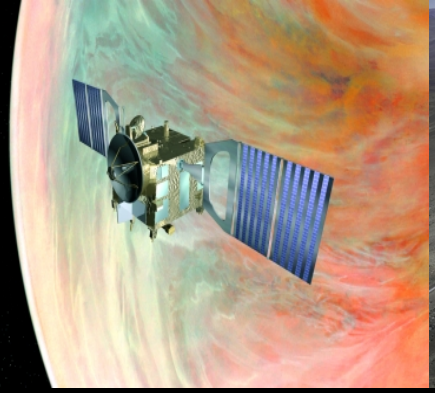


Cloud tracked winds at the lower cloud level using Venus' night side observations at 2.28 µm with TNG/NICS

Pedro Machado (2), T. Widemann (1), J. Peralta (3), J. Oliveira (2), D. Luz (2)

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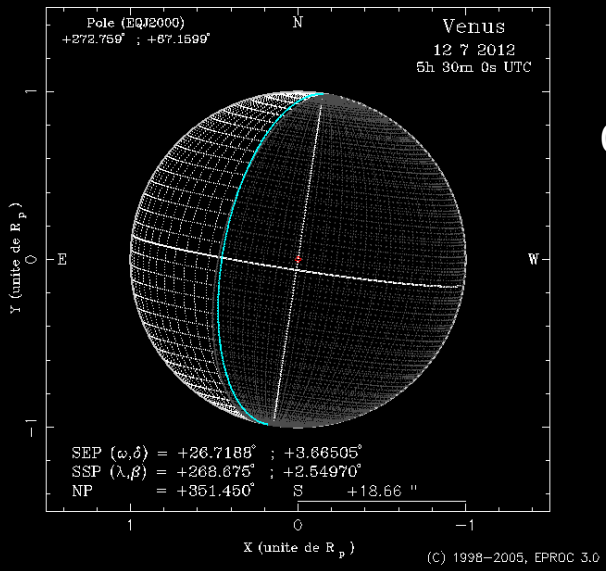
2 – IA- Instituto de Astrofísica e Ciências do Espaço, Lisboa, Portugal

3 – Institute of Space and Astronautical Science - Japan Aerospace Exploration Agency (JAXA), JAPAN

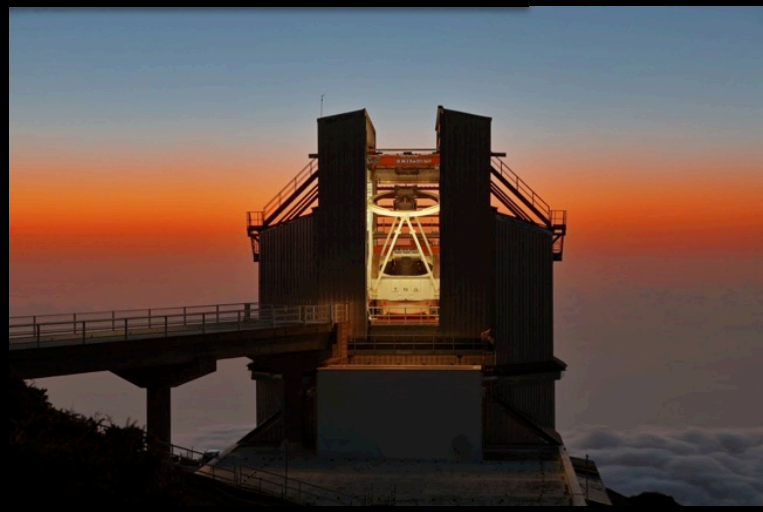
Instituto de Astrofísica e Ciências do Espaço



TNG -telescope

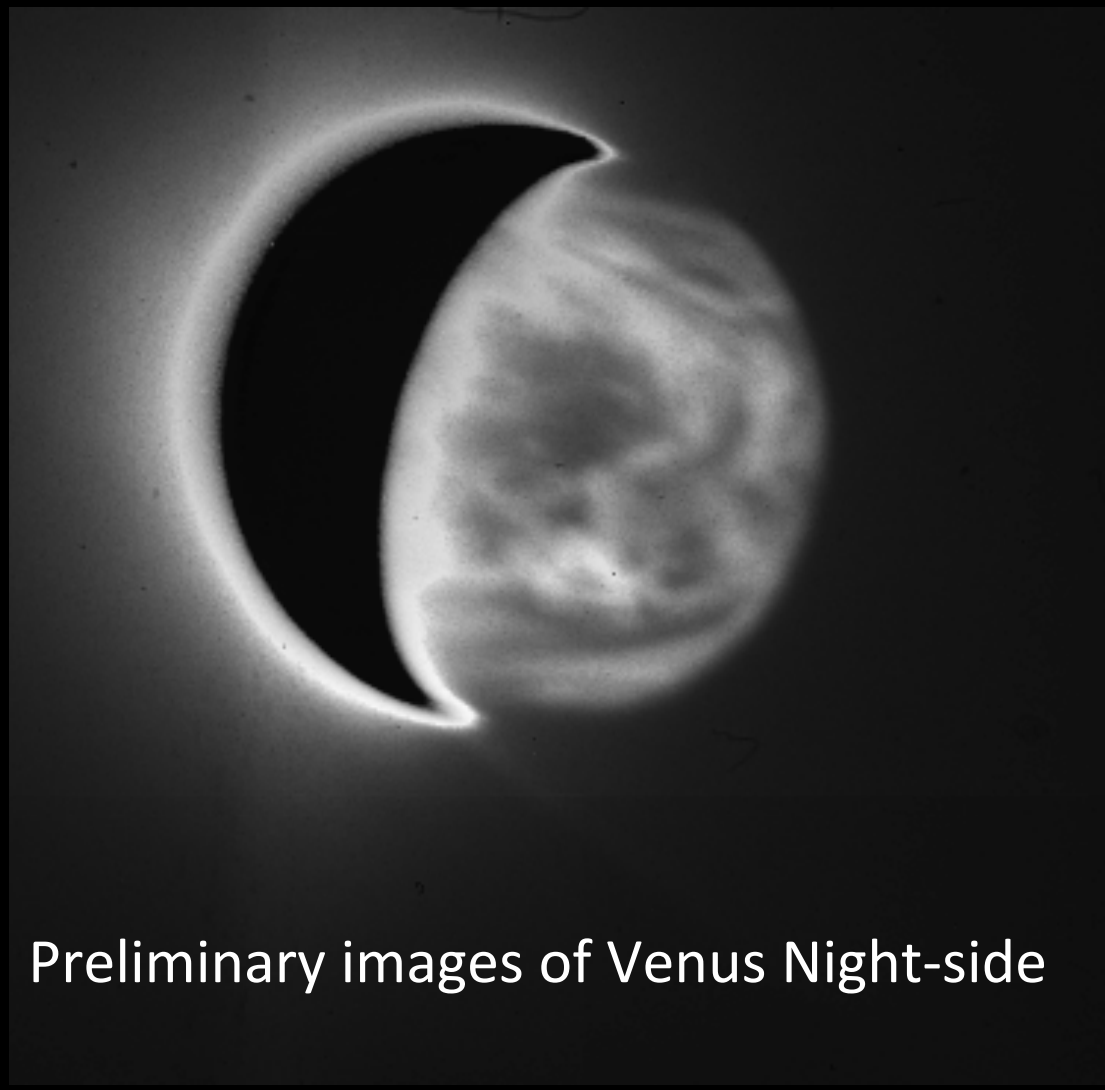
Observations at 2.28 μ (night side)

Current work

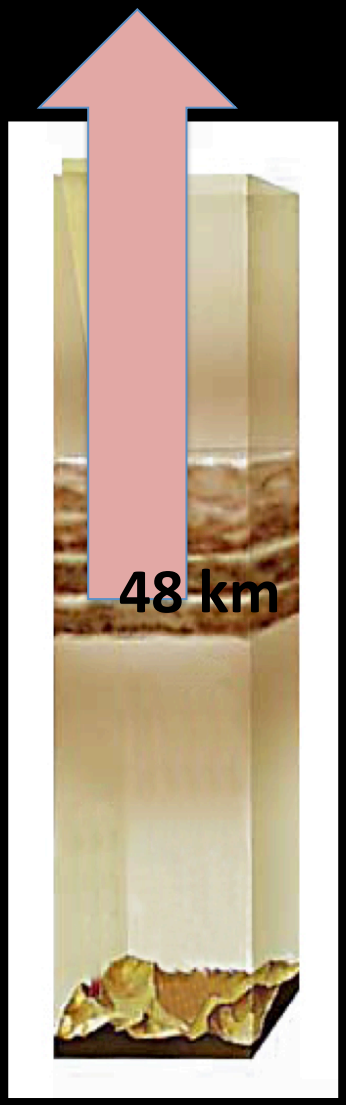


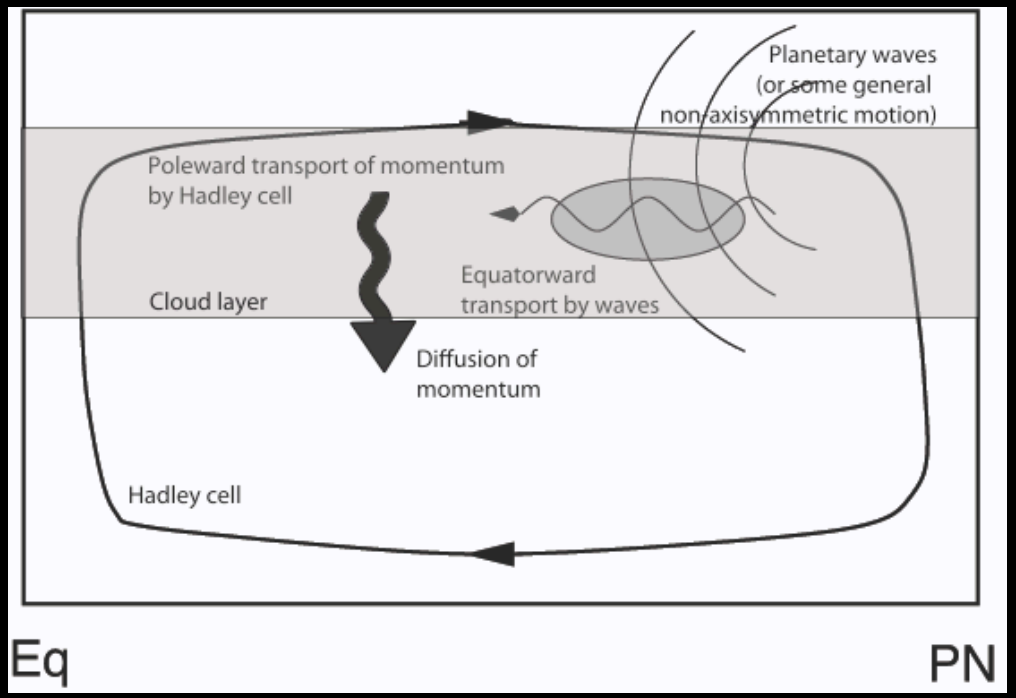
```
#
#           CONFIGURATIONS PHYSIQUES DES PLANETES & DES SATELLITES NATURELS
#
#
# > Corps : Venus
# > Rayon equatorial : +6051.80 km
# > Rayons des axes (a >= b >= c) : +6051.80 x +6051.80 x +6051.80 km
# > Coordonnees equatoriales du pole (J2000) : RA0 = 272.760 deg. ; De0 =  67.160 deg.
# > Angle de rotation absolue a l'epoque de ref. : W =  160.200 deg. ; sWp = -1.
#
#
#       Date UTC             SEP          SSP       NP   d pole    Mv   Phase    R.App       Dg          Dh      PAQ     Q       R.A.          Dec.
#                         Long    Lat.  Long    Lat.
#            h  m   s      o       o     o       o       o       "             o       "         ua          ua       o      "       h  m   s      d   '   "

10  7  2012  6 30  0.0  22.95    3.62 262.68   2.51 351.12  19.22  -4.48 119.992 19.258524 0.433273E+00 0.728231E+00  256.12  28.885    4 36 45.670 +17 26 39.53
11  7  2012  6 30  0.0  24.86    3.64 265.74   2.53 351.28  18.92  -4.48 118.845 18.954572 0.440221E+00 0.728233E+00  256.37  28.099    4 38 33.993 +17 29  9.32
12  7  2012  6 30  0.0  26.80    3.67 268.80   2.55 351.46  18.62  -4.48 117.725 18.657065 0.447240E+00 0.728233E+00  256.64  27.337    4 40 28.703 +17 32  4.35

#
# > Repere geocentrique
# > Theorie planetaire INPOP10
# > Ephemeride astrometrique J2000
# > Format des donnees : (I2,1x,I2,1x,I5,1x,I2,1x,I2,1x,F4.1,1x,F6.2,1x,F6.2,1x,F6.2,1x,F6.2,
# >                       1x,F6.2,1x,F6.2,1x,F6.2,1x,F7.3,1x,F9.6,1x,E12.6,1x,E12.6,2x,F6.2,
# >                       1x,F7.3,2x,I3,1x,I2,1x,F6.3,1x,A1,I2.2,1x,I2,1x,F5.2)
#
# (C) 1998-2005, EPROC 3.0
```

Cloud tracking in the near infrared (NIR).
The observational window in the night side of the continuum K to 2.28 microns allows monitoring of wind conditions in the lowest layer of clouds (60 km).
Ground-based observations are complementary to orbiter measurements,
allowing direct, determination of the winds.



