frontiers | Frontiers in Earth Science

TYPE Editorial
PUBLISHED 08 January 2024
DOI 10.3389/feart.2023.1338416

OPEN ACCESS

EDITED AND REVIEWED BY
Patrick Laux,
Karlsruhe Institute of Technology (KIT), Germany

*CORRESPONDENCE
Liang Zhao,
zhaol@lasg.iap.ac.cn

RECEIVED 14 November 2023
ACCEPTED 27 December 2023
PUBLISHED 08 January 2024

CITATION
Xiao Z, Zhao L, Zhou L, Huo W, Mironova I and Miyahara H (2024), Editorial: Impact of solar activities on weather and climate.
Front. Earth Sci. 11:1338416.
doi: 10.3389/feart.2023.1338416

Editorial: Impact of solar activities on weather and climate

Ziniu Xiao[1], Liang Zhao[1]*, Limin Zhou[2], Wenjuan Huo[3], Irina Mironova[4] and Hiroko Miyahara[5]

[1]State Key Laboratory of Numerical Modeling for Atmosphere Sciences and Geophysical Fluid Dynamics (LASG), Institute of Atmospheric Physics, Chinese Academy of Sciences (CAS), Beijing, China, [2]Key Laboratory of Geographic Information Science, Ministry of Education, East China Normal University, Shanghai, China, [3]Department of Ocean Circulation and Climate Dynamics, GEOMAR Helmholtz Center for Ocean Research Kiel, Helmholtz Association of German Research Centres (HZ), Kiel, Germany, [4]Department of Earth's Physics, Saint Petersburg State University, Saint Petersburg, Russia, [5]Humanities and Sciences/Museum Careers, Musashino Art University, Tokyo, Japan

KEYWORDS

solar activity, energetic particle precipitation and cosmic ray, climate change, climate system response, monsoon and ENSO, stratosphere-troposphere coupling, atmospheric electric field

Editorial on the Research Topic
Impact of solar activities on weather and climate

The Sun drives the atmospheric dynamics of our planet and plays a role in shaping weather and climate patterns on Earth. While the exact mechanism of solar influence on weather and climate on decadal or shorter time scales is still a challenge, scientists have proposed and even observed several ways in which solar activities can affect our planet's atmospheric conditions by different energy forms and physical processes.

This Research Topic, "*Impact of Solar Activities on Weather and Climate*", includes articles that address solar effects on weather and climate and explore the physical mechanism. Papers range from the impacts of the solar activity on the temperature, precipitation, tropical cyclones (TC), North Atlantic Oscillation (NAO), Atlantic meridional overturning circulation (AMOC), the El Niño–Southern Oscillation (ENSO), South Asian jet to response of clouds to the Galactic Cosmic Ray (GCR).

Two papers in this Research Topic are focused on the relationship between solar activity and surface climate variability. Lu et al. focused on the link between solar activity and the summer temperature distribution over Eurasian land and found a significant 11-year solar periodicity in the temperature patterns, particularly in Central Asia. Solar-induced negative geopotential height anomalies in Central Asia weaken high-pressure ridges and strengthen northwesterly, leading to regional lower temperatures. Hu et al. conducted research into the decadal fluctuations in precipitation over the Tibetan Plateau, in relation to the 11-year solar cycle. In the solar maximum years, a substantial surface warming over the Asian continent enhances the Indian summer monsoon through changing land-ocean thermal contrast and increases precipitation over the central-southern Tibetan Plateau.

Two papers are focused on the relationship between solar activity and TC. The first paper by Li et al. investigated the combined effect of solar activity and ENSO on TC genesis frequency in the Western North Pacific. El Niño years during declining phases of the solar cycle show significantly strong positive anomalies in TC genesis frequency. Various atmospheric and oceanic factors, such as sea surface temperature anomalies and wind patterns, contribute to the connections between solar cycle and TC genesis frequency. The

joint effect of Sun and ENSO on the asymmetry of TC frequency found in the second paper by Li et al. The second paper by Li et al. found that intensified solar activity significantly increased the number of TCs in high-solar activity years, while no significant modulation was observed in low-solar activity years. Increased solar radiation in high-solar activity years leads to stronger surface upward latent heat flux an evaporation, thereby enhancing local upward motion and cyclonic winds over the TC source.

Three papers are focused on the relationship between solar activity and the ocean. Leamon established a correlation between the occurrence of solar cycle terminations and the transition to La Niña based on observations and understanding of the solar 22-year magnetic activity cycle. They predicted a transition to La Niña in mid-2020, which indeed occurred and persisted until 2023 as a rare "triple dip" event. However, some of the solar predictions made did not occur until late 2021. The study examined the correlations between El Niño, La Niña, and geomagnetic activity indices, providing insights into the general trends of large-scale global climate in the next decade. Huo et al. investigated the solar modulation on the connection between NAO and ENSO. They found that the boreal winter NAO-like SLP anomalies have a linear covariation with the subsequent boreal summer El Niño Modoki-like SST anomalies in the tropical Pacific in the following 1 year during the high solar activity period. The positive NAO-like SLP anomalies can enhance the influence of the North Tropical Atlantic SST on the tropical Pacific SST by triggering significant and more persistent subtropical teleconnections. Ye et al. studied the influence of solar forcing on multidecadal variability in the AMOC, a crucial component of the ocean's thermohaline circulation system. In this study, they conducted experiments using an Earth System model with different total solar irradiance (TSI) series. They found that the declining AMOC could be attributed to the decadal variation in TSI.

Besides, Ma et al. found that the 11-year solar cycle can influence the South Asian jet by two mechanisms. One mechanism involves a solar-induced tilted NAO pattern, which triggered southeastward wave activity fluxes towards the South Asian jet. Another mechanism is the decreased convective activity over the Maritime Continent area, which can be attributed to the weakening of the Pacific Walker Circulation caused by solar activity.

The study by Miyahara et al. explored how GCRs affect high-altitude clouds via deep convective activities over tropical land areas. The authors found that susceptible areas are seasonally variable, with the most notable responses observed in August. Additionally, following the activation of high-altitude cloud formation, an increase in sea surface temperature gradient was observed over the Pacific. While the influence of solar radiation on sea surface temperature has been widely studied, the authors suggested that the impact of GCRs on cloud formation and subsequent changes in atmospheric circulations could be one of the underlying mechanisms.

Wang et al. reviewed four processes of energy transmission in the effectuation chain of solar forcing to the climate system: solar energy input into the atmosphere, atmospheric absorption of the input energy, transformation of the absorbed energy into dynamic and thermodynamic responses in the atmosphere, and coupling among all the layers affected by solar forcing. The paper detailed how solar radiation varies during the solar cycle and solar eruptions, and how the terrestrial atmosphere absorbs the input solar energy.

Overall, this Research Topic highlights the Frontier discoveries and advancements in the research on sun-climate relationships. The ten works analyzed the possible mechanisms and reasons from the perspectives of solar radiation and cosmic rays. They also highlighted the challenges and questions in studying the influence of the Sun on the Earth's atmosphere and climate on decadal and shorter time scales. Finally, we would like to express our sincere gratitude to all the authors and reviewers who have contributed their valuable insights and expertise to this Research Topic.

Author contributions

ZX: Conceptualization, Writing–review and editing. LZ: Formal Analysis, Funding acquisition, Investigation, Writing–original draft, Writing–review and editing. LZ: Writing–review and editing. WH: Writing–review and editing. IM: Writing–review and editing. HM: Writing–review and editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This work is supported by the National Natural Science Foundation of China (42075040 and 42274217).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note