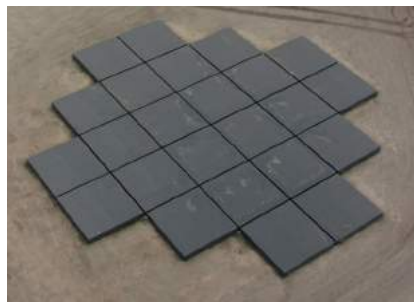


# LOFAR4SpaceWeather: Towards space weather monitoring with Europe's largest radio telescope

# LOFAR: World's largest and most flexible low frequency radio telescope



**Dense core 24 stations**  
in area with 3 km diameter:  
30 m – 3 km  
**Remote stations across the the Netherlands:**  
5- 200 km  
**International stations:**  
100-2000 km

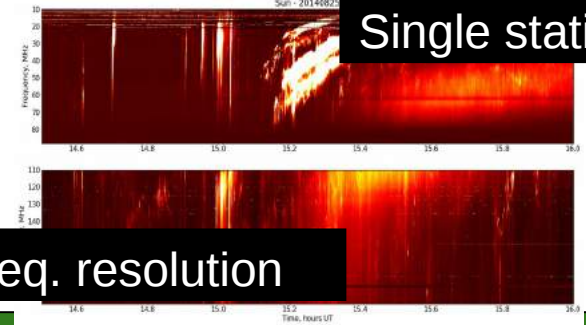
