

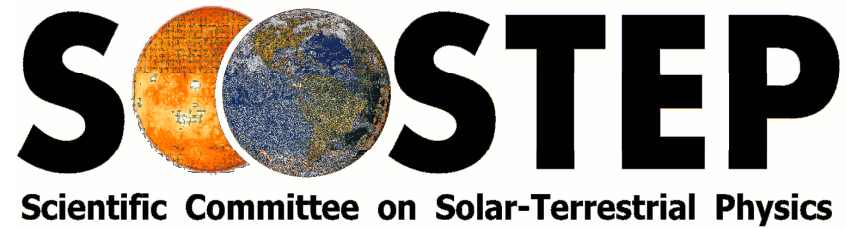
Variability of the Sun and Its Terrestrial Impact (VarSITI)

New SCOSTEP Scientific Program 2014-2018

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Activities

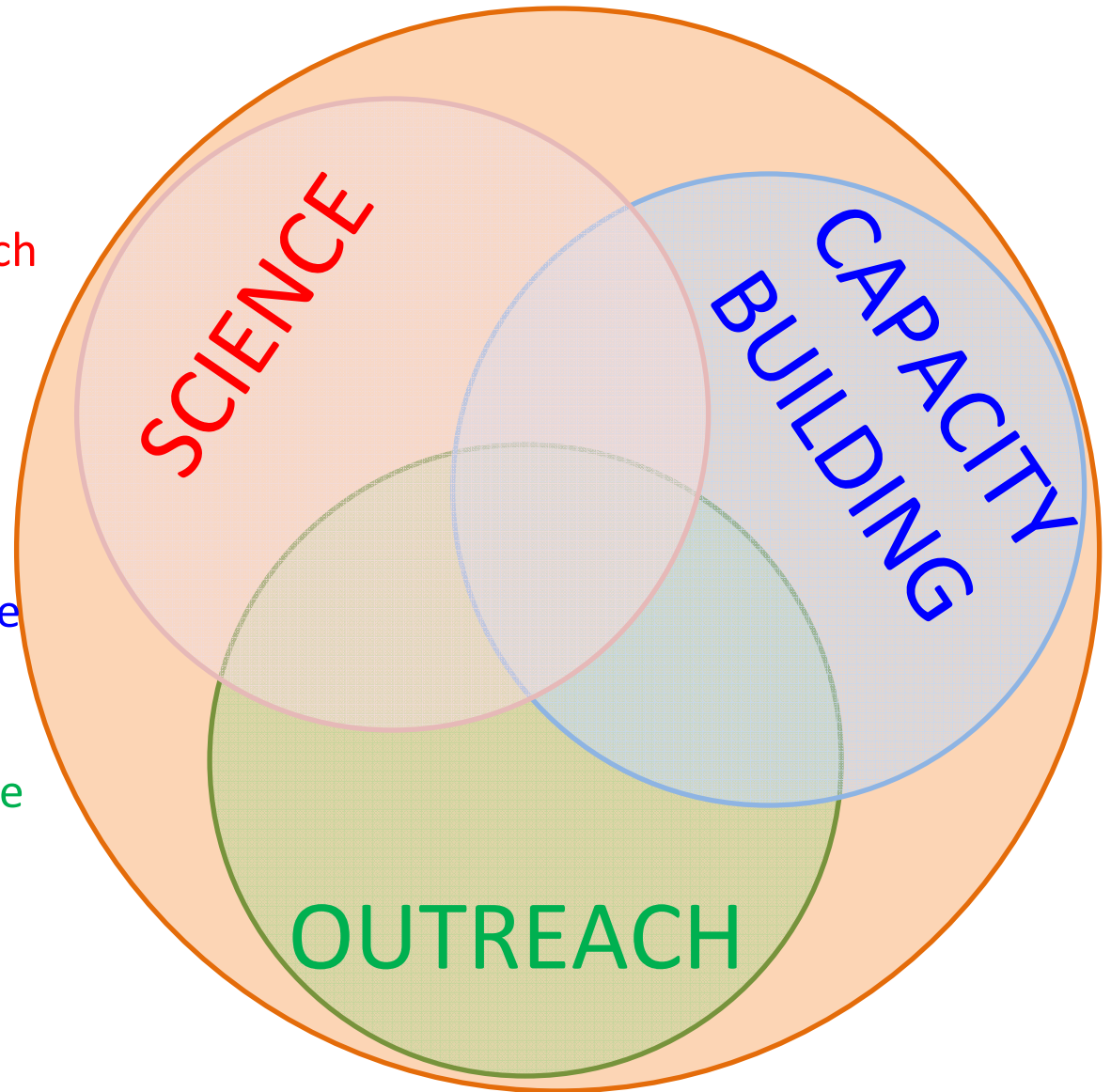


Long-term international interdisciplinary scientific research programs in solar terrestrial physics

