SHINE 2024

Radio Investigations for Space Environment Research (RISER): Year 1 Progress

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1. Abstract [1]

The NERC-funded Radio Investigations for Space Environment Research (RISER) project addresses the chain of events through which the Sun creates adverse space-weather conditions at Earth and within the Earth's space environment. RISER aims to investigate how the LOw Frequency ARray (LOFAR) can be utilised for continuous and accurate tracking of inner-heliospheric and ionospheric plasma structures, combined with magnetospheric modelling, leading to more-precise and advanced forecasts of space-weather conditions and their impacts at Earth. RISER will provide a comprehensive understanding of the Earth's space-environment through the use of novel radio observations and modelling techniques to investigate coupling between solar-driven inner-heliospheric structures and the Earth.

RISER brings together a unique set of different radio techniques along with various types of modelling and other data sets. It is a five-year project, which commenced on 01 September 2023 with partners in the UK and the USA. RISER will facilitate the upgrading of the LOFAR-UK Rawlings Array at Chilbolton to the new dual-beam, LOFAR For Space Weather (LOFAR4SW) capability, providing the potential for 24/7 space-weather observations towards the end of the five-year project.

Here, we give a reminder of the RISER project and its high-level objectives including the importance and relevance to advancing our understanding of space-weather science and impacts. We will report on progress to date throughout the first year of the project with an outlook on the next steps.

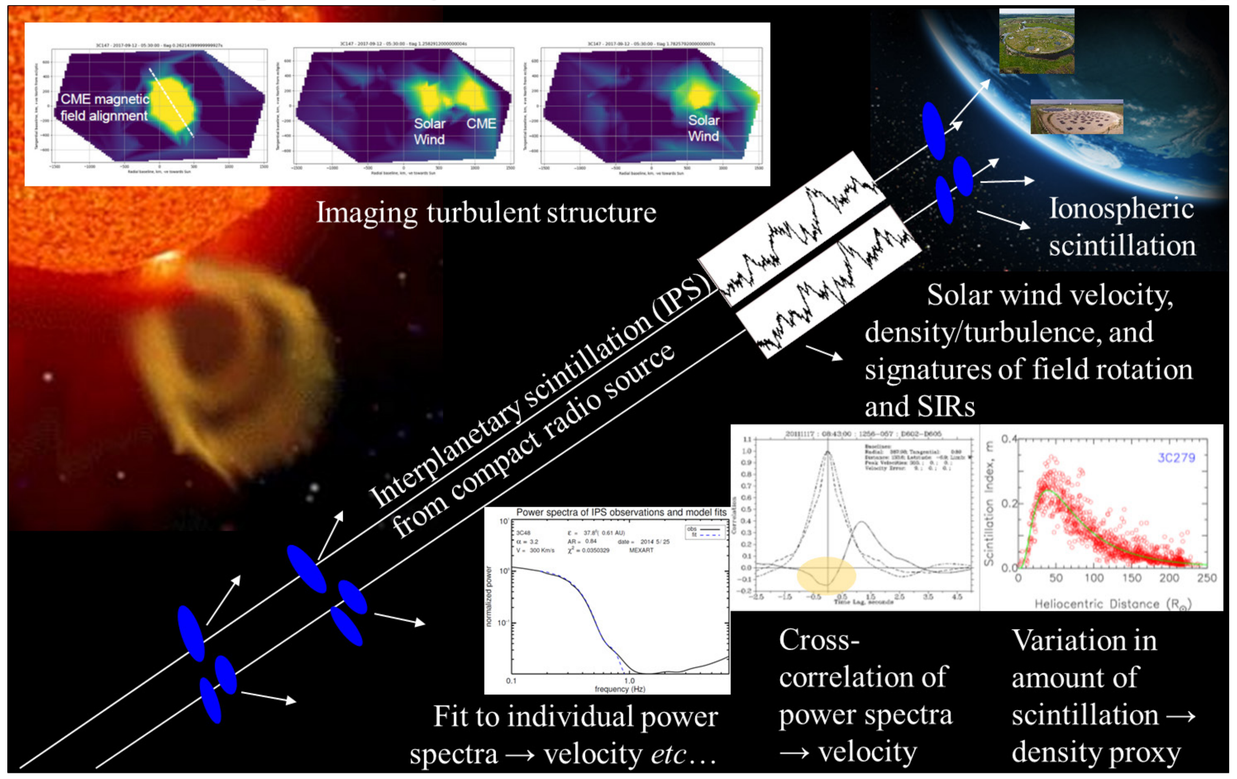
2. What is RISER?