Preliminary images of Venus Night-side

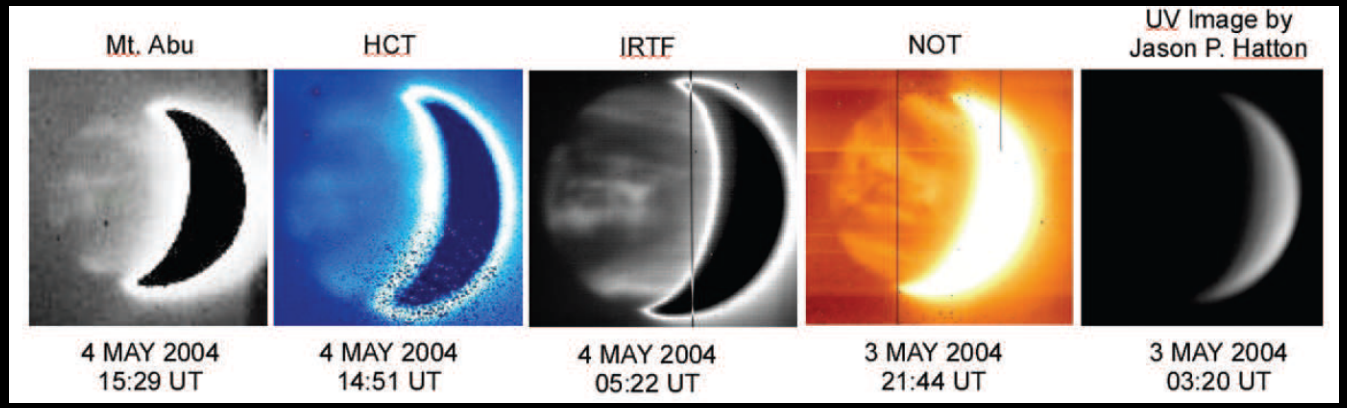




Left:
Gierasch-Rossow mechanism for maintaining superrotation

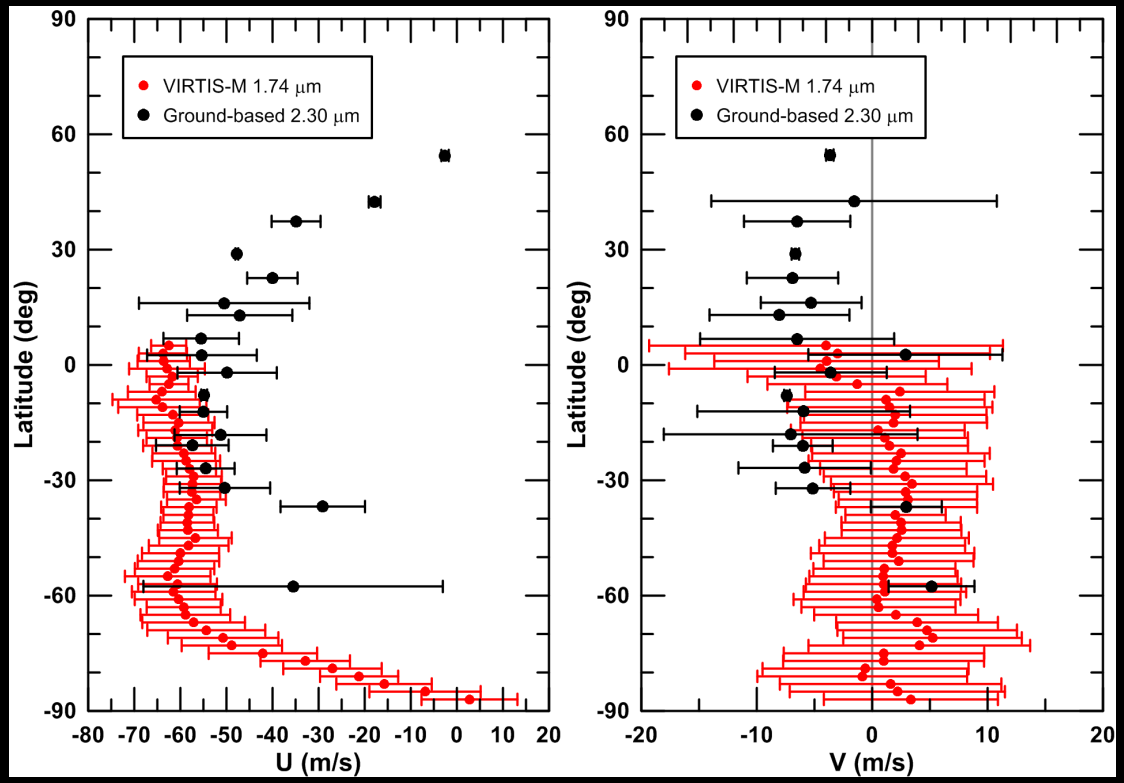
The lower venusian atmosphere is a strong source of thermal radiation, with the gaseaous CO2 component allowing radiation to escape in windows at 1.74 and 2.28 μ. At these wavelengths radiation originates below 35 km, and unit opacity is reached at the lower cloud level, close to 48 km. Therefore, in these windows it is possible to observe the horizontal cloud structure, with thicker clouds seen silhouetted against the bright thermal background from the low atmosphere.

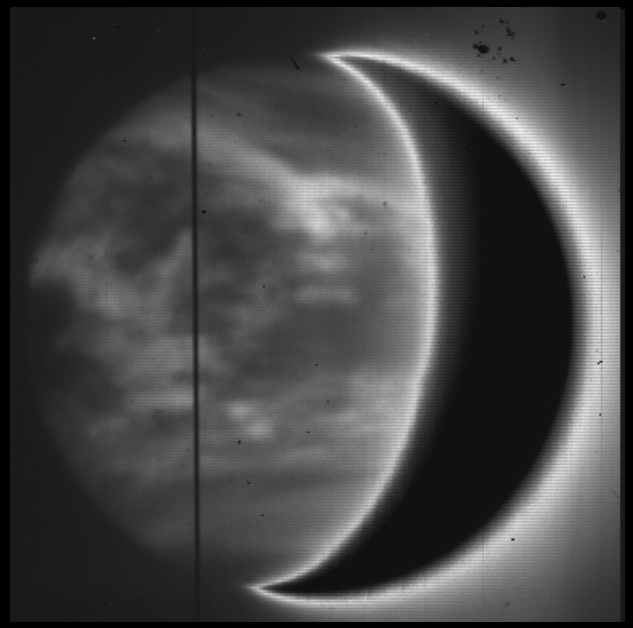
Ground-based observations: cloud tracking results



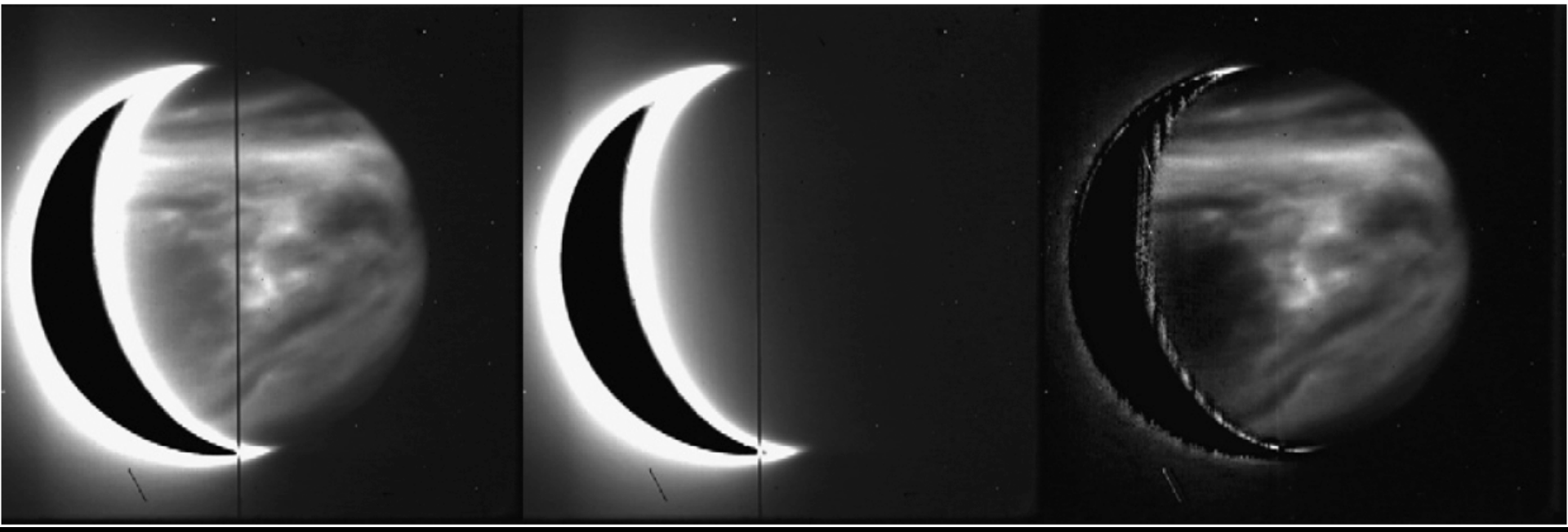
COMPARISON:

- 2.30 μm images (Limaye 2006)
- 1.74 μm images (Hueso 2012)



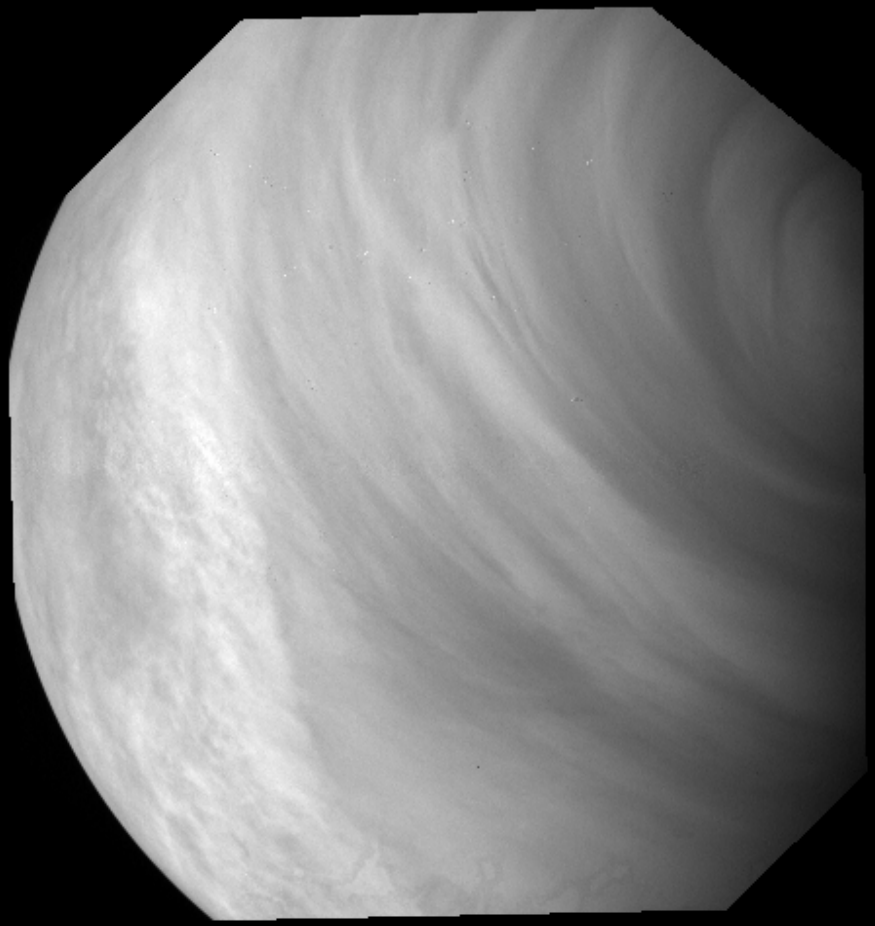


Kcont filter | Bracket ϒ filter | Image subtraction



(Tavenner et al., 2009):

