Results of December 2010 Observations of Venus

Candace Gray

May 23, 2011

1 Observations

We collected data using the echelle spectrograph, ARCES, on the 3.5-meter Astrophysical Research Consortium Telescope at Apache Point Observatory (APO) in 2010 on December 21, 23, 25, and 27. ARCES is a high resolution, cross-dispersed visible light spectrograph with a spectral resolution of $R \sim 31,500$. At 5577 $\AA$, this corresponds to a $\Delta\lambda = 0.177\AA$ or a velocity of 9.5 $km\ s^{-1}$. From December 21-27, Venus was moving at a radial velocity of $\sim 12.5\ km\ s^{-1}$ with respect to APO, corresponding to a Doppler shift of 0.234 $\AA$, (positioned at 5577.57 $\AA$), well within the detection limits of ARCES.

Venus night side and day side spectra were obtained, along with standard star observations. Sky conditions were non-photometric throughout the observing campaign. The dome was closed due to weather on Dec 23 and 25. Of the four observing nights, only December 21 and 27 had usable data. The December 27 data have been reduced and the analyzed and remaining data will be reduced and analyzed shortly.

2 Data Reduction

A quick reduction was done using an ARCES data reduction script in IRAF (Barentine and Krzesinski, personal communication). Due to the large amount of scatter from the bright day side of Venus, day side spectra were scaled to the night side and then subtracted. Since the Venusian green line is found to be spactially variable over several hundred km, the slit position needed to be stationary. Guiding camera images for the echelle show the slit location on the Venus day side did not deviate within $\sim 600\ km$ ($\sim$ 10 pixels), allowing reduced day side spectra to be combined before scaling.

Previous papers (e.g. Slanger 2001) scale the day side spectra to Fraunhofer lines on either side of the 5577 $\AA$ line. However, when we did this with our data, the continuum was not properly scaled, which led to an under-subtraction in the area of interest. Therefore, the continuum level near 5577$\AA$ was used to scale the day side spectra, but this resulted in an incorrect subtraction of the Fraunhofer lines. Also, the shape of the Fraunhofer lines on the night side and day side were not identical, leading to uneven subtraction. Figures 1-3 show the night side and day side scaled to the contiuum level with the terrestrial and Venusian wavelengths marked.

3 Results

Figures 1-3 plot the night side spectra and the scaled day side spectra. These were subtracted in order to remove scatter from the day side. The results are plotted in Figures 4-6, with the terrestrial and Doppler shifted venusian green line marked. The Fraunhofer lines were deeper on the day side than the night side. If the day side spectra were scaled by the Fraunhofer lines, then this would have resulted in an oversubtraction. Therefore, the day side spectra were scaled to the contiuum level of the night side and then subtracted. This resulted in the Fraunhofer lines not being completely subtracted, which can be seen in Figures 4-6. In addition to the Fraunhofer lines not having equal depth, they also exhibited a slightly different shape producing a peak and trough in Fiugures 4-6.

Figures 5 and 6 do not appear to show any Venusian green line emission, while Figure 4 does appear to exhibit some emission. However, a Gaussian fit to the feature has a FWHM 0.046, which is 3 times smaller than the resolution of the spectrograph. We therefore conclude that this feature is the result of noise rather than oxygen emission. A standard deviation was calculated over the continuum range between $5574 - 5577.7\ \AA$ and $5577.7 - 5580\ \AA$, straddling the terrestrial and Venusian green line. The terrestrial green line is 3.2σ from the continuum while the peak at 5577.57 $\AA$ has a standard deviation of 2σ.

According to archived data at Spaceweather.com, the most intensive flare detected near our observations dates was a C5 occuring on Dec 15. Assuming a speed equivalent to the solar wind of 600 $km\ s^{-1}$, it would have taken two days for the flare to reach Venus, which was two days prior to our first observation on December 19. If we assume that the presence of the oxygen green line is connected with solar activity, we would not have expected to see emission during our observation.

