Venus nitric oxide nightglow distribution: a clue to thermospheric dynamics

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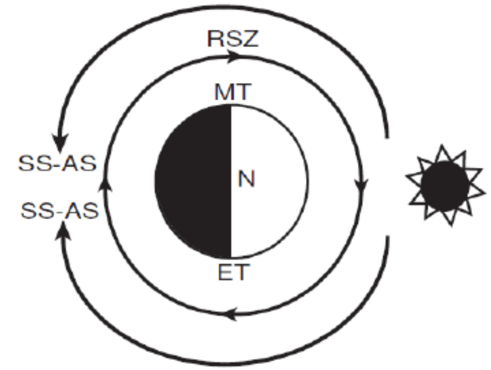
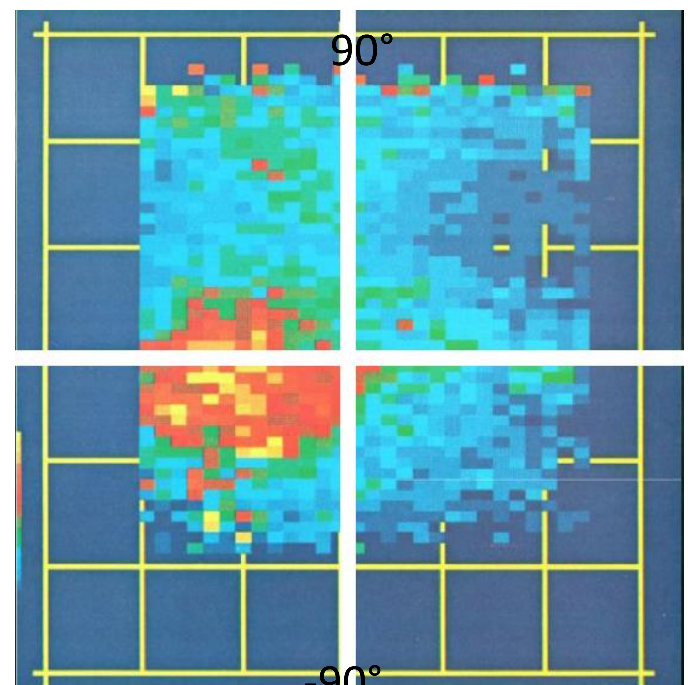
Motivations