Coordinated Space-based and Ground-based observations



Venus Express orbits:

- 2272
- 2273
- 2274
- 2275

TNG – observations

- 11 July 2012
- 12 July 2012
- 13 July 2012

Image pairs of VIRTIS – M observations with cloud features tracers

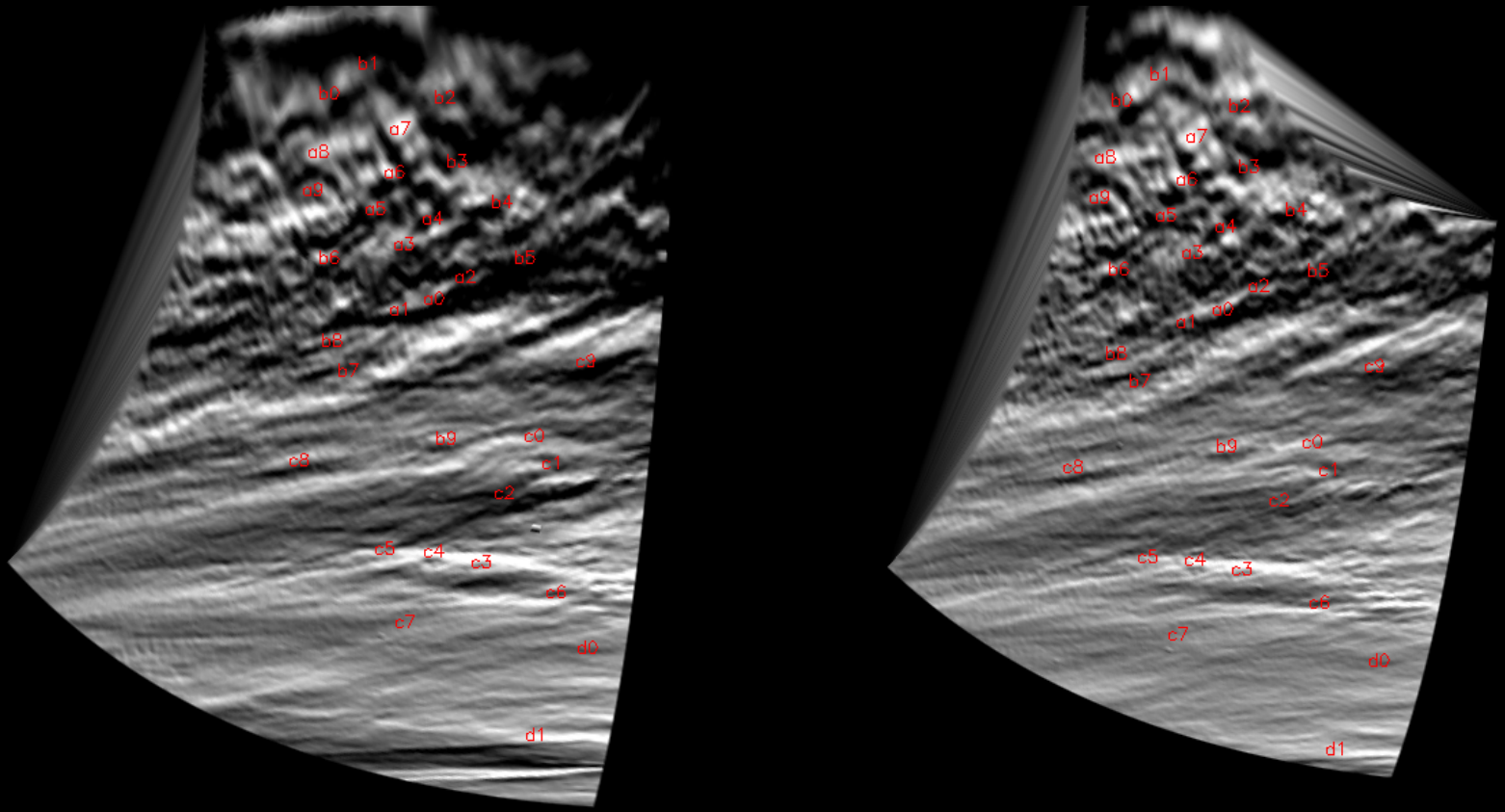
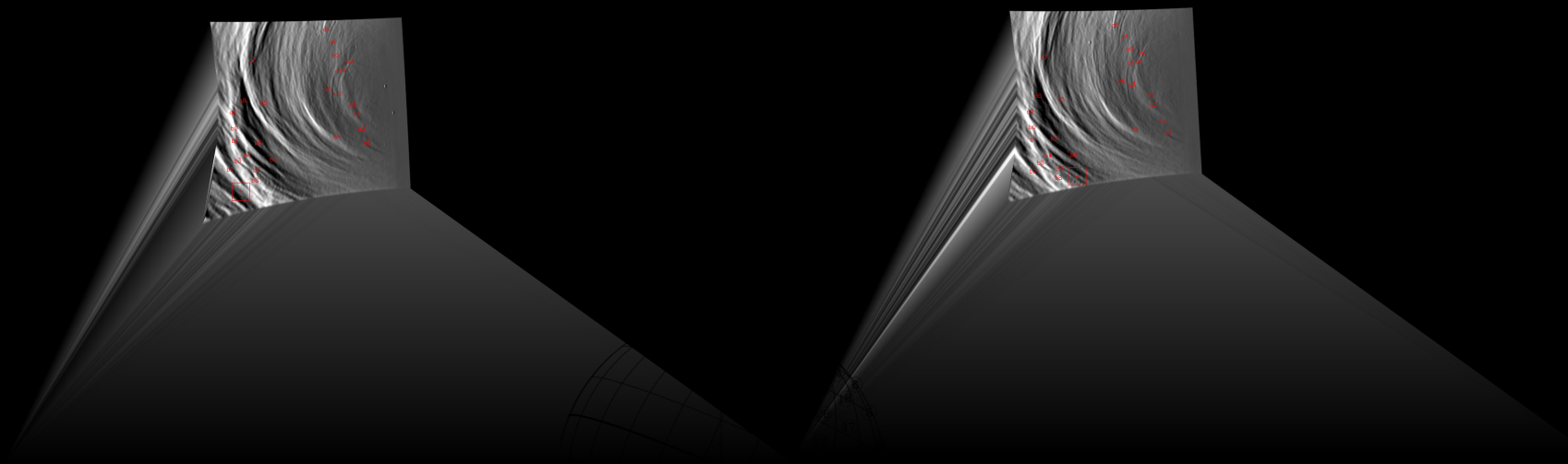
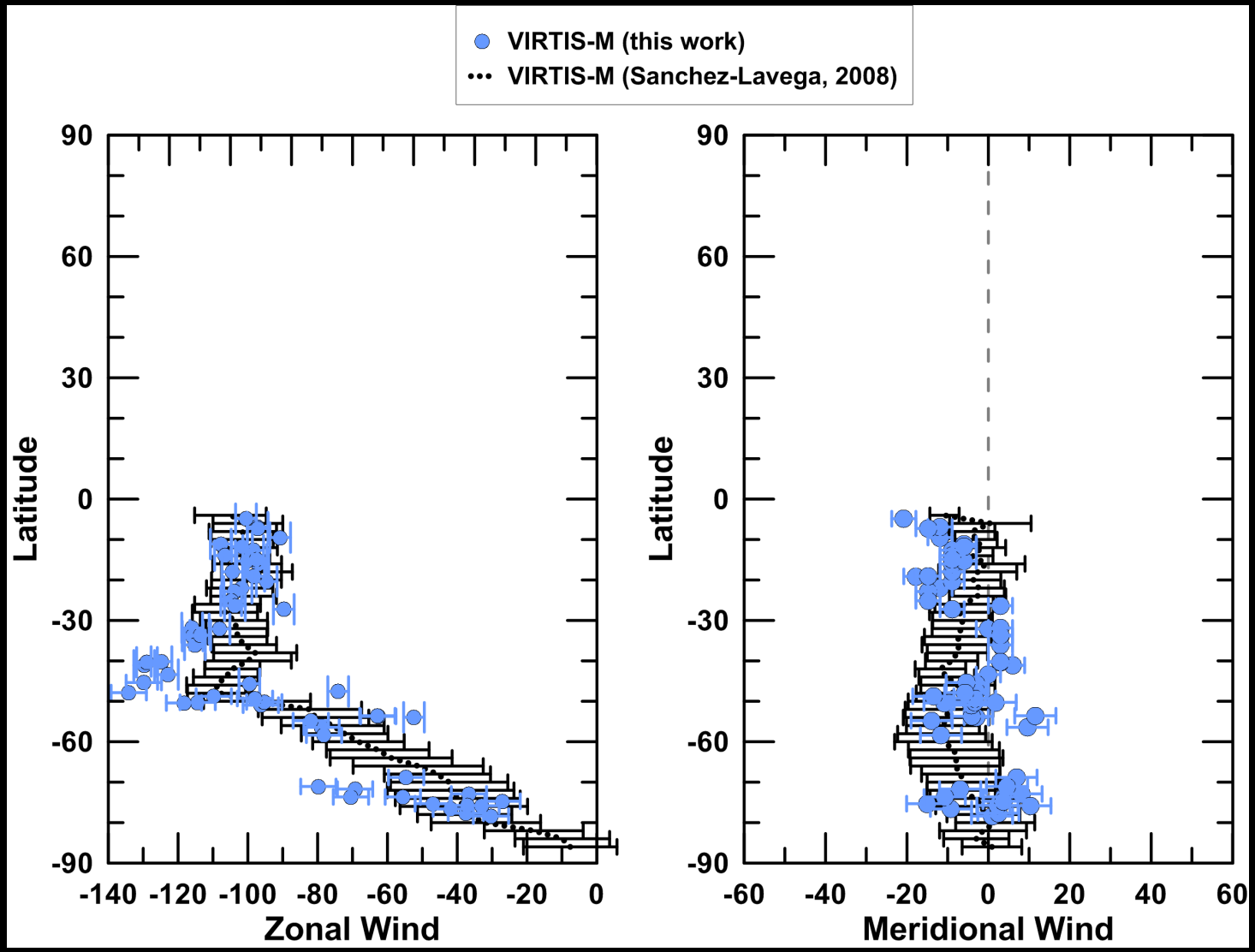
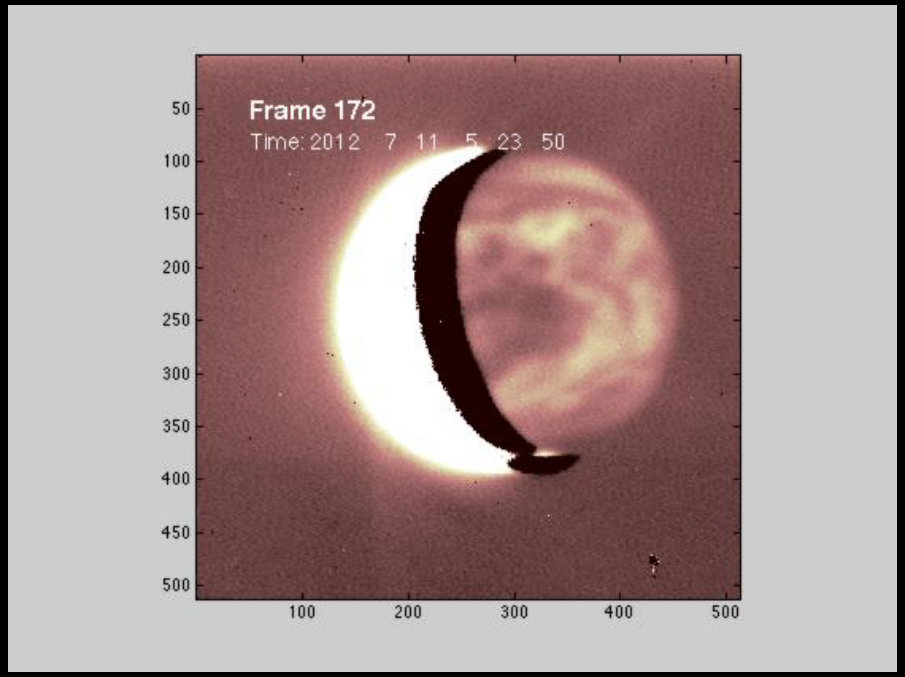


