DOWNLOAD PDF RESPONSE OF THE UPPER ATMOSPHERE TO VARIATIONS IN THE SOLAR SOFT X-RAY IRRADIANCE

Chapter 1 : NASA - NanoRacks-Miniature X-ray Solar Spectrometer CubeSat

Response of the upper atmosphere to variations in the solar soft x-ray irradiance February Terrestrial far ultraviolet (FUV) airglow emissions have been suggested as a means for remote.

TSI variations were undetectable until satellite observations began in late A series of radiometers were launched on satellites from the s to the s. Solar irradiance varies systematically over the cycle, [51] both in total irradiance and in its relative components UV vs visible and other frequencies. The solar luminosity is an estimated 0. This is caused by magnetized structures other than sunspots during solar maxima, such as faculae and active elements of the "bright" network, that are brighter hotter than the average photosphere. They collectively overcompensate for the irradiance deficit associated with the cooler, but less numerous sunspots. The primary driver of TSI changes on solar rotational and sunspot cycle timescales is the varying photospheric coverage of these radiatively active solar magnetic structures. The 30 HPa Atmospheric pressure level changed height in phase with solar activity during solar cycles 20â€" UV irradiance increase caused higher ozone production, leading to stratospheric heating and to poleward displacements in the stratospheric and tropospheric wind systems. With a temperature of K, the photosphere emits a proportion of radiation in the extreme ultraviolet EUV and above. Since the upper atmosphere is not homogeneous and contains significant magnetic structure, the solar ultraviolet UV , EUV and X-ray flux varies markedly over the cycle. The photo montage to the left illustrates this variation for soft X-ray , as observed by the Japanese satellite Yohkoh from after August 30, , at the peak of cycle 22, to September 6, , at the peak of cycle Solar UV flux is a major driver of stratospheric chemistry , and increases in ionizing radiation significantly affect ionosphere -influenced temperature and electrical conductivity. Solar radio flux[edit] Emission from the Sun at centimetric radio wavelength is due primarily to coronal plasma trapped in the magnetic fields overlying active regions. It represents a measure of diffuse, nonradiative coronal plasma heating. It is an excellent indicator of overall solar activity levels and correlates well with solar UV emissions. Sunspot activity has a major effect on long distance radio communications , particularly on the shortwave bands although medium wave and low VHF frequencies are also affected. High levels of sunspot activity lead to improved signal propagation on higher frequency bands, although they also increase the levels of solar noise and ionospheric disturbances. These effects are caused by impact of the increased level of solar radiation on the ionosphere. Speculations about cosmic rays include: Changes in ionization affect the aerosol abundance that serves as the condensation nucleus for cloud formation. Accelerator results failed to produce sufficient, and sufficiently large, particles to result in cloud formation; [70] [71] this includes observations after a major solar storm. Some researchers claim to have found connections with human health. In the stratosphere, ozone is continuously regenerated by the splitting of O2 molecules by ultraviolet light. Skywave Skywave modes of radio communication operate by bending refracting radio waves electromagnetic radiation through the Ionosphere. During the "peaks" of the solar cycle, the ionosphere becomes increasingly ionized by solar photons and cosmic rays. This affects the propagation of the radio wave in complex ways that can either facilitate or hinder communications. Forecasting of skywave modes is of considerable interest to commercial marine and aircraft communications , amateur radio operators and shortwave broadcasters. Changes in solar output affect the maximum usable frequency , a limit on the highest frequency usable for communications. Climate[edit] Both long-term and short-term variations in solar activity are theorized to affect global climate, but it has proven challenging to quantify the link between solar variation and climate. The cycle also impacts regional climate. Total solar irradiance " Radiative forcing ". The UV component varies by more than the total, so if UV were for some as yet unknown reason having a disproportionate effect, this might affect climate. Solar wind-mediated galactic cosmic ray changes, which may affect cloud cover. The sunspot cycle variation of 0. The current scientific consensus, most specifically that of the IPCC , is that solar variations do play a marginal role in driving global warming , [77] since the measured magnitude of recent solar variation is much smaller than the forcing due to greenhouse gases. Otherwise, the level of understanding of solar impacts on weather is low. Solar dynamo The year sunspot cycle is half of a year Babcock â€"Leighton solar dynamo cycle, which corresponds to an oscillatory exchange of energy between toroidal and poloidal solar magnetic fields. At solar-cycle maximum , the external poloidal dipolar magnetic field is near its dynamo-cycle minimum strength, but an internal toroidal quadrupolar field, generated through differential rotation within the tachocline , is near its maximum strength. At this point in the dynamo cycle, buoyant upwelling within the Convection zone forces emergence of the toroidal magnetic field through the photosphere, giving rise to pairs of sunspots, roughly aligned eastâ€"west with opposite magnetic polarities. The magnetic polarity of sunspot pairs alternates every solar cycle, a phenomenon known as the Hale cycle. At solar minimum, the toroidal field is, correspondingly, at minimum strength, sunspots are relatively rare and the poloidal field is at maximum strength. During the next cycle, differential rotation converts magnetic energy back from the poloidal to the toroidal field, with a polarity that is opposite to the previous cycle. Radio observations of brown dwarfs have indicated that they also maintain large-scale magnetic fields and may display cycles of magnetic activity. The Sun has a radiative core surrounded by a convective envelope, and at the boundary of these two is the tachocline. However, brown dwarfs lack radiative cores and tachoclines. Their structure consists of a solar-like convective envelope that exists from core to surface. Since they lack a tachocline yet still display solar-like magnetic activity, it has been suggested that solar magnetic activity is only generated in the convective envelope.

