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

Thomas Kronland-Martinet, Léo Poughon, Marcel Pasquinelli, David Duché,  
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# SkyPole - A bio-inspired method to locate the north celestial pole



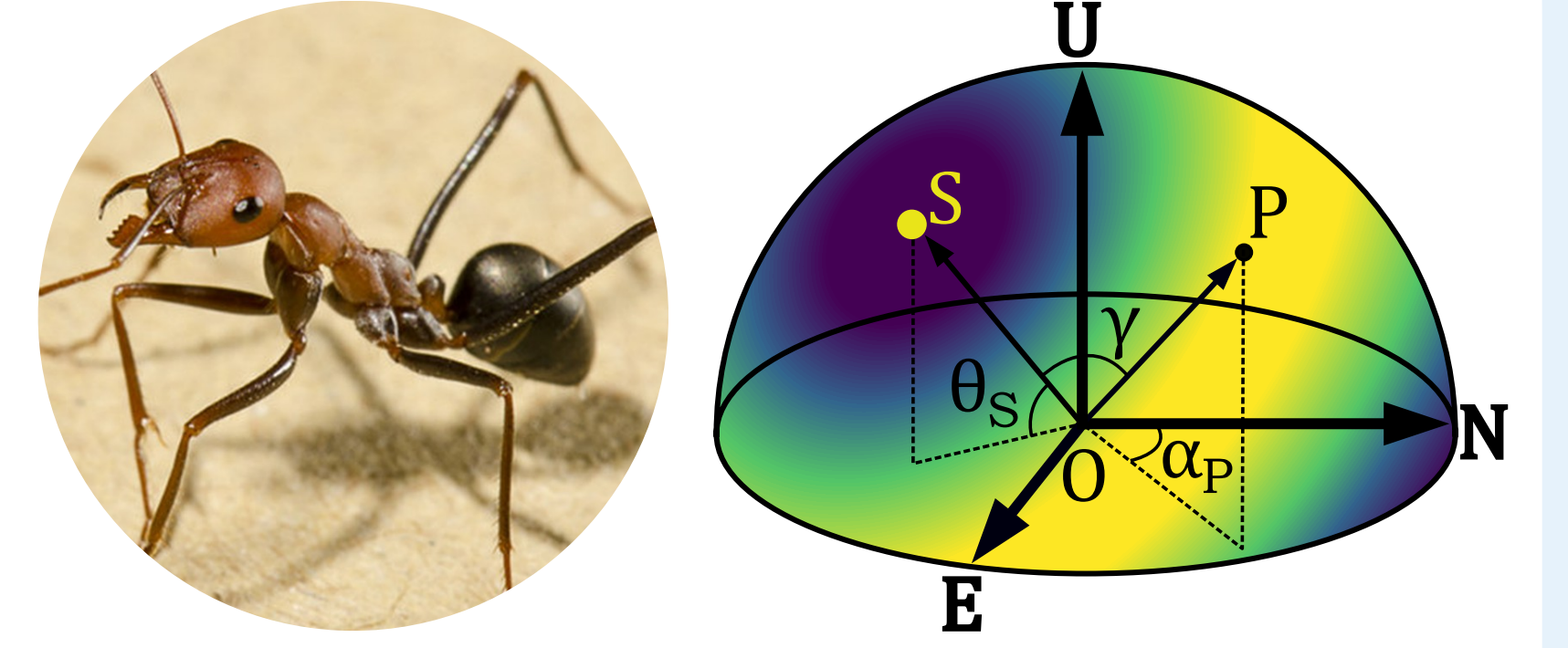
Thomas Kronland-Martinet<sup>1,2,\*</sup>, Léo Poughon<sup>1</sup>, Marcel Pasquinelli<sup>2</sup>, David Duché<sup>2</sup>, Julien R Serres<sup>1,3</sup>, Stéphane Viollet<sup>1</sup>

<sup>1</sup>Aix Marseille Univ, CNRS, ISM, Marseille, France    <sup>2</sup>Aix Marseille Univ, CNRS, IM2NP, Marseille, France  
<sup>3</sup>Institut Universitaire de France (IUF), Paris, France    \*thomas.kronland-martinet@univ-amu.fr