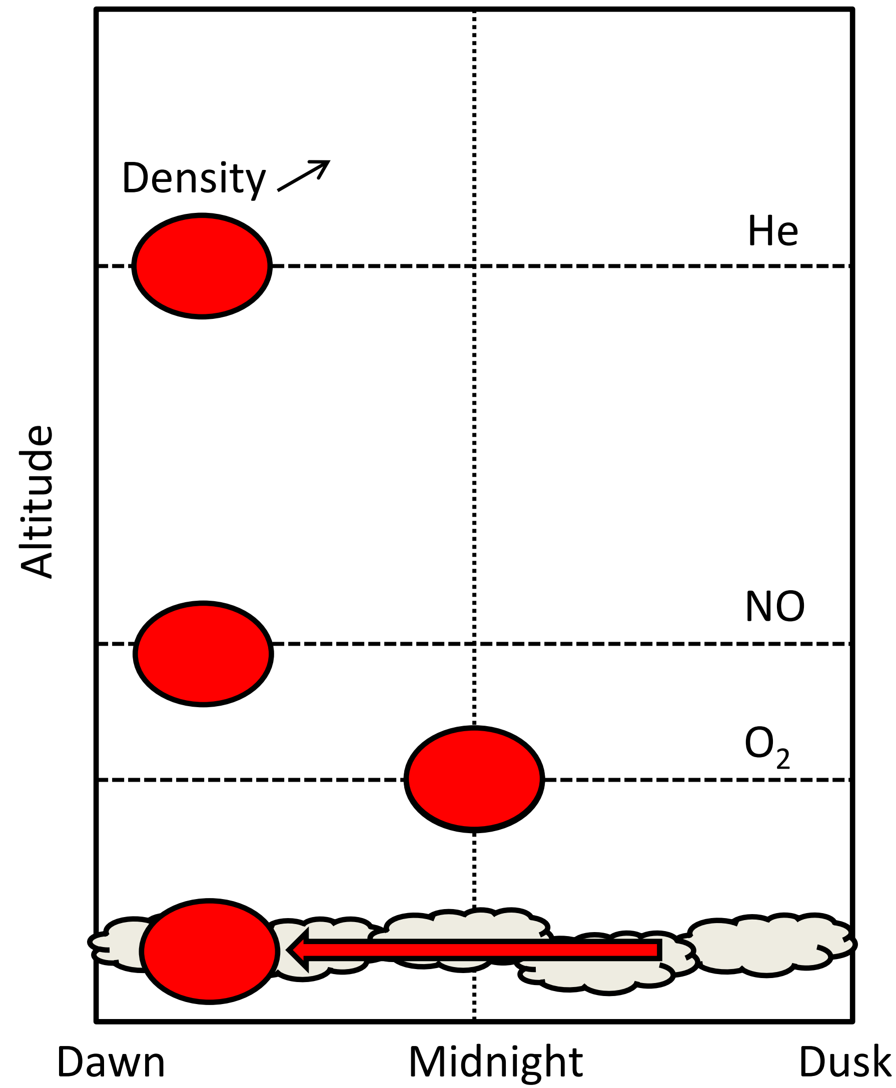


- The SS-AS circulation is expected to carry the N and O atoms from the subsolar to the antisolar point, where the NO emission should be brightest
- PV-OUVS images of the NO δ(0,1) indicated that the emission is brightest in a region statistically shifted from the antisolar point



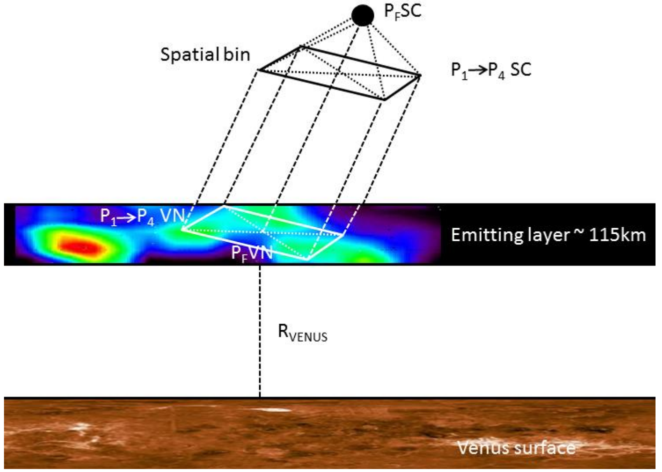
Motivation

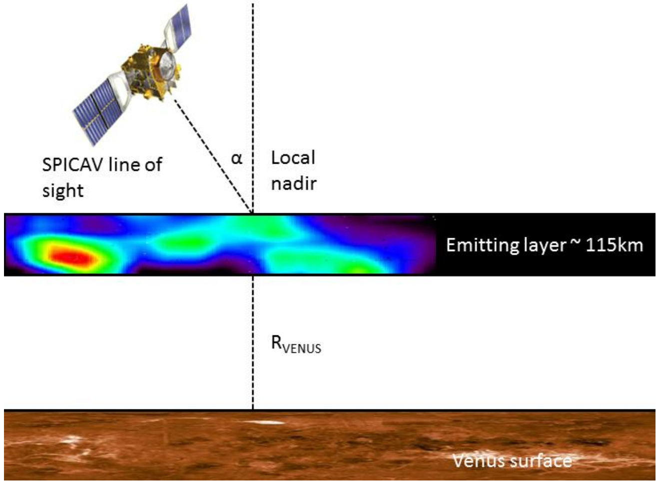
- Stewart et al. (1979) → the brightest NO UV spot is statistically shifted from the antisolar point
  - Zonal winds towards morning terminator
- Soret et al. (2010)
  - Analysis of O_2 ($a^1\Delta g$) at ~96km
  - Brightest spot located at the antisolar point
- At lower altitude (~70km)
  - Clouds motion towards the morning, carried by the superrotation of the atmosphere
- Niemann et al. (1980)
  - He density at high altitude (400 km) is shifted towards dawn
- **What is the mechanism that causes superrotation at altitudes above 100 km?**