Chapter 2 : Sunlight - Wikipedia

Solar irradiance at these wavelengths is known to be highly variable; studies of nitric oxide (NO) in the lower thermosphere have suggested a variability of more than an order of magnitude in the solar soft x-ray irradiance.

Changes occurring in the ultraviolet portion of the spectrum alter the amount of ozone in the atmosphere, which can impact large-scale atmospheric motions that couple the stratosphere and troposphere. In this focal plane, four photodiode detectors and an electrical substitution radiometer ESR are used to detect and conduct solar irradiance measurements. SIM contains two completely independent and identical mirror-image spectrometers to provide redundancy back-up and self-calibration capability. The new SOLSTICE makes daily ultraviolet nm solar irradiance measurements and compares them to the irradiance from an ensemble of 18 stable early-type stars. This approach provides an accurate monitor of instrument in-flight performance and provides a basis for solar-stellar irradiance comparison for future generations. Each spectrometer is independently housed and mounted on the spacecraft optical bench and can operate in either of two modes. These instruments utilize traditional techniques of scanning spectrometers to make ultraviolet spectral measurements in two intervals: Two instruments are required to simultaneously measure the two intervals, but each of the two SOLSTICE spectrometers is capable of measuring either interval. During normal operations, one of the spectrometers operates in the short-wavelength mode and the other operates in the long-wavelength mode. In the event of either a full or partial instrument failure, one instrument can serve the dual role of observing both spectral intervals but at a lower frequency. Using state-of-the-art technologies in its Electrical Substitution Radiometers ESRs and taking full advantage of new materials and modern electronics, the TIM measures TSI to an estimated absolute accuracy of ppm 0. Precise solar irradiance measurements obtained during the past 3 decades imply that the TSI varies on the order of 0. Variations in TSI occur over time scales from minutes to year solar cycles and longer. Climate models including sensitivity to solar forcing estimate a global climate change of up to 0. One is maintained in a LASP cleanroom, and the other is intended for intercomparisons to other calibration facilities or instruments. Ground witnesses of the critical components used in the TIM are maintained, including spare flight apertures, voltage references, and absorptive cavities. XUV Photometer System Studies of the solar XUV radiation began in the s with space-based rocket experiments, but the knowledge of the solar XUV irradiance, both in absolute magnitude and variability, has been questionable due largely to the very limited number of observations. Each set of 4 XPs is arranged in a circle for use with the filter wheel mechanism. The filter wheel, which has 3 different rings of filters for the 3 sets of XPs, has 8 positions: An observation run is a sequence of measurements from 5 consecutive filter wheel positions, normally starting and ending with dark measurements. XP are grouped in the inner ring. XP are grouped in the middle ring. XP are grouped in the outer ring. XP 1, 5, and 10 are redundant XPs as part of the in-flight calibration plan. XP 4, 8, and 12 are bare photodiodes for measuring the fused silica window transmission during each observation run. From this page you can see how satellite based solar irradiance measurements have become very sophisticated and technical.

