# A technique to identify the atmospheric composition of an exoplanet through polarimetry

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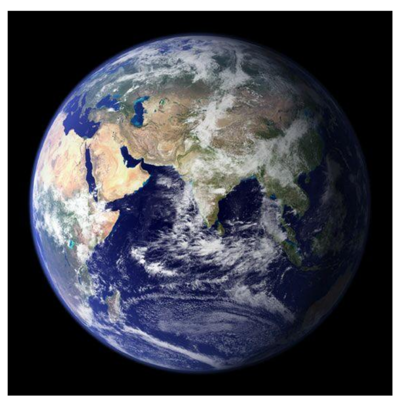
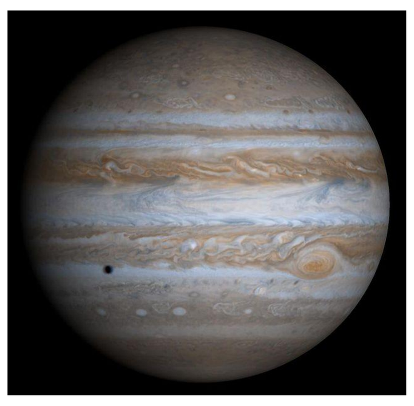
## Abstract

Polarimetry is a powerful tool that can be used to infer the atmospheric properties of an exoplanet, such as, for example, the cloud particle properties. We will discuss how observations in polarization at different wavelengths (λ) and range of phase angles (α) might be used to get information about the surface albedo (A), the molecular scattering optical thickness (τ) and the type of the main gas (through the depolarization factor δ) in the atmosphere of an exoplanet.

$CO_2$?

$N_2$?

