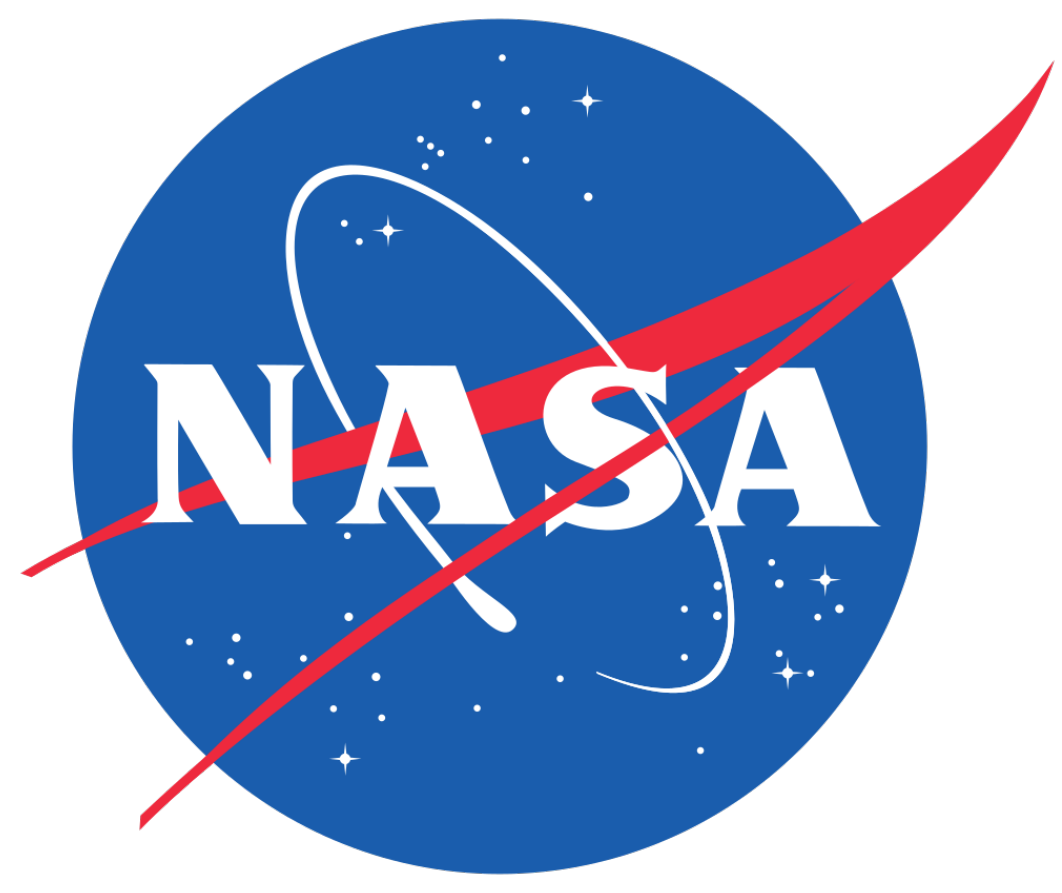




A Neural Network-based Data Analysis Technique for ESIS

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December 11, 2019



Abstract

The *EUV Snapshot Imaging Spectrograph* (ESIS) is a sounding rocket-borne computed tomography (CT) imaging spectrograph designed to observe the solar atmosphere in the O V (630Å) spectral line. We are developing a neural network-based data CT algorithm for analyzing ESIS observations. This algorithm uses observations from the Interface Region Imaging Spectrograph (IRIS) and the Hinode EUV Imaging Spectrograph (EIS) as a synthetic sun to train a neural network to invert a forward model of ESIS. We present progress on this algorithm, with performance tests and initial results from the ESIS dataset.

ESIS Instrument

CT imaging spectrographs consist of an array of slitless spectrographs, each with a different dispersion angle. Each slitless spectrograph in the array captures an *overlappogram*, an image with many shifted, overlapping copies of the FOV. The set of overlappograms can be interpreted as a spectrally-resolved image, an image with a spectral profile for every pixel in the FOV.

