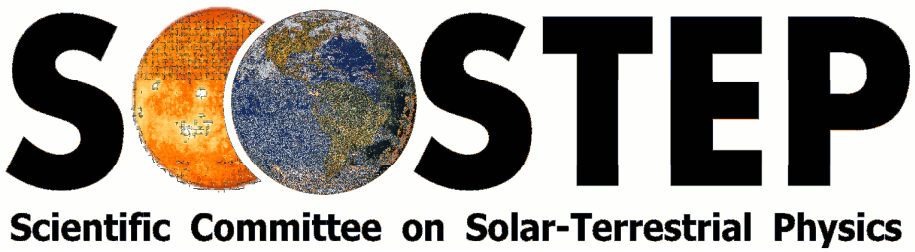


Variability of the Sun and Its Terrestrial Impact (VarSITI)

New SCOSTEP Scientific Program

for 2014-2018

UNCOPUOS, June 19, 2013, Vienna

contact: Nat Gopalswamy, President, SCOSTEP

(nat.gopalswamy@nasa.gov)

SCOSTEP

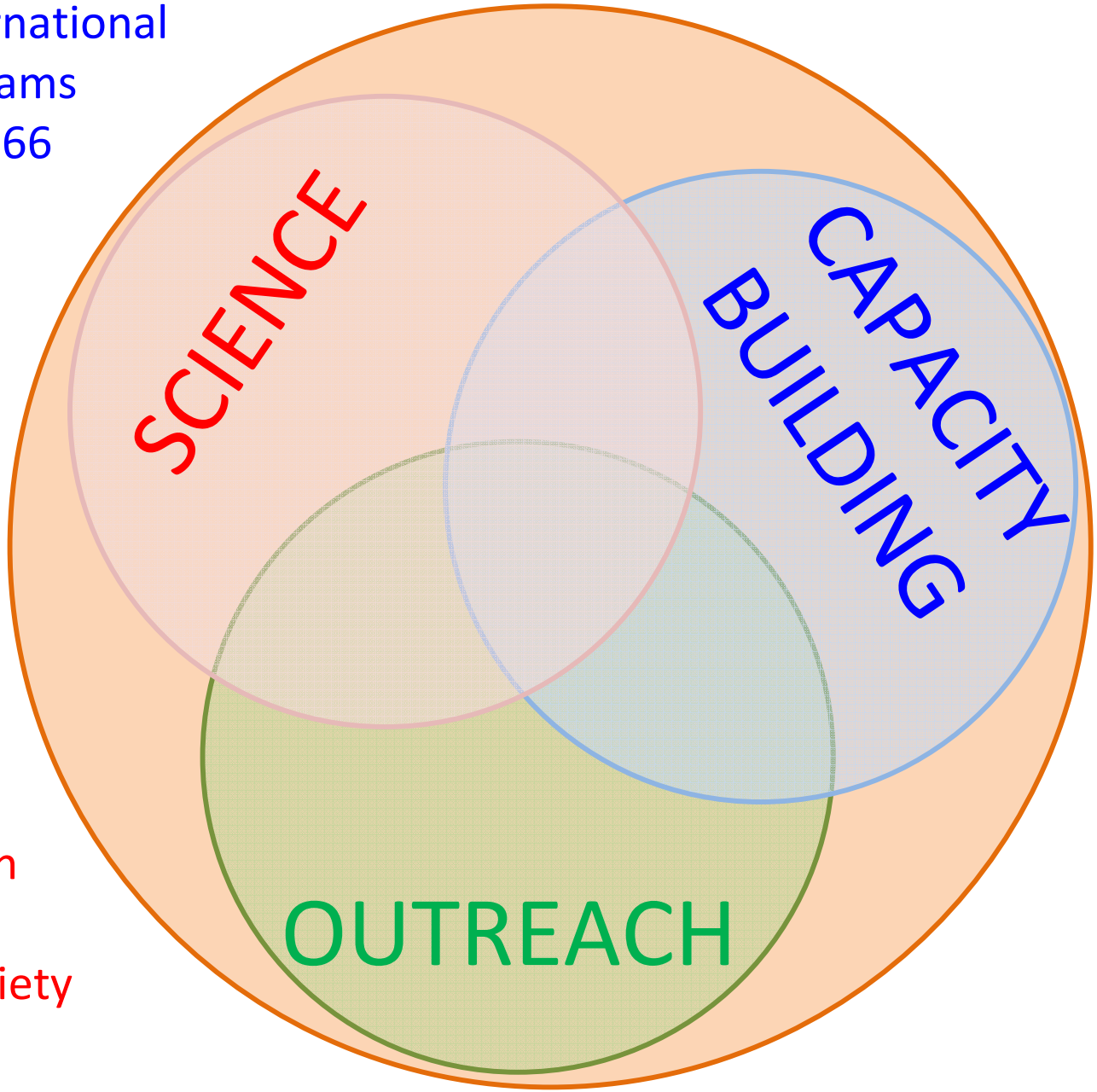
Scientific Committee on Solar-Terrestrial Physics

Runs long-term (4-5 years) international interdisciplinary scientific programs solar terrestrial physics since 1966

Interacts with national and international programs involving solar terrestrial physics elements

Engages in Capacity Building activities such as the annual Space Science Schools with ISWI

Disseminates new knowledge on the Sun-Earth System and how the Sun affects life and society as outreach activities



SCOSTEP Science Goal

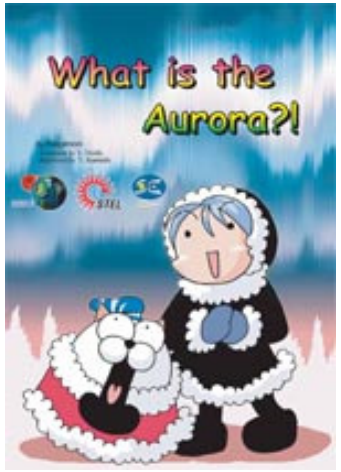
To advance our understanding of solar terrestrial relationship using

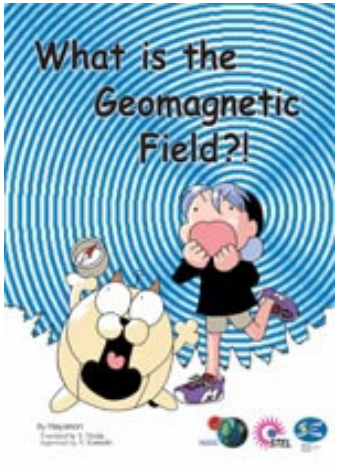
- Space- and ground-based data
- Cutting-edge models
- Theory
- International, Interdisciplinary Research

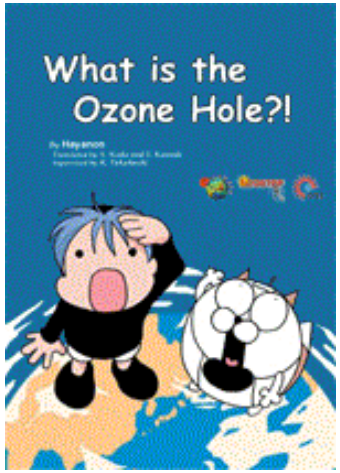
Capacity Building: Space Science Schools

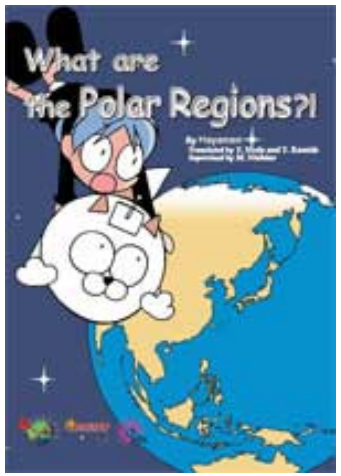
Indonesia (Sep 2012); Kenya (October 2013), Peru (2014)

