INFLUENCE OF SHORT-TERM SOLAR UV VARIABILITY ON THE DETERMINATION OF SOLAR CYCLE MINIMUM pdf

1: Solar cycle - Wikipedia

Solar variability on intermediate time scales (e.g. days), which has been observed previously in sunspot numbers, could also influence the identification of solar minimum.

Changes in insolation on a variety of time scales have been suggested as causes of known climate change, from the Milankovitch orbital cycles of thousands of years Hays et al. If solar irradiance were to vary over the next century, natural climate change might also result. Observations of total solar irradiance by spacecraft radiometers Willson and Hudson, ; Hoyt et al. Solar Influences on Global Change. The National Academies Press. Total solar irradiance is increased during times of maximum solar activity e. The differences in irradiance levels between the different measurements are of instrumental origin and reflect absolute inaccuracies in the measurements. Proposed future programs to measure total solar irradiance are indicated. During the first half of the s, forcing of the climate system by declining solar radiative output was more than sufficient to offset the estimated net anthropogenic forcing. Despite the similarity of the climate forcings over the decadal time scales shown in Figure 2. This is because the translation of radiative forcing to surface Page 25 Share Cite Suggested Citation: Combined greenhouse plus solar dashed line and net anthropogenic plus solar dash-dot line forcings are also shown. In each case, the thin lines are projections. The solar forcing is from the empirical model of Foukal and Lean , which accounts for irradiance changes during the year cycle caused by dark sunspots and bright faculae, but does not include additional variability sources acting on longer time scales. Zero point of solar forcing is the â€" mean. Adapted from Hansen and Lacis and Hansen et al. Page 26 Share Cite Suggested Citation: The observed irradiance changes do imply the potential for additional solar forcing in the future, making it incumbent on global change research to monitor, understand, and ultimately predict solar effects on climate. It also makes more compelling the search for a solar signature in the historical climate record. Understanding solar influences on climate requires the interaction of two primary research areas that are currently quite distinct: Origins of the solar radiative output variations are addressed in the broader context of the variable Sun in Chapter 6. However, current capabilities for precise determination of this variation exist only at wavelengths shorter than about nm, since at longer wavelengths the measurement uncertainties significantly exceed the amplitudes of the solar variations, which are thought to be less than 1 percent. Measurements of total spectrally integrated solar irradiance can be made with two orders of magnitude greater precision and currently provide the primary record of solar radiative output variations. Contemporary Measurements During the first three-quarters of the twentieth century, ground based observations were unable to detect total irradiance variations that were unambiguously solar in origin Frohlich, ; Hoyt, ; Newkirk, The two principal limitations were uncertainties due to instrument calibration and to atmospheric interference and attenuation. Launched in late , and operational until , the Earth Radiation Budget ERB experiment on the Nimbus 7 spacecraft has provided the longest solar irradiance data base Hickey et al. Solar variations measured by ACRIM have been corroborated by the ERB data, with the agreement between the two independent data sets improved by accounting for temperature dependent calibration errors and solar pointing limitations in ERB Hoyt et al. These latter instruments operate only about every second week and therefore have limited ability to characterize solar rotational modulations, which occur over day time scales. Differences do exist among the different irradiance data bases in the rate of decrease in cycle 21, the actual occurrence of minimum activity, and the rate of increase in cycle These differences are possibly the result of uncorrected sensor degradation. Preliminary data Figure 2. The data shown in Figure 2. The irradiance minimum in occurs near the activity cycle minimum of September as indicated by the sunspot number data in Figure 2. The subsequent rapid increase, corresponding to the buildup of solar activity in solar cycle 22, becomes clearly visible in , continuing to the cycle 22 maximum. Declining values in the latter half of herald the approach of the next solar activity minimum, expected in â€" Taken together, the solar radiometer data indicate that the amplitude of the recent year irradiance cycle is about 0. Page 29 Share Cite

