

Context

Since 1929, polarization has been used to characterize Venus' clouds and hazes refractive index, size and distribution. Most of our knowledge is based on measurements and modelisation made by Lyot[4], Hansen and Hovenier[1], Kawabata [2] and Sato[5] with ground and space observation. Our goal here is to make new measurements using the polarimetric data provided by the instrument SPICAV on Venus Express.

| | Main cloud layer | Hazes |
|-------------|--|--|
| Altitude | 50 to 75 km | 30 to 90 km |
| Composition | H ₂ SO ₄ -H ₂ O | H ₂ SO ₄ -H ₂ O |
| Radius | $r \sim 1 \mu\text{m}$ | $r \sim 0.25 \mu\text{m}$ |

Table: Current knowledge of Venus clouds.

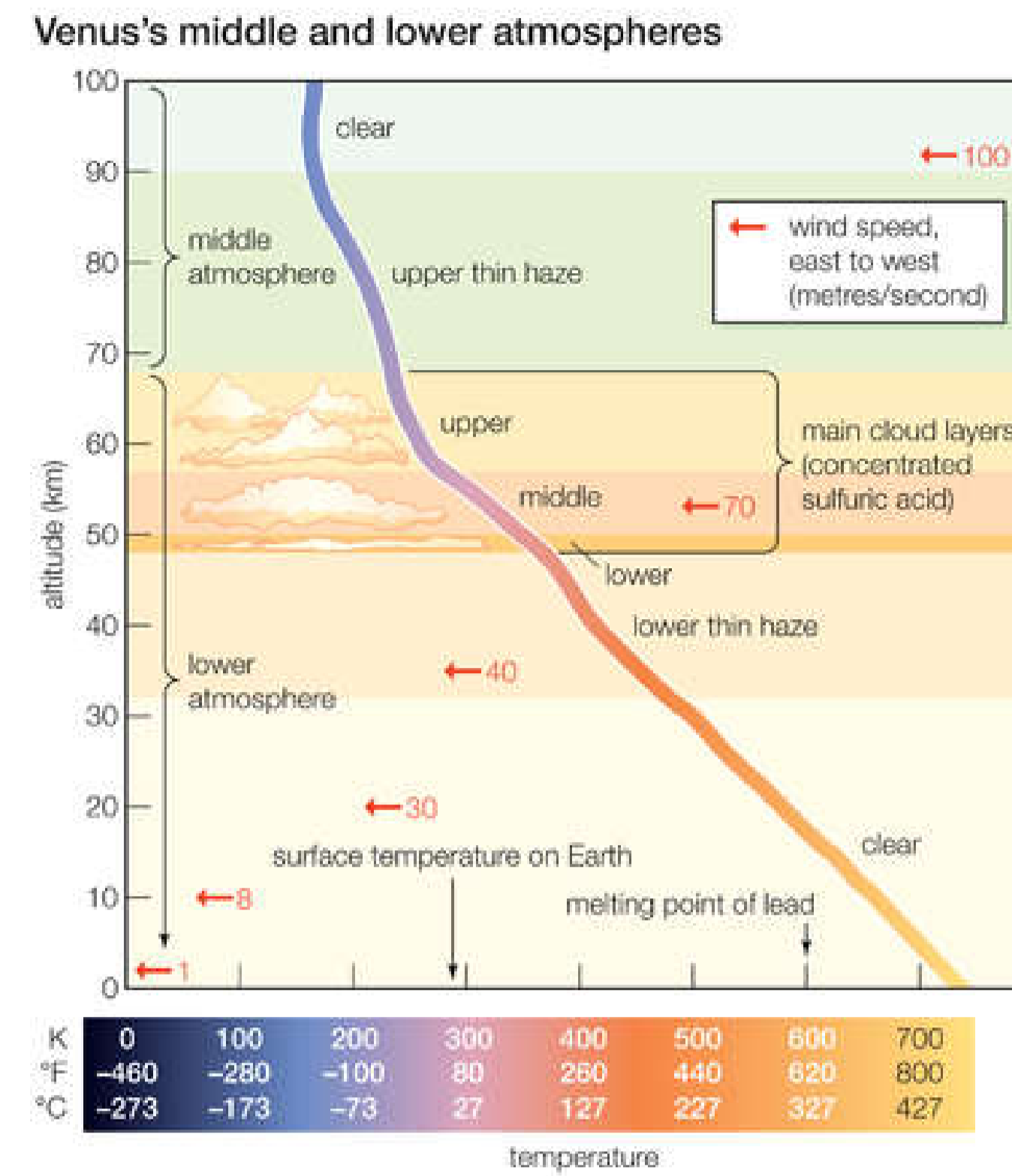


Figure: Structure of Venus clouds

Scattering processes

