1. Dynamo

[P01]The role of meridional flow in the generation of solar/stellar magnetic fields and cycles

Vindya Vashishth; Bidya Binay Karak

Indian Institute of Technology (BHU) Varanai

Meridional flow (MF) is crucial in generating the solar poloidal magnetic field by facilitating the poleward transport of the field from the decayed BMRs. As the meridional circulation changes with the stellar rotation, the properties of stellar magnetic cycles are expected to be influenced by this flow. In this study, we explore the role of MF in generating magnetic fields in Sun and Sun-like stars using the STABLE dynamo model. We find that STABLE captures the response of MF more accurately as compared to the traditional 2D dynamo models using alpha parameterization for the BL process. In particular, our findings align with SFT models, showing that a moderate MF increases the polar field by efficiently driving the trailing polarity flux toward the pole, while a strong flow tends to transport both polarities of BMRs poleward, potentially reducing the polar field. Similarly, the toroidal field initially increases with moderate flow speeds and then decreases after a certain value. This trend is due to the competitive effects of shearing and diffusion. Furthermore, our study highlights the impact of MF on the cycle strength and duration in stellar cycles. By including the MF from a mean-field hydrodynamics model in STABLE, we show that the magnetic field strength initially increases with the stellar rotation rate and then declines in rapidly rotating stars, offering an explanation of the observed variation of stellar magnetic field with rotation rate.

1. Dynamo

[P02]The origin of long-term solar magnetic variability: Deterministic chaos or stochastic fluctuation?

"Chitradeep Saha (1); Suprabha Mukhopadhyay (1,2,3); Dibyendu Nandy (1,2) "

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Direct observations and reconstructions of long-term solar activity clearly exhibit amplitude variability beyond the decadal timescale – the origin of which remains a mystery. Does such persistent modulation originate from purely deterministic nonlinear mechanisms, or do stochastic perturbations in the Sun' s interior play a vital role here? In this work, we directly address this issue to distill the cause of long-term solar activity modulation. Based on our multi-millennial dynamo simulations, we conclusively demonstrate that nonlinear mechanisms alone cannot explain long-term variation in solar activity and that stochastic fluctuation is the root cause of this modulation. This finding is significant for solar and stellar dynamo theory and has important implications for predicting solar activity.

1. Dynamo

[P03]Reconciling Discrepancies in Tilt Quenching of Solar Active Regions: Cross-Calibration

Lang Qin; Jie Jiang; Ruihui Wang

Beihang University

The tilt angle of solar active regions (AR) is crucial in the Babcock-Leighton (B-L) type dynamo models for the buildup of polar field. Two types of tilt quenching mechanisms have been proposed as nonlinear mechanisms modulating the amplitude of solar cycles. These mechanisms include an anti-correlation between the cycle-averaged tilt angle and cycle amplitude, and a non-monotonic relationship between tilt angle and magnetic properties (e.g., maximum magnetic field strength Bmax and magnetic flux) of ARs. However, discrepancies in results based on different databases have sparked controversy regarding the existence and specifics of tilt quenching. Here we aim to resolve the discrepancies using a novel method. Specifically, we cross-calibrate two datasets: the magnetogram-based WJL dataset and the white-light-based DPD dataset. This cross-calibration enhances the reliability of tilt angle records for solar cycles 23 and 24. Then using the refined tilt angle data, our analysis confirms the existence of both types of tilt quenching, in which tilt angle initially increases and then sharply decreases with increasing flux (rather than Bmax) of ARs. Our results provide observational support for the existence of tilt quenching and offer insights into the flux emergence process.

1. Dynamo

[P04]2D simulation including thermal convection of rising magnetic flux tube in solar convection zone

Koki Kikkawa; Hideyuki Hotta

Nagoya University

We investigated the relationship between the twist and rising magnetic flux tube in the convection zone (CZ) using two-dimensional simulation including thermal convection. It is believed that the sunspots result from flux tubes generated at the bottom of the CZ rising to the photosphere. Previous simulation studies of the rising process of flux tubes have shown that a certain amount of twist is required for flux tubes to rise without breaking. It is also shown that the greater the twist, the greater the retention of flux tubes when they reach the top boundary (Moreno-Insertis & Emonet, 1996). It is important of the effect of thermal convection on rising flux tubes has been pointed out in many studies. However, no comprehensive parameter survey of the relationship between twist and thermal convection has been conducted. In this study, a series of simulations of rising flux tubes in two dimensions, including thermal convection, was carried out to clarify the behavior of flux tubes in the CZ. The results show that the retention of flux when reaching the upper boundary tends to be lower including thermal convection than without thermal convection under the same initial conditions. It also found that in some cases, when including thermal convection, the flux tube cannot reach the upper boundary if the twist is increased. The rising flux tubes including thermal convection do not show a monotonic dependence on twist, so each case must be analyzed carefully.

1. Dynamo

[P05]High-resolution Radiative magnetohydrodynamic simulations for sunspot penumbra and Evershed flows

Hideyuki Hotta (1); Matthias Rempel (2)

(1) ISEE/Nagoya University (2) HAO/NFS NCAR

We present a series of radiative magnetohydrodynamics (RMHD) simulations to address the formation mechanism of the sunspot penumbra and Evershed flows. The sunspots are the region on the solar surface with strong magnetic fields. The central dark region of the sunspot is called the umbra. The region has a vertical and strong magnetic field. Around the umbra, there is a less dark region called the penumbra. The penumbra has an inclined magnetic field with radially outward flows called Evershed flow. There have been a number of RMHD simulations to understand the formation and maintenance mechanism of the penumbra and Evershed flows. Rempel (2012) found that when the magnetic field is forced inclined on the top boundary, the penumbra and Evershed flows are reproduced. Jurcak et al. (2020), however, pointed out that the magnetic field is too inclined in the simulation with the boundary condition compared with the observation. In this study, we pursue further influence of the higher resolution simulation. We adopt a potential boundary condition and 6 km grid spacing in the highest resolution simulation. We found that the penumbra and Evershed flows are gradually reproduced by increasing the resolution. When we increase the resolution, small-scale upflows in the penumbral region appear, providing mass to the Evershed region. Some details of the physical process will be discussed in the poster.

2. TSI

[P06]New SATIRE-S spectral and total irradiance reconstruction since 1974

Theodosios Chatzistergos; Natalie A Krivova; Sami K Solanki; Kok Leng Yeo

Max Planck Institute for Solar System Research

"The short time span covered by direct measurements of solar irradiance variations since the late 1970s necessitates reconstructions of past irradiance variations, crucial for assessing solar influence on Earth's climate and potentially predicting future trends. The variability of irradiance on time scales longer than about a day is driven by the solar surface magnetic field, manifested as bright faculae and network or dark sunspots. Thus, irradiance models require information on the evolution of these features. SATIRE is one of the most advanced models available. It computes the brightness of sunspots, faculae, and quiet Sun using radiative transfer codes and corresponding solar model atmospheres, while deriving their spatial distribution from solar observations. The previous version of SATIRE-S used four sources of magnetograms (HMI, MDI, and two sets from the Kitt Peak National Observatory) to derive the surface distribution of features. However, each set of magnetograms covered roughly one solar cycle with limited overlap between subsequent series, introducing uncertainty in the derived long-term trend of the irradiance. Here, we present a revised and updated version of the SATIRE-S model, using further sources of magnetograms. This allows reducing the uncertainty of the long-term change in TSI over the satellite era. Additionally, the new data span the entire ACRIM-gap, offering an independent evaluation and resolution of the ACRIM-gap dispute."

2. TSI

[P07]Reconstructing solar irradiance over the period 1996-2024

Ilaria Ermolli (1); Theodosios Chatzistergos (2); Fabrizio Giorgi (1)

"(1) INAF Italian National Institute for Astrophysics; (2) MPS Max Planck Institute for Solar System Research "

Knowledge of solar irradiance variability is critical to Earth's climate models and understanding the solar influence on Earth's climate. Direct measurements of the Total Solar Irradiance (TSI) have only been available since 1978 from instruments onboard multiple missions. Different calibrations of the individual instruments make estimates of the possible long-term trend in the TSI still uncertain. Knowledge of the Solar Spectral Irradiance (SSI) is even more undetermined. Here we use the carefully reduced observations from the Rome Precision Solar Photometric Telescope (Rome/PSPT) and semi-empirical irradiance models to reconstruct solar irradiance variations over the period 1996-2024. Results are discussed with respect to direct measurements and existing composite reconstructions.

2. TSI

[P08]Solar hydrogen Lyman lines and their effect on the Earth's ionosphere

Ryosuke Okubo(1);KyokoWatanabe(1);Shinnosuke Kitajima(1);Satoshi Masuda(2);Akimasa Ieda(2);Hidekatsu Jin(3);Chihiro Tao(3);Michi Nishioka(3)

(1)National Defense Academy of Japan;(2)ISEE, Nagoya University;(3)National Institute of Information and Communications Technology

"Lyman α line (121.6 nm, Ly α) is the strongest solar hydrogen line, accounting for over 50% of the EUV radiation in the chromosphere and transition region (Fontenla et al., 1991). However, due to its long wavelength, Ly α does not have sufficient energy to ionize atoms and molecules in the Earth's atmosphere. On the other hand, Lyman β line (102.6 nm, Ly β) emitted from same hydrogen atoms in the solar atmosphere has a shorter wavelength than Ly α and may have a greater ionizing effect on the Earth's atmosphere. Lemaire et al. (2012) studied the Ly α / β ratio during the solar cycle 23 and found that the ratio changes with solar activity levels. We examine the Ly α / β ratio during the solar cycle 24, their relationship during solar flares, and their effects on the Earth's ionosphere. The Ly α / β ratios from 2002-2016, observed by TIMED/EGS-SEE, showed no significant difference between the solar cycles 23 and 24. For 40 events of M-class or larger flares from February 2010 to May 2014, Ly α lines observed by GOES/EUVS-E and Ly β lines by SDO/EVE revealed that the average increase rates of Ly α and Ly β emissions were about 4.4% and 10.5%, respectively. This indicates Ly β has a higher increase rate compared to Ly α. The effects of EUV radiation and X-rays on the Earth's ionosphere during solar flares were evaluated using the GAIA model (Jin et al., 2008). It was found that Ly β lines significantly affect the ionization of O_2 in the E layer of the ionosphere. Finally, we compare GAIA' s results to Ionosonde data to discuss the consistency between the model and observations."

2. TSI

[P09]Reconstructing a Thousand Years of Solar Irradiance

Francesco Berrilli (1); Luca Bertello (2); Matteo Cantoresi (1); Serena Criscuoli (2); Lorenza Lucaferri (1); Valentina Penza (1); Raffaele reda(1); Simone Ulzega (3)

(1) University of Rome Tor Vergata; (2) National Solar Observatory; (3) Zurich University of Applied Sciences

"To understand the impact of solar variability on our atmosphere and climate, it is crucial to accurately estimate past solar irradiance. This knowledge enhances our ability to interpret historical climate patterns and make informed predictions about future climate conditions. By reconstructing solar irradiance, scientists can more effectively distinguish the human-induced component of climate change from natural solar variations. Solar irradiance varies significantly over a wide range of timescales, from days to millennia, due to various solar processes. The most well-known pattern is the eleven-year solar cycle, driven primarily by the emergence and disappearance of dark and bright magnetic features. However, longer-term changes also occur, potentially influenced by more diffuse magnetic fields. Historical evidence indicates that the Sun has experienced periods of significantly reduced activity, known as Grand Minima, which differ considerably from current solar conditions. To investigate how Earth's climate responds to periods of minimal solar activity, we constructed a thousand-year record of solar irradiance using the open magnetic field signal as a proxy to track long-term solar changes."

3. Long

[P10]Magnetic Power Spectra and Cycle Dependence of Magnetic Network

Yukun Luo; Jie Jiang; Ruihui Wang

Beihang University, Beijing, China

Magnetic power spectral analysis provides a powerful tool for understanding the various scales of the Sun' s magnetic fields and their interactions with plasma motions. The availability of high-resolution SOHO/MDI and SDO/HMI synoptic maps covering three consecutive solar cycle minima allows us to investigate power spectra over multiple solar cycles. We find that the calibration factor r between MDI and HMI power spectra varies with the spatial scale of the magnetic field, expressed as r(l)= $\sqrt{}$ $(-0.021l^{0.64} + 2)$. With the calibration, the most contemporaneous MDI and HMI magnetograms show consistent power spectra from about 8 Mm to the global scales. The calibrated magnetic power spectra reveal that the size of the magnetic network ranges from 26 Mm to 41 Mm without dependence on the solar cycle. The network field power accounts for approximately 20% of the total power during any phase of solar cycles. The power-law index between AR sizes and magnetic network sizes presents a strong anti-correlation with the activity level. Additionally, our study indicates that in the absence of sunspots on the solar disc, the magnetic power spectra remain time-independent, consistently exhibiting similarity in both shape and power. This study introduces a new method to investigate the properties of the magnetic network and provides magnetic power spectra for high-resolution simulations of the solar magnetic field at the surface at various phases of solar cycles.

