Variability of the Sun and Its Terrestrial Impact (VarSITI): SCOSTEP's scientific program in 2014-2018

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

1. Solar-Terrestrial Environment Laboratory, Nagoya University
2. Space Research and Technologies Institute, Bulgarian Academy of Sciences

SCOSTEP
Scientific Committee on Solar-Terrestrial Physics

United Nations / Japan Workshop on Space Weather "Science and Data Products from ISWI Instruments", March 3, 2015, Fukuoka, Japan.

SCOSTEP
Scientific Committee on Solar-Terrestrial Physics

VarSITI

International interdisciplinary programs in solar-terrestrial physics operated by SCOSTEP

1976-1979: IMS (International Magnetosphere Study)

1979-1981: SMY (Solar Maximum Year)

1982-1985: MAP (Middle Atmosphere Program)

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

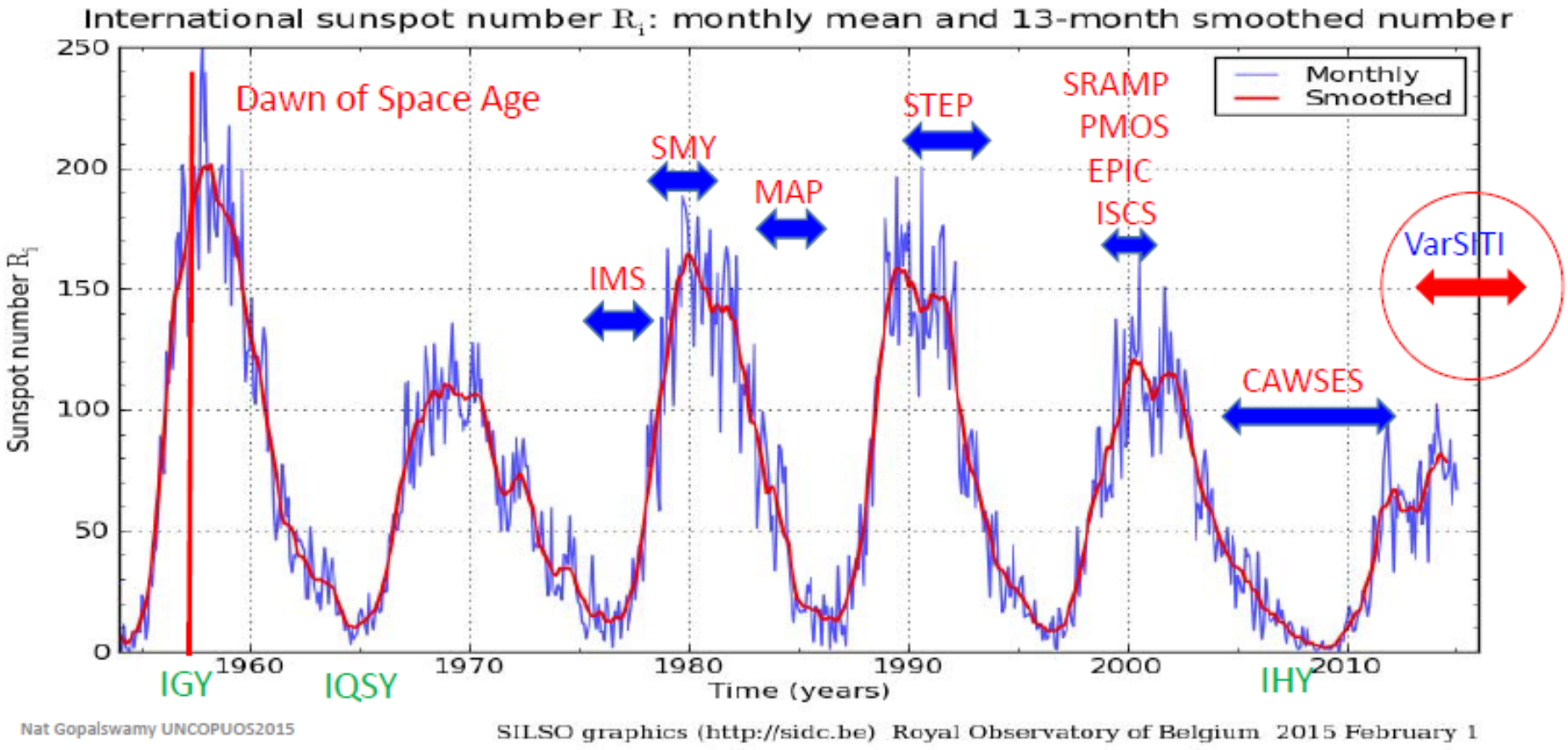
1998-2002: Post-STEP（S-RAMP, PSMOS, EPIC, and ISCS)

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

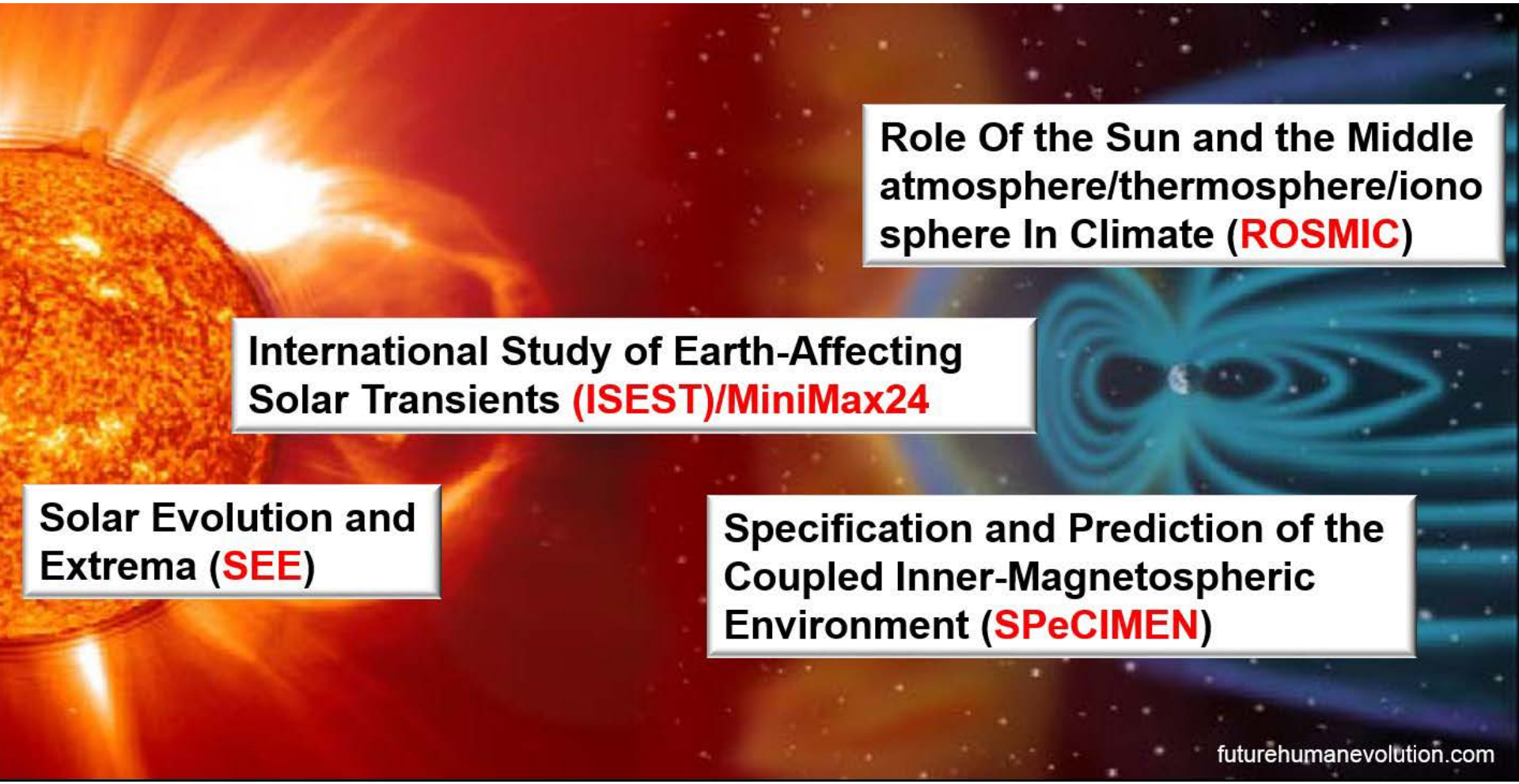
2009-2013: CAWSES-II (Climate and Weather of the Sun-Earth System-II）