Image pairs of VIRTIS – M observations with cloud features tracers




VIRTIS-M (this work)
VIRTIS-M (Sanchez-Lavega, 2008)
Latitude
90
60
30
0
-30
-60
-90
-140 -120 -100 -80 -60 -40 -20 0
Zonal Wind
Latitude
-60 -40 -20 0 20 40 60
Meridional Wind

Ground-based observations (TNG): Preliminary Venus' images



Kcont filter

Bracket ϒ filter

Image subtraction

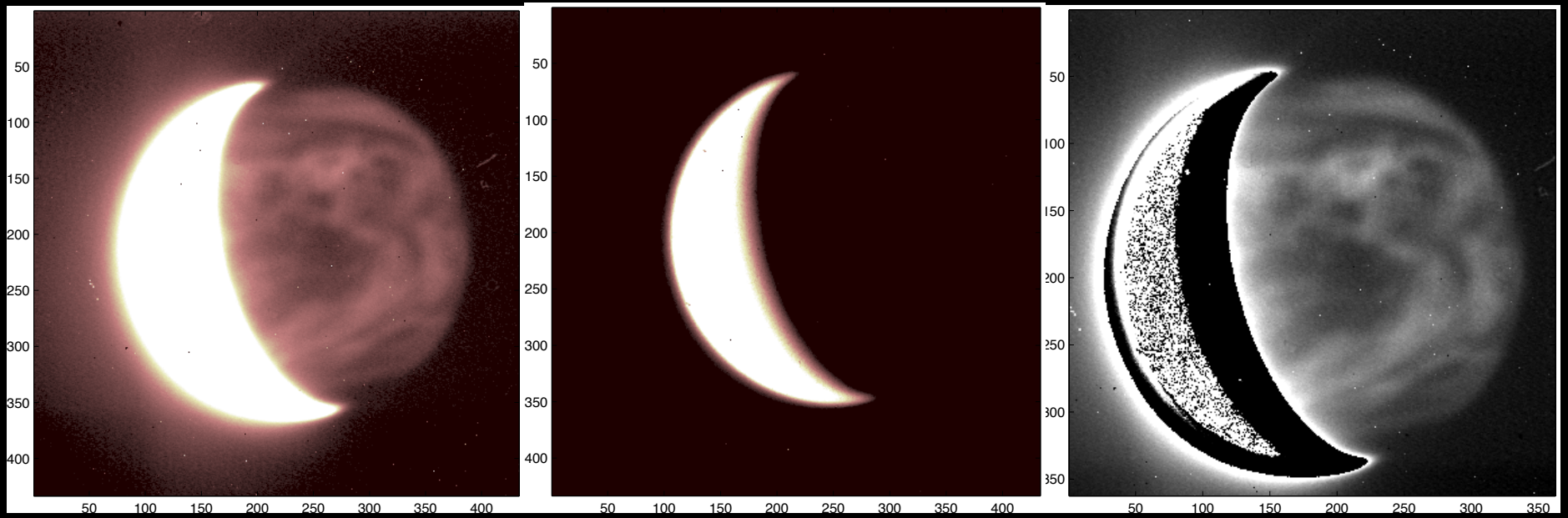
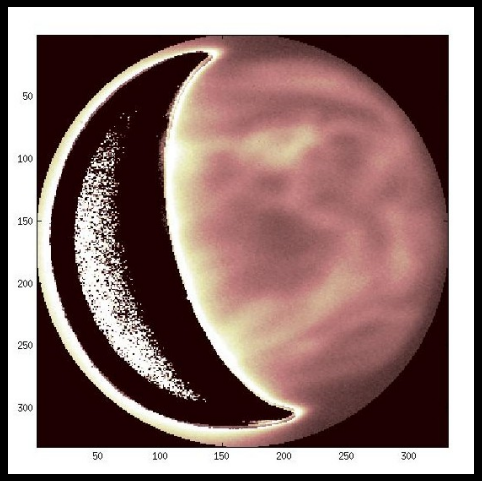
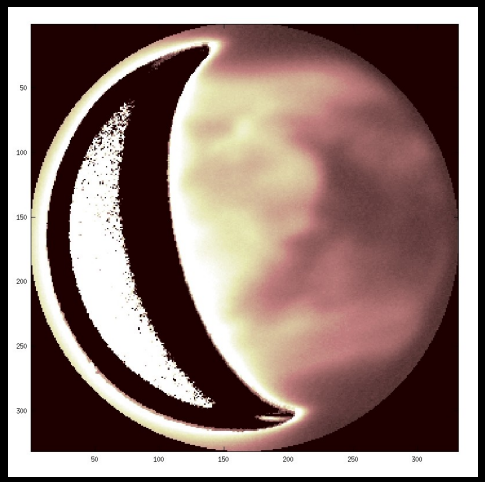


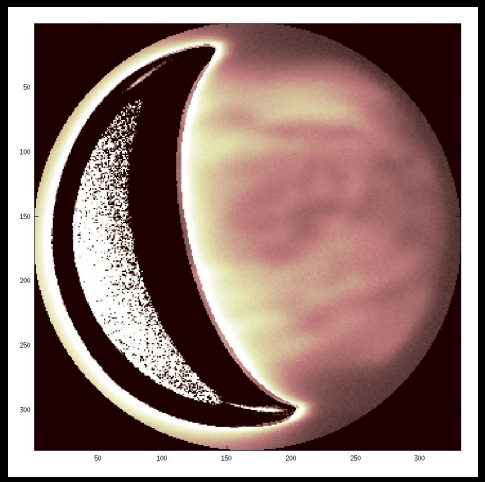
Image processing with similar strategy than Young et al. 2008 and Tavenner et al. 2009