HBA: 110-240 MHz

LBA: 20-80 MHz

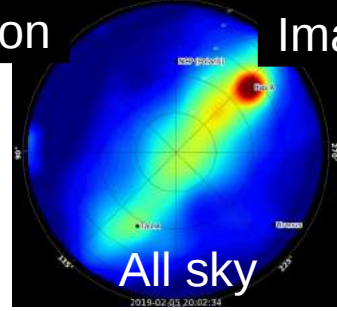


**Observing modes:**

Raw voltages

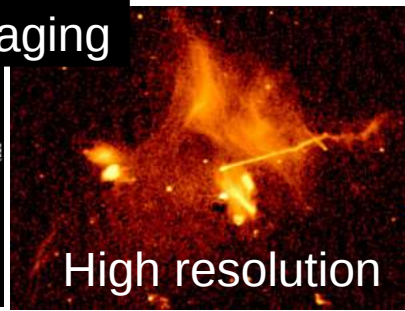


Single station



Imaging

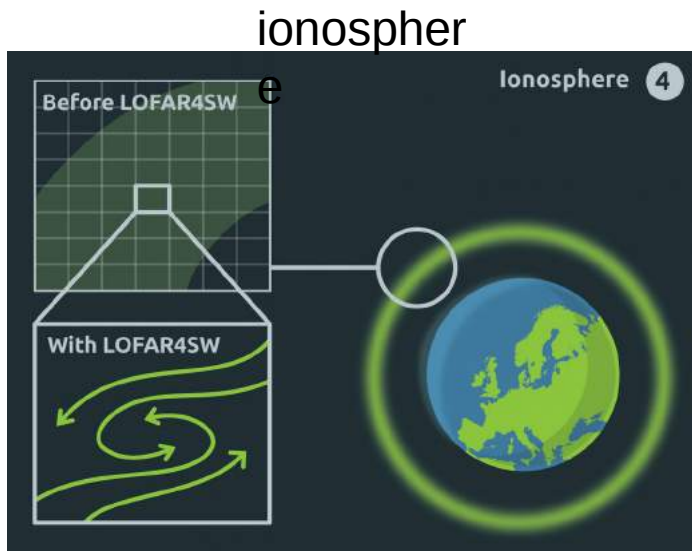
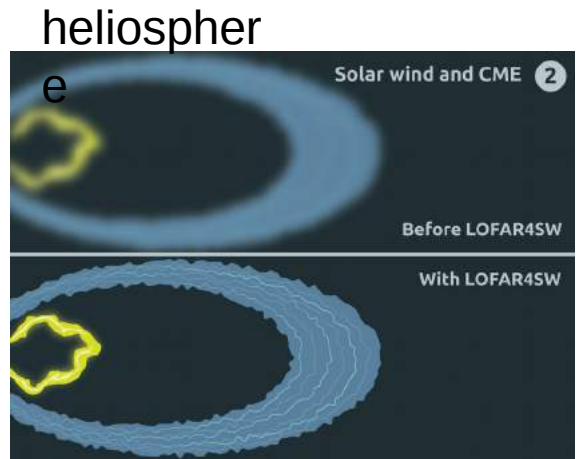
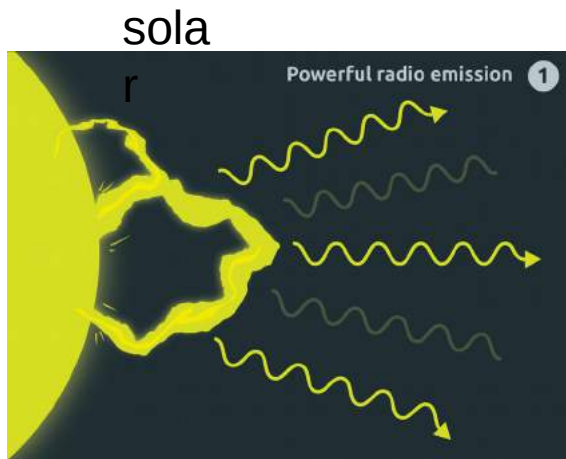
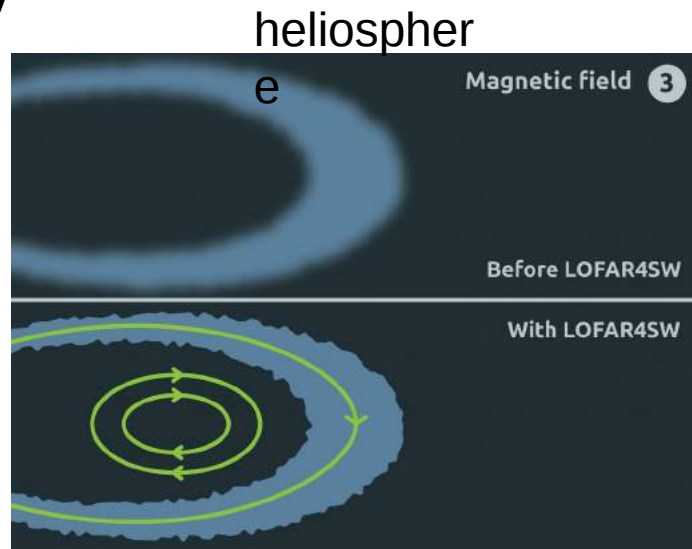
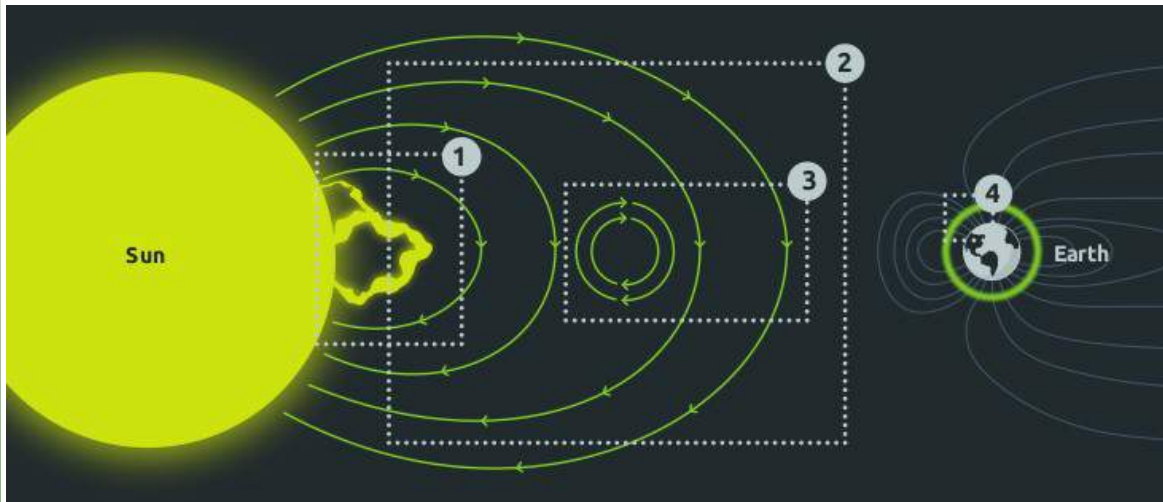
All sky