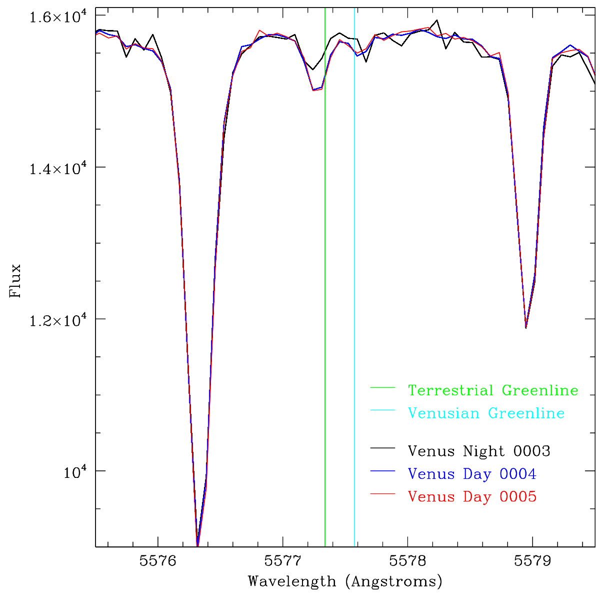

Figure 1: Spectrum of Venus night side (venusnight.0003.fits) overplotted with two scaled day side spectra.

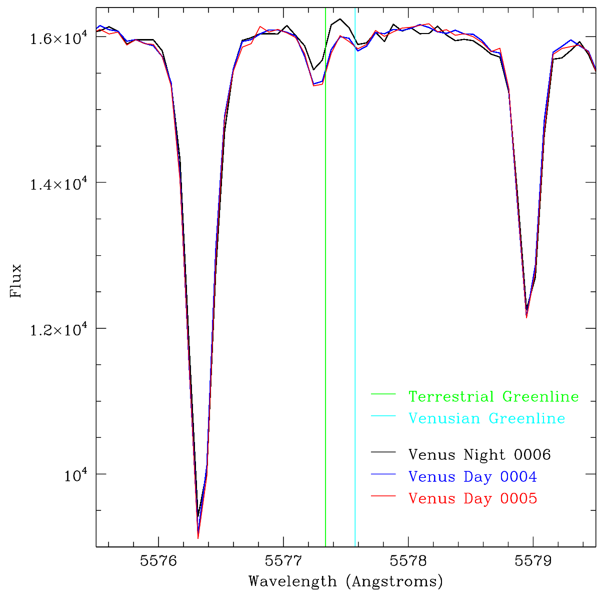

Figure 2: Spectrum of Venus night side (venusnight.0006.fits) overplotted with two scaled day side spectra.

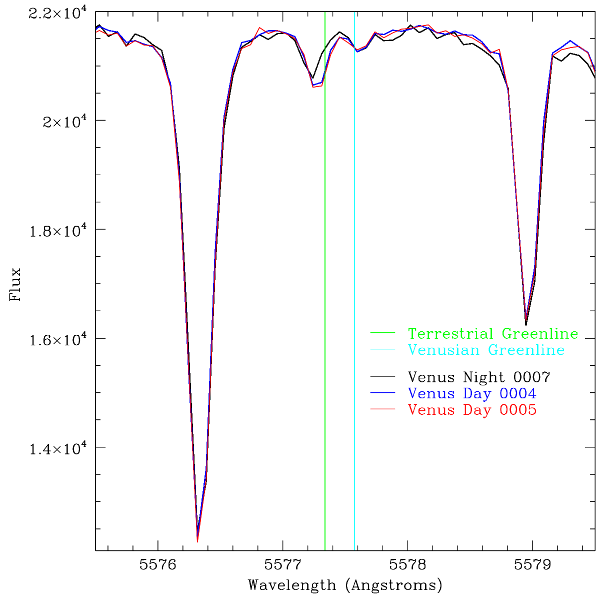

Figure 3: Spectrum of Venus night side (venusnight.0007.fits) overplotted with two scaled day side spectra.