Capacity Building activities to train graduate students and young scientists via Space Science Schools

Outreach activities to educate the public on the Sun-Earth System (e.g. comic books)

yorku.ca/scostep



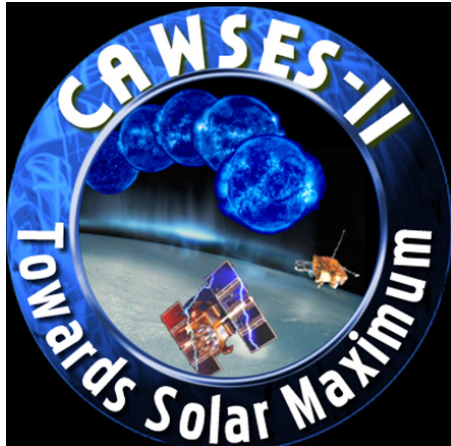
SCOSTEP Science Goal

To advance our understanding of solar terrestrial relationship using

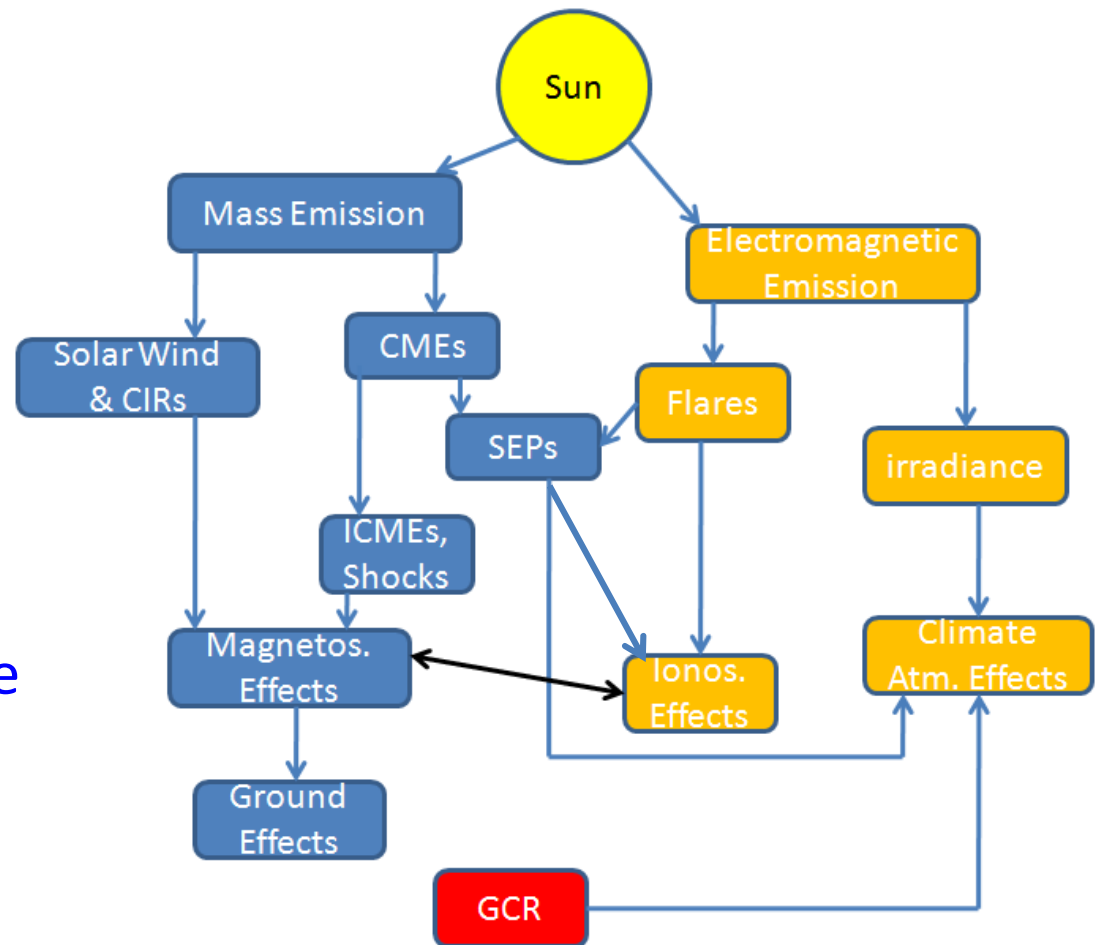
- Space- and ground-based data
- Cutting-edge models
- Theory
- International, Interdisciplinary Research