High resolution

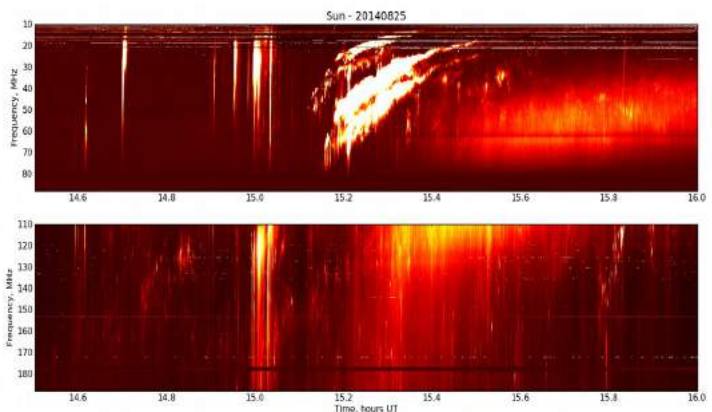
High time/freq. resolution

# LOFAR4SW: A Comprehensive Space Weather Observatory



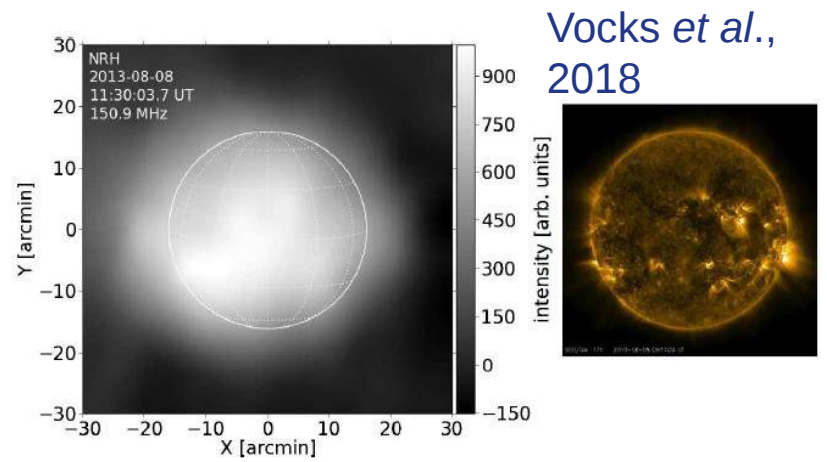


# Solar

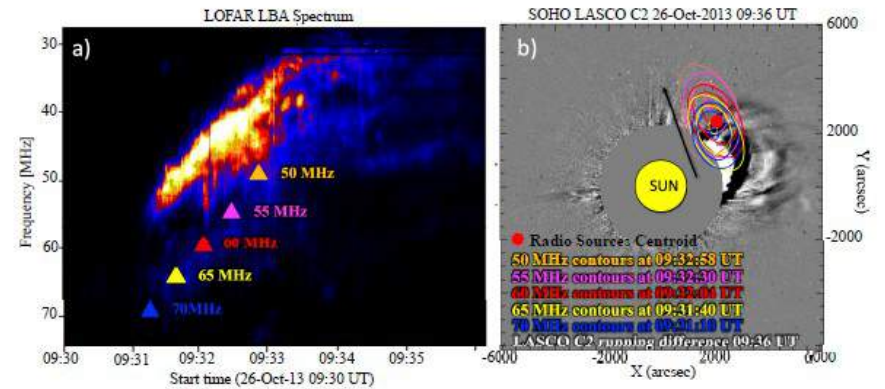


LOFAR has the capability to take simultaneous high-resolution dynamic spectra across the full observing band and high-resolution imagery at sub-second cadence.