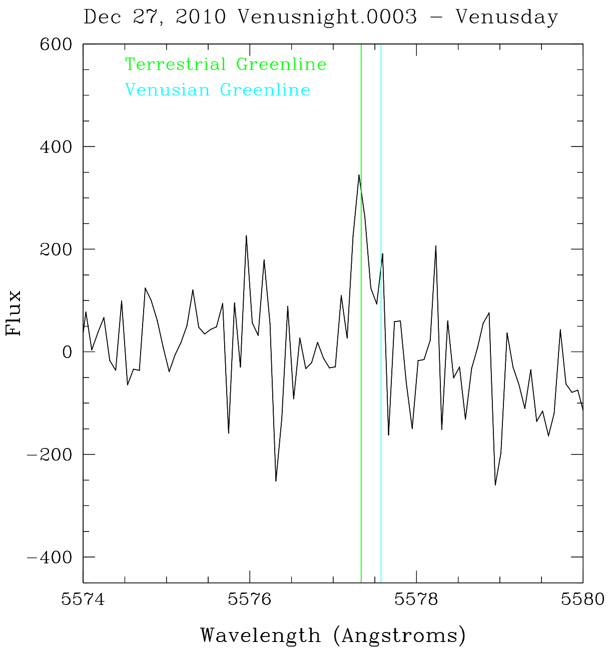

Figure 4: Result of scaled day side spectra subtracted from night side spectrum (venusnight.0003.fits). Notice the large peak and trough at 5576.5 $\mathring{A}$ and 5579 $\mathring{A}$. This is due to the unequal shape and depth of the Fraunhofer lines on the Venus night and day side.

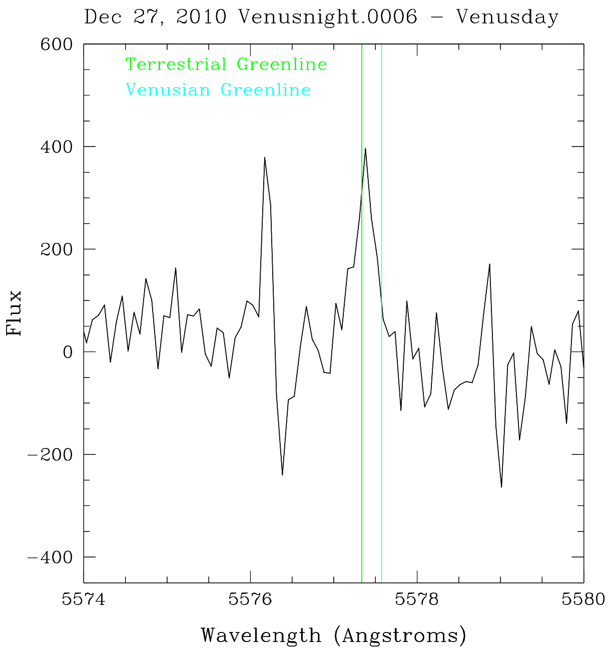

Figure 5: Result of scaled day side spectra subtracted from night side spectrum (venusnight.0006.fits.

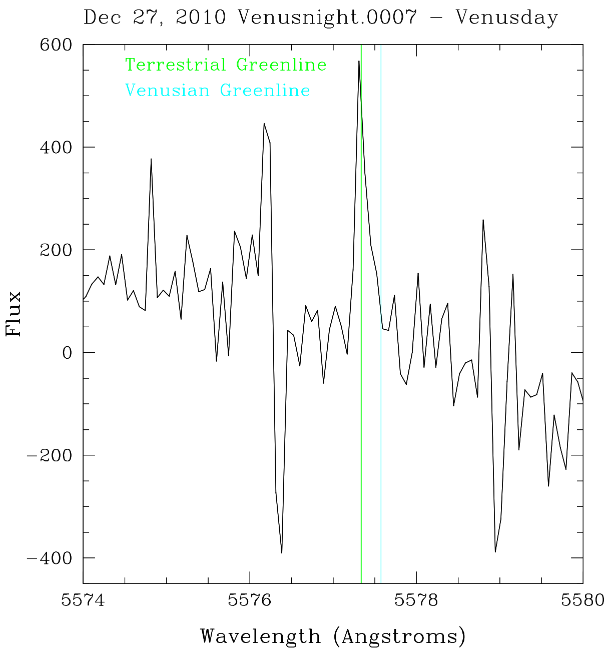

Figure 6: Result of scaled day side spectra subtracted from night side spectrum (venusnight.0007.fits.

