**Space Weather Prediction Through the Observation and Modeling of Coronal Magnetism**

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**Year 4 Report**

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The goal of our project is to develop a new methodology for assimilating coronal magnetic diagnostic data into magnetohydrodynamic (MHD) models in order to establish not only the magnetic structure of the source region of coronal mass ejections, but also the global field into which it erupts. Our project name is **Data-Optimized Coronal Field Model**, or **DOCFM**.

The DOCFM Team Meeting this year was hosted by Duncan Mackay of the University of St. Andrews. de Toma, Fan, Flyer, Gibson, Mathews, Dalmasse, Karna, Savcheva, Mackay, and Meyer were in attendance. Details on the presentations at this meeting and on other presentations described below, as well as on the project overall, may be found at https://www2.hao.ucar.edu/hao-science/data-optimized-coronal-field-model-docfm.

During this year we have completed demonstrations of coronal-magnetic-fitting for both a known observing system simulation experiment (OSSE), and for coronal observations of a pseudostreamer-cavity system.

For the first, Dalmasse is first author on a paper that will be submitted in the new year. Using an iterative version of the Radial-basis-function Optimization Approximation Method (ROAM) – an efficient optimizer algorithm developed for the DOCFM project and described in our Year 2 report (*Dalmasse et al., 2016*) -- we demonstrate how a flux-rope insertion model may be matched to synthetic observations of a "ground truth" solution, and reproduce the 3D magnetic field of that solution. Further refinements on the ground-truth simulation of the OSSE, including establishing more realistic (noisy) synthetic data were presented in two Astrophysical Journal publications (*Fan 2018, Fan et al. 2018*). Presentations on the DOCFM method were given by Gibson and Dalmasse at the DOCFM team meeting in St. Andrews and at the "Into the Red Dragon's Lair" meeting in Cardiff, Wales, in December 2017, and on the OSSE simulation by Fan at several international meetings in 2018.

For the second, a paper (*Karna et al 2018)* has been submitted to the Astrophysical Journal, in which flux-rope insertion is applied to the pseudostreamer of the *Gibson et al. (2017)* paper described in last year's report. By varying flux-rope insertion model parameters (axial and poloidal magnetic flux) "by eye", we demonstrate that adding a flux rope to the upper lobe of the pseudostreamer (where a prominence cavity is visible)

results in a larger closed field region, higher magnetic null point, and stronger magnetic expansion, and overall better matches observations including measurements of linear polarization magnitude and azimuth angle measured by the CoMP telescope. This is important because magnetic expansion is correlated with background solar wind speed, often predicted using current-free models. The assimilation of coronal data may allow proper accounting for the presence of currents in the solar corona and so improve prediction. In addition, *Karna et al (2018)* demonstrate that the continued energization of this magnetic flux rope leads to a CME from this region, as was observed. Karna presented these results at several meetings. Further, a study of CoMP pseudostreamers showing a systematic trend for current-free models to underestimate magnetic null heights was presented by de Toma at the COSPAR meeting in Pasadena this summer.

We also continue to work on methods for identifying "hot-spots" of non-potentiality, and on characterizing a cost function for our optimization method. Undergraduate Marcel Corchado Albelo returned to NCAR this summer, and is writing a paper (to be submitted in the new year) describing a "non-potentiality index" that may be applied to CoMP observations (Marcel also gave a talk on this subject at the Cardiff meeting). In addition, we continue our collaboration with S. Fineschi of the University of Torino and J. Zhao of Purple Mountain Observatory to explore the complementary properties of UV permitted line observations for constraining the coronal magnetic field. Fineschi visited this summer, and gave an oral presentation and Zhao presented a poster on the subject at the COSPAR meeting.

Publications this year:

Fan, Yuhong 2018: MHD Simulation of Prominence Eruption, Ap. J., 862, 54, https://doi.org/10.3847/1538-4357/aaccee

Fan, Yuhong, Gibson, S. E., and Tomczyk, S. 2018: The eruption of a prominence carrying coronal flux rope: forward synthesis of the magnetic field strength measurement by the COronal Solar Magnetism Observatory Large Coronagraph, Ap. J., 866, 57, https://doi.org/10.3847/1538-4357/aadd0e

Karna, N., Savcheva, A., Dalmasse, K., Gibson, S. E., Tassev, S., Deluca, E., and de Toma, G., Forward modeling of a pseudostreamer, submitted to ApJ, September 2018