3. Long

[P11]A live homogeneous database of solar active regions for solar cycle variability

Ruihui Wang; Jie Jiang; Yukun Luo

Beihang University, Beijing, China

Solar active regions (ARs) dominate solar polar fields, which cause solar cycle variability within the framework of the Babcock-Leighton (BL) dynamo. The contribution of an AR to the polar field is measured by its dipole field, which results from flux emergence and subsequent flux transport over the solar surface. The dipole fields contributed by an AR before and after the flux transport are referred to as the initial and final dipole fields, respectively. For a better understanding and prediction of solar cycles, we provide a database including AR' s initial and final dipole fields and the corresponding results of their bipolar magnetic region (BMR) approximation from 1996 onwards. To build the database, we develop a method to automatically detect ARs based on SOHO/MDI and SDO/HMI synoptic magnetograms, identify the repeated ARs, and optimize the transport parameters. Based on our database, we find that although the commonly used BMR approximation performs well for the initial dipole field, it exhibits a significant deviation for the final dipole field. To accurately assess an AR' s contribution to the polar field, the final dipole field with its real configuration should be applied. Despite the notable contributions of a few rogue ARs, approximately the top 500 ARs ordered by their final dipole fields are necessary to derive the polar field at the cycle minimum. While flux transport may increase or decrease the dipole field for an individual AR, its collective impact over all ARs in a cycle is a reduction in their total dipole field.

3. Long

[P12]A Grand Journey of Pink Noise in the Solar-Terrestrial System

Masahiro Morikawa; Yuko Motizuki

Astro-Glaciology Lab., RIKEN Nishina Center

"We focus on solar activity and climate through the lens of long-term fluctuations, specifically describing a characteristic fluctuation with a power spectral density nearly inversely proportional to frequency (pink noise), aligning with the conference's three objectives.

We first analyzed the SOHO-GOLF 16.5-year data on fluctuations of time elapsed for the waves circumnavigating the Sun, directly reflecting the resonance of solar five-minute oscillations (SFO). While the squared data shows apparent pink noise, the original data does not, analogous to behavior observed in music data. We speculate that pink noise generally originates from the beat of many waves with accumulating frequencies (amplitude modulation). Furthermore, we demonstrate that the resonance of SFO successfully yields amplitude modulation and pink noise. This pink noise is robust, inherited by solar flare time series and sunspot numbers through natural thresholding by magnetic reconnections.

Solar UV radiation in the stratosphere may subsequently inherit this pink noise from intrinsic solar activities. The complex chain of ion reactions would yield HNO_3, and its ion NO_3^- is stored in ice cores drilled around Dome Fuji station, Antarctica. Additionally, cosmic rays controlled by solar magnetic activity would modulate the amounts of 14C and 10Be. These all potentially show pink noise inherited from the Sun. Notably, our analysis of stored data spanning hundreds of years indicates that NO_3^- is a good proxy for long-period solar activity, exhibiting pink noise.

Finally, we describe the geo-contamination of pink noise. Earth's free oscillation (EFO) is known to be continually excited. The waves resonate with this EFO, producing pink noise. Despite attempting to find a connection between this geo-activity and NO_3^-, our efforts were in vain. Therefore, we claim that pink noise travels from the Sun to Antarctica. "

3. Long

[P13]Planetary hypothesis and deterministic forecasting of long-term solar activity

Eleni Petrakou

Universiti Malaya

In 2018 we published a model for the solar cycle in terms of solar flares based on the relative motion of planets Jupiter and Saturn. We now reload the model with data up to mid-2024. In addition to predictions for cycle 25, refinements are presented including the role of hemispheric activity, various cycle features, and a look at longer-term variability and historical extrema – all with respect to the hypothesis of planetary influence. We find continuing support for such a hypothesis, so we touch briefly upon possible sources and offer handles for its verification.

4. Stellar

[P14]Mean-Field Study of Stellar Activity-Rotation Relationship

Ryota Shimada(1); Takaaki Yokoyama(1)

(1) Kyoto University

"This study explores the relationship between stellar surface magnetic fields and rotation rates. Previous observations (e.g., Wright+ 2011, 2018) have established a connection between stellar activity and rotation rates, with recent observations by Reiners+ (2022) indicating a parallel trend in surface magnetic fields. Observations suggest an anti-correlation between the magnetic field and Ro within the moderate Ro range ($0.1 < \mathrm{Ro} < 1$), reaching saturation at extremely low Ro. Here, the Rossby number (Ro) is a crucial measure in assessing the impact of rotation on dynamics defined as the rotation period over convective turnover time. While global magnetohydrodynamic (MHD) simulations, such as those by Brun+ (2022), successfully replicate the anticorrelation in moderate Ro, the saturation phenomenon at extremely low Ro remains beyond the reach of current global simulations, and its driving mechanism remains unclear. To elucidate the saturation of the stellar magnetic field at extremely low Ro, we perform non-kinematic mean-field dynamo simulations by extending the solar case by Rempel (2006). Our findings reveal that the magnetic field strength is influenced by both stellar rotation rates and the assumed turbulent angular momentum (AM) transport process. Through detailed analysis, we demonstrate that the dependence of the magnetic field on Ro is intricately determined by the balance between AM transport by turbulence and the magnetic field. Notably, our results, in conjunction with recent insights into turbulence properties at low Ro (e.g. Kapyla 2024), align closely with observed magnetic field saturation patterns reported by Reiners+ (2022).
"

4. Stellar

[P15]Surface Radiation Dose via Solar Superflares during Hadean Periods of Early Earth

"Yosuke A. Yamashiki(1); Vladimir S. Airapetian (2,3); Tatsuhiko Sato (4); Ayu Shiragashi (1);Hiroyuki Maehara (5), Yuta Notsu(6); Kosuke Namekata(1) "

(1) Kyoto University; (2) NASA/GSFC; (3) American University; (4) JAEA; (5)NAOJ; (6) University of Colorado, Boulder

Early Earth was irradiated by Galactic Cosmic Rays (GCRs) and high fluence solar energetic particles (SEPs) associated with frequent superflares and coronal mass ejections (CMEs) from the magnetically active young Sun. Recent studies (Hu et al. 2022; Kobayashi et al. 2023) suggests that SEPs from the Sun in the early Hadean period (4.4 Gya) was the dominant source of ionizing radiation in the form of high fluence hard energy spectrum of energetic proton events precipitating the low atmosphere and surface of the early Earth. Here we report the results of the model study of the early Earth environments, where we have used SEP spectra induced by fast and energetic CME events during the early and late Hadean periods to calculate the dose of particle radiation at the Earth' s surface using the Particle and Heavy Ion Transport code System [PHITS]. Our simulations provide the first clues on the level of accumulated dose on Earth' s surface during the first 100 Myr after the formation of our planet (the early Hadean period) suggesting high rates of destruction of biomolecules of life. However, the fluence and the frequency of SEP events decreased over 1 order of magnitude in the next 0.4-0.5 Gyr (in late Hadean), and this significantly reduced the radiation dose making it possible to accumulate bioorganic compounds required for the onset and development of life. Also, at that period the production rate of amino acids induced by SEP events could have been high enough to make it possible to promote complexity of biologically relevant molecules of life.

4. Stellar

[P16]Long-term Magnetic Activity Variability in Nearby Sun-like Stars through Intensive H α Monitoring

Sanghee Lee(1); Yuta Notsu(2); Bun'ei Sato (3)

Kyoto University(1); University of Colorado Boulder(2); Tokyo Institute of Technology (3)

"We conducted intensive monitoring of activity variability in the H alpha line for Sun-like stars using the 1.88-m reflector at the Okayama Branch Office of Subaru Telescope over the past four years (2019-2022). Our aim was to explore various aspects of stellar magnetic activity behaviors, including activity cycles, amplitudes of variability, and the potential for exoplanet detection. By correlating the H alpha line variability of each star with stellar activity levels derived from the Ca II H&K line, we highlighted its effectiveness as a magnetic activity indicator. Each target star displayed unique magnetic activity patterns, indicating the possibility of short-term activity cycles in F-type stars, the periodic absence/existence of activity cycles, and co-existing cycles in G-/K-type stars. For stars hosting a hot Jupiter, we found no evidence of star-planet magnetic interaction, suggesting that the observed H alpha variability is more likely related to the star's intrinsic activity rather than the presence of a hot Jupiter. Additionally, we identified the amplitude ranges of H alpha variability that may or may not induce stellar noise in RV measurements with a precision of a few m/s. We are also progressing in monitoring young solar-type flare stars like EK Dra and will introduce updates on this aspect."

4. Stellar

[P17]Time-resolved spectroscopy of superflares on active K dwarfs

Hiroyuki Maehara(1); Namekata Kousuke(2); Yuta Notsu(3); Shun Inoue (2), Kai Ikuta (4); Satoshi Honda(5); Daisaku Nogami(2); Kazunari Shibata(2,6)

(1)National Astronomical Observatory of Japan; (2)Kyoto University; (3)University of Colorado Boulder; (4)University of Tokyo; (5)University of Hyogo; (6)Doshisha University

"Flares are energetic explosions in the solar/stellar coronae caused by the rapid and sudden release of magnetic energy. Solar flares are sometimes accompanied by mass ejections such as filament/prominence eruptions and coronal mass ejections. By analogy with solar events, the early phase of stellar mass ejections can be observed as the blue-shifted absorption/emission components in chromospheric lines (e.g., Odert et al. 2020). Recent time-resolved spectroscopy of stellar flares revealed that stellar superflares on G-dwarfs, RS CVn binaries, and M-dwarfs can produce fast and massive filament/prominence eruptions (e.g., Namekata et al. 2021, 2024, Inoue et al. 2023, Notsu et al. 2024). However, mass ejections associated with superflares on K-dwarfs have not yet been reported. In addition, the connection between stellar superflares and stellar mass ejections is still being debated. Therefore, we need more spectroscopic observations of stellar superflares on various types of stars simultaneously with photometry. We carried out spectroscopic observations of active K-dwarfs LQ Hya and V833 Tau using the 3.8-m Seimei telescope and 1.88-m telescope at Okayama simultaneously with the photometric observation by the Transiting Exoplanet Survey Satellite (TESS). We detected two superflares with a bolometric energy of $10^{34} - 10^{35}$ erg. For both superflares, we cannot find any asymmetries in the H-alpha line profile during these superflares. The absence of the line asymmetries in the H-alpha line suggests that the mass of the erupted plasma would be smaller than $10^{17} - 10^{18} g$ if we assume that the observed superflares are accompanied by the solar-like filament/prominence eruptions with the line-of-sight velocity of a few hundred km/s."

4. Stellar

[P18]Comparison of Spatially Resolved Velocities and Sun-as-a-star Spectra of Solar Prominence Eruptions

Takato Otsu; Ayumi Asai

Kyoto University

Flares are explosive phenomena in the atmospheres of the sun and stars. Solar flares are sometimes associated with filament/prominence eruptions which can lead to coronal mass ejections (CMEs). In stellar cases, Doppler shifted emissions/absorptions are often observed in chromospheric lines such as H-alpha and interpreted as plasma eruptions. Although spectra of solar eruptions can be obtained at each spatial point, a stellar spectrum is a superposition of spectra at different spatial points. Thus, in order to correctly extract the velocity field information of plasma eruptions from stellar spectra, it is essential to investigate the correspondence between the spatially resolved velocity distribution of the Sun and the Doppler shifted component of the spatially integrated spectrum. In this study, we investigated the relation between spatially resolved velocity distribution of solar prominence eruptions obtained by cloud model fitting and Doppler shifted components in spatially integrated spectra i.e., Sun-as-a-star spectra using H-alpha data taken by SMART/SDDI. As a result, averaged velocities of spatially resolved velocity distribution and Gaussian central velocity of Sun-as-a-star spectra were basically well matched. However, some eruptions showed a discrepancy between these two velocities. We discuss what factors of eruptions cause this discrepancy.

4. Stellar

[P19]Time-resolved spectroscopy and photometry of M-type star EV Lac during white-light flare

Shinnosuke Ichihara(1); Daisaku Nogami(1); Kosuke Namekata(2); Hiroyuki Maehara(3); Yuta Notsu(4); Kai Ikuta(5); Satoshi Honda(6); Kazunari Shibata(7)

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"Solar flares are sudden and energetic explosions in the solar atmosphere around sunspots. The energy of some stellar flares is over 10^{33} erg , which is called "super flare" , while that of solar flares is about $10^{(29 - 32)}$ erg. Since UV radiation associated with stellar flares affects the chemical evolution of the surrounding exoplanets, observational evaluation of its emission is important. Furthermore, continuous radiation range from UV to optical is thought to emit most of the radiant energy and is important in terms of the energy budget of a stellar flare. However, its radiation mechanism has not yet been clarified. We performed simultaneous photometric (TESS satellite : 600-1,000 nm) and spectroscopic (Seimei Telescope at Kyoto University : 410-850 nm) observations with a time resolution of 1-2 minutes on the highly magnetically active M-type star EV Lac (age : 3×10^8 yr, rotation period : 4.3 days). As a result, 10^31 erg flare was detected on September 14, 2019. Spectral analysis shows that the continuum optical spectrum at the flare peak can be well fitted by the blackbody radiation at about 8,000 K. This result suggests that an optically thick high-temperature plasma was formed at the peak. In addition to these time variations, the physical interpretation of the results will be discussed."