## 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]

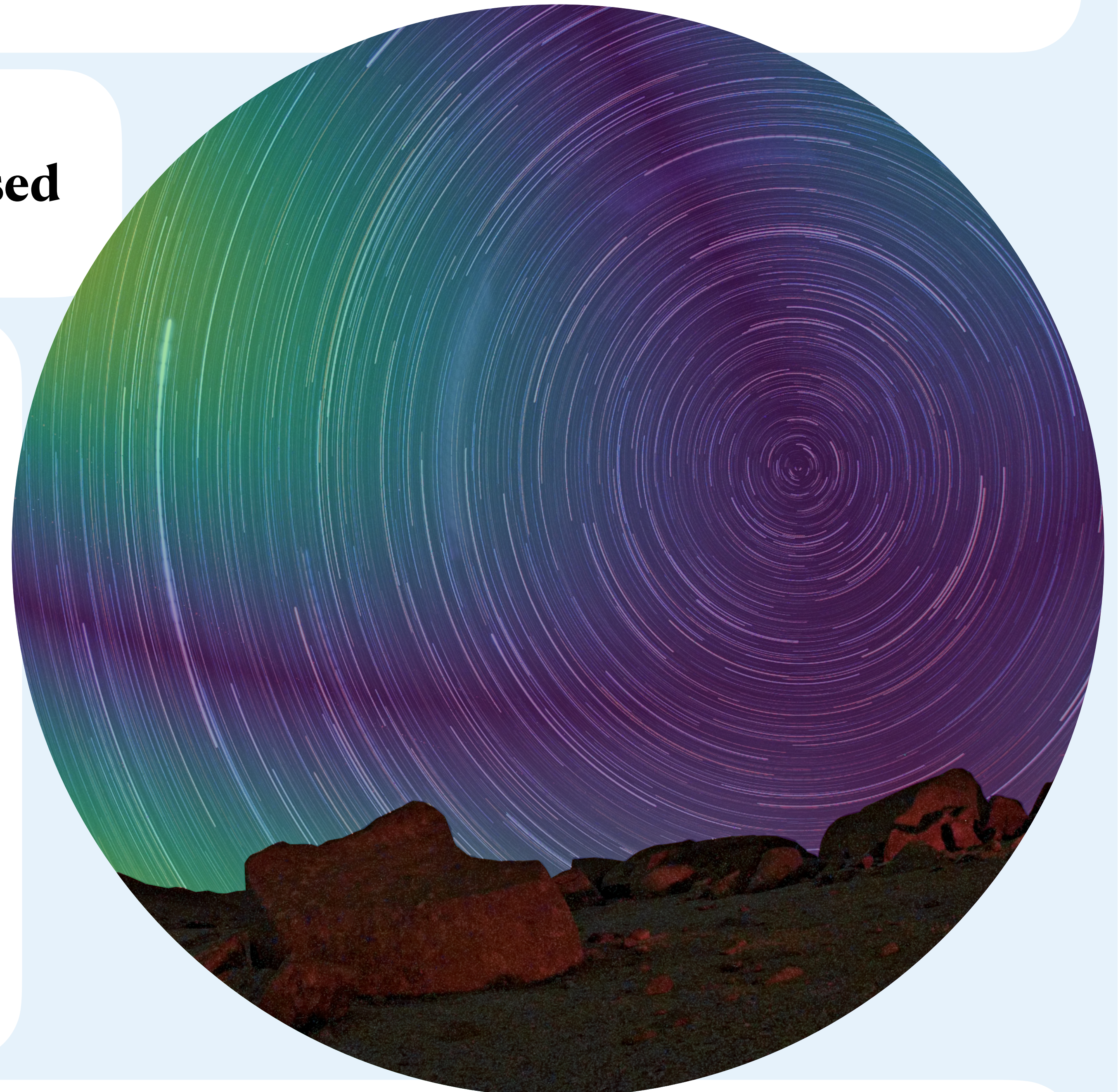
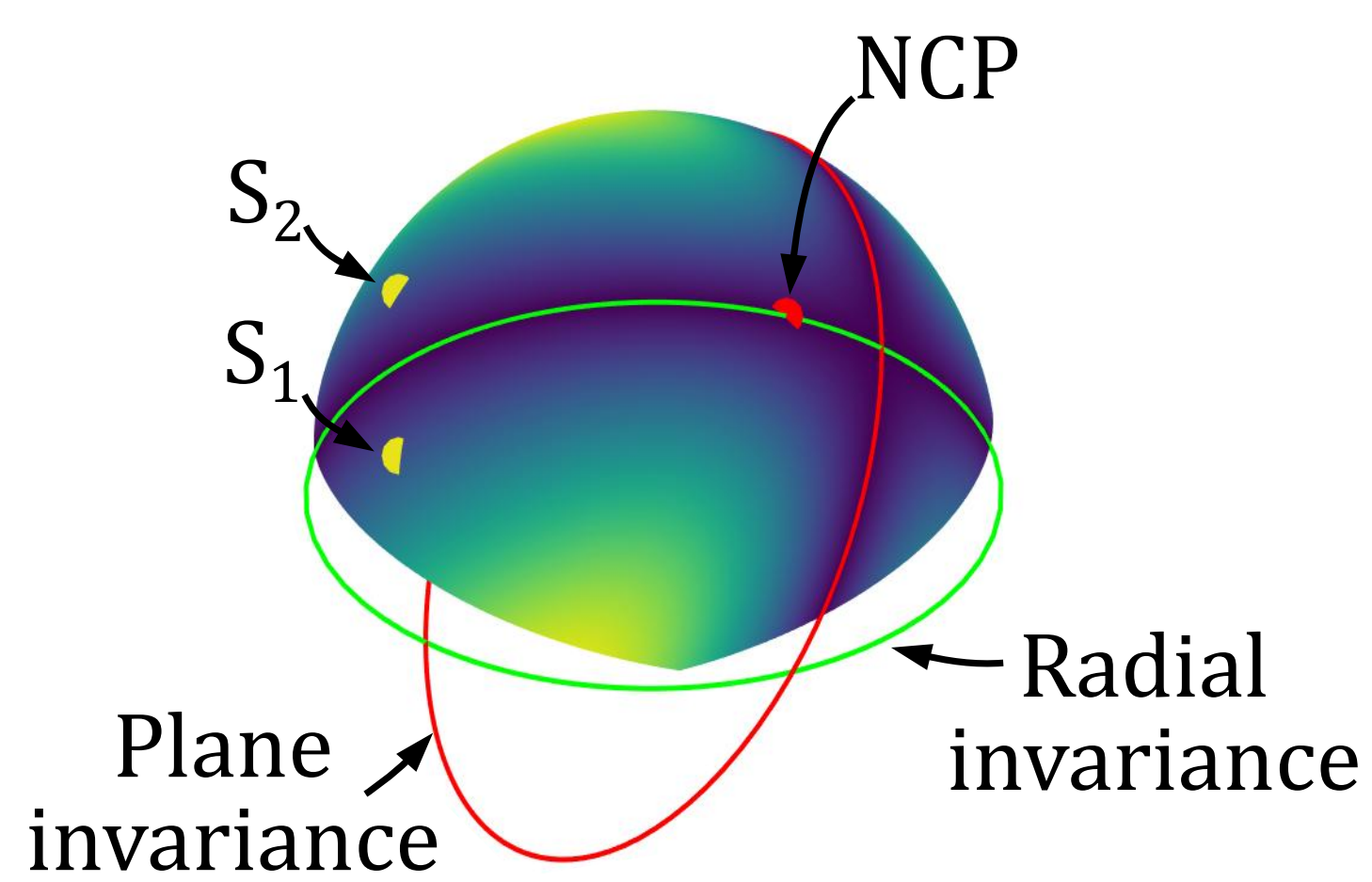


