



SkyPole - A bio-inspired method to locate the north celestial pole

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SkyPole - A bio-inspired method to locate the north celestial pole

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Supervised by Stéphane Viollet¹ and David Duché², in collaboration with Julien R Serres^{1,3} and Marcel Pasquinelli²

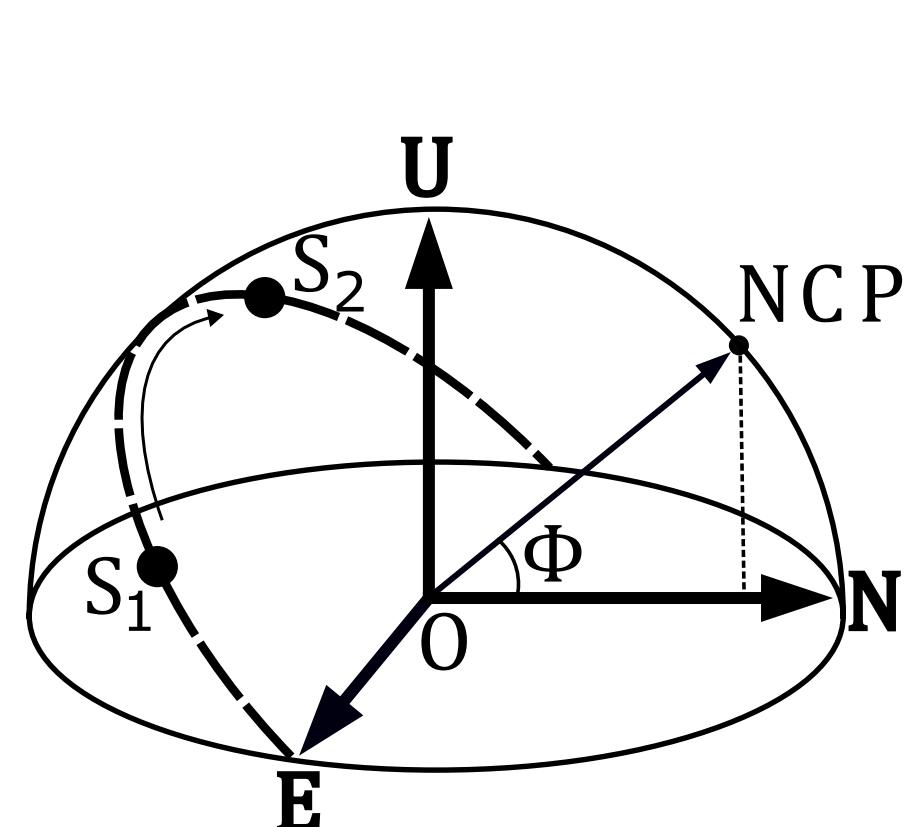
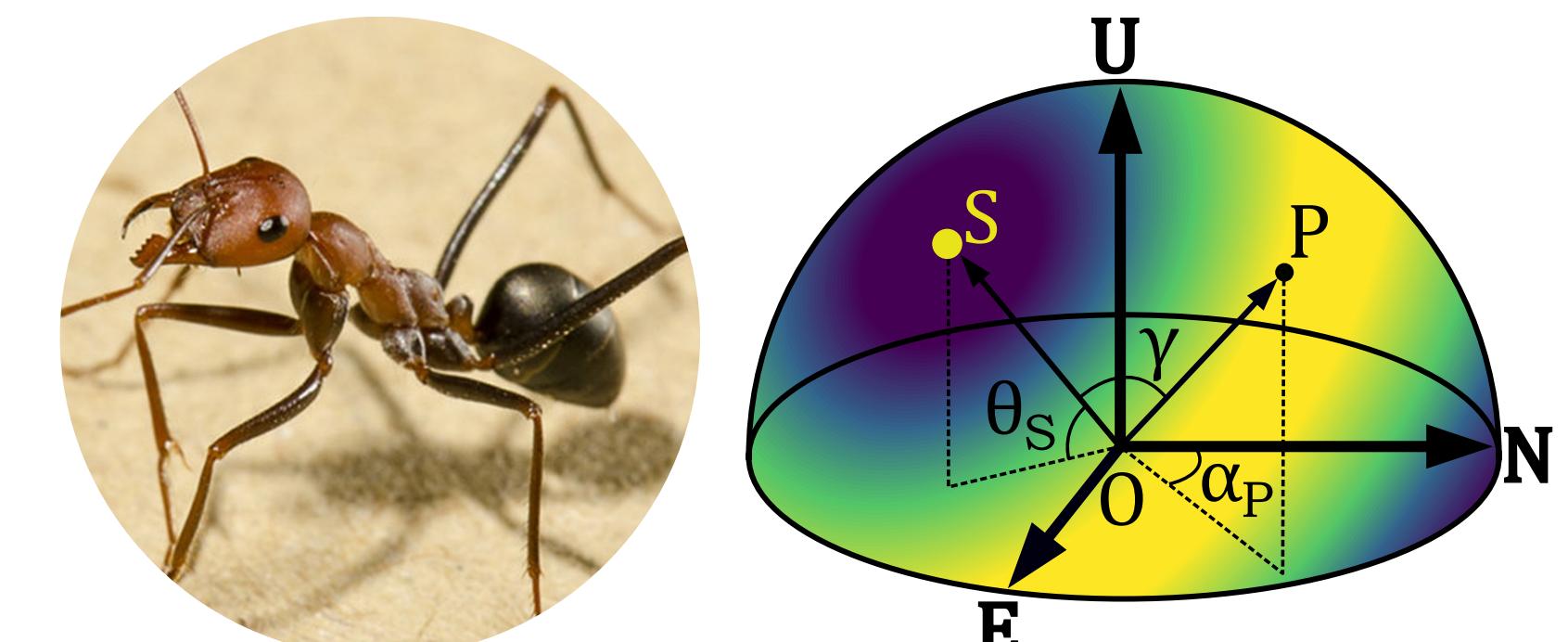
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Polarization vision