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

Solar Variability and SCOSTEP Scientific Programs



Four Elements of VarSITI



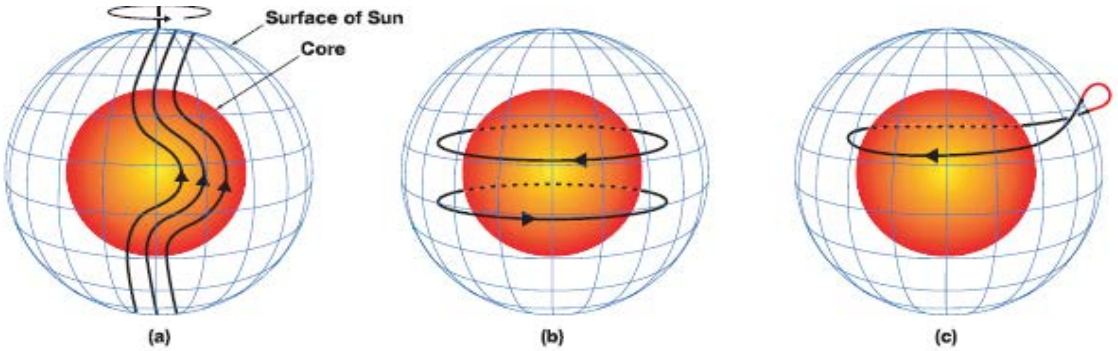
Solar Evolution and Extrema (SEE)

Solar Evolution and Extrema
SEE

Piet Martens,
(Smithsonian Astrophysical Observatory, USA)

Vladimir Obridko,
(IZMIRAN, Russia)

Dibyendu Nandi,
(IISER Kolkata, India)



Dynamo modeling of solar magnetic field (Dikpati and Gilman, 2006)

Predictions of sunspot cycle 24

Sunspot numbers

Precursor
Climatological
Dynamo model
Neural network
Spectral
Recent climatology

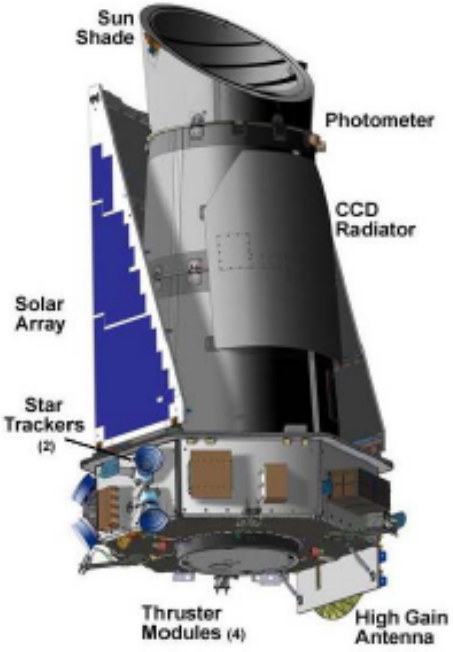
200
150
100
50
0

Maris, et al. (2004)
Cliverd, et al. (2004)
Badalyan, et al. (2001)
Konsor (2006)
Svalgaard, et al. (2005)
Javaraiah (2007)
Aguirre, et al. (2008)
Choudhuri, et al. (2007)
Schatten (2005)
Baranovski (2006)
Duhau (2003)
Hamid and Galal (2006)
Roth (2008)
Kryachko and Nusinov (2008)
Wang, et al. (2002)
Pesnell (2008)
Kane (1998)
Lantos (2006)
Tlatov (2006)
Hiremath (2007)
de Meyer (2003)
Euler and Smith (2006)
Thompson (2008)
Xu, et al. (2008)
Prochazka (2006)
Du and Du (2006)
Ahluwalia (2008)
Tlatov (2006)
Tlatov (2006)
Rabin (2007)
Pesnell (2008)
Selio (2006)
Echer, et al. (2004)
ea_4yr (2006)
Pesnell (2008)
Kim, et al. (2004)
Khramova et al. (2002)
Dabas, et al. (2008)
Nevanlinna (2007)
Tlatov (2006)
Tritakis et al. (2006)
Kennewell & Patterson (2006)
modified Feynman (2006)
Chopra and Dabas (2008)
Kane (2007)
Jain (2006)
Gholipour, et al. (2005)
Hathaway, et al. (2004)
Maris and Oncica (2006)
ea_min (2008)
Pesnell (2008)
Hathaway & Wilson (2008)
Dikpati, et al. (2006)
Podladchikova, et al. (2006)
Tsirulnik, et al. (1997)
Thompson (2006)
Horstman (2005)

