



**HAL**  
open science

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

Thomas Kronland-Martinet, Léo Poughon, Marcel Pasquinelli, David Duché,  
Julien Serres, Stéphane Viollet

### ► **To cite this version:**

Thomas Kronland-Martinet, Léo Poughon, Marcel Pasquinelli, David Duché, Julien Serres, et al.. SkyPole -A bio-inspired polarimetric compass for GPS-denied navigation. Journée des Jeunes Chercheurs en Robotique (JJCR 2023), Oct 2023, Moliets et Maâ, France. , 2023. <hal-04496956>

**HAL Id: hal-04496956**

**<https://hal.science/hal-04496956v1>**

Submitted on 9 Mar 2024

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons CC BY 4.0 - Attribution - International License

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



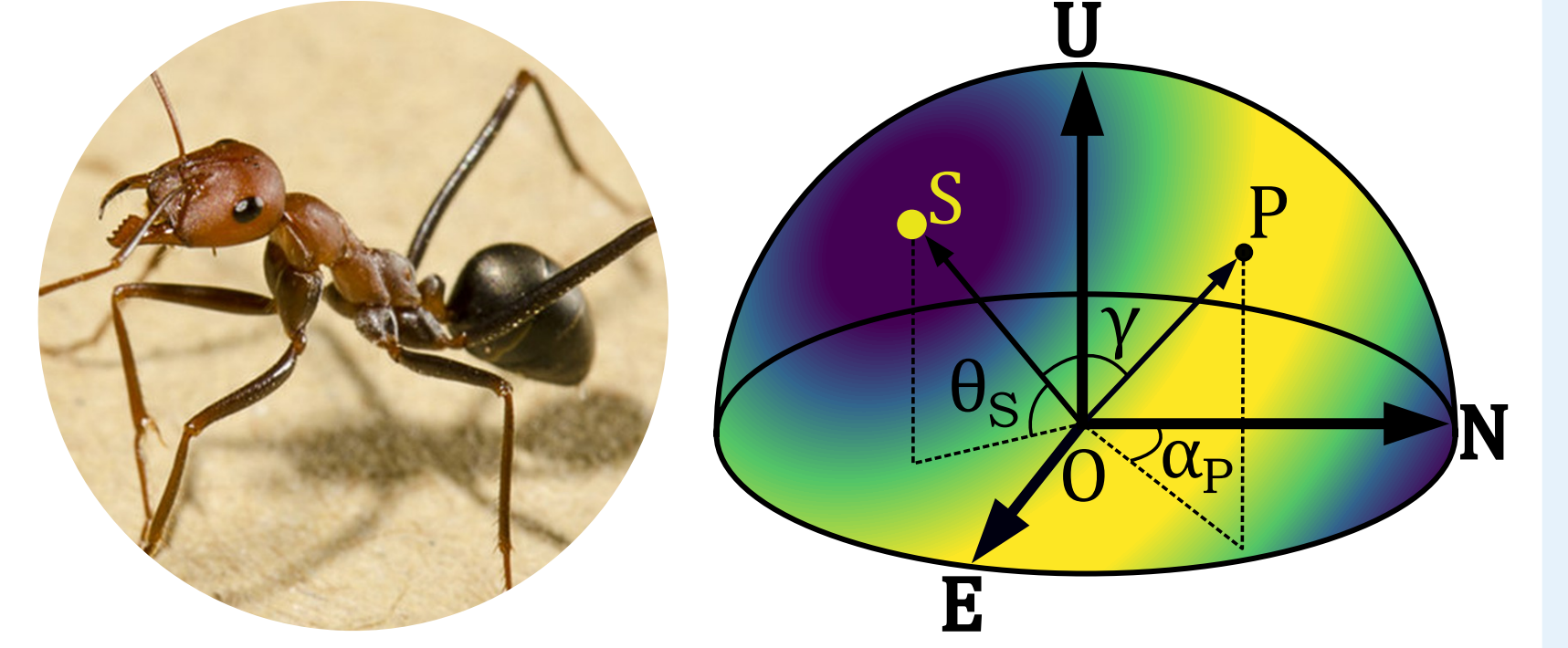
Thomas Kronland-Martinet<sup>1,2,\*</sup>, Léo Poughon<sup>1</sup>, Marcel Pasquinelli<sup>2</sup>, David Duché<sup>2</sup>, Julien R Serres<sup>1,3</sup>, Stéphane Viollet<sup>1</sup>

