National Aeronautics and Space Administration

Preliminary Measurements of Astrophysical Targets with Small Space Based Radio Interferometers

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Project Objective:

SunRISE is a Heliophysics mission managed by JPL designed to localize type II and type III radio emissions from the Sun (Figure 1). It will be the first low frequency radio interferometry in space and has full-sky imaging capabilities. This task is aimed at quantifying how well it will be able to operate as a radio astronomical observatory although not originally designed for this purpose.

Objective 1: Create the software to integrate interferometric images from space-based arrays to facilitate a multi-spacecraft radio telescope array (such as SunRISE) to make the first map of the sky below the ionospheric cutoff of 10 MHz.

Objective 2: Analyze the available SunRISE orbit simulations to identify periods that are most conducive to forming the highest possible resolution map for every given part of the sky, combining measurements from across the orbit to better sample the sky brightness.

Objective 3: Simulate the response of a SunRISE-like array on a multitude of relatively dim astrophysical targets.

FY18/19 Results:

- The sensitivity of the SunRISE array for various integration times and bright radio sources that can be observed with SunRISE were identified (Figure 2).
- A simulation pipeline using CASA (the industry standard) was developed that can accommodate the spacecraft orbits.
- The point spread function (PSF) was estimated using realistic simulations of the SunRISE orbits (Figure 2). The PSF becomes approximately Gaussian with low sidelobes after 24 hours of integration. The spacecraft orbits repeat every 24-25 hours.
- We can simulate the response of SunRISE using complex source sturctures as inputs. An example is shown in Figure 4.

Benefits to NASA and JPL (or significance of results):

- Results demonstrate the performance of SunRISE as the first interferometric low-frequency radio observatory in space.
- Future missions, such as RELIC (Belov et al. 2018) , have been designed to observe the history of activity of supermassive black holes in active galactic nuclei.
- These results and the performance of SunRISE will give JPL a strategic advantage for the development of future low frequency radio astronomical observatories with higher sensitivity and resolution.

References:

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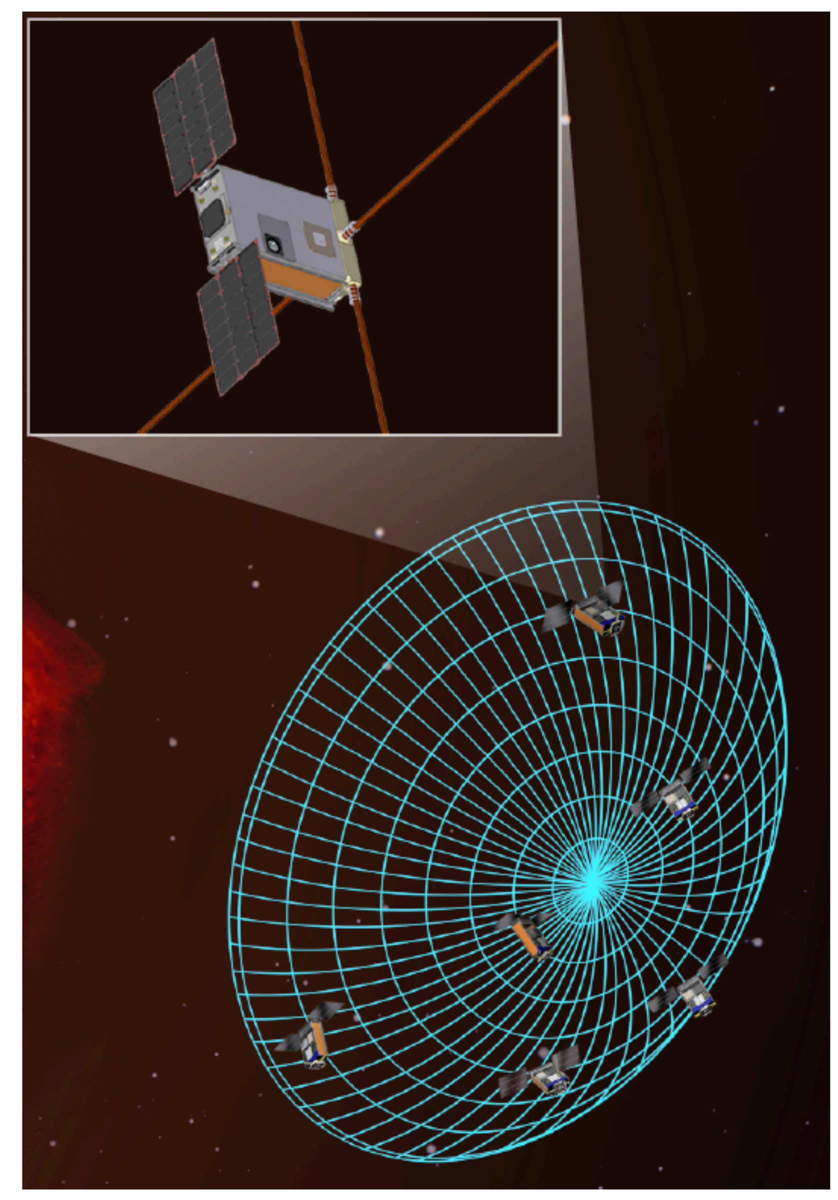