VarSITI explores Sun-like Stars to understand Extreme Events

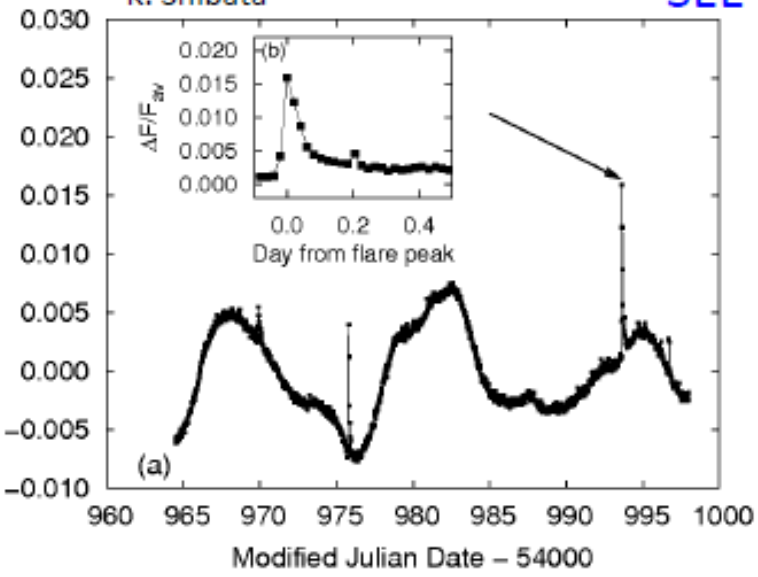
The OGLE Telescope with Milky Way
courtesy: Yuri Beletsky

Kepler Mission
NASA



K. Shibata

SEE

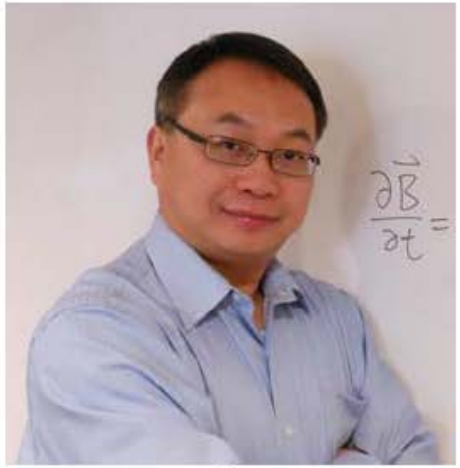


Japanese scientists have identified flares that are 1000 times more powerful than solar flares on scores of Sun-like stars observed by NASA's Kepler mission.

There is a small probability that such flares can occur on the Sun

International Study of Earth-Affecting Solar Transients ISEST/MiniMax24

International Study of Earth-affecting Solar Transients
ISEST

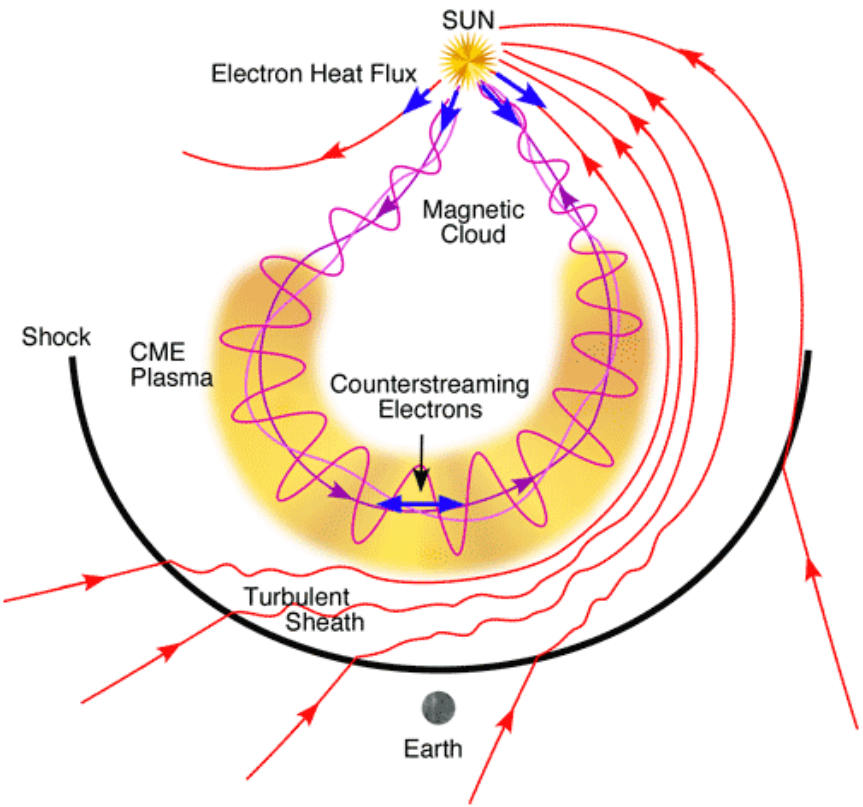


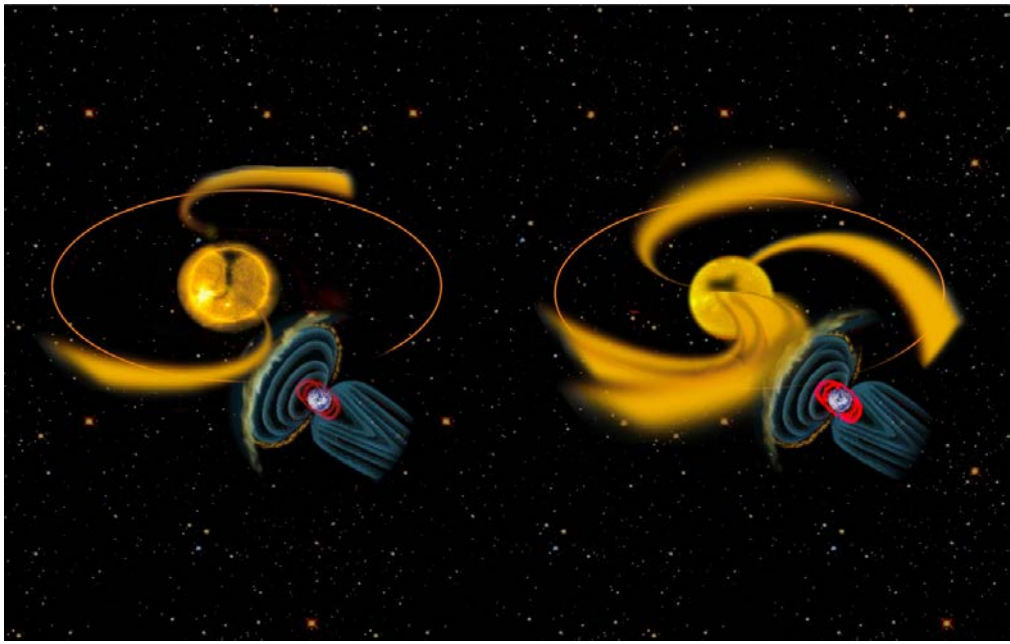
Jie Zhang,
(George Mason University, USA)

