



## SkyPole -A bio-inspired polarimetric compass for GPS-denied navigation

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

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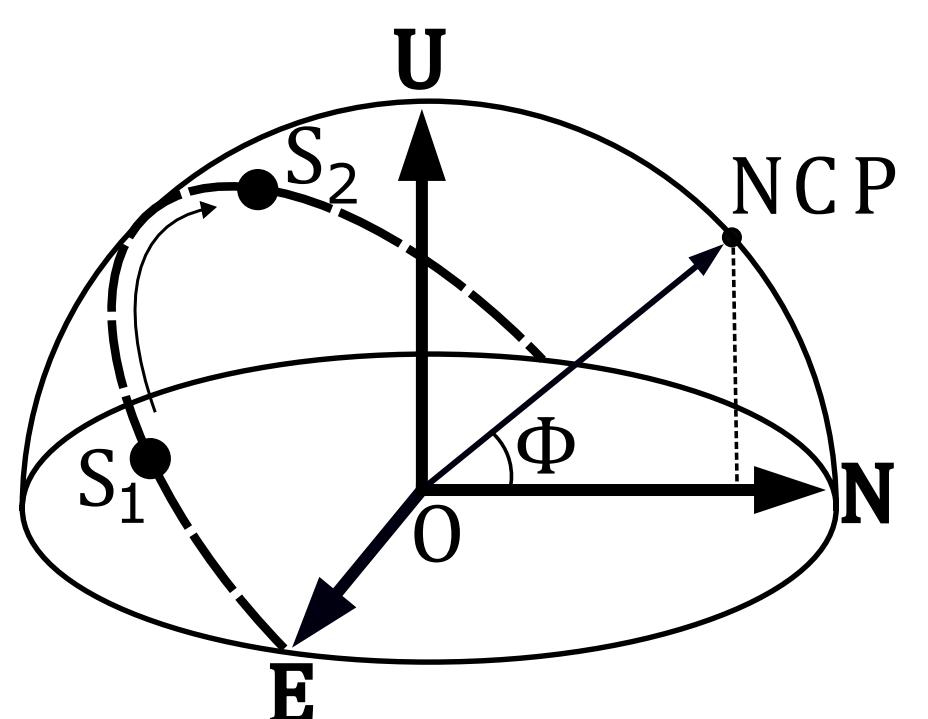
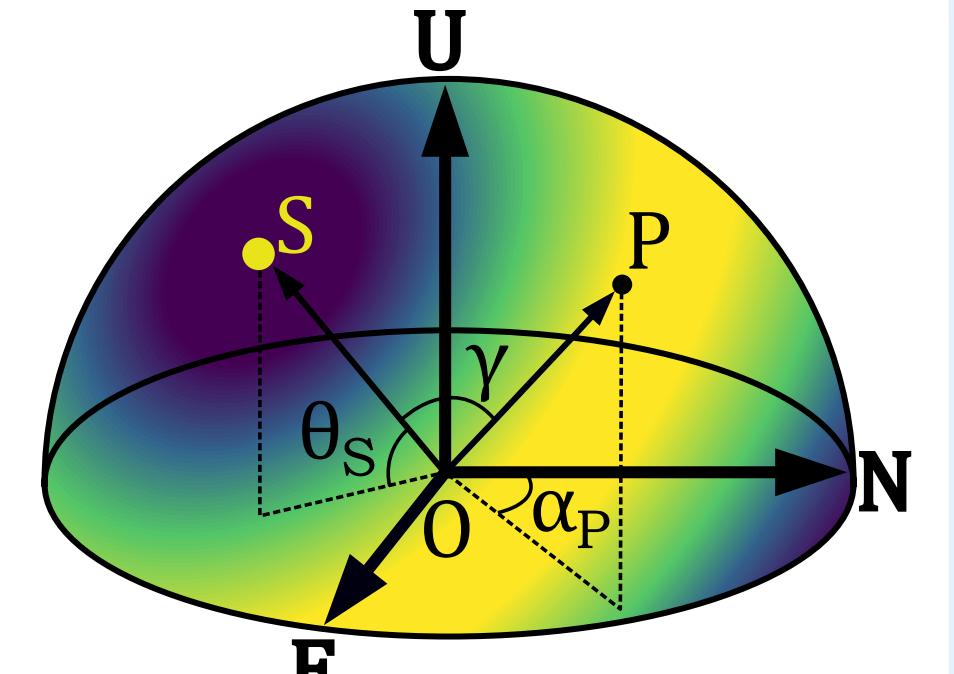
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## Animal Navigation