4. Stellar

[P20]Spectroscopic observations of the K-type Star PW And in the H α and near-infrared CaII Triplet lines

Haruhi Nagata(1);Satoshi Honda(1);Mai Yamashita(2);Daisaku Nogami(3)

(1)University of Hyogo;(2)ISAS/JAXA;(3)Kyoto University

"Observations of chromospheric emission lines have been conducted for various stars including the Sun to understand the stellar activities such as flares and sunspot formation in detail, The H α and the Ca II H&K lines have been used as chromospheric emission lines. However, the Ca II H&K lines are difficult to observe for cooler stars. In this study, we conducted observations of the active K-type star ""PW And"" using the Nayuta Telescope and the spectrograph (MALLS) at the Nishi-Harima Astronomical Observatory. We observed in 6300-8800 Å (including H α line and near-infrared Ca II triplet lines: Ca II IRT) to investigate whether the intensity variations synchronized with the rotational modulation of the starspots are seen in each emission line, and Ca II IRT lines reflect stellar activity like the H α line. To confirm the rotational period and variations in white light, the observations were conducted simultaneously with TESS (Transiting Exoplanet Survey Satellite) observations in October 2022. We found that the variations in the equivalent width of the H α line correspond to the rotational period obtained from the TESS data, confirming synchronization with the rotational modulation of the starspots. However, in the Ca II IRT line have no strong correlation with them. This suggests that the near-infrared Ca II IRT lines are not as indicative of stellar activity as that of the H α and CaII H&K lines. On October 5, 2022, a flare-like brightening was observed in the H α line. During this event, blue-shifted excess components were seen in H α , with the blue-shift velocity in the H α line being about 85 km/s. This is considered to be due to prominence ejections associated with the flare. "

4. Stellar

[P21]Atmospheric heating scaling laws for pre-main sequence stars

Mai Yamashita (1); Shin Toriumi (1); Takashi Ito (2); Kota Nakazawa (2); Ikuyuki Mitsuishi (2); Yoichi Itoh (3)

(1) ISAS/JAXA; (2) Nagoya University; (3) University of Hyogo

"The magnetic flux at the solar surface transports energy upwards and heats the chromosphere, transition region, and corona. Toriumi & Airapetian (2022) compared the power-law scaling between irradiance and total magnetic flux in the chromospheric and coronal emissions of the Sun and solar-type main-sequence stars. They found that the atmospheric heating mechanism is common among solar-type main-sequence stars, regardless of their age and activity level. Pre-main-sequence (PMS) stars rotate fast and have thick convection zone. The surface magnetic fields of PMS stars are strong, resulting in bright emission lines from the chromosphere and corona. In this study, we investigate whether the scaling laws between the magnetic field, coronal emission, and chromospheric emission can be extended for PMS stars and zero-age main-sequence (ZAMS) stars. We analyzed high-resolution optical spectra obtained with VLT/X-Shooter and UVES, and detected chromospheric emission lines of Ca II HK (3968, 3934 A), H α (6563 A), and infrared Ca II (8542 A). The X-ray luminosities from the corona are estimated from ROSAT and XMM-Newton. We find that the intensities of chromospheric emission lines and coronal X-rays of the PMS stars are consistent with the extensions of the power laws obtained from the solar data. However, PMS stars with strong magnetic fields show constant X-ray intensities to the magnetic field strength. It is suggested that the heating rates of the atmospheres of main-sequence stars are similar to those of the Sun, while those of the young stars with large magnetic fluxes may show a decrease in the heating rate. "

4. Stellar

[P22]Validating solar atmosphere models with IAG and DKIST observations: the case of Balmer lines.

Serena Criscuoli (1); Adam Kowalski (1,2); Tyler Case (3); Tom Schad (1); Joao da Silva Santos (1); Odele Coddington (2); David Kuridze (1)

(1) National Solar Observatory; (2) Laboratory for Atmospheric and Space Physics, Boulder; (3) Lycoming College

"Stellar atmosphere models are essential for a variety of studies, including the determination of stellar fundamental parameters, stellar dynamos, and exoplanet characterization, habitability, and detectability. Likewise, solar atmosphere models are fundamental for understanding how solar radiation and its variability affect the Earth's atmosphere and climate. Spatially resolved observations provide a unique opportunity to validate and improve the various atmospheric models proposed in the literature. In this work, we compare synthetic spectra of Balmer lines obtained using atmospheres often employed to model solar quiet and magnetic features, with state-of-the-art spectrographic observations obtained at the Institut für Astrophysik und Geophysik, and the US National Science Foundation's Daniel K Inouye Solar Telescope. Our findings indicate that the quiet Sun model from Fontenla et al. 2011 best reproduces observed quiet Sun profiles of Balmer lines, whereas models of magnetic features likely overestimate chromospheric temperatures. "

4. Stellar

[P23]Tracing the Young Sun' s Magnetic Activity From The Lunar South Pole

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According to the observations of young solar analogs and theoretical models of their activity, the young Sun in the first 200 million years was a source of frequent and energetic superflares affecting the bodies in the Solar System. We propose that the South Pole of the Moon represents an ideal site to study the impacts of magnetic activity from the young Sun as it possibly stores the traces of energetic particles with energy of > 1 GeV in the ices and regolith of the permanently shadowed regions. Over 4.3 Gyr ago when the Moon was magnetized, the energetic particles associated with superflares would predominantly penetrate the polar regions of the lunar surface and cause isotopic changes in stable isotopes including, D/H, 21Ne/22Ne, 15N/14N by spallation reactions. Here we present preliminary results of our calculations of production of cosmogenic isotopes by spallation of early Moon' s regolith and ice by applying the Particle and Heavy Ion Transport System (PHITS) code.

5. Corona

[P24]Evaluating a characteristic of magnetic flux in the spheromak to arrival time of CMEs in SUSANOO-CME

Hirofumi Isogai (1); Kazumasa Iwai (1); Daikou Shiota (1,2); Ken'ichi Fujiki(1)

(1) ISEE, Nagoya University, Japan; (2) NICT, Koganei, Japan

"Predicting the arrival of coronal mass ejections (CMEs) to the Earth is crucial for space weather forecasting, and global MHD models are essential tools. In MHD models, it is vital to independently quantify the contribution of each initial condition to improve accuracy of forecast. However, despite their importance in CME propagation, comprehensive parameter surveys for magnetic parameters in CME models have not been conducted enough. This study quantitatively evaluates the impact of magnetic flux in the spheromak on CME arrival times using SUSANOO-CME (Shiota & Kataoka, 2016) for the first time. We conducted ensemble simulations of the CME propagations by varying initial parameters, including magnetic flux, and calculated the arrival time of each CME at the Earth. Results show that magnetic flux dependence of CME arrival times systematically affected by other initial conditions, such as initial velocities of CMEs and ambient solar wind speeds. This implies that the required accuracy of magnetic flux estimation depends on other initial conditions of the spheromak and ambient solar wind. We present a diagram visualizing arrival time of CMEs under multiple initial conditions, enabling rough forecasts based on initial conditions prior to full calculations. We also discuss its effectiveness for ongoing data assimilation of SUSANOO using interplanetary scintillation observations by ISEE."

[P25]Development of digital backend for next generation interplanetary scintillation observation system

TAKEHARA Daichi; IWAI Kazumasa; FUJIKI Ken' ichi; WATANABE Haruto; KAGAO Yusuke

Nagoya University

Interplanetary scintillation (IPS) is a radio scattering phenomenon generated by the disturbances in the solar wind. Institute for Space–Earth Environmental Research (ISEE), Nagoya University has detected disturbances of the solar wind efficiently by using IPS observation system composed of 3 cylindrical parabolic antennas at 327 MHz. ISEE has been developing a next generation solar wind observation system (ngSW) which can generate approximately 10 times more solar wind speed data compared to the conventional observation systems. The ngSW is composed of 2D flat phased-array system, and installing digital multi beam forming devices which has 4 beam and 8 beam mode. This digital device has 1,024 analog inputs, and digitize input signals with 12 bits. As a phase-1 project, a 64 channel digital backend (64 ch), which is part of this system, has already been developed. Evaluation tests of the 64 ch system were executed in the laboratory. The results show that dynamic range is about 60 dB. This is good result because it is 83% of the theoretical value which is 72 dB. On the software side, grating lobes were reconstructed as expected, and this mean that implemented program for beamforming implemented appropriately. The duration of the Allan variance for white noise was approximately 448 seconds. This is shorter than expected value which is around 1000 seconds. One of the causes is temperature in the laboratory, which was not constant.

5. Corona

[P26]The Solar Coronal Structures Recorded around the Maunder Minimum and the Dalton Minimum

Hisashi Hayakawa (1)

(1) Nagoya University

Like the astronomical spectacle in this April, total solar eclipses have marveled the human beings and left their footprints in historical records for millennia. Such total solar eclipses benefit discussions on astrophysics, offering unique opportunity to observe the solar atmosphere and coronal dynamics. This is also the case with morphological evolutions of solar coronal streamers over the solar-cycle phases. As such, any of their past graphical records offer unique spot references for the solar-cycle phases, solar magnetic activity, and their underlying dynamo activity before the space age. This presentation reviews such eclipse records around the Maunder Minimum and the Dalton Minimum. These eclipse records contrast eclipses in the Maunder Minimum without significant coronal steamers against those in the Dalton Minimum and the aftermath of the Maunder Minimum with significant coronal streamers. This contrast indicates a unique solar-dynamo activity in solar cycles during the Maunder Minimum in contrast with those in other periods. This presentation also aims at extending similar comparisons to the Medieval Grand Maximum and Spörer Minimum.

5. Corona

[P27]Annual Variation of Solar Sources of Coronal Mass Ejections from 1996 to 2023

Sachiko Akiyama (1,2); Seiji Yashiro (1,2); Nat Gopalswamy (2); Grzegorz Michalek (3); Hong Xie (1,2); Pertti Mäkelä (1,2)

(1) The Catholic University of America; (2) NASA/GSFC; (3) Astronomical Observatory of Jagiellonian University

The SOHO/LASCO CME catalog has listed more than 38,000 CMEs since January 1996 and is extensively used for research on the long-term variations in solar cycle activities. Akiyama et al. (2019) identified the CME Solar Source (CME-SS) locations of 6,870 wide CMEs out of 8,420 that occurred during 1996 to 2018. They found that 48% of wide CMEs originated from the Active Regions (ARs) and 52% were from the Quiet Regions (QRs). This study is a continuation of Akiyama et al. (2019), extending the investigation period to the end of 2023 and focusing particularly on the relationship with the solar activity cycle. We prepared two data sets. One is a list of 10,601 wide CMEs whose angular width is $\geq 60^{\circ}$. Among the wide CMEs 53% were from AR and 47% from QR, excluding events for which the CME-SS could not be identified. However, this ratio strongly varied depending on the solar cycle activity from the solar maximum (AR=86% and QR=14%) to the solar minimum (AR=12% and QR=88%). Another is a list to check whether there are CMEs associated with 10,028 flares with X-ray intensity of C3 or higher. From this flare-CME list, the CME association rates were 92% of X-class, 54% of M-class, and 32% of C3-C9 class flares. We also present the statistical relationship between flares and CMEs.

5. Corona

[P28]Towards radiative magnetohydrodynamic modeling of the solar wind environment

Haruhisa Iijima (1); Daikou Shiota(2); Hideyuki Hotta (1); Hisashi Hayakawa (1)

(1) Nagoya University; (2) National Institute of Information and Communications Technology

We present a current status of our ongoing project to model the solar wind environment using radiative magnetohydrodynamic (MHD) simulations. In Iijima et al. (2023; ApJ, 951, L47), we presented the first solar wind simulation starting from the convection zone, allowing a nearly self-consistent modeling of the solar wind. We now extend this approach to infer the solar wind environment of the entire Sun based on a comprehensive parameter survey of radiative MHD simulations and observational data.