Two CT imaging spectrographs have been developed by the Kankelborg research group: the *Multi-order Solar EUV Spectrograph* (MOSES), which flew in 2006 (Fox et al., 2010), 2015, and 2019, and ESIS, which just completed its first flight in 2019. Both instruments only capture a few overlappograms, 3 for MOSES and 4 for the current implementation of ESIS. Because of the limited number of overlappograms, recovering a spectrally-resolved image from MOSES/ESIS observations is an ill-posed inversion problem.

To solve this inversion problem, we plan to implement a convolutional neural network (CNN)-based approach similar to the CNN-based approach used with MOSES (Figures 3 and 4). The MOSES CNN implementation uses observations from the *Interface Region Imaging Spectrograph* (IRIS) (De Pontieu et al., 2014) as a synthetic sun for training the CNN. We will likely have to use a different instrument for ESIS since none of the lines observed by IRIS match the formation temperature of the O V 630Å very well.

Before a CNN-based algorithm for ESIS can be successful, we need to implement a geometric correction procedure for ESIS. Using Courrier's Zemax model, we have manipulated the tip, tilt and roll of the grating and the distance from the grating to the detector to align images from Channels 2, 3, and 4 to Channel 1 on the skyplane. This model is very rough, and we plan to implement more degrees of freedom in the later versions.

ESIS Optical Layout

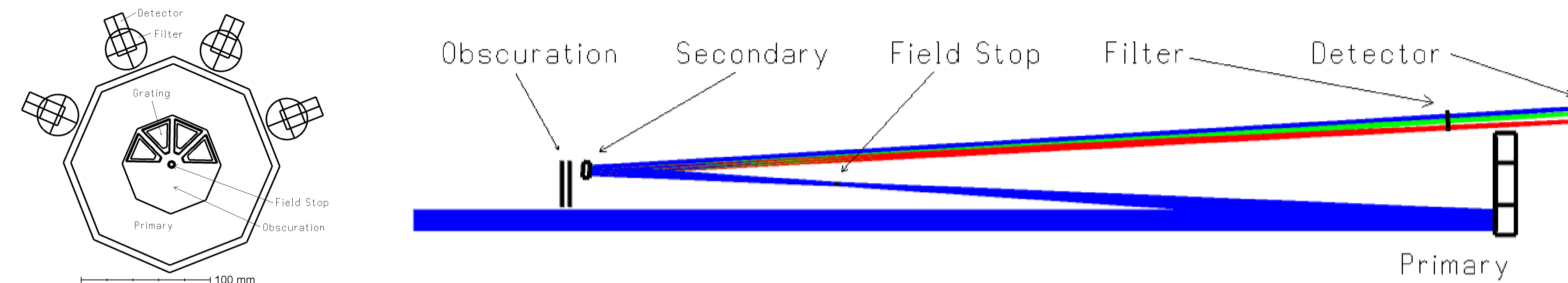


Figure 1: Optical layout of the ESIS instrument. On the left is a front view of ESIS demonstrating the orientation of each channel. On the right is a side view of a single channel with the ray path through the system for a single field angle and three wavelengths: O V 630Å (blue), Mg 610Å (green) and He I 584Å (red).