RISER is a £3.7M FEC NERC-funded (NE/X019004/1) Large Environment 5-Year Project (commenced 01 September 2023 – Kick-Off Meeting 06-08 September 2023) to addresses the chain of events through which the Sun creates adverse space-weather conditions at Earth and within the Earth's space environment.

RISER aims to investigate how the LOw Frequency ARray (LOFAR) can be utilised for continuous and accurate tracking of inner-heliospheric and ionospheric plasma structures, combined with magnetospheric modelling, leading to more-precise and advanced forecasts of space-weather conditions and their impacts at Earth.

RISER will provide a comprehensive understanding of the Earth's space-environment through the use of novel radio observations and modelling techniques to investigate coupling between solar-driven inner-heliospheric structures and the Earth.

3. Radio Techniques and Key Science Questions [2]



How can we better attribute magnetospheric-ionospheric response to inner-heliospheric variability?

How well can we establish a direct connection between parameters that characterise structures in the inner-heliosphere with the geo-effectiveness of geomagnetic disturbances?

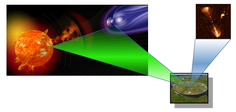
How can we identify and track plasma structures in the inner-heliosphere using scintillation data from low-frequency radio telescopes in a systematic way before they reach Earth?

What is the value of improved forecasts of adverse space-weather conditions when using radio-telescope observations and enhanced science of the inner-heliosphere/magnetosphere/ionosphere system?

4. RISER Project Structure

[3]

RISER brings together the wide and diverse scientific, technical, and engineering expertise essential to study the chain of environments through which the Sun creates space-weather effects at Earth and impact on critical UK infrastructures.



The project is organised across seven interlinking Work Packages (WPs) as follows:

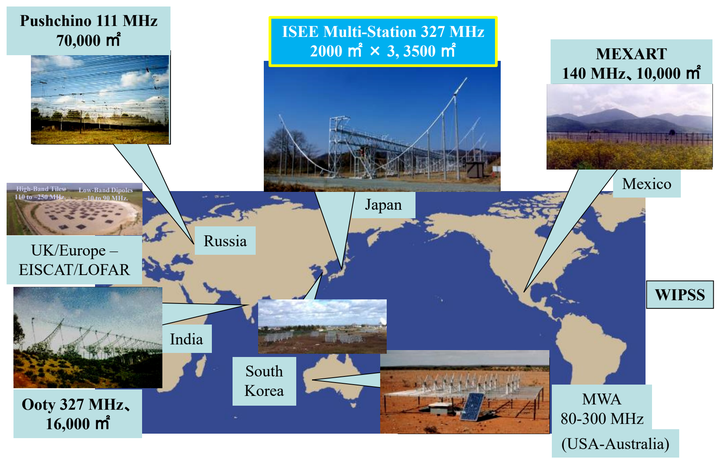
- WP1: Coordination/management of the project (M1-M60).
- WP2: Analysis and interpretation of typical LOFAR intensity scintillation data (M1-M60).
- WP3: Research on novel LOFAR observations (M13-M60).
- WP4: Analyses and modelling of the magnetosphere-ionosphere response to solar wind features observed by LOFAR (M1-M60)
- WP5: Observation of the impact on technology systems on Earth (M25-M60).
- WP6: Improvement of current space-weather forecasts (M1-M60).
- WP7: Upgrade of the LOFAR-UK station and collection of novel observations (M25-M60); a unique world-leading dual-beam telescope.

5. The Magnetospheric Connection

- Improve space-weather forecasts using Sun-to-Earth radio data.
- Move from 1-D (L1 monitoring) to 3-D space situational awareness.
- Provide validation and calibration using global-scale ground- and space-based networks of observatories, and simulations.
- Resolve solar wind structures on scales relevant to solar wind-magnetosphere coupling.
- Estimate the geoeffectiveness of incoming solar wind hazards.

6. The Worldwide IPS Stations (WIPSS) Network

WIPSS – the bringing together of all IPS-capable telescopes around the world with a common data format (IPSCDFv1.1).



LOFAR4SW

LOFAR4SpaceWeather: Towards Space Weather Monitoring with Europe's Largest Radio Telescope

A fully-implemented LOFAR4SW will be one of Europe's most comprehensive space weather observatories, shedding new light on several aspects of the space weather system, from the Sun to the solar wind to the ionosphere.

In collaboration with the Murchison Widefield Array (MWA), a new IPS source list is being formed and will be tested – it has over 2,000 new compact sources and so it will take some time to be able to test how many of these are suitable for observations using IPS with LOFAR.