Suggested Citation: That the uncertainties in measurements made by state-of-the-art solar radiometers are significantly larger than their long term precision, and than the changes caused by solar variability, has important consequences for the continuation of the irradiance data base. In the absence of a third party comparison between ACRIM I and ACRIM II, a decade of solar monitoring would have been terminated, since the solar radiometers lack the accuracies to measure real solar changes smaller than a few tenths percent, twice the year irradiance cycle. Instruments such as ACRIM and ERB record the variation in the total electromagnetic energy from the Sun without identifying the wavelengths of the radiation at which the variations are occurring. However, shorter wavelength, more variable solar UV radiation Figure 1. It is not known whether the entire solar spectrum varies in phase with solar activity, or how energy might be redistributed within the spectrum. Percentage variations at longer wavelengths are expected to be much smaller than those at UV wavelengths, on the order of a few tenths percent and not necessarily in phase with the activity cycle Figure 1. However, these longer wavelength spectral irradiance variations have yet to be observationally defined. Implications from Observations of Solar Surrogates The direct correlation of solar radiative output with solar activity over the year solar cycle is a major discovery from the ACRIM and ERB long term solar monitoring programs. These variations reflect the inhomogeneous emission of radiation on the solar disk. Solar radiation is depleted in active region sunspots and enhanced in active Page 30 Share Cite Suggested Citation: From the minimum to the maximum of the year activity cycle there is an increase in active regions, both sunspots and faculae, on the solar disk. Total solar irradiance is thought to be positively correlated with the year solar activity cycle because excess facular brightness, especially from the background active network of bright emission outside of the largest active regions, more than compensates for the sunspot deficit Foukal and Lean, ; Willson and Hudson, To understand the forcing of the climate system by solar irradiance changes, it is necessary to have empirical models capable of extrapolating the radiative output variations to epochs beyond present solar cycles. Knowing that total solar irradiance is enhanced at times of maximum activity, and that these variations appear to arise from the competing effects of two different types of active regions dark sunspots and bright faculae , suggests that past variations may be reconstructed from historical indicators of solar activity. Empirical parameterizations have been developed to investigate this possibility. Many of the major features of the irradiance data have been reproduced by a regression model using the equivalent width EW of the solar He I line; these models do not reproduce the high levels of irradiance measured by the radiometers in â€” near the maximum of solar cycle Either the empirical relationships differ between solar minimum and solar maximum, and perhaps from one solar cycle to the next, or the irradiance observations are too high because of instrumental artifacts. Page 31 Share Cite Suggested Citation: However, as discussed below, limits of solar variability, such as inferred from observations of Sun-like stars, provide circumstantial evidence for a brightness component that has been slowly increasing the total solar irradiance since the Maunder Minimum, a time of reduced solar activity from about to With changes in this additional brightness component superimposed on the year cycle variations, a reduction of 0. Solar observations made by telescopes in the seventeenth century also suggest increased solar diameter and equatorial surface rotation during the Maunder Minimum, compared with the modern Sun Eddy et al. Using apparent solar radius as a surrogate for solar irradiance leads to speculation of a reduction as large as 1 percent during the late seventeenth century Nesme-Ribes et al. In addition to uncertainties about the amplitude of solar irradiance values in the Maunder Minimum, there are also differences in reconstructions of the relative temporal variations in the irradiance since then -- over the past years. While derivations based on different solar surrogates -- such as the apparent solar radius record, the length of the sunspot cycle, the sunspot decay rate, or the mean activity level of the year cycle -- do agree about the overall increasing levels of solar activity during the past years, phase differences in specific episodic increases and decreases of activity may be as large as 20 years Hoyt and Schatten, Geophysical Proxies Relatively continuous, direct records of solar activity exist only since the telescopic discovery of sunspots in the early s. For estimating changes in solar activity over the past several thousand years, other indicators have been proposed, such as variations in cosmogenic 14

