# Characterising Atmospheric Gravity Waves on the nightside of Venus – A Systematic Study

José Silva (1), Pedro Machado (1), Javier Peralta(2), Francisco Brasil(1)

1 – Instituto de Astrofísica e Ciências do Espaço, Portugal;
2 - Institute of Space and Astronautical Science (ISAS/JAXA), Kanagawa, Japan;

Author contact: jsilva@oal.ul.pt

## Atmospheric Gravity Waves (AGW)

- Oscillatory disturbance on the atmosphere in which buoyancy acts as the restoring force. Only possible on a stably stratified atmospheric layer. Represent an efficient transport mechanism of energy and momentum across layers of the atmosphere.
- AGWs have been detected on Jupiter's cloud deck and temperature profile, on Mars' atmosphere (cloud formations) and on Venus' temperature profiles, upper and lower cloud decks.
- Source on other planets is currently unknown! Possible theories include Kelvin-Helmholtz instability, convective instability and topographic influence. Could have an importante role on the Dynamics of atmospheres of several planets, particularly Venus.
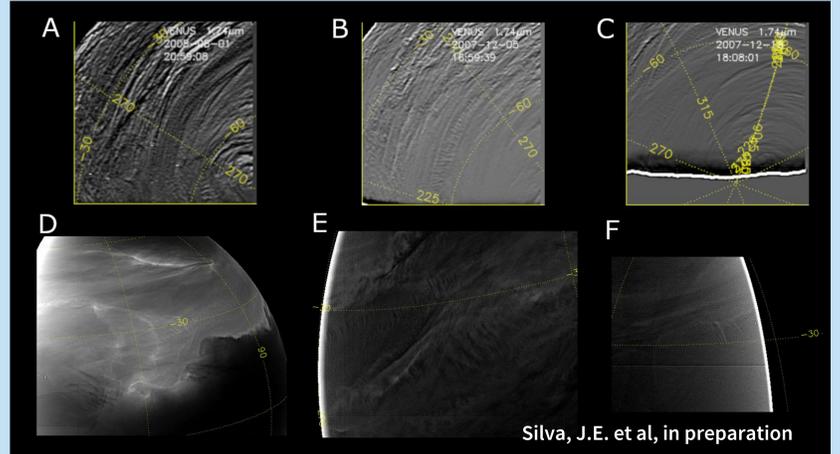


Fig 1 : Examples of detected waves on navigated images. A-C: VIRTIS images processed with a directional kernel and unsharp masking; D-F: IR2 images processed with Unsharp Masking and histogram equalization..

## Detection and Characterisation (VIRTIS and IR2)

- Observations with two instruments aboard different spacecrafts, Venus Express (VIRTIS) and Akatsuki (IR2):
  - VIRTIS (Visual and Infrared Thermal Imaging Spectrometer) that was able to retrieve both spectra and images on UV, visible and infrared wavelengths, accumulating them on a single cube of images;
  - IR2 (Infrared 2 μm camera) which is able to study weather events on the nightside of Venus, analysis the lower cloud layer at 44-48 km of altitude
- Image processing with dedicated software, mainly contrast enhancement techniques are applied to spacecraft data for AGW detection and further characterisation;
- Images are navigated with SPICE data for Manual and Semi-Automatic characterisation of the wave packets, which is performed for positive detections: Horizontal Wavelengths, Packet Lengths and Width, Location and Orientation. When possible the dynamics of the wave packets were also studied.
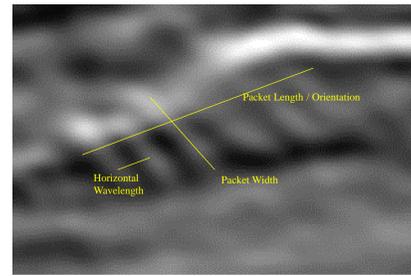


Fig 2: Morphological properties measurement. A line is traced on the navigated image so the distance between the two points and the orientation of the packet can be calculated below. Each property is measured at least 10 times for statistical robustness.

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$$Orientation = \tan^{-1}\frac{\Delta Lat}{\Delta Lon}$$

$$\underline{Distance\ Measurement}$$
$$\frac{\pi\sqrt{(Lon_2 - Lon_1)^2 + (Lat_2 - Lat_1)^2}}{180} \times \cos(Lat_{avg} \times \frac{\pi}{180}) \times (R_{Venus} + Height)$$

## Results

- Covered the entire VIRTIS-IR and IR2 data set for wave detection;
- In total we have close to 300 wave packet characterisations regarding their morphology and 170 dynamical results.
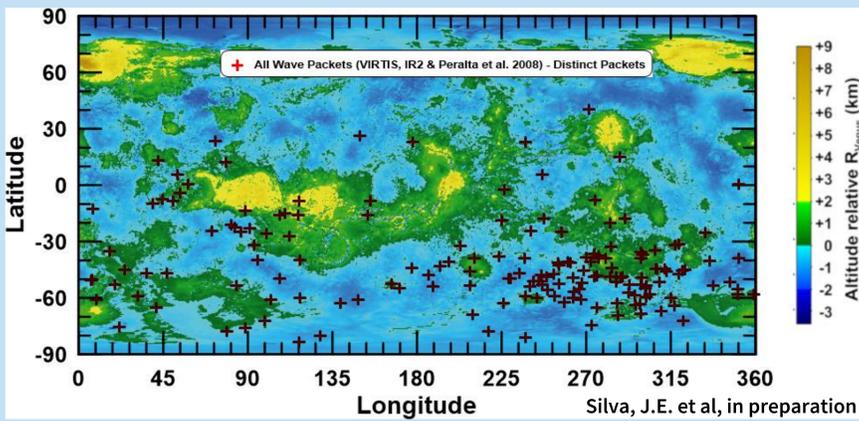


Fig 3: Topographic map Venus with the location of detected wave packets on the lower cloud (44-48 km). Each cross in this map is a different wave packet that was characterised. Credits: Magellan/NASA.