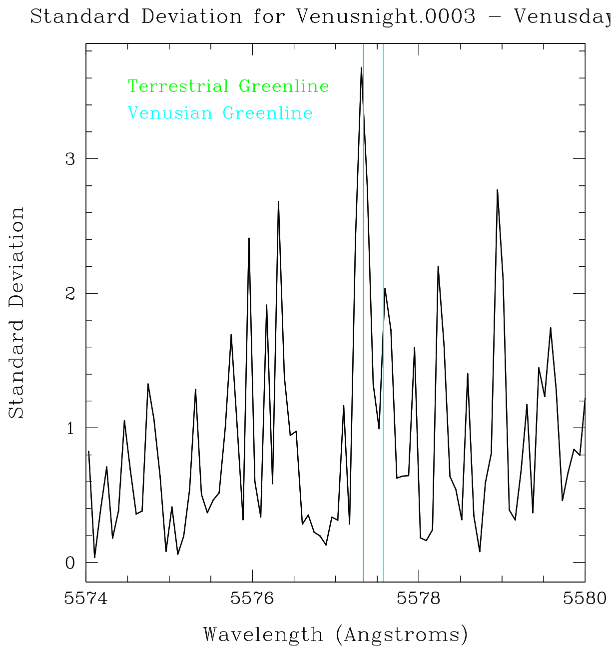

Figure 7: Standard deviation of features for venusnight.0003.fits. Notice the large peak at 5576.5 $\mathring{A}$ and 5579 $\mathring{A}$. This is due to the unequal shape of the Fraunhofer lines on the Venus night and day side.

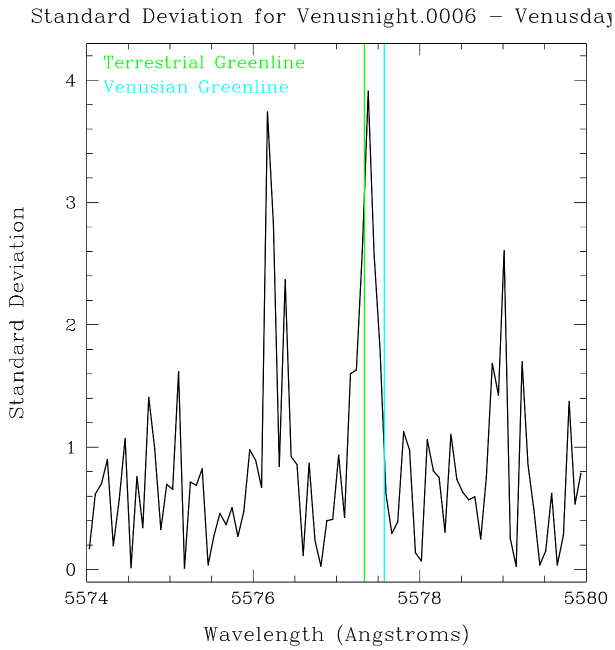

Figure 8: Standard deviation of features for venusnight.0006.fits.

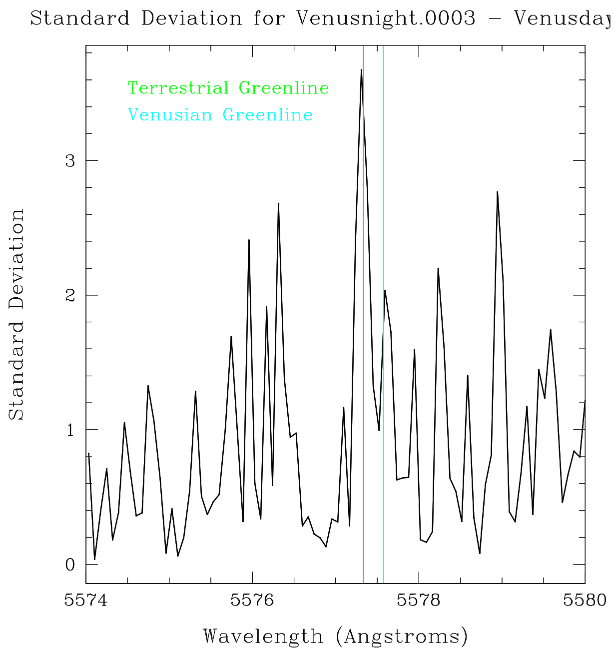

Figure 9: Standard deviation of features for venusnight.0007.fits.