Variability of the Sun and Its Terrestrial Impact

Lunch-time Meeting at COSPAR2014

August 4, 13:30-14:30

Room: S1-01

Kazuo Shiokawa and Katya Georgieva

VarSITI co-chairs

SCOSTEP

Scientific Committee on Solar-Terrestrial Physics

SCOSTEP is a Scientific Committee under ICSU. Its principal tasks are:

- **to promote international interdisciplinary programs in solar-terrestrial physics, and to organize and coordinate such programs of interest to, and approved by, at least two of the following bodies: IAU, IUGG, IUPAP, URSI, and COSPAR. Each specific program is normally of finite duration;**
- **to define the data relating to these programs that should be exchanged through the World Data Centers;**
- **to provide such advice as may be required by the ICSU bodies and World Data Centers concerned with these programs;**
- **to work with other ICSU bodies in the coordination of symposia in solar-terrestrial physics, especially on topics related to SCOSTEP's programs.**

International Programs operated by SCOSTEP

1976-1979: IMS (International Magnetosphere Study)

1982-1985: MAP (Middle Atmosphere Program)

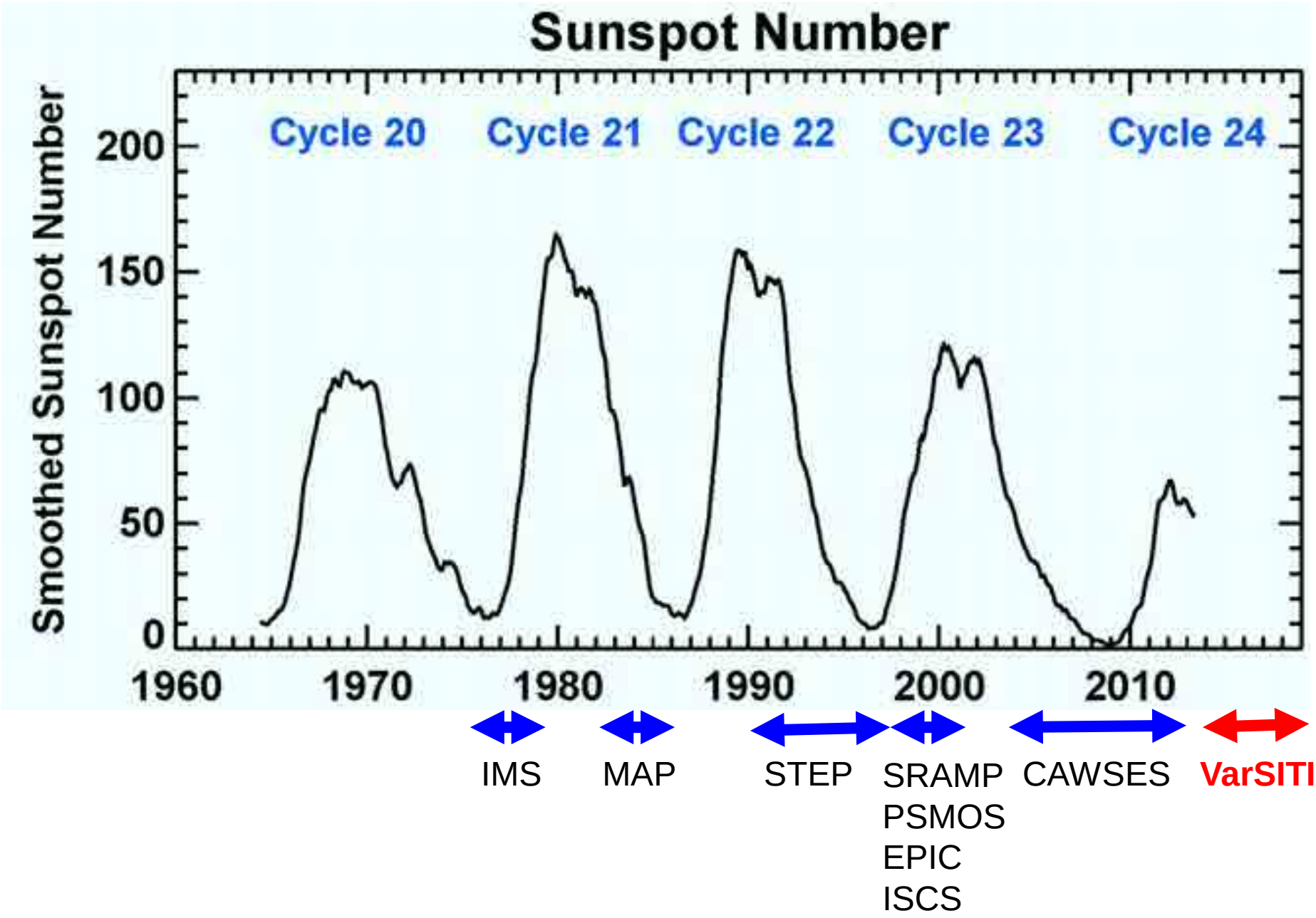
1990-1997: STEP (Solar-Terrestrial Energy Program)

1998-2002: Post-STEP（S-RAMP, PSMOS, EPIC, and ISCS)