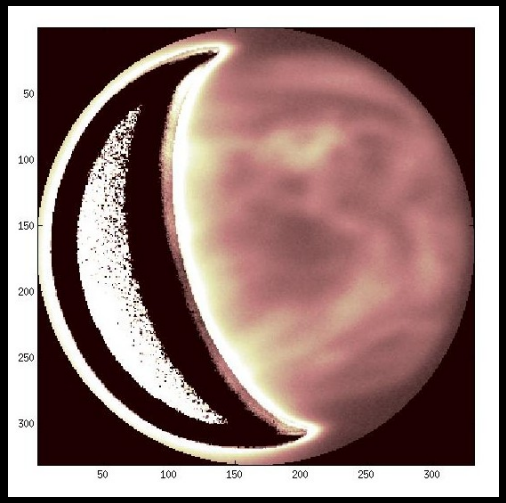
A



A



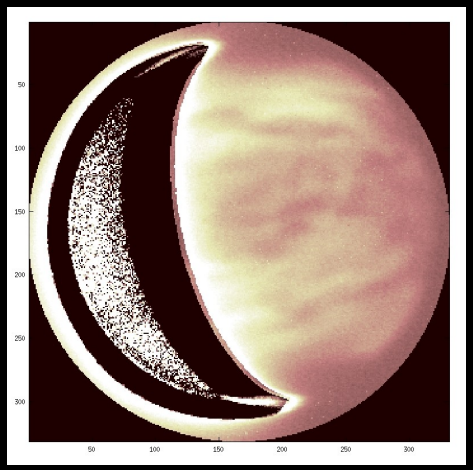
A



B

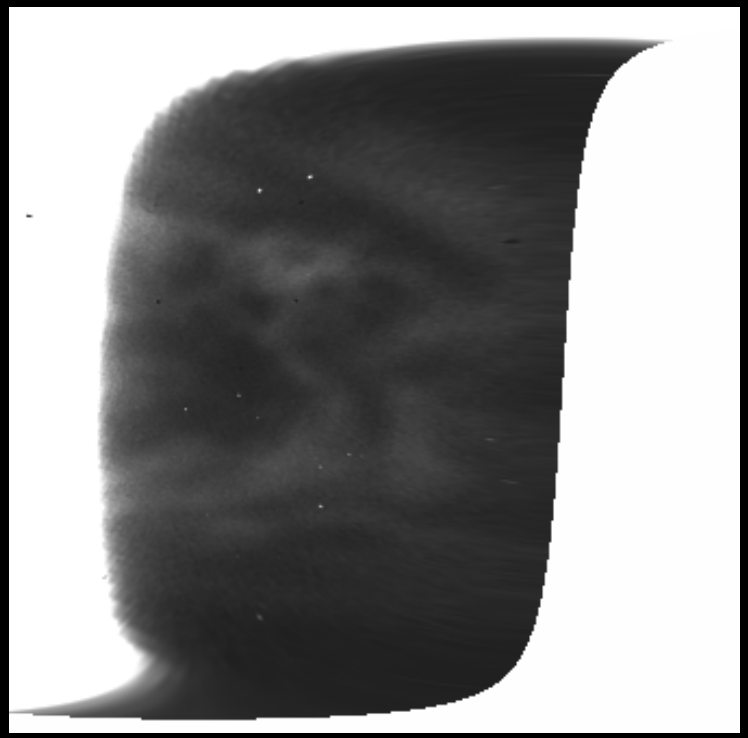
11 July 2012

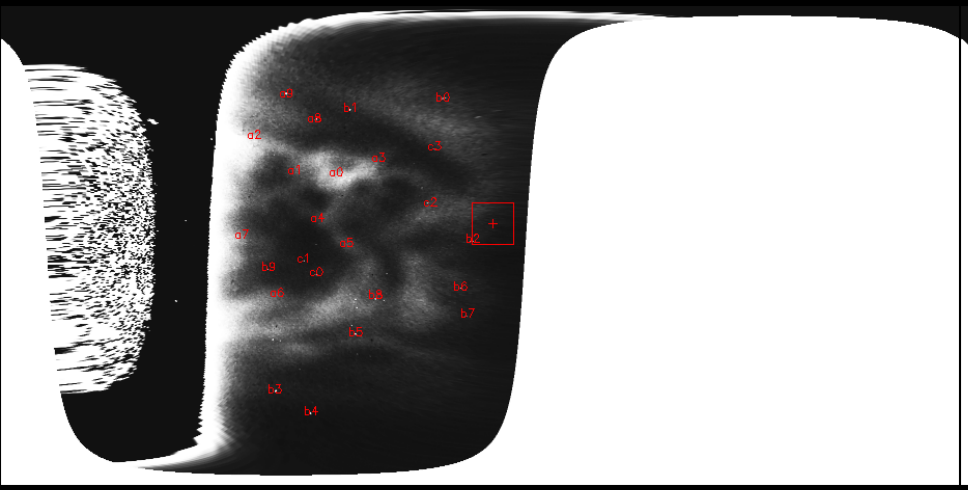
B

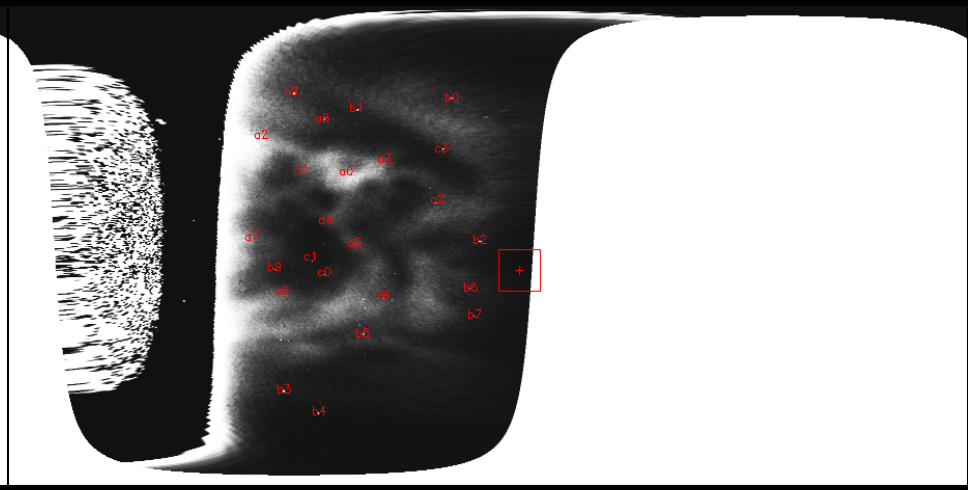


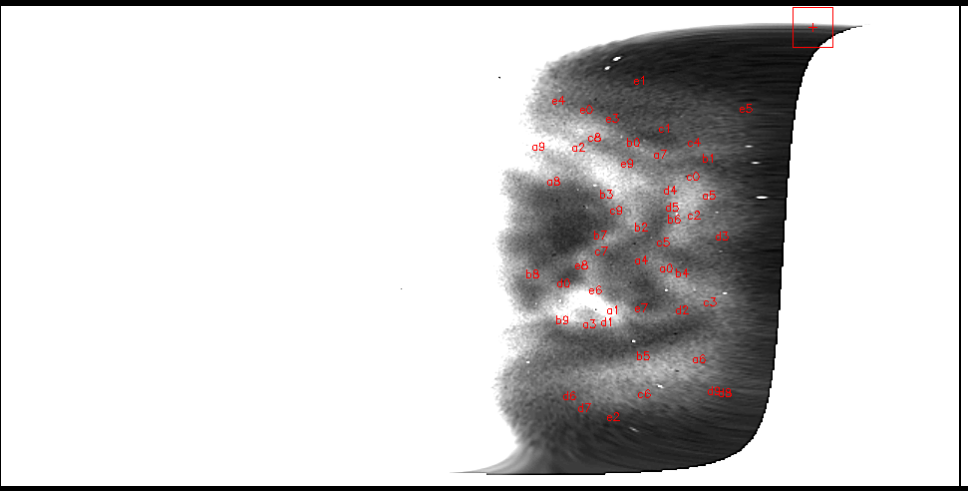
B

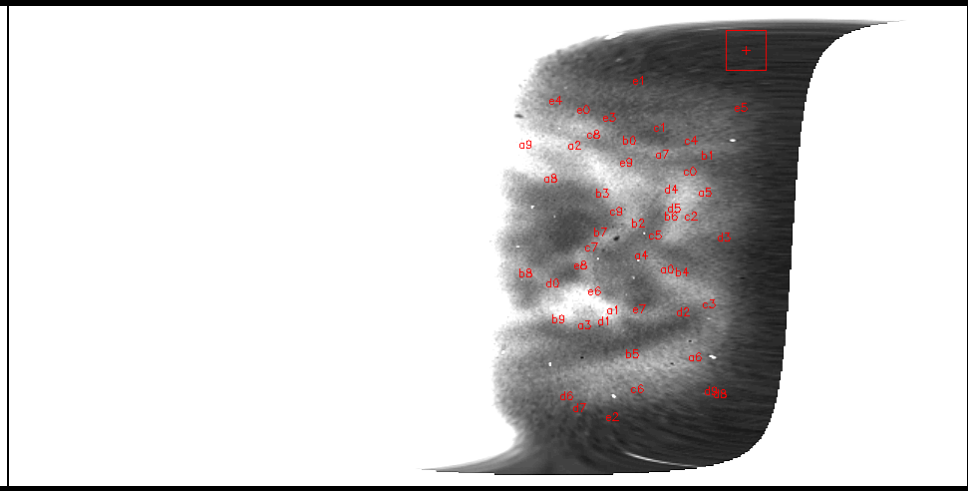
Images' cylindrical projections

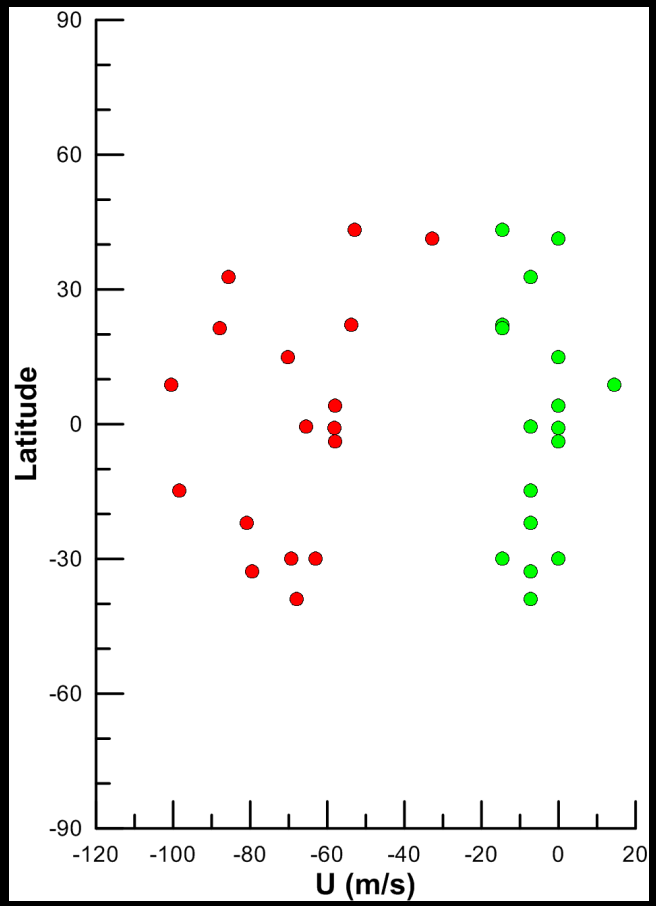


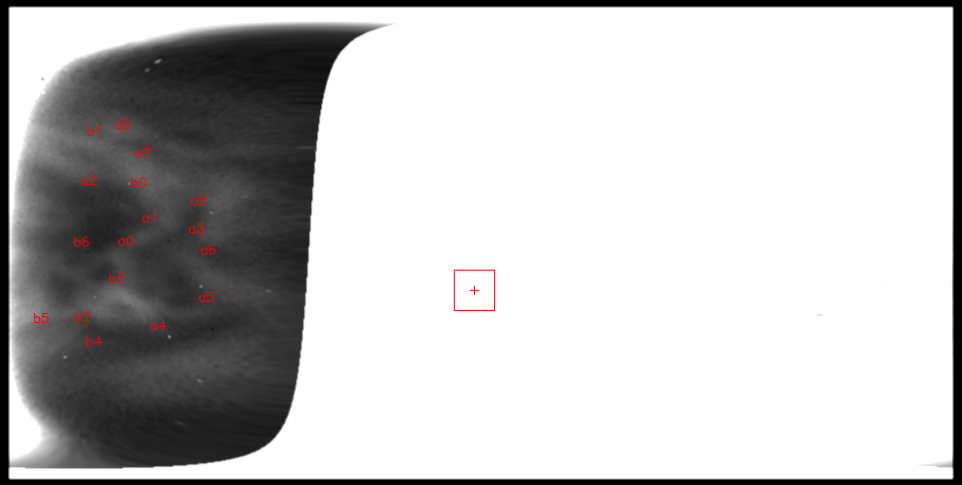