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Fig 5: Histogram plots of the morphological properties of retrieved waves on nightside images of VIRTIS-IR and VCO-IR2. Also included are the data from Peralta et al. 2008.
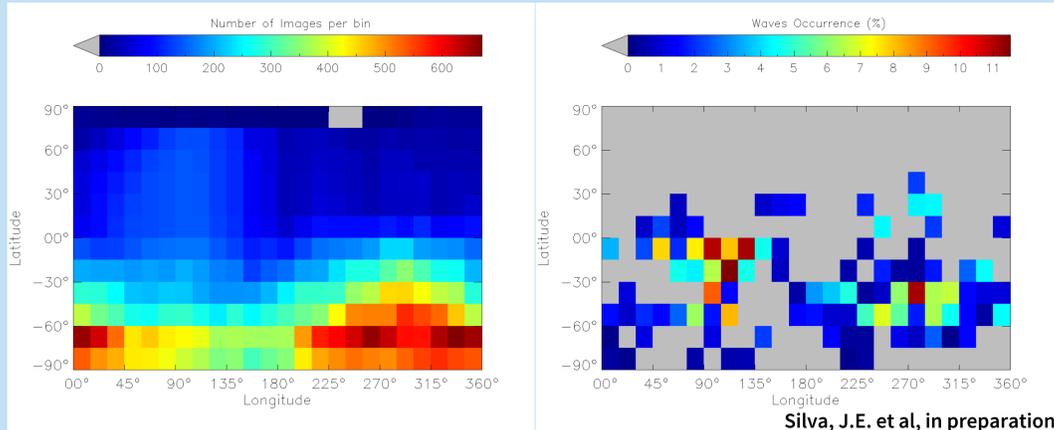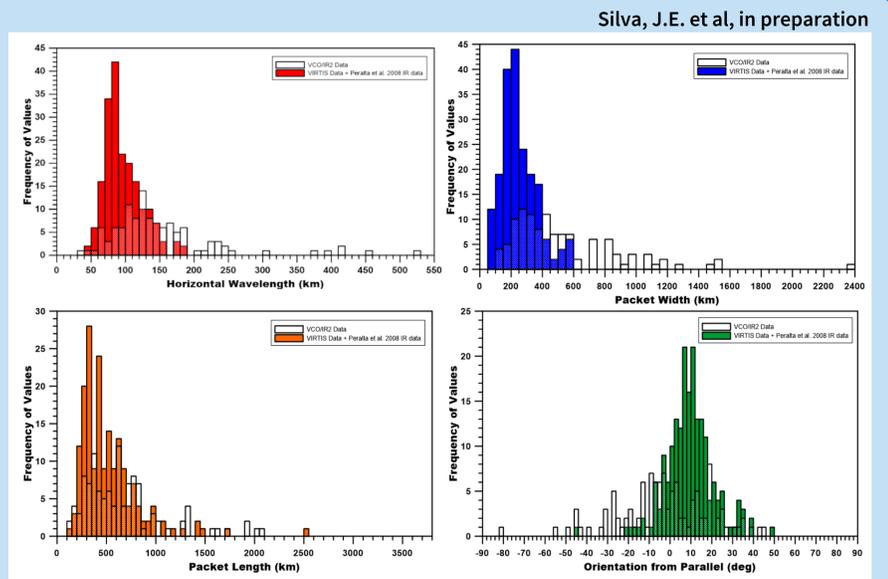


Fig 4: (left) Latitude/Longitude coverage map of VIRTIS and IR2 images during the period of observation for both datasets. It shows a higher number of images on the southern hemisphere; (right) Latitude/Longitude map of the percentage of wave occurrence within the number of images analysed.

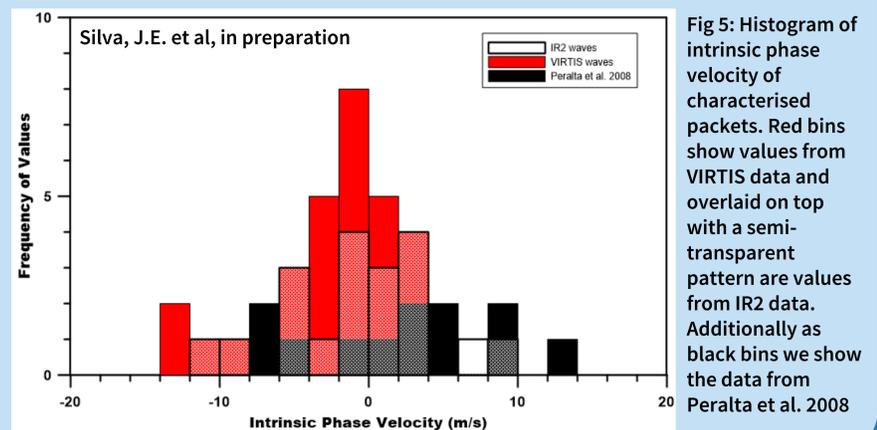Silva, J.E. et al, in preparation



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Fig 5: Histogram of intrinsic phase velocity of characterised packets. Red bins show values from VIRTIS data and overlaid on top with a semi-transparent pattern are values from IR2 data. Additionally as black bins we show the data from Peralta et al. 2008

### References

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