Depending on the radius r and the wavelength of observation, different scattering processes are involved. They can be distinguished with the size parameter $x = \frac{2\pi r}{\lambda}$.

Rayleigh regime ($x \ll 1$):

Isotropic diffusion, cross-section $\propto 1/\lambda^4$. Linear polarization is +100% for $\theta = 90^\circ$

Mie regime ($x \geq 1$):

Strong forward scattering. Polarization patterns are much more complicated. Dependence in n and x . Generates optical features such as glories at low phase angles. Particle size distribution described by r_{eff} , mean radius and ν_{eff} variance of the distribution.

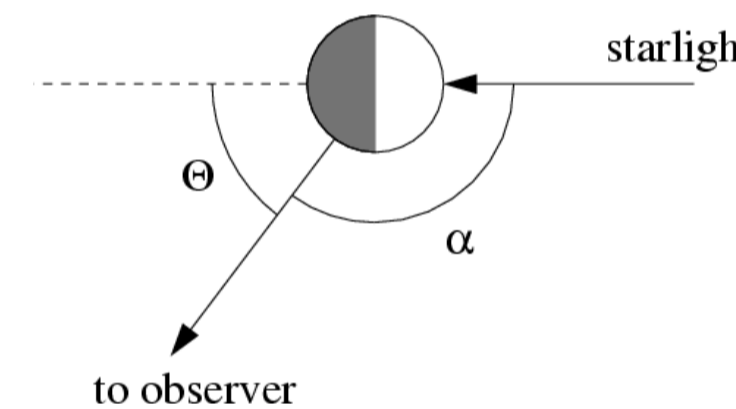


Figure: Illustration of the scattering angle Θ and the phase angle α .

Mie model

► Model based on spherical drops with $n_i \sim 0$

► $x \rightarrow 0$: Rayleigh regime

► Glory: strong negative polarization feature near 20° .