Design scientific programs accordingly

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

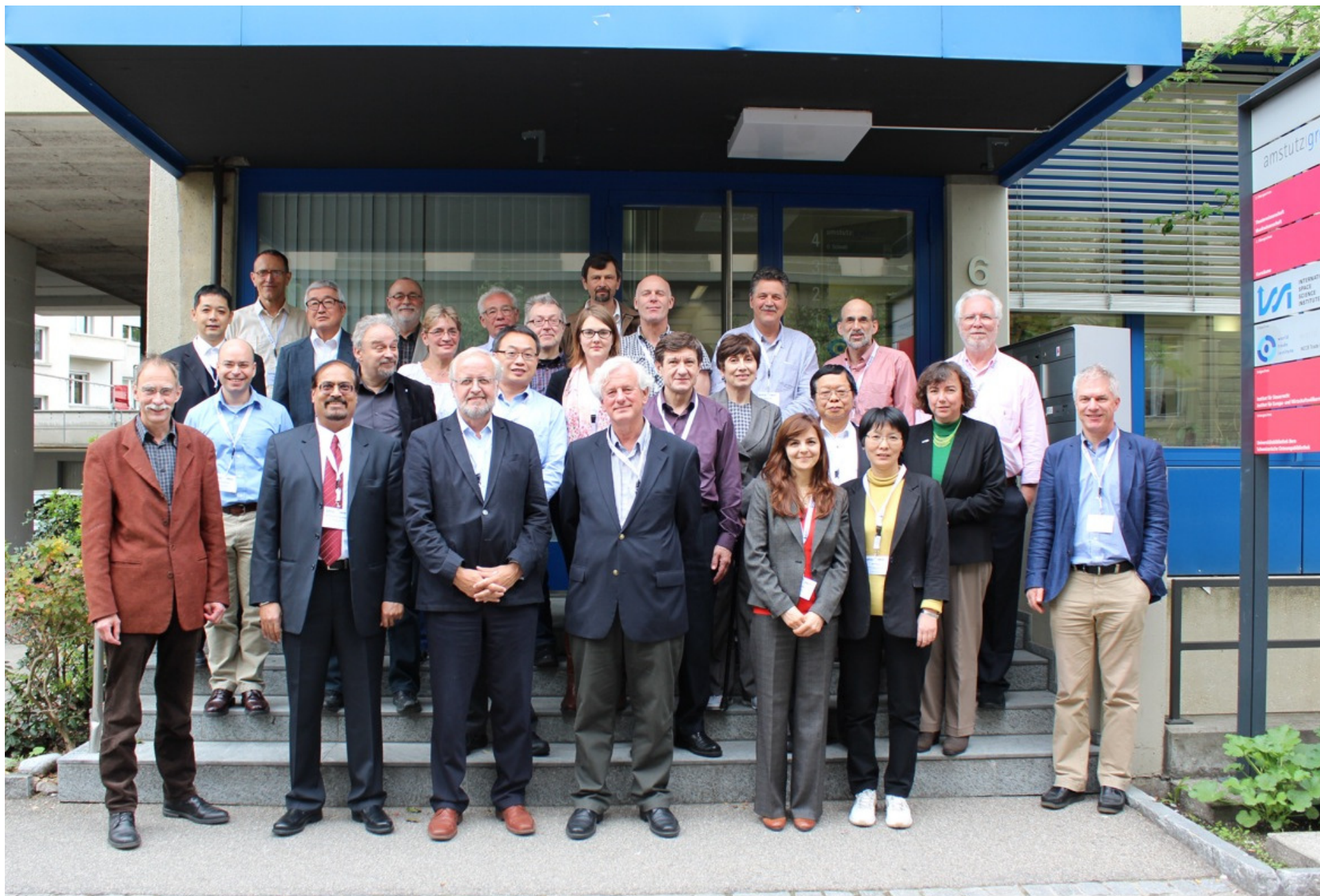


CAWSES ended in 2013

VarSITI was launched on January 13, 2014

Steps Towards VarSITI

- White papers were solicited for International, Interdisciplinary programs that can produce significant results in 4-5 years. Nine were received in 2012
- 27 international experts were invited (including the SCOSTEP Bureau and white-paper authors) brainstorming sessions at the International Space Science Institute (ISSI) in Bern, Switzerland 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**
- Further community input was solicited during the CAWSES-II Symposium in Nov 2013 (Japan) and at a Town Hall at the American Geophysical Union meeting in Dec 2013.
- VarSITI was launched on January 13, 2014 via press releases in member countries and social media (FaceBook, twitter, and YouTube)



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

Variability of the Sun and Its Terrestrial Impact



varsiti.org

**Dr. Katya Georgieva (Bulgaria) and
Dr. Kazuo Shiokawa (Japan) have been appointed
by SCOSTEP as VarSITI Co-chairs**

<http://www.youtube.com/watch?v=couR4MyxNP>

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Four Elements of VarSITI

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

Solar Evolution and Extrema (SEE)

Are we at the verge of a new grand minimum ?