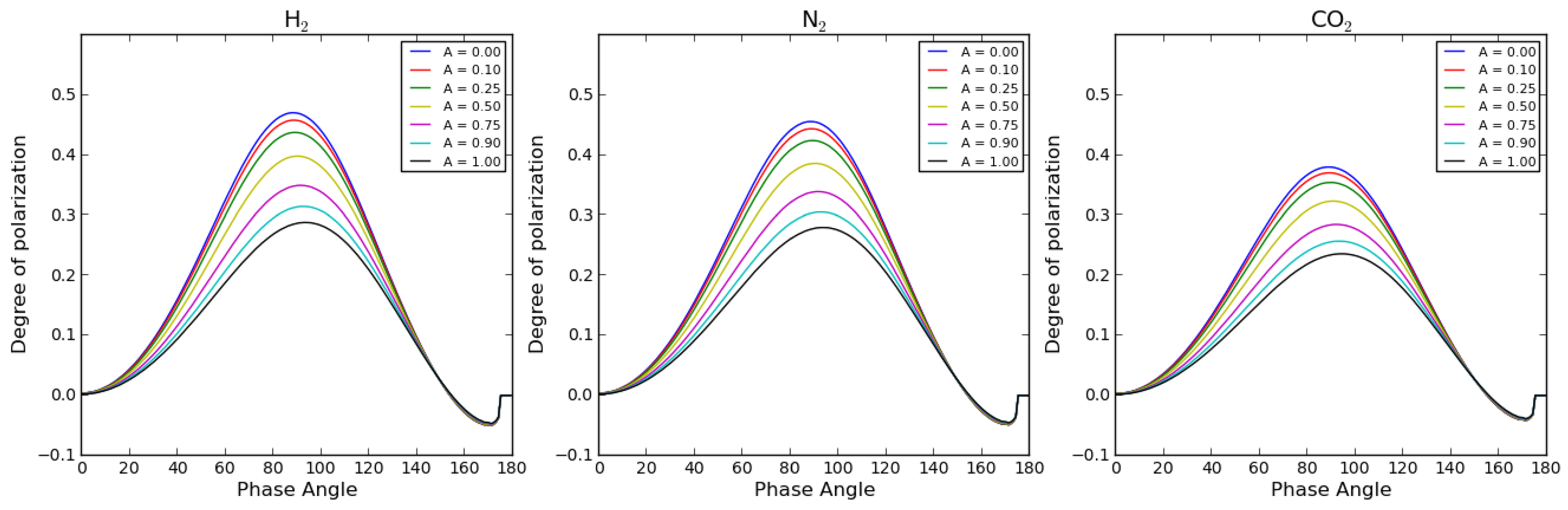




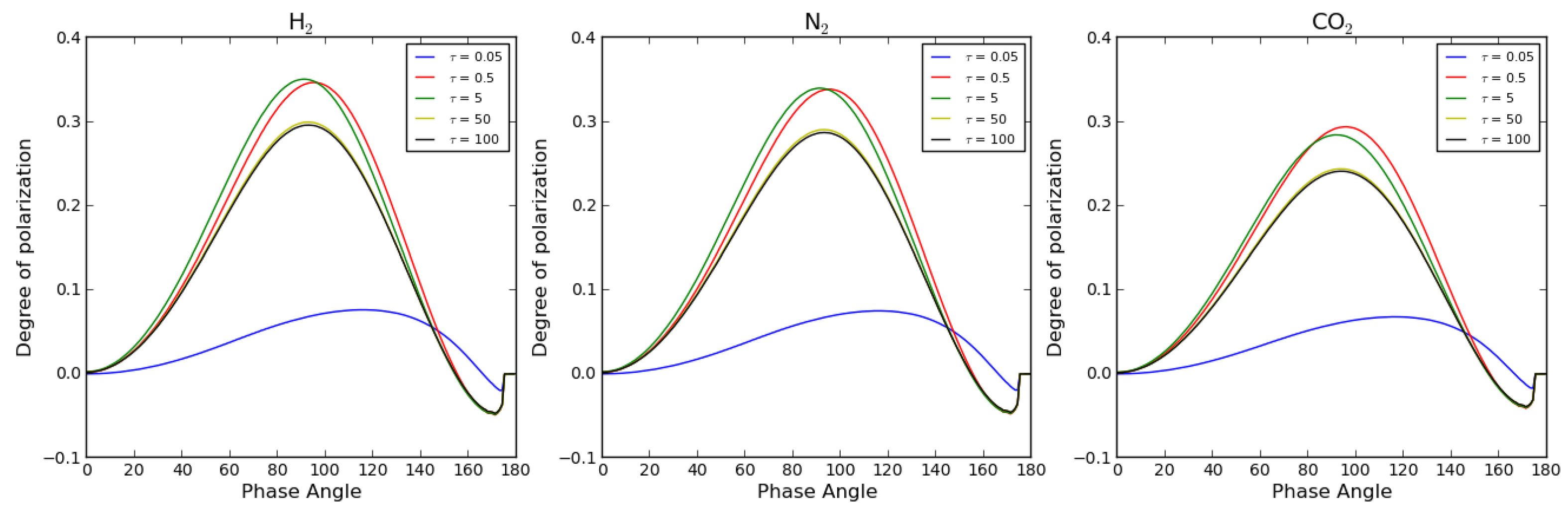
$H_2$?

## Sensitivity of polarized signals

Sensitivity of polarized signals to A ($\tau = 2$).