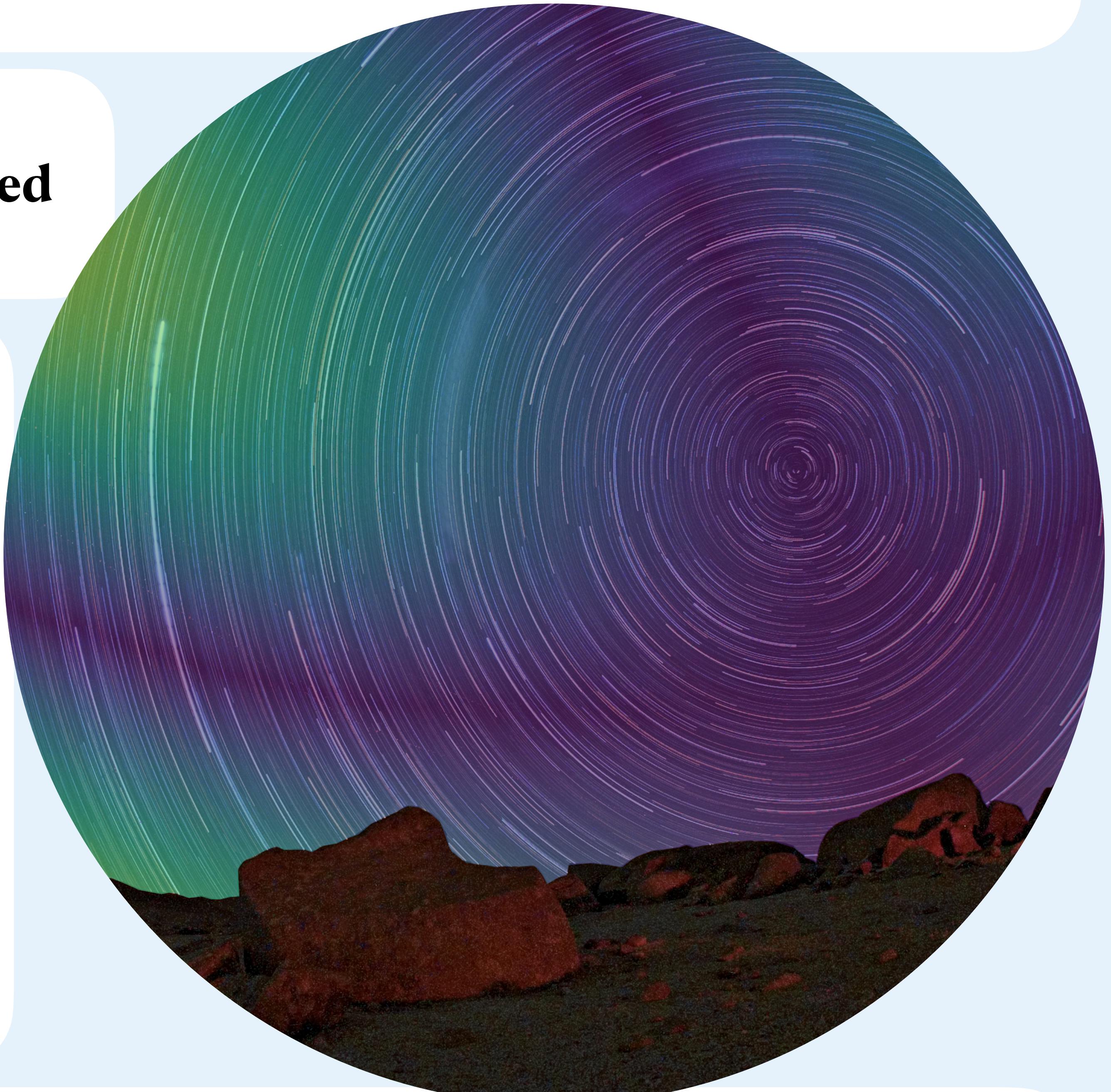
Polarization vision

- 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]