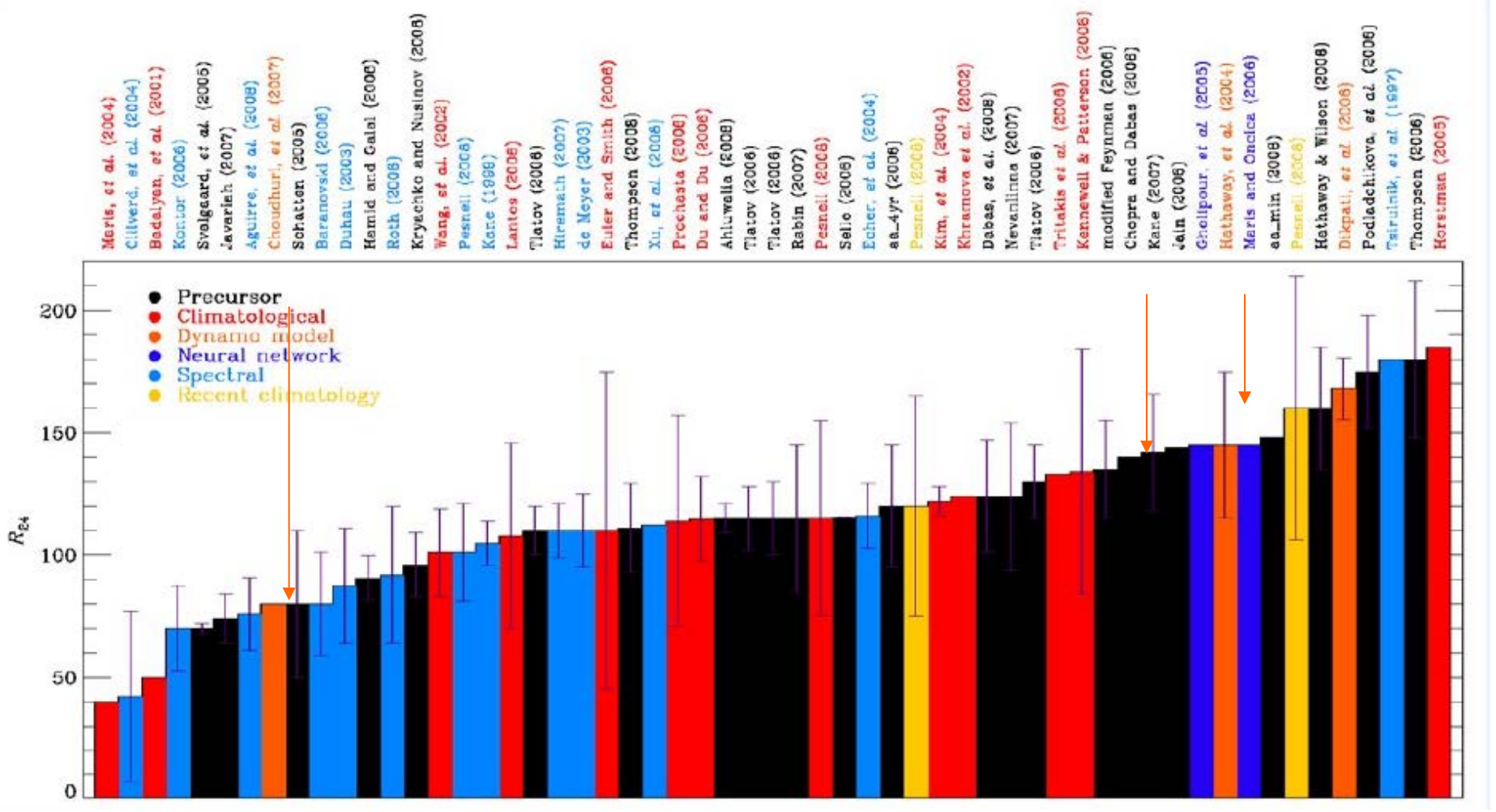
2004-2008: CAWSES (Climate and Weather of the Sun-Earth System）

2009-2013: CAWSES-II (Climate and Weather of the Sun-Earth System-II)

2014-2018: VarSITI (Variability of the Sun and Its Terrestrial Impact)

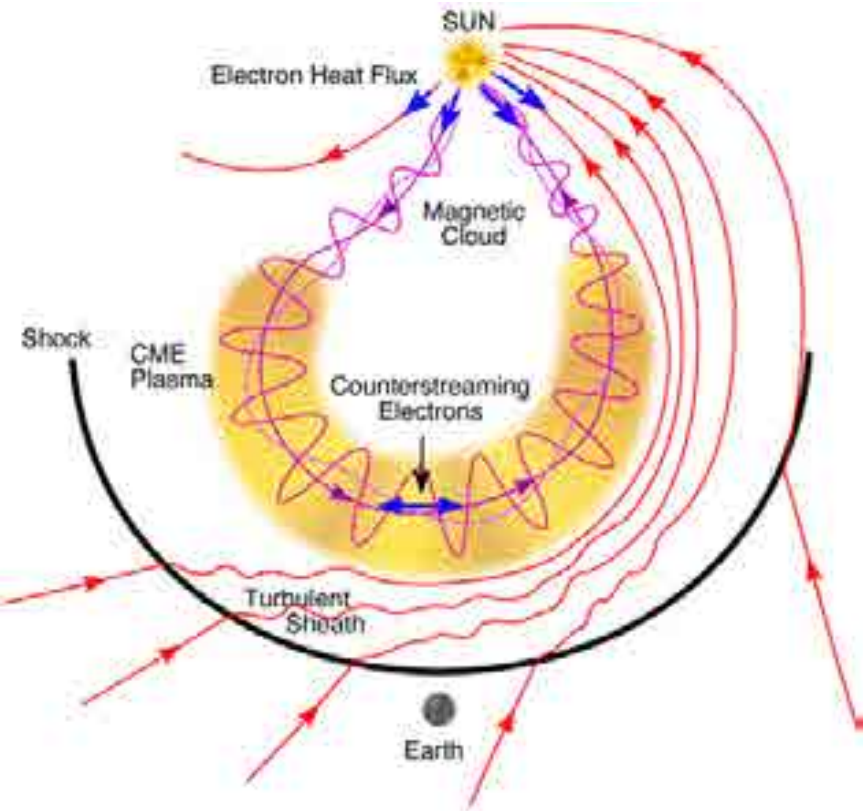

Sunspot Number
Smoothed Sunspot Number
200
150
100
50
0
Cycle 20
Cycle 21
Cycle 22
Cycle 23
Cycle 24
1960
1970
1980
1990
2000
2010
IMS
MAP
STEP
SRAMP
PSMOS
EPIC
ISCS
CAWSES
VarSITI

