

## Sunspot Band6

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### 1. Science Target Overview

These SV observations have been taken with the aim of testing ALMA solar capability at Band6 (239 GHz 1.25mm), on 18 December 2015 in 6<sup>th</sup> solar commissioning campaign.

The target of the observations is the preceding sunspot of the active region “AR 12470” (Figure 1). The summary of the active region can be seen in the webpage in “SolarMonitor”<sup>1</sup>. The preceding sunspot of AR12470 is the biggest sunspot in the solar disk on the observing day, and its magnetic polarity is negative. In the active region, two “C” GOES-class flares occurred on the observing day, but the time range of the observations does not cover the flares.

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<sup>1</sup> <https://www.solarmonitor.org/index.php?date=20151218&region=12470>  
(The footnotes in this document indicate the hyperlinks in the webpage.)

## Sunspot\_Band6: The preceding sunspot of AR12470 at Band6 (1.25mm)

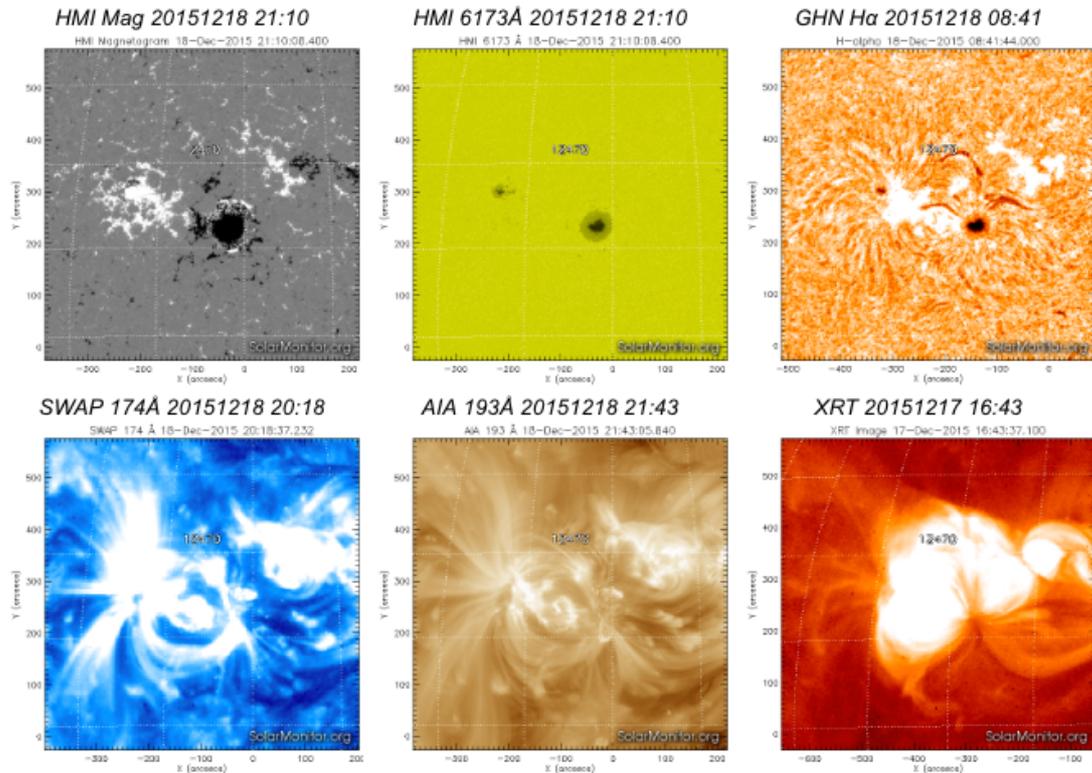


Figure 1. The multi-wavelength images of AR12470 observed with HMI/SDO, AIA/SDO, SWAP/PROBA2 and XRT/Hinode. The images are quoted from “SolarMonitor”.

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## 2. ALMA Data Overview

The CASA Guide shows the calibration, imaging and feathering steps for the ALMA Science Verification data of a sunspot.

The ALMA scientific commissioning observations on the sunspot in Band6 were carried out on December 18<sup>th</sup>, 2015. The observations consist of two individual datasets (ASDMs) as follows:

- uid\_\_A002\_Xae00c5\_X2a8d
- uid\_\_A002\_Xae00c5\_X2e6b

The first dataset (uid\_\_A002\_Xae00c5\_X2a8d) was taken with the heterogeneous array that consists from 21 12m-antennas and 9 7m-antennas.