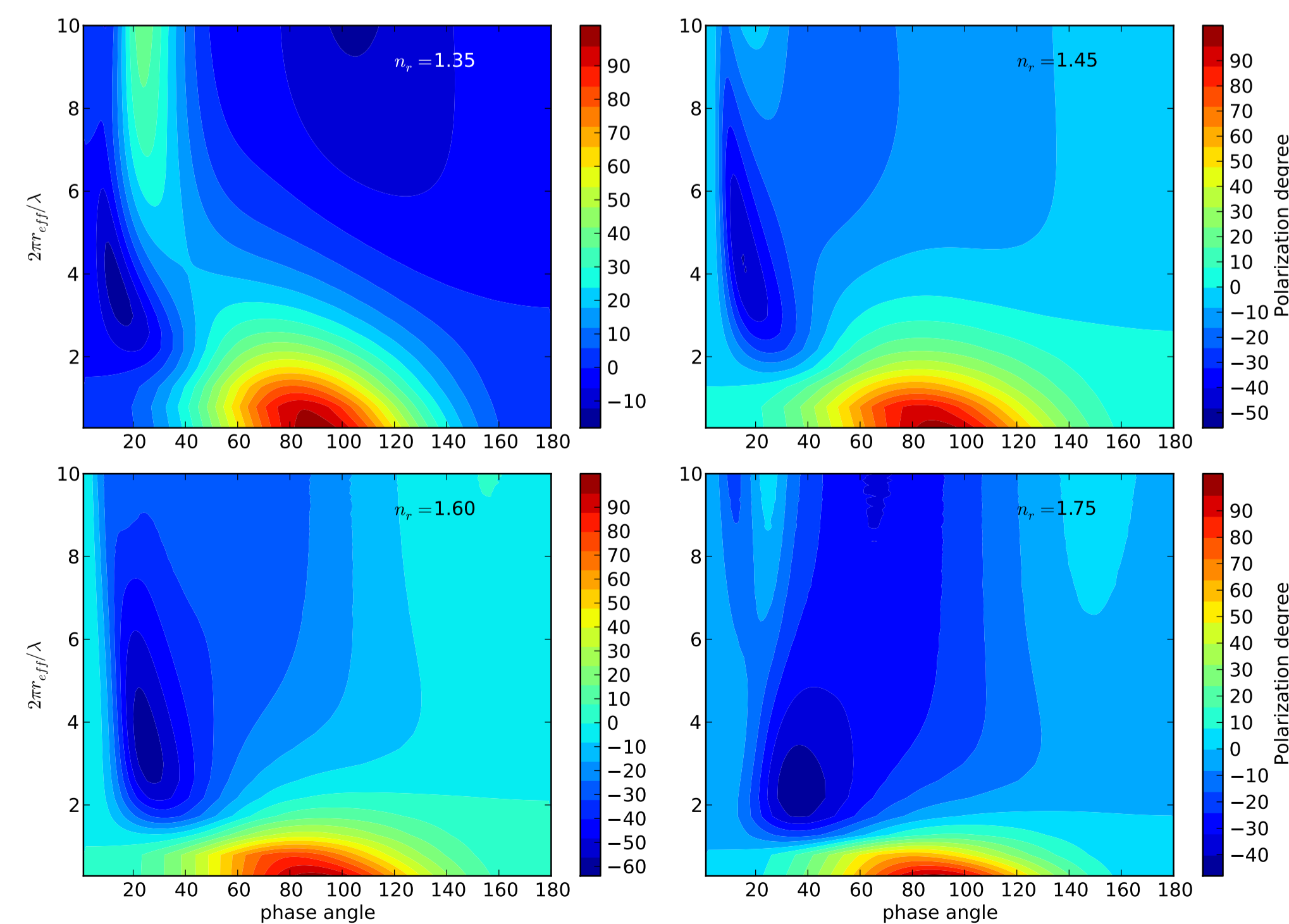


Figure: Linear polarization degree in function of phase angle and size parameter for four values of refractive index.

SPICAV

SPICAV is a spectrometer onboard the Venus Express spacecraft[3]. Based on an Acousto-Optical Tunable Filter (AOTF) which produces two beams linearly polarized in perpendicular directions.

Measure of the linear polarization degree:

$$P_\ell = \frac{P_\perp - P_\parallel}{P_\perp + P_\parallel} = \frac{d_1 - d_0}{d_1 + d_0}$$

Cross-calibration can be performed by knowing that for any wavelength $P_\ell(\alpha = 0) = 0$. Acquisition is made with spectral windows and sets of 3, 5 or 10 points for continuum measurement. We use the latter points to measure polarization.

| Channel | Coverage |
|---------|--|
| SW | 0.65 μm —1.05 μm |
| LW | 1.05 μm —1.7 μm |