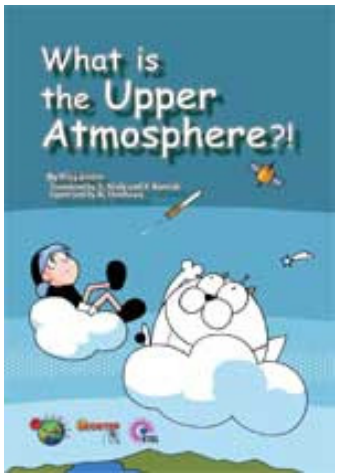
Partnered with International Space Weather Initiative (ISWI)

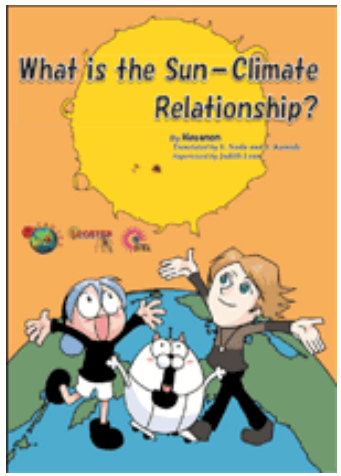


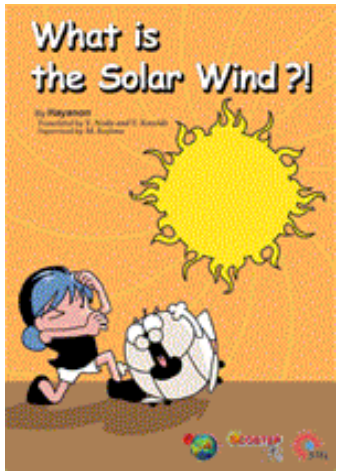


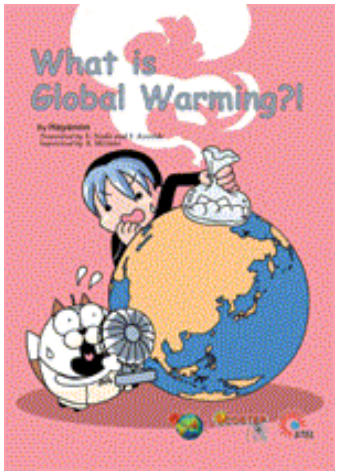


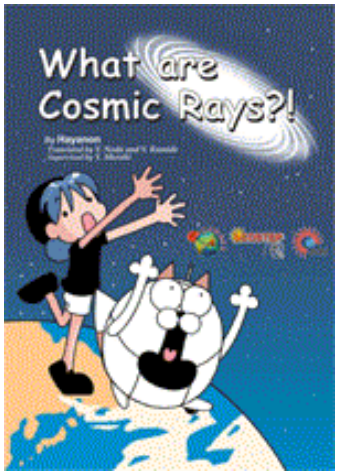








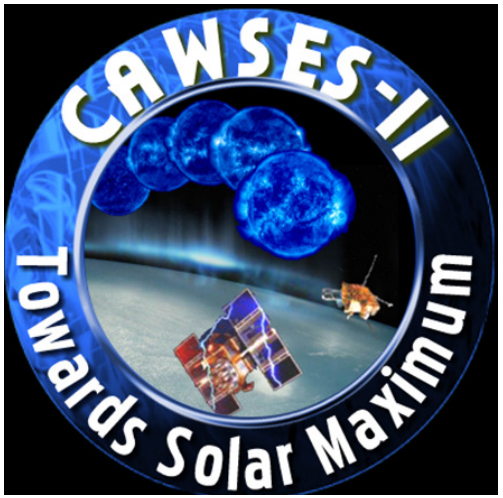


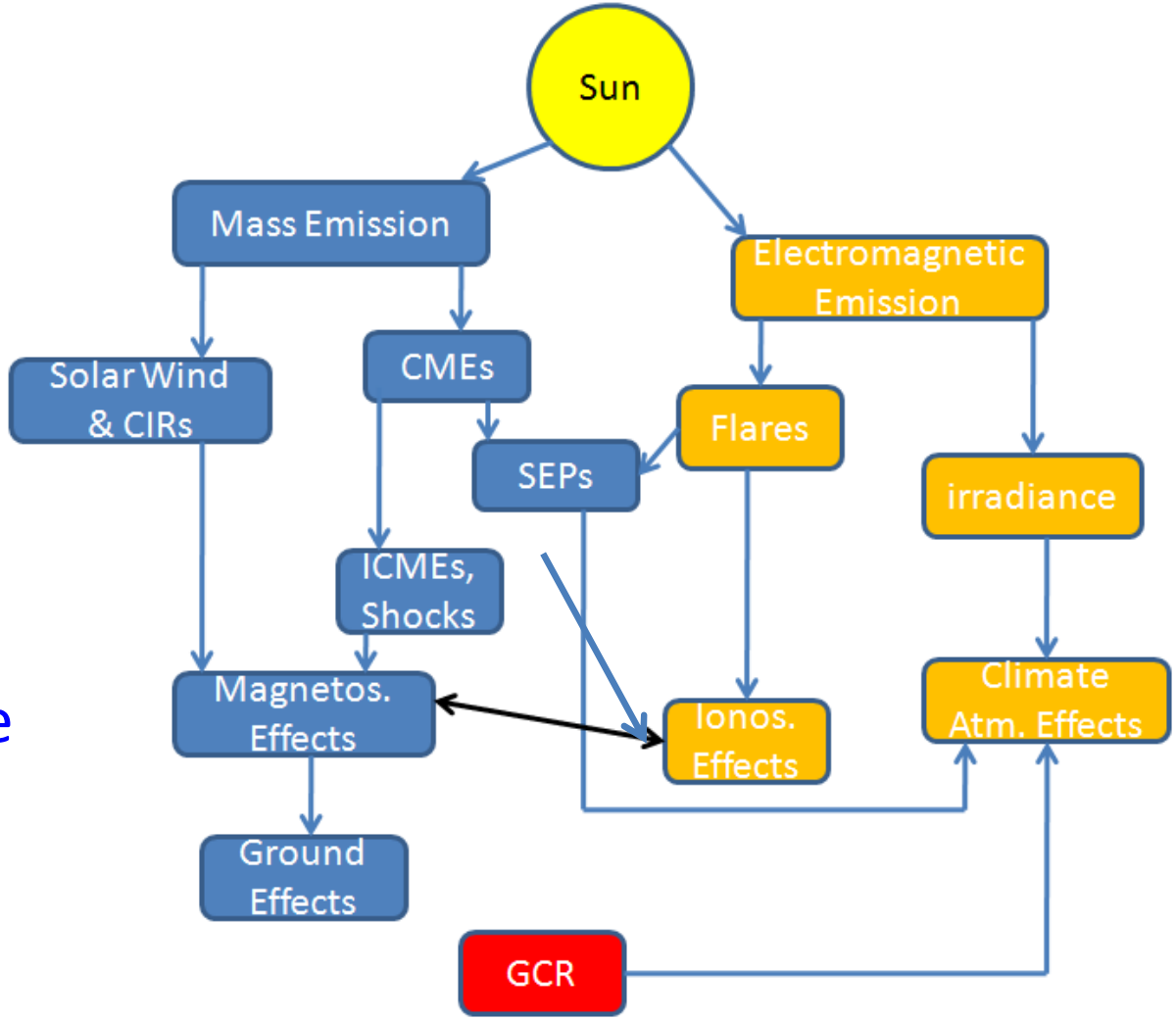


SCOSTEP Outreach: Comic Books

- To raise the public awareness on selected scientific topics (currently 9)
- Translated into many languages
- Available online: yorku.ca/scostep
- Translate into a new language!

