Can the planets drive the sun into quiescence?

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Research project
BISTOM – Bayesian Inference for Stochastic Models

Lead:
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Duration:
April 2018 – March 2020

Partner:
SDSC, Eawag, USI

Funding:
SDSC
(Swiss Data Science Center)

Research group Biomedical Simulation

Everybody knows that planetary dynamics are driven by the gravitational forces exerted on them by the huge mass of the sun. But can a few tiny planets affect internal solar dynamics to a detectable level?

Understanding the sun's magnetic activity is important because of its impact on the earth's climate and environment. The longest direct record of solar magnetic activity is provided by sunspots observations, which reveal a well-known 11-year cycle modulated on longer time-scales and a puzzling 70-year-long quiescent period in the 17th century characterized by the nearly total absence of sunspots, known as the Maunder Minimum. Unfortunately, sunspot observations are limited to the past 400 years, since the invention of the telescope. This is obviously an extremely short window on astronomical time-scales, resulting in a substantial lack of information that has left solar astronomers "in the dark": most observed phenomena, including long-term modulations and quiescent phases, have thus remained unexplained. However, recently, new exciting information has become available.

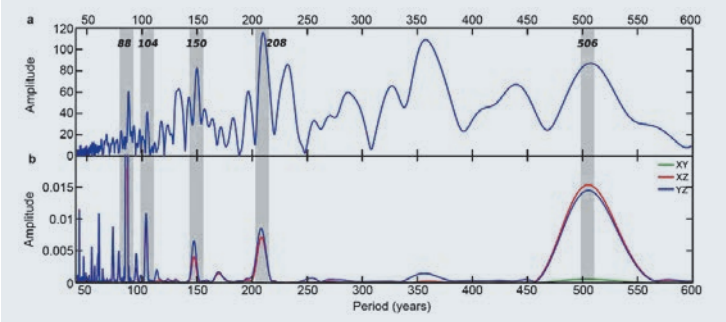

Fig. 1: The Fourier spectra of the solar magnetic activity (a) and of the planetary torque on the sun (b), calculated under three different conditions (not discussed here), reveal at least 5 matching periodicities. This correlation cannot be a mere coincidence. The solar activity calculation is based on 100k-year time-series of cosmogenic radionuclides. From: Abreu et al., Astronomy and Astrophysics 548, 2012

The sun: a noisy system

Sunspots are direct manifestations of strong internal magnetic fields breaking to the surface and releasing huge bursts of energy into space. The *solar wind* thus generated envelopes the earth (we can see it in the form of auroras, often referred to as polar lights) providing a shielding effect against galactic cosmic rays. Cosmic rays produce radioactive Carbon-14 and Berillium-10 nuclei in the earth's atmosphere, are then stored in wood and polar ice cores, respectively. Cosmic rays are modulated by the solar wind and the production rates of radioactive isotopes are indirectly modulated by the solar magnetic activity. Time-series of cosmogenic radionuclides thus turn out to be an exceptional proxy for solar activity on unprecedented multi-millennial time-scales, up to one hundred thousand years. These time-series exhibit a variety of interesting features such as long stable cycles and many Grand Minima, that is, extended periods of very low solar activity similar to the Maunder Minimum. In a seminal and hotly debated paper by Abreu et al. (Astronomy & Astrophysics 548, 2012), the authors present new evidence (see Figure) that solar magnetic cycles and their minima might be associated with gravitational perturbations exerted by the planets on the sun. In a noisy system like the sun, it is possible that an inherently nonlinear physics mechanism called *stochastic resonance* might boost an extremely tiny external periodic forcing to a level where its effects become observable. The question is still open and there is ongoing lively debate.

High performance computing is essential

The SCSC Swiss Data Science Center is funding a 2-year project for applying sophisticated Bayesian inference algorithms to the calibration of stochastic solar dynamo models on time-series of cosmogenic radionuclides. We have extended those methods with Machine Learning (ML) algorithms to compress long time-series into representative summary statistics. The coupling of Bayesian inference and ML methods make the problem computationally extremely expensive and requires an extensive use of the newly-established ZHAW HPC (high performance computing) facility in Wädenswil. Among several project goals, we intend to test solar dynamo models including the periodic tidal torque of the planets. A better agreement with the data would substantially contribute to giving more weight to the planetary hypothesis. The solar physics community is waiting for new input. Our algorithms are running. ■