Table: SPICAV characteristics

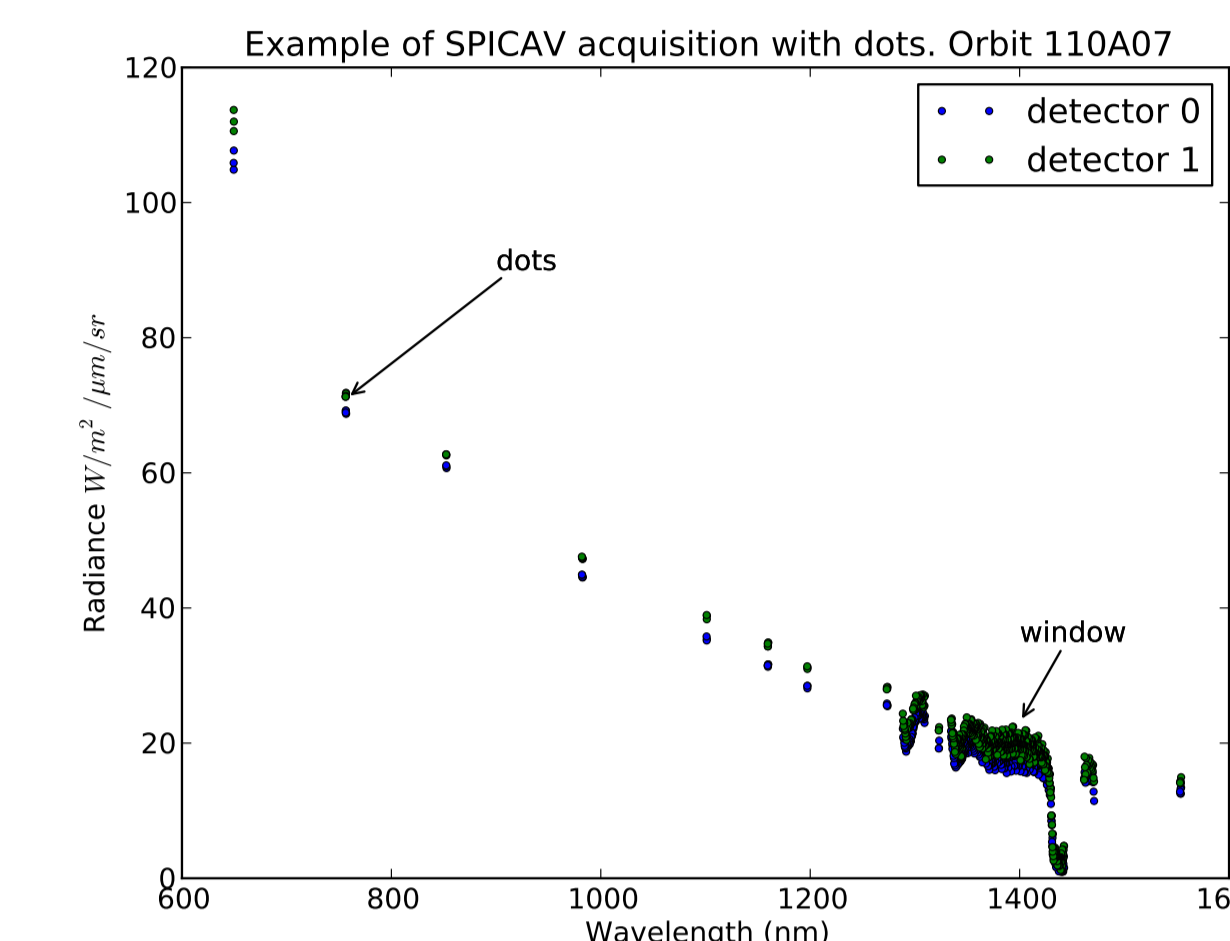


Figure: Example of SPICAV acquisition.

SPICAV observations

- Observations done in nadir mode
- Mostly located on dayside and in northern hemisphere
- Up to 14 wavelengths available