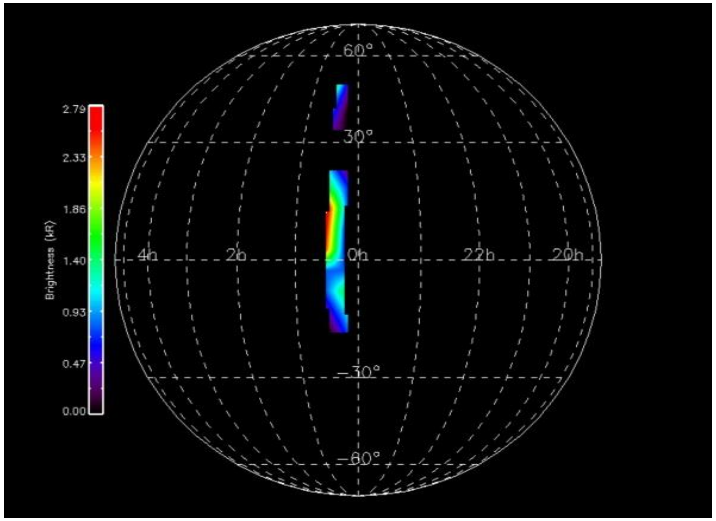


Data analysis

- Each recorded spectrum is
  - Cleaned from offset, dark current, …
  - Projected at the altitude of the max of the NO emission (i.e. 115 km – Stiepen et al., 2012)
  - Intensity is corrected for geometrical effects
- Spectra provide thin nadir slices of emission along latitudinal cuts that are accumulated over the years
- Accumulation of these cuts builds up a statistical global map of the NO emission