INFLUENCE OF SHORT-TERM SOLAR UV VARIABILITY ON THE DETERMINATION OF SOLAR CYCLE MINIMUM pdf

C in tree rings and 10 Be in ice cores Beer et al. Historical solar activity variations inferred from these cosmogenic Page 32 Share Cite Suggested Citation: For example the 14 C record is connected to solar activity as follows. Changes in the solar wind in response to solar activity variations modulate the heliospheric magnetic topology. During times of minimum solar activity, cosmic rays are swept out of the heliosphere less effectively by the solar wind than during maximum solar activity. This leads to increased production of 14 C, which accumulates in the biosphere where it is available for uptake by trees. The similarity between the recent 14 C record and the envelope of the sunspot record of solar activity is evident in Figure 1. Although many uncertainties exist in interpreting such phenomena, these records offer the potential for gaining improved understanding of solar behavior in the extended past, relevant to global change issues Wigley and Kelly, ; Damon and Sonett, Evidence from Observations of Sun-Like Stars The sun is a rather common star, and its behavior is thought to be typified by that of stars of similar age, mass, radius, and composition. Routine monitoring of the activity of a selection of Sun-like stars during the past decade has indeed revealed rotational and activity cycles on time scales similar to those seen in the Sun Radick et al. Also, observations of Ca II emission in Sun-like stars indicate that 4 out of 13 stars monitored monthly since exhibited no activity cycle, implying that extended periods of inactivity, as exemplified in the modern solar record by the Maunder Minimum, may be common Baliunas and Jastrow, This conjecture is roughly supported by the occurrence of minima that punctuate the 14 C geophysical record of solar activity. In the four Sun-like stars observed to be inactive, Ca II emissions were almost always lower than in the stars that exhibited activity cycles Baliunas and Jastrow, Their results, shown in Figure 2. Such a decrease is consistent with inferences about the level of solar radiative output during the Maunder Minimum reported by Wigley and Kelly from the climate record, and also with stellar observations that provide compelling evidence for variabilities of 0. Foukal notes that the larger luminosity changes observed in Sun-like stars do not necessarily imply equally larger changes in the Sun, at least in the present epoch, since these changes are actually consistent with current understanding of modulation by photospheric magnetism. The magnitude of climate change that can be associated directly with the changes in total solar irradiance measured during the recent solar activity cycle about 0. Assuming this result is the right order of magnitude, and that it scales linearly, the 0. However, the change from maximum to minimum activity of the year cycle occurs over about five years, too little time to allow for full equilibrium response of the climate system. Furthermore, where averaged over the solar cycle, the effect is reduced by the periodic nature of the forcing, the radiative change during the second half effectively Page 34 Share Cite Suggested Citation: The range of activity seen in the present-day Sun shaded area is typical of the one-third most active stars in the sample White et al. Estimated values of total solar irradiance, from Lean et al. To the extent that feedbacks of the climate system are not symmetric, it is possible that solar cycling could produce a net climate forcing that would accumulate over longer times. Page 35 Share Cite Suggested Citation: Yet the climate record suggests that larger effects may have resulted from solar forcing in both the distant and recent past, and that even today unexpected sensitivities may exist e. Furthermore, as a result of the expected cooling by aerosol and ozone changes, the net anthropogenic climate forcing may be only about half that expected for greenhouse gases alone Hansen et al. Solar-induced changes in the stratosphere could have a variety of indirect influences on the troposphere and climate e. Investigations with general circulation models Kodera, ; Rind and Balachandran, suggest that variations in solar ultraviolet energy input modify the ozone and temperature structure of the stratosphere, affecting the latitudinal temperature gradient. This modifies stratospheric wind speeds and the ability of long-wave energy to propagate out of the troposphere. Altered tropospheric stability affects various tropospheric dynamic processes, including the Hadley cell intensity at low and subtropical latitudes, and low pressure systems in the extratropics. Paleoclimate, like the recent climate, displays numerous examples of potential interactions between solar radiative forcing and climate. Indeed, ubiquitous in climate records are cycles with periods of about 23,, 41,, and , years that are widely attributed to variations in the distribution of insolation with orbital parameters -- the so-called Milankovitch forcing. Page 36 Share Cite Suggested Citation: Global Change Research Program, discussed below are three times scales associated with different mechanisms for solar variability: Eddy pointed out the coincidence in time between the Maunder Minimum of solar activity and the lowest temperatures of the Little Ice Age in Europe and North America see Figure 1. He also presented qualitative evidence that other century-scale variations in climate over the past millennium coincided roughly with variations in solar activity deduced from anomalies in the 14C cosmogenic isotope record. Thus, enhanced solar activity corresponds to 14C minima, and the mechanism proposed by Eddy for the apparent relationship between climate and the 14C wiggles involved changes in the total solar irradiance linked to the long term envelope of the year sunspot cycle and reflected in the 14C record.

INFLUENCE OF SHORT-TERM SOLAR UV VARIABILITY ON THE DETERMINATION OF SOLAR CYCLE MINIMUM pdf

2: Chapter 8 Section 4

Influence of Short-Term Solar UV Variability on the Determination of Solar Cycle Minimum Variability on the Determination of Solar. Current short-term UV activity differs from the cycle