Agrolina – An Online Decision Assistance for Swiss Agriculture

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Climate change is putting pressure on agriculture. Harvest losses due to droughts, changing climatic conditions or other extreme weather conditions are constantly increasing. Swiss agriculture, for example, was affected by crop losses in the dry year of 2018. In response to the demand of the local actors facing challenges in food production, the Institute of Applied Simulation and the Institute of Natural Resource Sciences established with the industry partner Hydrolina the Innosuisse project “Agrolina”. Its purpose is to develop an information and data platform for agriculture. We are putting together an app and online information platform that assesses and visualises risks in agriculture; it is an integrated model combining reliable weather and seasonal climate forecasts, soil data and crop yield forecasts. Based on real-time and historical weather, climate, soil and crop data and machine learning algorithms, the system calculates expected weather and climate conditions and crop yields, and supports agriculture with its real-time and online data in terms of production costs, irrigation management and required resources. By including users, who can manage and analyse their own data, the app provides a true information platform for agriculture. The information and data platform will thus help to plan ahead, to enable stable agricultural production, to mitigate the effects of climate change and to promote resource-saving and sustainable agriculture. ■

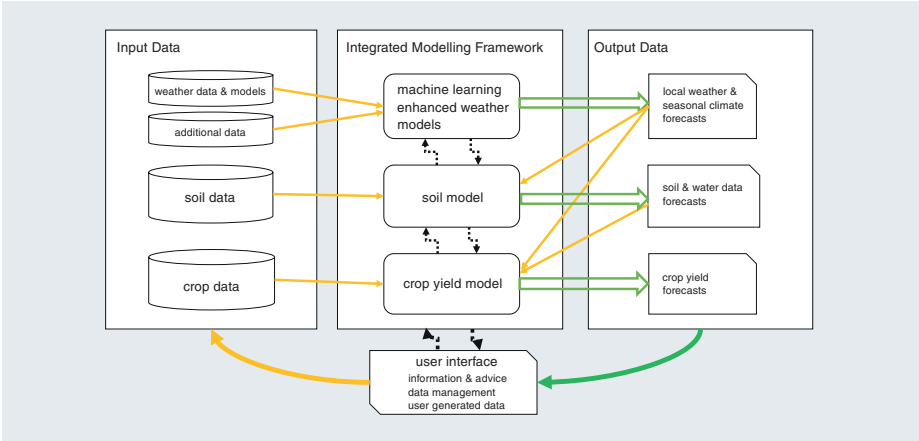

Fig. 1: Overview data and information processing platform

Repeat please!

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Protein repeats are abundant in all domains of life (Fig. 1), and are known for associations with diseases and immune functions. Tandem repeats have been successfully exploited in bioengineering due to modularity and designability. Matteo Delucchi and Maria Anisimova at the Applied Computational Genomics Team have concluded a large-scale study of protein repeats, their functional significance and mechanisms of their origin. For the first time, they systematically examined the interplay of tandem repeats with intrinsic disorder, and compared the repeat distributions of viral proteomes and their hosts. Based on state-of-the-art computational methods, the study unveils an unprecedented level of detail on the repeat universe. The results suggest that tandem repeats mostly originate by duplication and are involved in essential functions such as transcription processes, structural organisation, electron-transport, iron-binding and virulence. This work is funded by SBFI/SNF grant IZCNZ0-174836, EU grant REFRACT H2020-MSCA-RISE-2018 and COST action BM1405. ■

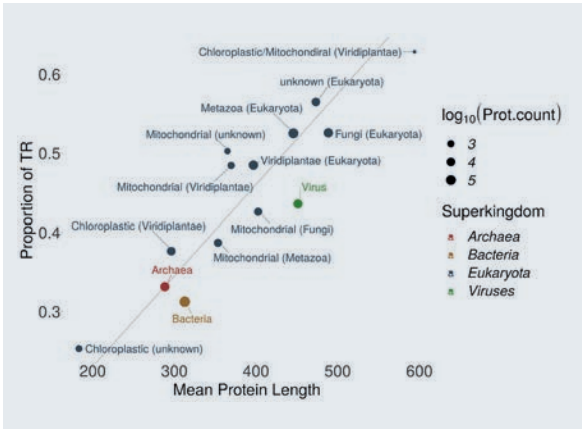

Fig. 1: Protein repeats are abundant in all domains of life. Displayed is the linear correlation of mean protein length vs. proportion of proteins containing tandem repeats (TR), from Delucchi, Schaper, Sachenkova-Lundström, Elofsson, Anisimova (submitted to Protein & Cell).