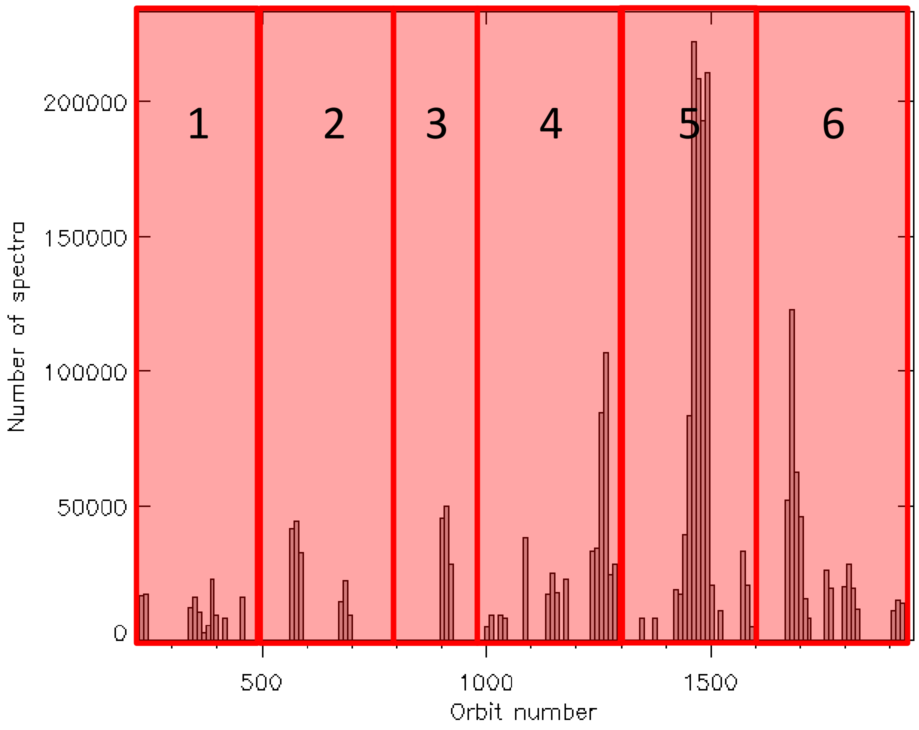






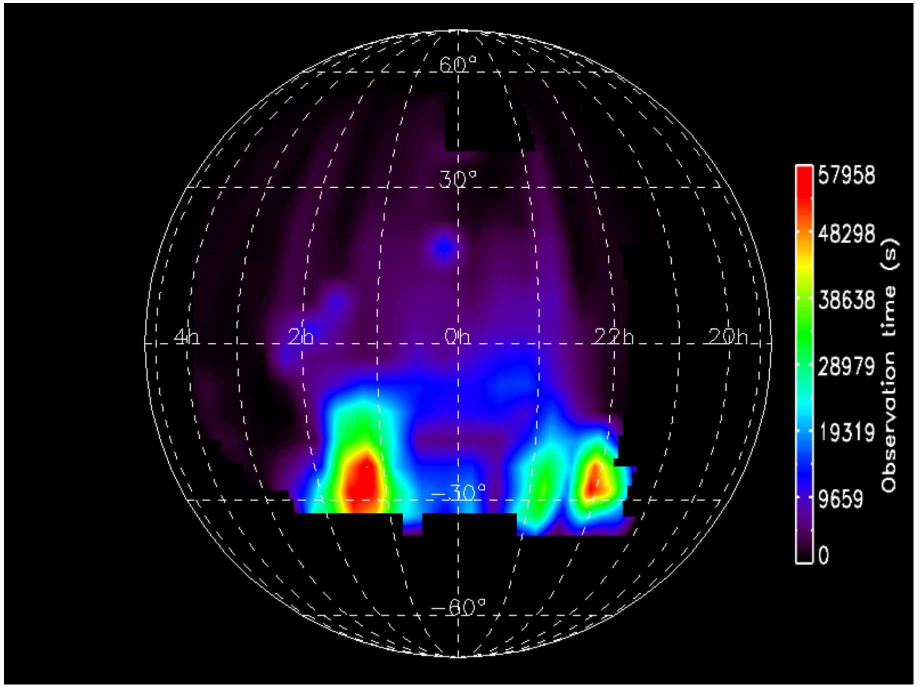
Time distribution of the data

- From 2006 to end 2011, six groups of data are identified
  - Group 1: orbits 1 to 500
  - Group 2: orbits 501 to 800
  - Group 3: orbits 801 to 1000
  - Group 4: orbits 1001 to 1300
  - Group 5: orbits 1301 to 1600
  - Group 6: orbits 1601 +



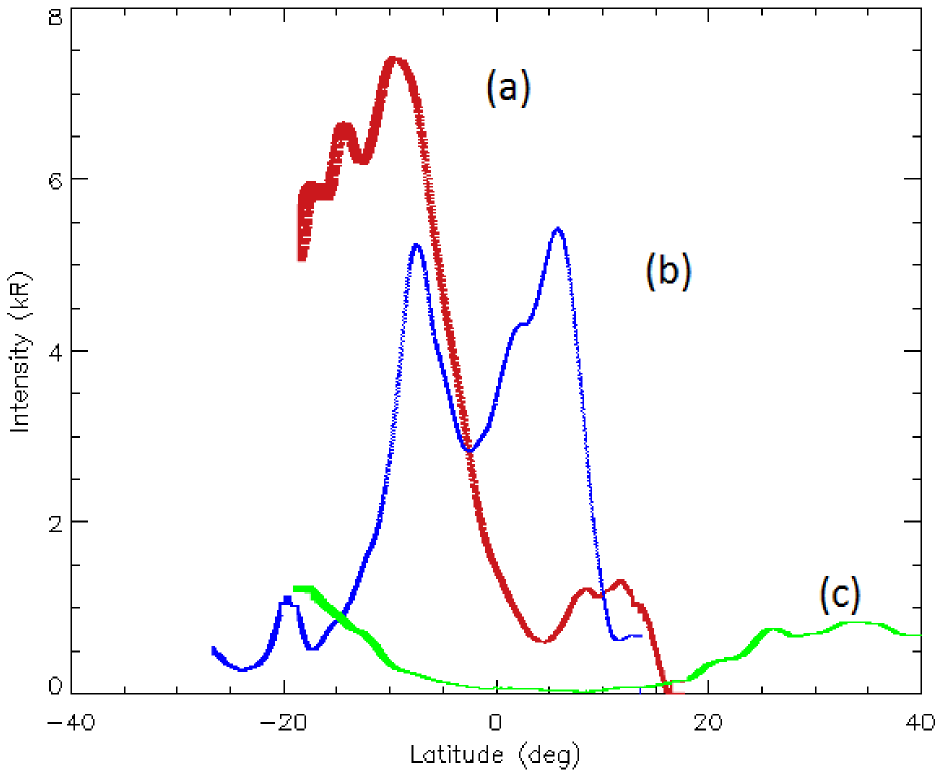
Time distribution of the data

- On the nightside map, the observation time spent within each pixel greatly varies from 0 (some regions are not observed at all) up to ~58 000 s
- In the brightest region (01:00 to 03:30 and 10°N to 25°S), the observation time extends from ~300 to ~10 000 s (mean ~1500 s)