Climate and Weather of the Sun-Earth System (CAWSES)





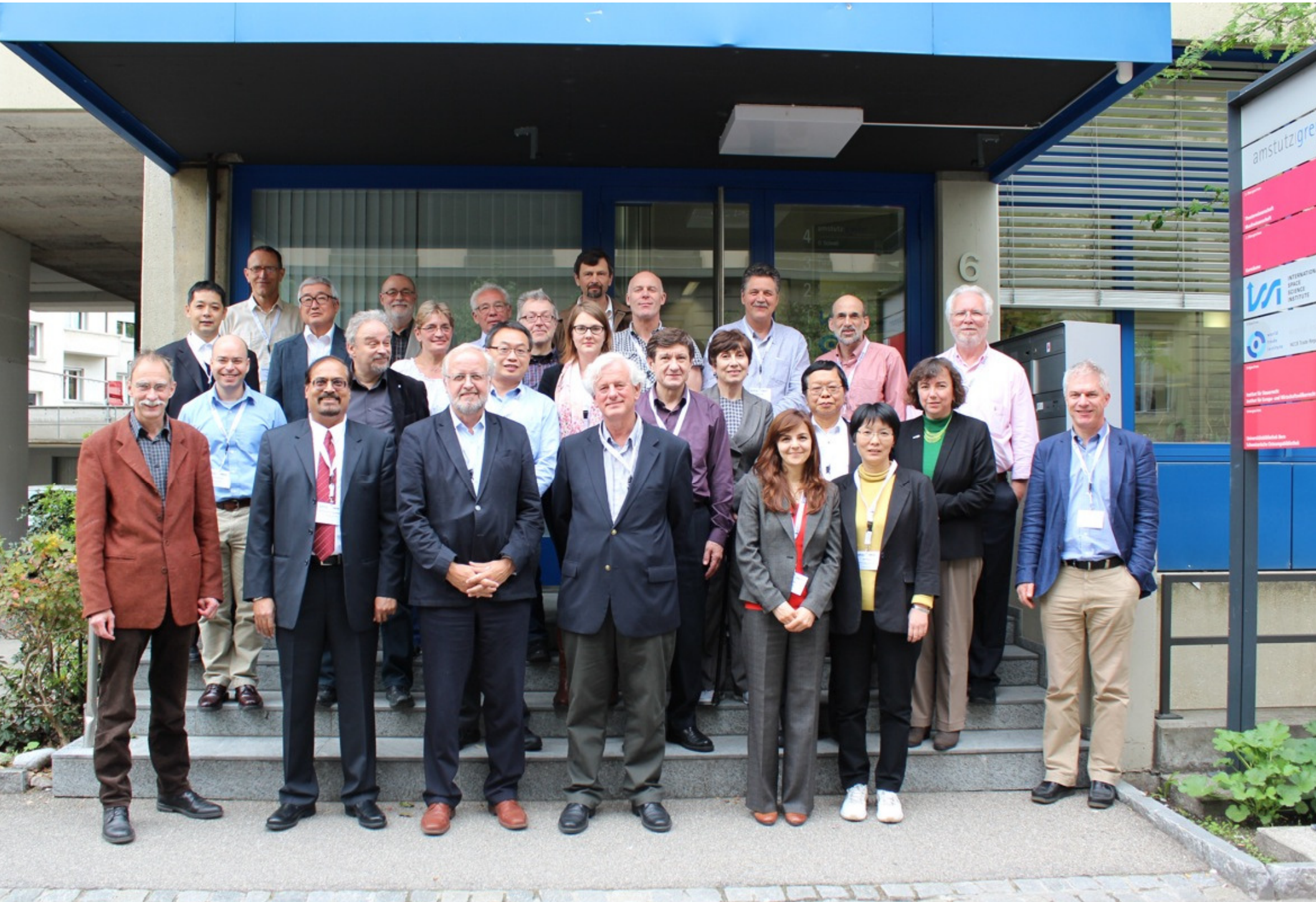
Mass and electromagnetic output from the Sun affect Earth's atmosphere and space environment on short and long time scales

CAWSES ends in 2013

VarSITI will start in 2014 and run through 2018

How did we create the New Program?

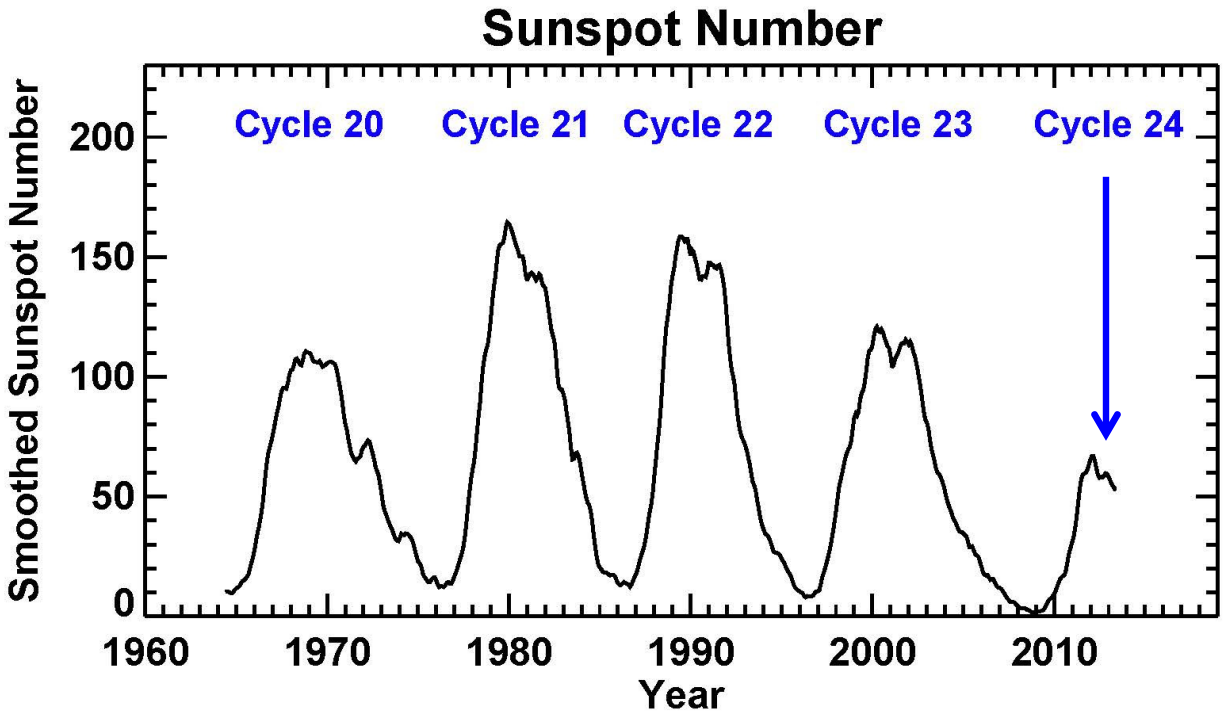
- White papers were solicited for International, Interdisciplinary programs that can produce significant results in 4-5 years. Nine received in 2012
- 27 international experts were invited (including the SCOSTEP Bureau and white-paper authors) to meet at the International Space Science Institute (ISSI) in Bern to brainstorm during May 7-8, 2013
- The ISSI forum on SCOSTEP defined the new scientific Program known as VarSITI: Variability of the Sun and Its Terrestrial Impact
- Variability involves from the lifetime of the Sun to day-to-day solar events (Space Weather and Climate)

