Science and Technology Facilities Council

RAL Space

Radio scintillation studies for prospects of space weather forecasting and analyses (RadioScint)

Oyuki Chang[1], Marcin Grzesiak[2], Barbara Matyjasiak[2], Mario Bisi[1], Hanna Rothkaehl[2], Richard Fallows[1], David Barnes[1]

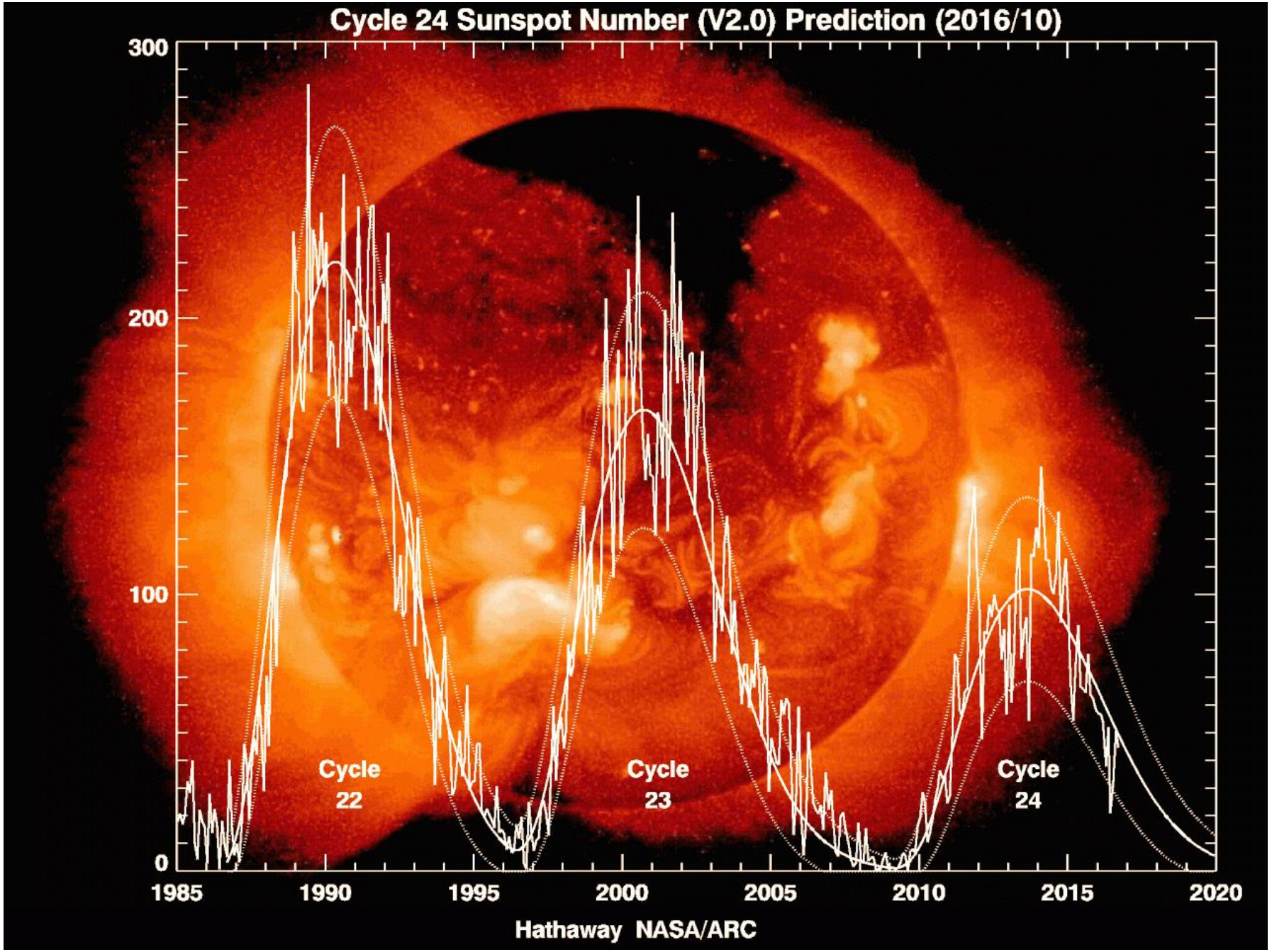
[1] UKRI STFC RAL Space, [2] CBK PAN