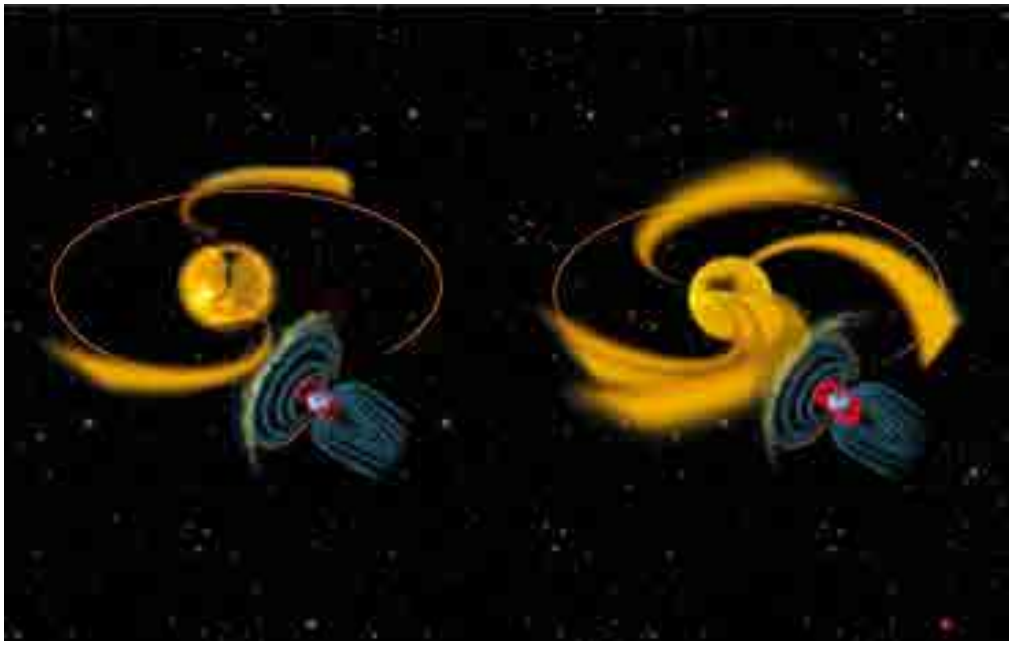
How well can we predict Sun's activity?



Predictions of sunspot cycle 24

How well do we understand the relation between solar events and the geoeffective disturbances?



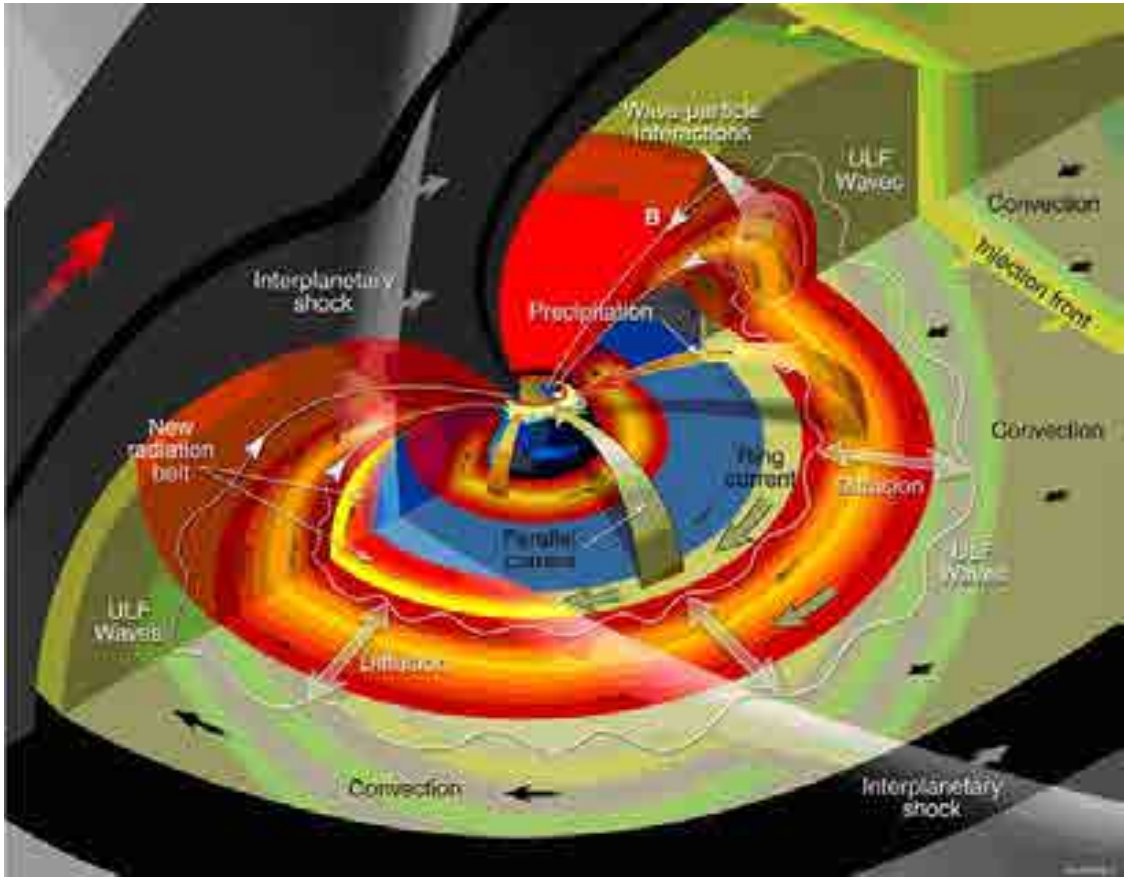


Can we predict a CME's magnetic field based on its solar origin?