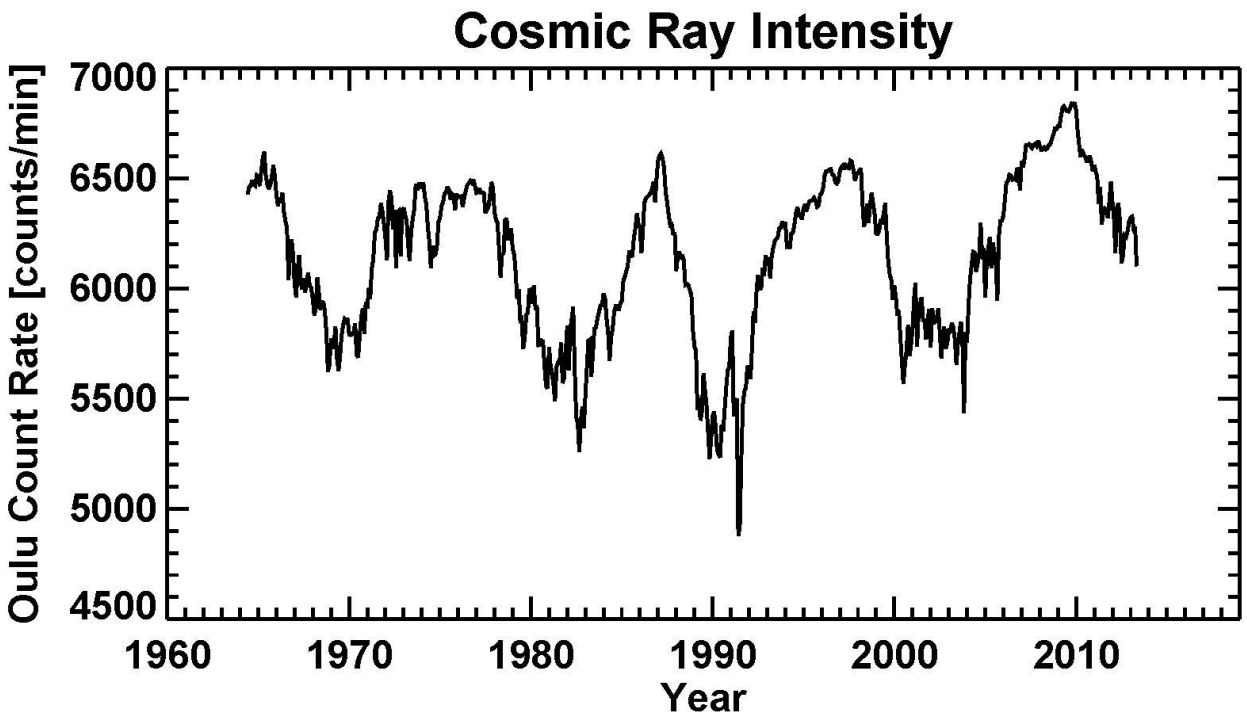


ISSI Forum on the next scientific program of SCOSTEP, May 7-8, 2013, ISSI, Bern, Switzerland

Four Elements of varSITI

- Solar Evolution and Extrema (SEE)
- MiniMax24/ISEST
- Specification and Prediction of the Coupled Inner-Magnetospheric Environment (SPeCIMEN)
- Role Of the Sun and the Middle atmosphere/thermosphere/ionosphere In Climate (ROSMIC)





SCOSTEP/VarSITI program will attempt to

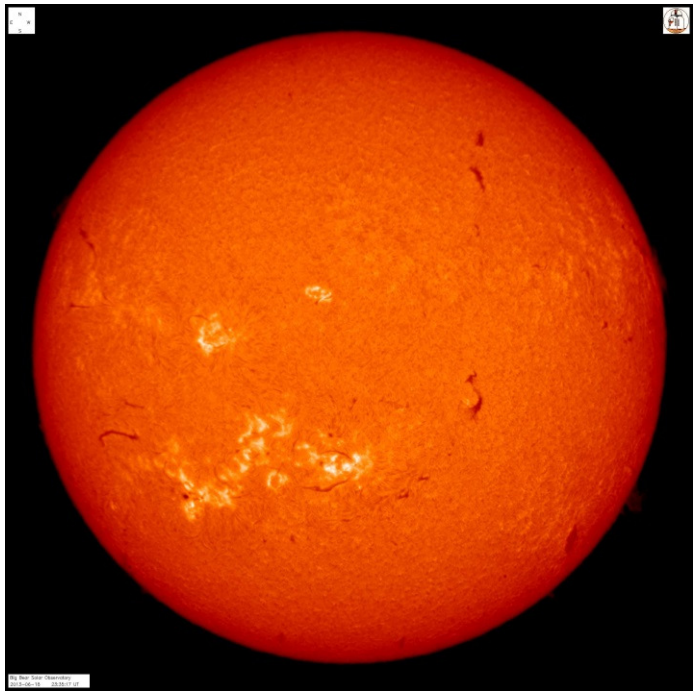
Understand the terrestrial effects of the weak solar activity

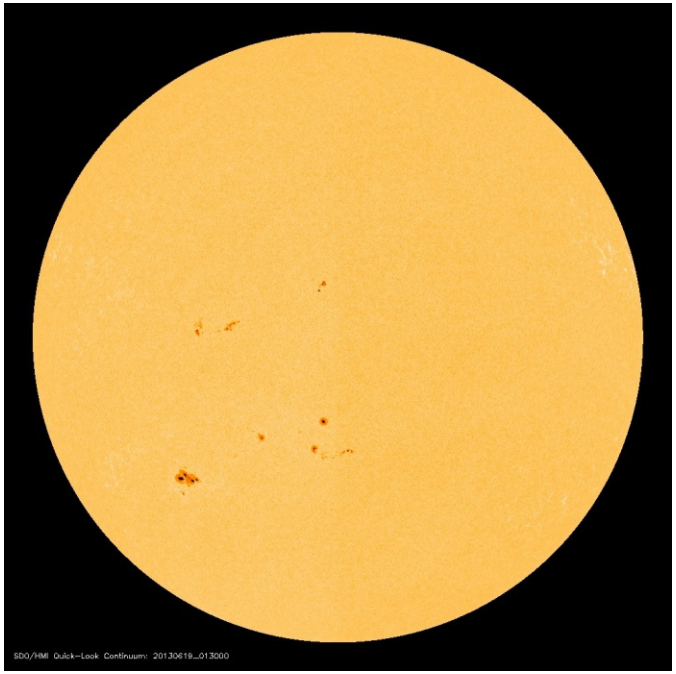
Contrast with historical activity level using natural archives such as ice cores and tree rings

Continuously monitor the sun via MiniMax24 and study the events using the ISEST program