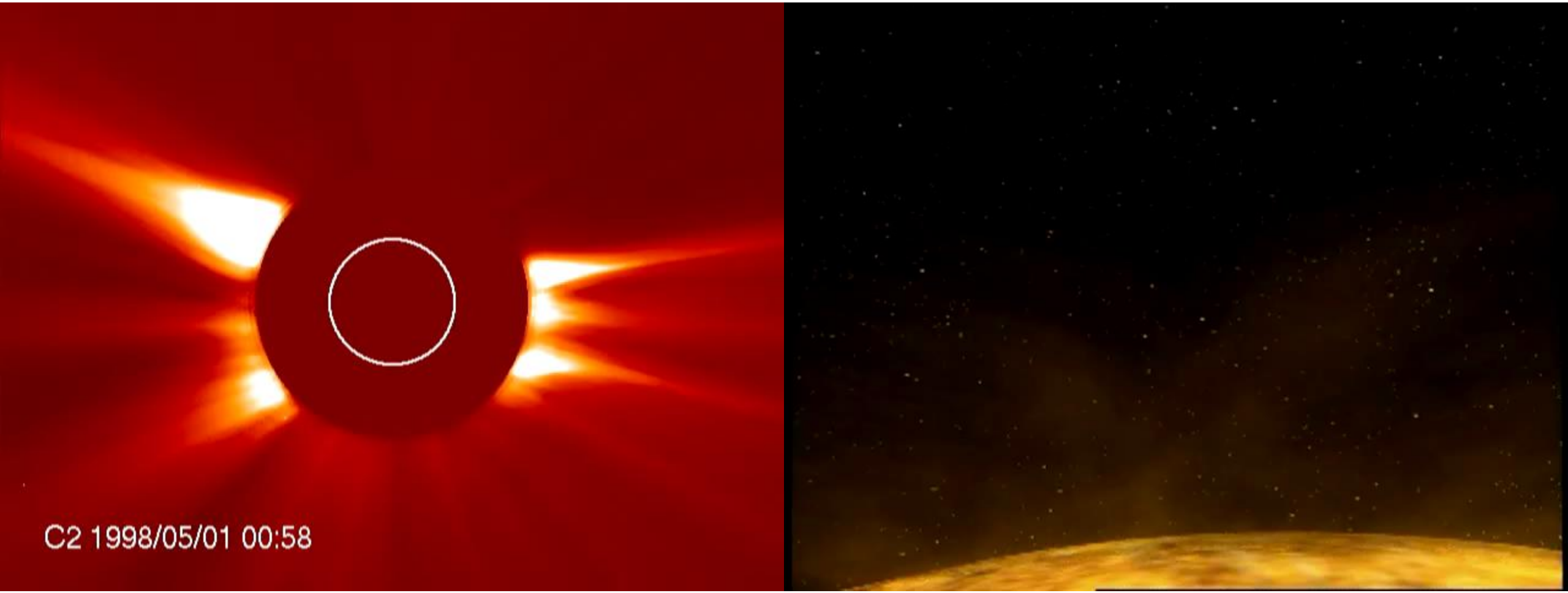
Second TNA Users Meeting

3 June 2025 | RMI, Brussels, Belgium

Introduction

Solar Cycle

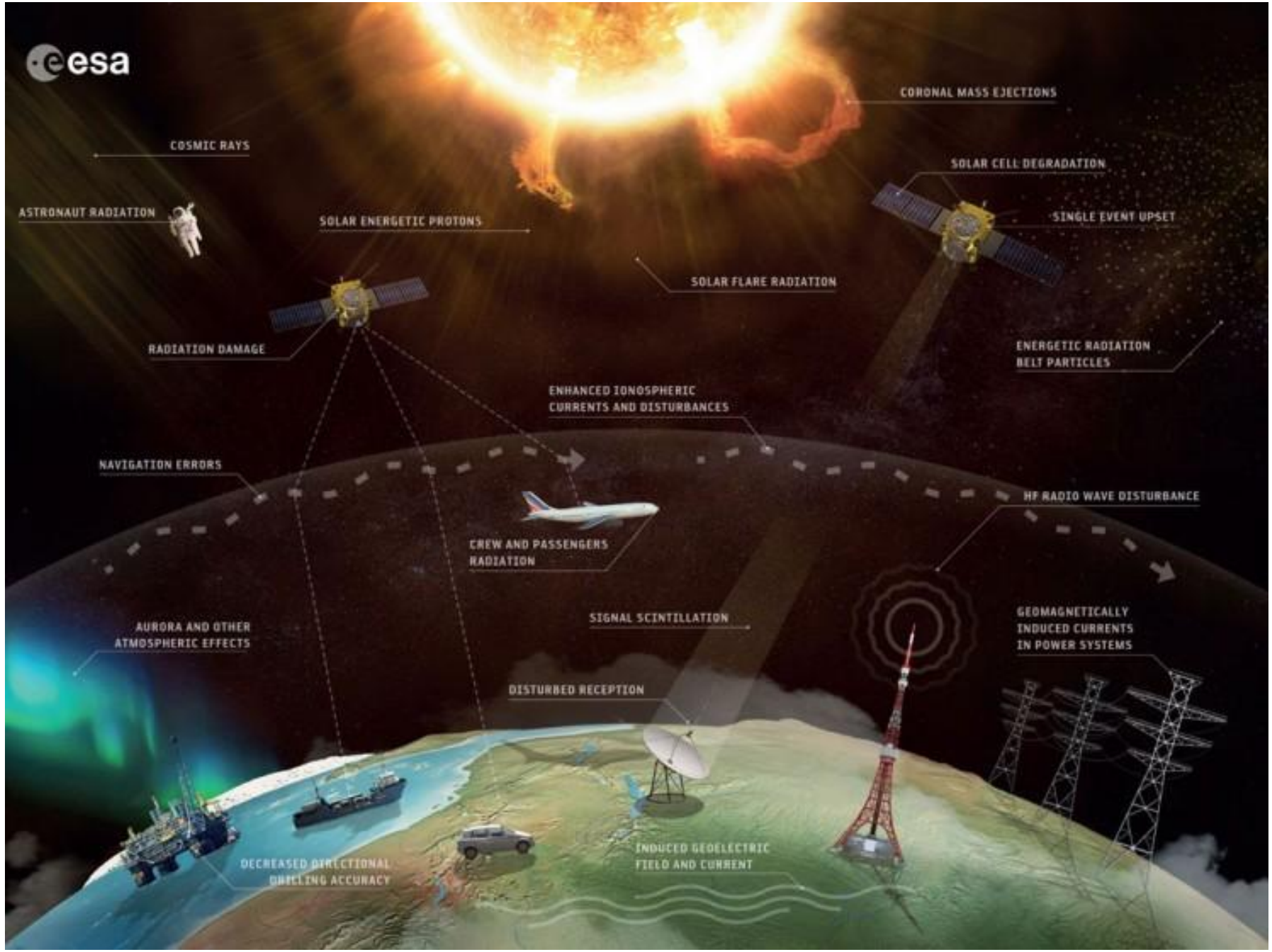

Cycle 24 Sunspot Number (V2.0) Prediction (2016/10)
300
200
100
0
1985
1990
1995
2000
2005
2010
2015
2020
Cycle 22
Cycle 23
Cycle 24
Hathaway NASA/ARC



