Monitoring of the solar atmosphere through radio imaging in the 18-100 GHz band: recent results and future challenges

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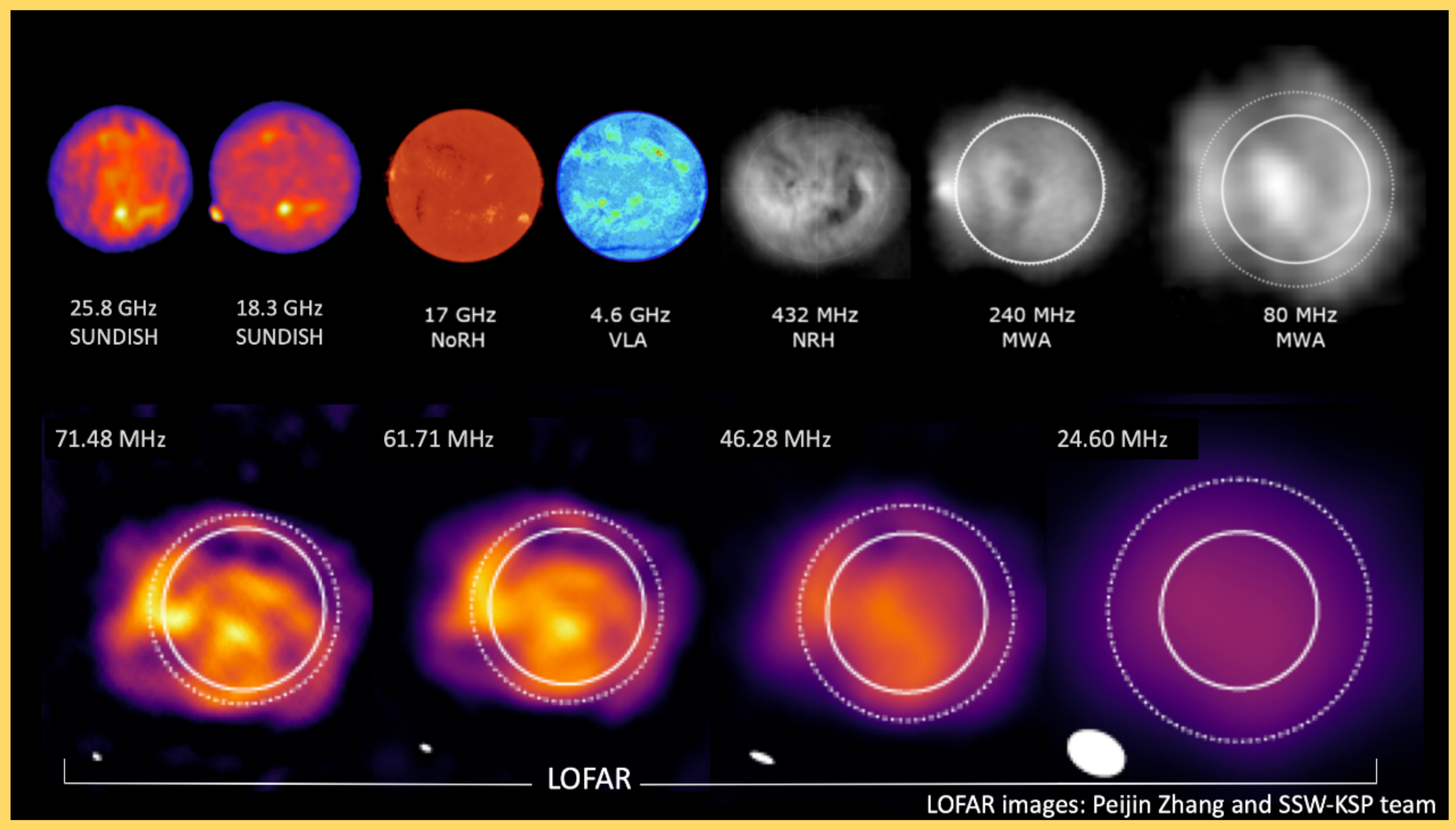
Abstract: In the frame of radio monitoring of the solar atmosphere with large INAF radio telescopes we are developing and exploiting innovative **single-dish radio imaging techniques at high-frequencies up to 100 GHz**. Since 2018, we have been **monitoring the solar atmosphere in the 18-26 GHz frequency range providing weekly images**, in perspective covering the entire current solar cycle (**SunDish project**) even at higher frequencies. In this context, a **new solar imaging system at high frequency (70-120 GHz) was recently approved as a permanent observatory in Antarctica** (**Solaris project**). It combines the implementation of dedicated and interchangeable high-frequency receivers on existing small single-dish radio telescope systems (2.6m class) available in our laboratories, on the Alps and in polar regions. Operations in Antarctica will offer unique observing conditions (very low sky opacity and **long Solar exposures for nearly 20h/day**) and unprecedented Solar monitoring. This opens for the **continuous monitoring of the chromosphere and the identification and spectral analysis of Active Regions before, after and during the occurrence of Solar flares**. The Solaris observatory will be **the only Solar facility offering continuous monitoring at 100 GHz**, and it will be able to collect and disseminate data in synergy with the existing national and international network of Space Weather facilities.