Understand how the particle populations in the Earth's magnetosphere evolve

From Big Bear Solar Observatory, California

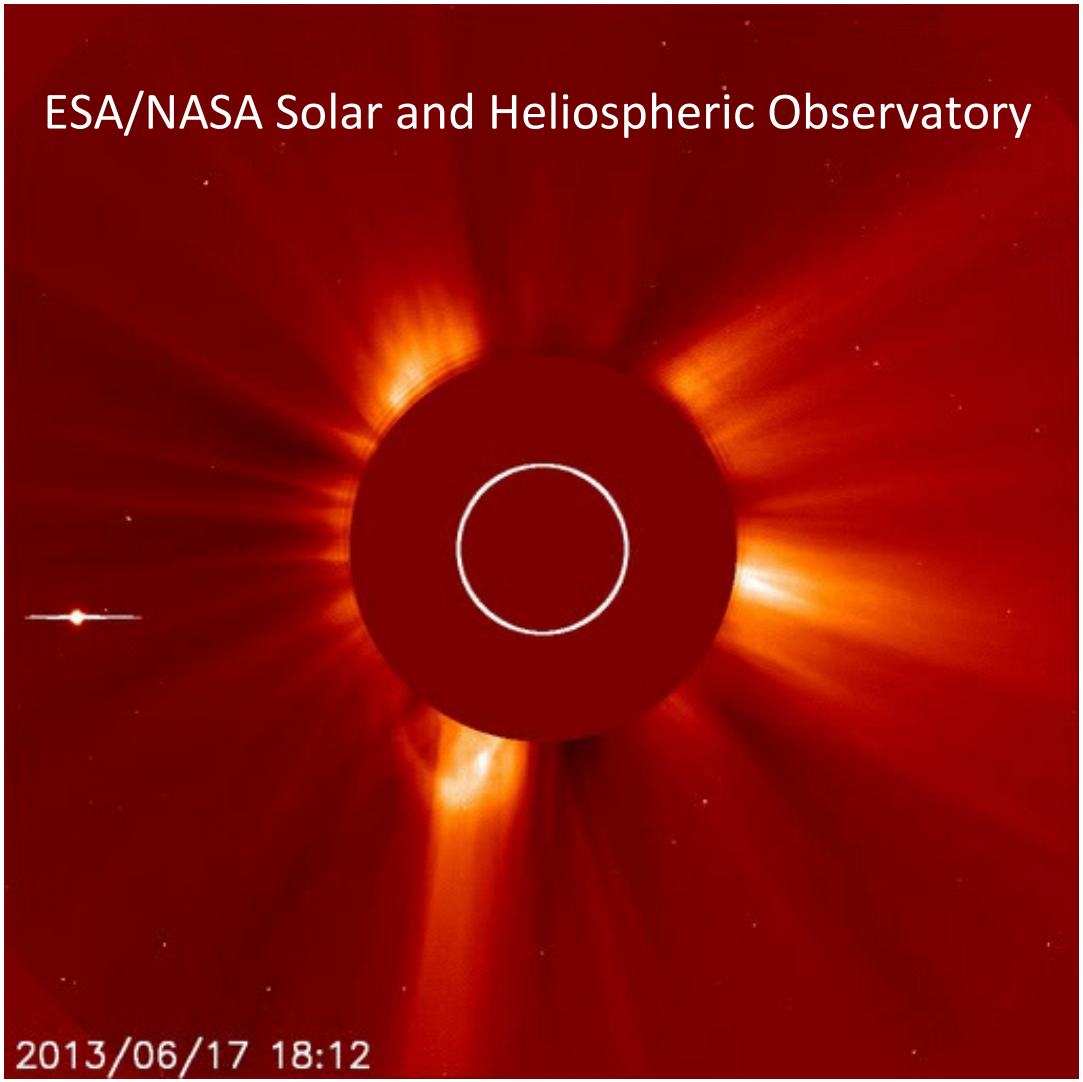




From NASA's Solar Dynamics Observatory

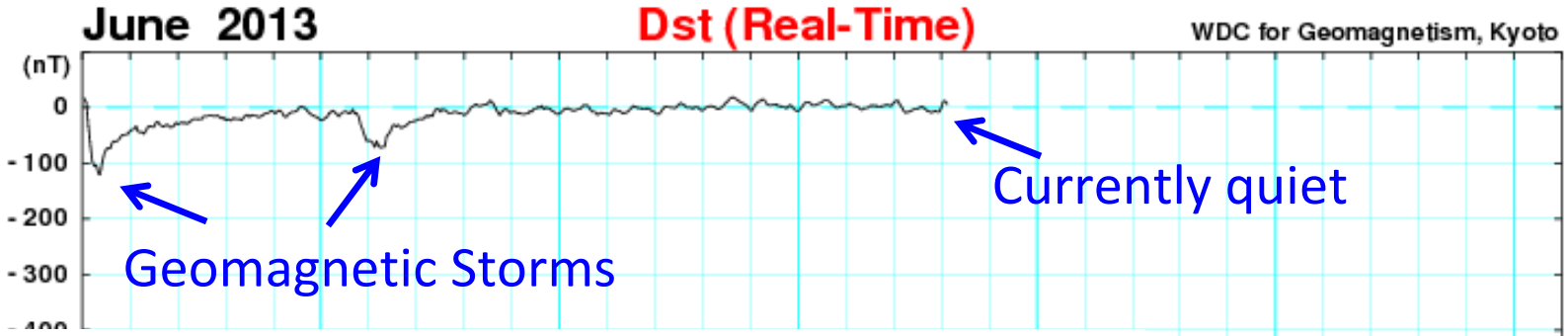
Today's Sun

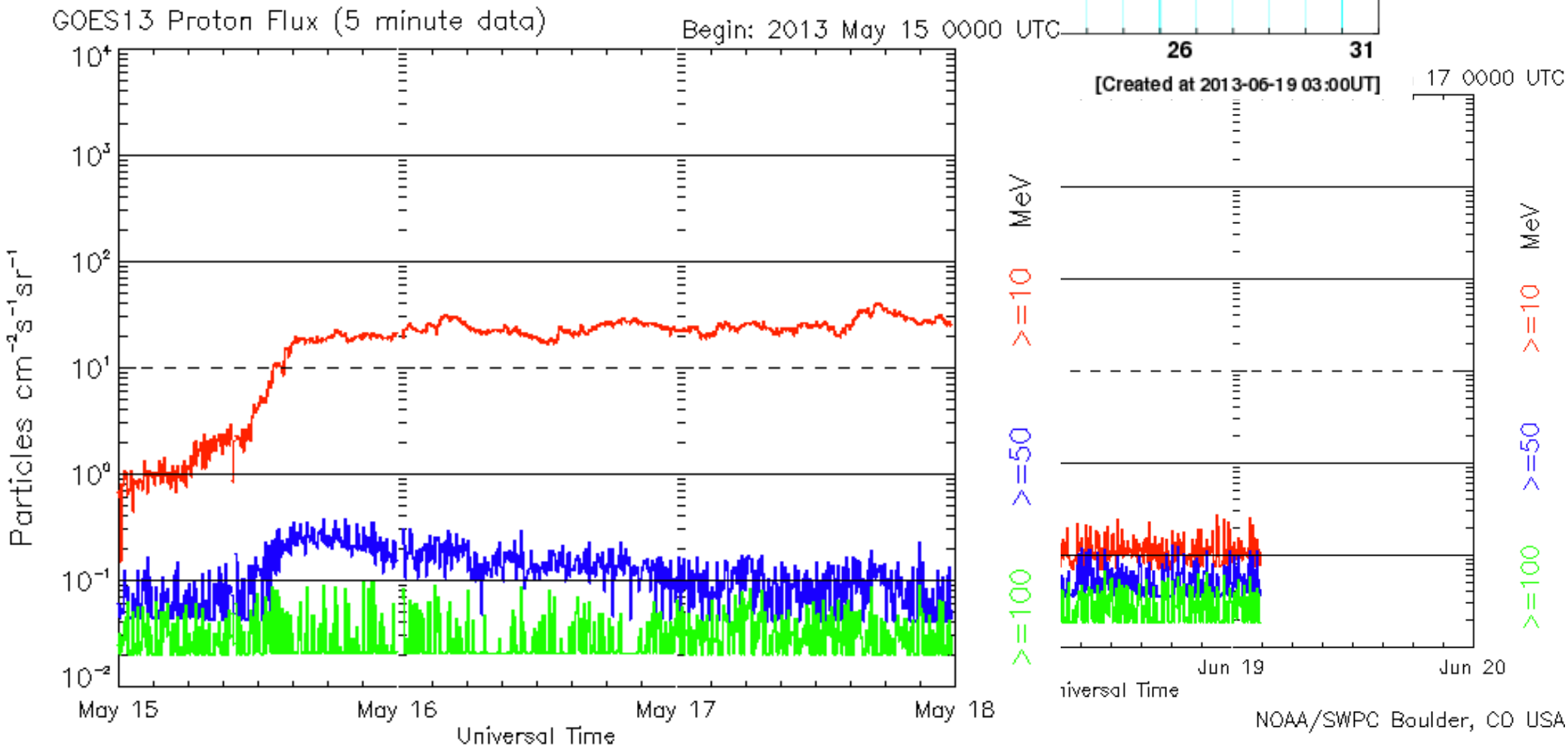
MiniMax24 Campaign collects info on all events



