Evolution of Solar Activity over a Solar Cycle – Work in Progress

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Abstract
We are investigating evolution of solar features over the solar cycle 24 using the high resolution SDO/HMI and SDO/AIA observations and using the spectroheliograms taken by the Geophysical and Astronomical Observatory in Coimbra (Portugal) in the frame of a mobility project Slovakia-Portugal, SRDA (APVV) Bratislava (SK-PT-2015-0004), FCT Lisbon (COOP_PT/ESLOV/441). The main aim is to get more detailed knowledge on astrophysical aspects of evolution of solar features distribution on the solar disc (meridional flows, Reynolds stress, etc.). Two main properties of the solar activity are in focus of the project work, namely: the differential rotation of the solar activity features and their north-south asymmetry. Special software tools for detection, identification and automatic tracking of various solar phenomena was already developed by the project team and it is being extended and improved in order to reach the proposed goals. These tools are tested on the sample SDO and Coimbra images to achieve besides the automatic tracking also an automatic detection and identification of features.

1. SCOPE

We are investigating the evolution of solar features over the current solar cycle 24 using the high resolution SDO/HMI and SDO/AIA observations and using the spectroheliograms taken by the Geophysical and Astronomical Observatory in Coimbra (Portugal).

2. DATA AND PURPOSE OF THEIR USE

Will use FITS images from the SDO (Pesnell, Thompson, and Chamberlin, 2012) with the highest resolution of 4096 x 4096 pixels. Namely, the following channels of the SDO/AIA instrument were selected in order to investigate the specified solar activity features: 94 Å → coronal bright points (CBPs); 131 Å → transition region bright points (TRBPs); 193 Å → CBPs, coronal holes (CHs); 1700 Å → plages.
The performed corrections were:
for effect of the PSF function (only EUV channels 193 Å, 131 Å, 94 Å).
The listed basic steps of the data reduction were peformed:

- telescope point spread function correction,
- noise filtering using the Lee box filtering,
- data photometric and spatial reduction (aia_prep.pro),
- intensity normalization,
- linear scaling of the stored data (level 2) to I2 data type.

In case of the SDO/MDI instrument we selected intensitygram → sunspots, longitudinal magnetogram → magnetic fields (negative, positive, total).
The performed corrections were:

- data spatial reduction (aia_prep.pro),
- linear scaling of the stored data (level 2) to I2 data type.

The final format of the data has spatial sampling = 0.6″/pixels (identical spatial scale for all SDO channels), - solar disk center position: X_C=Y_C=2048.5 pixels (co-aligned images of all SDO channels), - orientation: North = up, WEST - left (i.e. P angle corrected for all SDO channels).

The OGAUC Coimbra data selected are Ca II K1 and K3 spectroheliograms → sunspots, Ca plages.

EXPECTED OUTPUT: solar rotation profile based on detection and tracking of sunspots and CBPs., meridional flows, Reynolds stresses, N-S asymmetry of solar activity.