Difference Image

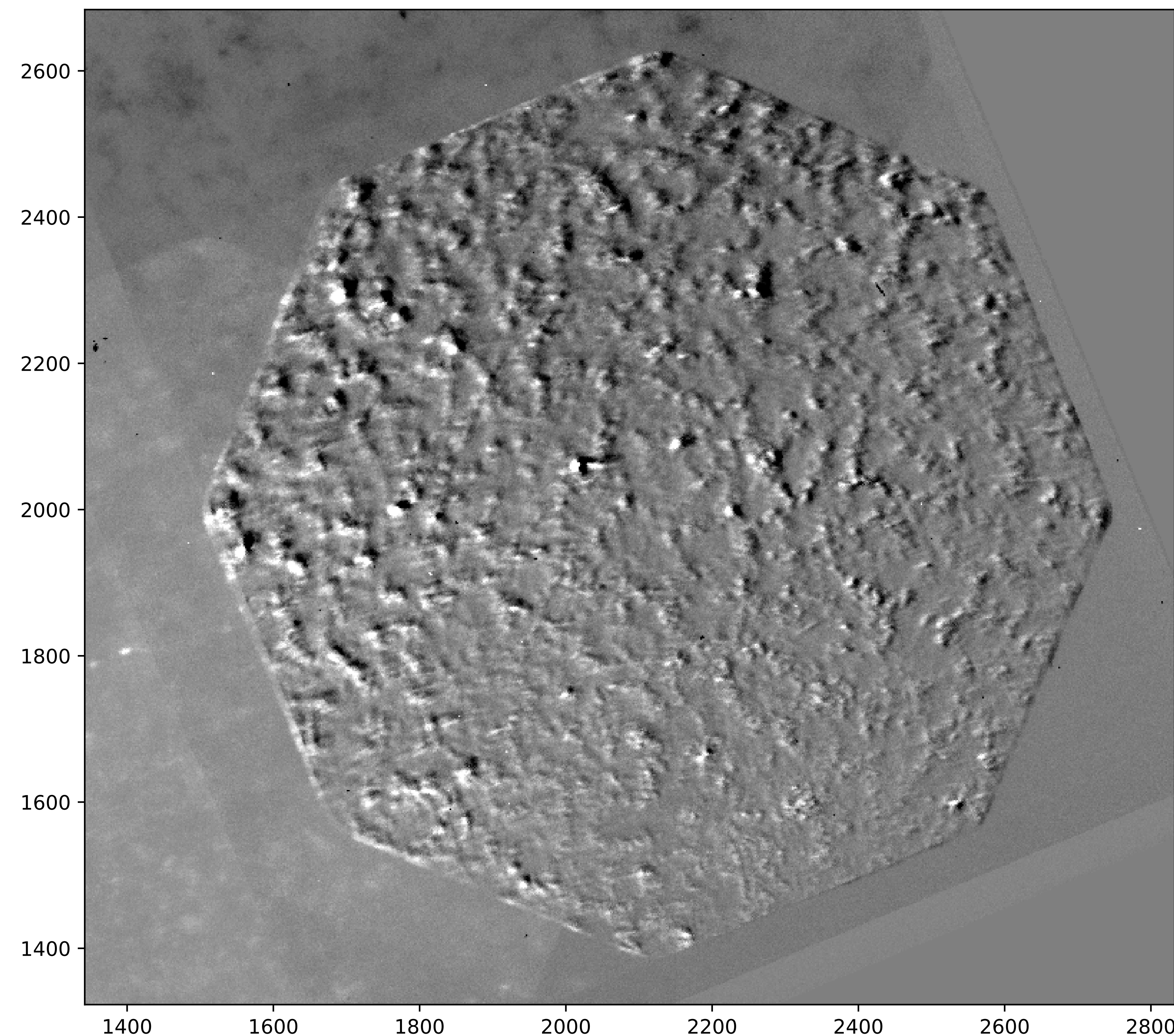


Figure 2: Corrected difference image of Channel 3 with Channel 1.

