Comparative analysis of pre-flare conditions in active regions

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Several attempts have been made to assess the level of nonpotentiality in solar active regions to find the most reliable diagnostic tools for the pre-flare state. Earlier methods used morphological classifications which were subjective, not quantified categorizations with no magnetic information. Later methods defined physical quantities of magnetic configurations by using magnetograms. The detailed Debrecen sunspot catalogue, the SDD (SOHO/MDI-Debrecen Data) also contains the magnetic data of the sunspots and this allows to define numerical measures of the mixed states of the sunspots with opposite polarities. The present work is a skill score analysis, it tests different pre-defined parameters characterising the level of mixed states by comparing their temporal variations with the onsets of M- and X-flares.

Classifications of morphological complexity

In Korsós et al. (2014) the following inter-spot gradient has been defined between opposite (*p* and *n*) polarity spots:

$$G_M = \left| \frac{B_p \cdot A_p - B_n \cdot A_n}{d} \right|$$

B: flux density, *A*: umbral area, *d*: distance of the spots. The present generalization of this parameter is the sum of G_M for all spot-pairs of opposite polarities within the group:

$$S_{GM} = \sum_{i,j} \left| \frac{B_{p,i} \cdot A_{p,i} - B_{n,j} \cdot A_{n,j}}{d_{ij}} \right|$$

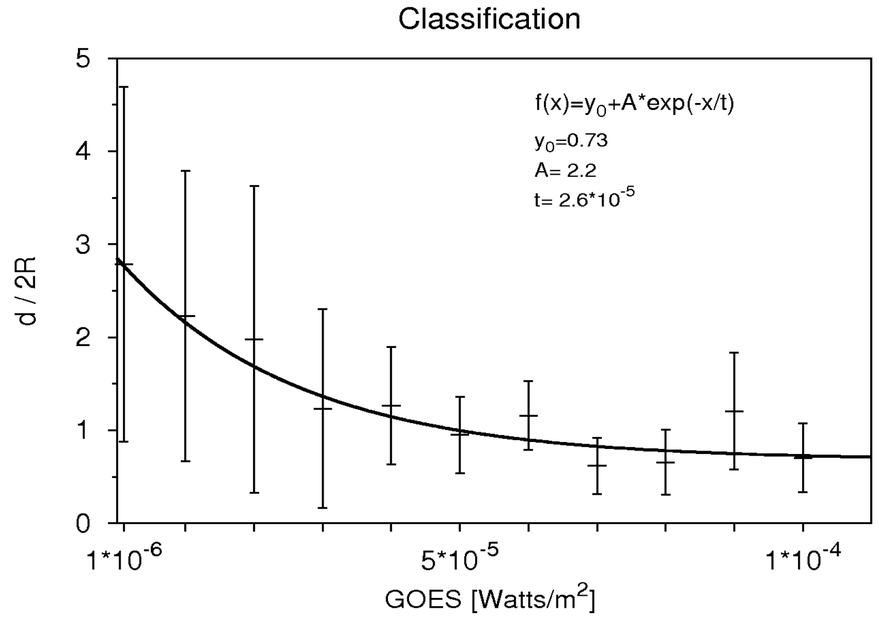
The second complexity parameter of this study characterises the mutual mixedness of the opposite polarity subgroups:

$$M_{l-f} = \frac{d_{lc-fc}}{2R_{\Sigma A}}$$

The numerator is the distance of the centers of the leading and following subgroups, the denominator is the diameter of a circle of area equal to the total area of umbrae.

