PREDISOL

Characterization of active region time evolution in view of solar flare prediction

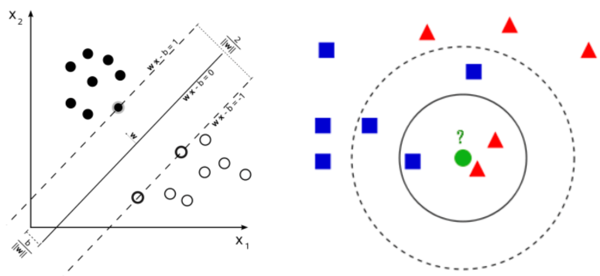
DURATION
01/10/2013 - 31/12/2015

BUDGET
148.920 €

PROJECT DESCRIPTION

Context

Solar flares are the most powerful examples of solar activity. When intense and directed towards the Earth, they may affect the ionosphere and radio communications. Providing a reliable prediction with confidence interval for their onset time is thus crucial for Space Weather applications. In particular it is important to predict as early as possible whether an active region will develop into a flare productive active region. About one out of ten active regions will produce one large flare or more (minority class), whereas nine out of ten will produce no or small flares (majority class), but a higher risk is associated to a wrong prediction of the minority class.



Objectives

The objective of PREDISOL is to characterize the evolution of active regions through quantities computed from magnetogram and continuum images, and to be able to link this evolution to the production of large solar flares. A first objective is to provide an optimal classification between flaring and non-flaring active regions that takes into account the specificities of the problem such as the imbalanced class distribution. The second objective is to model sequences of magnetogram and continuum images in order to: make inference about their correlation structure, derive a prediction model, and finally gain insight about the physical processes at work.

Methodological approach

To reach the first objective we consider a set of predictor variables that summarizes the status of an active region, and we compute these predictor variables on a dataset of three-day long image sequences showing the growing phase of active regions up till their first large flare, or up till they reach their peak phase. We then aim at differentiating prone-to-flare active regions from quiet ones via the different time evolution of those predictors. This will be achieved through the design of appropriate machine learning algorithms, with at their core methods such as support vector machines, k-Nearest neighbors, and ensemble classifiers. For the second objective, we will use techniques such as image patch analysis and Gaussian graphical models in order to analyze and make inference on the correlation structure within magnetogram and continuum images.

Nature of the interdisciplinarity

The success of this project relies on the combined expertise from solar physics and machine learning fields. Hence this project gathers solar physicists and mathematicians from ROB, a machine learning expert from Université catholique de Louvain, and a group specialised in statistical signal processing at the University of Michigan.

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While the solar physicist will be able to describe which input parameters, or predictor variables, are the most likely to be precursors of an upcoming flaring activity, the machine learning expert will help designing a learning algorithm that takes into account the specificities of the flare prediction problem, and use the observations in the most efficient way. For example, previous studies suggest that crucial information is hidden in the time evolution of parameters. Hence time evolution must be taken into account by the supervised classification, but this requires handling redundancy about values of a same parameter computed over time. The imbalance between minority class of interest and majority class also calls for specific algorithms that take into account this imbalance. Finally, the interpretation of the output from the classification algorithm as well as the strategy to identify the most discriminating parameters will also requires cross-talks between solar physicists and machine learning experts. Together with the group from University of Michigan we will explore new ways to extract information on spatial and temporal correlation structure from sequences of magnetogram and continuum images.

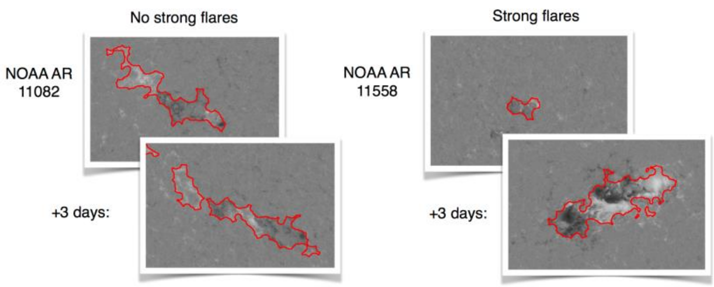
Impact of the research on science, society and decision-making

The classifier rules found in PREDISOL will allow to shed light on pertinent combination of photospheric properties necessary to produce strong flares, thereby constraining and providing input for theoretical flare modeling.

The aim of PREDISOL is to be able to give alerts for strong flares up to three days in advance. This will benefit space weather application in general, but also solar missions who need a precise planning days in advance. This will be the case for example for the Solar Orbiter mission whose launch is planned for 2017.

Description of finished products of research (model, scenario, report, workshop, publication, etc…) at short and medium term.

In the short term, we will produce reports on the advancement of the project. In medium term , we will submit our result in a refereed journal. We will also make available outputs such as our flare forecasting model, the dataset gathered for this study as well as the software used to analyze this dataset and to produce output from the forecasting model.



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LINKS

http://sdoatsidc.oma.be/web/sdoatsidc/SoftwarePREDISOL