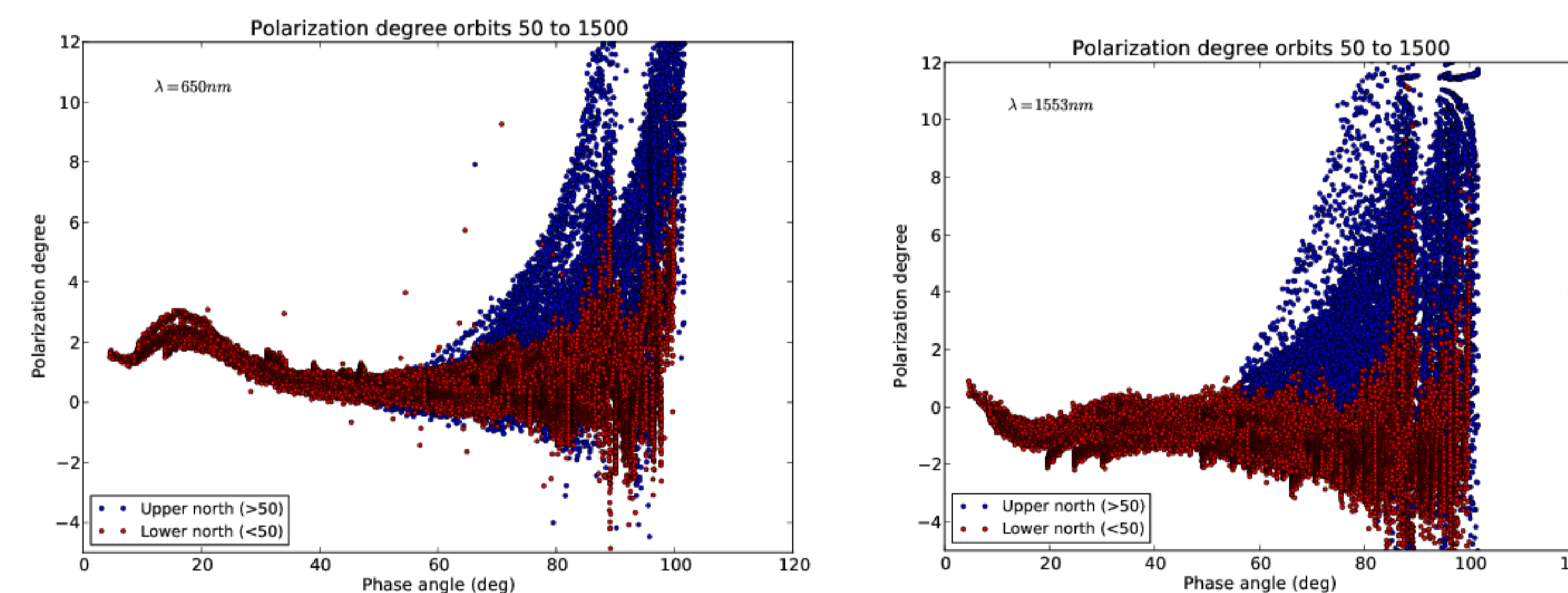


Figure: SPICAV polarization observations at 650 nm and 1553 nm for orbits 50 to 1500. The data show strong polarization for phase angles near 90° .

Strong positive polarization at phase angles near 90° and wavelengths $> 1 \mu\text{m}$ not compatible with $r \sim 1 \mu\text{m}$ particles, Rayleigh-like scatterers as the hazes ($r \sim 0.25 \mu\text{m}$) are necessary. Their influence is more visible at high latitudes which indicates a latitudinal variability with more hazes at higher latitudes.

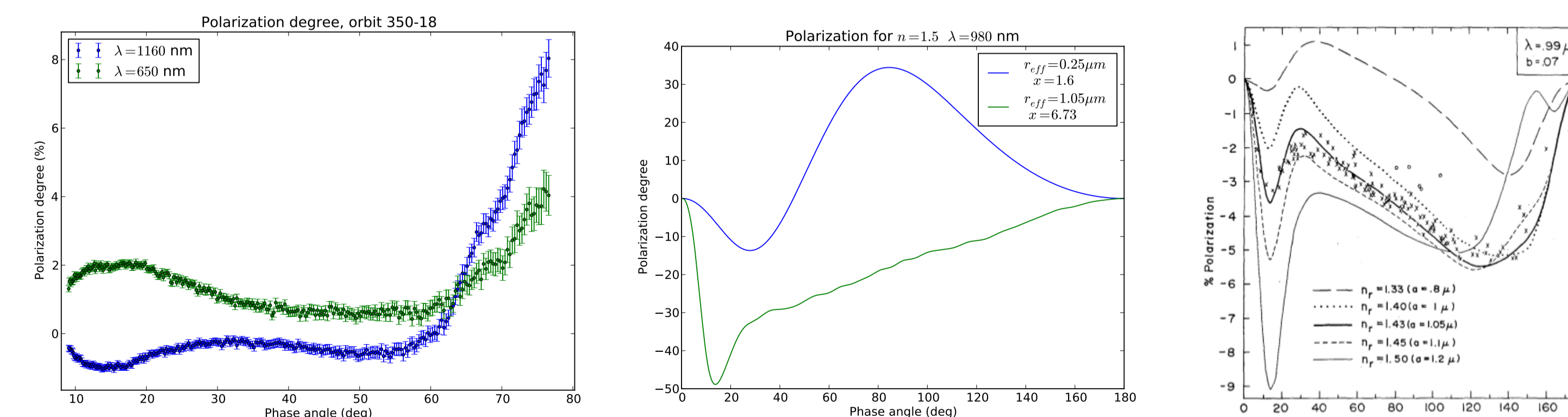


Figure: Left: Polarization observation for orbit 350-18 with error bars at 650 nm and 1160 nm. Middle: two scattering models for different size parameters. Right: Polarization observations at 990 nm by Hansen and Hovenier[1].