Can we predict a high speed stream's speed?

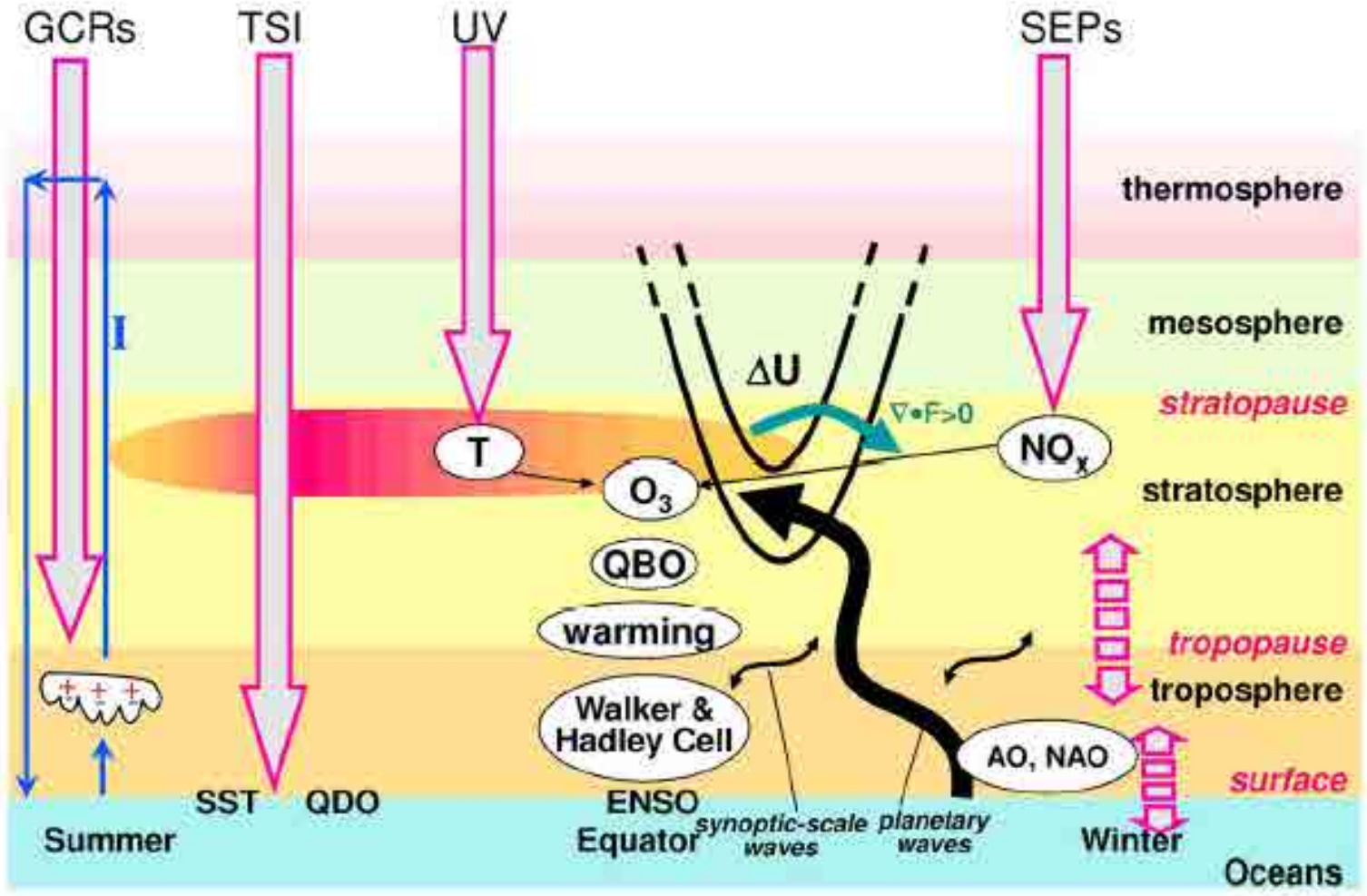
Do we know what happens to them during their way from the Sun to the Earth?

How well do we understand what happens in the Earth's magnetosphere based on inputs from the Sun and solar wind?



Can we go from modeling to predictions?

How well do we understand solar variability effects on the middle and lower atmosphere?



What is the relative importance of Solar and anthropogenic Influences on Climate?

VarSITI (Variability of the Sun and Its Terrestrial Impact) 2014-2018

VarSITI will focus on the solar activity variability and its consequences on Earth, for various time scales from the order of thousands years to milliseconds, and for various locations and their connections from the solar interior to the Earth's atmosphere.

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)**

VarSITI (Variability of the Sun and Its Terrestrial Impact) 2014-2018

We encourage more communication between solar and heliosphere scientists and Earth's magnetosphere, ionosphere, and atmosphere scientists.

- **Campaign data analysis from the Sun to the Earth**
- **Web pages (www.varsiti.org)**
- **Mailing lists (currently 401 members are registered)**
- **Newsletters**
- **Meetings (financial support is available)**

www.varsiti.org

VarSITI

Variability of the Sun and Its Terrestrial Impact

About | Organization | Projects | Meetings | Publications | Resources | News | HOME

Good Afternoon.