Figure 1: the SunRISE array consists of an array of 6 SmallSats in supersynchronous orbit.

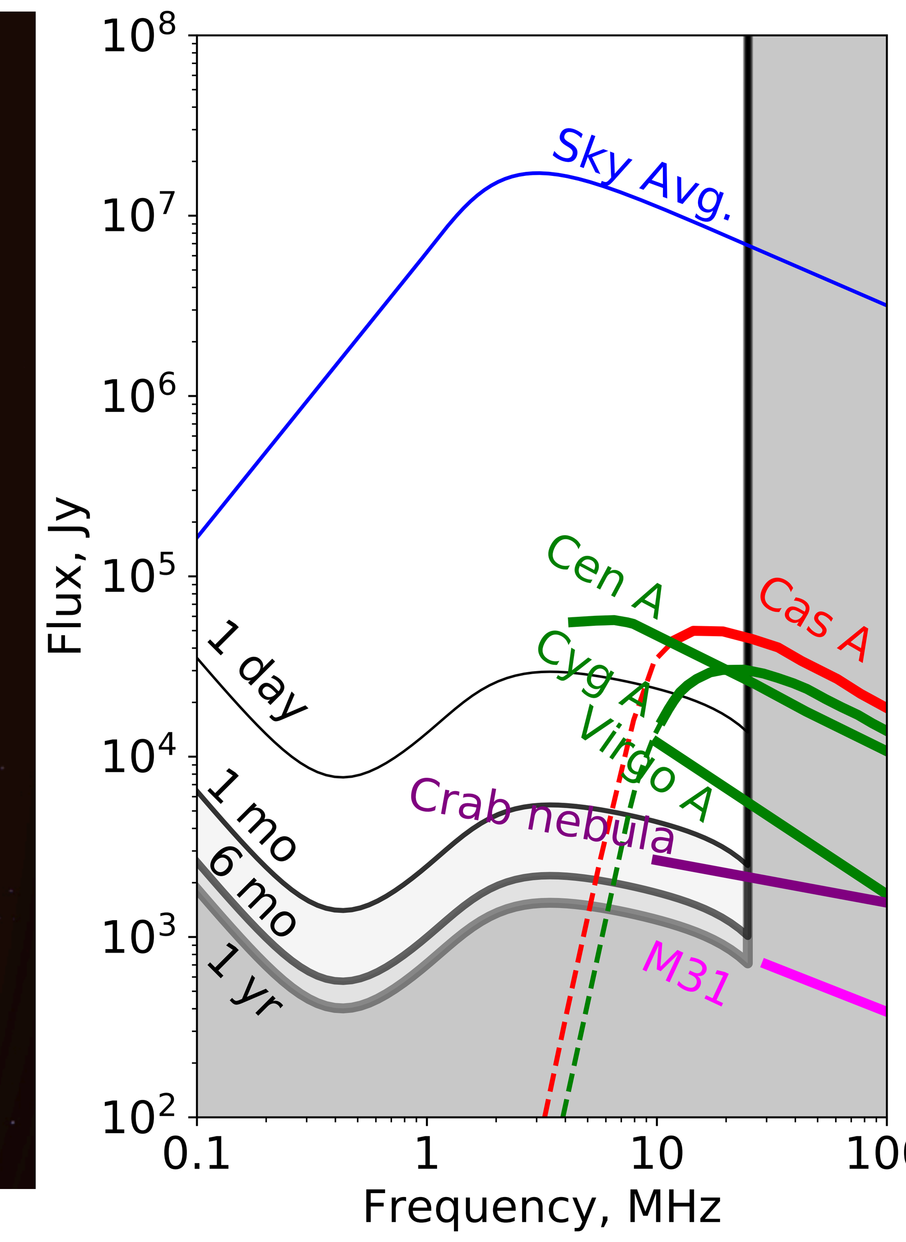

Figure 2: sensitivity estimates of the SunRISE array compared to the fluxes of bright low-frequency radio sources

