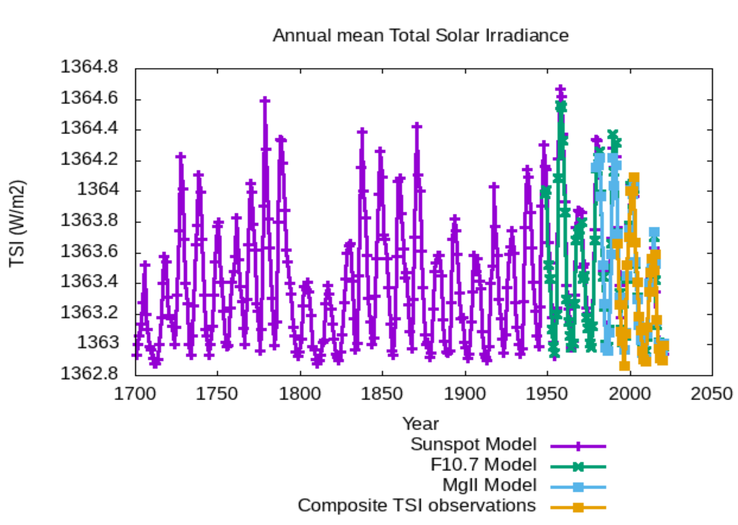
Research on the Influence of the Sun in Climate

ORB - KSB

Introduction

At the Royal Observatory of Belgium (ORB-KSB), we work on **the long-term variations of solar activity** through the **Sunspot Number,** and through the **total and spectral solar irradiance** which is of direct relevance for climate modelling. Since 1981, the ORB-KSB hosts the **World Data Center SILSO (Sunspot Index and Long-term Solar Observations)** which collects sunspot observations to produce the International Sunspot Number. This number gives a long-term measure of the level of solar activity, a continuous series that now covers more than 400 years, and is, in fact, the longest scientific experiment still ongoing ! Our scientists thus have unique expertise on the long-term evolution of solar activity. The ORB-KSB contributes to research on the solar irradiance evolution, either by the development of models, or by collecting measurements. The ORB-KSB also works on a **new concept for the space monitoring of the most essential of all climate variables: the Earth Energy Imbalance**.

With this expertise on the Sun and the Earth radiation, we can make an **internationally significant contribution** to the study of past, present and future climate change.



Sun radiation measurements

To characterise the influence of the Sun on climate change on Earth, we need to know the long-term variation of the solar energy input to the earth, quantified by the Total Solar Irradiance (TSI). Although measurements started in 1978, we do not have unique homogeneous measurements covering the whole period, so we need to reconcile measurements obtained by various instruments, sometimes limited to specific parts of the solar spectrum, or models [Dewitte & Nevens, 2016]. Over the years, the ORB-KSB has been involved in collecting such measurements, notably with space-borne instruments such as PICARD-BOS, PROBA2-LYRA, DIARAD-VIRGO and the future Solar-C SOSPIM. Based on those, the ORB-KSB has contributed to reconstructing this Climate Data Record through different projects: [Dewitte & Nevens, 2016], [Haberreiter et al, 2014], …

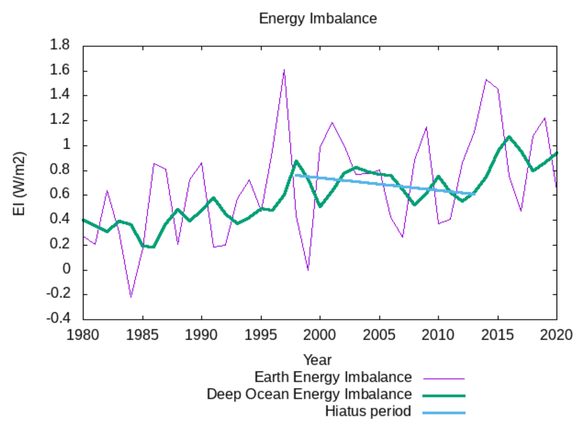
The most recent developments were described in [Dewitte et al, 2022], where we used the direct observation of the TSI by space radiometers from 1991 to 2021, for the calibration of a long-term reconstruction of the TSI based on the SILSO Sunspot Number from 1700 to the present.

