How the planets could drive the sun into quiescence. Good news for our climate?

Research group Biomedical Simulation

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Research project
BISTOM – Bayesian Inference for Stochastic Models

Lead:
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Partner:
SDSC, Eawag, USI, Instituto de Astrofisica de Andalucia, University of Vigo, Leibniz Institute for Solar Physics

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A new theory breathes new life into the controversial hypothesis that the planets affect solar magnetic activity. It sets out a complex mechanism by which a large system as the Sun can nevertheless be affected by the extremely tiny gravitational forces of its planets. If confirmed, the theory could lead to more accurate predictions of solar activity.

In 2012, ETH Professor Jürg Beer published new evidence supporting the old and fiercely debated hypothesis that the planets could influence the activity of the Sun (Astronomy & Astrophysics 548, 2012). Prof. Beer and his collaborators were able to reconstruct the cycles of solar magnetic activity over the last 10,000 years by analyzing cosmogenic radionuclides (beryllium-10) concentrations in ice cores and compared them with the tremendously small tidal forces exerted by the planets on the sun. The correlation was astonishing. Solar activity and planetary motions therefore present very similar periodicities, which clearly suggests a relationship between them. This raised hopes of being able to predict the long-term cyclical fluctuations of the solar activity based on the well-known planetary motions.

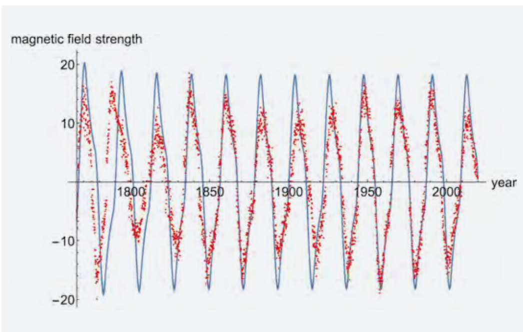
New theory for a controversial hypothesis

However, the so called "planetary hypothesis" is highly controversial in the scientific community. Many researchers argued that the influence of the planets is far too small to have an observable effect on solar activity. But now, in a large international collaboration we have found an explanation of how the tiny effects of the planets could nevertheless influence the activity of the much larger Sun: *Stochastic Resonance.* Under certain conditions, the phenomenon can greatly amplify weak external periodic signals to a level where they have significant consequences.

So how does this work for the Sun and the planets? Solar activity follows a well-known 11-year cycle. However, there are other cycles. Using complex mathematical models, we showed that the Sun basically has two stable states of activity in the 11-year cycle, that is, an active state with high solar activity, and a quiescent state with lower solar activity. This is known in physics as a *bistable* system. The Sun jumps back and forth between these two states due to turbulences in its interior. Since turbulences are random, these jumps should be completely irregular and unpredictable.

Planets set the pace

However, Beer's beryllium-10 data suggest that the change of states does not happen purely at random, but with a rhythm of about 200 years. This would be a longer 200-year cycle superimposed on the 11-year cycle. Jürg Beer and his colleagues have proposed the idea that the planetary tidal forces are responsible for this additional rhythm. Now our theory provides a possible explanation. Indeed, under suitable conditions, noise in a bistable system can massively amplify the influence of a periodic driver. This is called stochastic resonance. The turbulences inside the Sun (the noise) would thus amplify the weak influence of the planets (the periodic driver). In this way, the planets would enforce their beat on the Sun's random switches between the two states of activity and regulate the pace of solar activity.



Our model (blue) can accurately reproduce the solar sunspots record (red) over the past ~300 years. We aim at obtaining such a good fit using radionuclides-based data for the past 10,000 years and beyond.

Our new theory was recently published in the prestigious *Astrophysical Journal Letters* (Albert et al., ApJL 916, 2021) and appeared in the Spanish edition of *National Geographic.* In a next step, we will investigate to what extent our stochastic model can be used to reproduce observations of solar activity over the past centuries. This data-driven calibration of a stochastic model is a computationally challenging task that will require sophisticated algorithms and the resources of the ZHAW HPC (high performance computing) facility. It would back up the theory and naturally lead to a further step, namely the prediction of solar activity for the coming decades and centuries.

Are we observing a transition to a phase of weak solar activity?

Such a forecast would be of great interest. According to Beer's hypothesis, which is now supported by our theory, we are at the end of an active phase with a large amplitude of the 11-year cycle, and we should slowly be heading for a phase of weak activity. Such quiescent phases are called *Grand Minima.* Current sunspots observations seem to confirm that the 11-year cycle is weakening. The near-future evolution of solar activity is particularly interesting because the last occurrence of a grand minimum about 400 years ago is associated with the Little Ice Age in large parts of Europe, even if this connection has not yet been clearly proven. In a time of dramatic climate change, a slowdown in solar activity would of course be beneficial. Although it would hardly be able to compensate for anthropogenic global warming, it might be able to temporarily slow it down a little, thus buying us some precious time in the run to reduce greenhouse gas emissions. ■