Chapter 3 : Solar Irradiance Measurements | Global Greenhouse Warming

The linear response in brightness of the LBH bands to variations in solar irradiance is demonstrated. In addition to the N_2 LBH bands, atomic oxygen lines at and nm are also studied. Unlike the LBH bands, these emissions undergo radiative transfer effects in the atmosphere.

This tenuous layer of neutral and charged particles shields the human habitat from high energy solar radiation and particles, enables part of the extensive communication network on which society increasingly relies, and is the medium in which thousands of spacecraft now orbit. Unlike the relatively placid lower atmosphere, the upper atmosphere is a region of extreme spatial and temporal variability, constantly agitated by solar radiative and auroral forcings. Driving the processes that at any instant define the physical state of the upper atmosphere and ionosphere is the solar radiation at wavelengths less than about nm. The fact that the highly variable upper atmosphere is coupled to the middle atmosphere through chemical, radiative, and dynamical Page 74 Share Cite Suggested Citation: Solar Influences on Global Change. The National Academies Press. Understanding how the upper atmosphere varies naturally, and how it may be affected by human activities, is necessary from a societal and economic perspective because of the critical role played by the upper atmosphere in communications, navigation, national defense, and a wide assortment of space related endeavors, including the presence of humans in space. Furthermore, current modeling studies indicate that the upper atmosphere may itself be sensitive to global change caused by human activities. Solar cycle changes of percent are typical in solar radiation at wavelengths from 10 to nm; the soft X-rays 1 to 10 nm that penetrate to the lowest layers of the upper atmosphere vary by an order of magnitude. This highly variable energy from the Sun is deposited entirely in the terrestrial upper atmosphere via absorption of the primary constituents, O2, N2, and O. Without heating from the absorption of solar extreme ultraviolet EUV and UV radiation, the thermosphere and the ionosphere would not exist at all. This heating, which varies with solar activity, is responsible for the increase of temperature with height above about km see Figure 1. Large variability in the basic properties of both the thermosphere and ionosphere is the direct result of the variability in the solar EUV and UV input as illustrated in Figure 1. These measurements revealed a considerable increase in the solar EUV flux during the ascending phase of solar cycle Some emissions at wavelengths shorter than 30 nm increased by factors of 10 to between solar minimum conditions in and maximum activity in Radiation at wavelengths between 30 and nm, formed lower in the solar atmosphere the chromosphere , varied somewhat less, by factors of two to three from the minimum to the maximum of activity in solar cycle At still longer UV wavelengths, solar cycle variability decreases from a factor of two near nm to about 10 percent near nm. In addition to the overall change in solar radiation between solar minimum and maximum, the AE-E data showed shorter term fluctuations on a monthly, daily, and even an hourly basis, with the coronal emissions being much more variable than the chromospheric emissions. Essentially all interpretive studies of upper atmosphere phenomena now use scenarios of solar variability derived from the AE-E data base. However, AE-E did not monitor the highly variable soft X-rays, nor do the AE-E data agree with earlier rocket measurements about either the magnitude or the variability of the EUV irradiance Lean, Concerns about the validity and limitations of the AE-E data base continue to be raised. Heroux, private communication, Possible changes in the sensitivity of the AE-E instruments throughout the mission are unknown, since no provision was made for in-flight calibration. A comparison of the rocket measurement used for the AE-E calibration with a recent rocket measurement Woods and Rottman, indicates significant inconsistencies in that only the strongest emission lines were enhanced in the spectrum, for which solar activity levels were higher. This contradicts current understanding of the origin of the EUV irradiance variations, which predicts that solar activity causes an increase in the EUV radiation at all wavelengths. The discrepancy is most likely the result of instrumental effects see Lean, for details. AE-E ceased operation at the end of Some additional measurements of the EUV radiation integrated over very wide spectral bands have also been made from rockets Feng et al. None of these observations has succeeded in clarifying the true amplitude and variability of the solar EUV radiation. Like the AE-E observations, they are compromised by an assortment of instrumental effects that make it extremely difficult to extract true solar spectral variability. Since