5. Corona

[P29]Solar Prominence Formation Triggered by Single Heating Event

Takero Yoshihisa (1); Takaaki Yokoyama (1); Takafumi Kaneko (2)

(1) Kyoto University; (2) Niigata University

We studied by numerical simulations on mechanisms of solar prominence formation triggered by a single heating event. In the widely-accepted "chromospheric-evaporation condensation" model, localized heating at footpoints of a coronal loop drives plasma evaporation and triggers condensation. The occurrence of condensation is strongly linked to heating characteristics. Various theoretical studies have been conducted along one-dimensional field lines with quasi-steady localized heating. However, it is reasonable to consider that quasi-steady heating is a superposition of multiple heating events in multiple strands constituting a coronal loop. We investigated the condensation phenomenon triggered by a single heating event along a field line as the basic unit by performing 1.5-dimensional magnetohydrodynamic simulations. We found that, when a heating rate approximately 10^4 times greater than that of steady heating was applied, condensation occurred. By varying the magnitude of the localized heating rate, we investigated the conditions necessary for condensation. Condensation was observed when the thermal conduction efficiency in the loop was lower than the cooling efficiency, while the cooling rate remained significantly greater than the heating rate. Using the loop length L and the Field length λ F, the condition for condensation is expressed as λ F $<$ L/2 under conditions where cooling exceeds heating.

5. Corona

[P30]Motion of the source region of the type-II solar radio burst in HF frequency range

Naoto Kinno (1); Yuto Katoh (1); Atsushi Kumamoto (1); Kazumasa Iwai (2)

(1)Tohoku University; (2) Nagoya University

"Coronal Mass Ejections (CMEs) are phenomena ejecting large plasma masses into interplanetary space due to eruptive activities. Type II solar radio bursts (SRB II) are generated by energetic electrons produced by CME front shock waves. Since the emission frequency of SRB II is determined by the local plasma frequency, the speed of CMEs can be estimated from the frequency drift of SRB II by referring to the coronal plasma density model. Since CNEs have a significant impact on the space environment around the Earth, accurate prediction of the speed and the height of CMEs using the frequency-time variation of SRBs is the key to preventing space disasters. In this study, we used the Iitate HF-band monitor [15-40 MHz; Kumamoto+. 2011]. We analyzed the SRB II event observed on June 13, 2022, associated with a CME observed at 03:12 UT. The fundamental and harmonic lanes appeared in the spectra from 03:25 to 03:34 UT, and the frequency drift rate changed from $-7.5x10^{-3}$ MHz/s to $-1.18x10^{-2}$ MHz/s around 03:29 UT. The source speed between 03:26:10 and 03:28:00 UT was estimated to be about 200 km/s from the Baumbach-Allen model [Baumbach, 1938; Allen, 1947], and about 295 km/s from the 10-fold version of that model, in good agreement with 195 km/s estimated form SOHO/LASCO C2 images (03:24-03:36 UT). On the other hand, the estimated speed using the same density models was increased to 354-522 km/s during 03:28:20-03:34:20 UT. Although the acceleration of CME could explain this result, we need to consider the acceleration mechanism capable of explaining the time scale of the change of the drift rate. Another possibility is the propagation of the CME across two different density regions. A corona hole near the CME may support this hypothesis. "

5. Corona

[P31]The variability of helium in the solar corona and the solar wind

Leon Ofman(1); Yogesh (1); Silvio Giordano (2)

(1) Catholic University/NASA GSFC; (2) INAF - Astrophysical Observatory of Torino

The variation in the amount of helium in the solar corona and solar wind is an important indicator of solar activity, solar cycle, and of the sources of the solar wind. The helium relative abundance can vary typically in the 1%-10% range, depending on coronal sources and solar cycle. Recent UV imaging observations show that helium abundance is reduced in a quiescent streamer, compared to open field regions. Observations by Parker Solar Probe (PSP) at perihelia of the sub-Alfvénic solar wind associated with streamers and heliospheric current sheets find helium relative abundance below 1%. We present the results of a three-fluid model showing the different processes that cause changes in helium abundance. In this model, the solar wind is modeled as magnetized interacting electron, proton, and alpha particle fluids. The results of the model agree with the observations of helium variability in the solar corona, providing insight into the effects of heating, gravitational settling, and collisional coupling. This study helps us understand the coronal origin of the solar wind, and the variability of helium relative abundance throughout the solar cycle.

5. Corona

[P32]Solar wind evolution from the Sun to 7 AU during 1994-2009

Chin-Chun Wu(1) ● Kan Liou(2) ● Brian E. Wood(1)

"(1) US Naval Research Laboratory, Washington D. C., USA (2)Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland, USA "

Accurate reconstruction of the solar wind plays an important role in the study of the heliosphere and space weather prediction. A global three-dimensional (3-D) magnetohydrodynamic (MHD) numerical simulation model (G3DMHD) is employed to simulate solar wind evolution from the Sun to 7 AU for the period between 1990 and 2009 while Ulysses spacecraft was orbiting in the region between 1 – 5.6 AU. The G3DMHD model is a data-driven, time-dependent, global 3-D MHD numerical simulation model. The G3DMHD starts at 18 solar radii and is driven by the solar synoptic maps, a refined version of the Wang-Sheeley model, and a set of conservation laws. To validate the model performance, the simulation result is compared with the daily solar wind plasma and field data acquired by the Ulysses spacecraft in terms of several metrics: the yearly correlation coefficient (cc), mean squared prediction error (MSPE), mean absolute scaled error (MASE), and root mean squared error (RMSE). Following phenomena are found by comparing simulated solar wind data with Ulysses observation. (i) Simulated solar wind magnetic field, density, velocity are well correlated with observation. (ii) G3DMHD temperature is underestimated. (iii) Strength of the solar wind magnetic field is normally underestimated during the solar minimum period, and overestimated during the solar maximum period. (iv) Solar wind speed is underestimated, and solar wind density is overestimated in the minimum period (1994-1997; 2006-2009) while Ulysses was in the high latitude region. We will present a detailed comparison and discuss possible causes of the discrepancy. * Work of NRL are supported partially by Office of Naval Research and NASA grant.

15. May 2024

[P33]The May 12, 2024 versus Halloween Geomagnetic Storm: Comparison of the Geoelectric Field Changes

Anna Wawrzaszek (1); Agnieszka Gil (1,2); Renata Modzelewska (2); Bruce T. Tsurutani (3); Roman Wawrzaszek (1)

"(1) Space Research Centre, Polish Academy of Sciences (CBK PAN), Warsaw, Poland; (2) University of Siedlce, Institute of Mathematics, Siedlce, Poland; (3) Retired, Pasadena, CA, USA"

"Until recently, the 25th cycle of solar activity seemed to be as calm as the 24th cycle. However, a series of spring storms in 2024 disturbed this silence. The storm of May 12 was particularly strong. In our work, we compare the behavior of the geoelectric field during the May 2024 event, the most powerful geomagnetic storm in twenty years, since Halloween Storm, and the storm from late October 2003. In addition, our comparison includes slightly weaker events: the storm of April 2023 and September 2017. The tool that allows for an accurate comparison is the GeoElectric Dynamic Mapping (GEDMap). GEDMap procedure is used to perform systematic computation of geoelectric fields and to reveal the spatio-temporal evolution of magnitude and direction of the field during the studied powerful storms."

15. May 2024

[P34]Space Weather Forecast and Social Impacts in Japan in the Event of Large Solar Flaress in May 2024

Takuya TSUGAWA

National Institute of Information and Communications Technology, Japan

"Large solar flares, including 13 X-class flares, occurred from May 8 to 15, 2024. The multiple coronal mass ejections (CME) toward the earth were observed and the first one arrived around the earth at around 01:30 JST (UT+9h) on May 11, 2024, and large-scale geomagnetic and ionospheric disturbances were observed in Japan during May 11 and 13. The National Institute of Information and Communications Technology (NICT) has been issuing warnings and forecasts of these phenomena in its daily space weather forecast meetings since August 8. Due to concerns about the potential social impact in Japan, we created the special website on October 10 to disseminate information and informed the press and related government agencies and organizations, held an online press conference. As a result, the information was reported by many media outlets and attracted public attention. In the field of satellite positioning, it was reported that during the time of ionospheric storms, there were increases in positioning errors in single-frequency relative positioning, RTK positioning, etc. There were also reports of problems with shortwave communications used in aviation operations and amateur radio. In the field of satellite operation, a 400-meter loss of altitude was reported for a LEO satellite. On the other hand, no critical problems were reported in the operation of satellites, including those in GEO. In the field of aviation, several domestic and international aviation-related operators were alerted and warned based on actual space weather conditions and forecast information, and some took actions such as changing air routes. There were reports of temporary disruptions in shortwave communications. In this presentation, space weather forecast and social impacts in Japan for the May event will be reported."

15. May 2024

[P35]Dynamics of the inner magentosphere during the May 2024 gigantic storm: Arase satellite observations

Y. Miyoshi (1), I. Shinohara (2), N. Higashio (2), T. Mitani (2), T. Takashima (2), T. Hori (1), K. Asamura (2), S. Kasahara (3), S. Yokota (4), K. Keika (3), N. Kitamura (1), Y. Kasahara (5), F. Tsuchiya (6), A. Kumamoto (6), S. Matsuda (5), A. Shinbori (1), C.-W. Jun (1), A. Matasuoka (7), M. Teramoto (8), K. Yamamoto (1)

(1) Nagoya University, (2) JAXA, (3) U. Tokyo, (4) Osaka University, (5) Tohoku University, (6) Tohoku University, (7) Kyoto University, (8) Kyushu Institute of Technology

In May 2024, a gigantic magnetic storm with a Dst index exceeding -400 nT occurred. During this event, unusual solar wind-magnetosphere interactions were observed, including visible auroras in Japan. The Japanese Arase satellite, currently the only geospace exploration satellite capable of observing the inner magnetosphere and radiation belts, successfully captured geospace variations during this extreme magnetic storm, revealing various unusual aspects. Analysis showed that the Arase satellite observed a rapid flux enhancement of relativistic radiation belt electrons very close to Earth. These increased electrons persisted around Earth, suggesting that this storm event altered the radiation environments in geospace. Observations also indicated that the magnetopause moved inward, placing the apogee of the Arase satellite outside the magnetosphere, which suggests unusual distortion of the magnetosphere. Additionally, the Arase satellite observed a significant increase in ion flux near Earth, contributing to ring currents. This presentation will provide an overview of the unique observation data on geospace observed by the Arase satellite and compare these findings with other observations, such as those of the Sun and solar wind, to offer a comprehensive picture of this historic event.

15. May 2024

[P36]New sub-GLE event registered by neutron monitors on 8th June 2024

Olga Kryakunova (1); Stepan Poluianov (2,3); Botakoz Seifullina (1); Ilya Usoskin (2,3); Alexander Mishev (2,3); Sergey Koldobskiy (2,3); Irina Tsepakina (1); Nikolay Nikolayevskiy (1)

(1) Institute of Ionosphere, Kazakhstan (2) Sodankylä Geophysical Observatory, University of Oulu, Finland; (3) Space Physics and Astronomy Research Unit, University of Oulu, Finland

Solar active region AR3664 (AR3697 at the next rotation) caused a series of X-class solar flares in May 2024 and one major SEP event associated with ground-level enhancement (GLE) number 74. This long-living active region also produced another significant SEP event on 08 June 2024, which is reported here. On that day, a strong flare was observed at the west side of the solar disk (coordinates S17 W58) and registered as an M9.8 flare by the GOES X-ray detector. It was accompanied by a coronal mass ejection in the direction favourable for magnetic connection with the Earth. That resulted in the acceleration of solar protons, which were registered by the GOES proton detector as notable flux enhancements in its >100 MeV and even >500 MeV channels. The SEP event was also observed by two high-altitude polar neutron monitors SOPO and DOMC, both located on the Antarctic plateau and having reduced atmospheric and almost negligible geomagnetic rigidity cutoffs. The neutron monitor count rate increases started at 2 UT on 08 June 2024 and lasted for approximately two hours. A preliminary estimate of the count rate increase associated with SEP is 2.29 $\pm$ 0.47 %*h in SOPO and 2.61 $\pm$ 1.69 %*h in DOMC, both being statistically significant at the 95% confidence level. Other sea-level neutron monitors including polar ones didn' t show any statistically significant enhancements. Thus, the event is classified as a sub-GLE according to the formal definition.

15. May 2024

[P37]Social Impacts by the Extreme Space Weather Events in May 2024

Mamoru Ishii (1,2); Sergio Dasso (3)

(1) NICT; (2) Nagoya University; (3) Laboratorio Argentino de Meteorología del esPacio, LAMP

The solar flares and associated proton events, CMEs, that occurred in sunspot groups 13663 and 13664 since May 8, 2024 (Japan Standard Time) were the largest in the 25th solar cycle. It is the first time to observe 13 solar flares of X-class or higher occurred continuously since the current observational techniques were established. International Space Environment Services (ISES) is the only international organization formed by space weather forecasting organizations and currently consists of 21 Regional Warning Centers (RWCs) and 3 Collaborative Expert Centers (CECs). To become an ISES member, each country must be providing space weather information operationally, have national endorsement, and adhere to an open data policy. One of the strengths of ISES is its close relationships with end users in each country. In Japan, NICT has been promoting user communication through the Space Weather User Forum and the Space Weather User Council, and similar activities are being promoted by ISES members around the world. For this large-scale space weather phenomenon, we are utilizing these user communications to compile the social impacts. Many of the social impacts include confidential information, and we select this information with the consent of the provider of the information. In Japan, it has already been reported that shortwave communications and satellite positioning have been severely affected, and it has also been reported that aviation operations have been forced to change in high latitude areas. In this presentation, more detailed information will be presented.