Through the influence of ions from cosmic rays, the effect increases even 10 to times. Cropped from video by CERN. Fritz Vahrenholt present papers on another way the sun impacts climate: Clearly the sun has an entire bag of tricks when it comes to dominating climate on Earth, and we are only at the dawn of understanding. Fritz Vahrenholt German text translated by P. A new study from 28 April appearing in the Geophysical Research Letters once and fore all shakes this view. Scientists have been able to show that changes in solar UV radiation on a scale of months have a clear impact on temperatures at the lower weather atmospheric levels at the tropics. Hood of the Univeristy of Arizona in Tucson: Drivers of polar mesospheric cloud variability Polar Mesospheric Clouds PMCs are known to be influenced by changes in water vapor and temperature in the cold summertime mesopause. Solar variability of these constituents has been held responsible for year and day variability of PMC activity, although the detailed mechanisms are not yet understood. It is also known that the solar influence on PMC variability is a minor contributor to the overall day-to-day variability, which is dominated by effects of gravity waves, planetary waves, and inter-hemispheric coupling. The SOFIE data contain precise measurements of water vapor, temperature and ice water content among other quantities. These high-latitude measurements are made during the PMC season at the terminator, and therefore directly relate to the simultaneous measurements of mesospheric ice. We compare these results to previously published results, and show that the temperature sensitivity is somewhat higher, whereas the water sensitivity is nearly the same as published values. The time lags are shorter than that expected from direct solar heating and photodissociation, suggesting that the responses are due to day variations of vertical winds. The models are unable to reproduce the results. High solar cycle spectral variations inconsistent with stratospheric ozone observations Solar variability can influence surface climate, for example by affecting the mid-to-high-latitude surface pressure gradient associated with the North Atlantic Oscillation 1. One key mechanism behind such an influence is the absorption of solar ultraviolet UV radiation by ozone in the tropical stratosphere, a process that modifies temperature and wind patterns and hence wave propagation and atmospheric circulation 2 , 3 , 4 , 5. The amplitude of UV variability is uncertain, yet it directly affects the magnitude of the climate response 6: Here we present estimates of the stratospheric ozone variability during the solar cycle. Specifically, we estimate the photolytic response of stratospheric ozone to changes in spectral solar irradiance by calculating the difference between a reference chemistryâ€”climate model simulation of ozone variability driven only by transport with no changes in solar irradiance and observations of ozone concentrations. Subtracting the reference from simulations with time-varying irradiance, we can evaluate different data sets of measured and modelled spectral irradiance. We find that at altitudes above pressure levels of 5 hPa, the ozone response to solar variability simulated using the SORCE spectral solar irradiance data are inconsistent with the observations. Relationships between solar activity and variations in SST and atmospheric circulation in the stratosphere and troposphere Relationships between solar activity and variations in both sea surface temperature SST and atmospheric circulation at the time of the solar maximum are presented. The global distribution of correlation coefficients between annual relative sunspot numbers SSN and SST from July to December was examined over a year period from to Areas with a significant positive correlation accounted for The influence of solar activity on global atmospheric pressure variations and circulation in the maximum years was also analyzed from to The results indicated that higher geopotential height anomalies tended to appear in the stratosphere and troposphere in the northern hemisphere, centering on around the Hawaiian Islands from November to December, in the second year of the solar maximum. It is suggested that the solar activity had an influence on the troposphere via not only the stratosphere but also the sea surface. A stratospheric connection to Atlantic climate variability The stratosphere is connected to tropospheric weather and climate. In particular, extreme stratospheric circulation events are known to exert a dynamical feedback on the troposphere 1. However, it is unclear whether the state of the stratosphere also affects the ocean and its circulation. A co-variability of decadal stratospheric flow variations and conditions in the North Atlantic Ocean has been suggested, but such findings are based on short simulations with only one climate model 2. Here we assess ocean reanalysis data and find that, over the previous 30 years, the stratosphere and the Atlantic thermohaline circulation experienced low-frequency variations that were similar to each other. Using climate models, we demonstrate that this similarity is consistent with the hypothesis that variations in the sequence of stratospheric circulation anomalies, combined with the persistence of individual anomalies, significantly affect the North Atlantic Ocean. Our analyses identify a previously unknown source for decadal climate variability and suggest that simulations of deep layers of the atmosphere and the ocean are needed for realistic predictions of climate. Weather occurs in the troposphere. Researchers also knew that global circulation patterns in the oceans â€” patterns caused mostly by variations in water temperature and saltiness â€” affect global climate. But now we actually demonstrated an entire link between the stratosphere, the troposphere and the ocean. Stratospheric Winds and Sea Circulation Show Similar Rhythms Reichler and colleagues used weather observations and 4, years worth of supercomputer simulations of weather to show a surprising association between decade-scale, periodic changes in stratospheric wind patterns known as the polar vortex, and similar rhythmic changes in deep-sea circulation patterns. These winds extend from 15 miles elevation in the stratosphere up beyond the top of the stratosphere at 30 miles. The changes last for up to 60 days, allowing time for their effects to propagate down through the atmosphere to the ocean. Sometimes, both events happen several years in a row in one decade, and then none occur in the next decade. These changes to the stratosphere can alter the ocean, and any change to the ocean is extremely important to global climate. What happens in the Atlantic also affects the other oceans. If the water is close to becoming heavy enough to sink, then even small additional amounts of heating or cooling from the atmosphere may be imported to the ocean and either trigger downwelling events or delay them. They are stronger than jet stream winds, which are less than 70 mph in the troposphere below. But every two years on average, the stratospheric air suddenly is disrupted and the vortex gets warmer and weaker, and sometimes even shifts direction to clockwise. It already was known that that these stratospheric wind changes affect the North Atlantic Oscillation â€” a pattern of low atmospheric pressure centered over Greenland and high pressure over the Azores to the south. The pattern can reverse or oscillate. Because the oscillating pressure patterns are located above the ocean downwelling area near Greenland, the question is whether that pattern affects the downwelling and, in turn, the global oceanic circulation conveyor belt. Observations are consistent with the pattern revealed in computer simulations. Observations and Simulations of the Stratosphere-to-Sea Link In the s and s, a series of stratospheric sudden warming events weakened polar vortex winds. During the s, the polar vortex remained strong. Reichler and colleagues used published worldwide ocean observations from a dozen research groups to reconstruct behavior of the conveyor belt ocean circulation during the same year period. To reduce uncertainties about the observations, the researchers used computers to simulate 4, years worth of atmosphere and ocean circulation. This leads to the remarkable fact that signals that emanate from the stratosphere cross the entire atmosphere-ocean system.