- Insects such as *Cataglyphis* desert ants use **skylight polarization to navigate** [1]
- Skylight polarization can be described by its angle and degree of linear polarization (AoLP and DoLP), modeled from **Rayleigh single scattering model** [2]

Animal Navigation



Celestial rotation

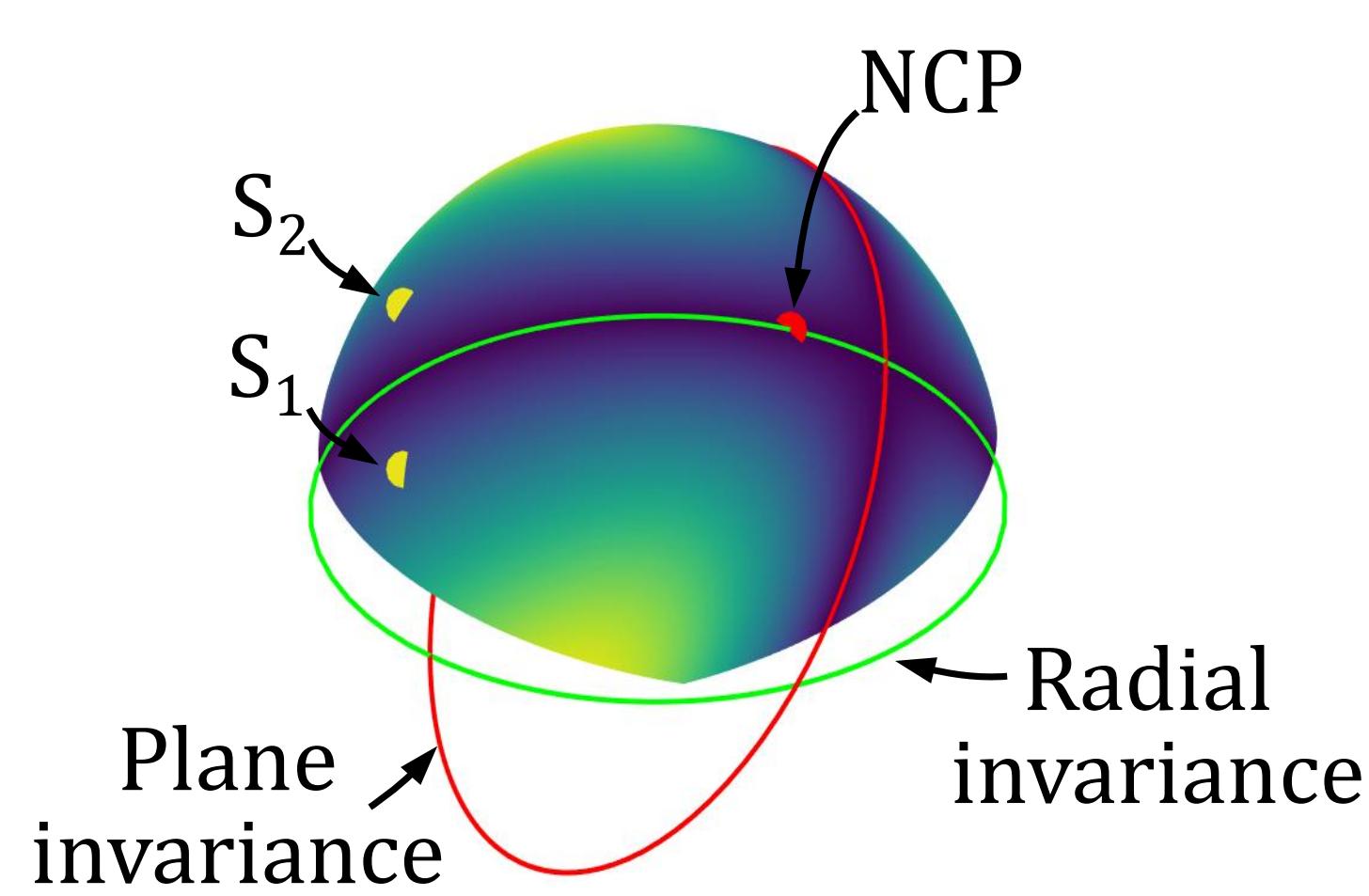
- Migratory birds such as homing pigeons use the **celestial rotation** as a reference for calibrating their magnetic compass [3] [4]
- Celestial rotation helps finding the **North Celestial Pole**, giving access to **geographical north bearing and latitude** [5]
- Celestial rotation can be observed **during night or daytime** [6]

Question

How could the moving skylight polarization pattern be used to locate the north celestial pole?