Project Co-Leaders:

Prof. Petrus C Martens, Montana State University, USA

Prof. Dibyendu Nandi, Indian Institute of Science Education and Research, Kolkata, India

Prof. Vladimir N. Obridko, IZMIRAN, Moscow, Russia

Goals & Objectives:

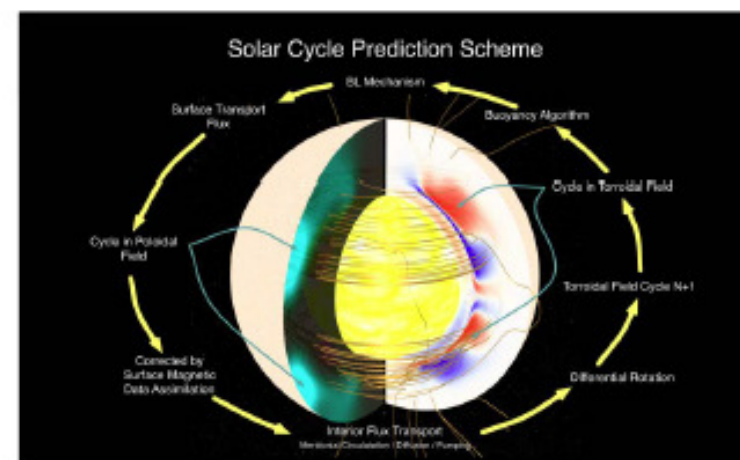
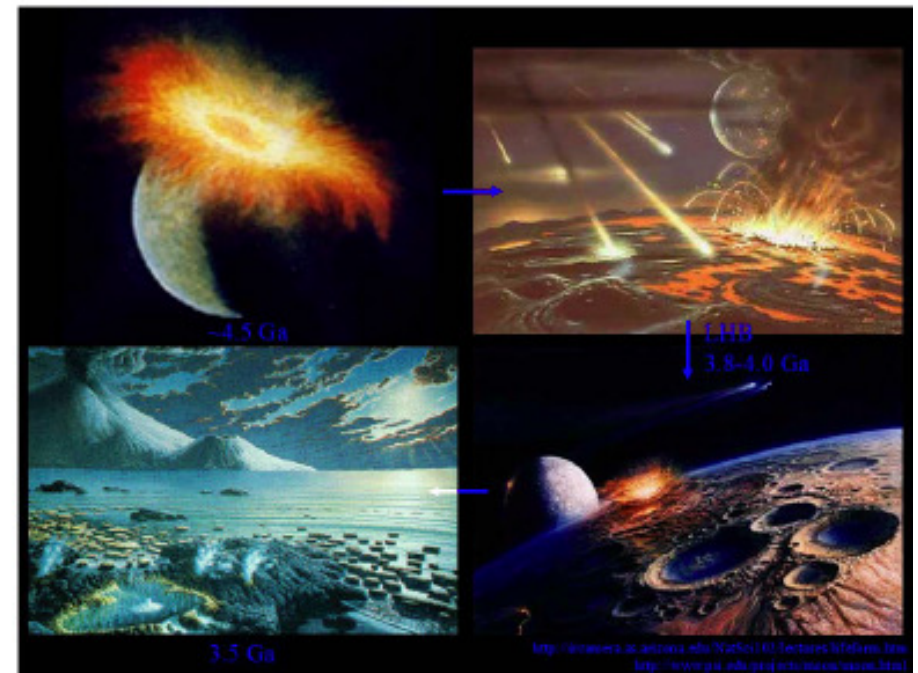
- 1) Reproduce magnetic activity as observed in the Sunspot record, including grand minima and extended minima in dynamo simulations,
- 2) Amalgamate the best current models and observations for solar spectral and wind output over the Earth's history,
- 3) Determine the size and expected frequency of extreme solar events.

Science 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) What is the largest solar eruption/flare possible? What is the expectation for periods with absence of activity?