Manuela Temmer,
(UNIVERSITY OF GRAZ, Austria)

Nat Gopalswamy,
(Lab. for Solar & Space Physics, NASA/GSFC, USA)

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





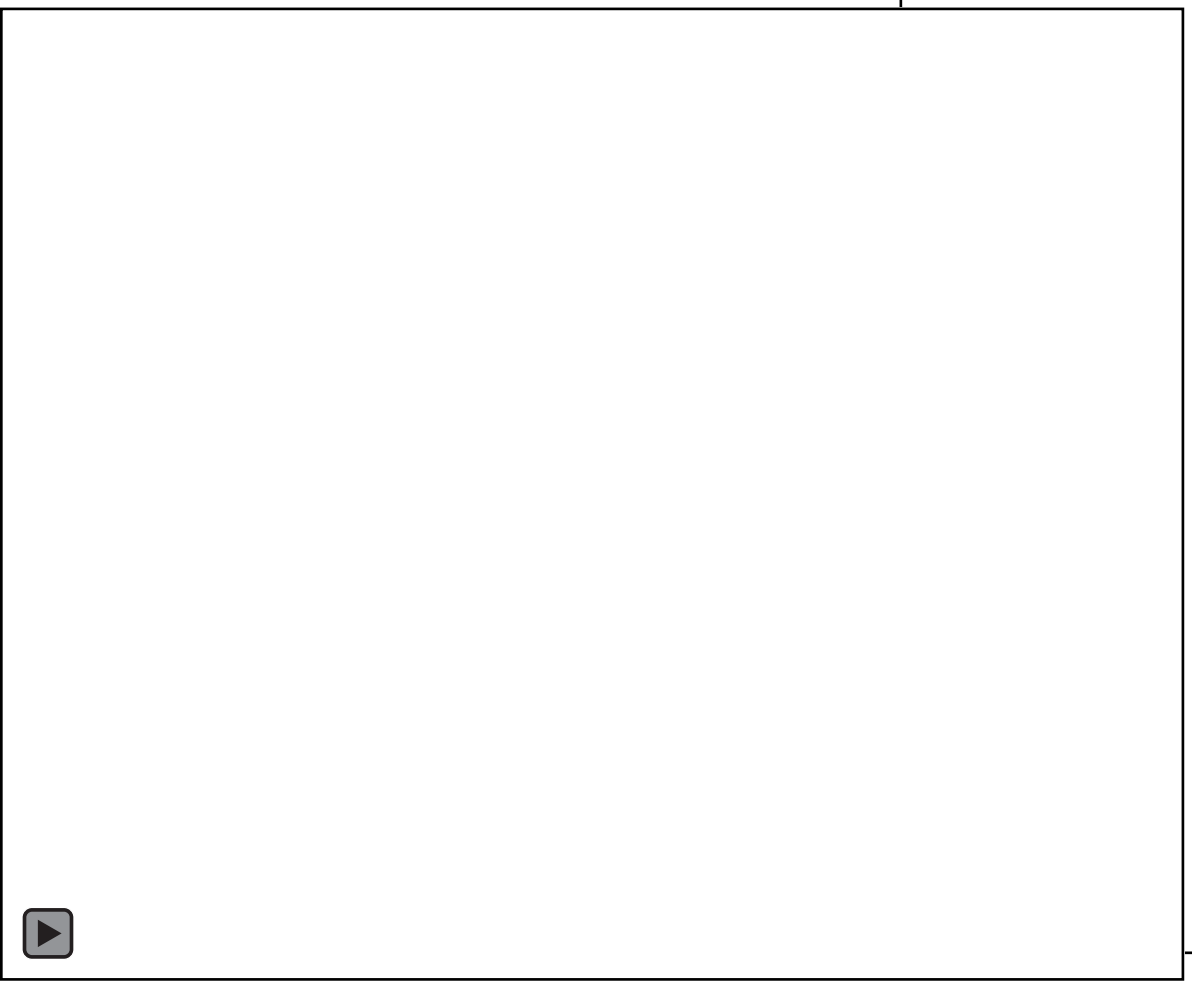
Can we predict a CME's magnetic field based on its solar origin?

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?

Evolution of the photospheric magnetic field.

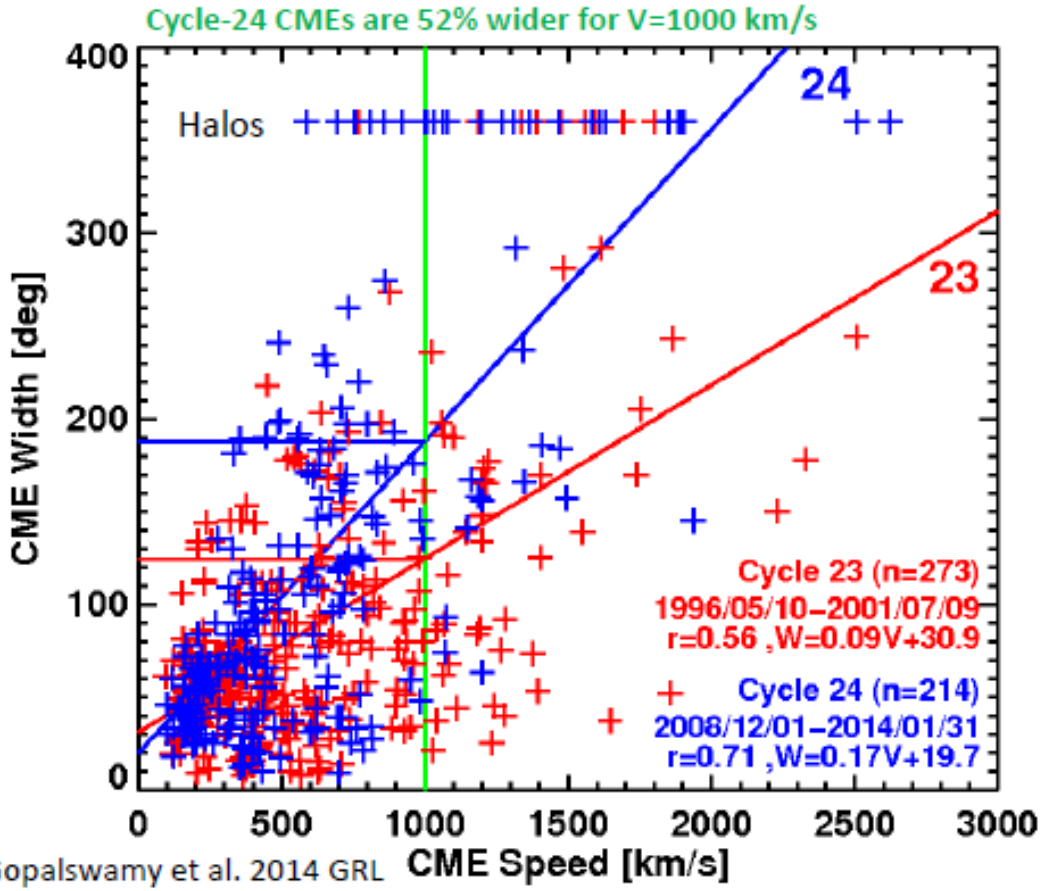
Emergence and formation of the Twisted Flux Rope.