Welcome to: Variability of the Sun and Its Terrestrial Impact (VarSITI)

Variability of the Sun and Its Terrestrial Impact

The **VarSITI** program is the next scientific program of **SCOSTEP** (2014-2018)

VarSITI was defined based on a community effort in the form of a forum organized by the **I**nternational **S**pace **S**cience **I**nstitute (**ISSI**) in *Bern* during *May 7-8, 2013*. The **VarSITI** program will strive for international collaboration in data analysis, modeling, and theory to understand how the solar variability affects Earth.

The **VarSITI** program will have ***four scientific elements*** that address solar terrestrial problems keeping the current low solar activity as the common thread:

- ✓ **SEE** (**S**olar **E**volution and **E**xtrema),
- ✓ MiniMax24/**ISEST** (**I**nternational **S**tudy of **E**arth-affecting **S**olar **T**ransients),
- ✓ **SPeCIMEN** (**Spe**cification and Prediction of the **C**oupled **I**nner-**M**agnetospheric **En**vironment), and
- ✓ **ROSMIC** (**R**ole **O**f the **S**un and the **M**iddle atmosphere/thermosphere/ionosphere **I**n **C**limate).

Variability of the Sun and Its Terrestrial Impact (VarSITI)
SEE / ISEST-Minimax24 / SPeCIMEN / ROSMIC
http://www.varsiti.org/

Vol. 1, March 2014

VarSITI Newsletter

Inside this issue

Article 1.

About the VarSITI

Variability of the Sun and Its Terrestrial Impact

K. Georgieva[1] and K. Shiokawa[2]

[1]Space Research and Technologies Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria

[2]Solar-Terrestrial Environment Laboratory, Nagoya University, Nagoya, Japan

The last solar minimum in 2008-2009 and the current solar minimum of sunspot cycle 24 show much lower activities compared with the previous two solar cycles 22 and 23. The scientists in the solar-terrestrial physics are watching very low solar activities and their consequences on Earth, which have never been observed since modern scientific measurements become available. The current solar dynamo theories are unable to predict the long-term solar activity variations. It is not clear whether the last deep solar minimum and the current low solar maximum may signal the end of the recent period of relatively high solar activity, and what long-term solar activity variations we can expect in the future. Moreover, it is not clear to which extend our present understanding of how the Sun influences the geospace, which is based on instrumental observations taken during only the recent period

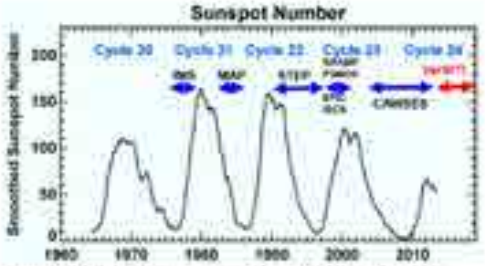


Figure 1. Variation of sunspot numbers and SCOSTEP programs. VarSITI is carried out during the lowest solar activities since the modern scientific observations become available.

Variability of the Sun and Its Terrestrial Impact (VarSITI)
SEE / ISEST-Minimax24 / SPeCIMEN / ROSMIC
http://www.varsiti.org/

Vol. 2, July 2014

VarSITI Newsletter

Inside this issue

Project SPECIMEN/ROSMIC

Article 1:

Coordinated investigations of solar, planetary radio emission, solar wind and Earth's ionosphere carried out in Ukraine with the world's largest radio telescopes

A. A. Konovalenko[1], N. N. Kalinichenko[1], O. A. Lytvynenko[1], V. V. Dorovskyi[1], V. N. Melnik[1], A. I. Brazhenko[2], V. V. Zakharenko[2], A. A. Stanislavskii[2], and V. A. Shepelev[3]

[1]Institute of Radio Astronomy of NASU, Kharkov, Ukraine

[2]Observatory URAN-4 of Institute of Radio Astronomy NASU, Odessa, Ukraine

[3]Poltava gravimetrical observatory of Institute geophysics NASU, Poltava, Ukraine

Ukraine has a substantial experimental base of radio remote sensing for research of VarSITI problems. Part of all the base includes the largest in the world decametre radio telescope UTR-2 and the URAN system of radio telescopes (Figure 1).

Figure 1. URAN decametre radio telescope system on Ukraine map: Radio telescope UTR-2 URAN-1, URAN-2, URAN-3 and URAN-4. They operate at the frequencies from 9 to 32 MHz.

Distributed through the VarSITI mailing list

VarSITI Registration Sheet for mailing list

VarSITI Registration sheet	Date:	Meeting name:
Please sign your name and e-mail address to register into the VarSITI mailing list		

first name	last name	e-mail address	country	interest of projects (choose as many as you like)
				SEE ISEST/Minimax SPeCIMEN ROSMIC ALL
				SEE ISEST/Minimax SPeCIMEN ROSMIC ALL
				SEE ISEST/Minimax SPeCIMEN ROSMIC ALL
				SEE ISEST/Minimax SPeCIMEN ROSMIC ALL
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Upcoming meetings related to VarSITI