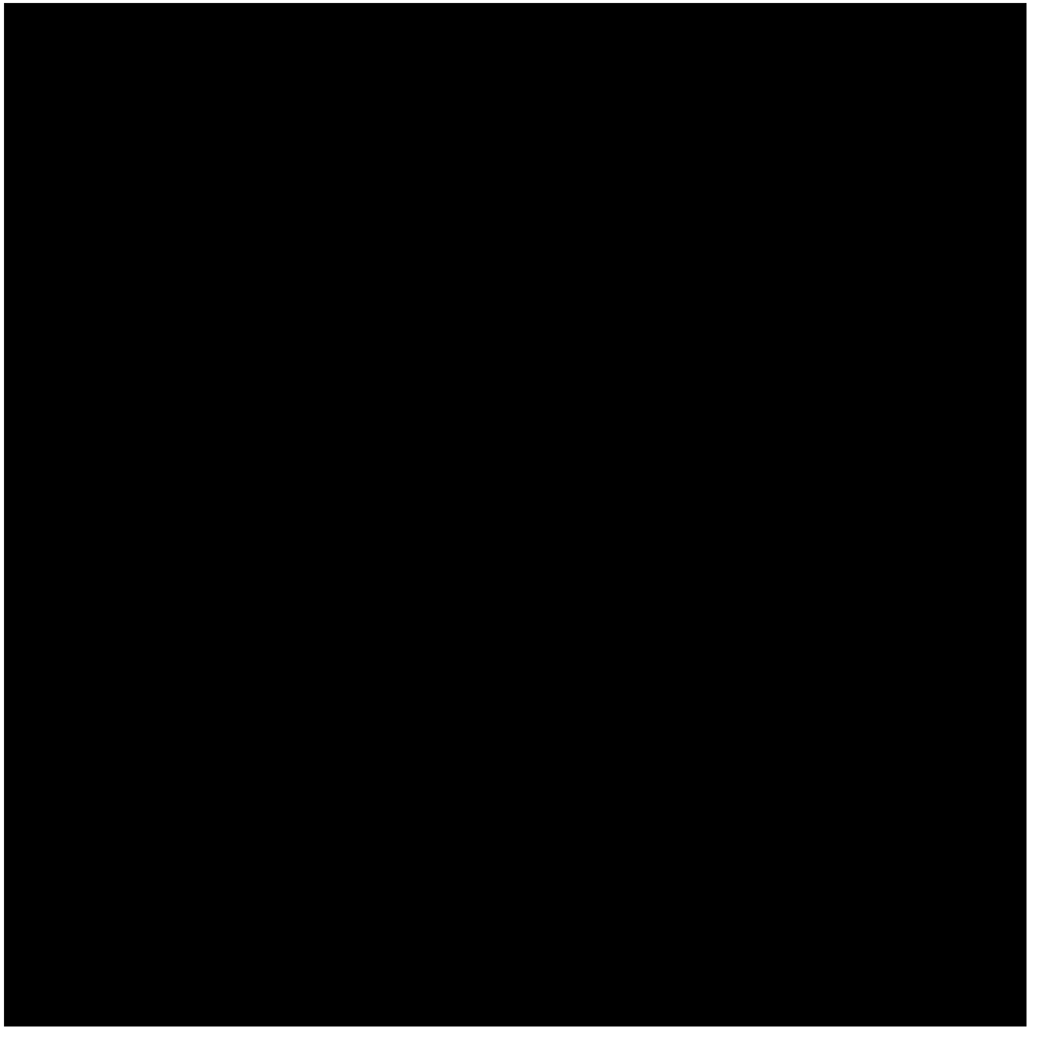


Local and temporal variability

- Three different observations between 02:00 and 03:00 in similar solar conditions
- The three observations cross throught the statistically bright region but different behaviors are observed
  - Curve (a) presents a secondary peak near 10°N
  - Curve (b) has two equally important peaks
  - Curve (c) has no maximum near 10°S



Data accumulation



Global mapping

Publications	Mean hemispheric intensity	Mean intensity in the brightest region
This study **Full NO emission**	1.9±1 kR	3.9±1.5 kR (from 0100 to 0330 LT and from 25°S to 10°N) 3.7±1.5 kR (from 0215 to 0245 LT and from ~20°S to ~0°N)
Bougher et al. (1990) **δ(0,1) NO band**	0.45 kR	1.9 kR (from 0215 to 0245 LT and from ~20°S to ~0°N)
Bougher et al. (1990) **Full NO emission**	2±0.5 kR	8.6±2.7 kR (from 0215 to 0245 LT and from ~20°S to ~0°N)