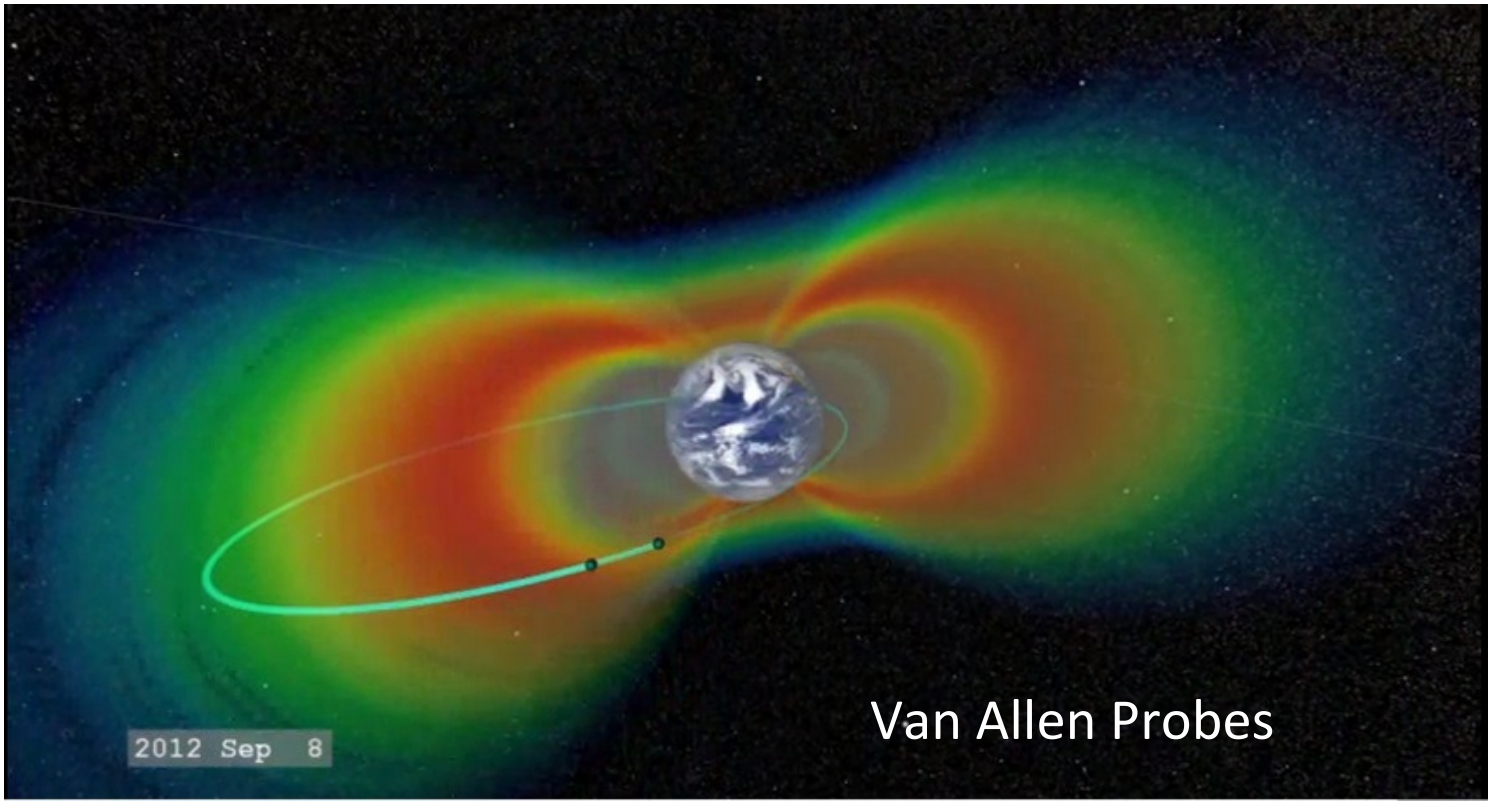
International Study of Earth-Affecting Solar Transients (ISEST) to analyze these events

Space Weather



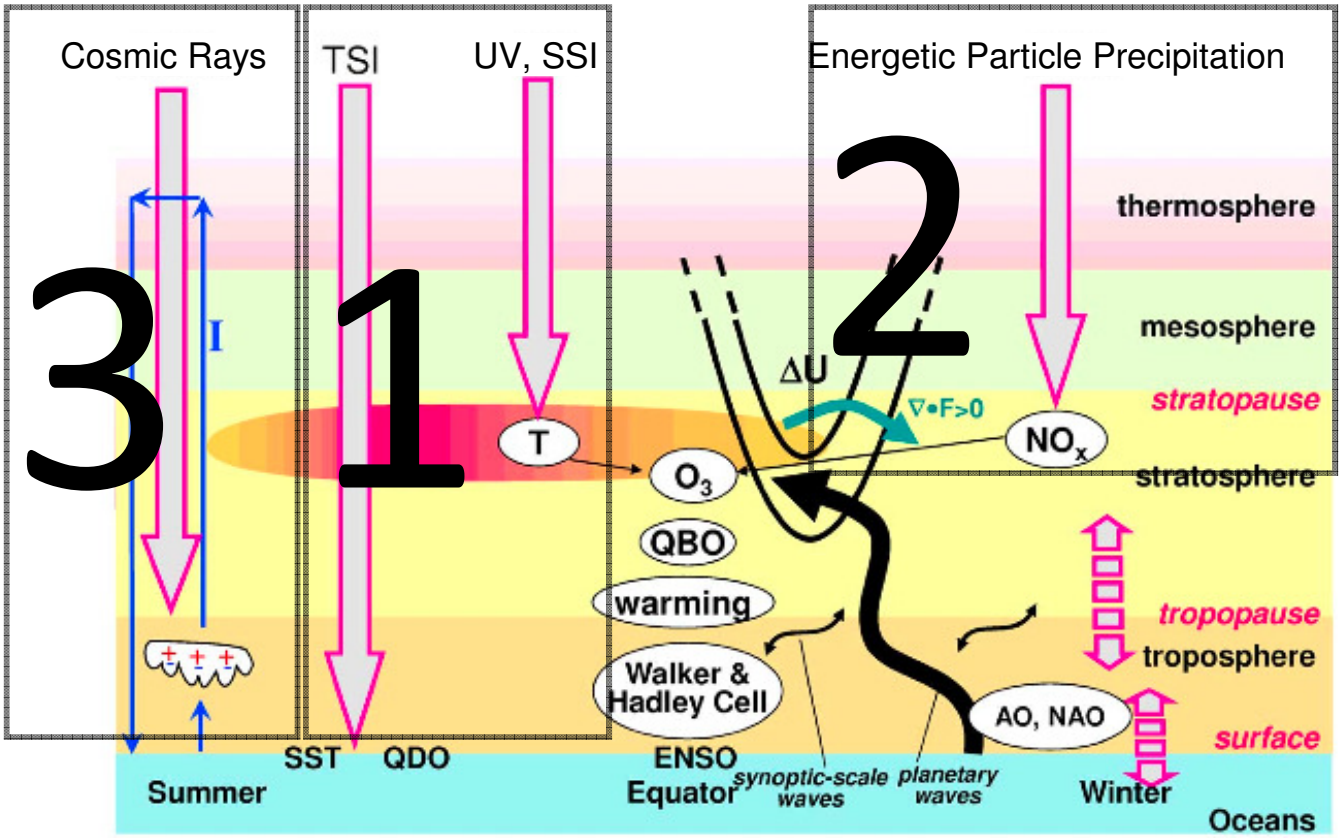


Specification and Prediction of the Coupled Inner-Magnetospheric Environment (SPeCIMEN)



- Radiation belts contains energetic protons & electrons that affect sustainability of space activities
- Radiation belts change in response to changes in solar mass output
- There are many weather and communication satellites in the inner magnetosphere
- New data from NASA's Van Allen probes to boost the SPeCIMEN study

ROSMIC: Role Of the Sun and the Middle atmosphere/thermosphere/ionosphere In Climate