INFLUENCE OF SHORT-TERM SOLAR UV VARIABILITY ON THE DETERMINATION OF SOLAR CYCLE MINIMUM pdf

3: Solar Variability and Terrestrial Climate | Science Mission Directorate

Add tags for "Influence of short-term solar UV variability on the determination of solar cycle minimum". Be the first.

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.

INFLUENCE OF SHORT-TERM SOLAR UV VARIABILITY ON THE DETERMINATION OF SOLAR CYCLE MINIMUM pdf

4: Solar Activity and Climate

Abstract Smoothing solar UV data on rotational timescale (approx. 27 days) improves identification of solar minimum. Smoothing intervals which are not multiples of rotational period (e.g. 35 days) can leave measurable residual signal.

The latter activity includes most prominently the year sunspot cycle and its modulations. Variations in the total solar irradiance broad spectral band irradiance: An increase or a decrease in the TSI is expected on this basis to increase or decrease the temperature of Earth. For example, the TSI changes over an year cycle in step with the cycle of sunspots with an amplitude of nearly 0. The Physical Science Basis. Tung, Surface warming by the solar cycle as revealed by the composite mean difference projection, Geophysical Research Letters, Page 4 Share Cite Suggested Citation: The National Academies Press. It is now understood that this decrease in cosmic rays is due to changes in the magnetic field geometry in the heliosphere, the bubble blown in the interstellar medium by the solar wind. Furthermore, solar energetic particle SEP events, created at the shock front of coronal mass ejections CMEs , for example, can influence the composition of the upper atmosphere. The higher-energy particles can penetrate well into the stratosphere where they ionize the atmosphere, producing nitrogen oxides, whereas lower-energy particles can create nitrogen oxides in the lower thermosphere and mesosphere that then descend into the polar stratosphere. These nitrogen oxides can destroy ozone, thus altering not only the chemistry but also the radiative balance of that region. The continuous year record of total solar irradiance from space-based observations is shown in Figure 1. This data record is the result of overlapping measurements from several instruments flown on different missions. Measurements made by individual radiometers providing the data shown in 9 A workshop conducted at the National Institute of Standards and Technology in Gaithersburg, Maryland, 10 sparked investigations into the effects of diffraction, scattered light, and aperture area measurements on the differences between instrument results. Evident in this combined, recalibrated record is an year cycle with peak-to-peak amplitude of approximately 0. Measurement continuity has enabled successive radiometric time series obtained from different space missions to be intercalibrated to produce a year-long composite TSI record. Saar, The outer solar atmosphere during the Maunder Minimum: A stellar perspective, The Astrophysical Journal Space Science Review Harrison, The global atmospheric electric circuit and climate, Surveys in Geophysics Dorman, Possible influence of cosmic rays on climate through thunderstorm clouds, Advances in Space Research 35 3: Solanki, The solar spectral irradiance since , Geophysical Research Letters Barnes, Sources of differences in on-orbital total solar irradiance measurements and description of a proposed laboratory intercomparison, Journal of Research of National Institute of Standards and Technology Page 5 Share Cite Suggested Citation: Offsets between measurements are the result of calibration differences between instruments. Page 6 Share Cite Suggested Citation: Proxy records of radioisotopes provide evidence of long-term change in solar activity, but these must be tuned and extrapolated from the existing TSI data record; however, based on present understanding, the irradiance variations inferred from them are no greater than those observed radiometrically over recent solar cycles. New evidence now suggests that secular variations of larger amplitude may have occurred on multi-decadal to millennial timescales. Although the ultraviolet region of the spectrum provides only a small fraction of the TSI, ultraviolet irradiance can change by several percent over the solar cycle, and thus represents an important source of modulation of the energy deposition and composition in the middle and upper atmosphere. Ultraviolet irradiance both changes the radiative balance of the atmosphere and affects the shape of the spectrum of radiation reaching the lower atmosphere. Such variations are thought to drive the top-down coupling mechanism. Results have indicated that ultraviolet trends during cycle 23 were larger than those observed in previous cycles, and were compensated by trends in other bands that increased with decreasing solar activity. Research into possible mechanisms of Sun-climate coupling