TITLE: The Evolution of the Solar Magnetic Field: A Comparative Analysis of Two Models

STUDENTS: Kirsten McMichael (Washington and Lee University) and Oliver Vierkens (St Andrews University)
MENTORS: Bidya Binay Karak, Lisa Upton, Mark Miesch (HAO)

ABSTRACT:

Understanding the complexity of solar cycles has been a task that has plagued scientists for decades. However, with the help of computer simulations, we have begun to gain more insight into possible solutions to the plethora of questions surrounding the Sun. Currently, STABLE (Surface Transport and Babcock Leighton) is a newly developed 3D dynamo model that can reproduce some basic features of the solar cycle. In this model, the tilted bipolar sunspots are formed on the surface based on the toroidal field at the bottom of the convection zone and the decay and dispersal of these spots produce the poloidal field (Babcock-Leighton process). Since STABLE is a 3D model, it is able to solve the full induction equation in the entirety of the solar convection zone as well as incorporate many free parameters such as spot depth, turbulent diffusion, and magnetic pumping. These free parameters allow us to look into the features of the solar interior, a zone which currently has no observational data. In an attempt to constrain some of these free parameters, we compared STABLE to a surface flux transport model called AFT (Advective Flux Transport) which solves the radial component of the magnetic field on the solar surface. AFT is a state-of-the-art surface flux transport model that has a proven record of being able to assimilate data taken from observation and reproduces solar cycles with great accuracy (Upton & Hathaway 2014a,b). In this project, we implemented synthetic bipolar sunspots into the two models for comparison for both single spot and full cycle cases and ran the models using identical surface parameters. We demonstrate that the 3D structure of the sunspot in the interior such as diffusion and magnetic pumping play an important role in establishing the surface magnetic field in STABLE. We found that when the sunspots are deeply rooted or when magnetic pumping is added the diffusion of the sunspot magnetic field is lessened, and thus STABLE produces a strong surface magnetic field.