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]

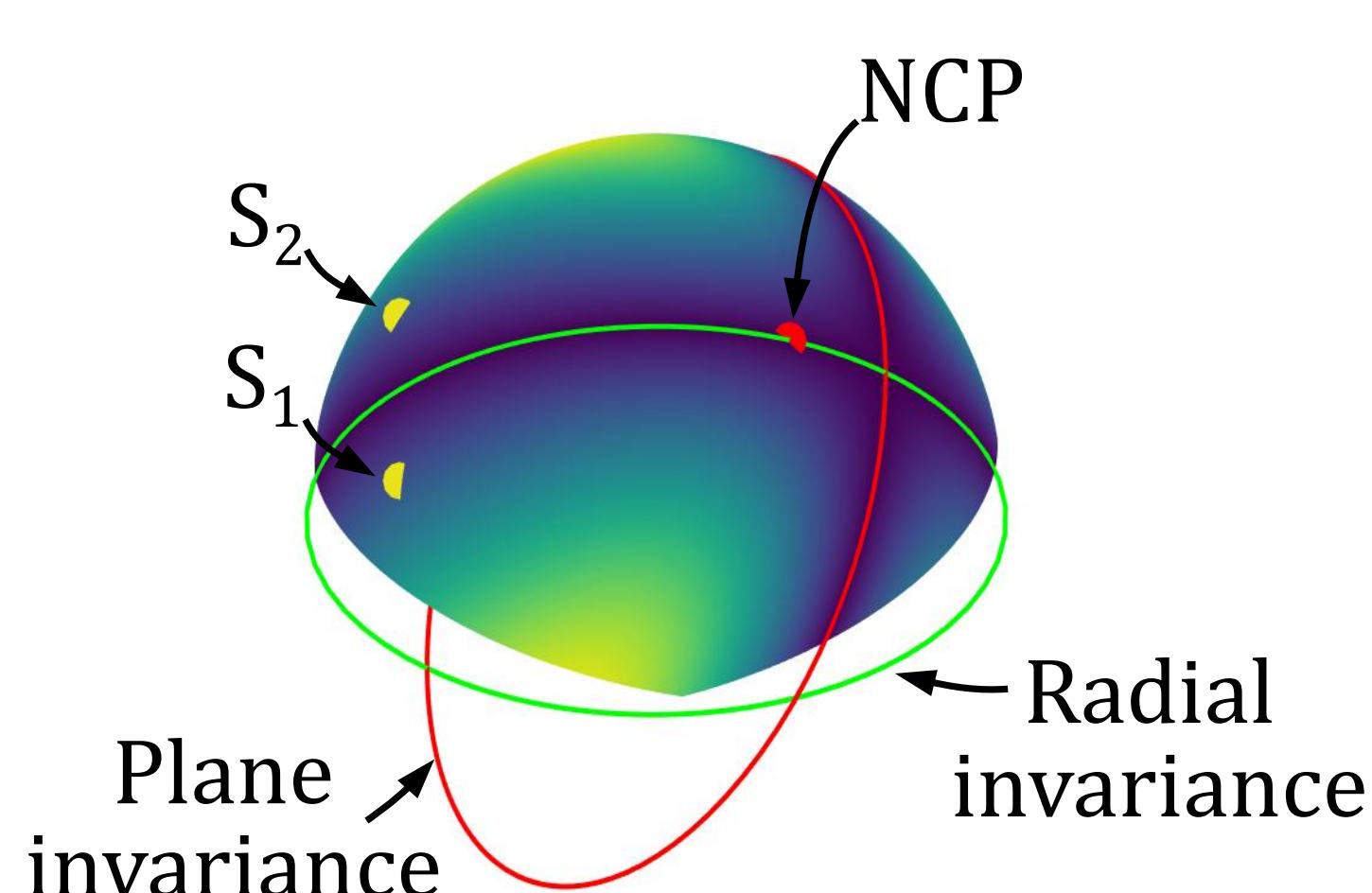


## Question

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

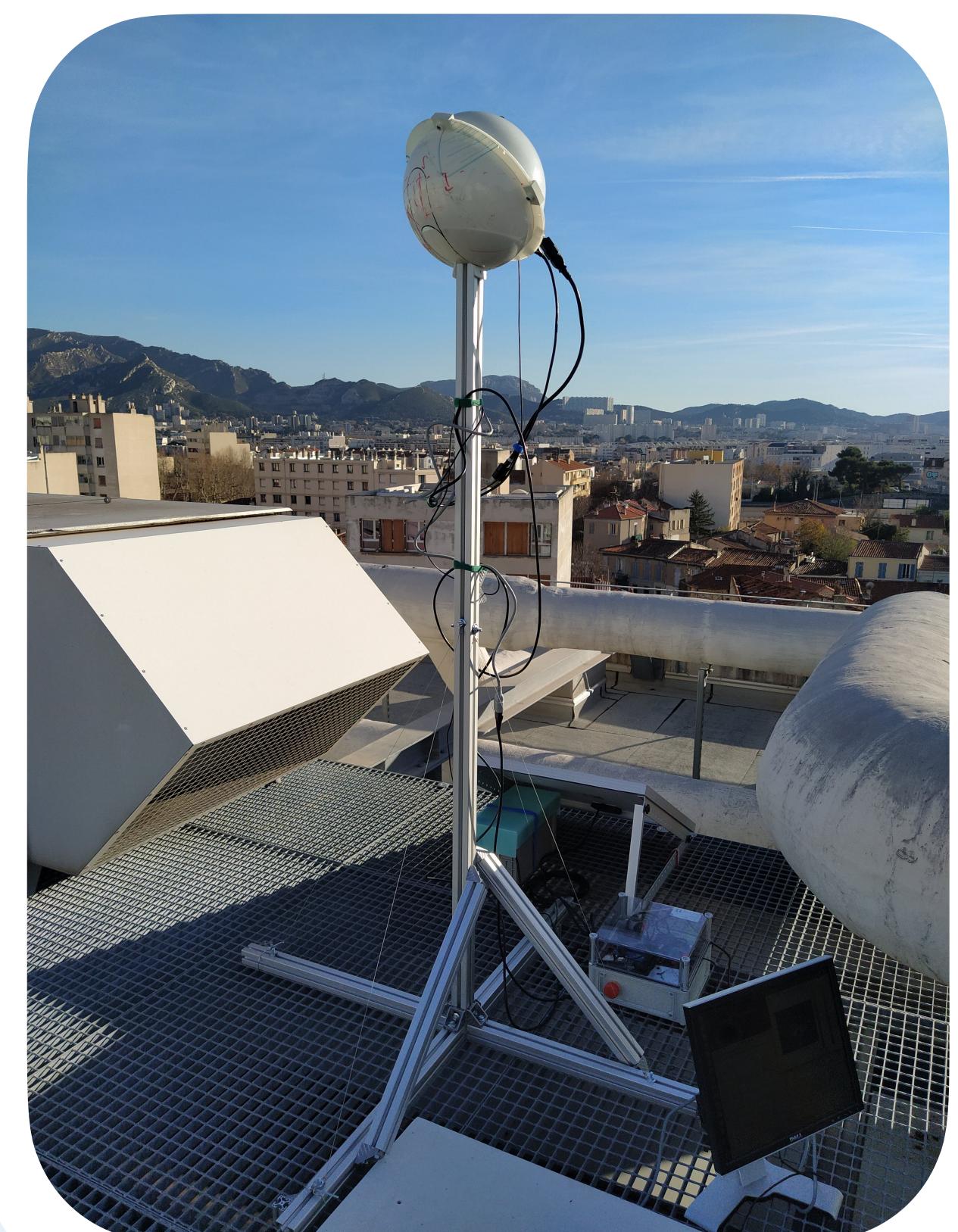
## Method

- 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**