has taken several paths. Progress is hampered by incomplete understanding of solar variability, climate, and their complex interaction. Cebula, Solar variation estimated from an empirical model for changes with time in the sensitivity of the solar backscatter ultraviolet instrument, Journal of Geophysical Research Woods, Trends in solar spectral irradiance variability in the visible and infrared, Geophysical Research Letters Page 7 Share Cite Suggested Citation: Periodic, or quasi-periodic, forcing 17 provides invaluable information on climate dynamics. Other than the seasonal variability on a yearly scale and the precession of the equinoxes the change of the season in which the minimum Sun-Earth distance occurs with scales of 20, years, the only quasi-periodic forcing term is the year solar cycle. In the first, the year cycle may affect the climate system via the bottom-up total solar irradiance path through which solar cycle effects can manifest themselves at the surface and its nearby environment. In general, this bottom-up driver is strongest in the tropics, where there are feedbacks from clouds, ocean currents, sea surface temperature, and so on present in the climate system that strengthen the effect and even show up at higher latitudes. A second avenue of inquiry is the top-down mechanism that makes use of the modulated absorption of ultraviolet radiation in the stratosphere. Top-down mechanisms operate through changes in the more energetic, shorter-wavelength components of the solar spectrum that influence stratospheric temperatures and winds directly and through absorption by stratospheric ozone. Early work by Karen Labitzke and Harry Van Loon on interactions of the solar cycle and the quasi-biennial oscillation of the equatorial stratosphere helped direct attention to the top-down pathway. Climate models also take this modulation as input and have demonstrated significant perturbations on tropospheric circulations. If borne out by future studies and shown to be of sufficient magnitude, this mechanism could be an important pathway in the Sun-climate connection, particularly in terms of regional impacts. However, it is important to realize that, unlike the bottom-up mechanism, it can in itself contribute very little to global temperature variations. The effects on climate of centennial timescale variations in TSI have been an even more difficult and contentious issue. Since the work of Jack Eddy in , 21 the claim that the lower temperatures of the Little Ice Age from roughly to are connected to the secular changes in the Sun, as reflected in paleoclimate data derived from cosmogenic isotopes in sediments and the observed record of sunspots, remains an unresolved research topic Figure 1. Recent findings that removal of small-scale photospheric fields could dim the Sun more than previously expected increase the likelihood of such variations in secular irradiance. As defined in S. Garcia, Attribution of decadal variability in lower-stratospheric tropical ozone, Geophysical Research Letters, The anomalies in the lower stratosphere of the northern hemisphere in the winter and a comparison with the Quasi-Biennial Oscillation, Monthly Weather Review The troposphere and stratosphere in the northern hemisphere in winter, Journal Atmospheric and Solar-Terrestrial Physics, Eddy, The Maunder Minimum, Science Page 8 Share Cite Suggested Citation: The Maunder Minimum is shown during the second half of the 16th century. The Intergovernmental Panel on Climate Change Fourth Assessment 23 and the recent National Research Council report on climate choices 24 agree that there is no substantive scientific evidence that solar variability is the cause of climate change in the past 50 years. Chapter 3 summarizes the panel discussion session. Appendix A contains the statement of task and work plan for the project. The full workshop agenda is included in Appendix B , and workshop presentation abstracts, prepared by the workshop speakers, are included in Appendix C. This report summarizes the views expressed by individual workshop participants. Although the committee is responsible for the overall quality and accuracy of the report as a record of what transpired at the workshop, the views contained in the report are not necessarily those of all workshop participants, the committee, or the National Research Council. Page 3 Share Cite Suggested Citation:

INFLUENCE OF SHORT-TERM SOLAR UV VARIABILITY ON THE DETERMINATION OF SOLAR CYCLE MINIMUM pdf

5: Solar variability and climate change: is there a link? | Astronomy & Geophysics | Oxford Academic

The effect of long-term (year solar cycle) solar UV variability on stratospheric chemical and thermal structure has been studied using a time-dependent one-dimensional model. Previous studies have suggested substantial variations in local and total ozone, and in stratospheric thermal structure from solar minimum to solar maximum.