Science and Technology Facilities Council

RAL Space

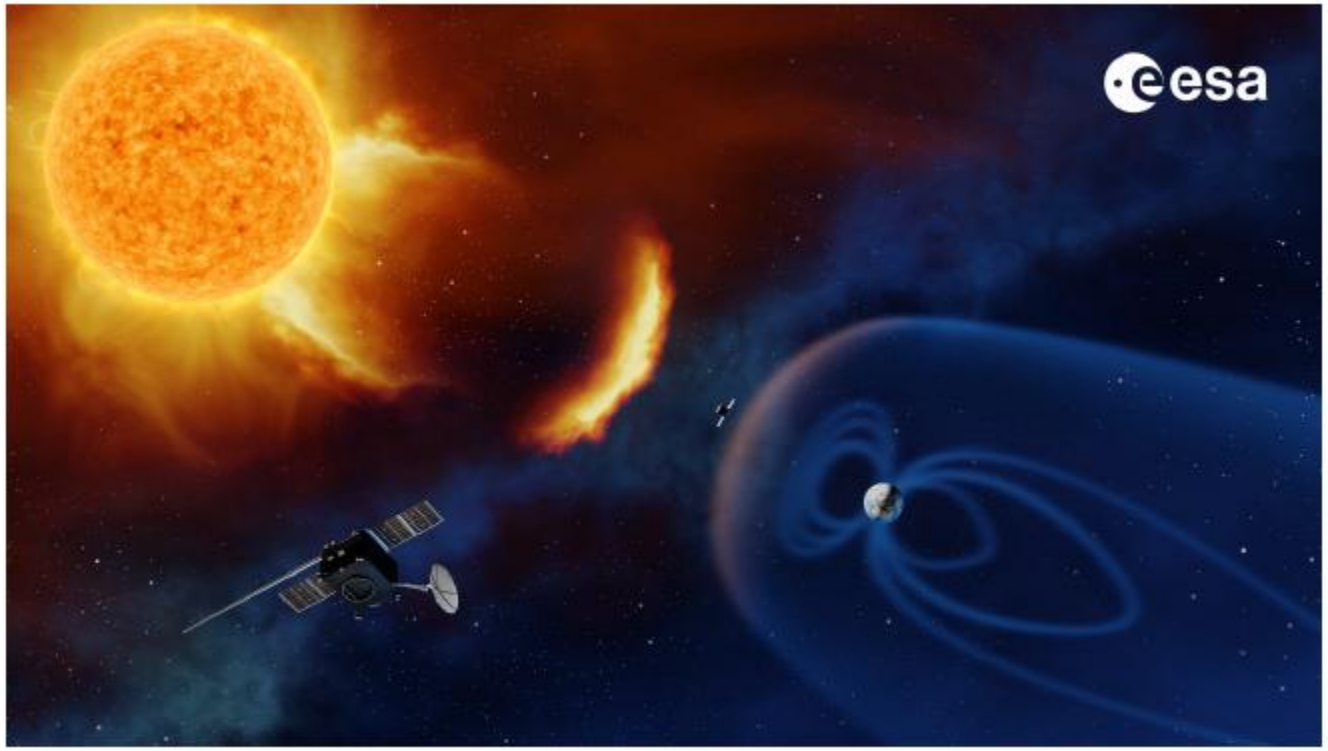
Space Weather

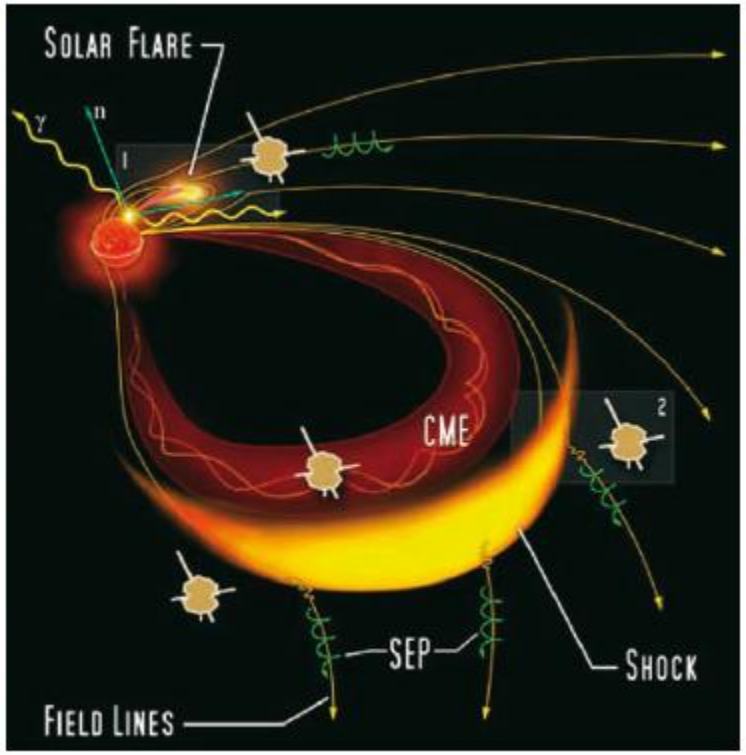


Science and Technology Facilities Council

RAL Space

Challenge: Understanding evolution of structures in the interplanetary medium.

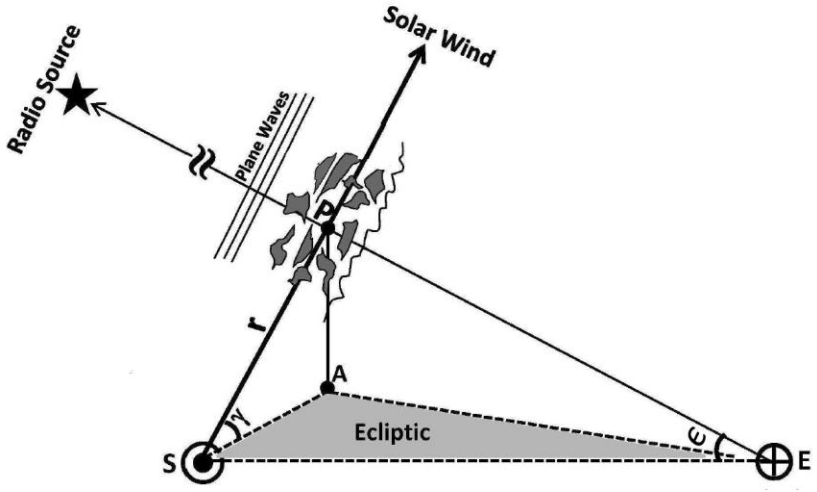




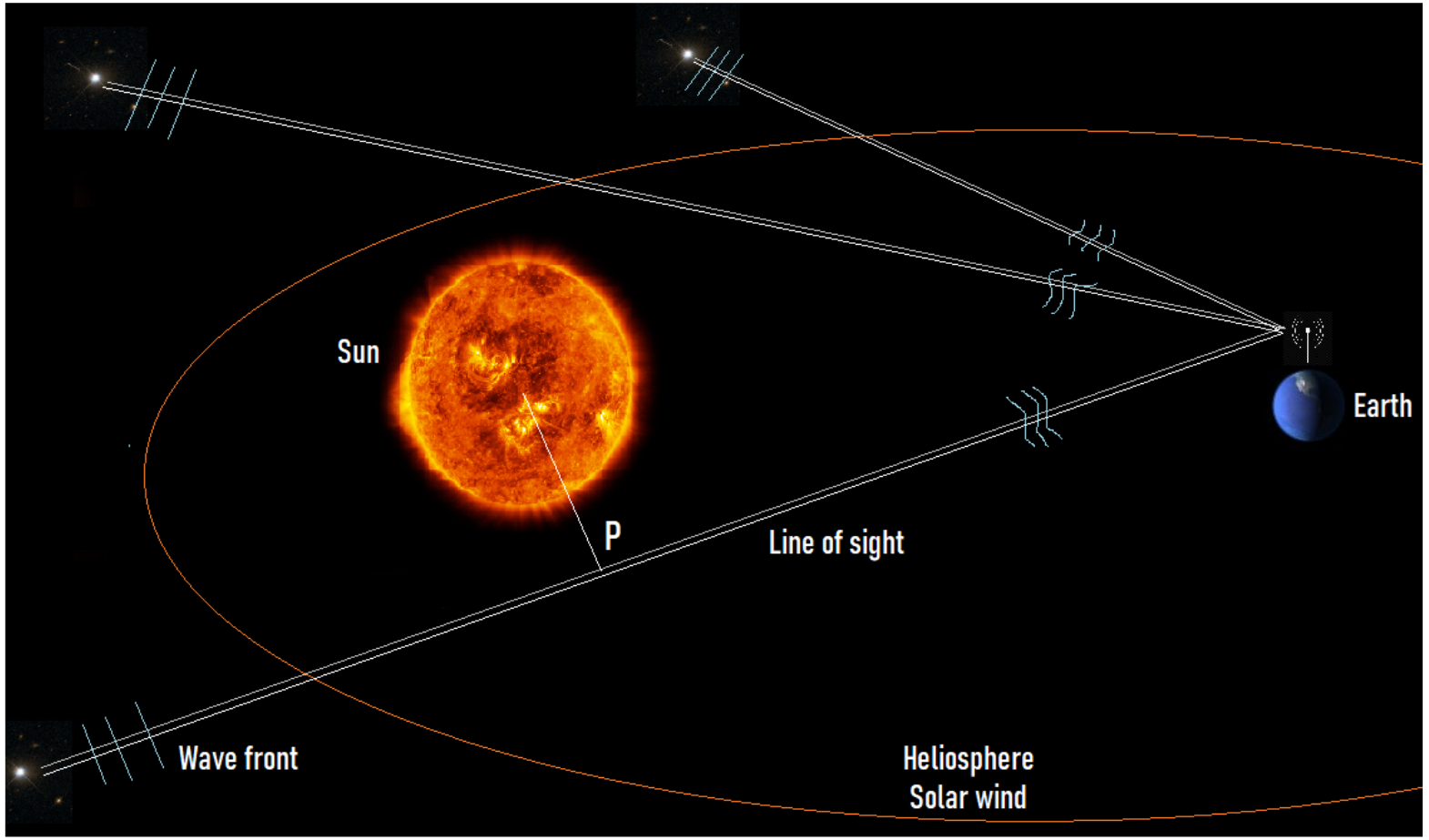
Techniques and Data analysis

Science and Technology Facilities Council
RAL Space

Observations of Interplanetary Scintillation (IPS)