Anticipated Outcome:

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



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

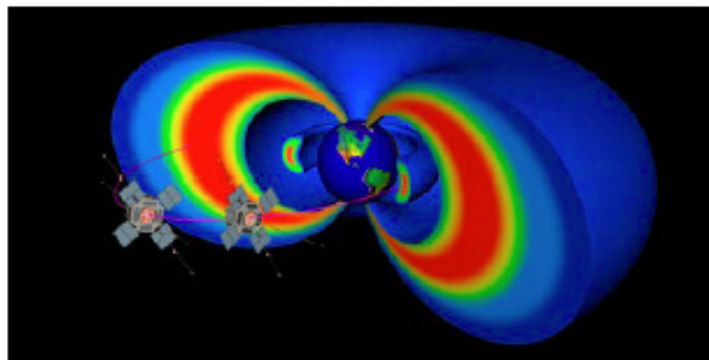
What is the physics behind radiation belt electron flux dynamics to enable the development of predictive models?

Project Co-Leaders:

Dr. Jacob Bortnik, University of California, Los Angeles USA

Prof. Craig J. Rodger, University of Otago, New Zealand

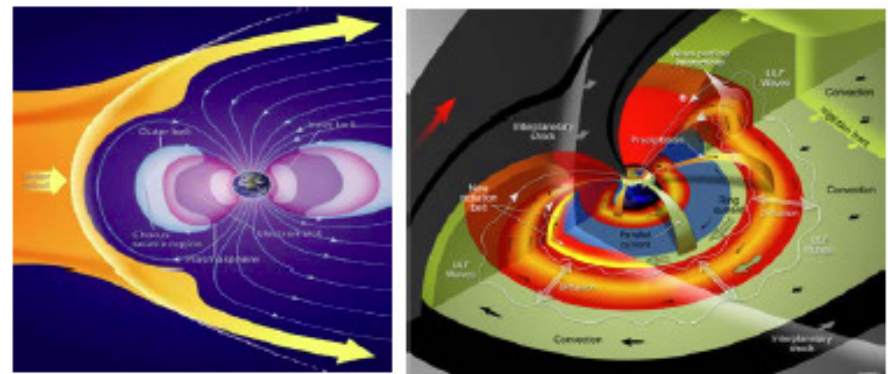
Goals & Objectives: The quantitative prediction and specification of the Earth's inner magnetospheric environment based on Sun/solar wind driving inputs.



The SPeCIMEN project is particularly timely given the recent launch of NASA's Van Allen Probes, the most recent mission to investigate the physical processes that control the dynamical behaviour of the Earth's radiation belts, eponymously named after its discoverer, Prof. James Van Allen. During the 5-year VanSIII programme multiple additional satellites are expected to be launched, providing a constellation of spacecraft focused on the inner magnetosphere.

Science Questions:

Can the state of the Earth's inner magnetosphere be specified and predicted to high accuracy, based on inputs from the Sun and solar wind?



A schematic of the inner magnetosphere, showing the high velocity solar wind impinging upon the Earth's magnetic field (yellow, left), compressing it, and flowing around the boundary forming the magnetopause. Closer to the Earth are pictured regions of high energy electrons in two distinct zones of radiation (inner belt, outer belt, and slot region separating them), the cool, high-density plasma region known as the plasmasphere, and a region dominated by an electromagnetic wave known as chorus. The formation of the radiation belts is an active area of research which is intimately coupled with the dynamics of the solar wind, plasmasphere, and chorus region.

Anticipated Outcome: A series of coupled, related models that quantitatively predict the dynamical evolution of the inner magnetospheric state (radiation belts, ring current, cold plasma distribution, plasmashet, convection electric field, and so on).