its launch in mid, the Yohkoh satellite Petersen et al. Continuing these observations into the upcoming solar minimum and subsequent activity maximum will contribute to improved understanding of solar forcing of lower thermospheric NO concentrations, and the possible transfer of chemical energy between the upper and middle atmospheres. Irradiance Variability Parameterizations The absence of continuous, reliable observations of the solar EUV spectral irradiance has forced reliance on empirical variability models based on solar activity surrogates to estimate EUV spectral irradiances for use in upper atmosphere research and in operational applications. The AE-E solar irradiance data have been used to construct parameterizations of the solar EUV flux variations as a function of primarily the solar The measured solar EUV flux values cover the period from to , but the solar flux models have been used to represent the solar EUV and UV fluxes for other periods, generating values that are typically inconsistent with earlier data Figure 4. Furthermore, different empirical models developed from ostensibly the same data base can predict quite different EUV spectral irradiances Lean, Aeronomic studies of thermospheric and ionospheric properties indicate, not surprisingly, that existing solar EUV irradiance variability models are inadequate for many geophysical applications. The variations are shown for a the coronal emission at The model calculations solid line are based on the AE-E data dots in solar cycle 21 and do not show very good agreement with rocket measurements asterisks during the previous solar activity cycle. Page 78 Share Cite Suggested Citation: This has led to the application of various correction factors to the original data to achieve agreement between model predictions and aeronomic observations. For example, the solar EUV flux below 20 nm has been doubled to force agreement with observed photoelectron spectra Richards and Torr, ; Winningham et al. Improved solar irradiance variability models are needed not just for aeronomic research but, increasingly, for operational applications such as forecasting ionospheric conditions Balan et al. The lifetime and utility of an Earth-orbiting object depend on the density structure of the upper atmosphere, which is controlled by solar EUV radiation and consequently varies over time scales from hours to decades White et al. Desired accuracies of 5 percent for thermospheric densities for operational purposes require a similar accuracy in knowledge of the solar EUV and UV spectral irradiance. The need for this knowledge is demonstrated in Figure 4. High uncertainty surrounded the launch of the Hubble Space Telescope because of insufficient knowledge of the atmospheric drag that it would experience when launched at a time near maximum solar activity Withbroe, The lower panel shows that the orbital decay rate solid line , determined as the change per day in the altitude, is strongly influenced by variations in solar energy input, as indicated by the daily F Active regions that cause enhancements of the UV radiative output also modify the Page 80 Share Cite Suggested Citation: At times, such as in brief periods during intense geomagnetic storms, energized electrons bombard the upper atmosphere, colliding with atmospheric constituents and transferring their energy, resulting in visual displays of auroral phenomena. The energy deposited at high latitudes in the aurora can increase by as much as two orders of magnitude relative to geomagnetically quiet conditions, locally exceeding the energy deposited from solar EUV radiation. Auroral energy inputs are known to have a significant effect on aeronomic processes and dynamics of the ionosphere, thermosphere, and mesosphere and perhaps indirectly via couplings to the stratosphere on the troposphere, even though the physical couplings are not understood. In addition to knowledge of radiative energy inputs, global dynamic models of the thermosphere and ionosphere system require knowledge of the global distributions of auroral particle precipitation, electric fields, and currents. During the past decade, spacecraft such as the Atmospheric Explorer and Dynamics Explorer, as well as various ground based programs, have provided a good first order understanding of the energy inputs to the thermosphere and ionosphere. Some information on global particle inputs has been derived from satellite images of UV and visible auroral airglow. However, many unresolved questions remain about the variability of the fundamental energy inputs and the global distribution of electric fields and currents. Many questions also remain about the impact of auroral processes on global change. For example, how are the atmospheric chemical species such as NO that are produced by auroral processes transported globally? How might they be transported to the lower atmosphere, where they may influence global atmospheric properties? Page 81 Share Cite Suggested Citation:

Chapter 4 : Solar cycle - Wikipedia

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Edit There have been proposals that variations in solar output explain past climate change and contribute to global warming. The most accepted influence of solar variation on the climate is through direct radiative forcing. Various hypotheses have been proposed to explain the apparent solar correlation with temperatures that some assert appear to be stronger than can be explained by direct irradiation and the first order positive feedbacks to increases in solar activity. The meteorological community has responded with skepticism, in part because theories of this nature have come and gone over the course of the 20th century. The sun has been at its strongest over the past 60 years and may now be affecting global temperatures Solar irradiance changes directly affecting the climate. This is generally considered unlikely, as the amplitudes of the variations in solar irradiance are much too small to have the observed relation absent some amplification process. Variations in the ultraviolet component having an effect. The UV component varies by more than the total. Effects mediated by changes in cosmic rays which are affected by the solar wind, which is affected by the solar output such as changes in cloud cover. Many of these speculative accounts have fared badly over time, and in a paper "Solar activity and terrestrial climate: Damon and Laut report in Eos [21] that the apparent strong correlations displayed on these graphs have been obtained by incorrect handling of the physical data. The graphs are still widely referred to in the literature, and their misleading character has not yet been generally recognized. In , Knud Lassen of the Danish Meteorological Institute in Copenhagen and his colleague Eigil Friis-Christensen found a strong correlation between the length of the solar cycle and temperature changes throughout the northern hemisphere. Initially, they used sunspot and temperature measurements from to , but later found that climate records dating back four centuries supported their findings. This relationship appeared to account for nearly 80 per cent of the measured temperature changes over this period see graph [39]. Damon and Laut, however, show that when the graphs are corrected for filtering errors, the sensational agreement with the recent global warming, which drew worldwide attention, has totally disappeared. Nevertheless, the authors and other researchers keep presenting the old misleading graph. Sallie Baliunas , an astronomer at the Harvard-Smithsonian Center for Astrophysics, has been among the supporters of the theory that changes in the sun "can account for major climate changes on Earth for the past years, including part of the recent surge of global warming. Something else is acting on the climate It has the fingerprints of the greenhouse effect. Their study looked at both " natural forcing agents " solar variations and volcanic emissions as well as " anthropogenic forcing " greenhouse gases and sulphate aerosols. They found that "solar effects may have contributed significantly to the warming in the first half of the century although this result is dependent on the reconstruction of total solar irradiance that is used. In the latter half of the century, we find that anthropogenic increases in greenhouses gases are largely responsible for the observed warming, balanced by some cooling due to anthropogenic sulphate aerosols, with no evidence for significant solar effects. They predicted that continued greenhouse gas emissions would cause additional future temperature increases "at a rate similar to that observed in recent decades". It should be noted that their solar forcing included "spectrally-resolved changes in solar irradiance" and not the indirect effects mediated through cosmic rays for which there is still no accepted mechanism â€” these ideas are still being fleshed out. Weart in The Discovery of Global Warming writes: The study of [sun spot] cycles was generally popular through the first half of the century. Governments had collected a lot of weather data to play with and inevitably people found correlations between sun spot cycles and select weather patterns. Respected scientists and enthusiastic amateurs insisted they had found patterns reliable enough to make predictions. Sooner or later though every prediction failed. An example was a highly credible forecast of a dry spell in Africa during the sunspot minimum of the early s. When the period turned out to be wet, a meteorologist later recalled "the subject of sunspots and weather relationships fell into dispute, especially among British meteorologists who witnessed the discomfiture of some of their most respected superiors.

Chapter 5 : Solar variation | Gravity Wiki | FANDOM powered by Wikia

Solar irradiance in the ultraviolet, extreme-ultraviolet, and X-ray spectral regions are a key determinant of the state and variation of upper atmosphere and ionosphere parameters, including.