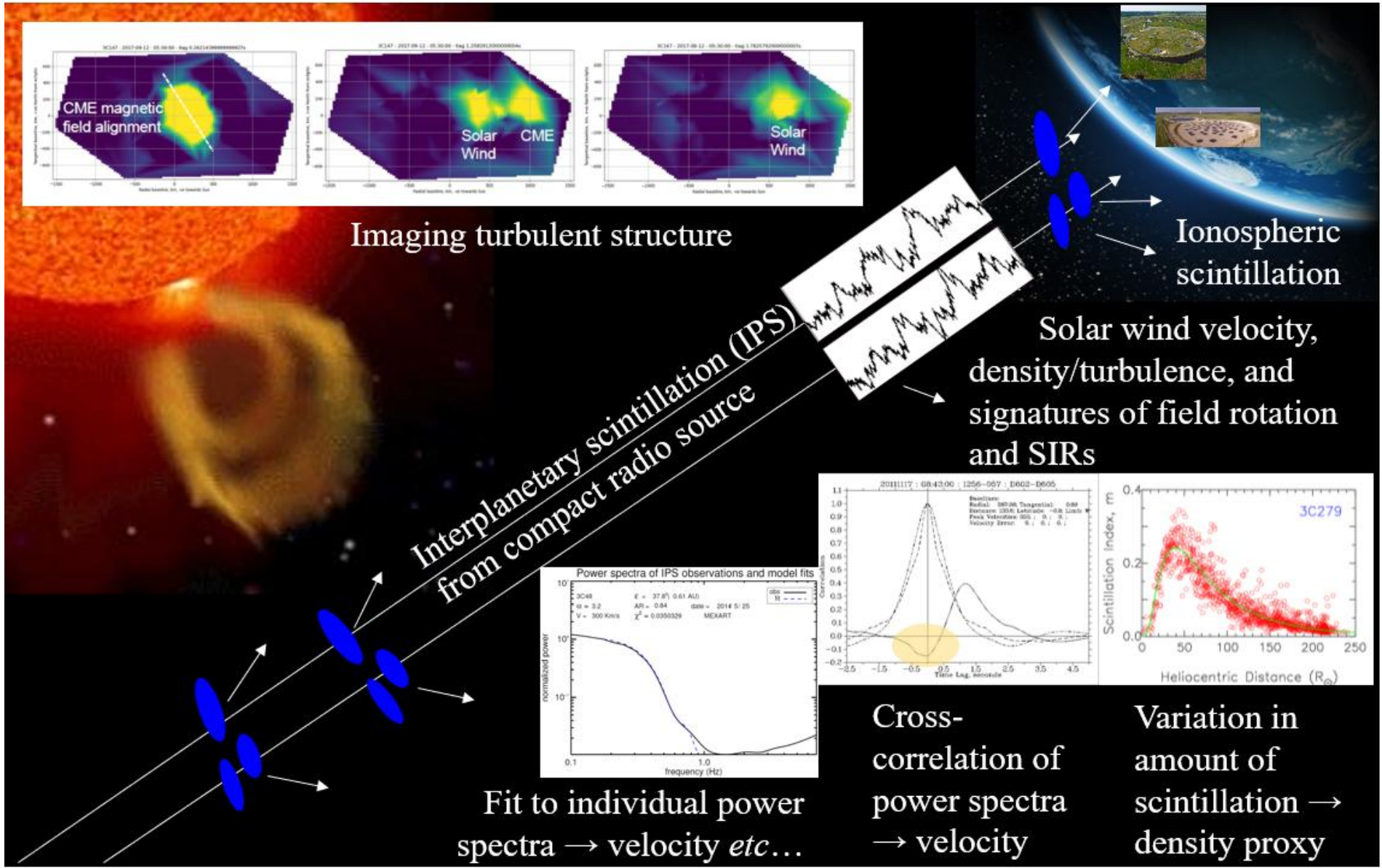
Bisoi et al. 2014



Science and Technology Facilities Council

RAL Space

Radio Techniques



Science and Technology Facilities Council

RAL Space

PITHIA-NRF TNA Project

Project description

- Physical access to CBK PAS NODE.
- Applicability of the Grzesiak et al., 2009 methodology to wider scintillation observations (solar wind plasma)
- Cross-comparation with former methodologies, using the same dataset.

Ann. Geophys., 27, 2843–2849, 2009
www.ann-geophys.net/27/2843/2009/

Annales Geophysicae

Dispersion analysis of spaced antenna scintillation measurement

M. Grzesiak and A. W. Wernik

Space Research Centre of Polish Academy of Sciences, ul. Bartycka 18A, 00-716 Warsaw, Poland

Received: 6 March 2009 – Revised: 18 June 2009 – Accepted: 9 July 2009 – Published: 16 July 2009

Abstract. We present a dispersion analysis of the phase of GPS signals received at high latitude. Basic theoretical aspects for spectral analysis of two-point measurement are given. To account for nonstationarity and statistical robustness a power distribution of the windowed Fourier transform cross-spectra as a function of frequency and phase is analysed using the Radon transform.

Keywords. Radio science (Ionospheric physics; Signal processing; Instruments and techniques)

ing of the high-latitude scintillation is of outmost importance. With this in mind, we got involved in the MISTECS (Monitoring of Ionospheric Scintillation and Total Electron Content on Spitsbergen) project. Monitoring equipment has been installed in the Polish Polar Station in Hornsund on Spitsbergen.

One of the components of MISTECS is the spaced receivers experiment in which three GPS scintillation receivers (GISTM) are placed at the corners of the triangle (Fig. 1). The aim of the spaced receivers experiment is estimation

Instruments

LOFAR

- 38 NL stations and 14 international stations.
- 1 new station to come in Italy (2023?).
- 1 new station to come in Bulgaria (2024?).

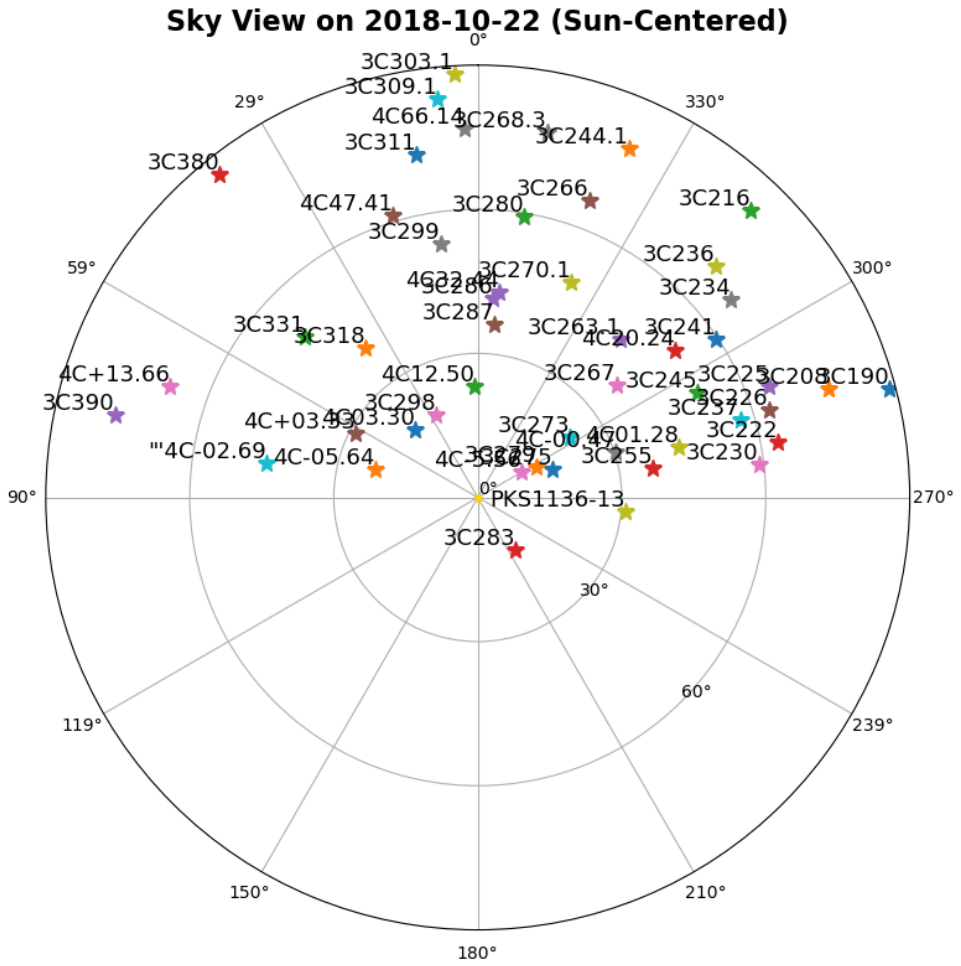
- Frequency range: 10-250 MHz.
- High time and frequency resolution.