Conference	Date	Location	Contact Information
8th IAGA/ICMA/SCOSTEP Workshop on Long-Term Changes and Trends in the Atmosphere	Jul. 28-31, 2014	Cambridge, UK	www.antarctica.ac.uk/trends2014
Asia Osceania Geosciences Society (AOGS) 11th Annual Meeting	Jul. 28- Aug. 1, 2014	Sapporo, Japan	http://www.asiaoceania.org/aogs2014/
40th COSPAR Scientific Assembly	Aug. 2-10, 2014	Moscow, Russia	https://www.cospar-assembly.org/
5th IAGA/ICMA/SCOSTEP Workshop on Vertical Coupling in the Atmosphere-Ionosphere System	Aug. 11-15, 2014	Antalya, Turkey	http://5thiagaworkshop.akdeniz.edu.tr/en
31st URSI General Assembly and Scientific Symposium	Aug. 16-23, 2014	Beijing, China	http://www.chinaursigass.com/
12th Asia-Pacific Regional IAU Meeting (APRIM 2014)	Aug. 19-22, 2014	Daejeon, Korea	http://www.aprim2014.org/
AGU Chapman Conference on Low-Frequency Waves in Space Plasmas	Aug. 31- Sep. 5, 2014	Juju Island, Korea	http://chapman.agu.org/spaceplasmas/waves-spaceplasmas/
14th European Solar Physics Meeting	Sep. 8-12, 2014	Trinity College, Dublin, Ireland	http://www.espm14.ie/
International Conference on "Geospace Revisited"	Sep. 15-20, 2014	Rhodes, Greece	http://geospacerev.space.noa.gr/
2nd ANGWIN Workshop	Sep. 22-24, 2014	Logan, UT, USA	
SCOSTEP's 13th Quadrennial Solar-Terrestrial Physics Symposium (STP 13)	Oct. 12-17, 2014	Xi'an, Shanxi, China	http://stp13.csp.escience.cn/dct/page/1
New Challenges in the Study of the Impact of Solar Variability and on Climate	Oct. 13-17, 2014	Trieste, Italy	
12th International Conference on Substorms (ICS-12)	Nov. 10-14, 2014	Ise-Shima, Japan	http://www.stelab.nagoya-u.ac.jp/ICS-12/
International School on Space Weather, GNSS, GIS Internet and Data base	Nov. 10-21, 2014	University of Koudougou, Burkina Faso	

Database development is also important for VarSITI.

- **Discussion for coordination between SCOSTEP and WDS (World Data System) is going on.**

- **Example: IUGONET meta-database (a Japanese consortium) (http://www.iugonet.org/)**

IUGONET: Inter-university Upper atmosphere Global Observation NETwork

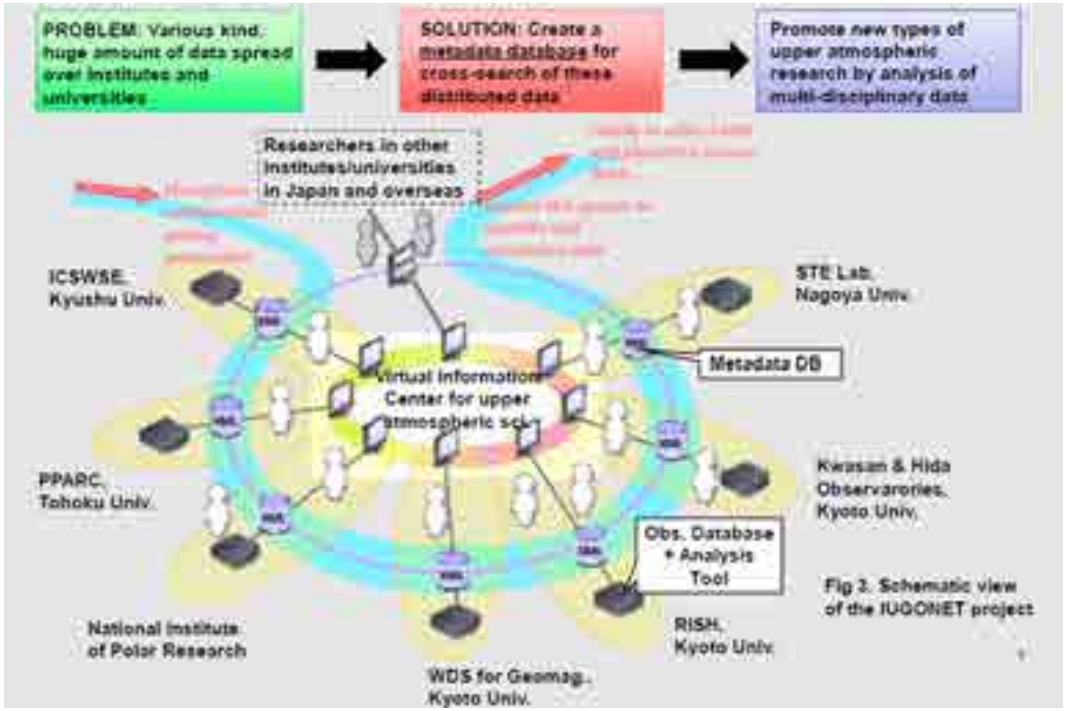


Fig 3. Schematic view of the IUGONET project

Hayashi et al. (Data Science Journal, 12, WDS179-WDS184, doi:10.2481/dsj.WDS-030, 2013)