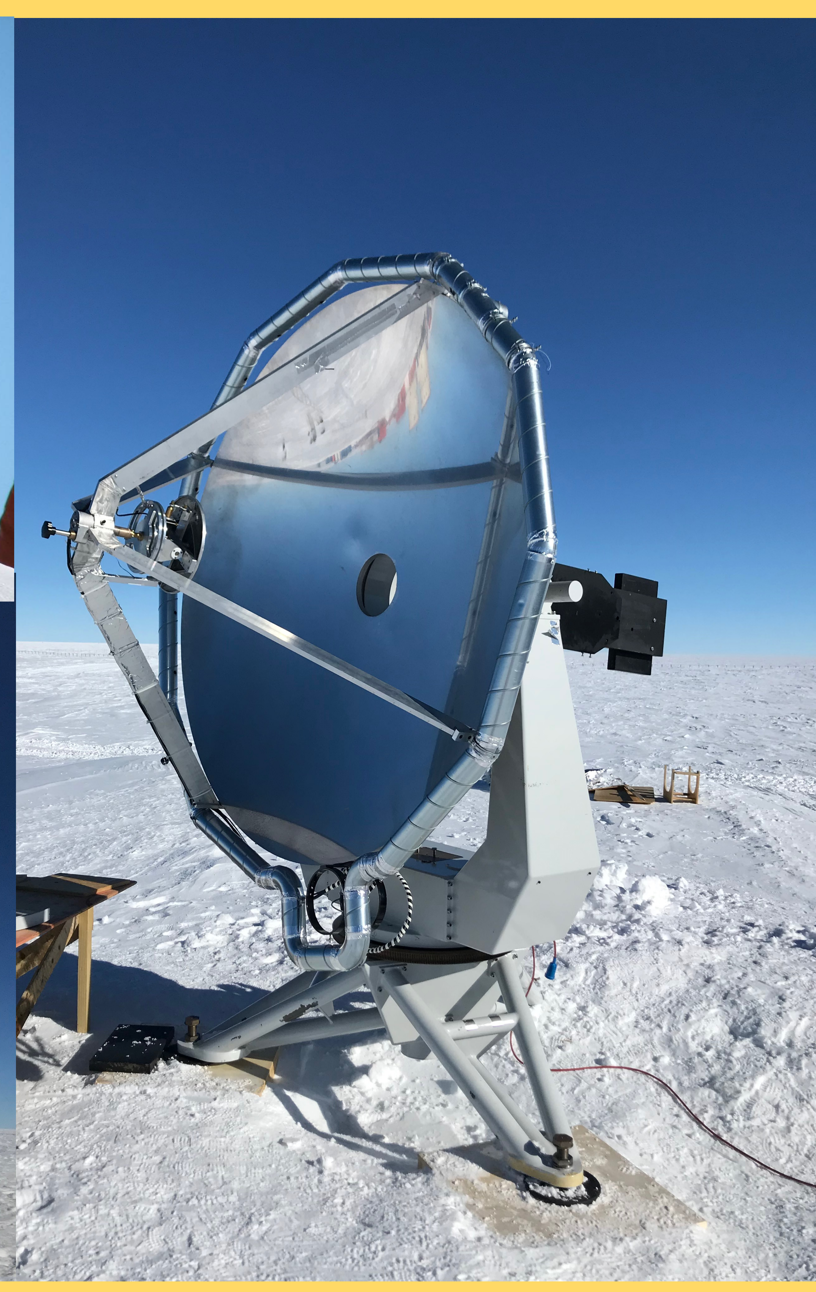
Challenges of Solar imaging at high radio frequencies: lack of continuous monitoring for Space Weather applications

Solar imaging observations in the **radio band offer the opportunity to investigate different layers of the solar atmosphere**. Higher the frequency, deeper the probe in the Sun structure. For example, low radio frequencies observations (10-100 MHz) can measure coronal temperature in the optically thick regime, while **high-frequencies (>10-15 GHz) can shed light on the thermal and gyro-magnetic processes in the chromosphere useful for Space Weather applications and flare forecast (see e.g. Pellizzoni et al. 2022)**. The study of **the dynamical phenomenology of the solar atmosphere would require a frequent monitoring** (ideally h24) to follow the evolution of the Active Regions, Coronal Holes and other peculiar features, as well as energetic burst emission, flare and Coronal Mass Ejections. Most of existing radio imaging instrumentation and facilities can offer just sporadic observations.