MOSES Inversions

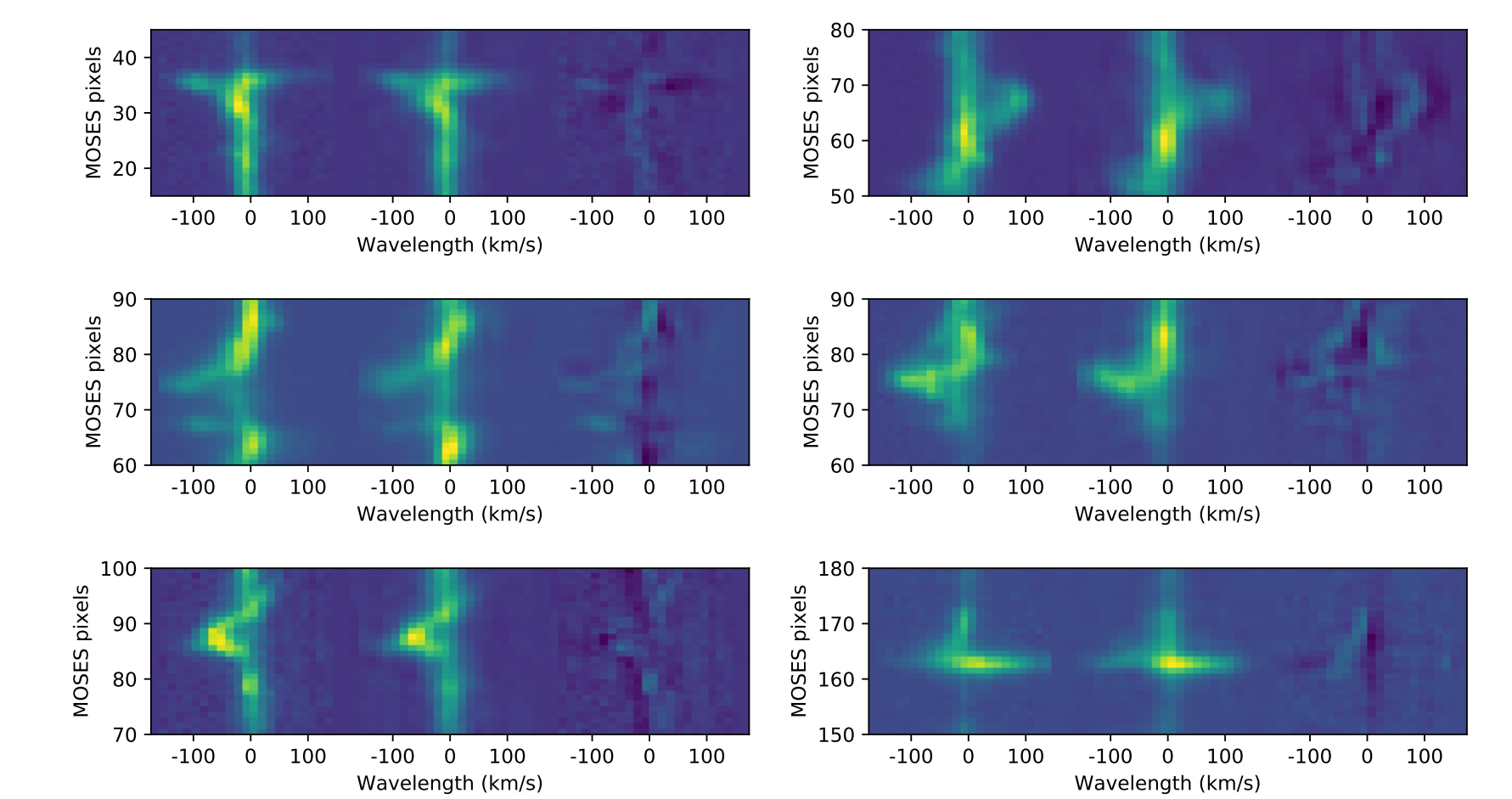


Figure 3: Demonstration of the MOSES CNN inversion algorithm on six explosive event examples from IRIS Si iv 1394Å. From left to right: true image, recovered image, error between true and recovered image.