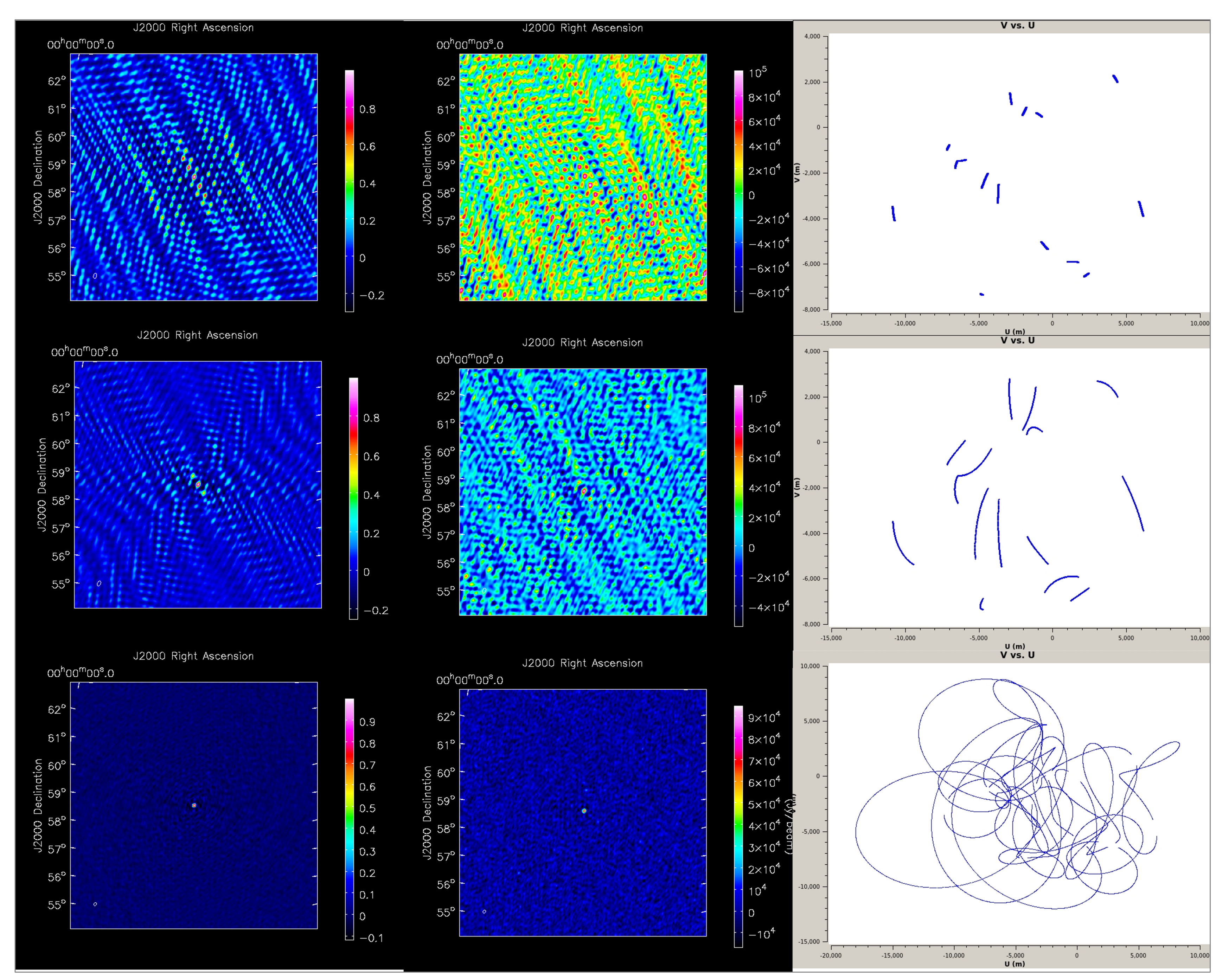

Figure 3: Left Column: Point spread functions over 30 minutes, 2 hours, and 24 hours for the SunRISE synthetic aperture pointed in the direction of Cas A. Middle Column: Noisy dirty image of a point source at 10 MHz made by the SunRISE array after 30 minutes, 2 hours, and 24 hours of integration for a point source with a flux density of 100 kJy imaged over a system