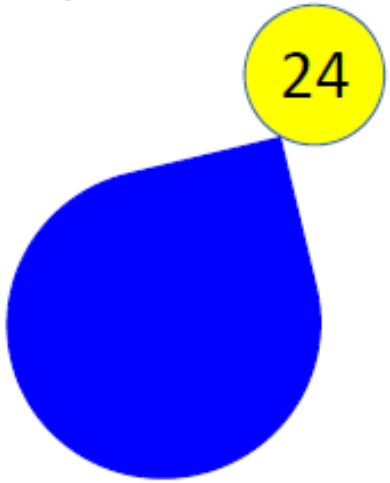
Amari et al. (Nature Letter, 2014): Observation and modeling of magnetic flux rope as a origin of CME.

Anomalous Expansion of CMEs in Cycle 24

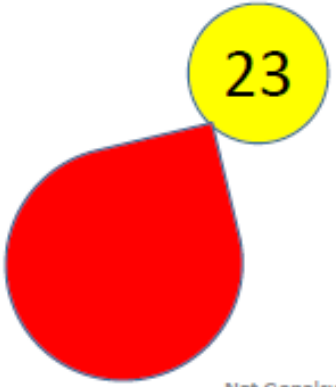
ISEST/MiniMax24



Gopalswamy et al. 2014 GRL



Lower outside Pressure --> larger CMEs



Higher outside Pressure --> Smaller CMEs

Nat Gopalswamy UNCOPUOS2015

Gopalswamy et al. (GRL, 2014): CME size difference by different background pressure condition in Cycle 23 and 24.

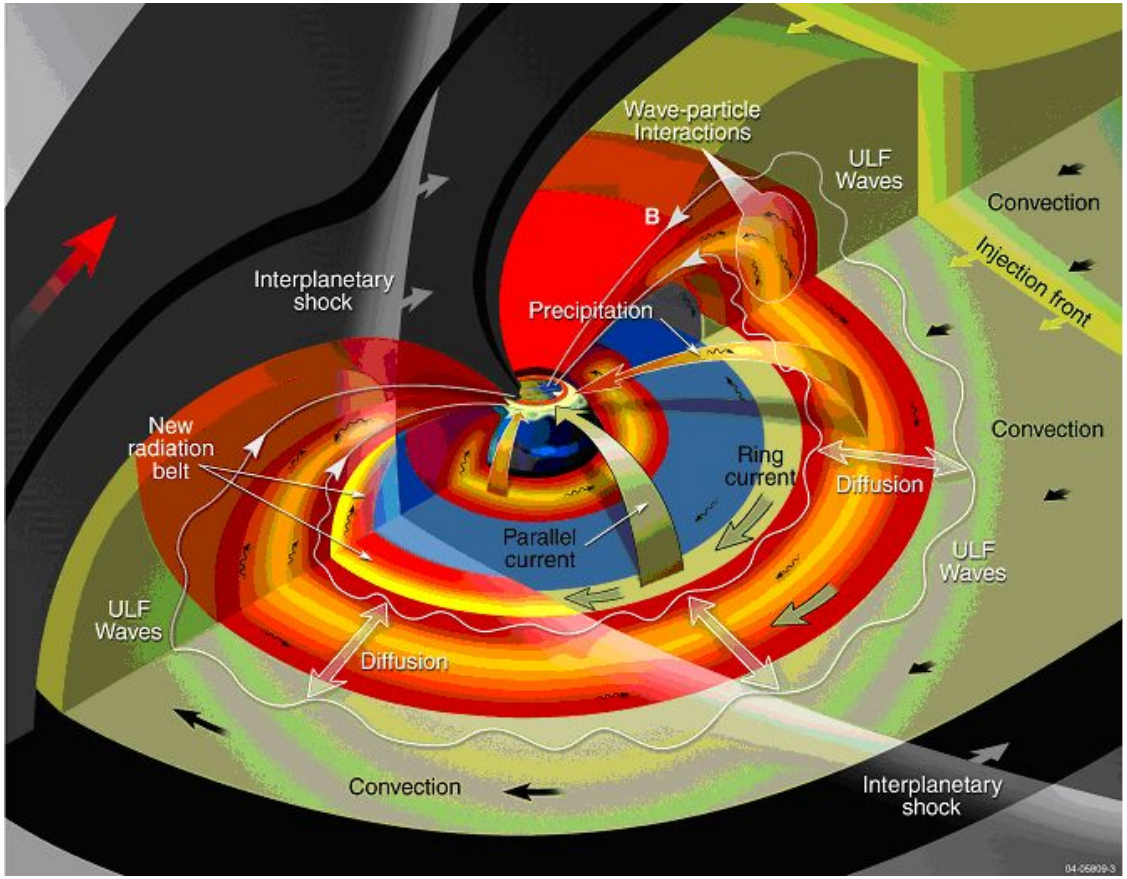
Specification and Prediction of the Coupled Inner-Magnetospheric Environment (SPeCIMEN)

Specification and Prediction of the Coupled Inner-Magnetospheric Environment
SPeCIMEN