But increased amounts of data from the Sun and about the climate on Earth over recent years mean that rapid progress is being made. In this paper, I review the current debate on the influence of the Sun and summarize the state of play in this area of solar physics. The Earth is a warm and cosy cradle dangling in cold and largely empty space made even less hospitable by harmful high-energy particles and short-wavelength radiation. Changes in the solar spectrum, in particular in the UV, could enhance or dampen this influence, by affecting stratospheric chemistry: It is important to find a firm answer to these questions in order to put the solar contribution into proper perspective within the global warming debate and in particular to determine its weight relative to that of the man-made greenhouse gases. Let me begin by describing the relevant features of the Sun. Solar variability There are two major causes of solar variability: The Sun is typical among stars of similar mass, composition and age. It is currently near the middle of its approximately billion-year tenure on the main sequence. During this time the Sun is expected to roughly double in brightness and also to increase substantially in radius. Upon leaving the main sequence the evolution of the Sun speeds up, with large and rapid excursions both in brightness and radius. This is far in the future, however, and need not concern us here. But what about the past? Since ice reflects almost all the incoming radiation, this enhanced albedo would make it impossible for even the bright present-day Sun to melt this ice cover. Note the three different time scales, as the evolution speeds up. Adapted from figure 4 of Sackmann et al. The major ingredients determining the strength and structure of the resulting magnetic field are the differential rotation of the Sun and the turbulent convection at and below the solar surface. The differential rotation produces a mainly toroidal field near the base of the convection zone. With time the strength of this field increases. Above a certain critical strength the field becomes unstable and individual loops start to rise towards the solar surface, which they finally reach and pass through. At this point the magnetic field becomes accessible to observation. The interaction with the convection leads to the concentration of the field in filaments or bundles of field lines called flux tubes. The largest of these, the sunspots, have diameters similar to that of the Earth and are visible as dark features on the solar surface. A relatively symmetric sunspot is shown in figure 2. The more common smaller flux tubes appear as bright points having diameters below km and are called magnetic elements. Concentrations of large numbers of these are visible as bright faculae in the active regions where also the sunspots are found and as a network distributed over the whole solar surface figure 3. View large Download slide Image of a sunspot and the surrounding photosphere. The inner, darker part is called the umbra, the outer striated part is the penumbra. The sunspot is surrounded by granules, convection cells with a bright core harbouring hot upflows and dark boundaries so-called intergranular lanes composed of cool downflowing gas. An image of the full solar disc taken in the light of singly ionized calcium. The dark features are sunspots, the bigger bright patches are faculae and the small bright features present all over the solar disc are network elements. View large Download slide An image of the full solar disc taken in the light of singly ionized calcium. In particular the closed magnetic field gives rise to a large number of phenomena, such as sunspots, chromospheric plages, hot coronal loops, filaments and prominences, flares and the associated high-energy radiation, and coronal mass ejections, to name but a few. These phenomena are collectively described under the heading of solar activity. The solar magnetic field, and hence also the associated activity, is strongly time-dependent. The most prominent feature of this time dependence is the solar activity cycle with a period of roughly 11 years. This cycle is beautifully illustrated by the number of sunspots visible on the solar disc at any given time, which increases tenfold or more between activity minimum and maximum see figure 4. At the same time sunspots provide the longest direct record of solar activity. The yearly sunspot-number record since the beginning of telescopic observations. The period in the second half of the 17th century that was practically free of sunspots is called the Maunder minimum. View large Download slide The yearly sunspot-number record since the beginning of telescopic observations. It is obvious from figure 4 that some cycles are stronger than others. In addition, some cycles are also longer than others, although these variations are not sufficiently large to be clearly visible from the figure. In extreme cases cycles become so weak that they cease to be recognizable as such. This was the case during the Maunder minimum in the latter half of the 17th century, when practically no sunspots were present on the solar surface. Incidentally, this coincided with the so-called Little Ice Age in Europe, a time of severe cold and great hardship, when the Thames froze regularly and alpine glaciers grew deep into the valleys. The sunspot record and other, often more indirect, proxies of solar magnetism have invited comparison with records of climate. For several such records a significant correlation is indeed present. One of the most striking correlations was found between the air temperature above land masses in the northern hemisphere and the length of the sunspot cycle by Friis-Christensen and Lassen , shown in fig. Eleven-year running mean of the annual average northern hemisphere land-air temperature relative to the average temperature â€” and the filtered length of the sunspot cycle. From Friis-Christensen and Lassen , by permission. View large Download slide Eleven-year running mean of the annual average northern hemisphere land-air temperature relative to the average temperature â€” and the filtered length of the sunspot cycle. If the correlation is not a product of chance, which cannot be ruled out completely for time series of this length, then there must be a physical link with an unknown mechanism. One of the relevant forms of solar variability must therefore be closely connected with the length of the solar cycle, a parameter previously not known to play a decisive role in solar variability. The forms of solar activity that may be relevant for climate are total and spectral irradiance i. The total solar irradiance i. The plotted record is pieced together from different data sets because no single instrument survived the whole period. In addition to the presence of the year cycle with an amplitude of roughly 0. One such excursion is plotted on an expanded horizontal scale in figure 7 , together with continuum images of the solar disc on five days during the temporary darkening. These reveal a pair of small sunspots crossing the solar disc, which are the cause of the darkening. The other darkenings in figure 6 are also all associated with sunspots or sunspot groups. Sunspots are dark because their strong magnetic field suppresses convection, which is the dominant form of energy transport just below the solar surface. The vertical transport by radiation is too inefficient to compensate for the loss of convective transport and sunspots are too large for a horizontal inflow of radiation to have any significant effect on their brightness. View large Download slide Composite of total solar irradiance covering more than two solar cycles, as measured by radiometers flying on spacecraft. Data from four instruments have been used to create this composite. The face of the Sun in white light on five selected days during the dip is also shown. Note the sunspots on the solar disc. Figures 6 and 7 indicate that the energy blocked by a sunspot is stored within the Sun to be released at another time. This temporary storage of heat is only possible because the convection zone has a very high thermal conductivity and heat capacity, as pointed out by Spruit This combination implies that heat blocked by a sunspot from reaching the surface will quickly diffuse throughout the convection zone due to the high thermal conductivity whose temperature will be raised only imperceptibly due to the large heat capacity , so that all in all the solar brightness is decreased. The stored heat is eventually radiated away, but only very gradually over a period of years corresponding to the thermal relaxation time of the convection zone. This important insight leads to the next question: Recent work has, however, given more credence to the other point of view that it is the magnetic field at the solar surface that produces this brightening. The basis for this hypothesis lies in the fact that sunspots are only the largest and by far the rarest of the broad range of magnetic features magnetic flux tubes in the solar photosphere. The smaller flux tubes forming the faculae and the network see figure 3 are bright. Like sunspots they also inhibit convection in their interiors, but they are sufficiently narrow that radiation flowing in from the sides into the highly evacuated flux tubes more than compensates for this loss. Like the sunspots, the number of these small magnetic elements also increases from activity minimum to maximum. Furthermore, the area covered by these elements increases by a far larger amount than that covered by the sunspots. Consequently, the brightening due to the faculae outweighs the darkening due to the sunspots in the long run, i. View large Download slide Upper frame: Support for the important role of the magnetic field at the solar surface is provided by the fact that the irradiance variability can be reproduced quantitatively by a simple three-component model, with the individual components representing the quiet Sun, faculae and sunspots. Figure 9 shows a comparison between measured and reconstructed solar irradiance. Note the excellent agreement between model and data, both on short time scales on which the Sun rotates and active regions evolve upper two frames and on the longer time scale from solar activity minimum to maximum lower frame. This suggests that the basic premise underlying such a model is correct and that it is indeed the manifestations of the magnetic field at the solar surface i. View large Download slide Total solar irradiance measured by VIRGO solid curve and as reconstructed using a model assuming that the magnetic field at the solar surface is responsible for irradiance variations stars. The period from the last activity minimum to near the current activity maximum is shown in the lower frame. Blow ups of the two shorter periods indicated by the red and green stars are presented in the upper frames.