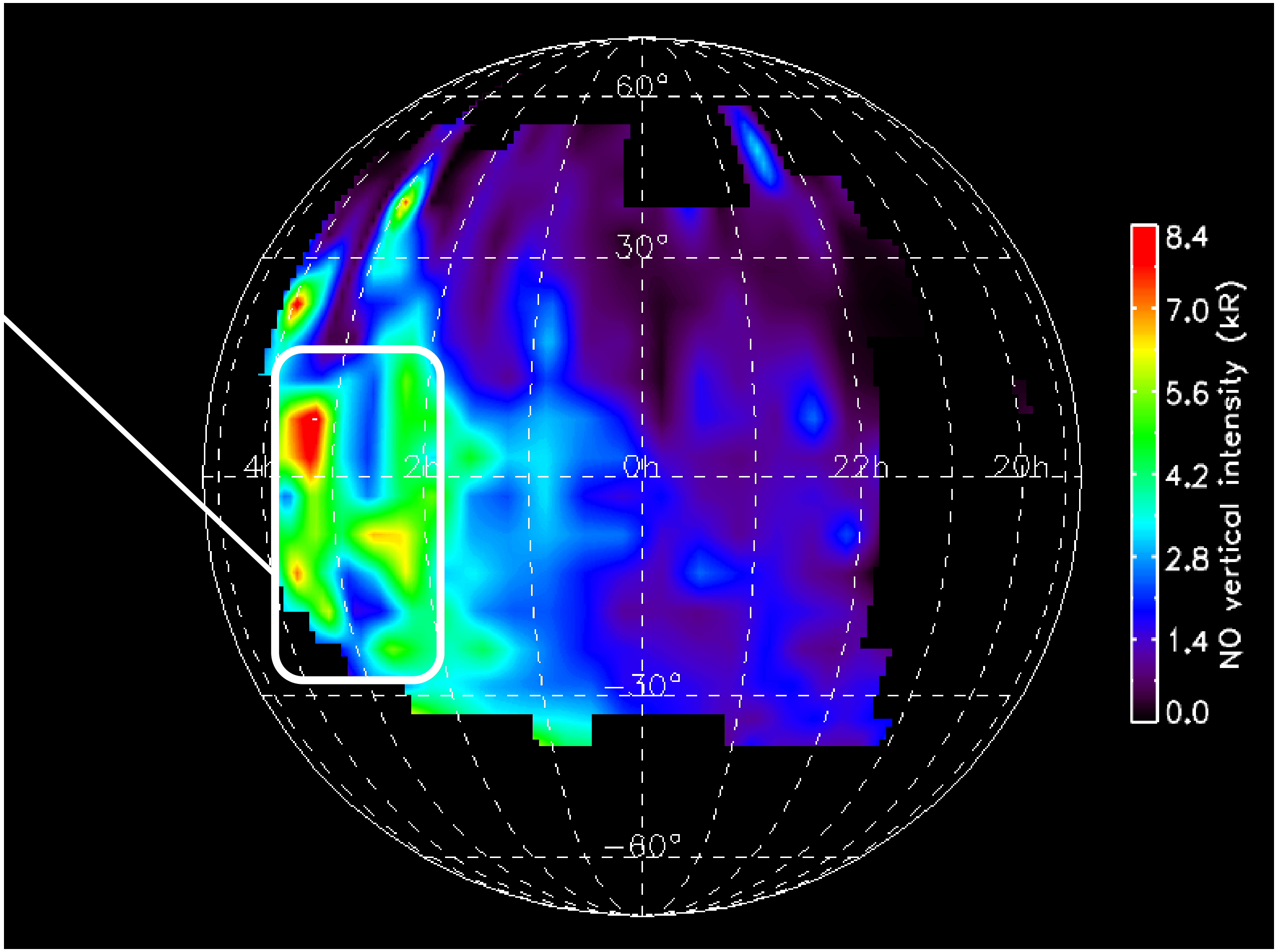
The factor to scale the intensity of the (0,1) δ band to the full NO emission is derived from the Earth's measurements by Tennyson et al. (1986)

We note similar values for the hemispheric brightness, but a smaller value within the bright region

The PV-OUVS brightness values were recalculated and corrected by Bougher et al. (1990)

Global mapping

The bright region extends from 01:00 to 03:30 and from 10°N to 25°S



PV-OUVS measurements were performed during maximum solar activity. SPICAV measurements cover low to medium solar activity periods. Stewart et al. (1979) did not find a correlation between solar acitvity and intensity values. Similarly, we find not evidence for such a correlation. Hemispheric brightness values are very similar despite the difference in solar conditions.