www.varsiti.org

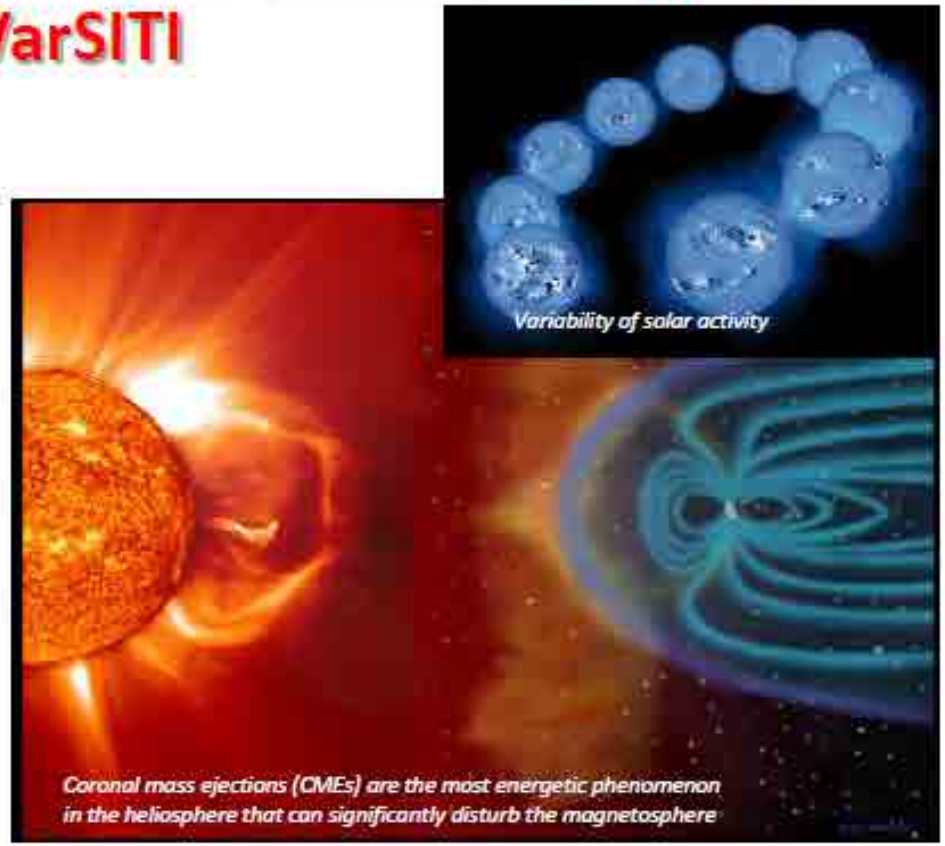
Variability of the Sun and Its Terrestrial Impact
VarSITI

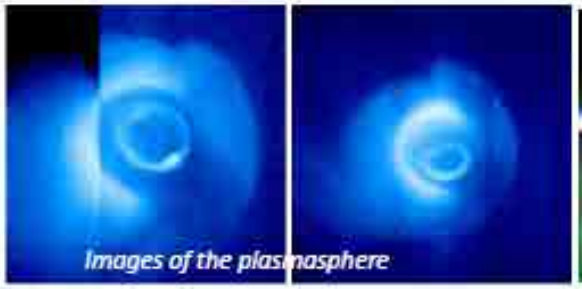
SCOSTEP is an ICSU Interdisciplinary Body tasked with the responsibility to organize long-term scientific programs in solar terrestrial physics and *Variability of the Sun and Its Terrestrial Impact (VarSITI)* is that program for the period 2014 – 2018. VarSITI was defined based on a community effort in the form of a forum organized by the International Space Science Institute (ISSI) in Bern in May 2013. The VarSITI program will strive for international collaboration in data analysis, modeling, and theory to understand how the solar variability affects Earth. The VarSITI program will have four scientific elements that address solar-terrestrial problems keeping the current low solar activity as the common thread:

1) SEE (Solar evolution and Extrema)
2) ISEST (International Study of Earth-affecting Solar Transients/MiniMax24)
3) SPeCIMEN (Specification and Prediction of the Coupled Inner-Magnetospheric Environment), and
4) ROSMIC (Role Of the Sun and the Middle atmosphere/ thermosphere/ionosphere In Climate).

VarSITI Co-Chairs:

Prof. Katya Georgieva, Bulgaria
Prof. Kazuo Shiokawa, Japan





backup slides
(description of each project)

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:

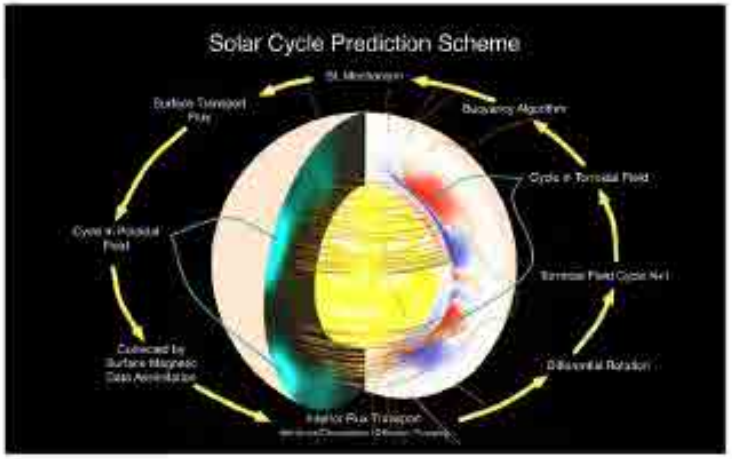
1) Reproduce magnetic activity as observed in the Sunspot record, including grand minima and extended minima in dynamo simulations,
2) Amalgamate the best current models and observations for solar spectral and wind output over the Earth's history,
3) Determine the size and expected frequency of extreme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



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

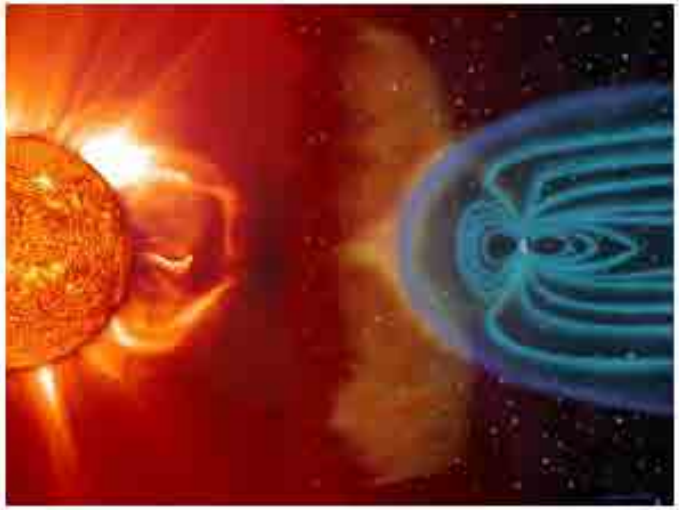
Can we predict the impact of solar transients on space weather?