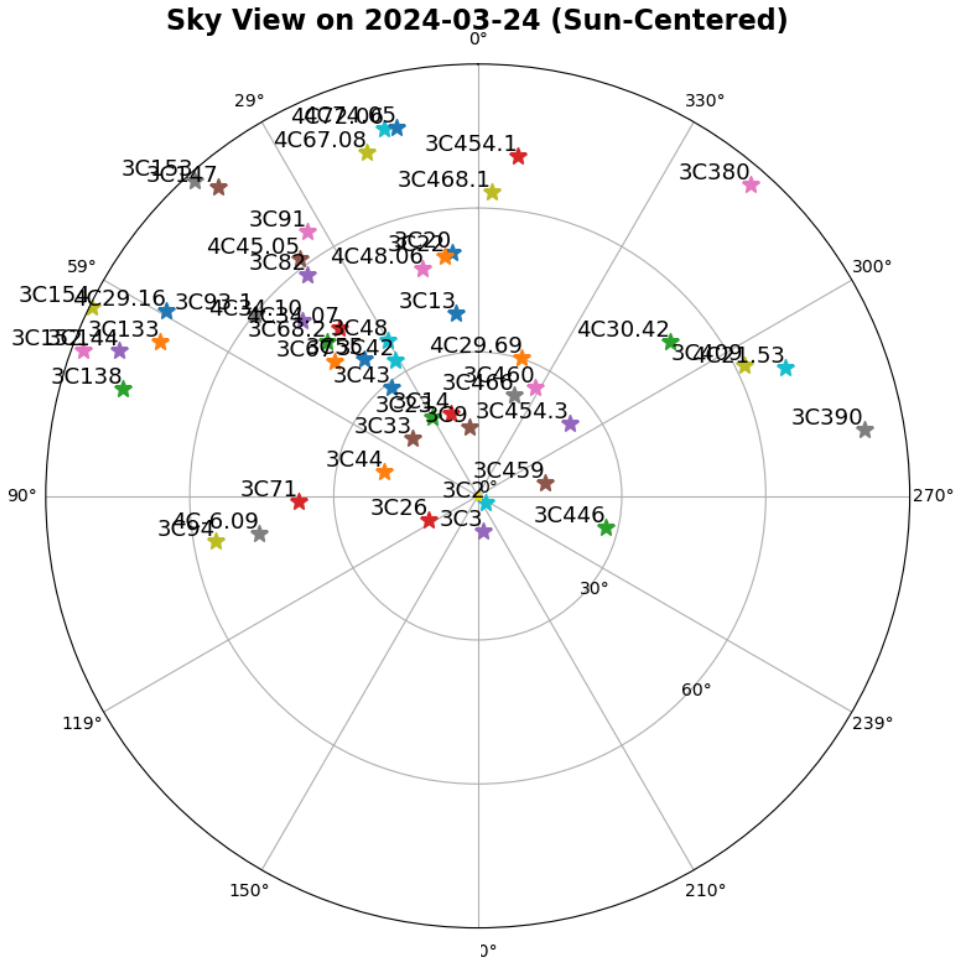
Science and Technology Facilities Council

RAL Space

Data access and description

Radio sources and LOFAR stations





Data used in the analysis came from LOFAR stations:
'UK608HBA', 'PL611HBA', 'PL610HBA', 'PL612HBA', 'DE609HBA', 'IE613HBA', 'DE603HBA',
'DE604HBA', 'FR606HBA', 'RS509HBA', 'RS310HBA', 'SE607HBA', 'LV614HBA', 'DE605HBA'

Science and Technology Facilities Council
RAL Space

Results and discussion

Methodology

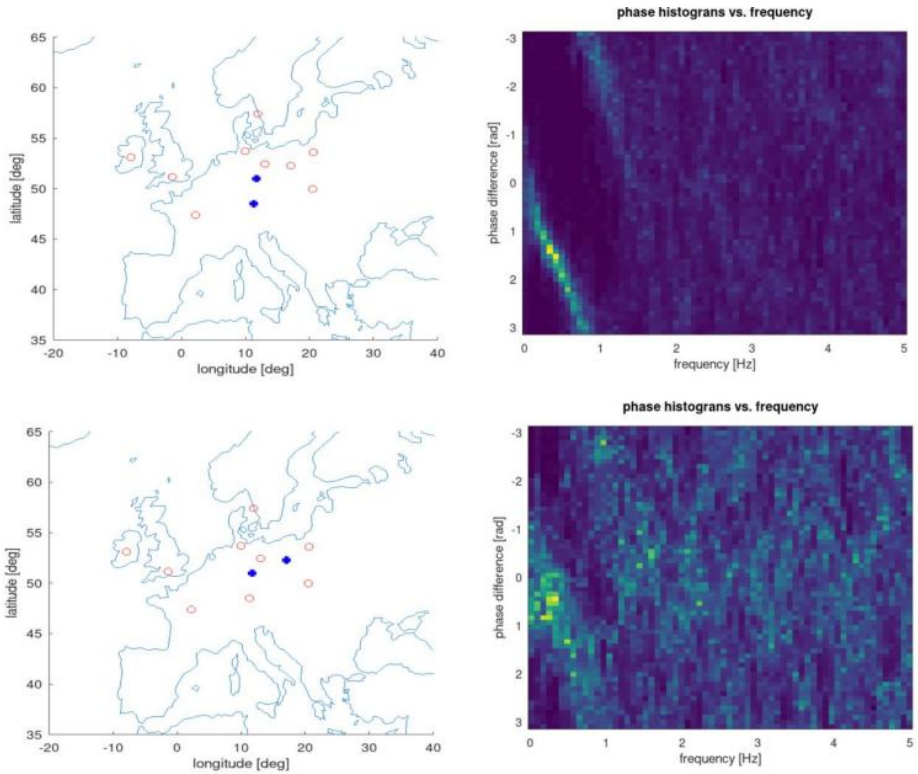
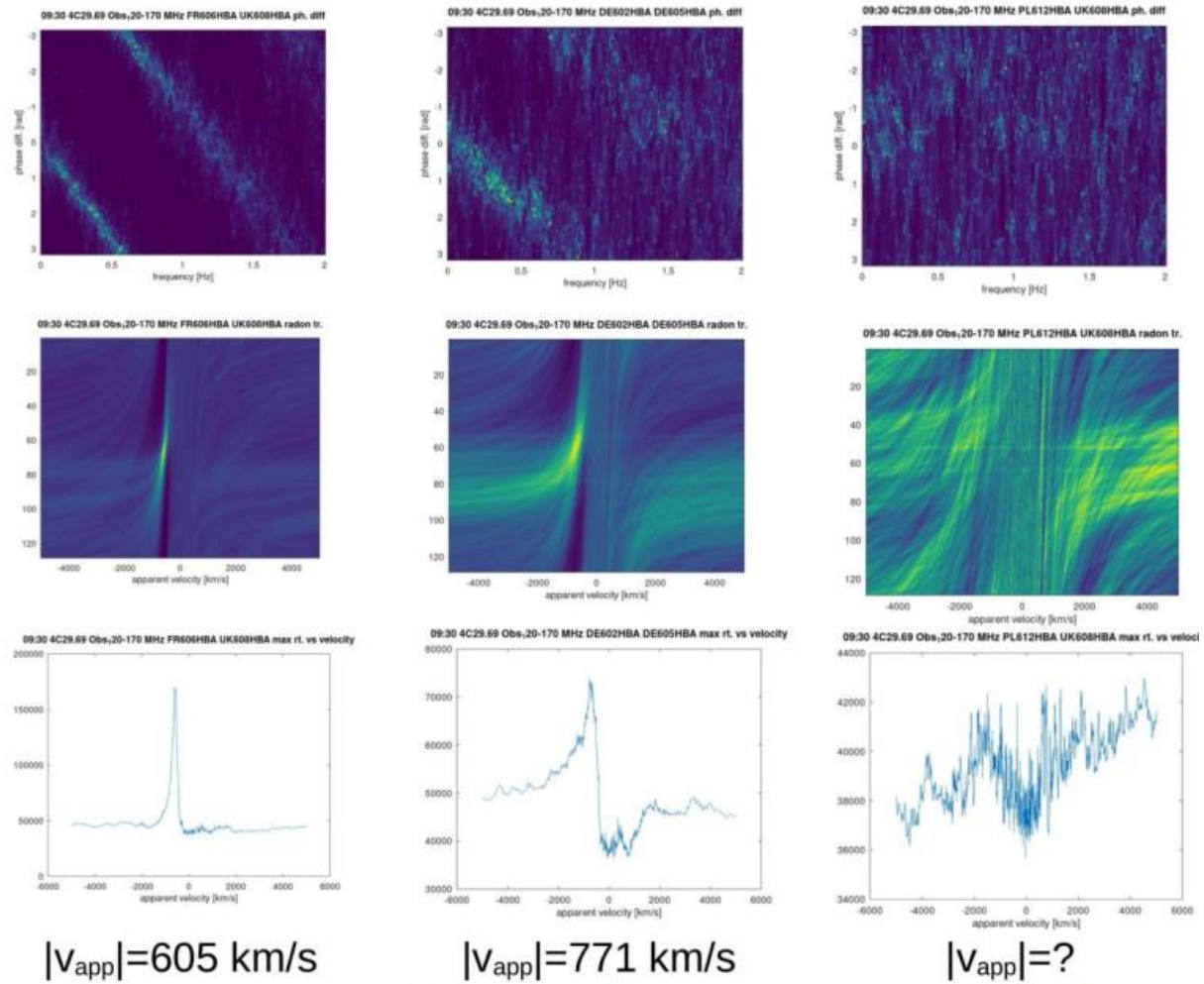