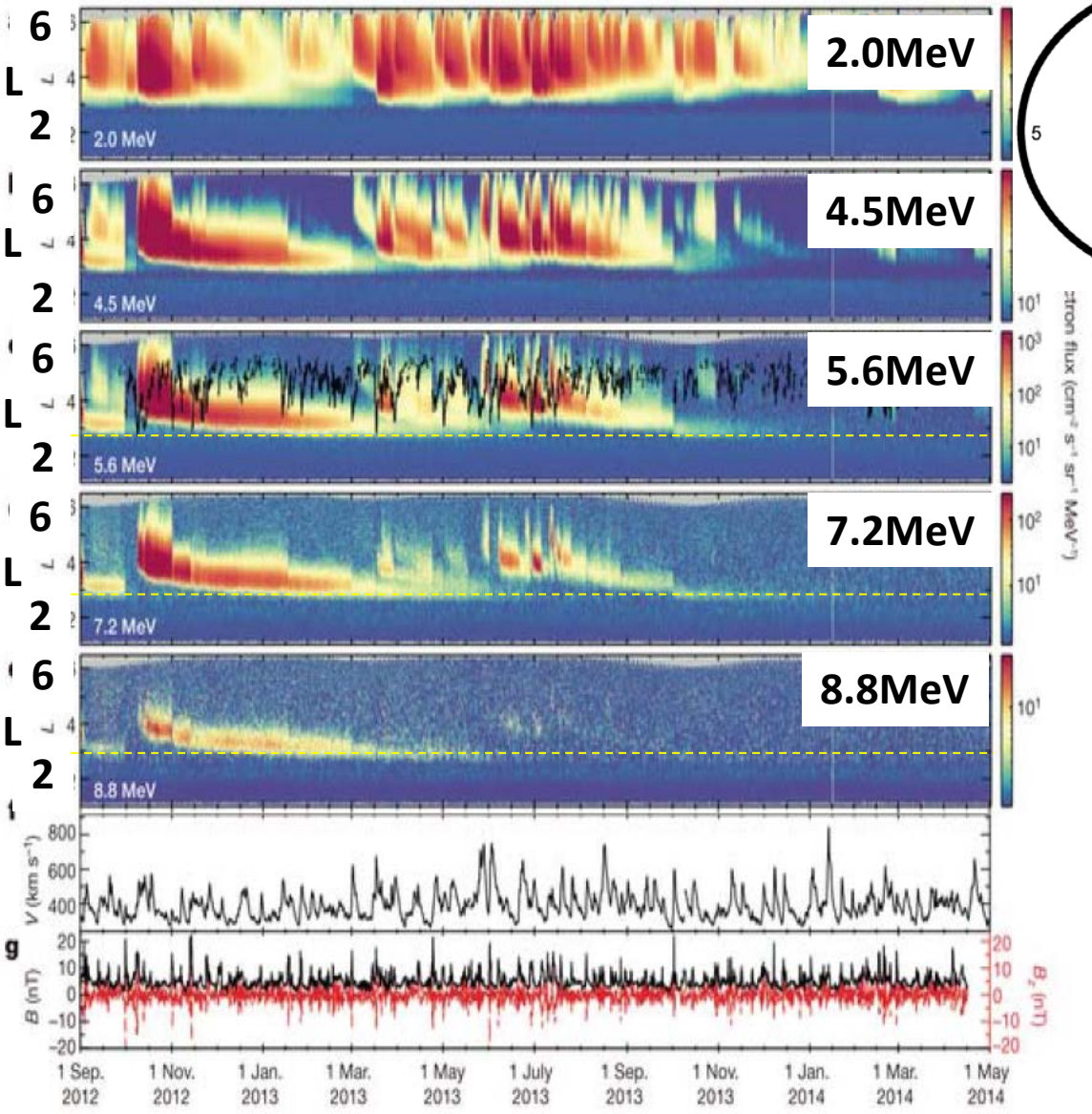
Jacob Bortnik,
(Dept. of Atmospheric and Oceanic Sciences
UCLA, USA)

Craig Rodger,
(University of Otago,
New Zealand)

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

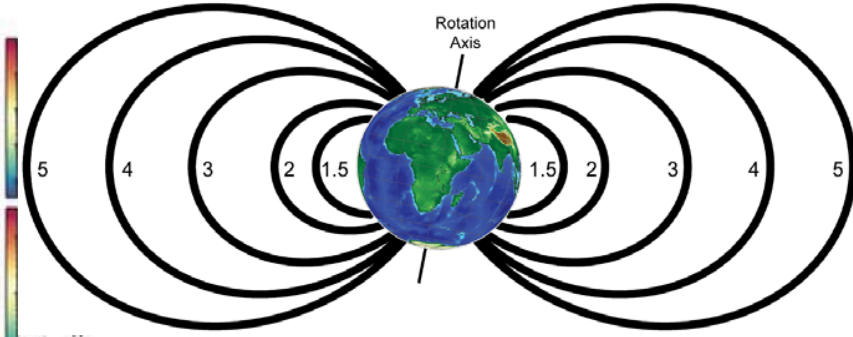


Can we go from modeling to predictions?



Sep.2012

May 2014



In **a**–**e** the highly energetic electrons measured by REPT sensors throughout the mission never seem to extend inwards of $L \approx 2.8$. This forms a particularly clear and sharp boundary for the ultrarelativistic electrons as shown in **c**–**e**.

Baker et al. (Nature, 2014): Discovery of sharp inner boundary for the ultrarelativistic (E>5MeV) electrons in the Earth's radiation belts.

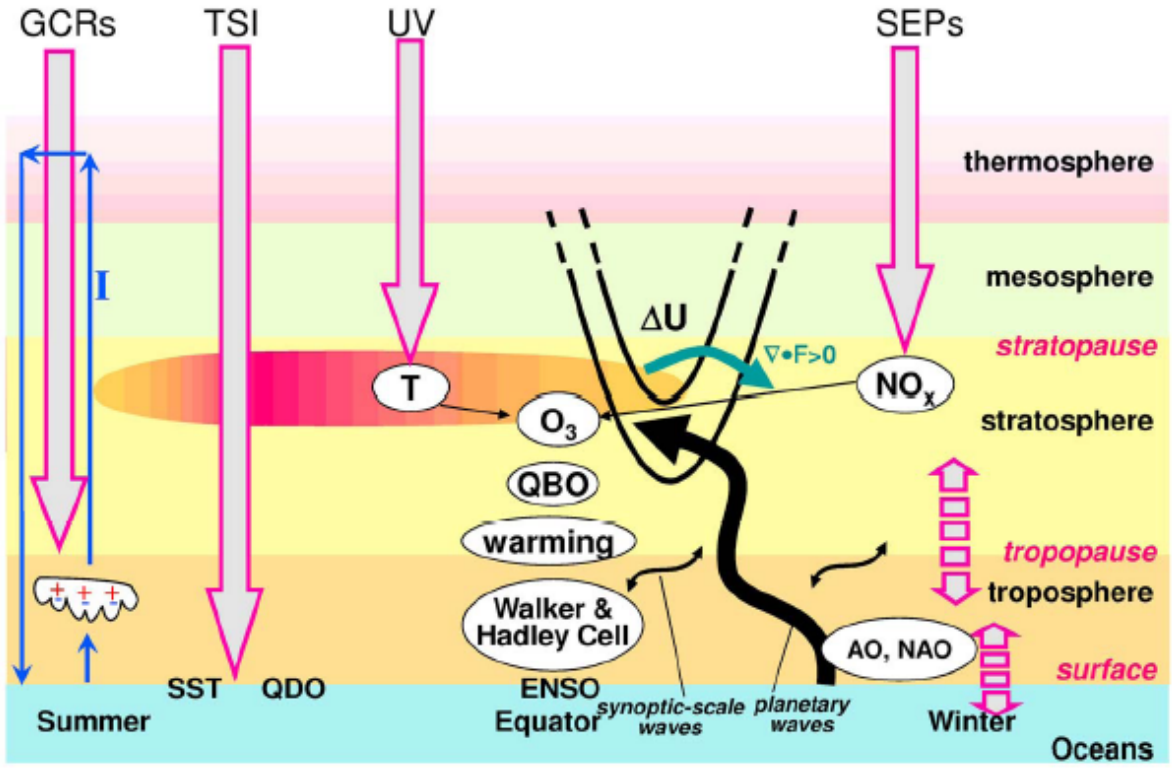
Role Of the Sun and the Middle atmosphere/ thermosphere/ionosphere In Climate (ROSMIC)