<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]

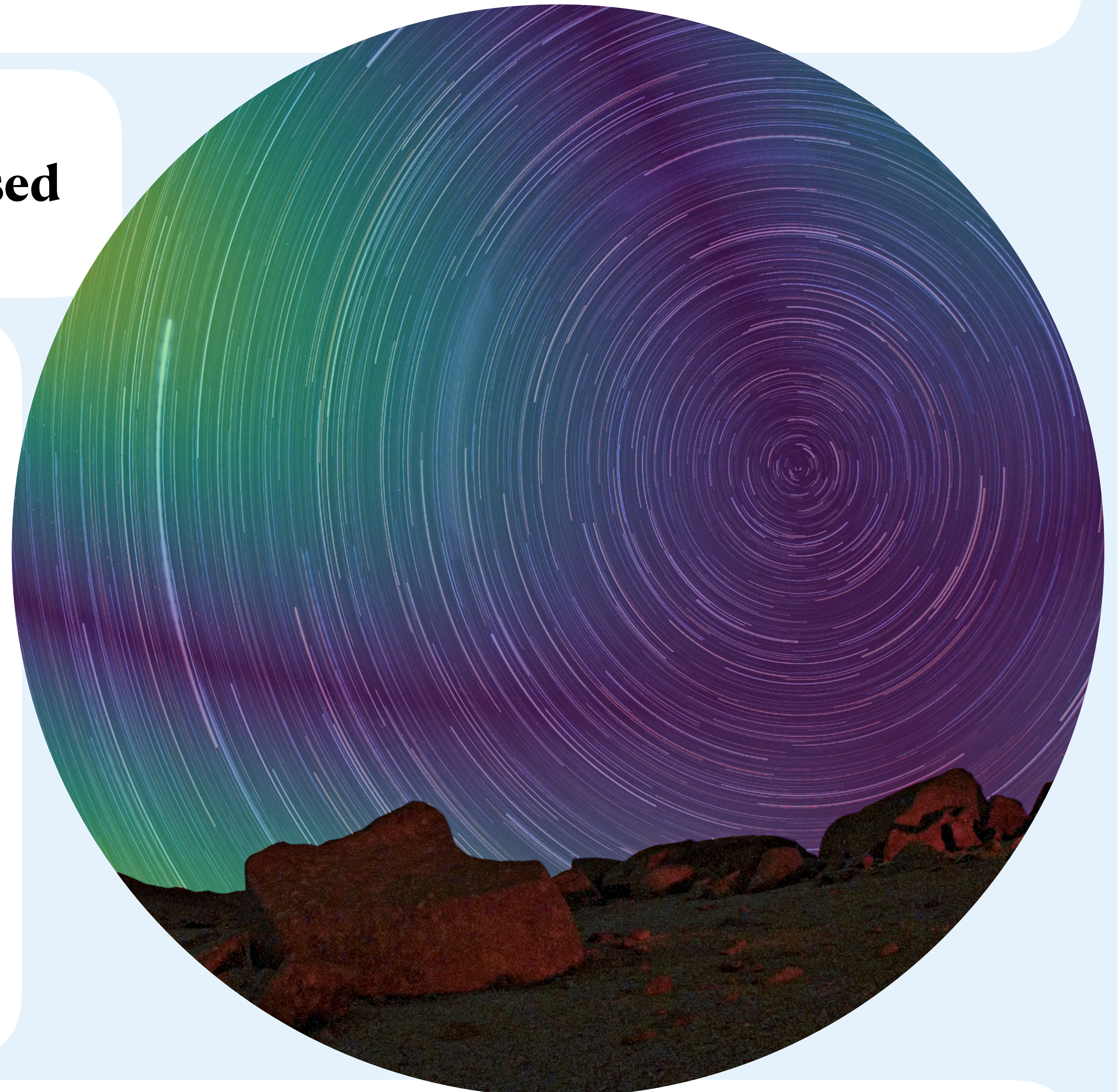
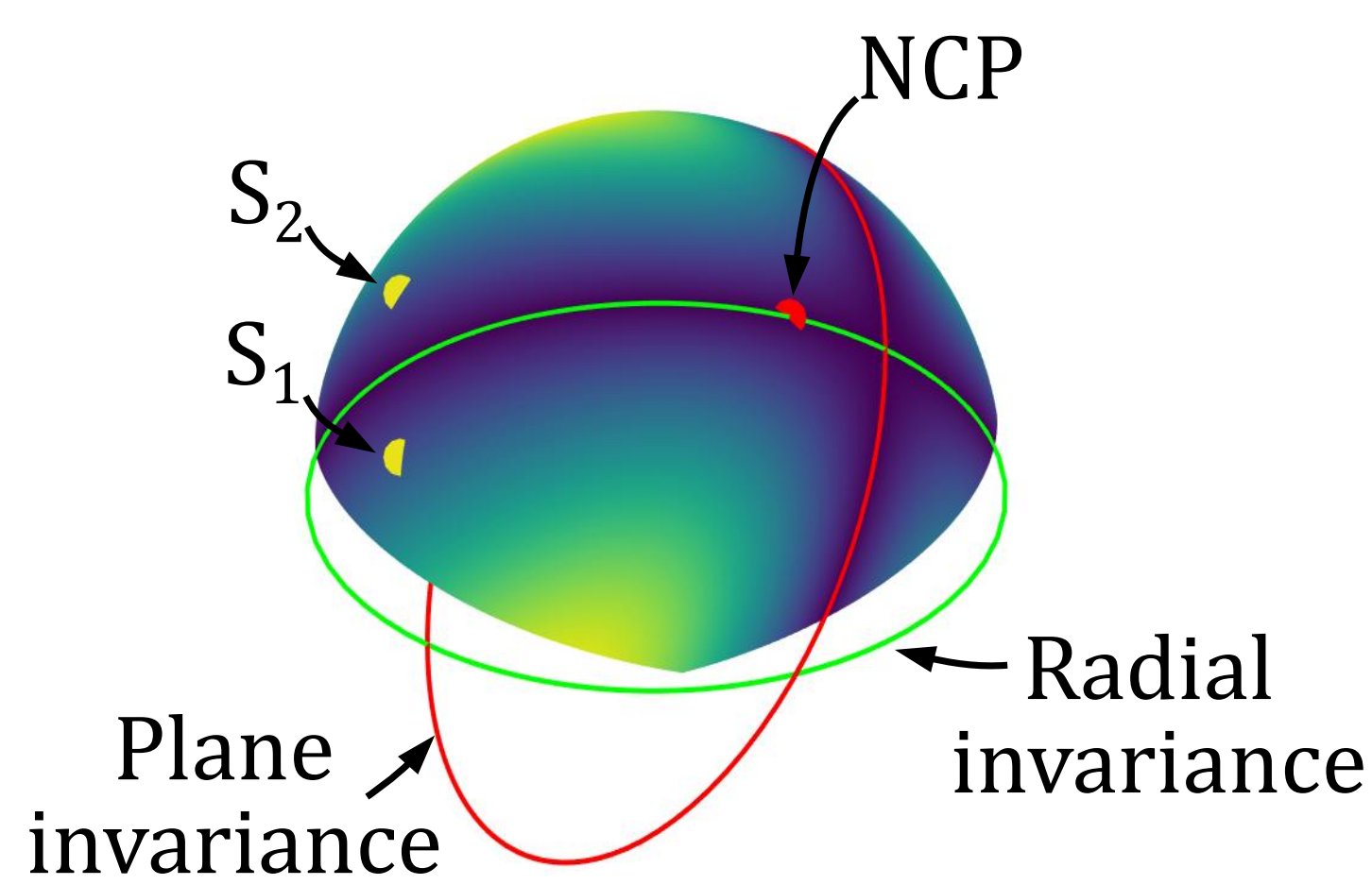