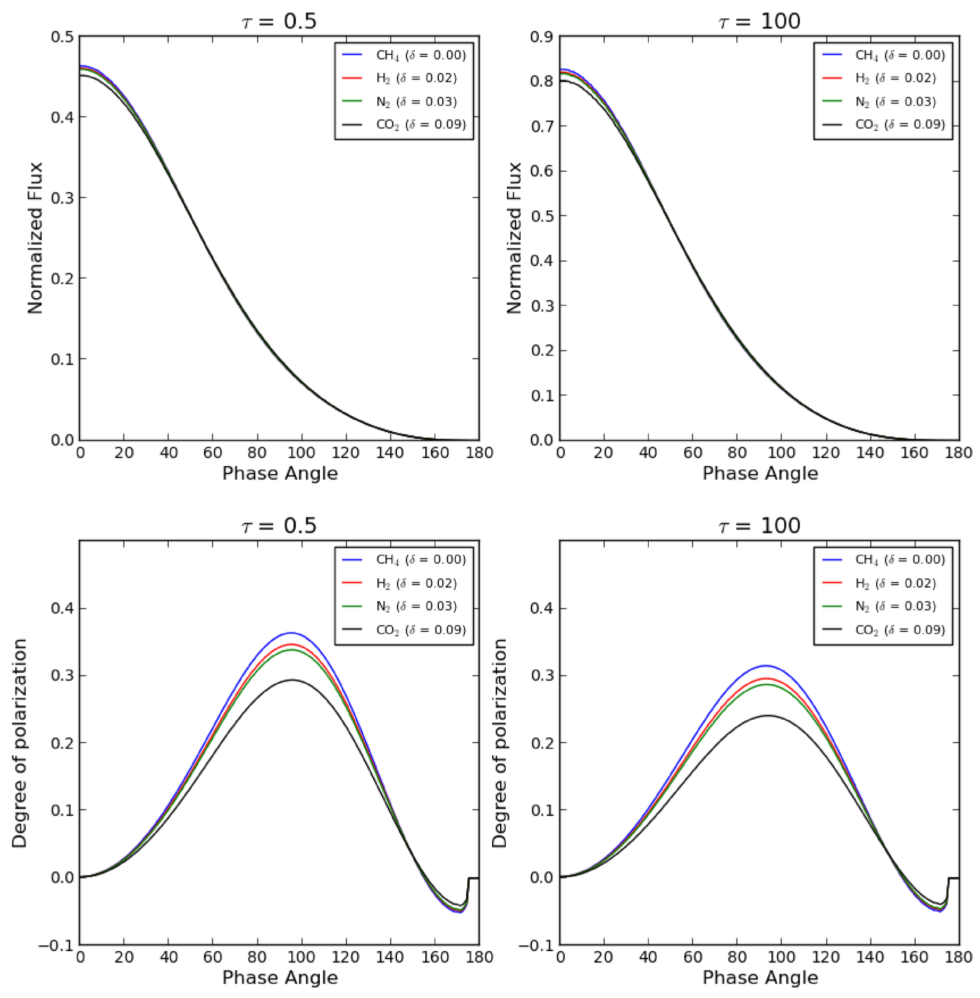



Sensitivity of polarized signals to $\tau$ ($A = 1$).



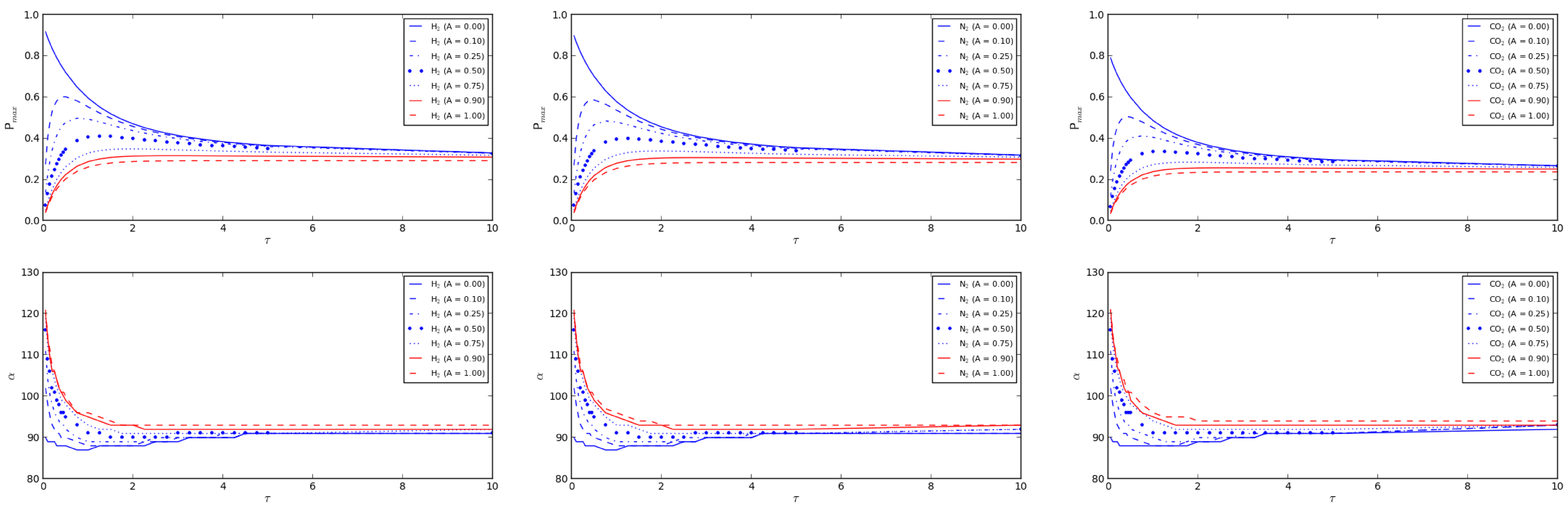

Sensitivity of polarized signals for the depolarization factor ($\tau = 100, A = 1.0$).

The depolarization factor is a measure of the anisotropy of molecules.

