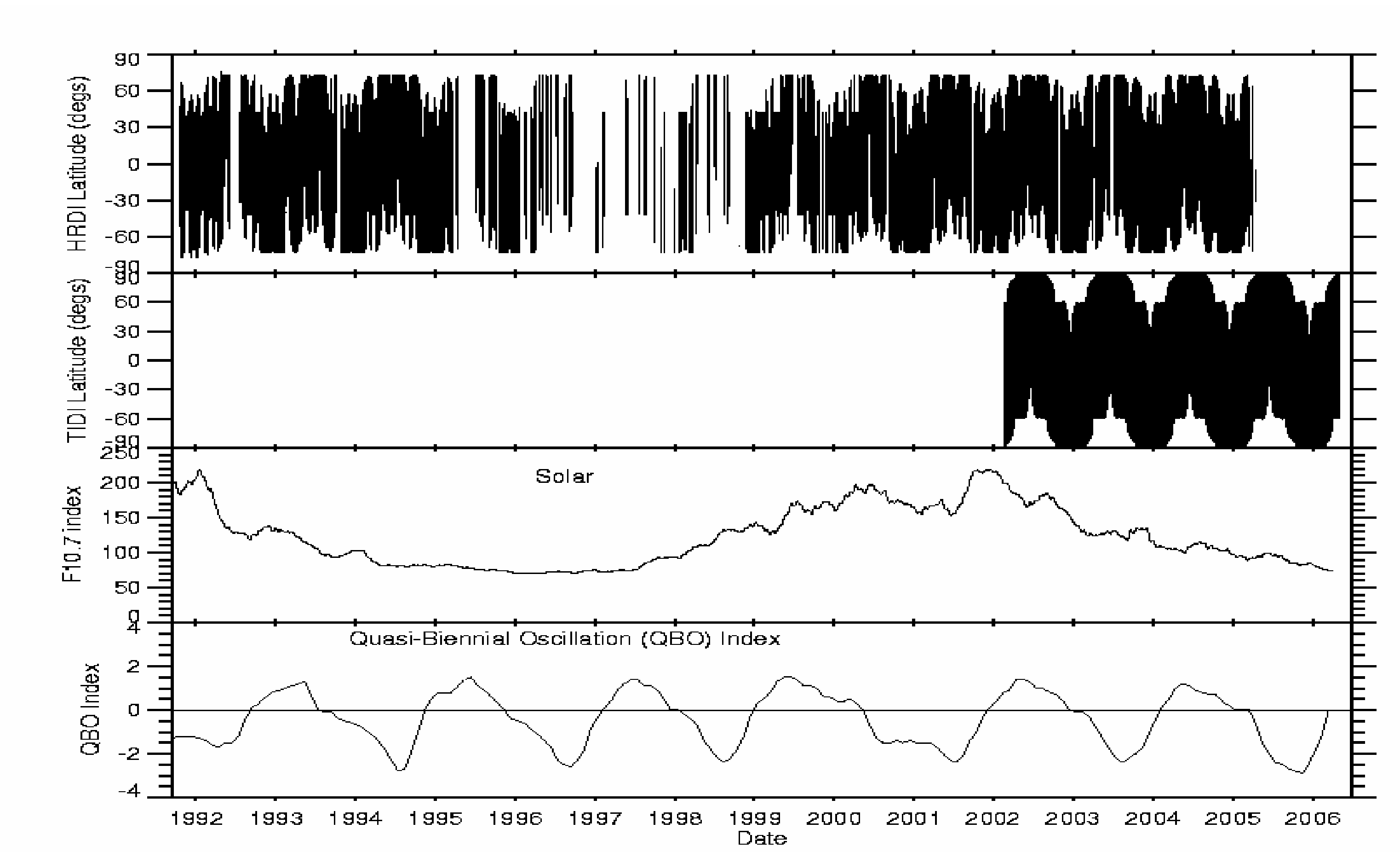
# Tidal amplitudes as day of year