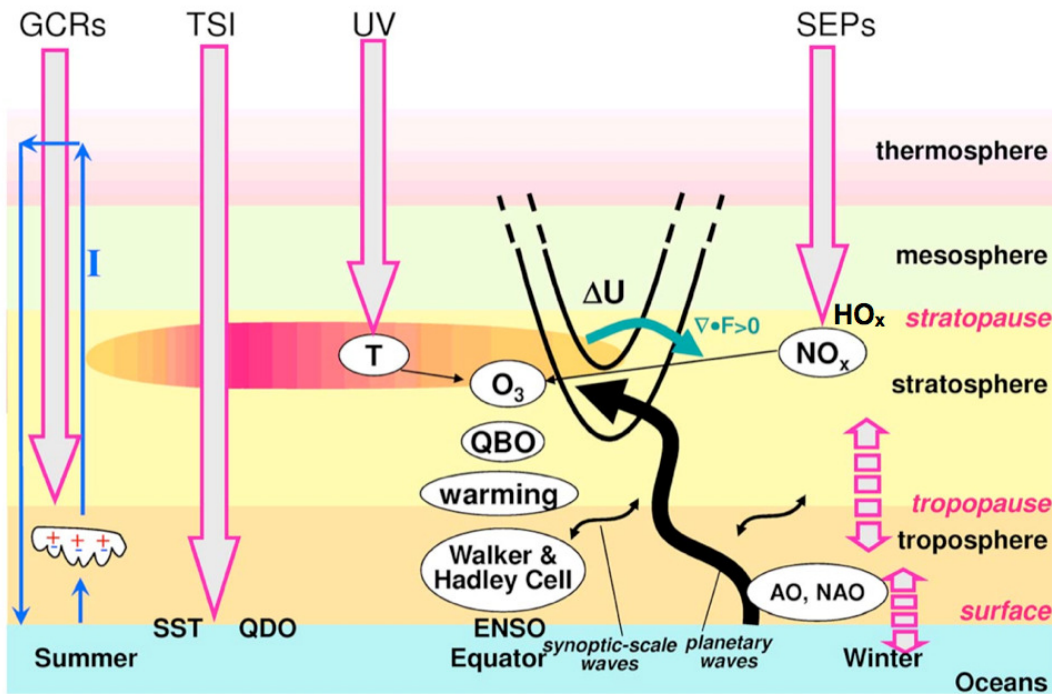
Role Of the Sun and the Middle atmosphere/thermosphere/ionosphere In Climate (ROSMIC)

Goals & 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 anthropogenic forcing over various time scales from minutes to centuries.

Anticipated Outcome: The development of a better understanding of the impact of solar activity on the entire atmosphere, relative to anthropogenic forcing and natural long term variability.

ROSMIC Co-chairs:

- Prof. Dr. Franz-Josef Lübken, Leibniz Institute of Atmospheric Physics, Germany
- Dr. Annika Seppälä, Finnish Meteorological Institute, Finland.
- Prof. William E. Ward, University of New Brunswick, Canada



Mechanisms of Solar Influence (after Gray et al, 2010)

Working Groups

- Solar Influence on Climate
 - Coupling by Dynamics
 - Trends in the MLT
 - Trends and Solar Influence in the Thermosphere
- Support scientific activity through workshops, conference sessions on their topic at international conferences, international campaigns, modelling comparisons, establishing data archives, etc.

The terrestrial atmosphere/ionosphere is a complex non-linear system which responds non-locally to external forcing (Solar variability, cosmic ray variations) and changes in its internal characteristics (such as anthropogenic changes to the constituent distributions, volcanic eruptions or large meteor collisions).

ROSMIC is directed toward identifying the effects of external forcing on and predicting the effects of internal changes to the atmosphere/ionosphere.

International Study of Earth-affecting Solar Transients/MiniMax24 (ISEST)

Can we predict the impact of solar transients on space weather?

Project Co-Leaders:

Prof. Jie Zhang, George Mason University, USA

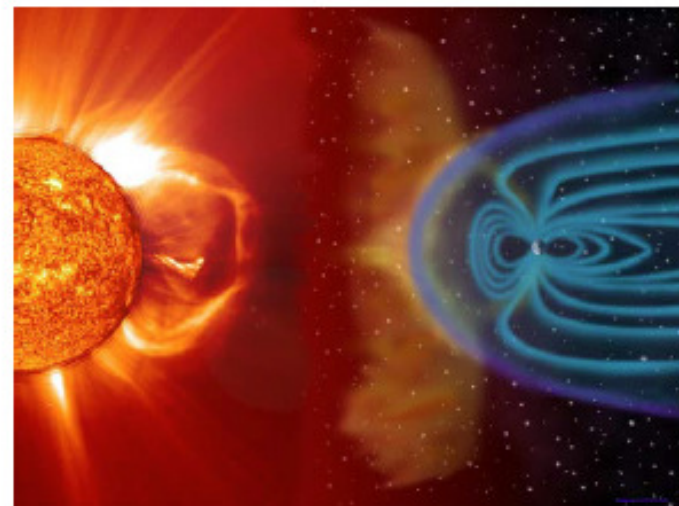
Prof. Manuela Temmer, University of Graz, Austria