## Question

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

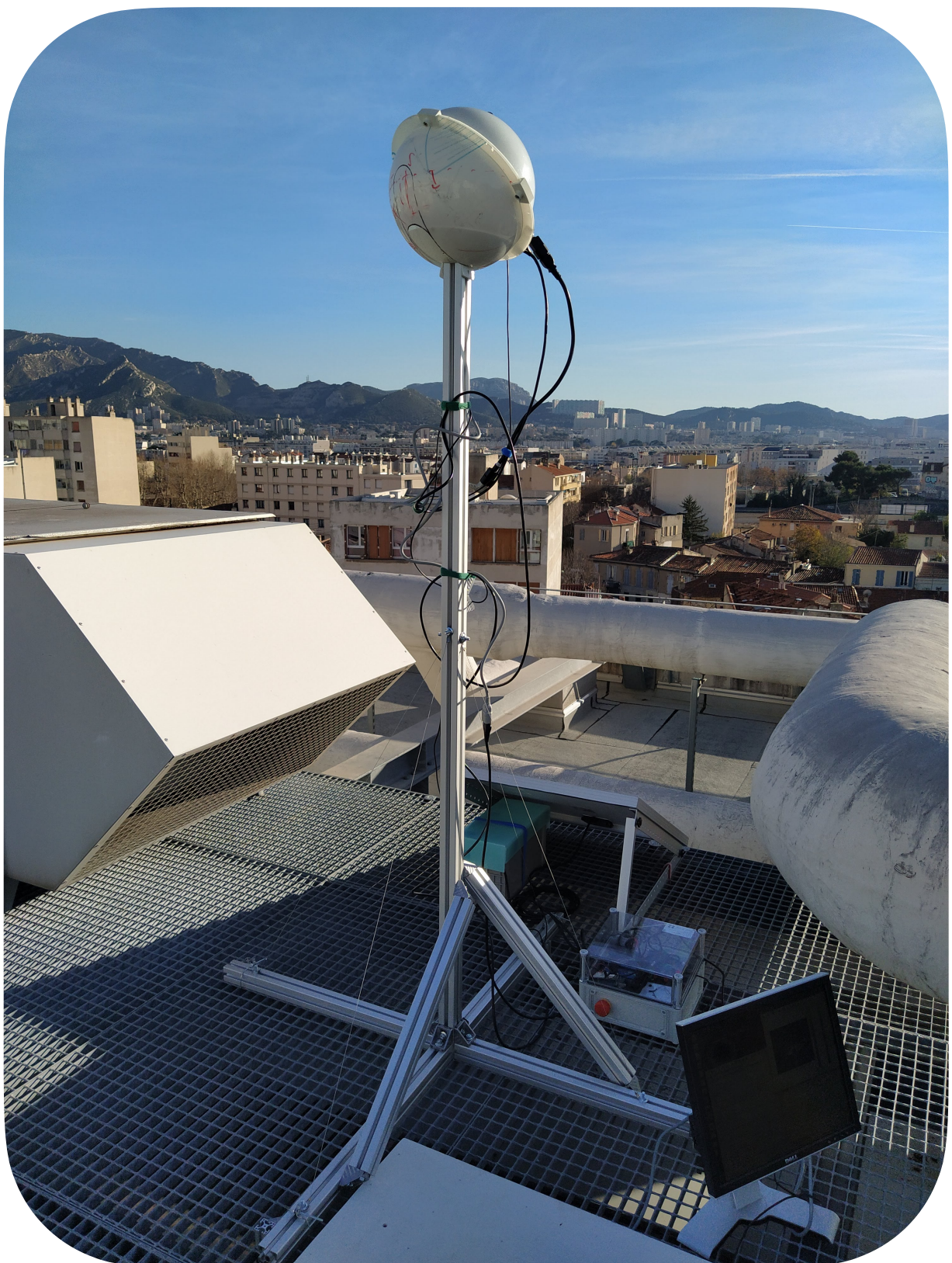
## Method

- 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**

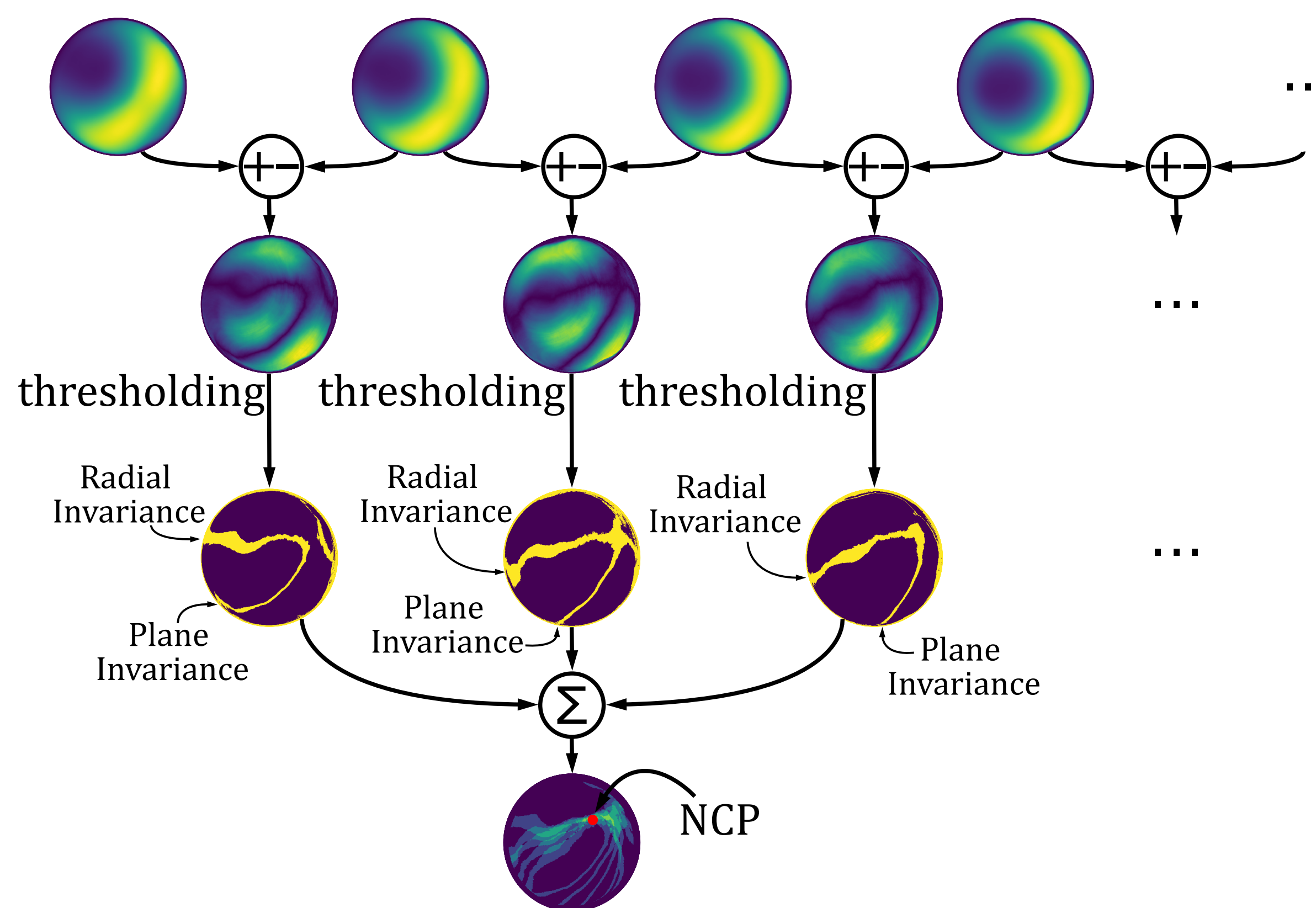