15. May 2024

[P38]Low-latitude auroras and ionospheric convection during geomagnetic storms: SuperDARN observations

N. Nishitani (1); T. Hori (1); K. Hosokawa (2); A. Shinbori (1); Y. Obana (3); M. Teramoto (4); K. Shiokawa(1); R. Kataoka(5)

(1) ISEE, Nagoya University, Japan; (2) UEC, Japan; (3) Kyushu University, Japan; (4) Kyushu Institute of Technology, Japan; (5) NIPR, Japan

The SuperDARN HOP radars (consisting of Hokkaido East and West radars), currently located at the lowest geomagnetic latitude, have been in operation since 2006 and 2014, respectively, and successfully obtained the ionospheric convection flow data during several geomagnetic storm events such as those in March 2015, November 2023, December 2023, and May 2024, when low-latitude auroras were observed in Rikubetsu Town, Hokkaido (37° geomagnetic latitude). The data are essential because there has been very little opportunity to obtain such information using radar instruments such as the HF radar. In general, low-latitude auroral precipitation regions are accompanied by sheared zonal ionospheric flows, but detailed flow patterns vary from event to event. In addition, the brief ($<$ 10 min) variations in line-of-sight velocity observed by the SuperDARN HOP radars appear to have a characteristic time scale similar to auroral variability. More detailed analysis, discussion, and interpretation of the ionospheric flow patterns associated with these low-latitude auroras will be presented.

6. GCR

[P39]Forbush decrease observation by the ALPAQUITA air shower array to access high rigidity

Takashi Sako (1); ALPACA Collaboration (2)

(1) ICRR, the University of Tokyo; (2) ALPACA Collaboration

Forbush decreases (FDs) are usually observed by the world-wide neutron monitor network and muon telescopes. The rigidity thresholds are determined by the geomagnetic cutoff or absorption of muons by overburden. In this talk, we will present a new method to observe FDs with different rigidity thresholds by using the air shower array experiment ALPAQUITA operating in Bolivia. Counting rates of Any1 to Any4 coincidence levels allow observations with thresholds at 10GV to 1TV at the same site. We will present our observation of an FD detected on May 10, 2024, and discuss the maximum rigidity of this FD by comparing with the response function determined by Monte Carlo simulations.

6. GCR

[P40]Sub-GLE events observed with high-altitude polar neutron monitors in 1968-1969

Stepan Poluianov(1,2); Oscar Batalla(3); Alexander Mishev(1,2); Sergey Koldobskiy(1,2); Ilya Usoskin(1,2)

(1) Sodankylä Geophysical Observatory, University of Oulu, Finland; (2) Space Physics and Astronomy Research Unit, University of Oulu, Finland; (3) National Autonomous University of Mexico, Mexico City, Mexico

In this work, we present the investigation of the historical neutron monitor data over the active part of solar cycle 20 (1964-1969), when the global network included two operational high-altitude polar neutron monitors South Pole and Vostok with exceptionally high sensitivity to low-energy cosmic rays. The purpose of the study was the search for possibly unknown SEP events registered by those detectors, so-called GLE (ground-level enhancements) and sub-GLE events. As expected, we found no previously unknown GLE events, but two new notable sub-GLEs were identified in the data set. They occurred on 09 June 1968 and 27 February 1969 and both were associated with strong solar flares and significant enhancements of the proton intensity J(>60 MeV) measured at spacecraft. We analysed the neutron monitor data to reconstruct the high-energy spectra of protons during these events. With the presented results, the database of known GLE and sub-GLE events has been expanded with two new entries.

6. GCR

[P41]Cosmic rays recurrence during the Solar Cycles 24 and 25

Agnieszka Gil

" University of Siedlce & Space Research Centre, Polish Academy of Sciences"

Beginning of the Solar Cycle 25 was full of explosive phenomena, as well as cyclically repeating transequatorial coronal holes giving the opportunity to observe the variability of galactic cosmic rays related to the solar rotation. In this work, we consider the incidents of clearly noticeable recurrence by tracking the causes of particular events. We show during which events the role of changes in the solar wind speed was decisive, and during which the heliospheric magnetic field behavior was more important. Our results are obtained based on the analysis of the neutron monitor measurements, as well as on a full 3-D Parker transport equation modeling with all the fundamental processes being included, namely convection, diffusion, drifts and adiabatic cooling. We present a good agreement of modelling outcomes with the ground-based observations.

7. Cosmogenic

[P42]Multidecadal solar cycles embedded in nitrate concentrations in Antarctic Dome Fuji ice cores

Yuko Motizuki (1,2); Yoichi Nakai (1); Kazuya Takahashi (1); Takashi Imamura (3, 4); Hideaki Motoyama (5,6)

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"Ice cores are known to yield information about past astronomical phenomena as well as information about past climate. We report time series analyses of annually resolved nitrate concentration variations in an ice core (DF01) drilled at the Dome Fuji station in East Antarctica, corresponding to the period from CE 1610 to 1904, a period when nitrate data and sunspot numbers observed by telescopes overlapped. Our analyses revealed clear evidence of 11-, 22-, and 90-year periodicities, comparable to the respective periodicities of the well-known Schwabe, Hale, and Gleissberg solar cycles. Also, a 210-year De Vries (Suess) cycle appears to be seen in our data. These results show for the first time that ice core nitrate concentrations can be used as a proxy for past solar activity on multidecadal time scales. Furthermore, we detected 11-year and 22-year periodicities in nitrate concentrations even during the Maunder Minimum (1645–1715), supporting the cyclic behavior of the solar dynamo during the minimum. In this presentation, we will also report the results for another Dome Fuji ice core (DFS10), which was drilled about 10 km south of the Dome Fuji station."

7. Cosmogenic

[P43]Transition of solar cycle lengths around the onset of Grand Solar Minima

Hiroko Miyahara (1); Fuyuki Tokanai (2); Toru Moriya (2); Mirei Takeyama (2); Hirohisa Sakurai (2); Motonari Ohyama (3); Kazuho Horiuchi (4); Hideyuki Hotta (5)

(1) Musashino Art University; (2) Yamagata University; (3) Tohoku University; (4) Hirosaki University; (5) Nagoya University

In this presentation, we discuss the evolution of solar cycle lengths around the onset of the Grand Solar Minima based on the high-precision data of carbon-14 content in tree rings. We have been working on improving the precision of carbon-14 measurements since the installation of the Accelerator Mass Spectrometer at Yamagata University in 2010, and we have now achieved a precision of 0.05%. Based on these high-precision measurements, we found that solar cycle lengths tend to stretch for a few cycles before prolonged sunspot absence. Notably, we observed cycles lasting up to 16 years just before the onset of Maunder and Spoerer Minima. It suggests that the slowdown of the meridional circulation within the convection zone may have contributed to the prolonged disappearance of sunspots.

7. Cosmogenic

[P44]Key ionic reactions affecting stratospheric O_3 and HNO_3 changes caused by solar proton events

Soh Hirasedo (1,2); Yuko Motizuki (1,2); Yuma Hasebe (1); Chihoko Y. Cullens (3); Yoichi Nakai (1); Hideharu Akiyoshi (4,1); Takashi Imamura (4,5); Satoru Katsuda (2)

(1) Astro-Glaciology Lab., RIKEN Nishina Center; (2) Saitama University; (3) University of Colorado Boulder; (4) National Institute for Environmental Studies; (5) Tokyo Metropolitan Research Institute for Environmental Protection

"Composition changes in the polar stratosphere caused by solar proton events (SPEs) have been observed (e.g., Funke et al., 2011). Both ionic and neutral reactions are crucial for understanding the observed variations, particularly in the D-region, the polar lower ionosphere (Verronen et al., 2005; 2016). To study key ionic reactions affecting composition changes in the polar stratosphere induced by SPEs, we developed two box models: RIKEN Box-i model and Box-n model. The RIKEN Box-i model includes 605 ionic and 147 neutral reactions, whereas the RIKEN Box-n model includes only 147 neutral reactions. Using these models, we simulated the temporal evolution of chemical species concentrations during and after the "Halloween" SPE in October 2003. The RIKEN Box-i model clarified the rapid decrease and subsequent recovery in O_3 and the fast increase and decrease in HNO_3 concentrations observed in the stratosphere. These observed changes continued over a period of about 10 days. In contrast, the RIKEN Box-n model failed to account for these observed short-term features. We identified that reaction pathways forming water clusters are crucial for these short-term changes, as proposed by Egorova et al. (2011). In this presentation, we will also discuss the temporal changes in O_3 and HNO_3 concentrations during the May 2024 storms, using observational data from the MLS on board the Aura satellite and the RIKEN Box-i model."

8. Extreme

[P45]The magnetic field shielding for the celestial bodies

Jiawei Gao

Institute of geology and geophysics, Chinese academy of sciences

The geomagnetic field prevents energetic particles, such as galactic cosmic rays, from directly interacting with the Earth’ s atmosphere. The geomagnetic field is not static but constantly changing, and over the last 100,000 years, several geomagnetic excursions occurred. During geomagnetic field excursions, the field strength is significantly decreased and the field morphology is strongly influenced by non-dipole components, and more cosmic ray particles can access the Earth’ s atmosphere. Paleomagnetic field models provide a global view of the long-term geomagnetic field evolution, however, with individual spatial and temporal resolution and uncertainties. Here, we reconstruct the geomagnetic shielding effect over the last 100,000 years by calculating the geomagnetic cutoff rigidity using four global paleomagnetic field models, i.e., the GGF100k, GGFSS70, LSMOD.2, and CALS10k.2 model. We compare results for overlapping periods and find that the model selection is crucial to constrain the cutoff rigidity variation. However, all models indicate that the non-dipole components of the geomagnetic field are not negligible for estimating the long-term geomagnetic shielding effect. We provide a combined record of global cutoff rigidities using the best available model for individual time intervals. Our results provide the possibility to estimate the cosmogenic isotope production rate and cosmic radiation dose rate covering the last 100,000 years according to the best current knowledge about geomagnetic field evolution, and will be useful in further long-term solar activity and climate change reconstruction.

9. Iono+magn

[P46]Study of the sub-relativistic electron population using Van Allen Probes data

Evangelia Christodoulou, Christos Katsavrias, Ioannis A. Daglis

Department of Physics, National and Kapodistrian University of Athens, Athens, Greece

The behavior of sub-relativistic electrons in the Earth' s outer radiation belt and ring current is crucial for understanding space weather dynamics and improving space weather prediction models. This study utilizes electron flux data from the Hope and MagEIS instruments on board the RBSP satellites (1-400 keV), along with solar parameters and geomagnetic indices obtained from the OmniWeb2 data service. We calculate the correlation coefficients between these parameters and electron flux, including time lags to highlight any temporal dependencies. Our analysis shows significant correlations between source electron (10-100 keV) population and substorm activity, while also showing that seed electrons (100-400 keV) are not purely driven by substorm events. By introducing time lags, we observed a delayed response of electron flux to changes in solar wind conditions, and we identified specific time lag periods where the correlation peaks. This work provides important information and forms the basis for future research.

9. Iono+magn

[P47]Climatological statistical Analysis of 30-800 keV electron fluxes in the inner magnetosphere

Alexandra Triantopoulou, Christos Katsavrias, Ioannis A. Daglis

Department of Physics, National and Kapodistrian University of Athens, Athens, Greece

"The variability of the lower energy electron fluxes of the outer Van Allen belt is crucial for the inner magnetosphere dynamics and satellite operations. Especially, the subrelativistic population is important for two main reasons: first, source and seed electrons act as a reservoir that can be accelerated to relativistic energies; second, they are responsible for surface and internal charging effects on satellites. This study explores the dynamics of these electrons, ranging from tens to hundreds of keV. Using 9 years of data (2011-2019) from the THEMIS-A, D and E missions, spanning Solar Cycle 24, we analyzed climatological (i.e., long-term) differential electron flux characteristics across nine energy channels (30 - 800 keV). These energy channels represent seed (10 – 100 keV), source (100 – 300 keV), and relativistic electrons (>500 keV). We correlated these fluxes with various magnetospheric and solar wind parameters from NASA's Space Physics Data Facility and OMNI database, using a comprehensive binning process. We also utilized the Epsilon parameter, Half-wave rectifier, and Newell' s function, which have been shown to predict how the solar wind interacts with the magnetosphere. In addition, we conducted a cross-calibration with fluxes recorded by GOES 13 and 15. This research provides key insights for predicting electron variability and mitigating risks to satellite systems. We will discuss the resulting features and their implications for predicting electron variability."