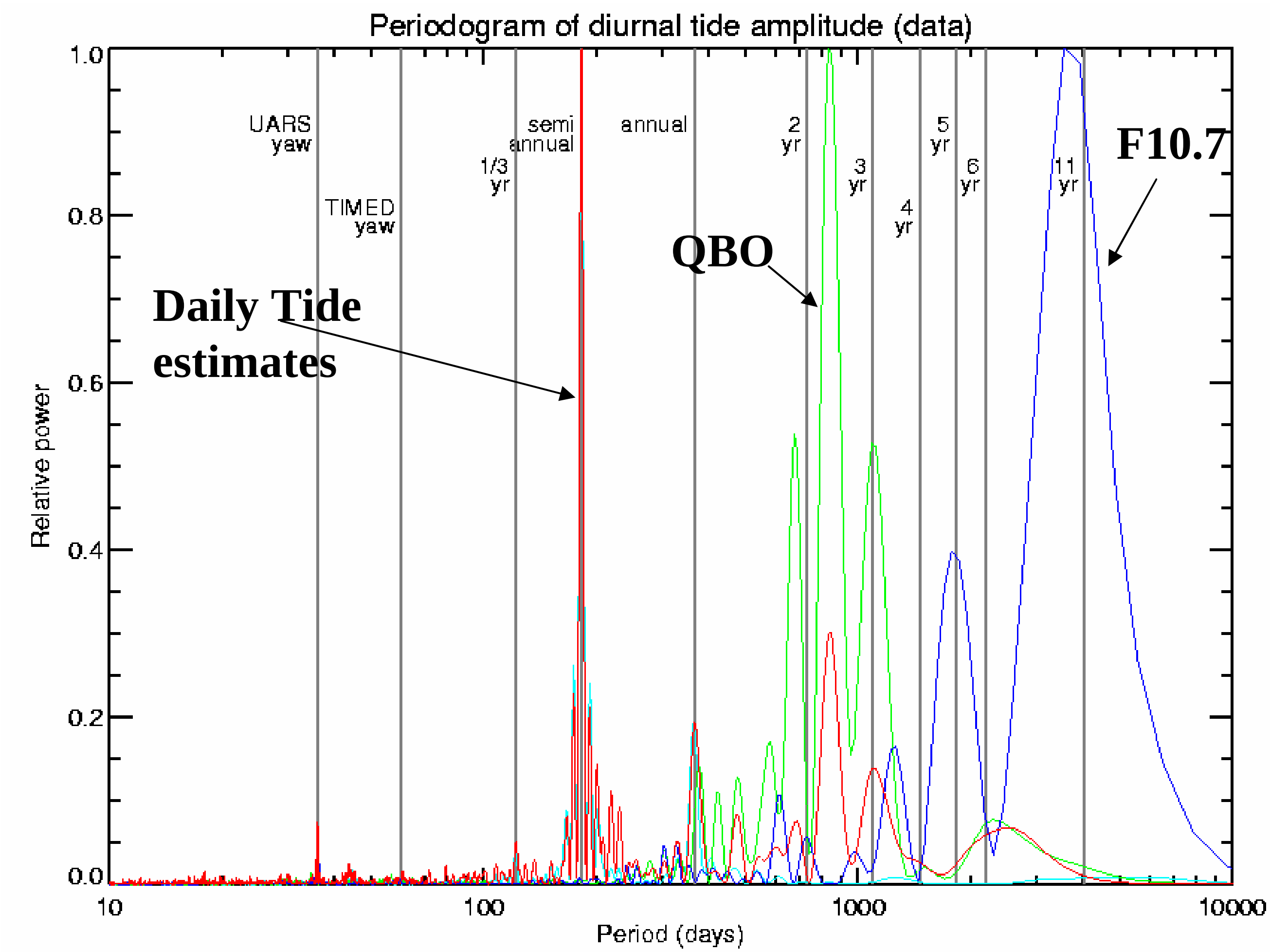
# Mean diurnal tide as function of day of year



