Development of Empirical Tools for Forecasting Safe or Dangerous Space Weather from Magnetograms

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Just as with Earth weather forecasting, being able to forecast the chance of severe space weather is important. The drivers of the most severe space weather in Earth-Moon space are CMEs that originate on the Sun 0-4 days earlier. By identifying the likely source regions of CMEs and assessing their combined chance of producing a CME, we could forecast the chance of a CME occurring during the next 24 hours and if the chance was sufficiently low, say ≤5%, we could then declare the coming day an All-Clear Day. There are two kinds of CME source regions, active regions with strong transverse fields (sunspot active regions) and former sunspot active regions with weaker transverse fields (spotless active regions); sunspot regions produce most of the powerful CMEs, but spotless active regions cannot be ignored. We are developing a tool to assess the chance that a source region of either type will produce a CME during a forecast period. We have found that the CME productivity of a sunspot active region is strongly correlated with a measure of its total nonpotentiality from a magnetogram (Falconer et al 2003, & 2005), where total nonpotentiality is the magnetic size times the magnetic twist of the active region. From this measure, the prediction that all strongly nonpotential sunspot active regions will produce at least one CME during a 3 day period and all weakly nonpotential sunspot active regions will not produce a CME during the same 3 day period is right 75% of the time. Using our present sample (48 magnetograms of 43 sunspot active regions), we have begun to empirically determine the chance of CME occurrence as a function of active region total nonpotentiality for several forecast windows. We find that the more nearly potential active regions have low to negligible chance of CME occurrence (for a 24 hour forecast window the two weakest nonpotentiality categories have a 0% and 7% rate), but the uncertainties in the actual chance of CME occurrence are large due to our present small sample size (1σ range 0-6% and 2-16% respectively). We have submitted a proposal to NASA's LWS TR&T Program to increase our sample size several fold by evaluating the total nonpotentiality of active regions in our sample on the 4 days when the active region is near disk center ($<30^{o}$). Due to weather, MSFC vector magnetograms often do not exist for each day when the active region is near disk center, but we can use the space-based SOHO/MDI magnetograph which has continuous coverage with good cadence (15 full-disk magnetograms a day). The disadvantage of MDI relative to MSFC is that MDI only measures the line-of-sight component of the magnetic field, but in Falconer et al (2003) we devised a measure of total nonpotentiality that can be evaluated from a line-of-sight magnetogram. We also propose to use MDI magnetograms to test this measure for spotless active regions. The results presented in this poster show that our measure of active-region total nonpotentiality from line-of-sight magnetograms is a useful tool for operational forecasting of dangerous CMEs, and warrants further testing and evaluation as a predictor of CMEs or the absence of CMEs.