Fig 2. Left: blue dots represent pairs of LOFAR stations from which data were analyzed. Right: histograms of the phases of the cross-spectrum vs. frequency for the station pairs.



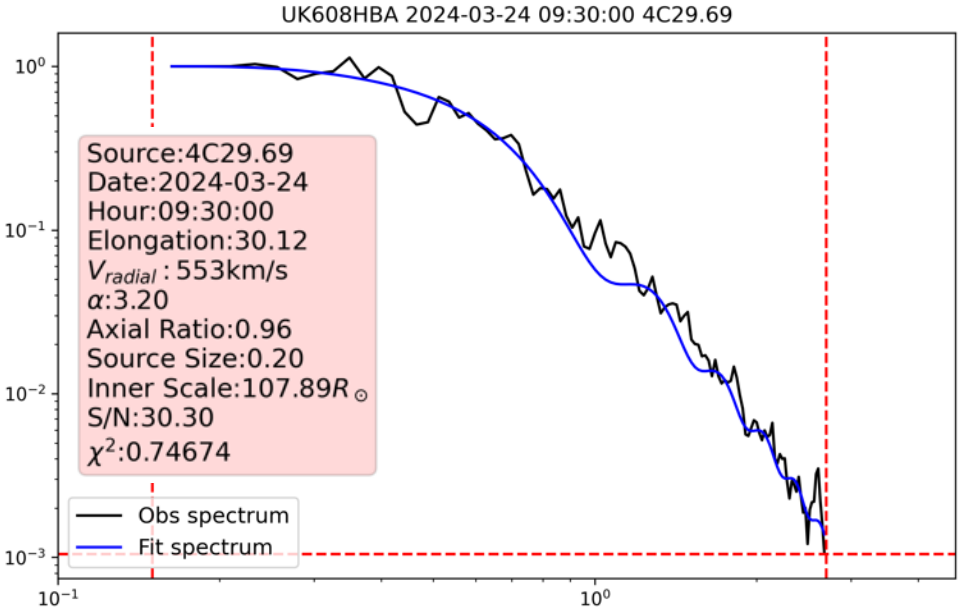
$|v_{app}|$=605 km/s $|v_{app}|$=771 km/s $|v_{app}|$=?

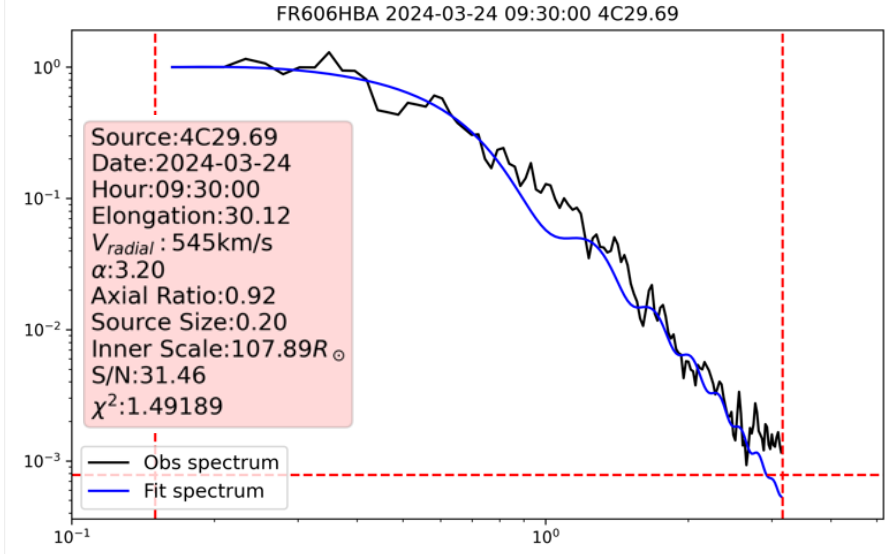
Fig 3. Upper row: histograms of the phases of the cross-spectrum vs. frequency for the station pairs. Middle row: Radon Transformation of histograms. Bottom row: abscissa of the RT plot maximum gives the apparent velocity.