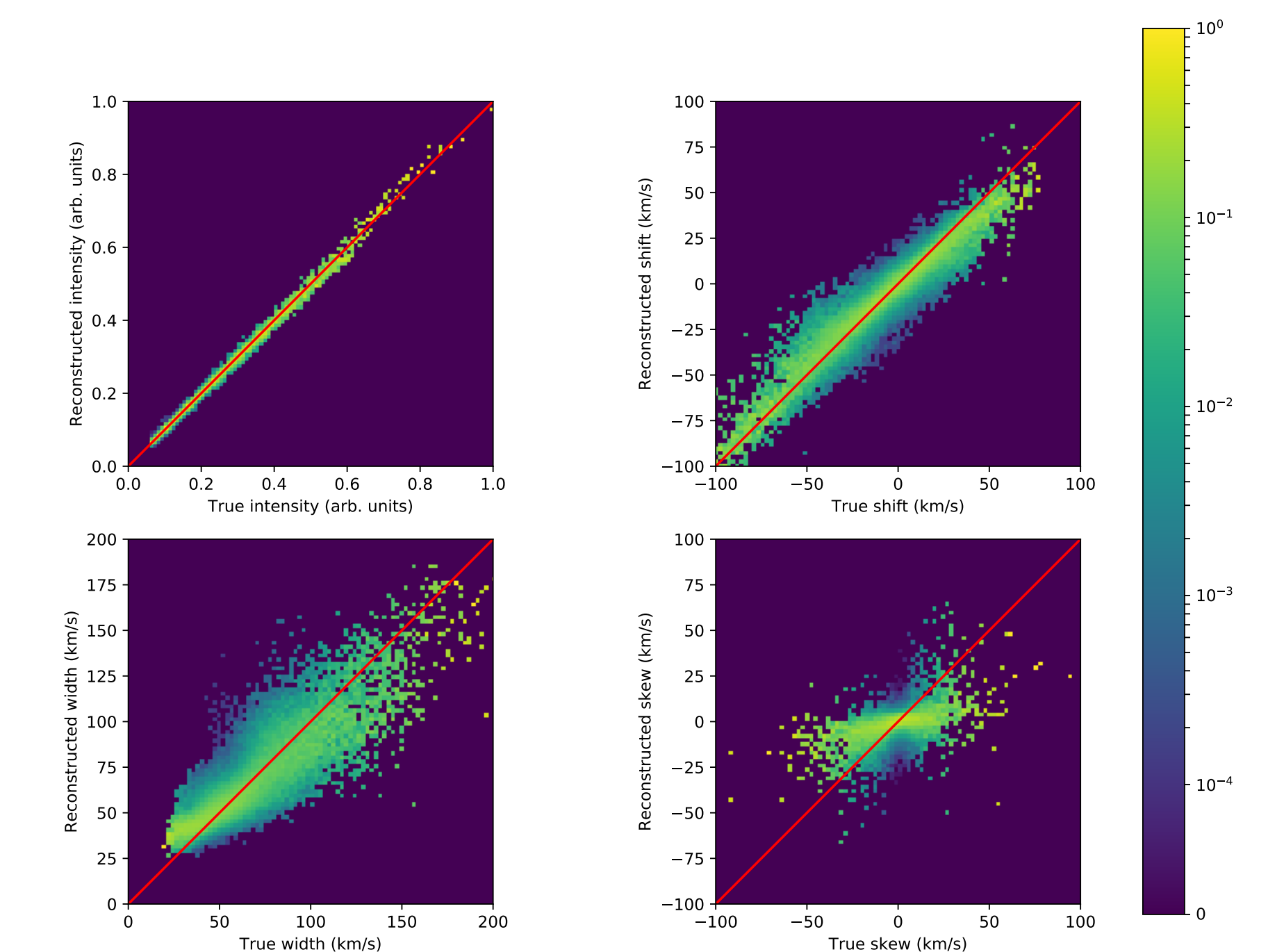


Figure 4: Statistical performance of the MOSES CNN inversion algorithm for four moments of the spectral line profile.

References

- De Pontieu, B., Title, A. M., Lemen, J. R., et al. 2014, Solar Physics, 289, 2733
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Acknowledgments

This work is supported by the NASA Low-cost Access to Space program (NNX14AK71G), the NASA Heliophysics Technology and Instrument Development for Science program (NNX14AK71G), and the NASA Earth and Space Science Fellowship program (80NSSC17K0524).