Sunspot\_Band6: The preceding sunspot of AR12470 at Band6 (1.25mm)

At the solar observation, the all antennas were connected to the 64-channel correlator. Hence, the combine process between the data obtained with 12m- and 7m- arrays is not needed. The spectrum setup for the observation is the Time Domain Mode (TDM) with 128 channels per one spectrum window (2GHz), and the frequency of the first Local Oscillator (LO1) is set at 239 GHz as the same as the default observing frequency of the solar observations with Band6 in Cycle 4. For the observation, the bandpass calibrator is J1924-2914, and the flux and phase calibrators are J1733-1304 (NRAO 530).

The second dataset (uid\_\_A002\_Xae00c5\_X2e8b) was taken with the TotalPower (TP)-array using the fast-scanning mode. The field of view of the map is a circle with 2400" diameter (Full Sun). The frequency of the LO1 is the same as the previous dataset, but any correlator is not used for taking the dataset. The dataset consists from the output of the square-law detectors at the four basebands. Therefore, the number of the channels per one spectrum window is one.

#### **Using the data for publication:**

The following statement should be included in the acknowledgment of papers using the datasets listed above: "This paper makes use of the following ALMA data: ADS/JAO.ALMA#XXXX.XXXXX.SV. ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada) and NSC and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ."

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### 3. Obtaining the Data

To download the data, click on the regional closest to your location:

East Asia<sup>2</sup>

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<sup>2</sup> <ftp://alma-dl.mtk.nao.ac.jp/alma/sciver/SunspotBand6>

Sunspot\_Band6: The preceding sunspot of AR12470 at Band6 (1.25mm)

Europe<sup>3</sup>

North America<sup>4</sup>

Here you find three gzipped tar files, which after unpacking, will create three directories:

- Sunspot\_Band6\_UncalibratedData - This file contains the raw data files in ALMA Science Data Model (ASDM) format, and the reduction and imaging scripts.
- Sunspot\_Band6\_CalibratedData - The fully-calibrated u-v data and SD data, ready for image synthesis, and the imaging scripts.
- Sunspot\_Band6\_ReferenceImages – The file includes the FITS files of the synthesized image obtained with the 12m+7m array, full-sun map obtained with TP-array, and combined image from the synthesized image and full-sun map.

You can work with these data products at any of the three stages. To see which files you will need, read on below. The downloads to your local computer will take some time, so you may wish to begin them now.

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#### 4. Sunspot Data Reduction Tutorial

The tutorial (or casaguide) for reduction these data using CASA version 4.7 has been split in to calibration imaging and feathering pages:

##### 1) Sunspot\_Band6\_Calibration\_for\_CASA\_4.7

This section of the tutorial steps you through inspection and calibration of the visibility (u-v) data. To complete this part, you will need the data

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<sup>3</sup> <https://almascience.eso.org/almadata/sciver/SunspotBand6>

<sup>4</sup> <https://bulk.cv.nrao.edu/almadata/sciver/SunspotBand6>

Sunspot\_Band6: The preceding sunspot of AR12470 at Band6 (1.25mm)

in the Sunspot\_Band6\_UncalibratedData directory

**2) Sunspot\_Band6\_SingleDish\_for\_CASA\_4.7**

This section of the tutorial steps you through calibration and imaging from the TP-array data. To complete this section, you will need the data in the Sunspot\_Band6\_UncalibratedData directory

**3) Sunspot\_Band6\_Imaging\_for\_CASA\_4.7**

This section of the tutorial focuses on constructing images from the fully calibrated visibility data. If you wish to skip calibration and proceed directly to this part of the tutorial, you will need the fully-calibrated visibility data in the Sunspot\_Band6\_CalibratedData directory.

**4) Sunspot\_Band6\_Feathering\_for\_CASA\_4.7**

This section of tutorial focuses on the “feathering” process from the synthesized image and single-dish map. To complete this section, you will need the fully-calibrated visibility data in the Sunspot\_Band6\_CalibratedData directory, and carry out the process described in 3).

We also provide the final intensity images in the Sunspot\_Band6\_ReferenceImages directory.

**Note: For the tutorials, both of CASA 4.7 (or later)<sup>5</sup> and Analysis Utilities<sup>6</sup> package are required.**

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5. How to use this casaguide

The scripts that include all commands shown in the above tutorials are provided from the download sites described in section 3 “Obtaining the data”. After downloading the scripts, you can carry out the reduction processes along the tutorial. The detail and usage of the scripts are described in each above tutorial.

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<sup>5</sup> <https://casa.nrao.edu/>

<sup>6</sup> [https://casaguides.nrao.edu/index.php/Analysis\\_Utilities](https://casaguides.nrao.edu/index.php/Analysis_Utilities)