9. Iono+magn

[P48]Reproduction of electron density in the lower ionosphere during solar flares using PHITS models

Shinnosuke Kitajima (1); Kyoko Watanabe (1); Hidekatsu Jin (2); Chihiro Tao (2); Satoshi Masuda (3); Michi Nishioka (2); Kiyoka Murase (4)

(1) National Defense Academy of Japan; (2) National Institute of Information and Communications Technology; (3) Nagoya University; (4) The Graduate University for Advanced Studies

"Shortwave fadeout (SWF) occurs when the electron density in the lower ionosphere increases rapidly in a short period, mainly due to X-ray emission during solar flares. There are several simulation models for the whole global atmosphere, which can provide electron density variations throughout the ionosphere in solar flare emissions. However, these models do not calculate the electron density variations in the lower ionosphere accurately. In this study, we used the PHITS code (Sato et al., 2024), a particle transport and collision simulation code using the Monte Carlo method, to reproduce electron density variations in the lower ionosphere due to flare X-ray emission. We input the GOES X-ray data into PHITS and simulated the ionization rate (q). We used the effective recombination coefficient (α eff) and derived the electron density (ne) in the lower ionosphere. The variations of minimum frequency in the ionogram (fmin) during solar flares correspond to the electron density variations in the lower ionosphere. We simulated fmin value using the electron density variations from the PHITS. We compared their simulated fmin with observed fmin and validated the reproduction of electron density using PHITS. We also compared the electron density using PHITS with the observed electron density. The correlation coefficient between the simulated and observed fmin values indicated a good correlation of 0.88 by a linear function, and the true positive rate was 68%. We found that PHITS might reproduce the electron density during flares. In this presentation, we will discuss the reproduction of electron density variations using PHITS in detail."

9. Iono+magn

[P49]Predicting geomagnetic activity cycles

Timo Qvick; Timo Asikainen; Kalevi Mursula

University of Oulu, Finland

"Long-term space climate predictions mostly concentrate on forecasting the 11-year sunspot cycle, while predictions of geomagnetic activity are usually made only for the short term, from hours up to a month. The prevalence of sunspot predictions is partly motivated by the fact that the largest near-Earth magnetic disturbances are caused by coronal mass ejections, whose occurrence approximately follows the sunspot cycle. However, most geomagnetic activity is driven by high-speed solar wind streams, which are most frequent in the declining phase of the solar cycle.

Here we aim to predict the geomagnetic activity cycle, measured by a 180-year composite of the geomagnetic aa index. We fit each cycle of aa between two sunspot minima with a parameterized asymmetric Gaussian function and show that each cycle can reasonably be described using only two free parameters. We discuss the forecasting of the model parameters using past aa values and a recently developed sunspot prediction model. Utilizing the forecasted parameter values, we hindcast each past aa cycle from solar cycle 10 onwards and predict aa in cycle 25, also estimating the uncertainties in the model using a leave-one-out cross-validation methodology. For solar cycle 25, our prediction gives the aa maximum of 21 (+- 3) nT early in the cycle in July 2022, suggesting that the current cycle will not have a strong, long-lasting peak of geomagnetic activity in the declining phase."

10. Atmosphere

[P50]Potential impact of solar activity on climate through modulating tropical convective cloud activity

Hiroko Miyahara(1); Kanya Kusano(2); Ryuho Kataoka(3); Shin-ichiro Shima(4); Emile Touber(5)

(1) Musashino Art University; (2) Nagoya University; (3) National Institute of Polar Research; (4) University of Hyogo; (5) Okinawa Institute of Science and Technology

Paleo-climate and meteorological data indicate that the Sun influences the Earth's system across various timescales, from millennial to monthly. However, the detailed mechanisms behind this connection have not been fully resolved. In this presentation, we discuss the potential impact of solar activity on the climate system through the modulation of tropical convective cloud activity, based on satellite data of clouds from the past four decades. We have found that the most notable responses to solar activity occur over tropical land areas and that deep convective cloud activities are intensified around solar minima when the flux of galactic cosmic rays increases. We suggest that deep convections mediate the Sun-climate connection by promoting encounters between cosmic ray-induced ions and aerosol precursors at mid to high altitudes in the troposphere.

10. Atmosphere

[P51]Solar activity and urban heat islands dominate cherry blossom flowering over the past 1200 years

Genki Katata (1); Ronan Connolly (2,3); Willie Soon (2,4); Peter O' Neill (5); Michael Connolly (2,3); Rodolfo Gustavo Cionco (6,7); Víctor M. Velasco Herrera (8); Yasuyuki Aono (9)

(1) The Canon Institute for Global Studies (CIGS), Japan; (2) Center for Environmental Research and Earth Sciences (CERES), USA; (3) Independent Scientist, Ireland; (4) Institute of Earth Physics and Space Science (HUN-REN EPSS), Hungary; (5) School of Mechanical and Materials Engineering, University College Dublin, Ireland (Retired); (6) Consejo Nacional de Investigaciones Científicas y Tecnológicas (CONICET), Argentina; (7) Grupo de Estudios Ambientales, Universidad Tecnológica Nacional, Argentina; (8) Instituto de Geofisica, Universidad Nacional Autónoma de México, México; (9) Osaka Metropolitan University, Japan

Global warming is known to manifest in temperature rise and to cause phenological shifts, such as cherry blossom flowering. Due to its cultural significance in Japan, the longest records of the flowering dates in Kyoto intermittently since the 9th century and regularly since the 15th century. For this reason, the Kyoto records are often used for studying the changes in the onset of spring, and even as a temperature proxy for the spring. However, Kyoto is also affected by urban heat island (UHI) in addition to global warming. Efforts to quantify the UHI contribution to the observed Kyoto cherry blossom trends have been challenging. Fortunately, records for about 80 stations across Japan are available in both urban and rural areas since 1953. Therefore, we have used this nationwide dataset to quantify the UHI contribution to the cherry blossom flowering in urban areas including Kyoto. Although cherry blossoms in urban areas have been blooming earlier and earlier since the mid-20th century, this was not the case for rural areas. This suggests that urban warming has become the dominant driver of the changes in spring onset in urban Japan, including Kyoto. We compare this urban contribution to the Kyoto record to the contributions from greenhouse gases, solar activity, orbital forcing and volcanic activity. Before the 20th century, the most prominent driver of spring changes in the Kyoto record is solar activity, whereas since the 20th century, the most prominent driver is UHI.

10. Atmosphere

[P52]Historical Records Reveal Extreme Regional Drought During the Maunder Minimum

Yuqi Wang(1,2); Yong Wei(1,2); Fei He(1,2);Limei Yan(1,2),Si Chen(3)

"(1)Key Laboratory of Earth and Planetary Physics, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China (2)College of Earth and Planetary Sciences, University of Chinese Academy of Sciences, Beijing, China (3)Aerospace Information Research Institute, Chinese Academy of Sciences, Beijing, China"

"Extreme solar activity can cause space weather disasters and have a major impact on Earth's weather and climate. Direct observations of sunspots date back about 400 years, when the Maunder Minimum (1645-1715) was discovered and was accompanied by a prolonged period of severe cold in Earth's climate. But because the number of sunspots observed during the Maunder Minimum is so small, the details of solar activity during this period and its impact on climate remain unclear. The aim of this study is to develop a long-term solar activity index database and a regional climate database to analyze regional precipitation changes under extreme solar activity. The main knowledge and results obtained are as follows: (1) Compiling a database of ancient auroras on the Korean Peninsula and analyzing unique variations in solar activity during the Maunder Minimum (2) Reconstructed continuous annual precipitation in Seoul from 1625 to the present based on ancient books including the world's earliest continuous instrumental rainfall records (3) based on an independent precipitation database, we found significant correlations between solar activity and regional precipitation on multiple time scales. The variation of regional precipitation has an 11-year sunspot cycle. During the grand solar minimum, summer rainfall and winter snowfall decrease significantly on the interdecadal scale, and this process may be related to the cosmic ray-cloud formation mechanism. The mechanism by which solar activity affects the air-sea coupling and thus the precipitation in the Pacific region is complex. The study of precipitation change under extreme solar activity is of great significance for human production and coping with drought and flood disasters."

11. SW

[P53]A Decadal Study of Unusual Particle Precipitation During Strong-to-Extreme Geomagnetic Storms

Delores Knipp(1); Janet Kozyra (2); Hannah Marlowe(3); Liam Kilcommons(1)

(1) University of Colorado, Boulder; (2) Heliophysics Division, NASA Headquarters, Washington, DC; (3) Amazon Web Services

"We use machine learning methods to distinguish unique particle precipitation features of the strongest geomagnetic storms from 1997-2006. DMSP particles sensors record the characteristics of 30 eV - 30 keV electrons and ions in the topside ionosphere. After data re-processing to handle missing data and non-physical outliers, we apply an anomaly detection (AD) algorithm to identify patterns and relationships in the cleaned data. Extreme events are amenable to AD because fair-to-moderate space weather provides most of the observations and a baseline against which to identify anomalies. AD identifies outlier data points that may exist concurrently in data streams provided to the detection algorithm. The algorithm provides an anomaly score that rises with event extremity. We consider: the deepest equatorward penetration of dawn-side cool ions ($<$ 1 keV); the equatorward extent of the 1 keV-30 keV auroral electrons; and the reduction in the average energy of auroral electrons. When geomagnetic activity impulsively increases, cool ions rapidly appear at low latitudes, sometimes at $<$ 30 deg magnetic latitudes. Cool ions can transfer energy to the ionospheric electrons enhancing the sub-auroral electron temperature peak and the intensity of associated Stable Auroral Red arcs, potentially into the visible range. Storm-time penetrating electric fields are possible explanations for these events. Simultaneously the auroral electrons show decreases in average energy that we associate with enhanced auroral precipitation and reflection of plasmasheet electrons. We provide scenarios for getting the low energy ions in place and for reducing the average electron energy in the broadened auroral zone. We show examples of severe storm behavior. "

11. SW

[P54]Predicting IP Shock Occurrence for SC 25: Opportunities and Challenges in Space Weather Research

Denny M. Oliveira (1, 2), Robert C. Allen (3), Livia R. Alves (4), Séan P. Blake 5, 6), Brett A. Carter (7), Dibyendu Chakrabarty (8), Giulia D' Angelo (9, 10), Kevin Delano (1, 2), Ezequiel Echer (4), Cristian P. Ferradas (11, 2), Matt G. Finley (12, 13, 2), Bea Gallardo-Lacourt (11, 2), Dan Gershman (2), Jesper W. Gjerloev (14), John Bosco Habarulema (15), Michael D. Hartinger (16), Rajkumar Hajra (17), Hisashi Hayakawa (18), Liisa Juusola (19), Karl M. Laundal (20), Robert J. Leamon (1, 2), Michael Madelaire (20), Miguel Martínez-Ledesma (11, 2), Scott M. McIntosh (21), Yoshizumi Miyoshi (18), Mark B. Moldwin (22), Emmanuel Nahayo (15), Dibyendu Nandy (23, 24), Bhosale Nilam (25), Katariina Nykyri (2), William R. Paterson (2), Mirko Piersanti (9, 10), Ermanno Pietropaolo (9, 10), Craig J. Rodger (26), Trunali Shah (25), Andy W. Smith (27), Nandita Srivastava (28), Bruce T. Tsurutani (29), S. Tulasi Ram (25), Lisa A. Upton (30), Bhaskara Veenadhari (25), Sergio Vidal-Luengo (31), Ari Viljanen (19), Sarah K. Vines (3), Vipin K. Yadav (32), Jeng-Hwa Yee (14), James W. Weygand (33), and Eftyhia Zesta (2)

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Interplanetary (IP) shocks are perturbations observed in the solar wind. IP shocks correlate well with solar activity, being more numerous during times of high sunspot numbers. Earth-bound IP shocks cause many space weather effects that are promptly observed in geospace and on the ground. Such effects can pose considerable threats to human assets in space and on the ground, including satellites in the upper atmosphere and power infrastructure. Thus, it is of great interest to the space weather community to 1) keep an accurate catalog of shocks observed near Earth, and 2) be able to forecast shock occurrence as a function of the solar cycle (SC). In this work, we use a supervised machine learning regression model to predict the number of shocks expected in SC25 using three previously published sunspot predictions for the same cycle. We predict shock counts to be around 275 $\pm$ 10, which is 47% higher than the shock occurrence in SC24 (187 $\pm$ 8), but still smaller than the shock occurrence in SC23 (343 $\pm$ 12). With the perspective of having more IP shocks on the horizon for SC25, we briefly discuss many opportunities in space weather research for the remainder years of SC25. The next decade or so will bring unprecedented opportunities for research and forecasting effects in the solar wind, magnetosphere, ionosphere, and on the ground. As a result, we predict SC25 will offer excellent opportunities for shock occurrences and data availability for conducting space weather research and forecasting.

11. SW

[P55]Can GOES-16 Ultraviolet Measurements Predict the X-ray Properties of Flares?