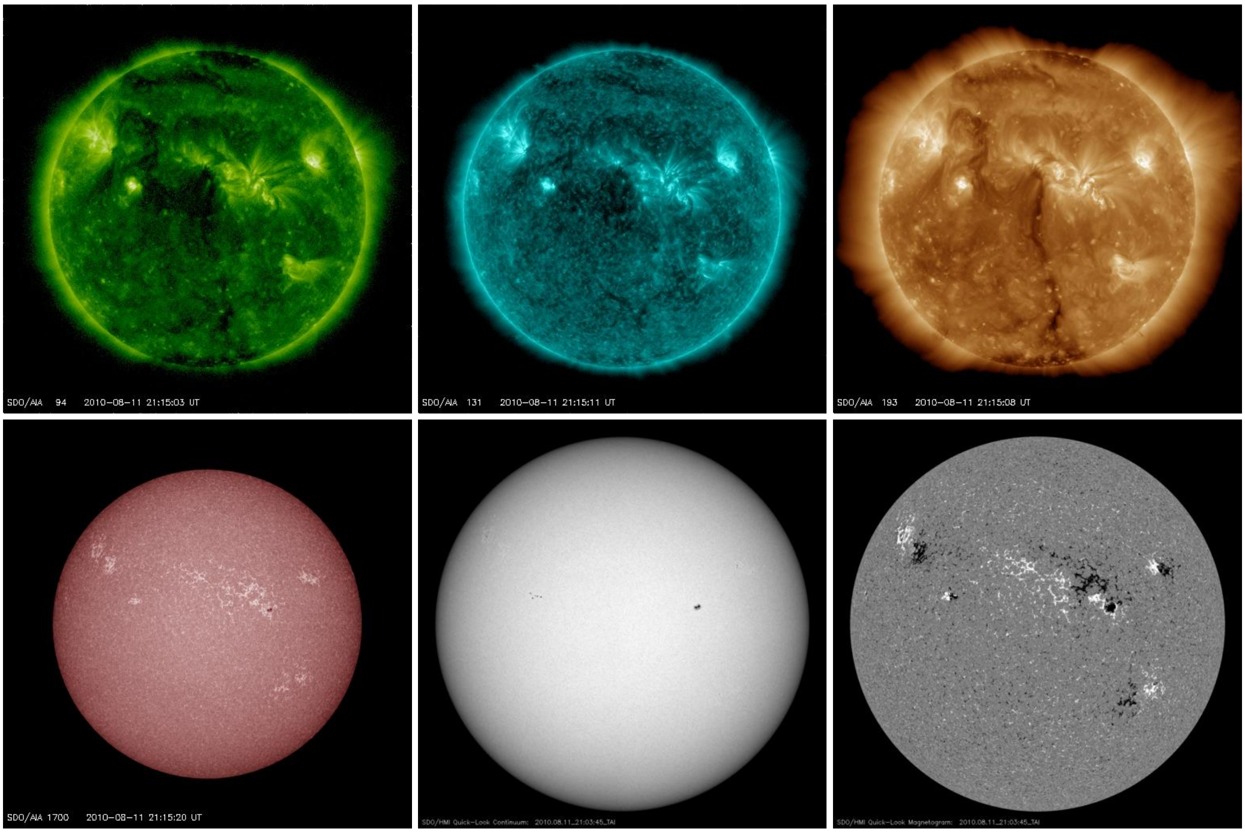

Figure 1. Sample solar images in individual SDO/AIA and SDO/HMI channels, 11 August, 2010.

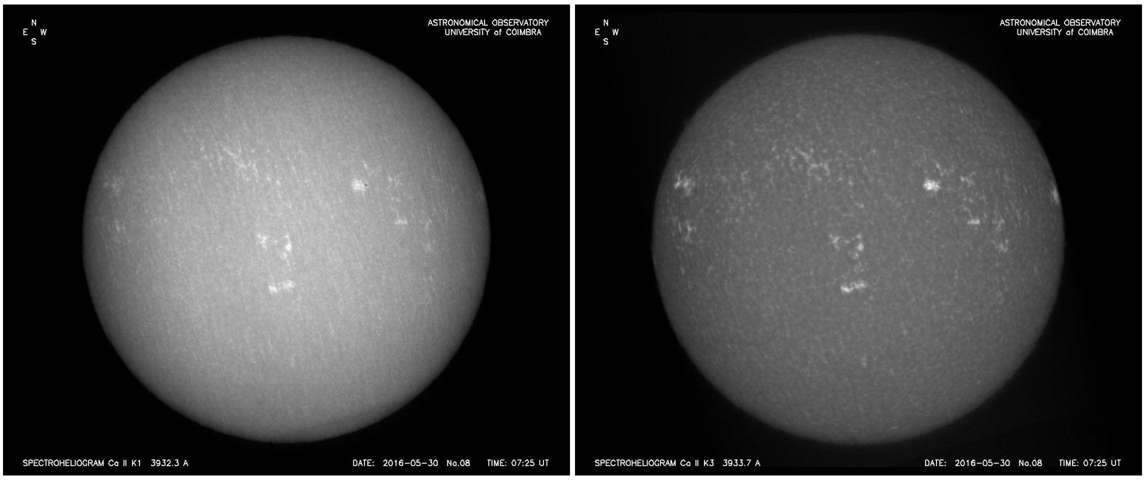

Figure 2. Sample spectroheliograms from the University of Coimbra: Ca II K1 (left panel) and Ca II K3 (right panel), 30 May, 2016.

3. SOFTWARE

The team of software engineers from the CTS/UNINOVA-CA3 (Caparica, Portugal) recently developed a software tool for automatic tracking of sunspots and CBPs (Dorotoviļ et al., 2014; Shahamatnia et al., 2016**)**. However, an automatic detection and identification tool [such as presented e.g. in Sudar et al. (2015) ï segmentation method, or SWAMIS (Boulder)] is **necessary** to enable us to process a huge number of solar images.

The project partners from the OGAUC (Coimbra, Portugal) evaluated automatic detection methods of sunspots in order to select the one which had the best performance concerned to the detection of the contour and areas of sunspots, and the ability to differentiate the umbra and penumbra, applied to Coimbra spectroheliograms. Our aim is to apply in the present work the best method tested previously (based on mathematical morphology) in a set of images belonging to the solar cycle 24.

Acknowledgment

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