7. RISER IPS Aspirations

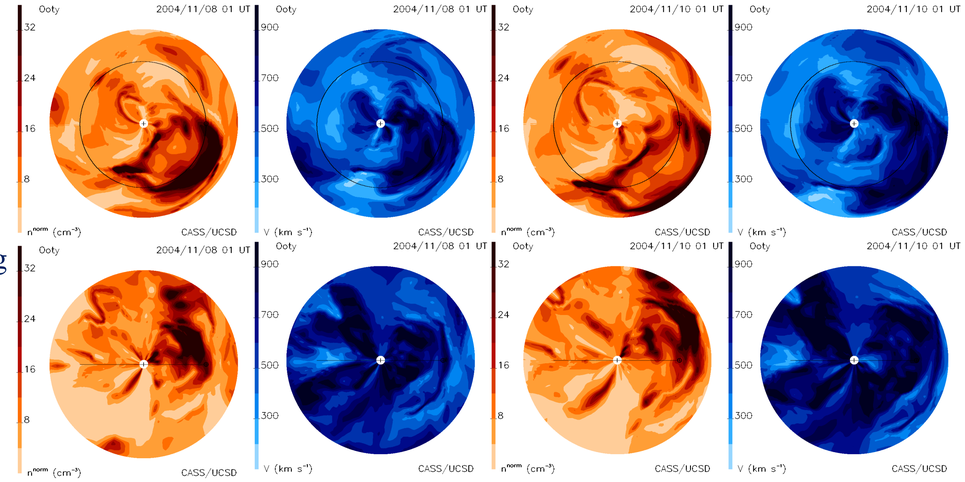
[4]

With the addition of the extra sources from LOFAR-MWA collaborations, LOFAR should be able to provide several hundred observations of IPS per day with a variety of analyses techniques available.

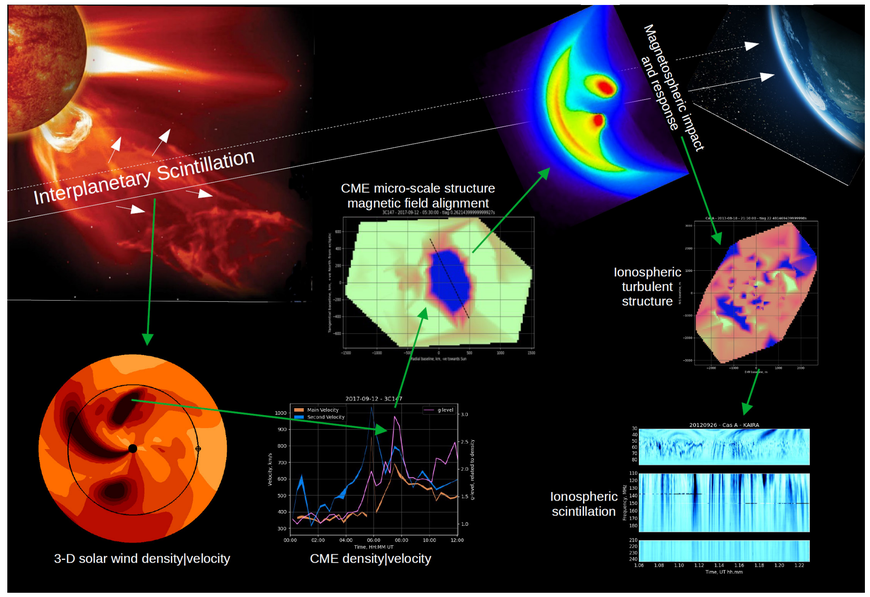
The results can be formulated into the IPSCDFv1.1 for input to the University of California, San Diego (UCSD) tomography which can subsequently be used to drive ENLIL for improvements and backup options for space-weather forecasting (IPS-ENLIL).

Reconstructions from many Ooty science data IPS results (see Bisi *et al.*, Ann. Geo., 2009, for full details).

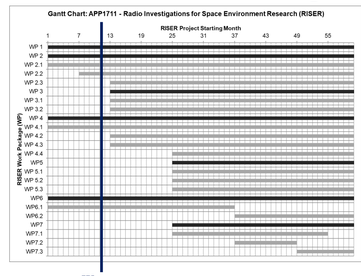
Demonstrating the improvement by using UCSD 3-D Tomography for space-weather reconstructions with more data input!



8. Summary…



Bringing aspects of the RISER project together will allow for a comprehensive Sun-Earth observational and modelling combination of studies and monitoring to improve our understanding of space-weather phenomena and impacts as well as to feed into enhanced forecast techniques.



We are here!

9. Acknowledgements

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RISER

UKRI Science and Technology Facilities Council
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