Use Case	Subject	Science Priority	Operations Priority
1	SW monitoring	Medium	Top
2	CME imaging	Top	High
3	Type II/shocks	High	Medium
4	Type III/particles	High	Medium
5	Quiet Sun/C-holes	High	High
6	Long term sources	High	Medium
7	Fine Structure	Medium	None

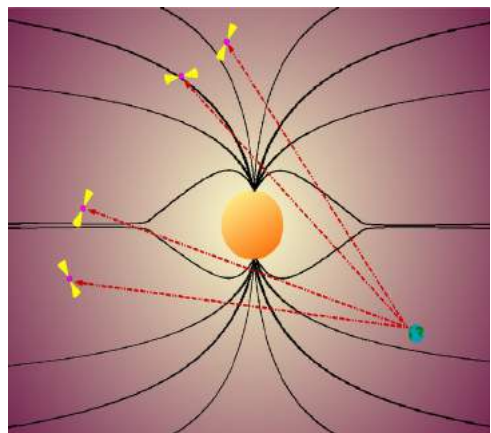


Vocks et al., 2018



Zucca et al., 2018

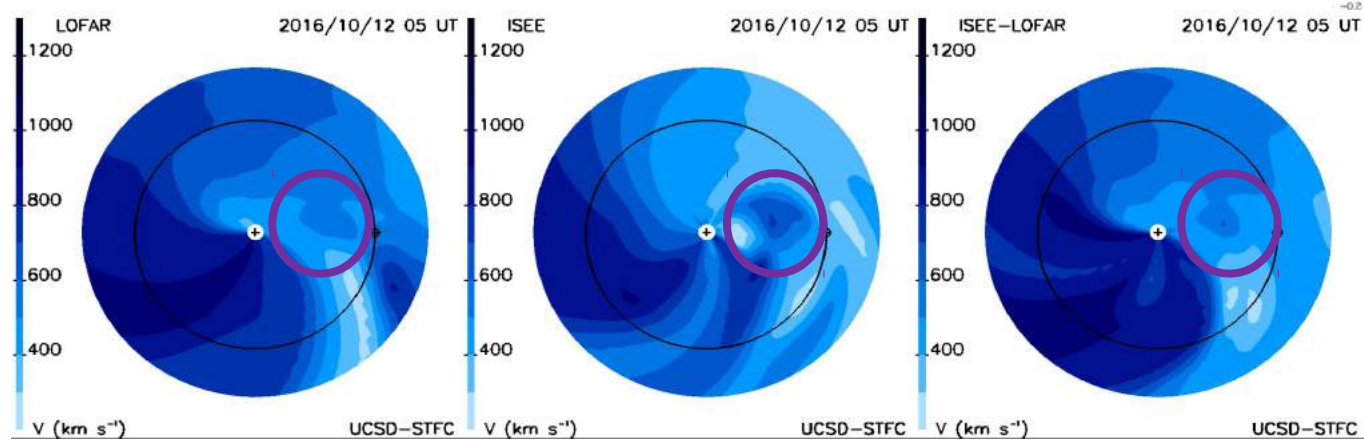
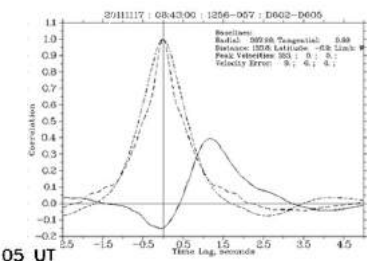
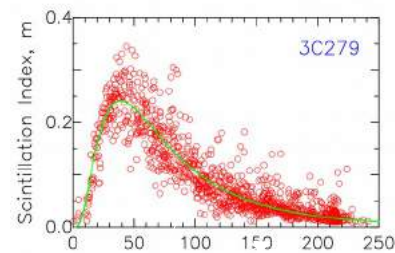
# Heliosphere



Measure solar wind velocities and g-levels (density) through interplanetary scintillation (IPS):

- Single source monitoring
- All sky snapshot imaging

Faraday rotation of polarised emission (pulsars/diffuse galactic) → magnetic field



CME reconstructed using LOFAR, ISEE, and ISEE-LOFAR combined data inputs to the UCSD tomography...