Dr. Nat Gopalswamy, USA

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

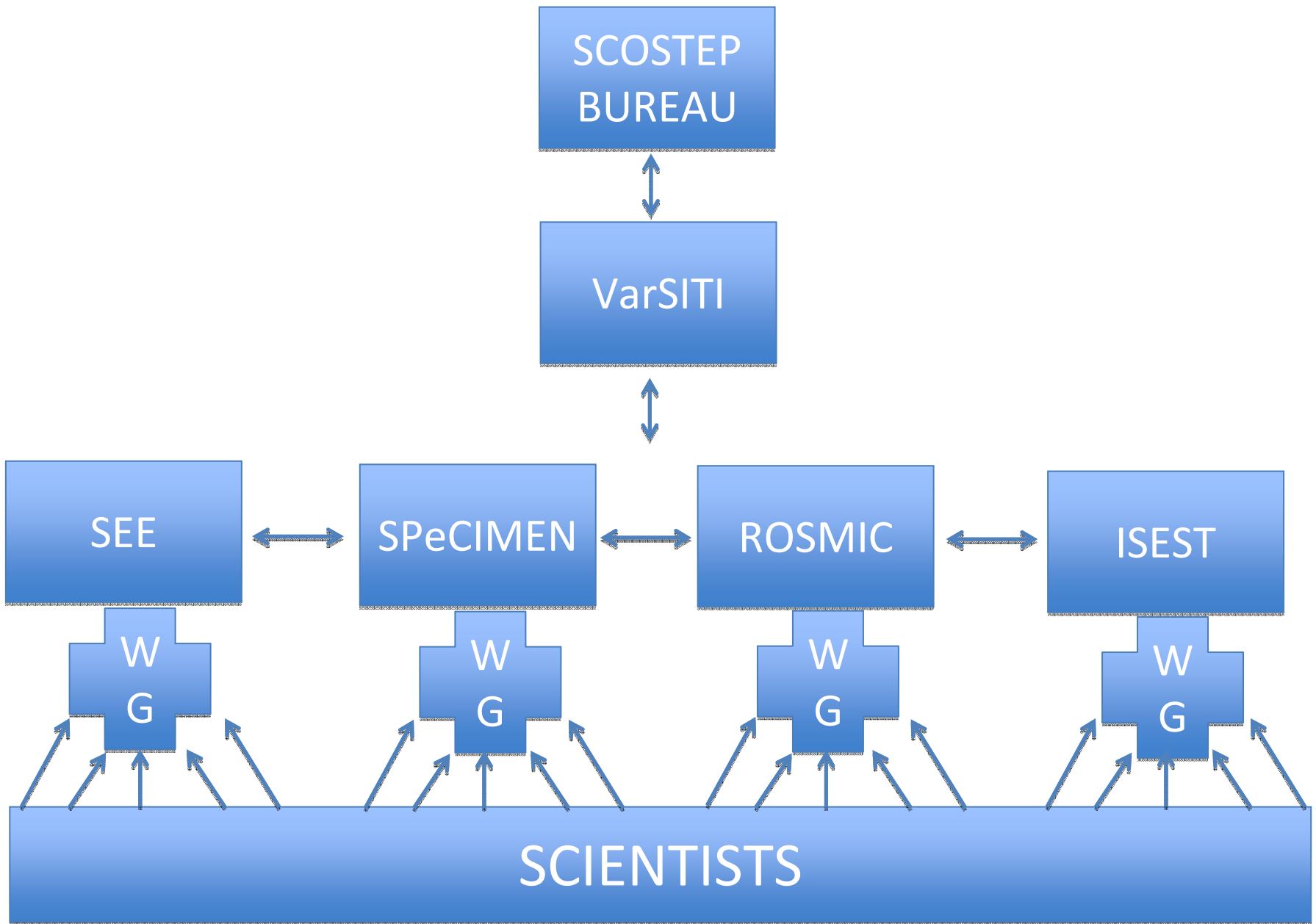
- 1) Carry out campaign study to integrate theory, simulations and observations in order to get a complete view and understand of the chain of cause-effect activities from the Sun to the Earth.
- 2) Use observations to identify all Earth-affecting flares, CMEs, SEPs and CIRs during the STEREO era and their solar sources.
- 3) Use theoretical studies and numerical simulations to understand the structure, evolution and dynamics of CMEs and the global context of transient events.
- 4) Carry out campaign study to integrate theory, simulations and observations in order to get a complete view of the chain of cause-effect activities from the Sun to the Earth.