Stiepen et al., Icarus, in press

Discussion

- Comparison with previous studies shows
  - No shift at 95 km
  - Shift at lower altitude (super rotation at cloud level)
  - Dawn ‘He bulge’ at 400 km
- Possible explanations
  - Gravity waves deposits momentum in the thermosphere in the NO airglow altitude region (Zalucha et al., 2013)
  - Ionospheric convection drags the neutral atmosphere towards dawn down to the altitude of the NO emission (Lundin et al., 2011) but not down to 95 km

Conclusions

- This study obtains the first UV NO nightglow mapping since the Pioneer-Venus era 35 years ago, with consistent results in both the brightness and the position of the statistically bright patch. The hemispheric brightness is very similar, in spite of quite different solar conditions
- the NO emission is variable both spatially and temporally. Comparison with atmospheric tracers at other altitudes raises the ongoing question of the mechanism(s) causing the superrotation
- Two possible mechanisms for momentum transfer: gravity waves deposition or ionosphere drag

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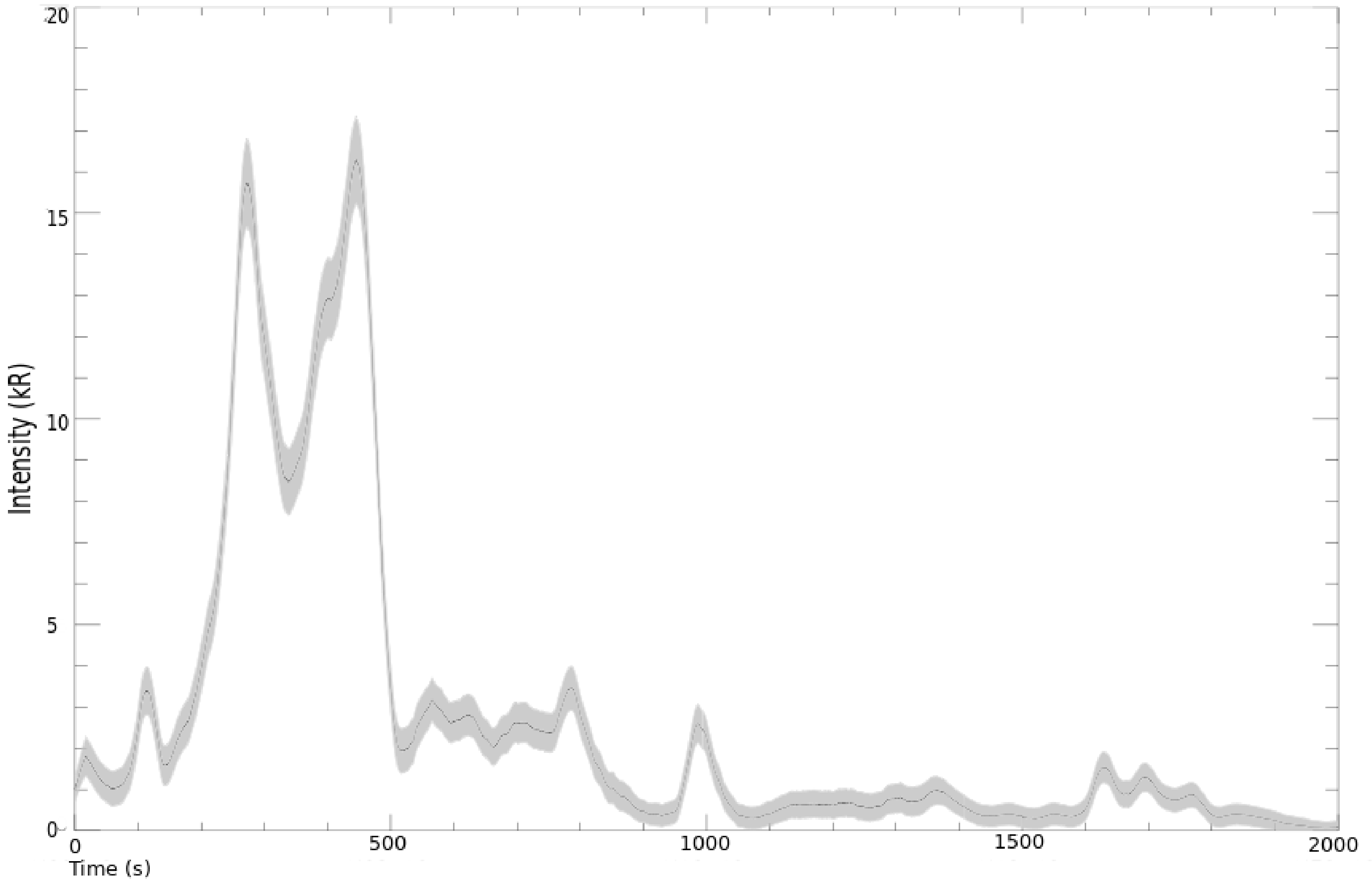
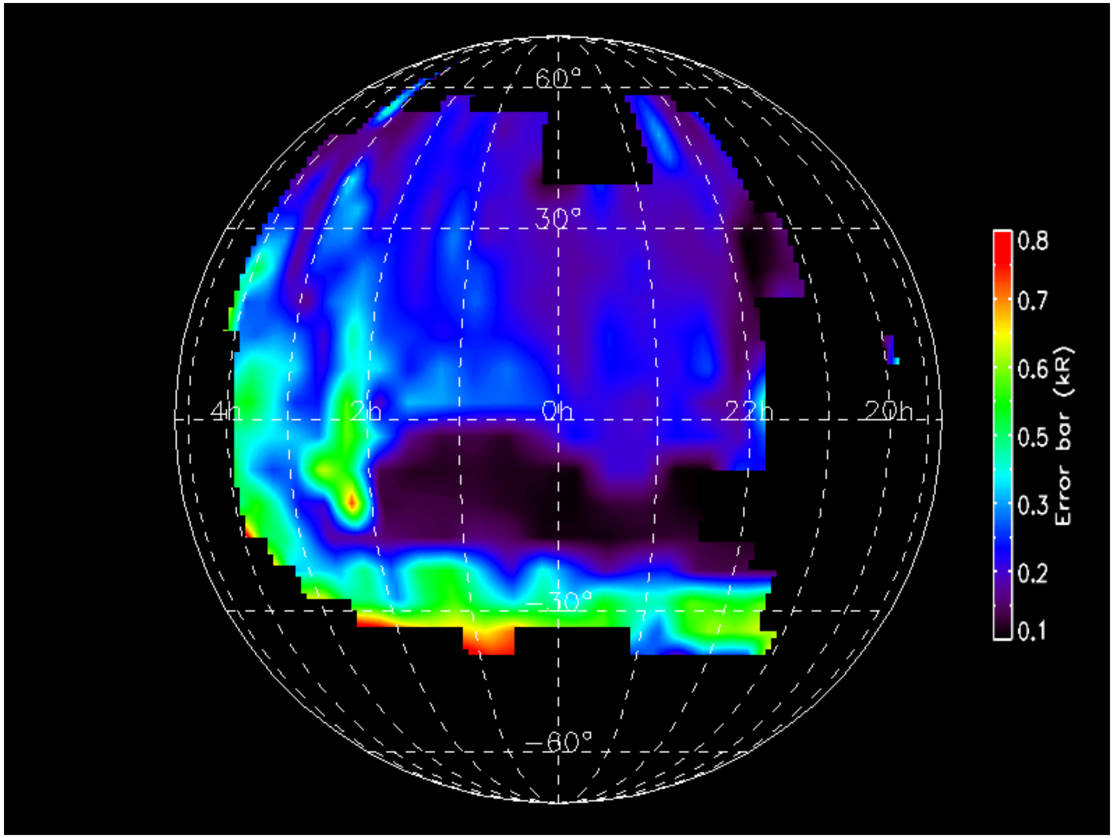
Backup

Residual noise



Stiepen et al., In Press

Residual noise



Stiepen et al., In Press