# TIDI and HRDI daytime MLT latitude coverage



# Periodogram of tidal estimates, QBO, and F10.7



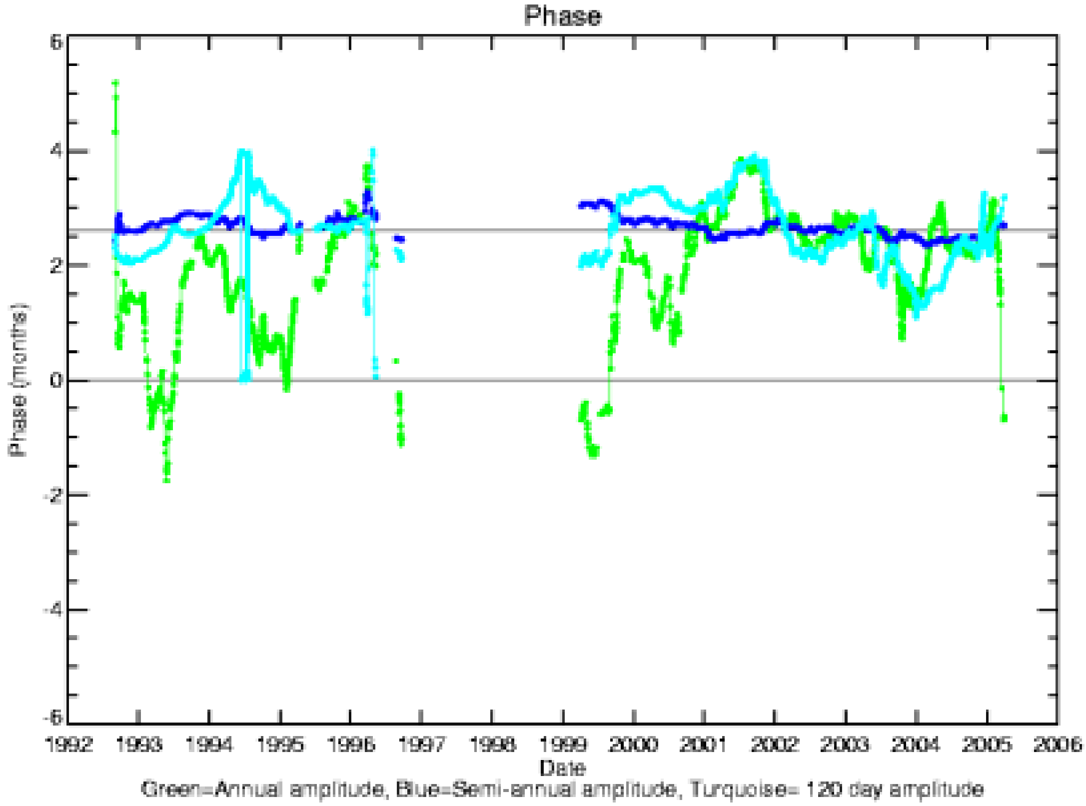
# Fit to tidal amplitude

- One year of data is fit to:

$$A(t;t_0) = a_0(t_0) + \sum_{n=1}^{3} a_n(t_0)\cos\left(\frac{2\pi nt}{365.25} - \phi_n(t_0)\right) + b(t_0)t$$

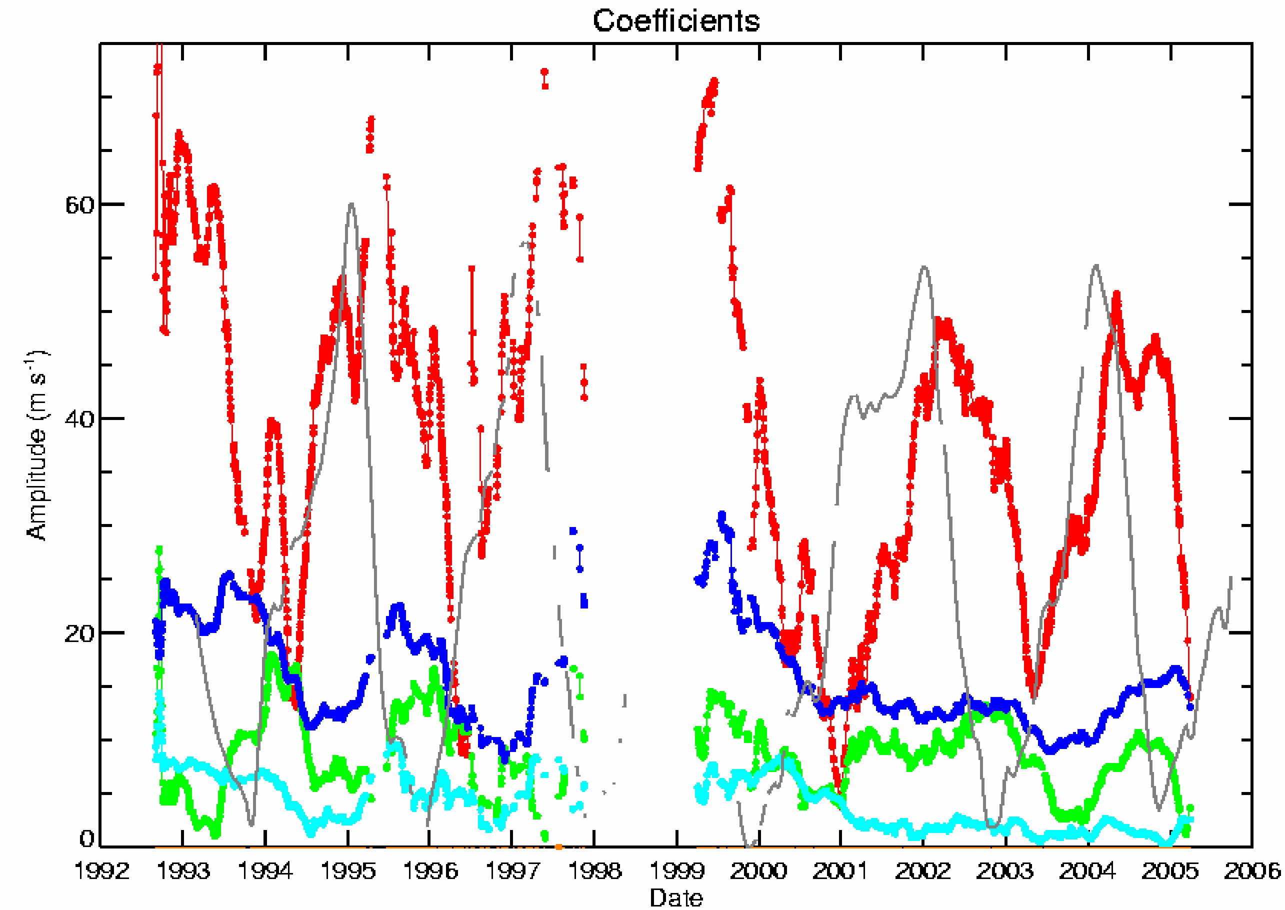
i.e. annual, semi-annual and ter-annual terms plus a yearly trend. The data to be fit runs from $t_0$-365 to $t_0$, and coefficients are generated for every day