## Results

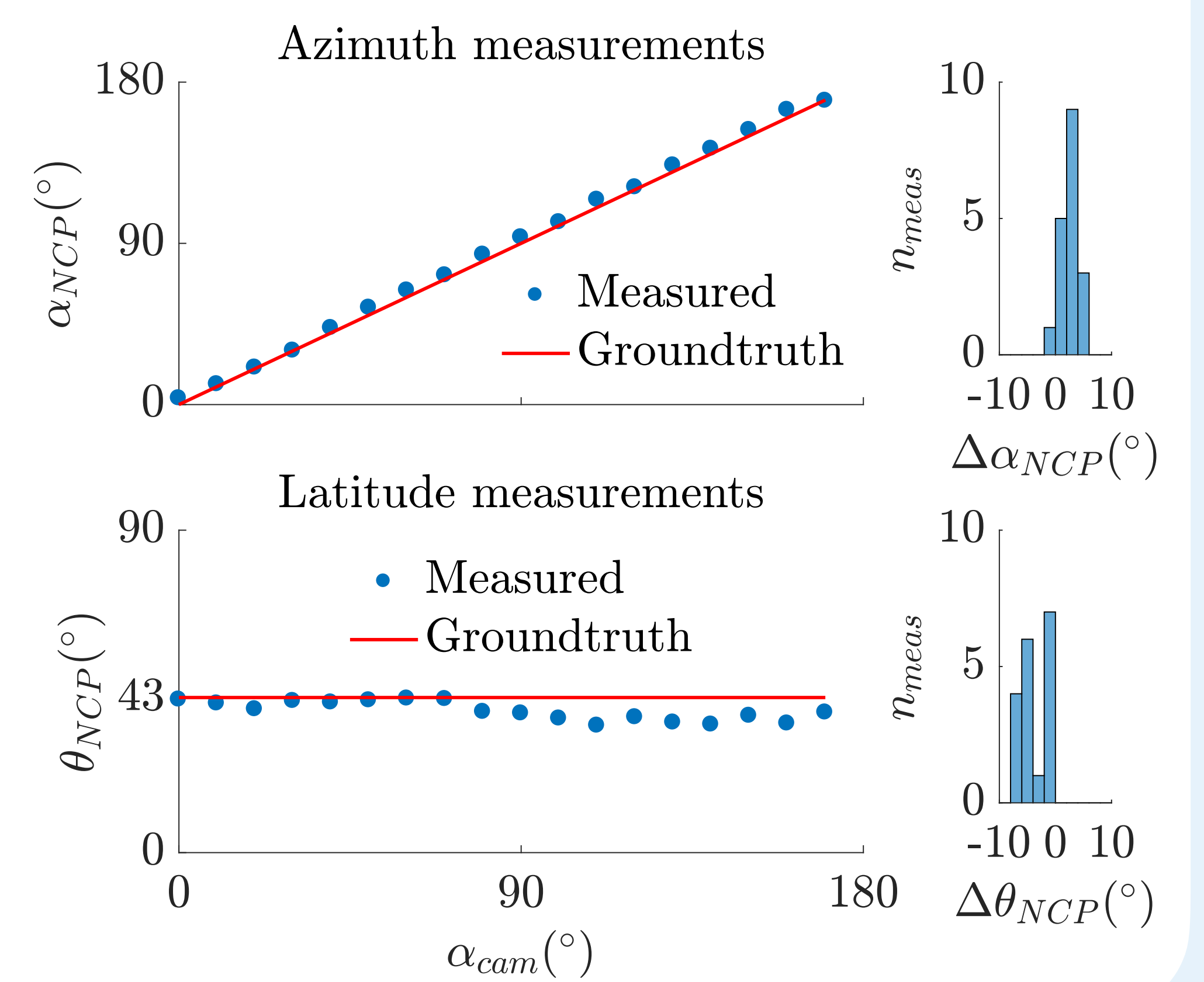
### Measurement device



### 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** [1] Wehner, Harvard University Press, 2020  
 [4] Able et al., J. of Comp. Phys., 1995  
 [7] Kronland-Martinet et al., PNAS, 2023

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 [5] Smart, Cambridge University Press, 1977

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

## Image References

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