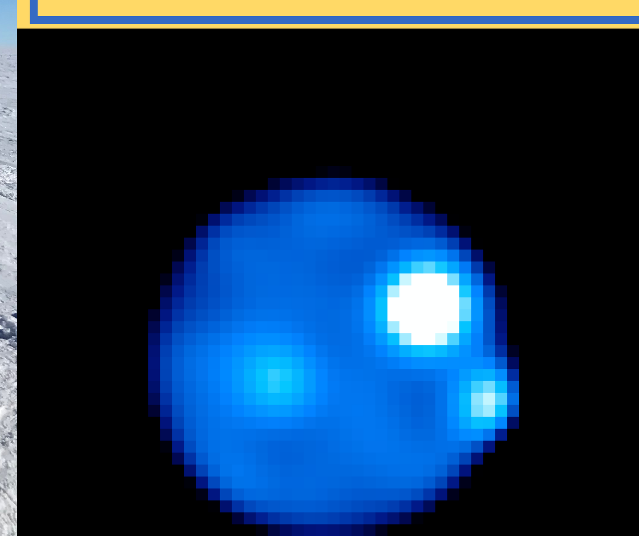


LOFAR images: Peijin Zhang and SSW-KSP team

Solaris: monitoring the Sun at high-frequencies for nearly 24h/day in good observing conditions during polar summers



Solaris exploit existing small (1.5/2.6m) and **flexible radio telescopes in our laboratories and in Antarctic sites** (OASI/MZS, COCHISE/Concordia) that can be customised for solar observations. These systems can be coupled with state-of-the-art receivers (e.g. based on ALMA technology) and innovative solar imaging techniques (from SunDIsh INAF project) in order to **operate in polar regions with optimal solar visibility and sky opacity conditions for high-frequency observations (70-120 GHz) with a few arcmin spatial resolution**.


Solaris simulated image: 4.5' BWHM, 1000/2000/3500 K AR

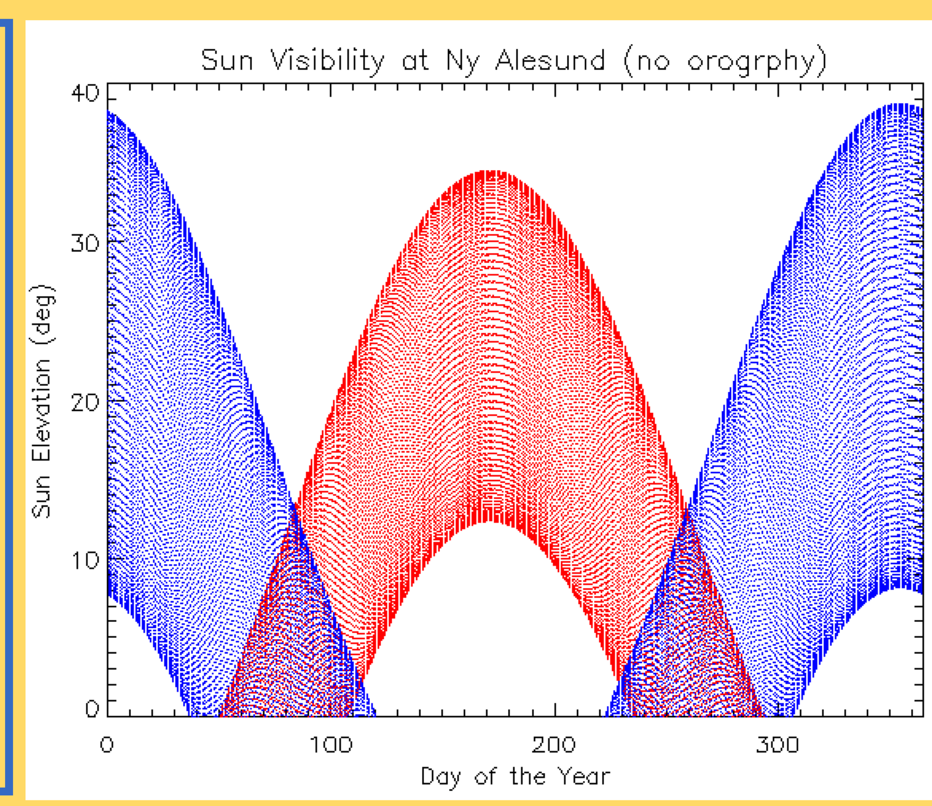
Solaris can provide continuous solar monitoring during the Antarctic summer: frequent imaging observations and search for flaring emission in the active regions. **The study of Active Regions and flares before, during and after their occurrences can offer tools for Space Weather forecast** and to contribute to prompt response in the frame of international networks.

The Solaris prototypes

The **Solaris prototypes** are developed, tested and optimised in our laboratories before operations in remote polar sites, also offering training and educational resources together with challenging science.

The Solaris program: towards a global coverage

The **implementation of different Solaris stations both in the south (Antactica) and in the north (Arctic regions) hemisphere** can offer an interrupted solar monitoring. Solaris can be the only facility offering radio coverage at 100 GHz for the whole year, nearly h24. Example of solar visibilities (plot): north (red), south (blue).



For more information and collaborations, please contact us!

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Solaris website: https://sites.google.com/inaf.it/solaris