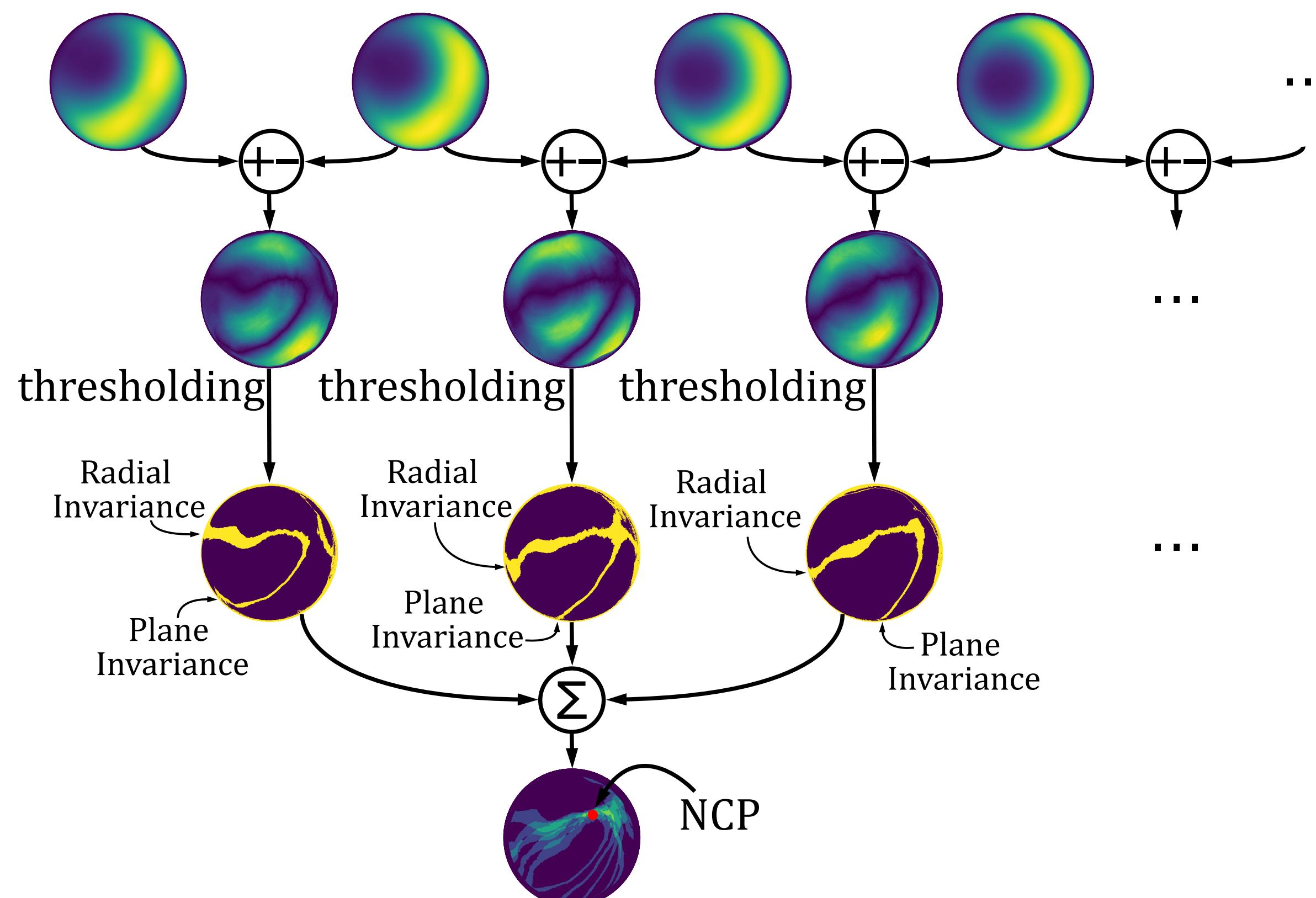


## Results

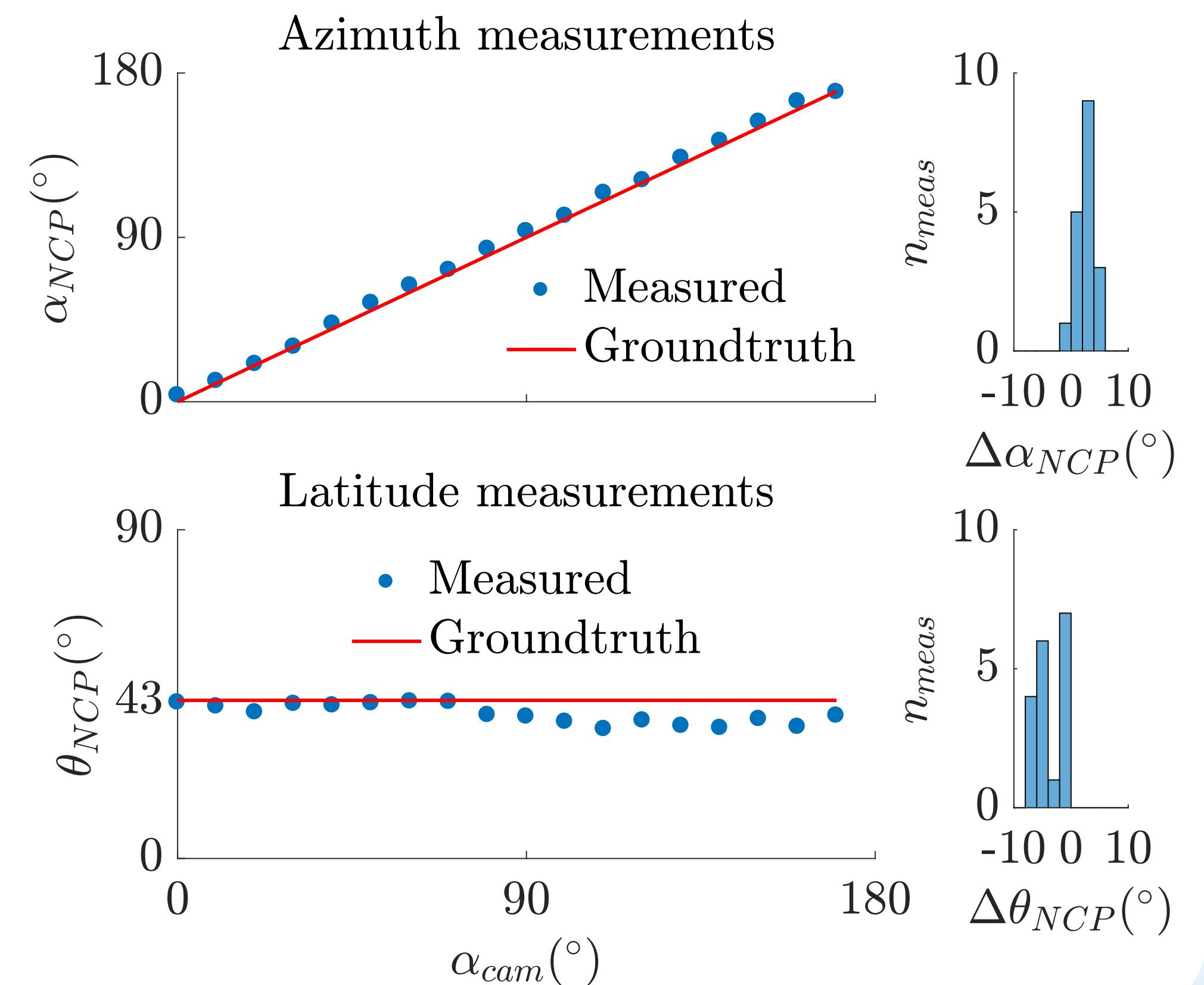
### Measurement device



### Method implemented on real polarimetric images



### Measured north celestial pole's coordinates



## Conclusion

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

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[4] Able et al., J. of Comp. Phys., 1995

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[5] Smart, Cambridge University Press, 1977

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[6] Brines, J. Theor. Biol., 1980

### Image References

Desert Ant : © Michael Mangan & Hugh Pastoll.

Homing Pigeon : © Tim Mossholder – Unsplash

Circumpolar Stars : © Benedikt Markus

Skypole : © T. Kronland-Martinet & ESO/B. Tafreshi