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

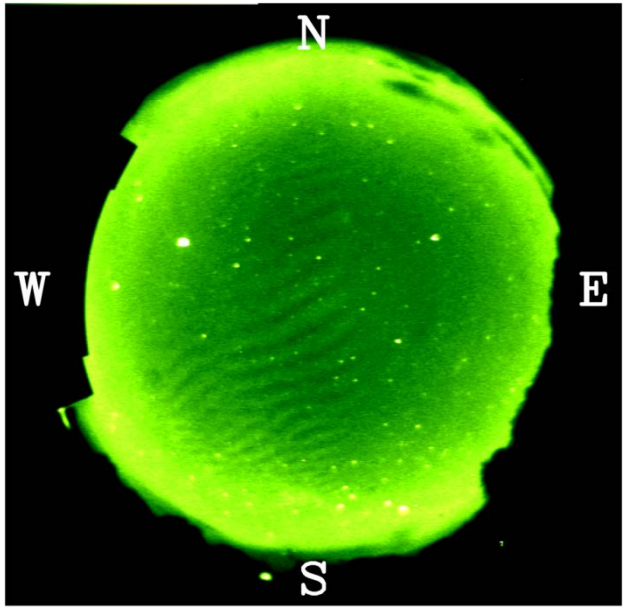
F.–J. Lübken,
(Leibniz-Institut für Atmosphärenphysik, Germany)

Annika Seppälä,
(Finnish Meteorological Institute, Finland)

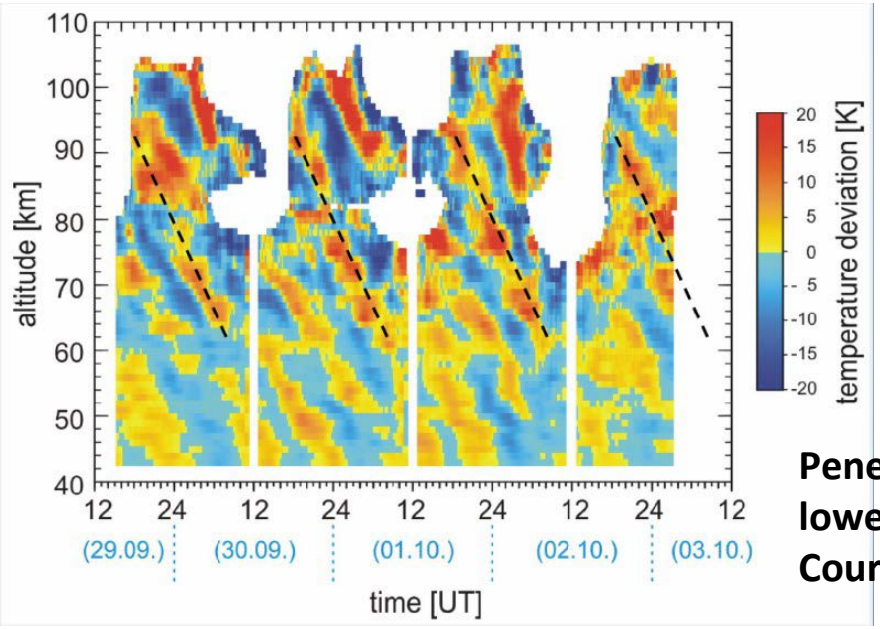
William Ward,
(University of New Brunswick, Canada)



Various solar effects that possibly make climate change (Gray et al., RG, 2010)



Gravity waves in the mesospheric airglow images. Courtesy of STEL, Nagoya University



Penetration of gravity waves (in temperature data) from the lower atmosphere into the ionosphere and thermosphere. Courtesy of IAP Kühlungsborn.