## Question

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

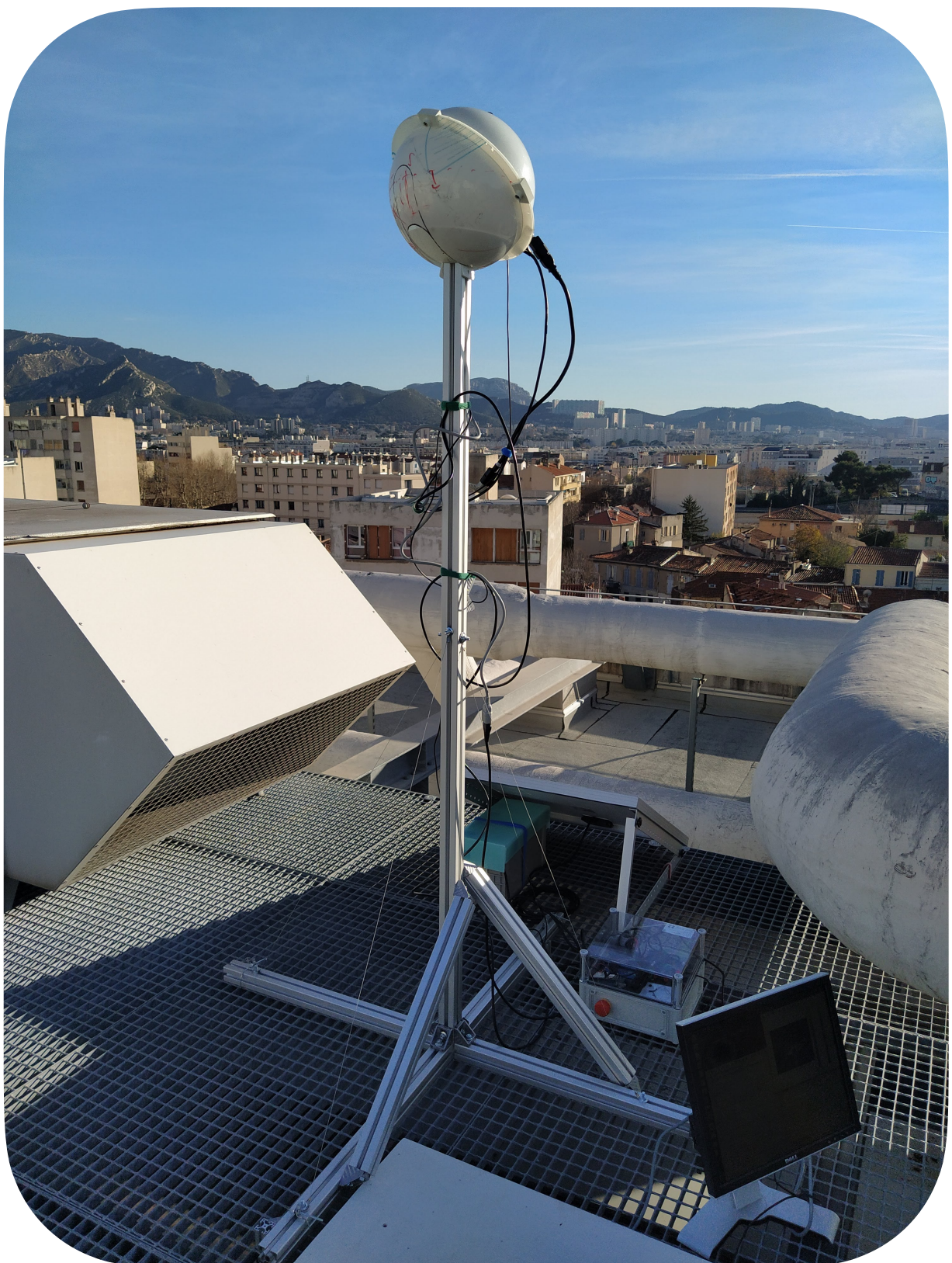
## Method

- 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**