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

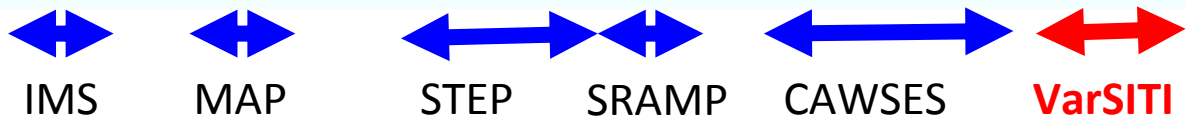
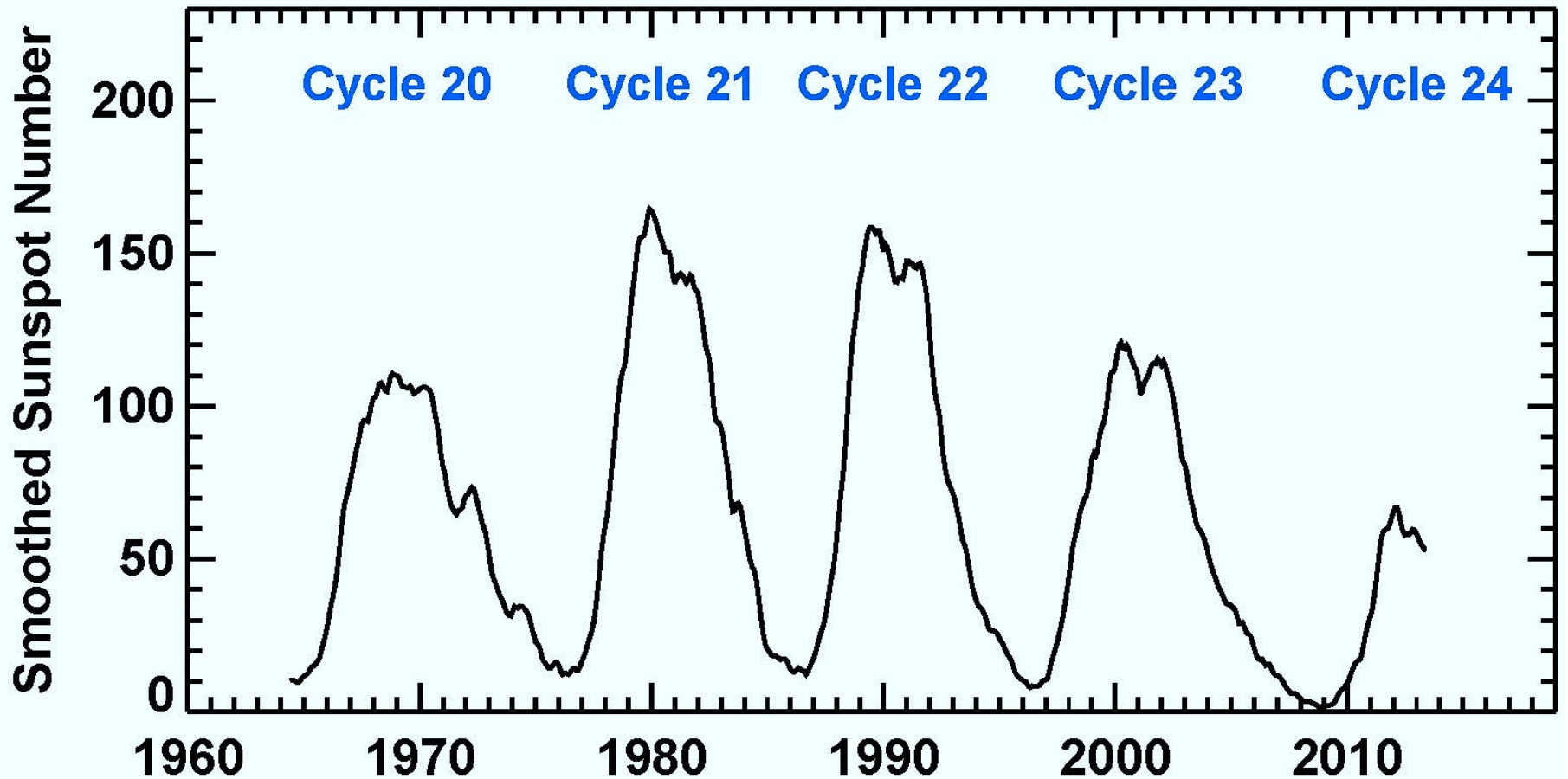


Data/theory/modeling: Establish a database of Earth-affecting solar transient events including CMEs, CIRs, flares, and energetic particle events based on remote sensing and in-situ observations from an array of spacecraft, run observation campaigns such as MiniMax24, develop empirical, theoretical, and 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. A significant improvement of space weather prediction to forecast the arrival time and expected intensity of solar transients.



Sunspot Number



The weak solar activity is an underlying theme of all the VarSITI Projects

PSMOS
EPIC
ISCS

First VarSITI Results at STP13



<http://stp13.csp.escience.cn/dct/page/1>

All are welcome!

Summary

- VarSITI is the new SCOSTEP scientific program to run during 2014-2018
- Scientists from all over the world will participate in the VarSITI program to advance Sun-Earth connection studies
- Solar terrestrial science will reach as many developing countries as possible via SCOSTEP's capacity building and outreach activities