# Ionosphere

Use cases:

Absorption: All sky imaging riometer

Small scales: amplitude scintillation

Scintillation index @ low frequencies

Imaging small scale structure flows

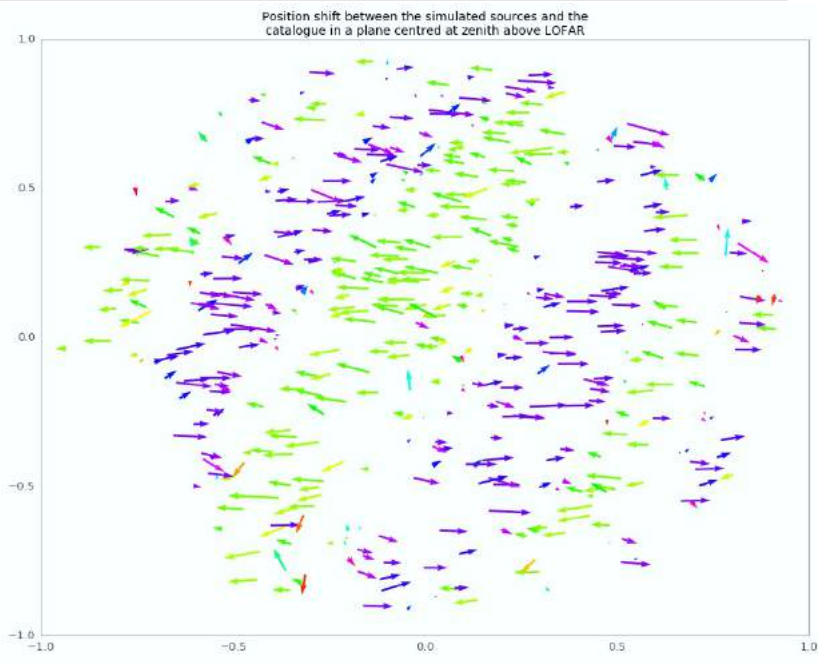
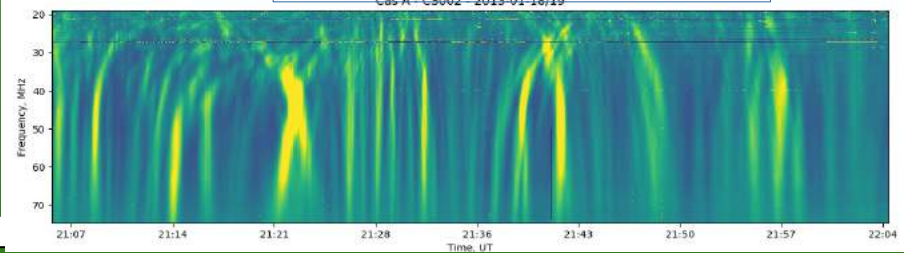
Large scales: TID detection

Real time all sky imaging of large scale ionospheric structures

Passive Radar: receive meteor echoes + reflected transmitters @ lower ionosphere

Ionospheric disturbances alter the phases and amplitudes of signals from radio sources  
 With LOFAR we can measure these with very high accuracy (dTEC/space/time)

Amplitude scintillation



Refractive shifts of simulated wave

- With LOFAR we can significantly improve measurements in the Solar, Heliospheric and Ionospheric domains
- LOFAR can do all these measurements simultaneously
- At a much lower costs than space based facilities
- Easily maintained and upgraded

LOFAR4SW: deliver a fully documented **design** for LOFAR as Space Weather instrument (next to Radio Astronomy)





LOFAR<sub>4SW</sub>

## **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.