Abigail Mthethwa

(1) University of Johannesburg; (2) South African National Space Agency

Solar flares are powerful phenomena with significant implications for space weather. Understanding their characteristics and predicting their behavior is crucial for mitigating potential risks and ensuring the safety of space-based operations. This research project aims to investigate whether ultraviolet (UV) measurements obtained from the Geostationary Operational Environmental Satellite (GOES) can be used to predict the X-ray properties of solar flares. By analyzing high-cadence UV solar spectral irradiance data from the GOES Extreme Ultraviolet and X-ray Sensors (EXIS) instrument, the study seeks to establish a reliable relationship between UV observations and X-ray flare behavior. The ultimate goal is to develop a model that enables real-time prediction and interpretation of solar flares, empowering space weather forecasters to make accurate forecasts and take necessary precautions.

12. data resque

[P56]Updates from Kodaikanal archive and new cross-calibrated time series

Dipankar Banerjee(1); Hisashi Hayakawa(2)

(1) ARIES, Nainital, India; (2) Nagoya University, Japan

Kodaikanal Observatory (KSO) has archived more than 100 years of solar images in three different wavelengths namely, white light, Ca K and H-alpha. Four sets of data consist of while light photoheliograms since 1904, the Ca-K line spectroheliograms since 1906, H-alpha spectroheliograms from 1912 to 1998 and K-pr prominences spectroheliograms from 1912 to 1998. The butterfly diagrams as produced from these different datasets reveal new trends and features to understand the irregularities of solar cycle behaviors. We have now cross calibrated these data series with other archives and the combined data series provides new insight in our understanding of the solar cycle irregularities. New techniques are also applied to identify new features including reproduction of pseudo magnetograms.

12. data resque

[P57]Historical records of low latitude auroras on September 1770 in Nagoya, Japan

Kentaro Hattori

Kansai University and Nagoya University

”On September 17, 1770, from dusk till dawn the next day, a red glow with white stripes was observed in the northern sky over China and Japan in East Asia. Recently, the auroral phenomena were observed on the southern and western hemispheres. Recently, the event has been analyzed with contemporary sunspots and interpreted as a low-latitude aurora by Hayakawa et al. (2017) . As in other parts of Japan, this phenomenon was also observed in Nagoya, which is now a major city in the Tokai region of Japan. Nagoya was ruled by the Owari Tokugawa family, one of the prestigious samurai families in the Edo period, and was a large castle town. There are several auroral records of the 1770 September event by people in Nagoya. One is “Enkoan Zuikan Zue”, an illustrated book depicting the situation in Nagoya at that time, by Tadanobu Koriki (1756-1831), a samurai of Nagoya and also a ukiyoe artist (painter of Japanese woodblock prints) artist. In the book, he illustrates a fiery sky in northern parts seen from Nagoya and the situation of confused people who saw it. In addition, Miyoshi Shozan (? - 1850), a samurai of Nagoya and also an essayist, explained the aurora in “Shozan Chomon Kishu”, a collection of Shozan’s essay. These two records were reviewed in Hayakawa et al. (2017), but there is still need for further study of historical documents of Nagoya. In this presentation, we organize auroral records of the 1770 September event in Nagoya and its surrounding areas.”

12. data resque

[P58]HIGHLIGHTING THE TOTAL SOLAR ECLIPSE OF 1868: A WATERSHED EVENT IN SOLAR PHYSICS

Wayne Orchiston (1); Darunee Lingling Orchiston (2)

(1) University of Science and Technology of China; (2) University of Southern Queensland

"The long-duration total solar eclipse of 18 August 1868 was observed by British, Dutch, French, German and Indian teams of scientists from Aden, India, Siam (present-day Thailand) and the Dutch East Indies (present-day Indonesia).

In this poster we will show how this eclipse was a 'watershed event' in solar physics, with identification of the chemical composition of prominences and the corona; the detection of the chemical helium; and the little-known discoverY of the 'green coronal line'. "

12. data resque

[P59]TRACKING THE EARLY HISTORY OF JAPANESE SOLAR RADIO ASTRONOMY

Wayne Orchiston

(1) University of Science and Technology of China, Hefei, China; (2) University of Southern Queensland, Toowoomba, Australia

"Japanese scientists were quick to begin research on solar radio astronomy following WWII, and by 1950 there were four different teams in carrying out systematic observations, from Tokyo, Osaka and Nagoya.

In this paper I will outline the instrumentation at each of these localities and summarise their major research achievements. During the early 1950s, Japan was leading participant in international solar radio astronomy. "

12. data resque

[P60]THE SPACE WEATHER EVENT OF 30 OCTOBER–1 NOVEMBER 1903: A REVIEW OF THE NEW ZEALAND EVIDENCE

Wayne Orchiston (1); Hisashi Hayakawa (2); Bob Evans (3); Ross Dickie (4); Glenn Vallender (5); Ian Cooper (6)

"Orchiston: (1) University of Science and Technology of China, Hefei, China; (2) University of Southern Queensland, Toowoomba, Australia. Hayakawa: Nagoya University, Nagoya, Japan Evans, Dickie, Vallendar, Cooper: Historical Section, Royal Astronomical Society of New Zealand, New Zealand"

"The study of aurorae and magnetic storms are important for our increased understanding of the historical association of 'space weather events' with solar activity. Most major historical 'space weather' events have been studied from a Northern Hemisphere perspective.
In this paper we illustrate the potential New Zealand has to contribute to this research by analysing New Zealand newspaper reports of auroral activity and geomagnetic irregularities associated with the 30 October–1 November 1903 space weather event. "

12. data resque

[P61]Current Activities of the World Data Center for Cosmic Rays (WDCCR)

Takashi Watanabe (1); Yoshizumi Miyoshi (2)

(1) NICT; (2) ISEE, Nagoya Univ.

The WDC for Cosmic Rays (WDCCR) was established in 1957 in Japan at the Institute of Physical and Chemical Research (RIKEN) by ICSU (currently, International Science Council, ISC) during the IGY (1957-1958) to provide the database of worldwide neutron-monitor observations. The WDCCR was moved to the Solar-Terrestrial Environment Laboratory (currently, Institute of Space–Earth Environmental Research, Nagoya University), in 1991. WDCCR continues its activity as the Candidate Member of the World Data System (WDS) created by ICSU in 2008. Our principal data holdings (pressure-corrected and scale-adjusted one-hour count rate of cosmic-ray neutrons since 1953) have been opened in a unified format at https://cidas.isee.nagoya-u.ac.jp/WDCCR/. The total number of available stations is 139, including multiple systems. We also keep original data sheets and documents submitted to WDCCR by neutron-monitor stations before the advent of the digital era. Principal data sources of current neutron-monitor measurements are those being opened on the websites of NMDB, IZMIRAN, and several stations, respectively. Continuity of the traditional on-hour data held by WDCCR and these with higher time resolutions (counts/sec or counts/min) has been kept by applying appropriate conversion procedures. More information is given in icrc2023 Po 20230729.

12. data resque

[P62]Introduction of New Solar Radio Polarimeter in Japan; Yokosuka Radio Polarimeter (YoRP)

Kyoko Watanabe (1); Masumi Shimojo (2); Kazumasa Iwai (3)

(1) National Defense Academy of Japan; (2) National Astronomical Observatory of Japan; (3) Nagoya University

"Solar microwave observations in Japan began more than 70 years ago in Toyokawa, moved to Nobeyama in the 1990s and continue today as the Nobeyama Radio Polarimeters (NoRP; Shimojo and Iwai, 2023) . The NoRP has seven observation frequencies of 1, 2, 3.75, 9.4, 17, 35 and 80 GHz, and can observe the quiet sun as well as non-thermal emissions from solar flares. Variations in microwave emission from the Sun are known to correlate well with variations in EUV emission, which has a significant impact on the Earth' s upper atmosphere. In particular, F10.7 has a good correlation with the sunspot number and is still used to determine the space weather condition. However, the correlation between microwave and EUV depends on the microwave frequency and the EUV wavelength. This is due to the different emission mechanisms of each emission. Microwave is a superposition of thermal bremsstrahlung from the solar atmosphere, gyroresonance emission from sunspots and gyrosynchrotron emission from flares, while the main component of EUV is line emissions reflecting the temperature of the solar corona. In order to accurately predict the solar EUV spectrum from microwave observations, a dynamic spectrum of microwave emission over a wide range of frequencies is required. We have therefore set up a microwave observation system at our institute in Yokosuka, Japan. In this presentation, we introduce the Yokosuka Radio Polarimeters (YoRP) and report on the latest data acquisition status."

12. data resque

[P63]Digital Data Rescue of Old Magnetograms (1867-1933) of Magnetic Observatory of Coimbra University

Paulo Ribeiro (1); Alexandra Pais (2); Hisashi Hayakawa (3)

(1) University of Coimbra, CITEUC, Geophysical and Astronomical Observatory, Portugal; (2) University of Coimbra, CITEUC, Department of Physics, Portugal; (3) Nagoya University, Institute for Space–Earth Environmental Research, Japan

"The Meteorological and Magnetic Observatory of the University of Coimbra (Portugal) was established in 1864. This observatory started regular absolute magnetic measurements in 1866 and continuous recording of magnetic variations in 1867 using Adie' s magnetographs (Kew pattern). These self-recording magnetographs were installed in the basement of the observatory's main building and operated for over six decades until 1933 except for a brief interruption between October 1882 and August 1885. During this period, approximately 19000 daily magnetograms of declination (D) and horizontal (H) and vertical (Z) components were recorded on photosensitive paper at a normal speed of 15.5 mm/h, with the recording sheets replaced daily about noon. The Coimbra collection of old magnetograms, spanning nearly six solar cycles, constitutes a valuable historical dataset for studying long-term solar activity trends and their impact on space climate. These records also benefit determining short-term geomagnetic field variations, from daily changes to the rapid and irregular fluctuations upon magnetic storms caused by the interaction of the energetic solar wind with the magnetosphere and ionosphere. In recognition of the scientific importance of these old magnetograms and the risk of their loss due to preservation challenges, we have been involved in raising funds and coordinating their digital data rescue and in making the scanned versions available to the scientific community. The magnetograms were digitized under the project "COIMAG-BASE: Database of historical magnetograms of Coimbra", partially funded by SCOSTEP (through the PRESTO program) and by the Centre for Earth and Space Research of the University of Coimbra (CITEUC). All the images are publicly available at https://almamater.uc.pt/ogauc/mg."

12. data resque

[P64]A “Citizen Science” Project for Sunspot Observation Data Rescue in NAGANO, Japan

“Kouji Ohnishi(1); Hisashi Hayakawa(2); Toru Suyama(3); Mayuko Watanabe(4)”

“*(1) National Institute of Technology,NAGANO;(2) Nagoya University;(3) Nagano City Museum;(4) Chino City Yatsugatake Museum*”

”In our modern digital society, it is important to monitor the solar activity in various fields such as space weather, long-term variability, and their impact on terrestrial environments. Currently, SILSO is working on revising the International Sunspot Number, which will serve as the source of reference data on these long-term solar variations. However, considerable fraction of the Japanese data is missing in their source datasets. Currently, under “Astro-Nagano Project””, a citizen science project is going on to digitize such local Japanese records. One """"Citizen Science"""" Project is aiming at rescuing sunspot records from the past century in Nagano Prefecture in Japan, such as Katsue Misawa and Kenichi Fujimori, in collaboration with local citizens (relatives, schools, local citizen scientists) and Project members. Using their datasets, we can create a time series of stable sunspot datasets from 1921 to the present. For example, we have shown that the sunspot observation record by Katsue Misawa from 1921 to 1934 can be a critical reference for confirmation and recalibration of the revision work during this period (Hayakawa et al., 2023). Currently, we are working on Kenichi Fujimori’s archival data in collaboration with local citizens. Such activities benefit not only scientific research but also STEM education as a ””citizen science project””. ”

12. data resque

[P65]Digitization project of historical analogue magnetograms in Japan

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"The Japan Meteorological Agency has been conducting long-term magnetic observations at Kakioka (1913-), Memambetsu (1952-) and Kanoya (1958-), archiving those observations in magnetograms. We have already converted them into digital images at 600 dpi for 1924-1983 (Kakioka), 1962-1984 (Memambetsu and Kanoya). For the period after 1956, we have been producing 1-minute and 7.5-second digital values by using our self-developed automated tracing software. The automatic digitization has been completed for 1956-1983 (Kakioka) and 1967-1984 (Memambetsu and Kanoya), except for times of some extreme phenomena. We keep working on them with our manual reading software, because the automatic tracing is hardly applicable to extreme phenomena. We have managed recently in digitizing the 11 February 1958 storm at Kakioka into 7.5-second values. We have initiated our project to digitize the records prior to 1956, which involve a number of extreme events (PC, SFE, SC) including the 24 March 1940 event, the greatest SC event since 1868. Our 7.5-second data would be useful resources for elucidating the Sun-Earth coupling processes. Issues to overcome include: (1) difficulty in strict time identification from the gaps signifying the hours, (2) difficulty in tracing lines due to dimness of the magnetograms, and (3) inaccuracy of the time axis due to paper distortion. Development of new working tools is now under way, and a certain amount of labor will be further required."