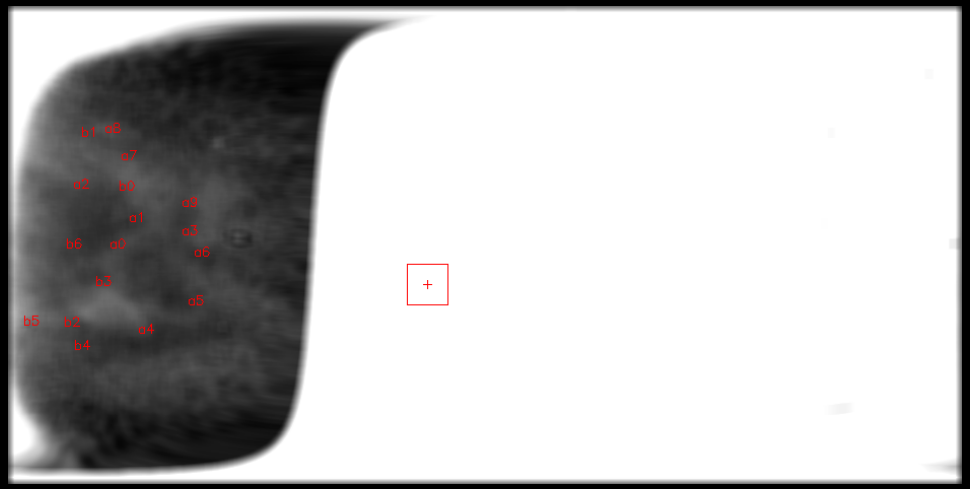




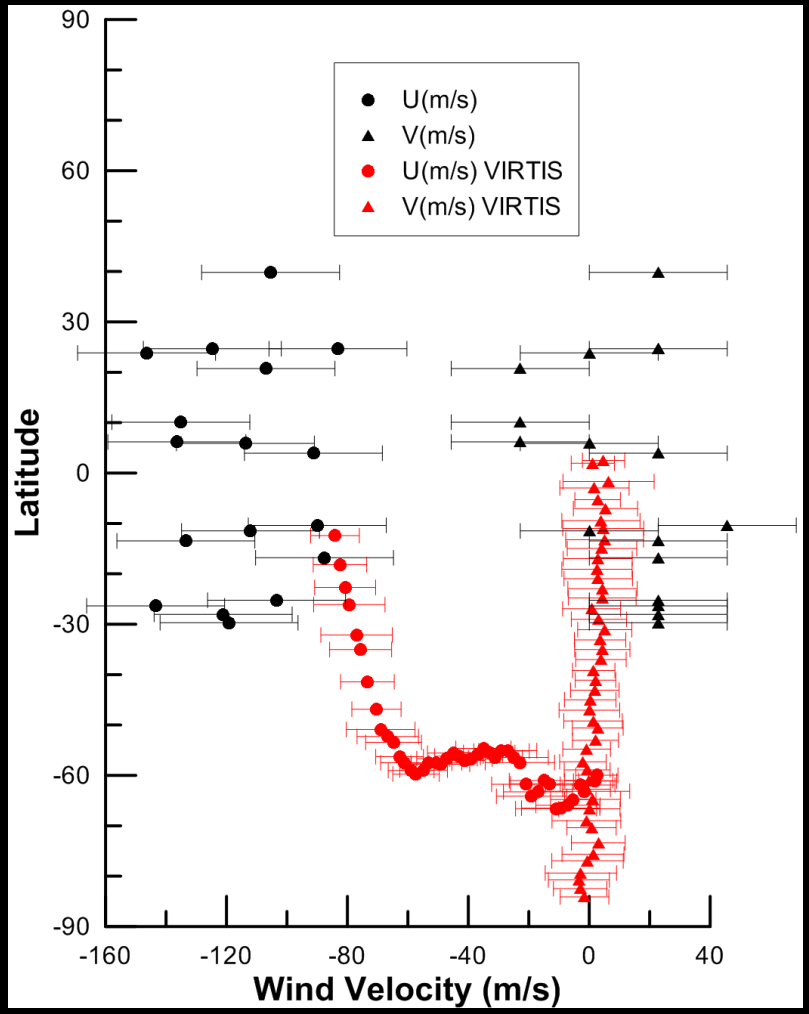


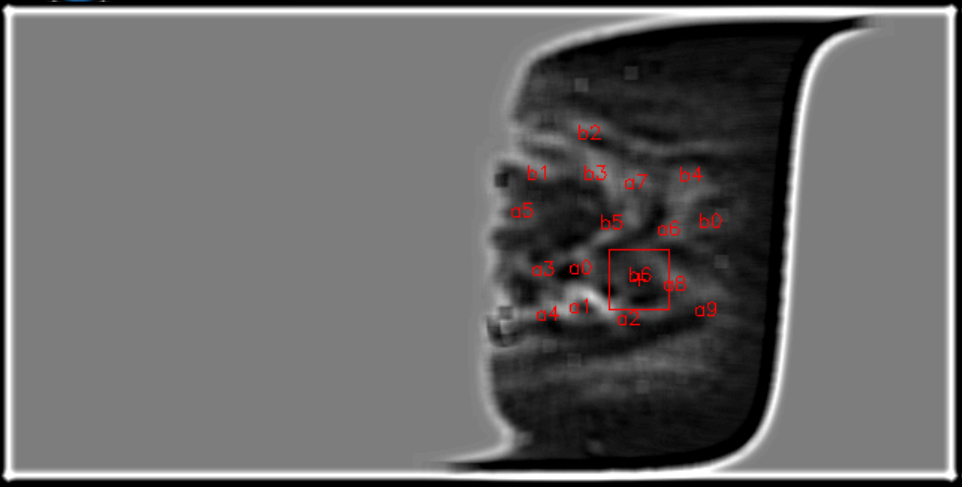


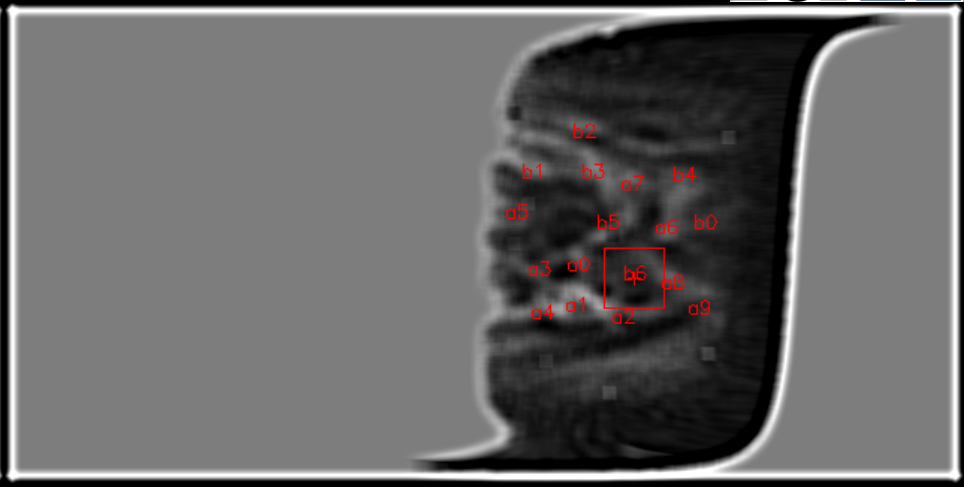


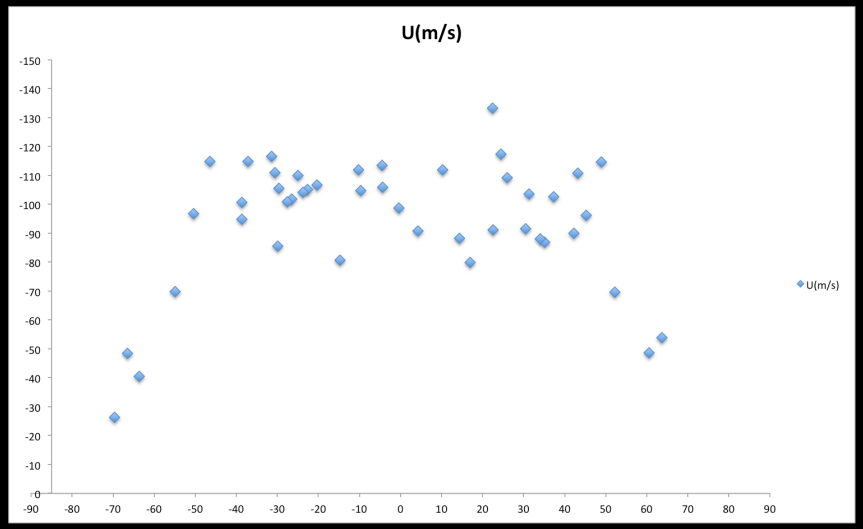


Red: Zonal Wind
Green: Meridional Wind

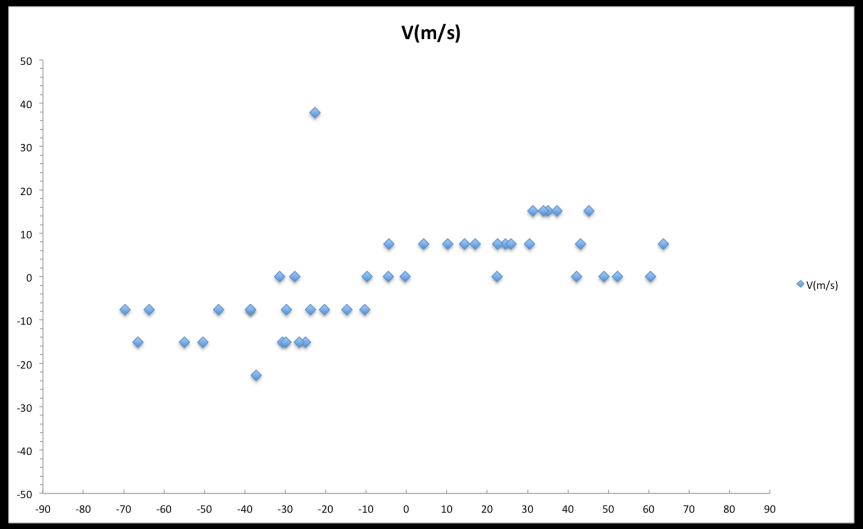

U(m/s)
V(m/s)
U(m/s) VIRTIS
V(m/s) VIRTIS
Latitude
90
60
30
0
-30
-60
-90
-160
-120
-80
-40
0
40
Wind Velocity (m/s)