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.

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

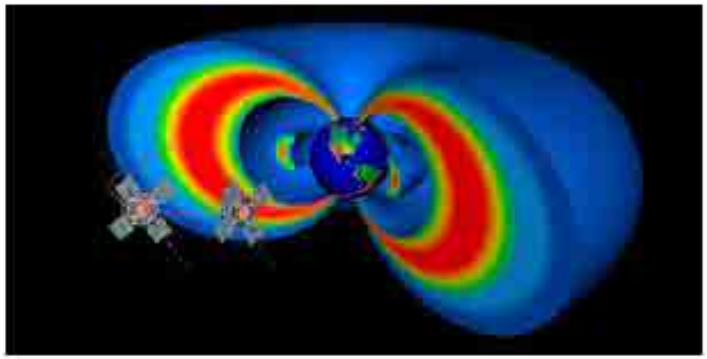
What is the physics behind radiation belt electron flux dynamics to enable the development of predictive models?

Project Co-Leaders:

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

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

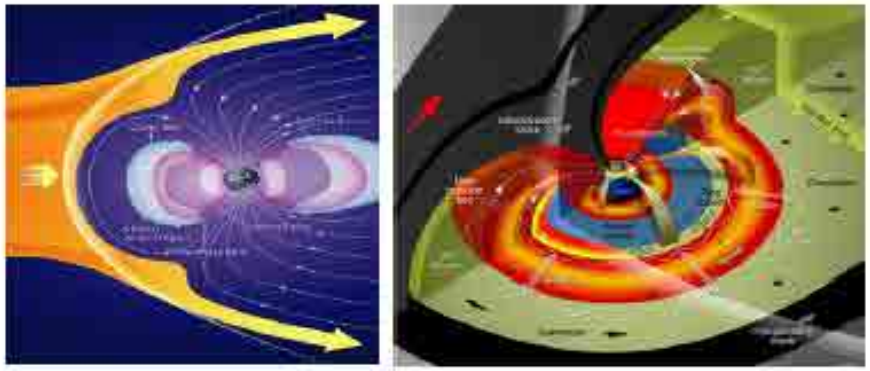
Goals & Objectives: The quantitative prediction and specification of the Earth's inner magnetospheric environment based on Sun/solar wind driving inputs.



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 discovered, Prof. James Van Allen. During the 5-year VarSITI 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, plasmasheet, convection electric field, and so on).

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

What influence does Solar Forcing have on Climate and Weather?

Project Co-Leaders:

Prof. Dr. Franz-Josef Lübken, Leibniz Institute of Atmospheric Physics, Germany

Dr. Annika Seppälä, Finnish Meteorological Institute, Finland

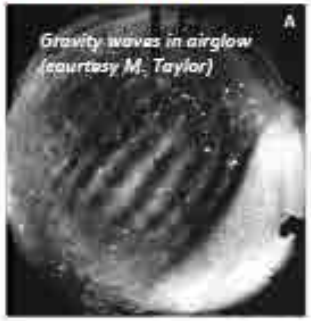
Prof. William E. Ward, University of New Brunswick, Canada

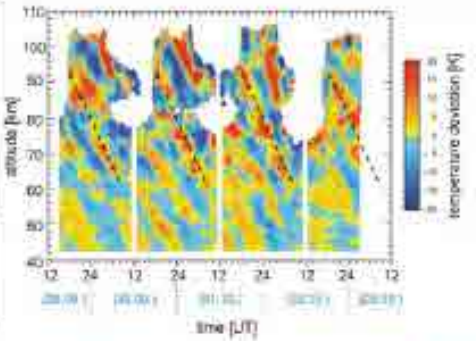
Goals & Objectives: To understand the impact of the Sun on the terrestrial middle atmosphere/lower thermosphere/ ionosphere (MALTI) and Earth's climate and its importance relative to anthropogenic forcing over various time scales from minutes to centuries.

Science Questions:

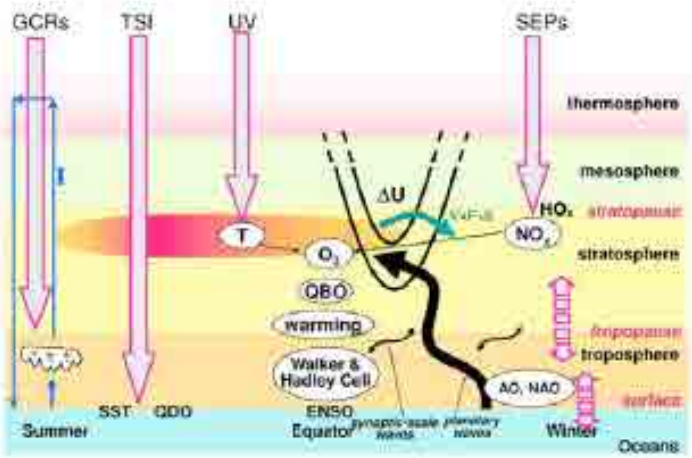
1) What is impact of solar forcing of the entire atmosphere? What is the relative importance of solar irradiance versus energetic particles?
2) How is the solar signal transferred from the thermosphere to the troposphere?
3) How does coupling within the terrestrial atmosphere function (e.g. gravity waves and turbulence).
4) What is the impact of anthropogenic activities on the Middle Atmosphere, Lower Thermosphere, Ionosphere (MALTI)?
5) What are the characteristics of reconstructions and predictions of TSI and SSI?
6) What are the implications of trends in the ionosphere/ thermosphere for technical systems such as satellites.

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.





Gravity waves in temperature (Courtesy of IAP, Kühlungsborn)



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