Science and Technology Facilities Council

RAL Space

Results





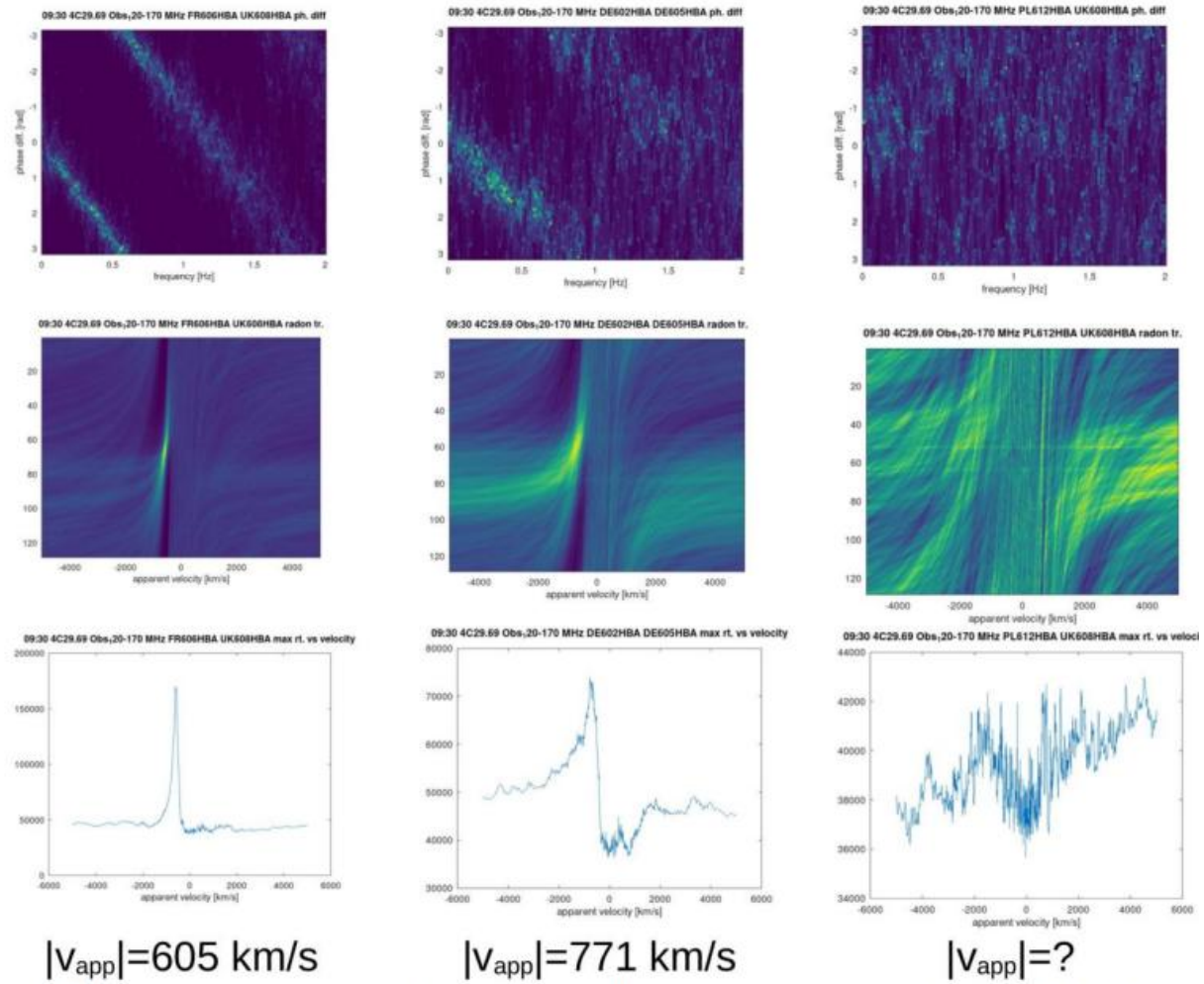
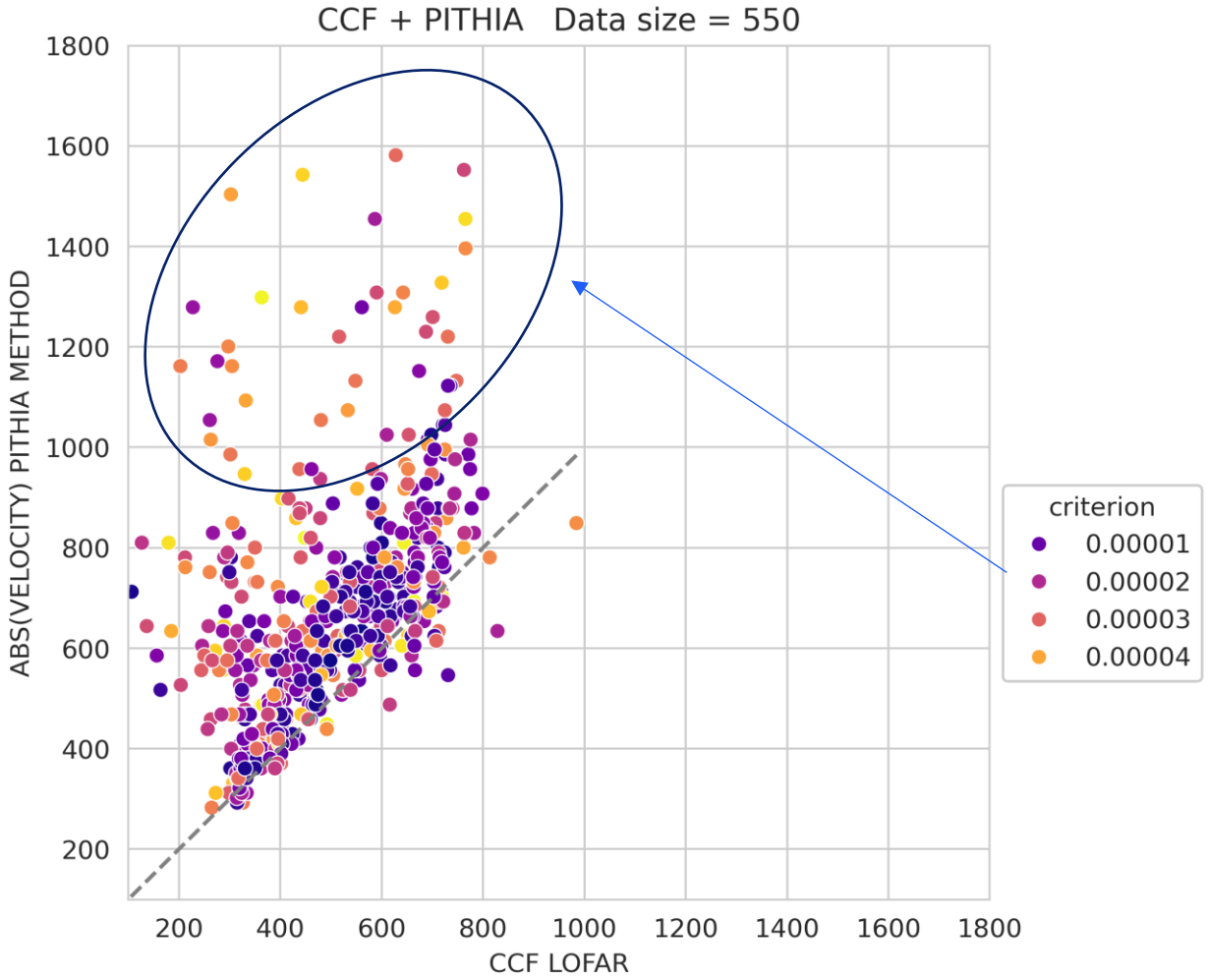