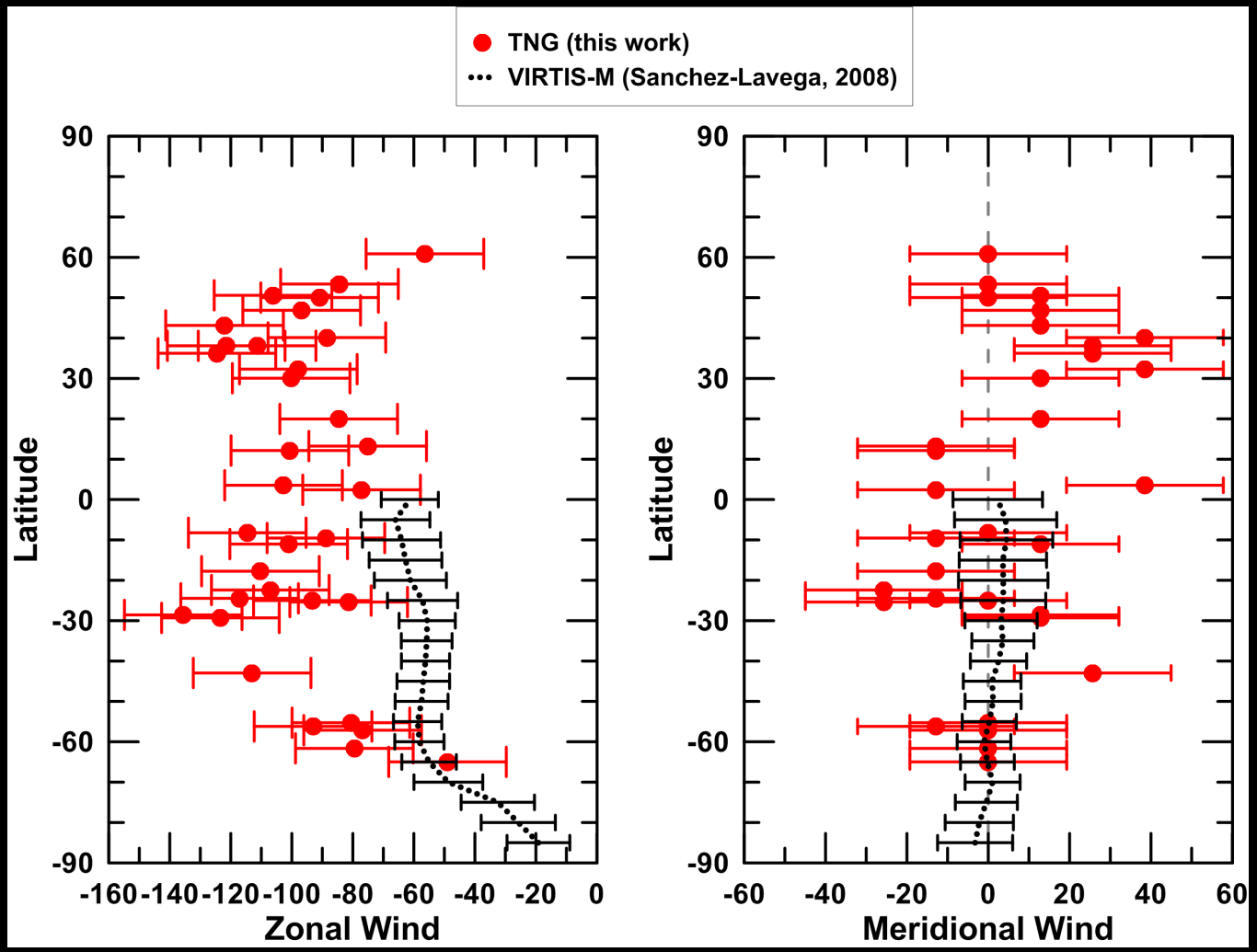


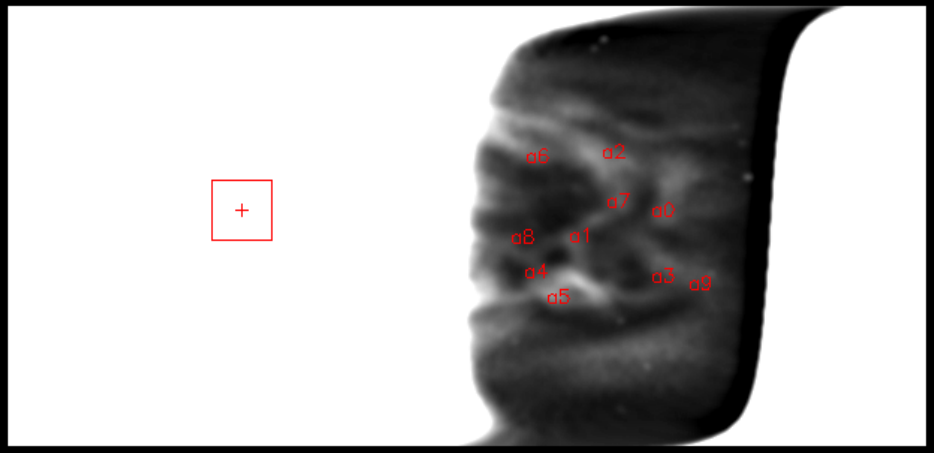


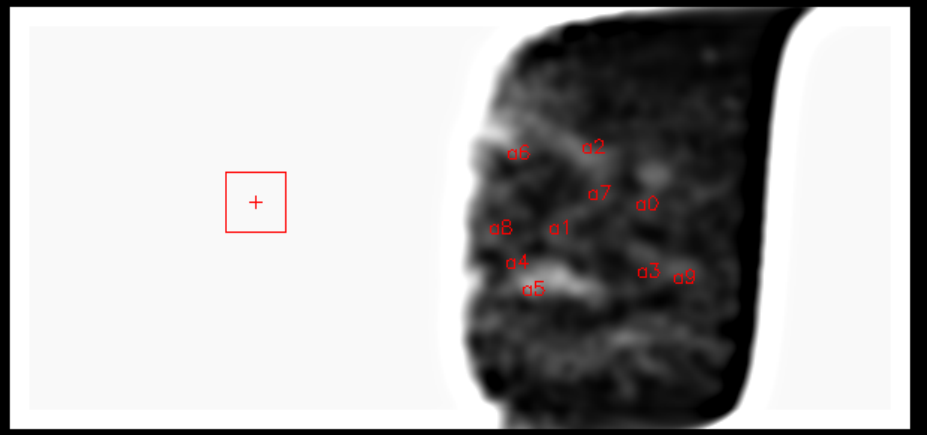
Zonal Wind

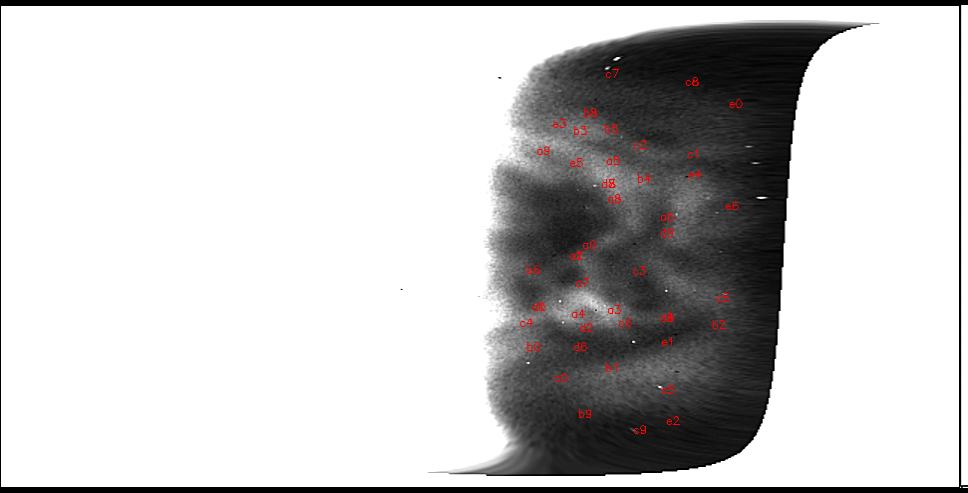


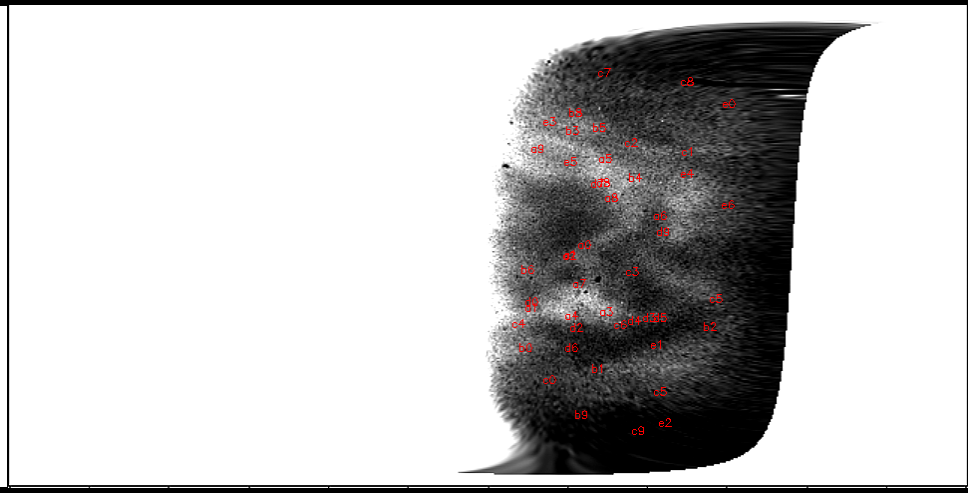
Meridional Wind

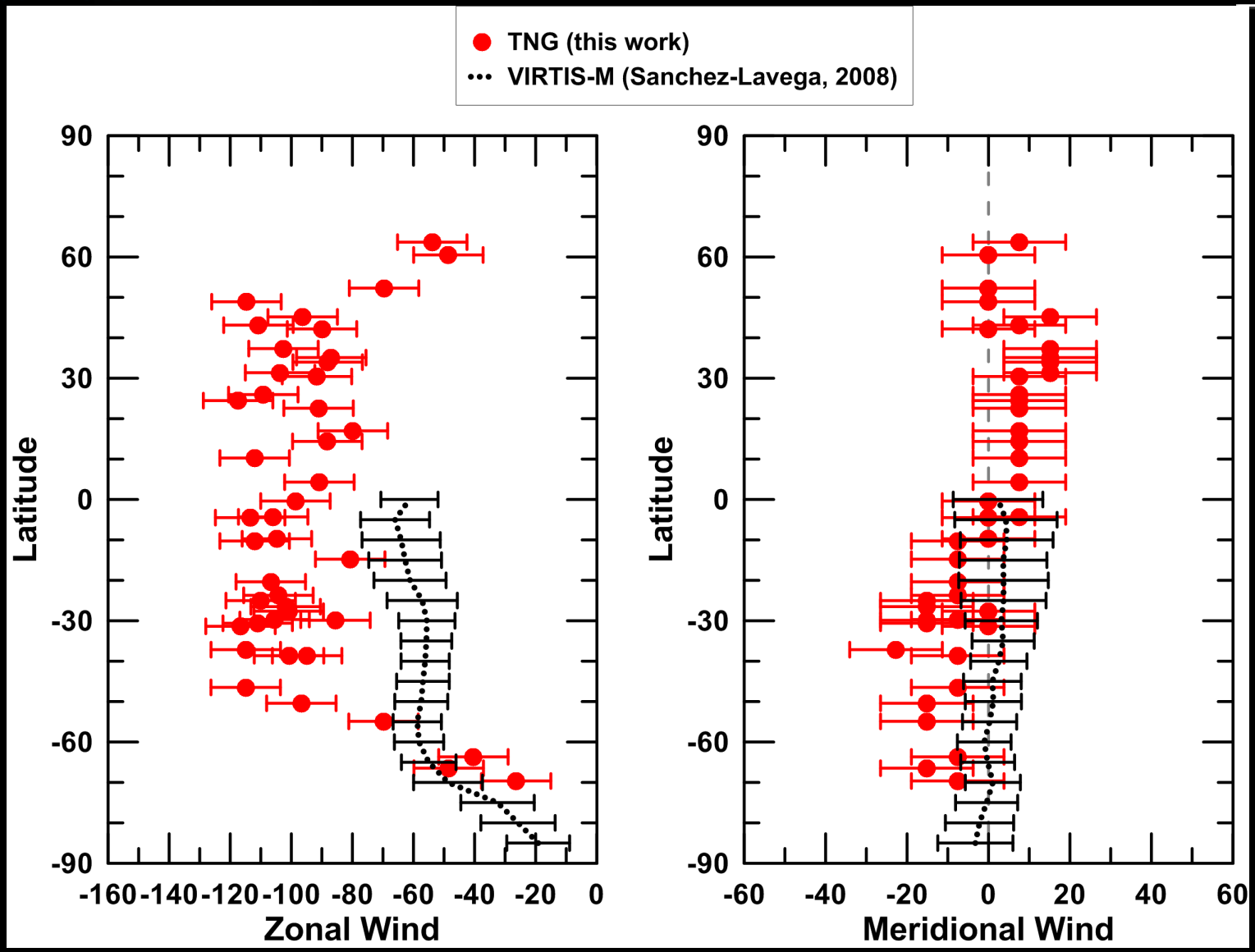

TNG (this work)
VIRTIS-M (Sanchez-Lavega, 2008)
Latitude
90
60
30
0
-30
-60
-90
-160 -140 -120 -100 -80 -60 -40 -20 0
Zonal Wind
Latitude
90
60
30
0
-30
-60
-90
-60 -40 -20 0 20 40 60
Meridional Wind