# Fit phases



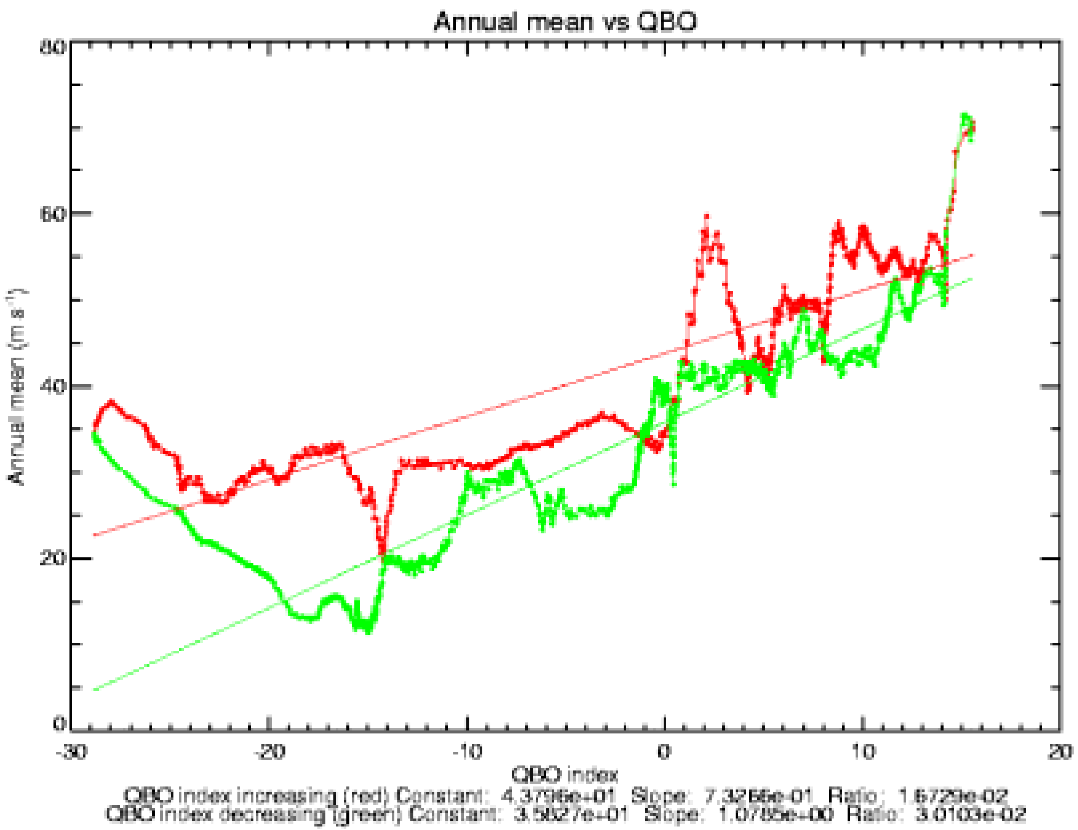
Phase
6
4
2
0
-2
-4
-6
Phase (months)
1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006
Date
Green=Annual amplitude, Blue=Semi-annual amplitude, Turquoise= 120 day amplitude

# Coefficients to yearly fit




Red=Annual mean, Green=Annual amplitude, Blue=Semi-annual amplitude, Cyan=120 day amplitude

# Fit of annual mean to QBO



# Summary

- Space-based MLT winds have now been measured for almost 15 years. This is long enough to start to look at effects of multi-year phenomena (e.g. QBO), but still short for solar cycle and long term trends
- Diurnal tide estimates from the three instruments (UARS/HRDI, UARS/WINDII, and TIMED/TIDI) show good agreement
- The amplitude of the diurnal tide shows a significant QBO effect and no indication of a solar cycle influence