Long-term evolution of the Sun

The Sun's influence on Climate is important even if it is overshadowed by human-made changes in the current global warming crisis. Moreover, contrary to what was previously thought, solar activity has not reached exceptional levels in the last 50 years. In 2015, the WDC SILSO and scientists from around the world have carried out a global recalibration of the sunspot number series, to correct the different ways of recording sunspots by the hundreds of observers of the past centuries [Clette & Lefèvre, 2016]. They discovered that the solar activity over the last 50 years is not essentially different from that of the three previous centuries. The sunspot number is a measure of the Sun's activity that undergoes a periodic eleven-year change called the solar cycle. Over this solar cycle, the solar irradiance varies mainly in the ultraviolet causing an impact on the Earth's global temperature of about 0.1 degree. The study of sunspots is thus important to quantify the Sun's influence on climate compared to that caused by human activities. After the recalibration, the WDC-SILSO team is working with colleagues from around the world to gather historical sunspot data and reconstruct the Sunspot Number series from scratch [Bhattacharya et al. 2021, 2022]. The data are available on the website of the SILSO World Data Centre, managed by the Observatory: https://www.sidc.be/silso. This ongoing effort of recalibration and reconstruction is partly described at https://www.issibern.ch/teams/sunspotnoser/ and will be the topic of a review paper by the ISSI team to be published in 2023.

Earth Energy Imbalance

The Earth Energy Imbalance (EEI) can be considered as the most Essential of all Climate Variables (ECVs), it is defined as the small difference between the incoming solar radiation, and the outgoing terrestrial radiation. If mankind is successful in the implementation of the Paris Climate Agreement, in order to avoid catastrophic climate change, the EEI should not grow beyond its current value around 1 W/m² in the decades to come. In [Dewitte et al, 2019], we investigate the recent EEI variation measured from space, and we find that during the so-called hiatus period from 1998 to 2013 – where the rate of global temperature rise has temporarily slowed down, the EEI had a downward trend, in contrast with the overall upward trend of the EEI over the period from 1980 to the present. In [Schifano et al, 2019] we propose a new space mission concept for the monitoring of the EEI with improved accuracy and stability. We are working towards the proposal of this new space mission concept as an ESA Earth Explorer 12 candidate in 2023.



The ORB-KSB has a unique expertise in the long-term monitoring of solar activity through the SILSO Sunspot Number, the measurement of the total and spectral solar irradiance, and the Earth Energy Imbalance, that can provide a valuable contribution to the newly created Belgian Climate Centre.

References

[Bhattacharya et al, 2021] Bhattacharya, S., Teague, E.T.H., Fay, S., Lefèvre, L., Jansen, M., Clette, F.: 2021, A Modern Reconstruction of Richard Carrington's Observations (1853-1861). Solar Phys. 296(8), 118. DOI. ADS.

[Bhattacharya et al, 2022] Bhattacharya, S. et al., 2022, Scale Transfer in 1849: Heinrich Schwabe to Rudolf Wolf, Submitted to Solar Phys.

[Clette & Lefèvre, 2016] F. Clette and L. Lefèvre, "The New Sunspot Number: Assembling All Corrections", Solar Physics, November 2016, Volume 291, Issue 9-10, pp 2629-2651, https://rd.springer.com/article/10.1007/s11207-016-1014-y

[Dewitte & Nevens, 2016] Dewitte, S. and Nevens, S., 2016. The total solar irradiance climate data record. The Astrophysical Journal, 830(1), p.25.

[Haberreiter et al, 2014] Haberreiter, M., Delouille, V., Mampaey, B., Verbeeck, C., Del Zanna, G. and Wieman, S., 2014. Reconstruction of the solar EUV irradiance from 1996 to 2010 based on SOHO/EIT images. Journal of Space Weather and Space Climate, 4, p.A30.

[Dewitte et al, 2022] Dewitte, S., Cornelis, J. and Meftah, M., 2022. Centennial Total Solar Irradiance Variation. Remote Sensing, 14(5), p.1072.

[Dewitte et al, 2019] Dewitte, S., Clerbaux, N. and Cornelis, J., 2019. Decadal changes of the reflected solar radiation and the earth energy imbalance. Remote Sensing, 11(6), p.663.

[Schifano et al, 2019] Schifano, L., Smeesters, L., Geernaert, T., Berghmans, F. and Dewitte, S., 2020. Design and analysis of a next-generation wide field-of-view earth radiation budget radiometer. Remote Sensing, 12(3), p.425.

CLIMATE CENTRE