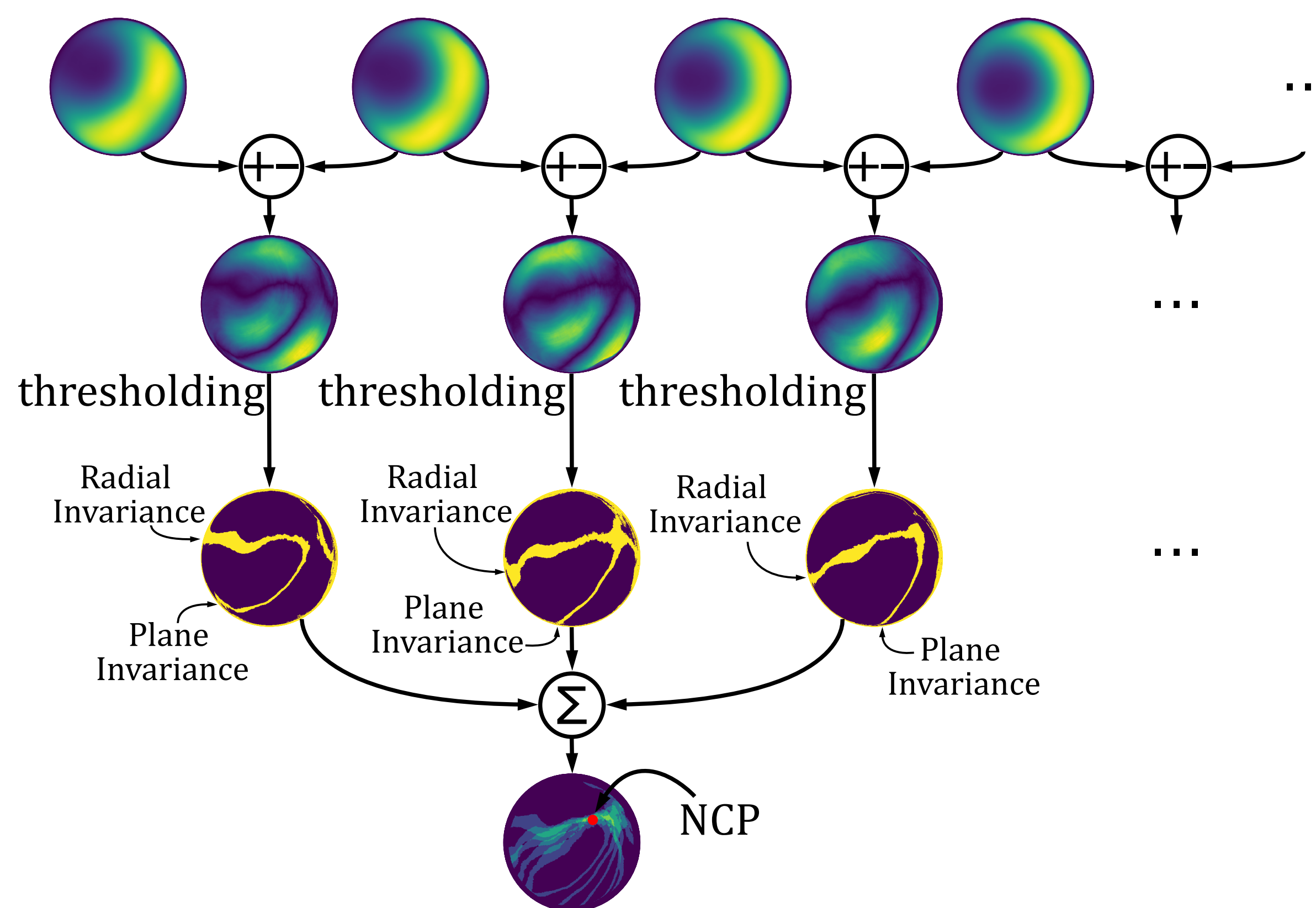


## Results

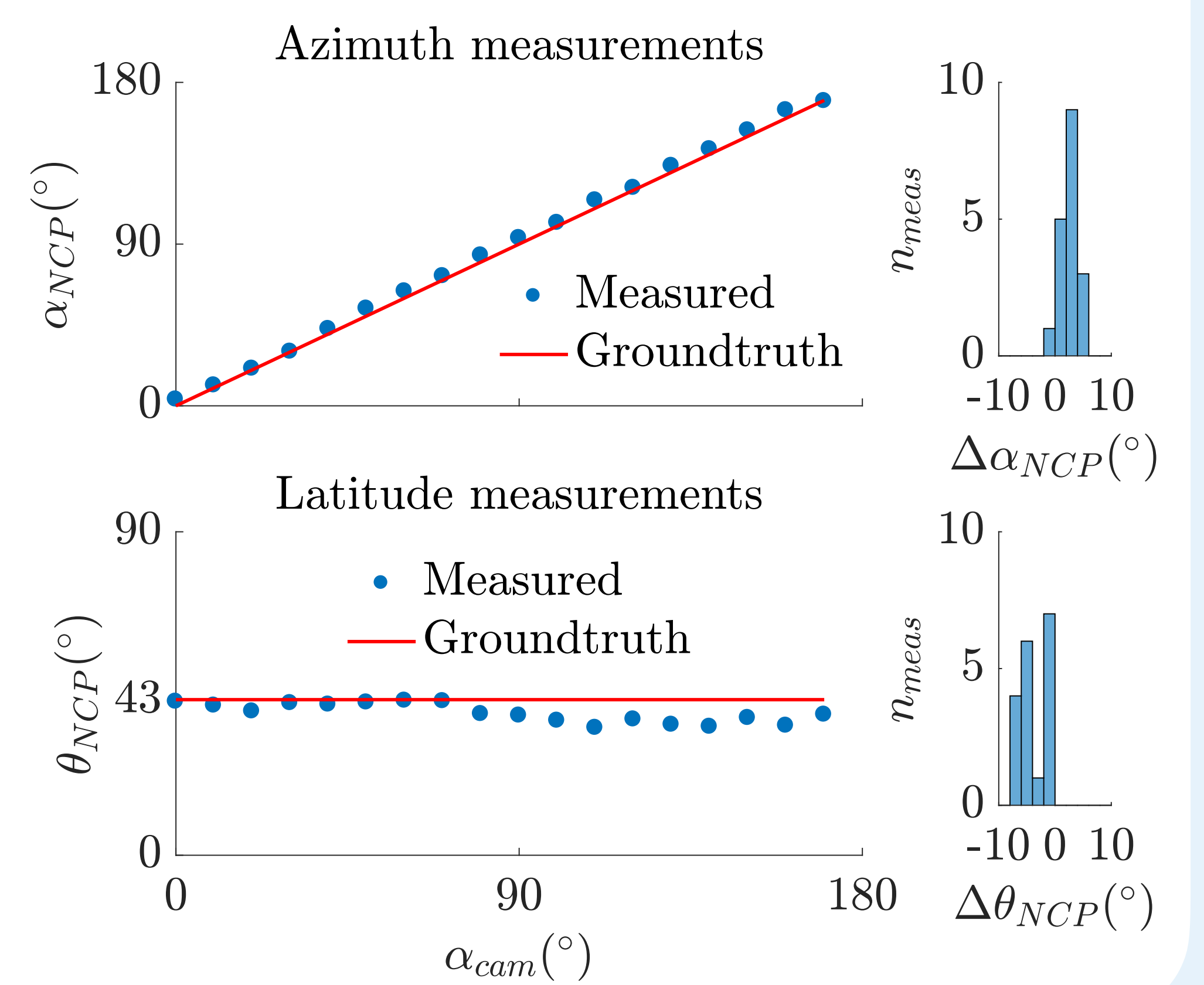
### Measurement device



### 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

[2] Coulson, A. Deepak Pub., 1988  
 [5] Smart, Cambridge University Press, 1977

[3] Emlen, NASA Spec. Pub., 1972  
 [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