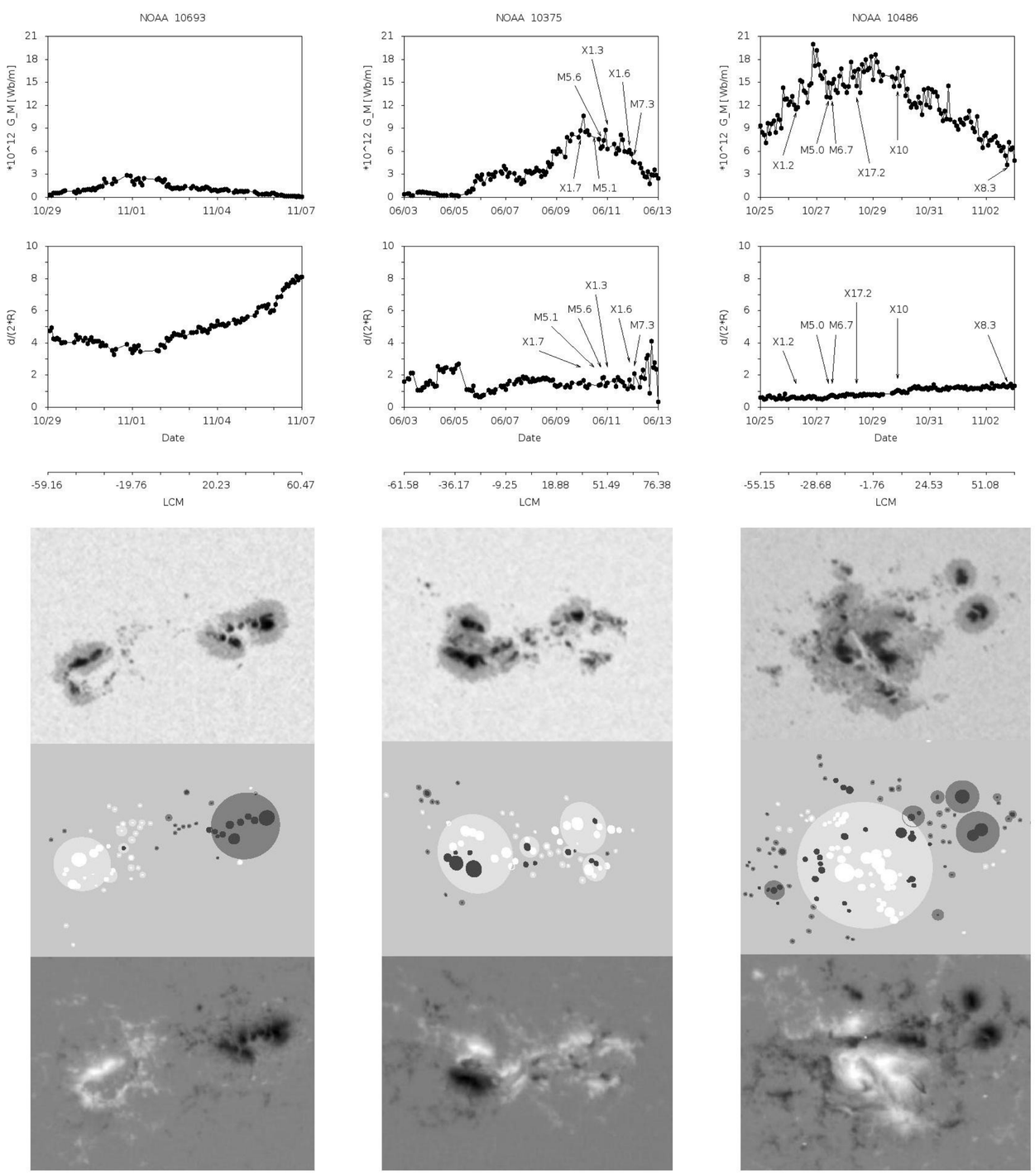
The pre-flare behaviour of the two parameters are different. In case of flare-risk $M_{l\text{-}f}$ is typically lower than unity, in quiet areas it is higher than four. The S_{GM} exhibits similar variation to the G_M : steep rise and some decrease prior to flares (Korsós et al. 2014).

The monitoring of the two parameters may contribute to the reliability of simultaneous parallel methods.



Flare intensities in 597 sunspot groups of different mixedness

Active regions of different complexities



bipolar case
NOAA 10693

medium case
NOAA10375

mixed case
NOAA 10486

Panels of upper row: pre-flare variation of SGM ; second row: pre-flare variation of Ml-f ; third row: white-light images, fourth row: reconstructions of the active regions from the SDD data, fifth row: magnetograms. The times and intensities of the flares are indicated.

The two methods are attempts to replace the traditional (Zürich, McIntosh, Mount Wilson) classification schemes by single parameters based on data of sunspots and their magnetic fields.

Korsós, M., Baranyi, T., Ludmány A.: Pre-flare dynamics of sunspot groups 2014, *ApJ* , **789**, 107

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