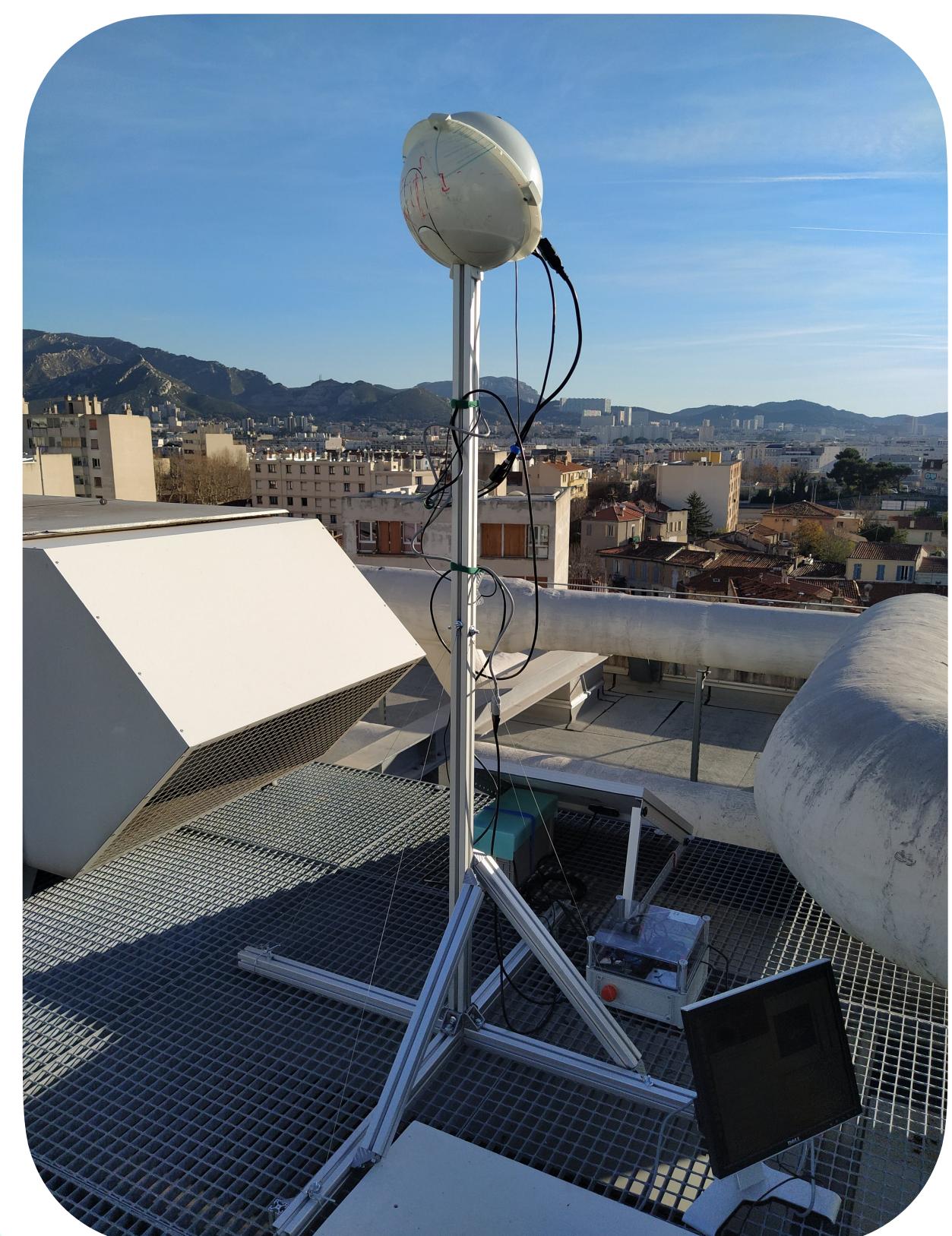
Method

- DoLP has **plane and radial symmetries**
- Due to those symmetries, comparing DoLP at two moments leads to **radial and plane invariance axes**
- **North celestial pole (NCP) is always located on the radial invariance axis**