1. Total Solar Irradiance (TSI). Surface

   Solar Spectral Irradiance (SSI). Stratosphere

2. Energetic Particle Precipitation. Stratosphere-mesosphere-lower thermosphere

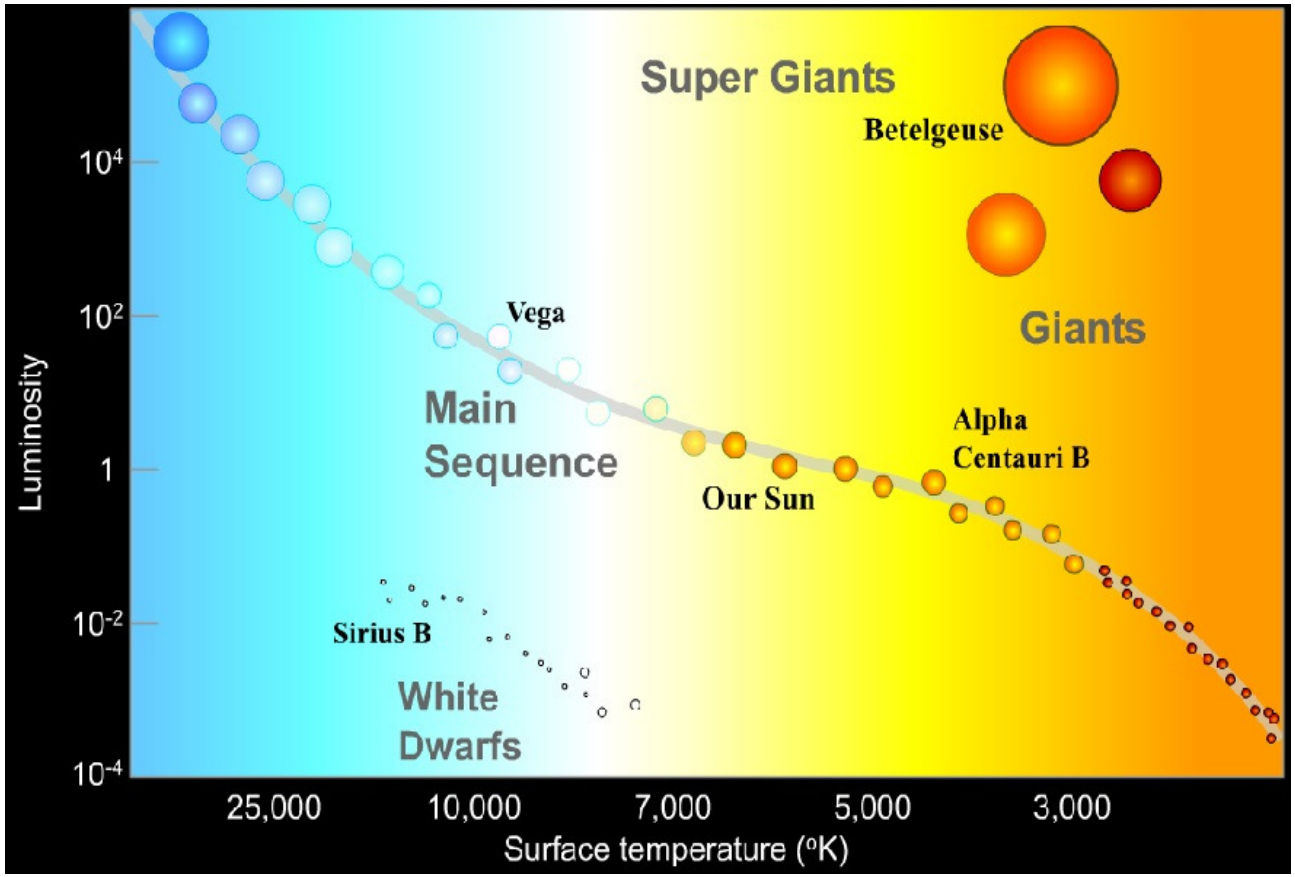
3. Cosmic Rays. Lower stratosphere-troposphere

upward energy flow in the form of waves

Figure 21. Schematic diagram of solar influence on climate based on *Kodera and Kuroda* [2002]. Shown are the direct and indirect effects through solar irradiance changes (TSI and UV) with respect to S_{max} as well as corpuscular radiation effects (energetic particles and GCRs). The two dashed arrows denote the coupling between the stratosphere and the troposphere and the coupling between the ocean and the atmosphere.

Solar Influence on Climate in the Context of Weak Solar Activity

Solar Evolution and Extrema (SEE)



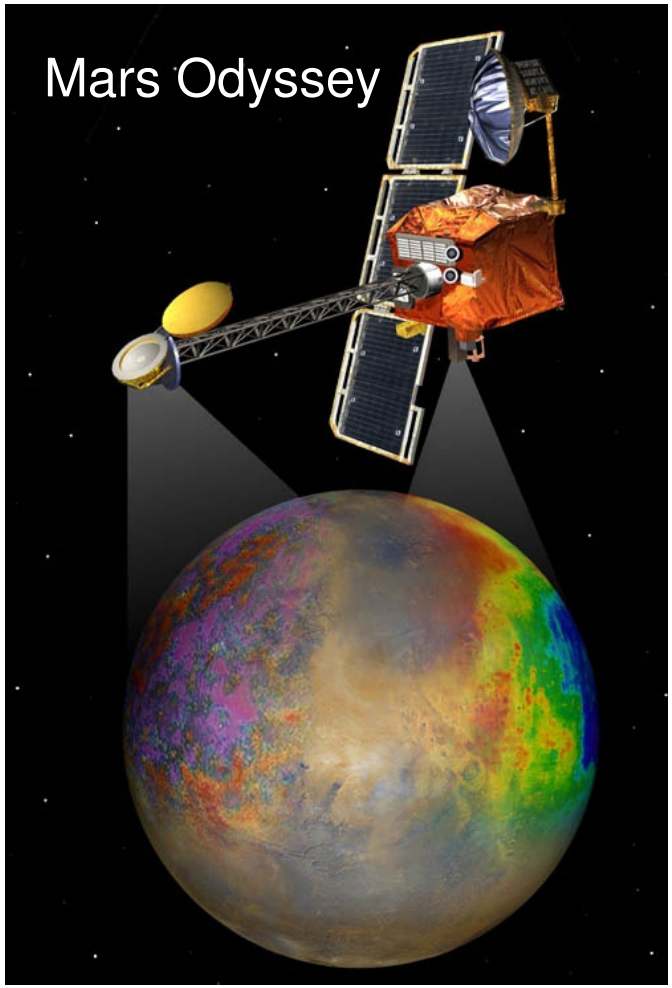
Reproduce magnetic activity in dynamo simulations

Amalgamate the best current models and observations for solar spectral and mass output over the Earth's history

Determine the size and expected frequency of extreme solar events [flares and coronal mass ejections (CMEs)]

