DISTRIBUTION OF THE O_2 NIGHTGLOW AT VENUS FROM THE NASA INFRARED TELESCOPE FACILITY (IRTF) SPEX INSTRUMENT. E. M. Royer[1], E. F. Young[2] and M. A. Bullock[3], [1]Planetary Science Institute, 1700 East Fort Lowell Suite 106, Tucson, AZ 85719, emilieroyer@psi.edu, [2]Southwest Research Institute, 1050 Walnut St #300, Boulder, CO 80302, [3]Science and Technology Corporation, Boulder, CO

Introduction: We present a new technique to retrieve the O_2 nightglow signal at Venus using the IRTF Spex Instrument. Airglow emissions occurring in Venus' upper atmosphere are ideal tracers of the atmospheric dynamics at high altitudes between 90 and 120 km. In particular, the 1.27 µm O_2 airglow, peaking around 95 km of altitude, is at the convergence of two circulation regimes: a retrograde superrotating zonal flow below ~100 km and a sub-solar/anti-solar circulation (SSAS) above 100 km altitude. The O_2 airglow arises from the three-body recombination reaction of oxygen atoms that were produced during daytime from the photo-dissociation of CO_2, CO, O_3 and O_2. Its counterpart, the nitric oxide (NO) nightglow, peaks at about 110 km of altitude and arises from the night side radiative recombination of oxygen and nitrogen atoms produced similarly on the dayside.

From 2006 to 2014, the European Space Agency (ESA) Venus Express (VEX) mission provided us with extended observations of both the NO and O_2 nightglow at Venus and demonstrated the complexity of the dynamical pattern in Venus' thermosphere. According to models of the sub-solar/anti-solar circulation, both the NO and O_2 nightglow are expected to peak at equatorial latitudes at midnight solar local time. This behavior was generally observed for the O_2 nightglow. However, the NO nightglow, whose peak is only about 15 km above the O_2 peak, is shifted toward southern latitudes and 2AM local time. To date, models are not able to reproduce such discrepancies in the behavior of the two nightglows, illustrating our need of additional datasets for a better understanding of Venus' upper atmosphere dynamics and transport mechanisms.

By using IRTF SpeX ground-based observations taken before, during and after the VEX mission, our objective is to complete the spatial and temporal coverage and improve our knowledge of the characteristics of the O_2 airglow at Venus. In particular, data from the Visible and Infrared Thermal Imaging Spectrometer (VIRTIS) instrument onboard Venus Express have shown a second localized maximum near 50ºN and 30º N, which is not currently reproduced in models and can be investigated using the IRTF-SpeX data.

Method: The SpeX instrument acquired Venus observations from 2001 to 2020, through a program dedicated to the investigation of the Venusian clouds. However, signal from the 1.27 µm O_2 airglow (an average of 2 images at 1.27 µm per night) was also acquired during observations. The new technique presented here allows for the retrieval of the O_2 airglow intensity and distribution from this dataset, as shown in Figure 1. Corrections for stray light, thermal emission from the lower atmosphere of Venus, sky background, telluric absorption and correction of Venus O_2 airglow emission that is scattered to the Earth by the underlying clouds were applied to extract the O_2 nightglow brightness. Scanning the SpeX slit across Venus' disk provide the necessary spatial coverage to image nightglow patches at the limb and on the disk.

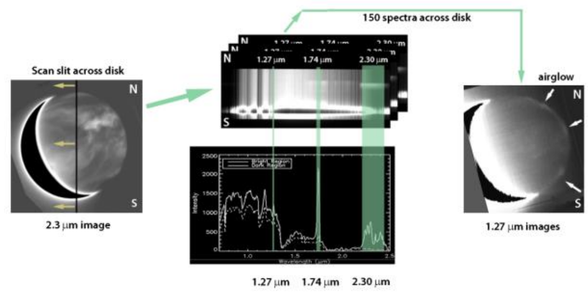

Figure 1: Construction of an O_2 IRTF SpeX Image. The cartoon shows a SpeX spectrum (center_bottom) and its associated spectral cube showing spectral and spatial variations across the Venus disk (center_top). O_2 images are created by stacking multiple slit exposures from a scan across the Venus disk. The 2.3 µm image on the left displays the position of the slit. The resulting O_2 image at 1.27 µm is shown on the right. White arrows on the picture on the right indicate the position of O_2 airglow patches visible at the limb.

Geometrical correction is then applied to retrieve the latitude and longitude of each pixel on the disk and to reconstruct a geometrically accurate image of the Venus disk as seen at 1.27 µm. Slight variations in the telescope's tracking and timing of spectrum exposures during a scan sometimes result in Venus not appearing as a circular disk. Since each spectrum is accompanied by simultaneous imaging by the SpeX guide camera, we can determine the location of the slit on Venus' disk with a 1-σ error of about 60 - 100 km in all directions.

This unique dataset provides a novel vantage point on the O_2 1.27 µm at Venus, allowing for the analysis of short-term nightglow morphology changes on nights when the SpeX instrument acquired multiples images. Additionally, the 19 years of available data also provide the necessary information for long-term analysis of the airglow behavior, complementary to existing mission datasets.