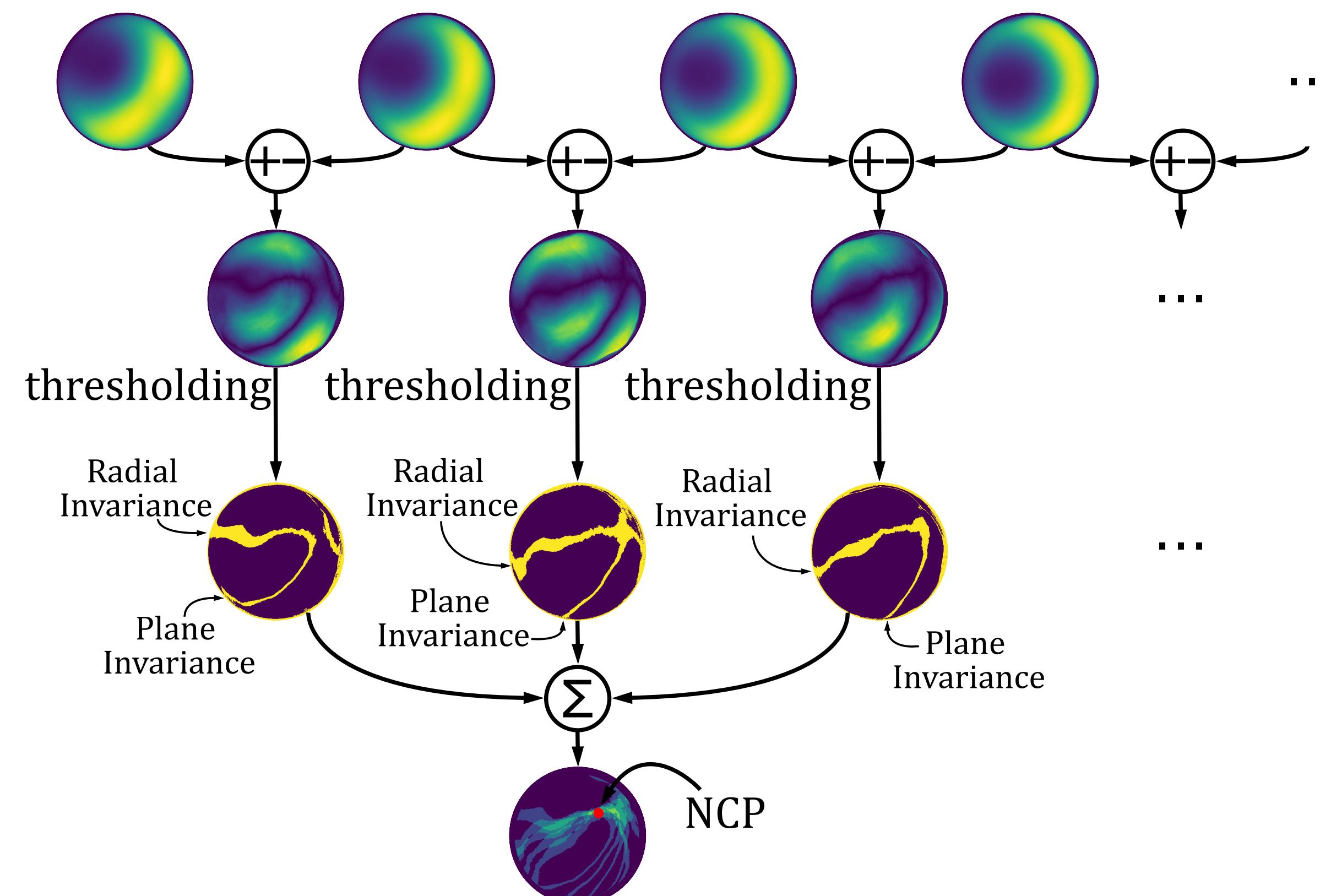


Results

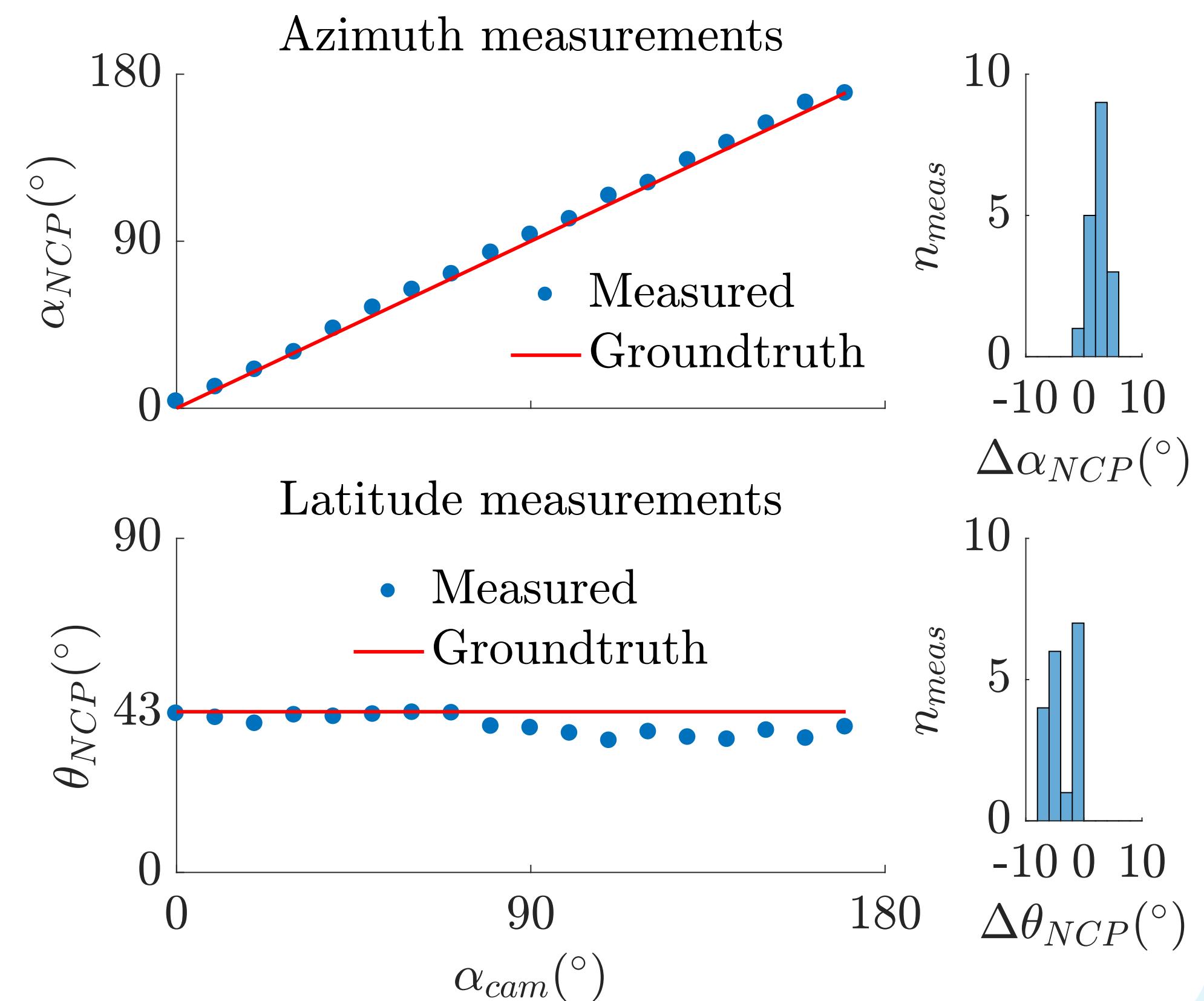
Measurement device



Method implemented on real polarimetric images



Measured north celestial pole's coordinates



Conclusion and Environmental Impact

The proposed method is, to our knowledge, the **only method providing global navigation cues based only on sky polarization images**. No ephemeris, time or GPS signal are required, and its simplicity results in **low computational cost and resources**.

References

- [1] Wehner, Harvard University Press, 2020
- [2] Coulson, A. Deepak Pub., 1988
- [3] Emlen, NASA Spec. Pub., 1972
- [4] Able et al., J. of Comp. Phys., 1995
- [5] Smart, Cambridge University Press, 1977
- [6] Brines, J. Theor. Biol., 1980
- [7] Kronland-Martinet et al., submitted paper, 2023

Image References

- Desert Ant : © Michael Mangan & Hugh Pastoll.
- Homing Pigeon : © Tim Mossholder – Unsplash
- Circumpolar Stars : © Benedikt Markus
- Marseille : Adapted from © Serinus - Pexels