13. Pretelescopic

[P66]Graphical Records of Auroral Candidates in Wickiana Broadsheets immediately after Spörer Minimum

Tomoya Inoue (1); Hisashi Hayakawa (2)

(1) Gifu High School; (2) Nagoya University

Solar eruptions and high-speed solar wind streamers occasionally cause geomagnetic storms and extend auroral oval towards lower magnetic latitudes. They allow us to indirectly trace back historical solar activity, especially before telescopic sunspot observations from 1610 onward. In this context, historical records also contain some graphical records of candidate aurorae. However, while their presence has been known, these graphical records have not been actively used in the scientific discussions. Here, we analyze 16th-century German woodcut broadsheets of Wickiana graphical records of candidate records. These records are unique references of early graphical records for candidate aurorae. With philological surveys, we show their overview, reliability of depictions, observational context in the geomagnetic latitudes, and contextualize them to the recent solar-cycle reconstructions in annual resolutions. Our study locate these aurorae over solar cycles immediately after the Spörer Minimum.

13. Pretelescopic

[P67]Analyses of historical solar eclipse records in Hokkaido Island in the 19th century

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" Solar eclipses have been recorded throughout history and across various ethnic groups. Their records have benefitted scientific discussions on multiple topics. These astronomical spectacles have also been recorded in Japan, but little has been known of the historical observations in Hokkaido, the northern end, prior to the occurrence of the solar eclipse 1887. Here, we show analyses on two such early eclipse accounts from Hokkaido, both philologically and astronomically on the basis of Hayakawa, Soma, and Daigo (2022). We first located eclipse sketches in Kan'ichiro Mozume's diary and confirmed the local visibility of the annular eclipse in Otaru in 1872 June. We further analysed John Batchelor's eclipse folklore and identified the reported eclipse with a total solar eclipse in 1824 June. We further analyse descriptions in Batchelor' s quote and found a probable evidence for the solar coronal streamers and located it near the minimum of solar cycles near the Dalton Minimum. This result may provide unique information for the solar coronal structure around the Dalton Minimum which is otherwise known only for the case of the 1806 total solar eclipse."

13. Pretelescopic

[P68]Hypothesis on the Relationship between Buddha and Eclipse in the Theravāda scriptures.

Takato Tokuno (1)

(1) University of Tokyo

Sri Lankan Buddhism holds a significant position as the origin of Theravāda Buddhism. Previous research has suggested that descriptions of the Buddha's visit in two of the most important Pāli chronicles of Sri Lankan Buddhism, the Mahāvaṃsa and Dīpavaṃsa, may be interpreted as references to a total solar eclipse in the 5th century BCE. Although this interpretation could represent a phenomenon of scientific and historical interest, few previous studies have examined this hypothesis due to the scarcity of detailed descriptions. To indirectly examine this, I have investigated whether related traditions exist in the Pāli texts of India and Southeast Asia. In this presentation, I will propose a hypothesis regarding how the relationship between the Buddha and eclipses was passed down from India to Sri Lanka and from Sri Lanka to Southeast Asia, supported by texts of Buddhist scriptures. This study may offer a new perspective on the historical astronomical value of Buddhist scriptures.

13. Pretelescopic

[P69]A possible reference for a naked-eye sunspot in the mid-7th Century BCE

Sanae Ito; Hisashi Hayakawa

Nagoya University

"Solar activity is quantified with number and total area of sunspot groups and individual sunspots over the solar surface. Some of these sunspot groups grow so large that they could be seen by naked eye. Their records are confirmed all the way back to 165 BCE in Chinese records and offer some hints on the past solar activity. However, little was known for such sunspot records in Mesopotamia. Here, we examine a possible record in a commentary on Marduk' s Address to the Demons which is a scholarly literary, religious, and performative ritual text in Akkadian Cuneiform. We describe the text background and provide transcriptions and translations. On their basis, we show their possible date range and contextual use this report to the proxy-based reconstructions of the long-term solar activity.
"

13. Pretelescopic

[P70]Aurorae observations mentioned by Classical Authors: Aristotle, Pliny the Elder, and Plutarch

Yukiko Kawamoto (1), Hisashi Hayakawa (1), Atsushi Kojima (1)

Nagoya University

"In Meteorologia 341b 24-28, Aristotle (384-322 BCE) refers to ""a burning flame of the kind one sees when stubble is being burnt on ploughland"" in the sky. He also mentions ""chasms,"" ""trenches,"" and blood-red colors in the sky in Meteorologia 342a 34ff. Previous scholarship generally interpreted these references as descriptions of aurorae. However, his passages do not make it clear whether he observed such celestial events firsthand. Later textual evidence by Pliny the Elder (NH 2.26-27) and Plutarch (Tim. 8.5-7) reveal that there were aurorae events. Based on these attestations, Stothers 1979 suggested that Aristotle must have been in Macedonia to have seen an aurora. However, the event recorded by Pliny took place in 394 BCE, meaning Aristotle could not have witnessed it. On the other hand, the event recorded by Plutarch may have been observed by Aristotle, considering the aurorae appeared when Timoleon set sail to Sicily from Corinth in 344 BCE. In this poster, we aim to narrow down where aurorae observations were made and consider whether Aristotle himself witnessed aurorae events."

14. SN calibration

[P71]Katsue Misawa's sunspot observations in 1921–1934: a reference for the Wolfer-Brunner transition

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"Long-term solar variability has been evaluated with the International Sunspot Number (SILSO SN V2), a composite index based on multiple sunspot observers. However, this index has been poorly understood for 1919 – 1944. Upon these efforts, individual long-term sunspot observers have played significant roles in these efforts, owing to their data homogeneity over long time scales.

In this presentation, we will report on the observation data of one of an early Japanese observer, Katsue Misawa. His records have not been acquired to the World Data Center of 'Sunspot Index and Long-Term Solar Observations' (SILSO). We digitized their observational records, documented his observational methodologies, and reconstructed his sunspot number and hemispheric sunspot number. We compared their data with the International Sunspot Number and evaluated their stability. Misawa' s data series generally agrees well with the SILSO SN V2.

Misawa' s data shows a minor drift in 1925 – 1928, where Zürich Observatory changed the pilot observer from Wolfer and Brunner. This is probably coming from his unique counting method. For the Wolfer-Brunner transition, our analyses confirm stability and homogeneity of the Zürich datasets in the sunspot group number, cast moderate caveats on the homogeneity in the individual sunspot number and relative sunspot number, and require further investigations and recalibrations for the SILSO SN V2 in 1919 – 1944."

[P72]A search for sunspot data in Italian solar drawings of 19th century

Ilaria Ermolli (1); Theodosios Chatzistergos (2); Fabrizio Giorgi (1); et al. (1)

(1) INAF Italian National Institute for Astrophysics; (2) Max Planck Institute for Solar System Research

Angelo Secchi and Pietro Tacchini, two outstanding Italian astronomers of the 19th century, performed regular solar observations for many years at the Collegio Romano in Rome and at the Palermo Observatory, respectively. Results from their observations, spanning the entire second half of the 19th century, are reported in articles published in the scientific journals of the time, as well as in drawings and notebooks that are stored in the historical archives of the Istituto Nazionale di Astrofisica at the Rome and Catania Observatories. The material in these archives has been recently digitized for preservation purposes and for allowing the scientific exploitation of data not easily accessible so far. Here we present the archival assets and digital data derived from them. We also present results obtained to date from the analysis of the new digital data and ongoing work that includes a citizen science activity.

14. SN calibration

[P73]Archival Investigations for the Solar Cycles in the Last Four Centuries

Hisashi Hayakawa (1)

(1) Nagoya University

Telescopic sunspot observations have offered unique references for the sunspot group number and sunspot positions to quantify solar activity. These datasets consist of multiple individual telescopic observations since 1610. These records have been used to reconstruct, quantify, and visualize solar cycles over the last four centuries. However, their reconstructions have considerable variations before the mid 19th century and accommodated considerable data gaps and uncertainty. This presentation aims at reviewing recent developments of archival investigations on the sunspot records, focusing on the Dalton Minimum, the neighborhood of the Dalton Minimum, and the beginning of the 17th century. The recent archival investigations fill their data gaps, cross validate some anomalous features in the Maunder Minimum, and extend our datasets even back to 1607. These datasets offer not only the source data for further recalibrations but also source data to reconstruct almost continuous butterfly diagrams since 1607, to quantify the past solar cycles and contrast solar cycles in the Maunder Minimum with solar cycles in the other periods.

14. SN calibration

[P74]Automated Sunspot Detection for the Continuation of the Sunspot Counts and Sunspot-Area Measurements

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We developed an automated method for sunspot detection using digital white-light solar images to make it feasible to continue the sunspot counts and sunspot-area measurements in the future. To establish the long-period record of solar activity, which is one of the keys to the space climate study, historical observations are being explored actively. At the same time, it is important to continue traditional observations such as the sunspot counts and sunspot-area measurements. However, their continuation is not taken for granted. Now it is becoming difficult to secure manpower to carry out such observations. Therefore, many sunspot-drawing observations were shut down, and only a few institutes continue the sunspot-area measurements. To save the manpower, automatizing observational procedures can contribute considerably. Then we developed an automated method to detect sunspots on digital images, paying attention to preventing the detection of false spots produced by the seeing effect and preventing missing small, isolated spots. We checked the performance of the proposed method and concluded that the results of the sunspot counts and the sunspot-area measurements are comparable to the reference data. Our method can be widely used by public observatories and amateurs, and therefore, it is expected that the method makes various observers continue the sunspot observations.

14. SN calibration

[P75]Three Centuries of Solar Activity [part 1]

Leif Svalgaard

Stanford University

"In this 3-part poster series, we Review the discrepancy between the sunspot number and the Hoyt & Schatten group sunspot number. The proposed solutions [SSN workshops and ISSI team 417] were all inconclusive and must be seen as failures. We need to take a 'systems 'approach' where 'everything' must fit.

In this first part we investigate the diurnal variation of the geomagnetic field in relation to solar activity. The ionosphere is created and maintained by the solar extreme ultraviolet [EUV] flux. The magnetic field of the Sun measured by spacecraft SOHO [MDI] and SDO [HMI] follows the EUV [and its proxy: F10.7) flux when allowed for a [noise] offset. 300 years ago G. Graham discovered that the geomagnetic field varied during the day in a regular manner. J. Canton in 1760 found that the variation was regular on most days (where the variation was largest in summer) and that on days that did not show the regular variation, a northern light could be seen in London. Observations of the regular variation from 129 magnetic observatories allows construction of a time series of the regular variation of the East Component for 1840-2014 [rY]. The ionosphere allows reflection of radio waves and reception of signals across oceans [Marconi, 1901]. The diurnal regular variation gives direct measurement of the conductivity of the ionosphere and hence of its source, the EUV. "

14. SN calibration

[P76]Three Centuries of Solar Activity Part 2

Leif Svalgaard

Stanford University

In part 2, we look at the days when Canton [1760] observed irregular daily variation. He noted that on these, aurorae were invariably seen; and thought that 'some other cause' [than solar radiation] must be operating'. Ed Sabine [1862] found that those disturbed times [that von Humboldt [1808] called 'Ungewitter' (a tempest); geomagnetic storm] varied in phase with the newly discovered Sunspot Cycle [Schwabe, 1843]. Celsius and Hiorter in Sweden noted that a strong geomagnetic storm in 1741 was also observed by Graham in London, showing that such storms were not local weather phenomena. Today we know that they are due to electric currents in the Earth's 'magnetosphere' [term coined by Gold, 1959]. There are several such currents; each with a different dependence on solar wind parameters. Of particular interest is the so-called 'Ring Current' [RC], due to charged particles trapped in the 'Van Allen Belts' [Van Allen, 1958]. The IDV geomagnetic index [Svalgaard et al., 2003; Svalgaard & Cliver, 2005] measures RC and is strongly regulated by the magnetic field, B, in the solar wind and has been used to infer [i.e. to measure] B back to 1844. We found that B is related to the [square root of the] SSN 'riding' on a constant 'floor' [when SSN = 0]. To compare B with solar activity proxies like the sunspot and group numbers, Svalgaard and Schatten [2016] used a 'backbone' approach to infer the Group Number. The result suggests that there has been no upwards trend for last 300 years.

14. SN calibration

[P77]Three Centuries of Solar Activity Part 3

Leif Svalgaard

Stanford University

In Part 3, we introduce observations of solar activity made with replica telescopes with the same optical flaws as telescopes had in the 18th century. With the replicas, 2-3 times fewer groups and spots are observed. This allows us to calibrate 18th century observations to the scale of modern observations, going back three centuries. Unfortunately, the policy of SILSO to not release the raw group and spot counts since 2011 makes it impossible to reproduce the newest versions of the SN and GN and hinders research into the possibility of different population over time. We note the the simple average of all observers is as good as our carefully normalized backbones, confirming the 1880 discontinuity. We raise a fundamental issue: What is a group? and note that the definition has changed over time. We compare reconstructed solar activity records over the past several millennials and conclude that there has not been any long-term trend in solar activity.