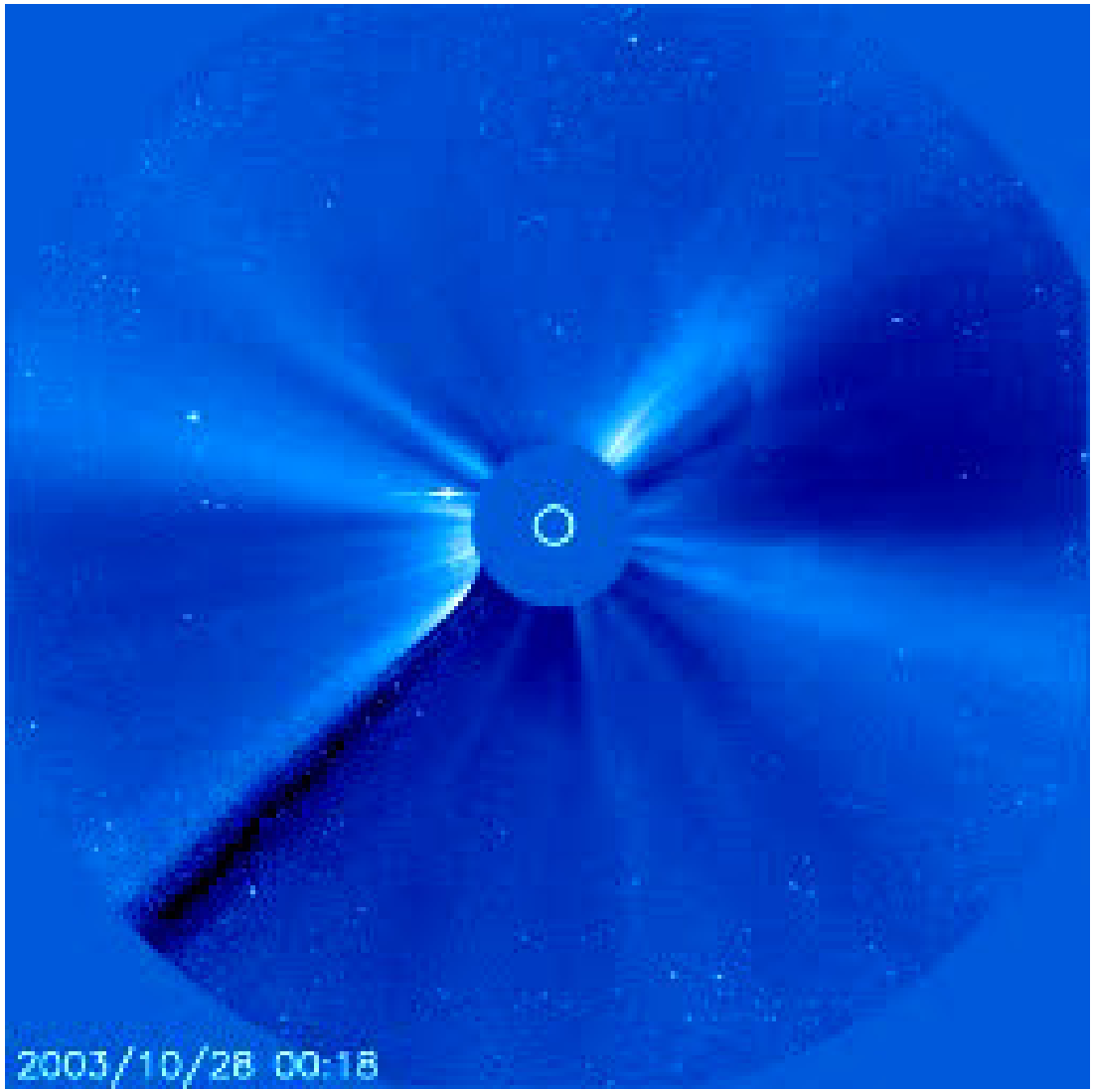
Solar Activity in a Broader Context

Knowledge on Extreme Solar Events Important in Designing Interplanetary Spacecraft



MARIE: The Martian Radiation Environment Experiment was destroyed by the Halloween 2003 extreme solar events

SOHO coronagraph movie showing two CMEs



Conclusions

- The VarSITI program is the next scientific program of SCOSTEP (2014- 2018)
- VarSITI has four elements dealing with current and urgent issues in Solar Terrestrial Connection
- VarSITI Flavor will be added to the Capacity Building and Outreach activities
- Any global cooperation in making the best use of the VarSITI program will be appreciated

SEE summary slide

Name: Solar Evolution and Extrema (SEE)

Goals and Objectives: 1) Reproduce magnetic activity as observed in the Sunspot and cosmogenic records in dynamo simulations, 2) Amalgamate the best current models and observations for solar spectral and wind output over the Earth's history, and 3) Determine the size and expected frequency of extreme solar events such as flares and coronal mass ejections (CMEs).

Questions: 1) Are we at the verge of a new grand minimum? If not, what is the expectation for cycle 25? 2) Does our current best understanding of the evolution of solar irradiance and mass loss resolve the "Faint Young Sun" problem? What are the alternative solutions? 3) For the next few decades, what can we expect in terms of extreme solar flares and storms, and also absence of activity? Another Carrington event? What is the largest solar eruption/flare possible? What is the expectation for periods with absence of activity?

Data/Theory Model: Dynamo models, stellar evolution calculations including mass loss and rotation, early solar wind simulations, observations of solar-type stars, observations of very large events on stars, statistical analysis of event distributions.

Anticipated Outcome: 1) Dynamo Models for the near future, including a prediction for cycle 25, or for an upcoming grand minimum, 2) A timeline of solar activity -- spectral radiation, wind, CMEs -- from the Earth's formation up to the present, 3) A frequency distribution and near term likelihood prediction of extreme events.

Key Members: Piet Martens, Vladimir Obridko, Dibyendu Nandi

ROSMIC summary slide

Name: Role Of the Sun and the Middle atmosphere/thermosphere/ionosphere In Climate

Goals and objectives: To understand the impact of the Sun on the terrestrial middle atmosphere/lower thermosphere/ionosphere (MALTI) and Earth's climate and its importance relative to anthropenic forcing over various time scales from minutes to centuries.

Scientific questions:

(a) What is impact of solar forcing of the entire atmosphere? What is the relative importance of solar irradiance versus energetic particles?

(b) How is the solar signal transfered from the thermosphere to the troposphere?

(c) How does the coupling take place within the terrestrial atmosphere?

(d) What is the impact of anthropogenic activities on MALTI ?

(e) What are the signatures causes of long term MALTI variations?

(f) What are the characteristics of reconstructions and predictions of TSI and SSI?

(g) What are the implications of trends in the ionosphere/thermosphere for satellites and space debris?

Data/theory/modeling: Use existing data records plus new measurements from a wide range of ground based, in-situ, and space-based instruments. use/develop dedicated models for a better understanding of specific processes (e.g. gravity wave breaking, ice formation). Modify and apply global-scale models from the ocean to the thermosphere.

Anticipated outcome: Better understanding of the impact of solar activity on the entire atmosphere, relative to anthrogenic forcing and natural long term variability

Key members: F.-J. Luebken, Stan Soloman, Annika Seppala, W. Ward

SPeCIMEN summary slide

Name: Specification and Prediction of the Coupled Inner-Magnetospheric Environment (SPeCIMEN).

Goals and objectives: The quantitative prediction and specification of the Earth's inner magnetospheric environment based on Sun/solar wind driving inputs.

Questions: How does the inner magnetosphere respond as a coupled system to Sun/solar-wind driving?

Data/theory/modeling: A combination of physical and statistical (machine learning) modeling, theory, and observations from various platforms.

Anticipated outcome: A better understanding of the physical processes leading to a series of coupled, related models that quantitatively predict the dynamical evolution of the inner magnetospheric state.

Key members: Jacob Bortnik (USA), Craig Rodger (NZ), Richard Thorne (USA), Mark Clilverd (UK), Richard Horne (UK), Yoshi Miyoshi (Japan), David Shklyar (Russia), Ian Mann (Canada), Eric Donovan (Canada), Ioannis Daglis (Greece), Mark Lester (UK) [will be updated with representatives].

ISEST / MiniMax24 summary slide

Name: International Study of Earth-Affecting Solar Transients (ISEST)

Goals and objectives: Understand the propagation of solar transients through the space between the Sun and the Earth, and develop space weather prediction capability.

Questions: How do coronal mass ejections (CMEs) and corotating interaction regions (CIRs) propagate and evolve, drive shocks and accelerate energetic particles in the heliosphere?

Data/theory/modeling: Establish a database of Earth-affecting solar transient events including CMEs, CIRs, flares, and energetic particle events based on remote sensing and in-situ observations from an array of spacecraft, run observation campaigns such as MiniMax24, develop empirical, theoretical, and numerical models of CME propagation and prediction, validate models using observations

Anticipated outcome: A comprehensive database of Earth-affecting solar transients will be created, and space weather prediction capability will be significantly improved.

Key members: Jie Zhang (USA), Bojan Vrsnak (Croatia), Manuela Temmer (Austria), Nat Gopalswamy (USA)