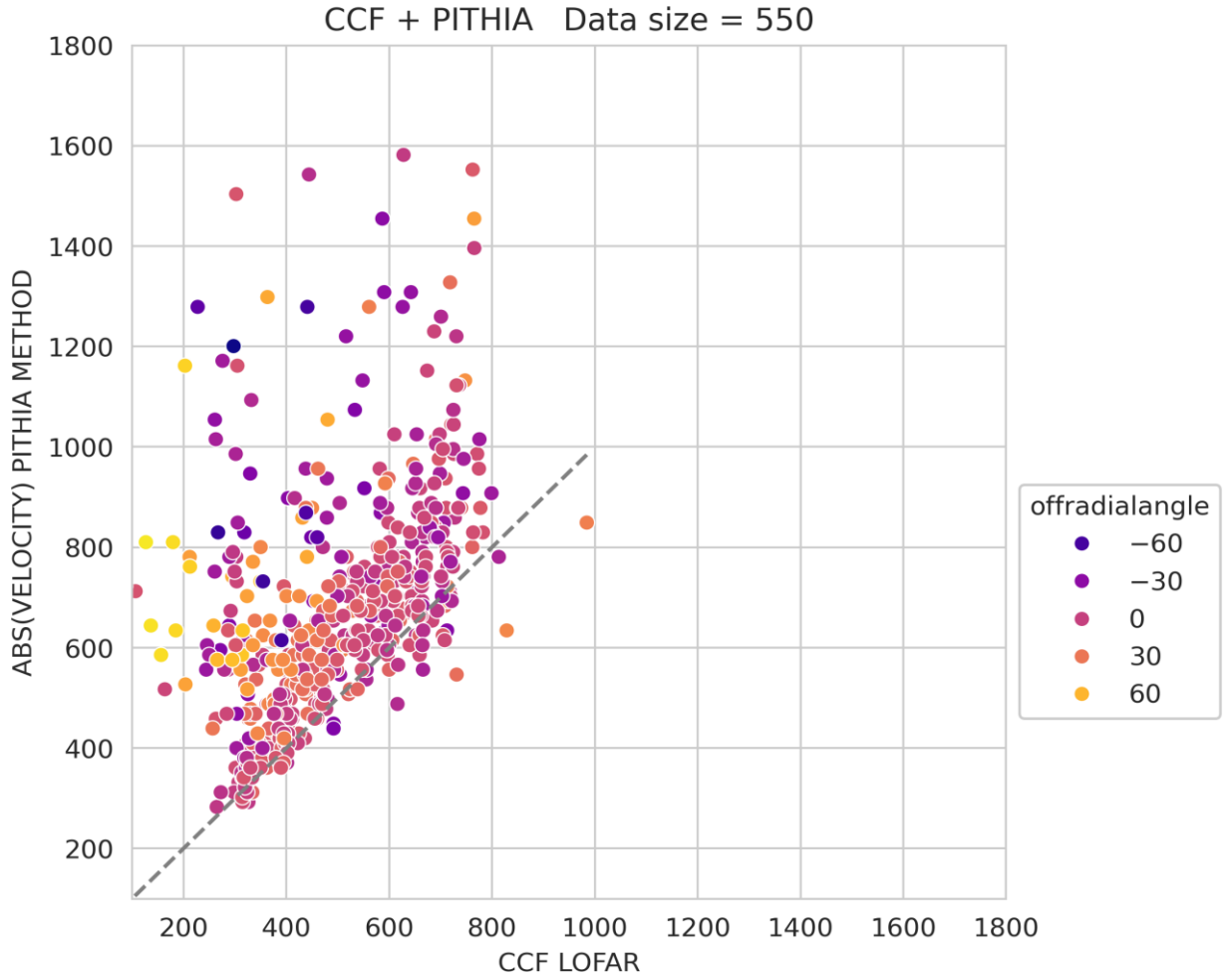
Fig 3. Upper row: histograms of the phases of the cross-spectrum vs. frequency for the station pairs. Middle row: Radon Transformation of histograms. Bottom row: abscissa of the RT plot maximum gives the apparent velocity.

Science and Technology Facilities Council

RAL Space

Results





Science and Technology Facilities Council

RAL Space

Summary

- We applied the methodology from Grzesiak et al. (2022) to estimate the velocity of solar plasma irregularities.
- It not only provides a means to compare and validate other techniques but also serves as a complementary tool for continuous measurement when other methods are unavailable or less effective.
- We successfully demonstrated that the proposed method is highly effective in calculating solar wind velocities using LOFAR stations.
- The results offer a novel approach, but further work is required to fully understand its limitations. Additionally, more effort is needed to optimize the use of all the techniques described here, ensuring their effectiveness for continuous monitoring of the interplanetary medium for space weather purposes.

Science and Technology Facilities Council

RAL Space

Thank you

TNA has significantly enhanced our ability to collaborate more effectively on an international scale. By offering physical access to PITHIA-NRF Node and additional remote support, , it has created an environment where resources and knowledge can be shared seamlessly.

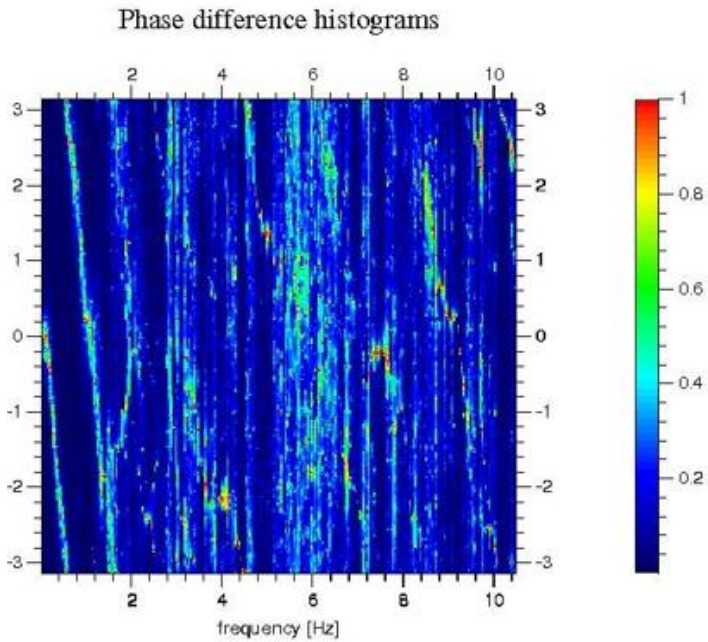
Questions ?

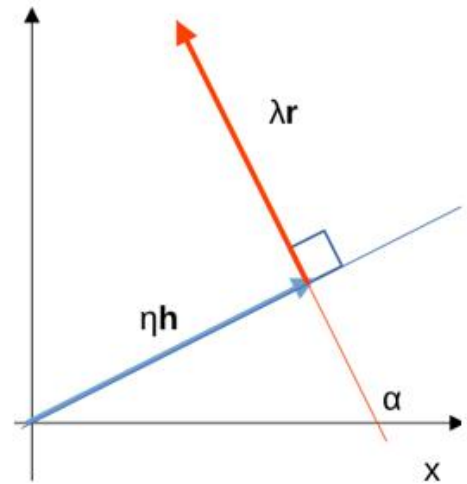
Science and Technology Facilities Council

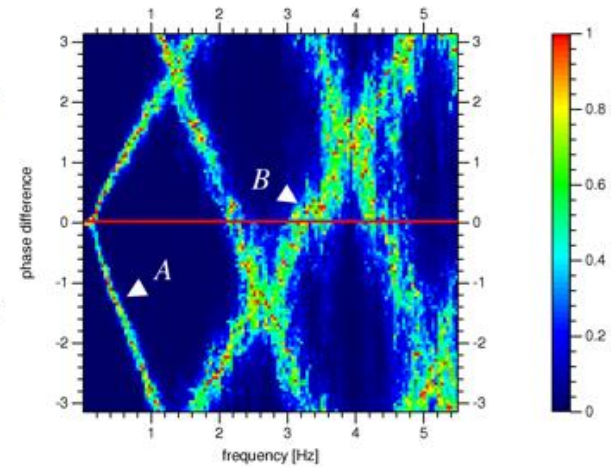
RAL Space

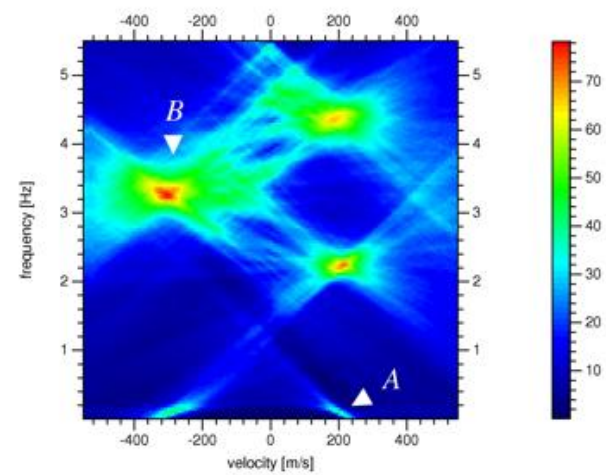
•The Radon transform

$$\mathrm{R}[f](\alpha,\eta) = \int d\lambda f(\lambda \boldsymbol{r}, \eta \boldsymbol{h})$$









Science and Technology Facilities Council

RAL Space