Analysis

The glory position and shape is dependent on values of n_r , r_{eff} and ν_{eff} . We can use this property to constrain the refractive index under a single scattering assumption.

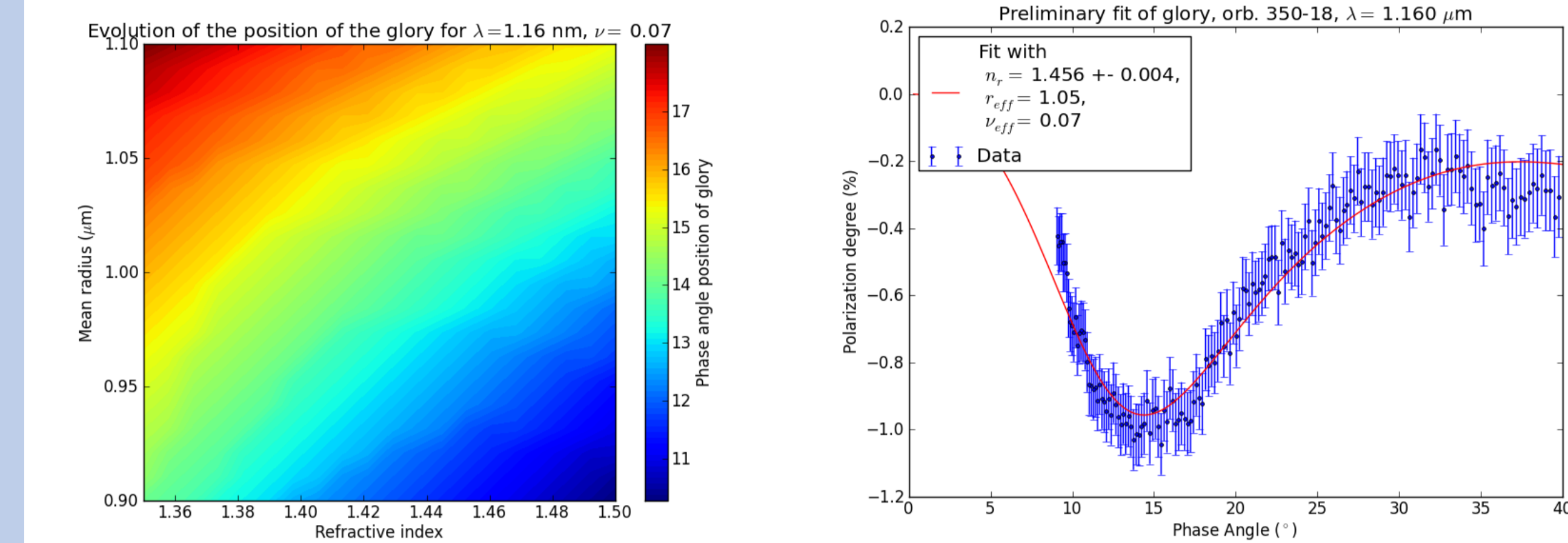


Figure: Left: Glory minimum position with respect to index and mean radius for $\nu_{eff} = 0.07$. Right: preliminary fit of the glory at $\lambda = 1160 \text{ nm}$, with $r_{eff} = 1.05 \mu\text{m}$ and $\nu_{eff} = 0.07$.

Preliminary fit on orbit 350-18 for $r_{eff} = 1.05 \mu\text{m}$ and $\nu_{eff} = 0.07$ yields $n = 1.456 \pm 0.004$ at 1160 nm.

Conclusion and perspectives

Conclusion

- SPICAV polarization data is fully exploitable
- Coherent with previous observations: same features and order of magnitude
- Good coverage in latitude, phase angle and time: possible study of variations
- Glories are a tool to constrain n_r , r_{eff} and ν_{eff}

Perspectives

- Make more studies of the glories under the single scattering assumption
- Integrate the Mie model into a multiple scattering radiative transfer model to fit the observations
- Make use of the spot tracking observations to decouple the SZA and the phase angle
- Investigate the temporal and spatial variability, particularly the latitudinal structure

Aknowldgments

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References

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