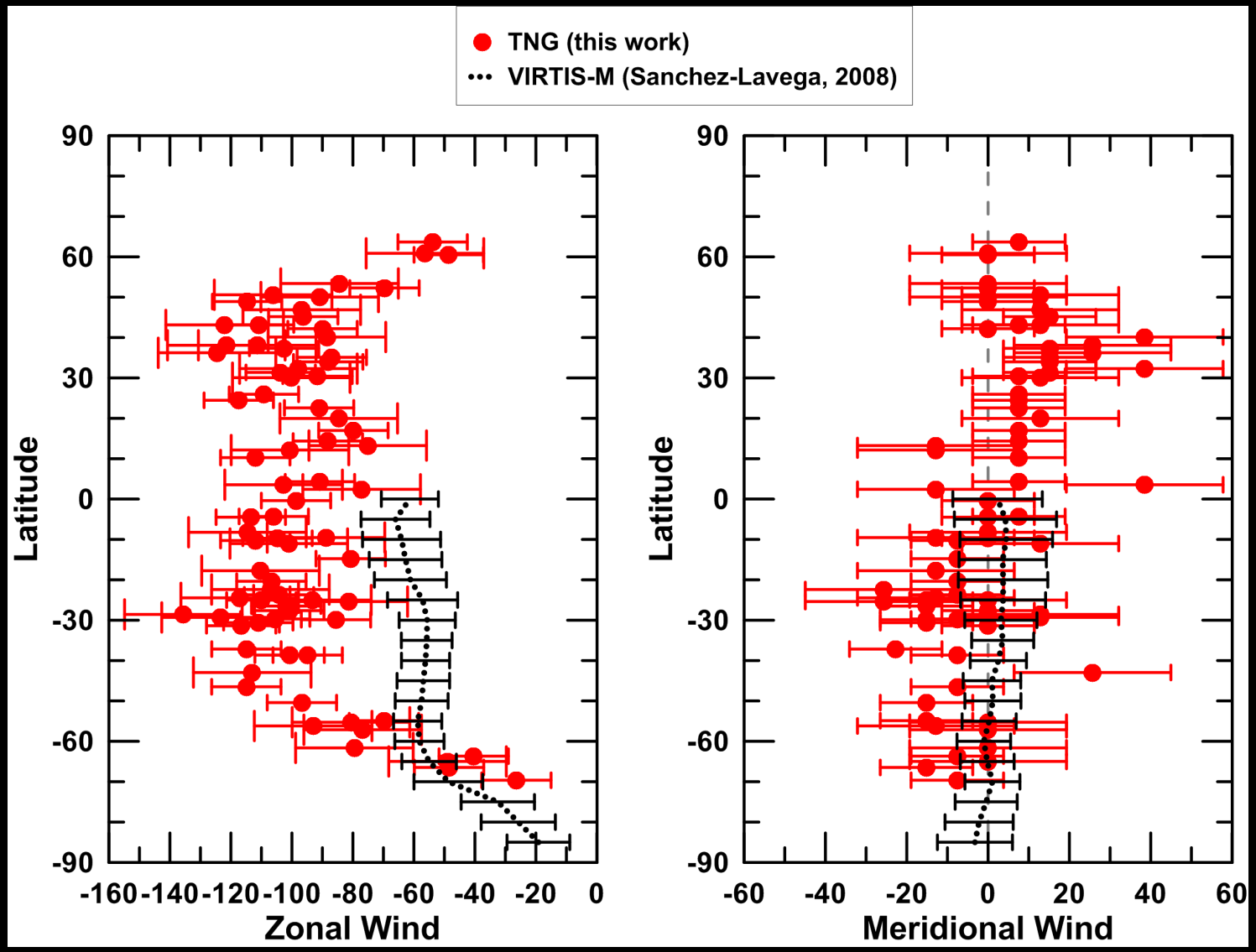




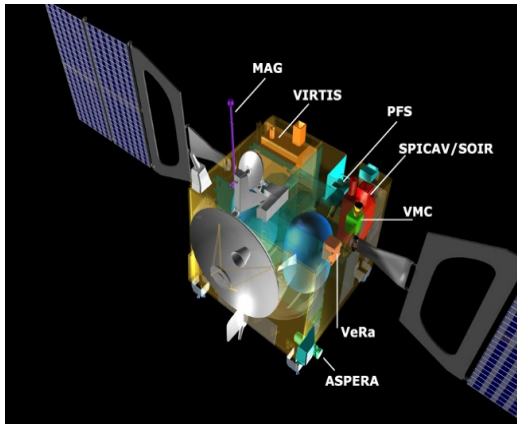


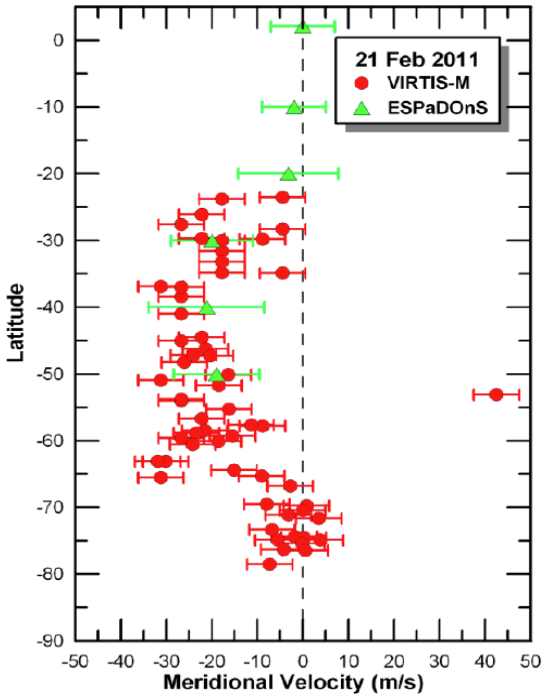


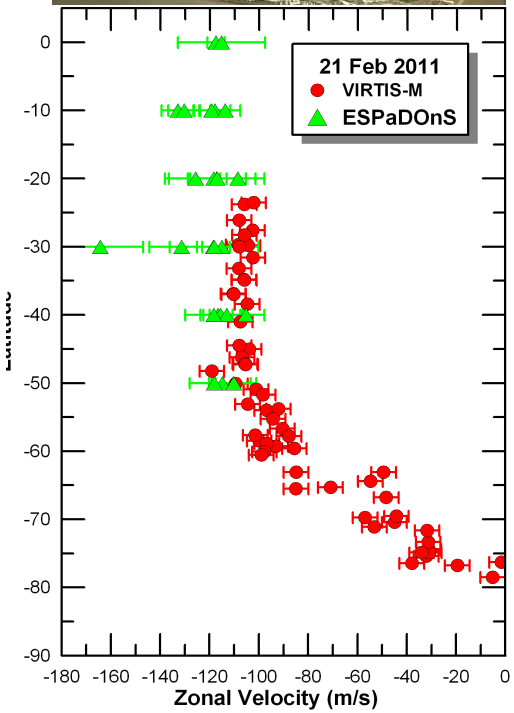

TNG (this work)
VIRTIS-M (Sanchez-Lavega, 2008)
Latitude
Zonal Wind
Meridional Wind
90
60
30
0
-30
-60
-90
-160 -140 -120 -100 -80 -60 -40 -20 0
-60 -40 -20 0 20 40 60


TNG (this work)
VIRTIS-M (Sanchez-Lavega, 2008)
Latitude
90
60
30
0
-30
-60
-90
-160 -140 -120 -100 -80 -60 -40 -20 0
Zonal Wind
Latitude
-60 -40 -20 0 20 40 60
Meridional Wind

Ground-based observations: Doppler results

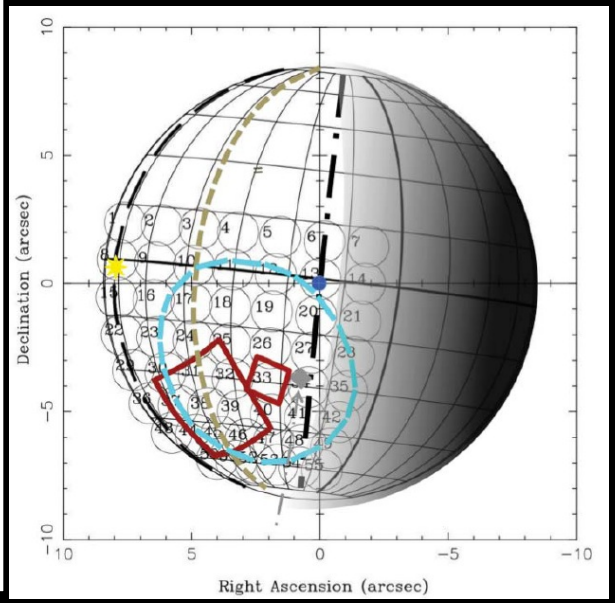




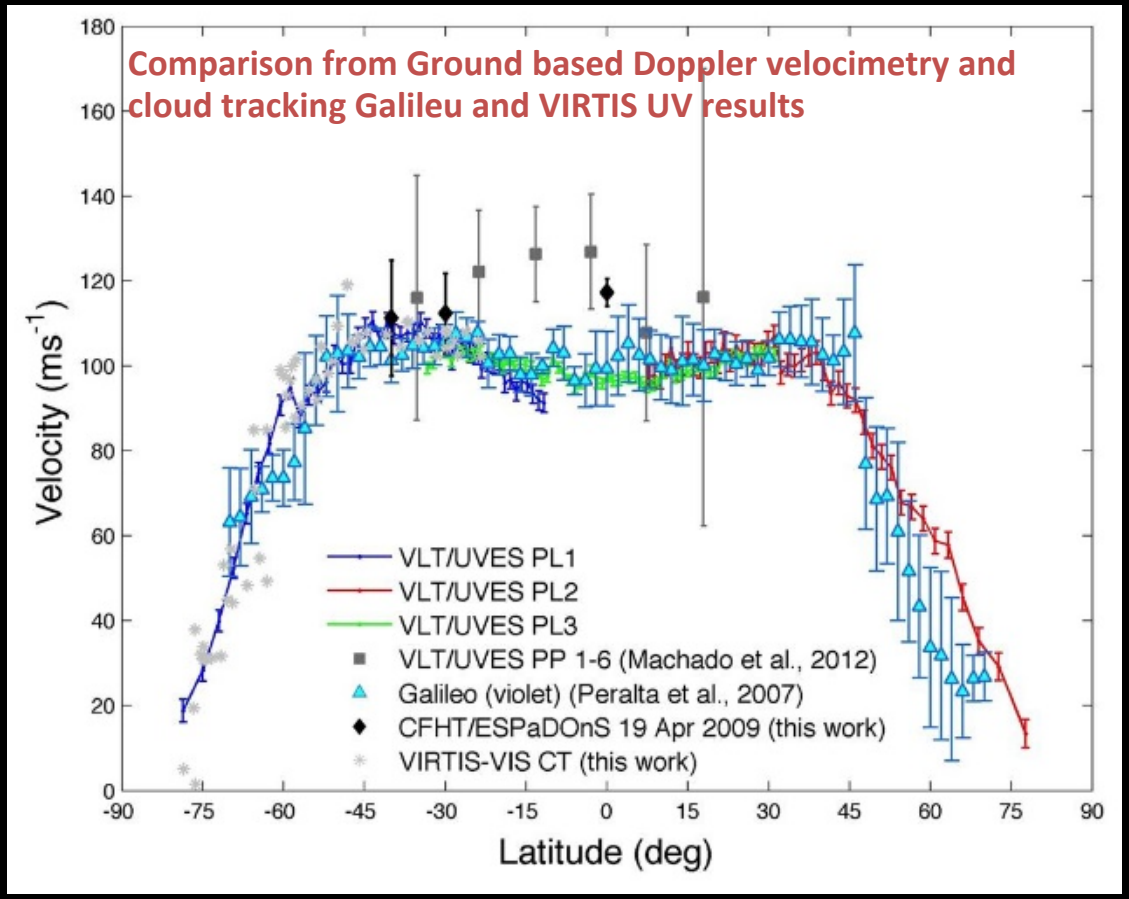


COMPARISON:

- 480 nm images (Peralta 2007)
- 380 nm images (Machado 2014)
- UV/VIS spectra (Machado 2012; Machado 2014)



Ground-based observations: Doppler results



COMPARISON:

- 480 nm images (Peralta 2007)
- 380 nm images (Machado 2014)
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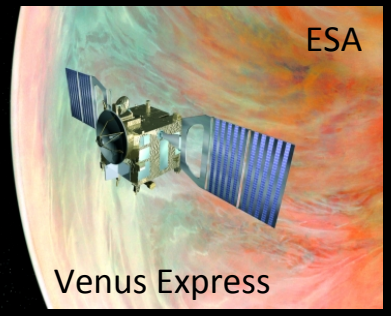


VIRTIS-M cloud top tracking
v_{eq} = - (102 ± 10) m/s
(Sánchez-Lavega et al., 2008)
V_{eq} = - (112 **± 5.8) m/s**
(Machado et al. 2014)

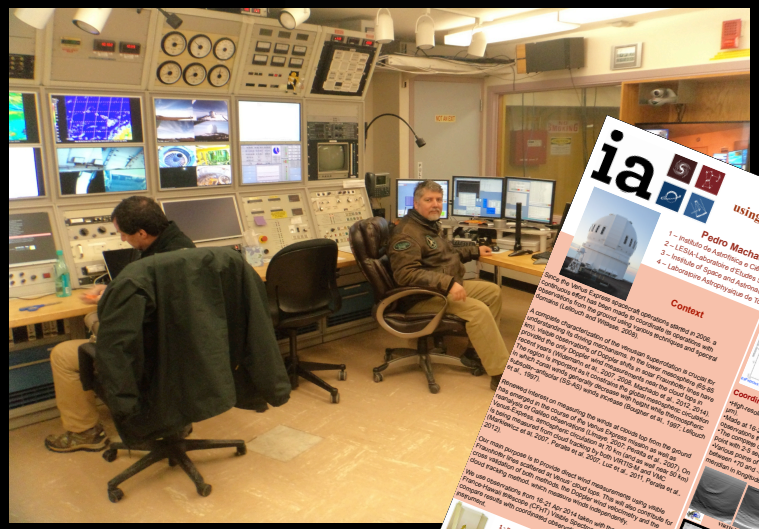
Ground-based Doppler - sequential
2-4 Jul. 2007 :
v_{eq} = - (104 ± 10) m/s
(Widemann et al., 2008)
19-21 Feb. 2011
v_{eq} = - (117 ± 14) m/s
(Machado et al. 2014)

Ground-based Doppler – long slit
May 2007 :
v_{eq} = -(106 ± 21) m/s
to -(127 ± 14) m/s
(Machado et al., 2012)

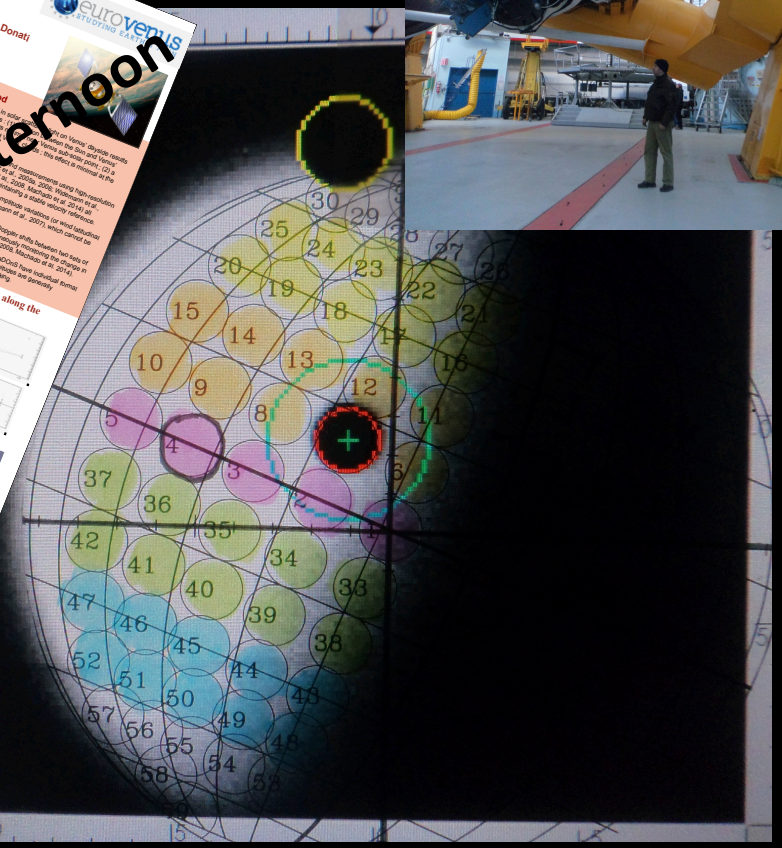
Coherence between ground-based and VEx cloud tracking for the background, longitudinally averaged, zonal circulation

Instituto de Astrofísica e Ciências do Espaço

CFHT/ESPaDOnS and VIRTIS/Vex Coordinated observations



This March (24-29) CFH observations will be coordinated with simultaneous IRTF observations in or study the possibl coupling of the winds and che species that dynamical tracers



Thank you for your attention