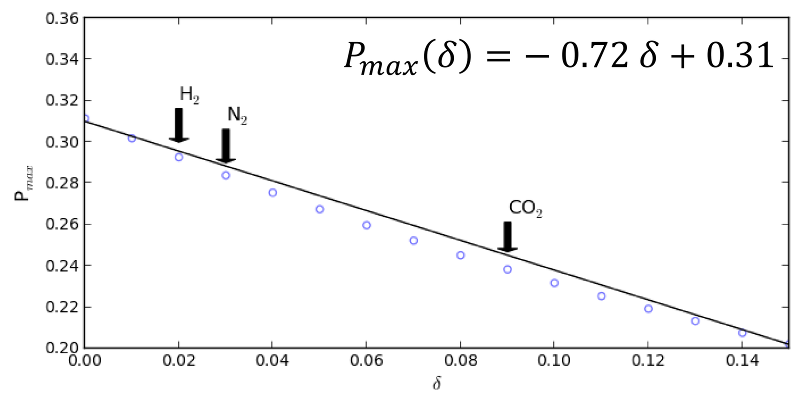



## Method

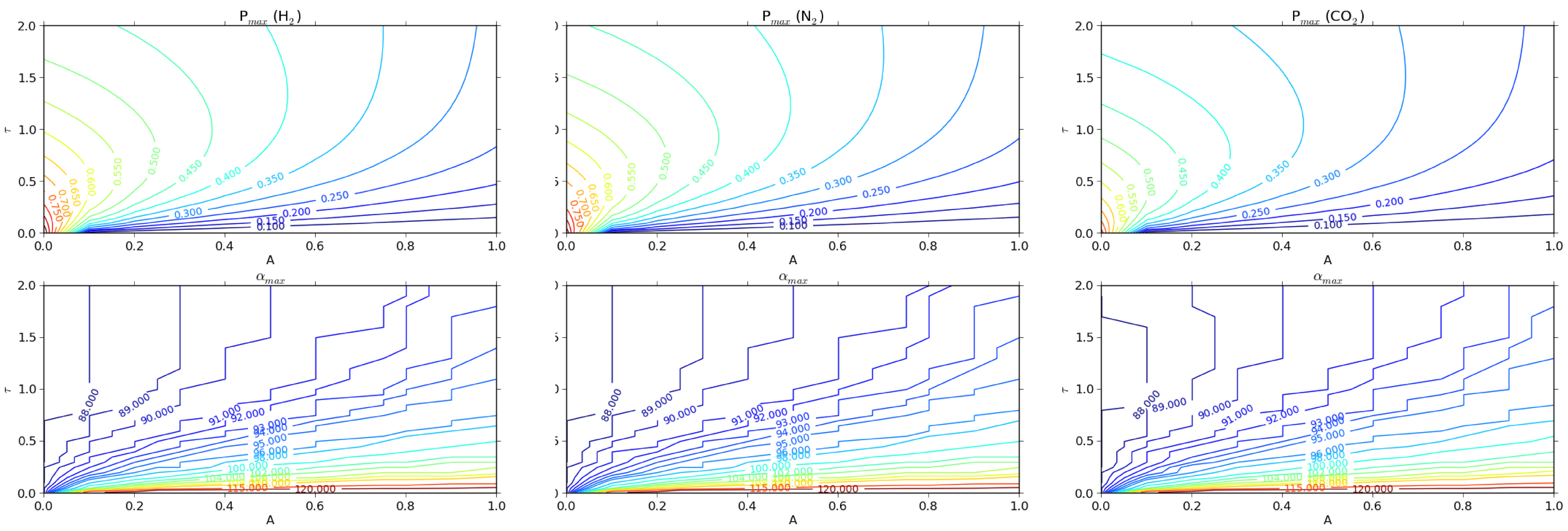
**Step 1:** Analyze if you are in the convergence regime (region where $P_{max}$ does not depend on τ). To identify this regime, one needs the $P_{max}$ values at two wavelengths. It is advisable to check in the continuum wavelengths.



**Step 2:** In the convergence regime, one may derive δ using the formula shown in the plot. Data points were calculated for an atmosphere with τ=100 and a surface albedo A=1.0. The regression formula is represented by the solid curve.




**Step 3:** Once you have identified the main gas of the atmosphere, analyse the contour plots of $P_{max}$ and α shown below, at a longer wavelength (that is not in the convergence regime).




**Example:** $P_{max}$ = 0.4134 and α = 91° (δ = 0.09).

**Input values (Solution):** τ = 0.75 and A = 0.30.

## Summary

To identify the main gas in an atmosphere through this methodology, one need to combine up to three polarized signals measured at different wavelengths.

## Future work

Test the impact of clouds in this method.

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