INFLUENCE OF SHORT-TERM SOLAR UV VARIABILITY ON THE DETERMINATION OF SOLAR CYCLE MINIMUM pdf

As Easy as Breathing Treatise on pharmacy for students and pharmacists Memorial of Samuel Whitney Hale, Keene, N.H. Born April 2, 1822 Vera in the kitchen Botany books in telugu The long march home Yorkshire Dales A-Z (Mini Books) Biomedical instrumentation systems shakti chatterjee 1. Video File Types Awe-Inspiring Rites of Initiation Propaganda institutionalized The third floor front Diseases of the soul Contemporary philosophy; studies of logical positivism and existentialism Little me piano sheet music Will We Still Be a Family The criminology of terrorism and counter-terrorism State science and technology policy advice How to incorporate and start a business in Nevada A place for poetry : Shin-hanga landscape in modern Japan Kendall H. Brown Insurance accounts receivable management Disintegration of paradise : the Indo-Sri Lankan crisis Assertions of style: rhythm and repetition in A tale of two cities and Our mutual friend Arkansas Made: A Survey of the Decorative Mechanical and Fine Arts Produced in Arkansas, 1819-1870 Volume Sports Illustrated-The Super Bowl The system of minerology of James Dwight Dana, 1837-1868 Teen fathers and their families of origin Faces of two worlds Graph paper Mary Todd Lincoln, presidents wife Good Little Wives Keynote address : development in an unstable world : a Japanese experience to promote human security Hisa Understanding suicide A day at the Golden Temple The Editor of Love and Other Stories Therapeutic Agents, Volume 2, Burgers Medicinal Chemistry and Drug Discovery Paradise and other stories Advances in Transport Processes Dungeons and dragons 2nd edition monstrous manual Universal Abandon? the Politics of Postmodernism (Cultural Politics)