Neue Verrechnungsmodelle für die Maschinenindustrie

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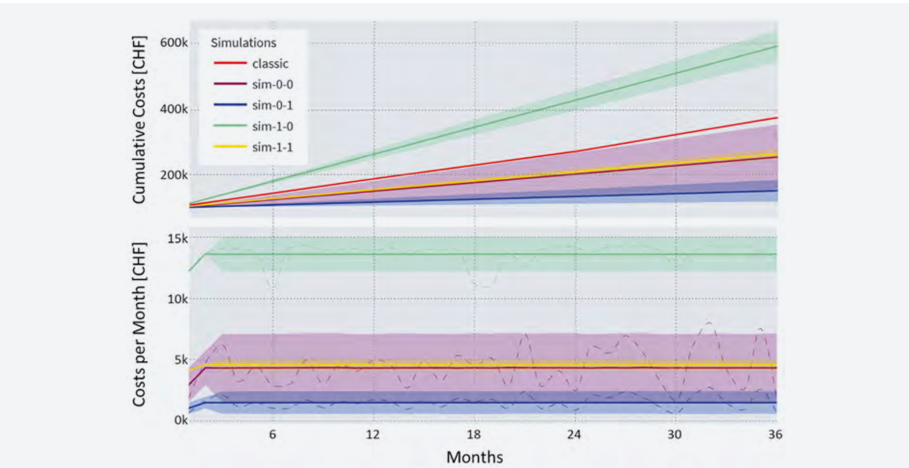
Seit längerem lässt sich Software – und inzwischen auch ganze IT-Systeme – als Service in der Cloud beziehen. Die grossen Cloud-Computing Anbieter haben Preismodelle entwickelt, bei denen nicht die Infrastruktur an sich, sondern nur dessen effektive Nutzung in Rechnung gestellt wird. Insbesondere kleinere Unternehmen, die solche Systeme nicht zu 100 Prozent auslasten, profitieren erheblich davon.
In diesem Innosuisse-Projekt entwickelt, simuliert und untersucht das ZHAW-Institut für Angewandte Simulation zusammen mit dem Institut für Technologiemanagement (ITEM) der Universität St. Gallen, acht Industriepartnern aus dem Maschinenbausektor und einem Beratungsunternehmen verschiedene Preismodelle, in denen grosse Industriemaschinen als Service angeboten werden. Die erarbeiteten Verrechnungsmodelle werden dabei mit verschiedenen Nutzungsmodellen kombiniert und mit klassischen Kaufoptionen statistisch verglichen.
Die neuen Modelle lassen sich je nach Anwendungsfall für unterschiedliche Szenarien und Branchen konfigurieren. So lässt sich die Nutzung einer Maschine zum Schleifen von Werkzeug basiert auf Stückzahlen verrechnen, aber ebenso die Nutzung einer Membranschäumungsanlage, bei der die Betriebsstunden und das Rohmaterial die treibenden Faktoren sind. ■



Simulation der monatlichen und kumulativen Kosten für vier Simulationen mit zwei Verrechnungs- und zwei Nutzungsmodellen. Die schattierten Bänder stellen die 95 %-Konfidenzintervalle dar, die der Nutzer*in ein Gefühl für die Varianz in der Prognose der Kosten vermitteln.

Neue Projekte

Klassifikation von Drohnensignalen
Dauer: 31.03.21 – 30.03.22
Projektpartner: Bundesamt für Rüstung armasuisse

Shapescience – Künstliche Intelligenz für die Fruchtbestimmung
Dauer: 01.07.21 – 28.02.25
Projektpartner: Realisation Schmid AG

Weitere Projekte
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Weiterbildung

23.02.2022
Process Simulation Fundamentals

23.03.2022
Simulating of Complex Processes

Diverse Kurse und Angebote
➔ zhaw.ch/ias/weiterbildung

Bioinformatics for colorectal cancer

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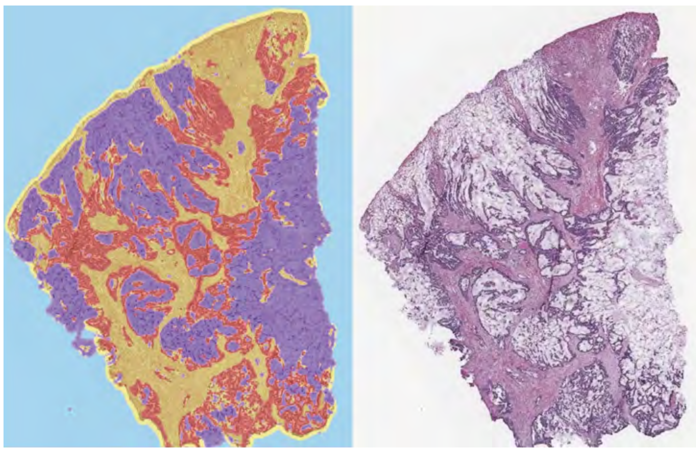
Colorectal cancer (CRC) is one of the leading death causes worldwide. For CRC patient stratification and treatment decisions, clinical doctors rely on microsatellite instability (MSI) and consensus molecular subtype (CMS) classification. In collaboration with Institute of Pathology in Bern, we investigated the association of CMS classification and mucin-to-tumor area quantified using a deep learning algorithm, and the expression of specific mucins in predicting CMS groups and clinical outcome. Performance was compared to two pathologists' scores, then applied to two cohorts. We obtained a high inter-observer agreement between pathologists and algorithm's scores (ICC = 0.92). We concluded that mucinous histology combined with MSI helps to predict CMS groups and should be considered in future image classifiers of molecular subtypes. This work is funded by the SNSF Sinergia CRSII5_193832 "Trans-omic approach to CRC". ■



Example of tissue detection in H&E CRC slides using deep learning, with mucin in purple, tumor in red, normal tissues in yellow, background and artifact in cyan. From: Nguyen et al. (2021) *Modern Pathology,* doi: 10.1038/s41379-021-00894-8