equivalent flux density (SEFD) of 25 Mjy. Right Column: UV coverage in the frame pointed towards the source.

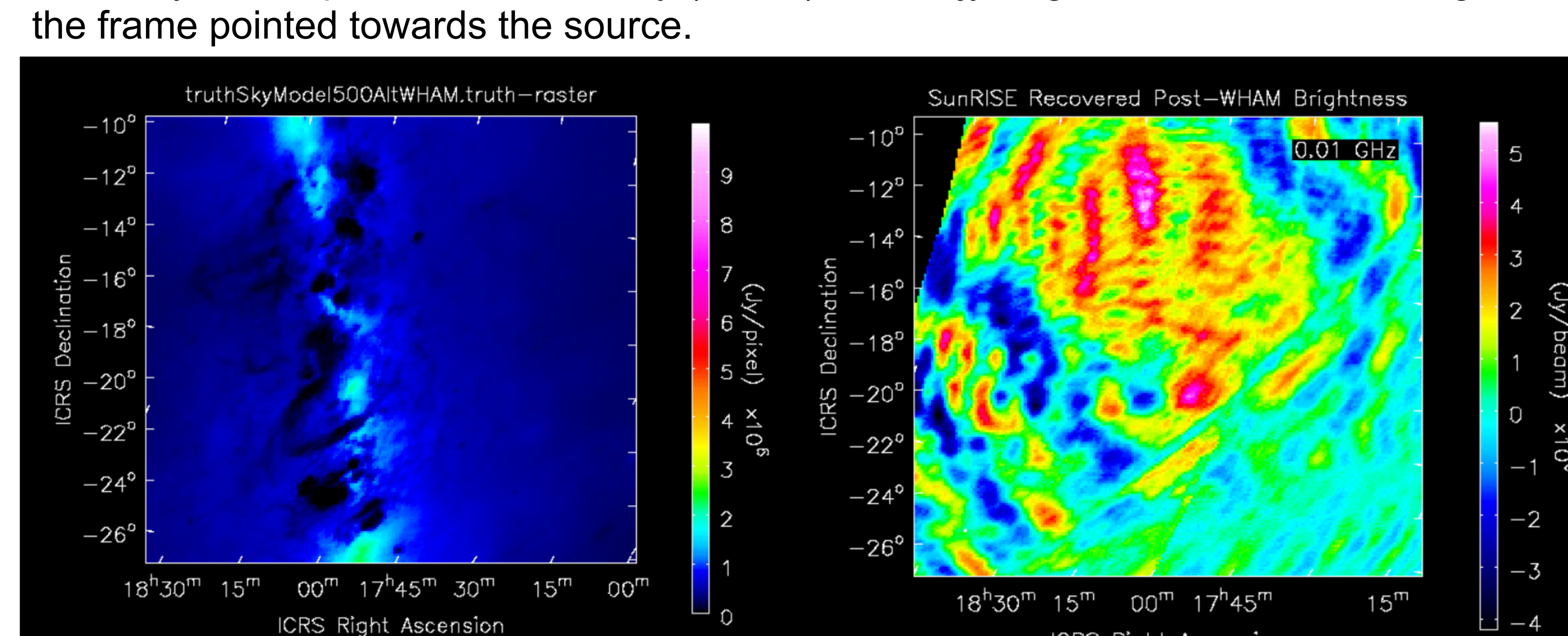

Figure 4: Left: input image from the de Oliveria using radio absorption predictions from Reynolds 1990 and the Finkbeiner hydrogen intensity map as an input. Left: reconstructed image using SunRISE at 10 MHz.

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