particle precipitation
from the magnetosphere

magnetosphere

plasma sheet

ratiation
belts

ionosphere

aurora

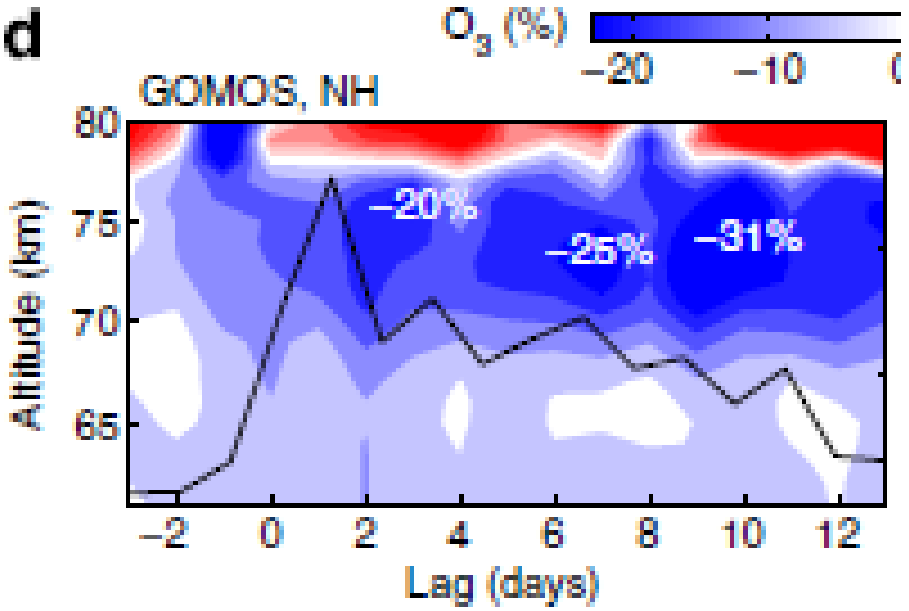
NOx

Ozone

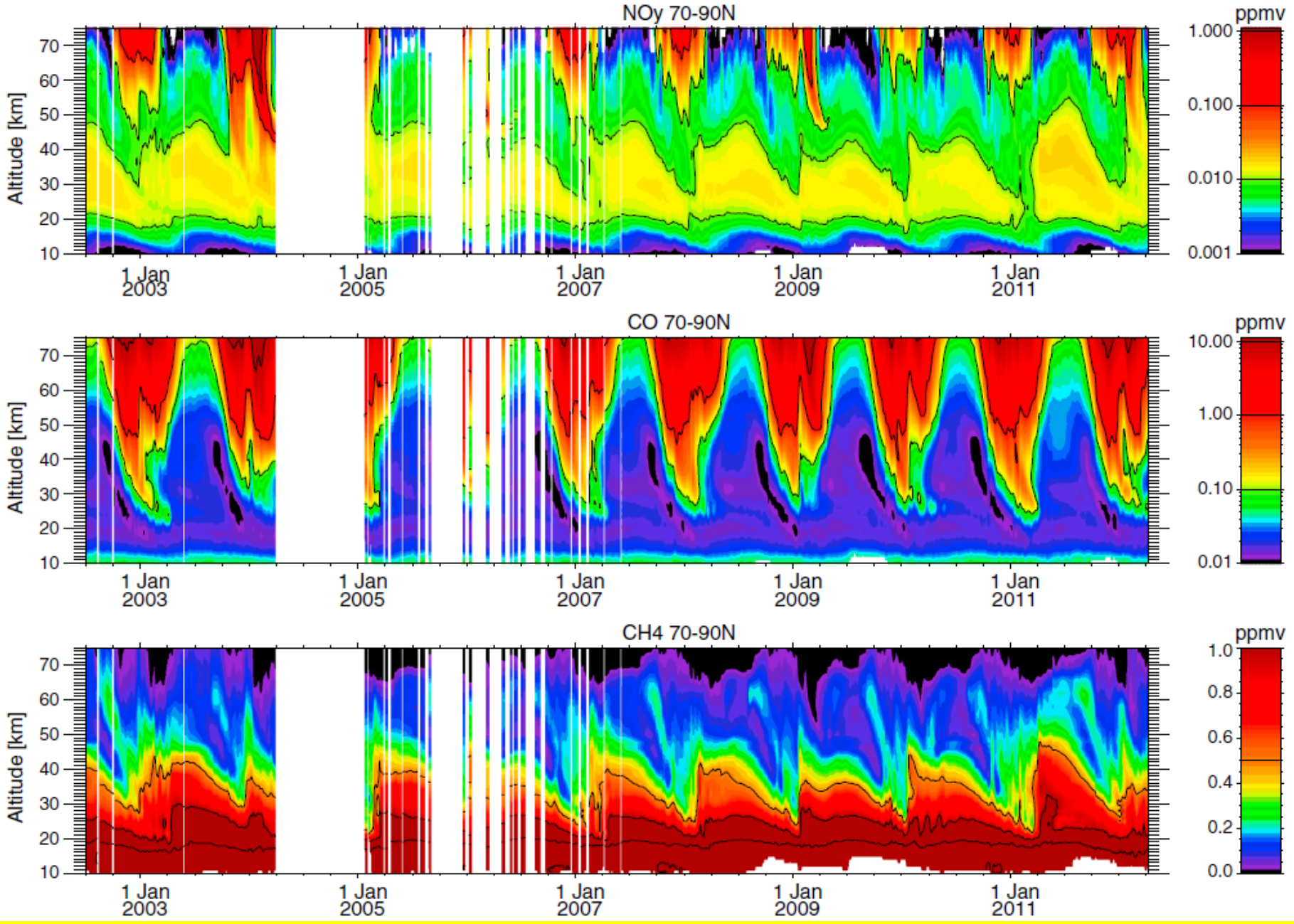
middle
atmosphere

troposphere

Polar region



Andersson et al. (Nature Comm., 2014): First evidence for radiation belt electron precipitation impact on atmospheric ozone in long term.



Funke et al. (JGR, 2014): Use of a long satellite dataset to determine the contribution of energetic particle precipitation produced NOy to the total polar atmospheric NOy budget.

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 558 mail addresses are registered)
- Newsletters
- Meetings (financial support is available)

www.varsiti.org

VarSITI
Variability of the Sun and Its Terrestrial Impact

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


Katya Georgieva


Kazuo Shiokawa

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 maximum 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

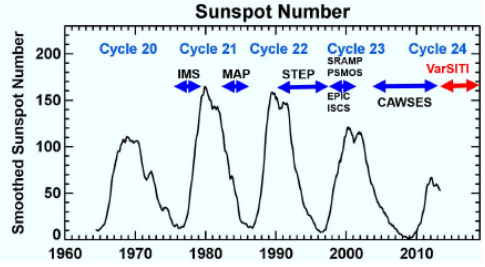


Figure 1. Variation of sunspot numbers and SCOSTEP programs. VarSITI is carried out during the lowest solar activities since the modern scientific observations become available.

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 SEE/ISEST/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[2], V. V. Dorovskii[1], V. N. Melnik[1], A. I. Brazhenko[3], V. V. Zakharenko[1], A. A. Stanislavskii[1], and V. A. Shepelev[1]
[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


Konovalenko Alexander


Kalinichenko Nikolay


Lytvynenko Oleg


Dorovskii Vladimir


Melnik Valentin


Brazhenko Anatoly


Zakharenko Vyacheslav


Stanislavskii Alexander


Shepelev Valery

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

Figure 1. URAN decameter radio telescopes system on Ukraine map: Radio telescopes 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

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

Vol. 3, October 2014

VarSITI Newsletter

Inside this issue

Project ROSMIC

Article 1:

The Swarm mission: Understanding the space environment in the changing Earth's magnetic field

C. Stolle[1] and R. Floberghagen[2]
[1]Helmholtz Centre Potsdam, GFZ, German Research Centre for Geosciences, Potsdam, Germany
[2]European Space Agency, ESRIN, Frascati, Italy


Claudia Stolle


Rune Floberghagen

The interaction between the upper atmosphere and the geomagnetic field is important for both of them. The location of ionospheric currents and the direction of plasma drifts, but also partly the direction of thermospheric winds depend on the shape of the geomagnetic field. Their amplitude and therefore also effective energy deposition through, e.g., Joule heating are governed by the field's strengths. In turn, currents that result from the atmospheric dynamo or from steep plasma density gradients amplify the magnetic field. Hence, simultaneous observations of the magnetic field in high precision and of plasma and thermospheric parameters have largely advanced our understanding of processes in the upper atmosphere (e.g., Olsen and Stolle, 2013; Lühr et al., 2011).

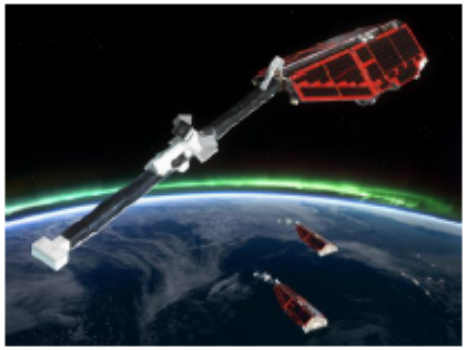


Figure 1. Artist illustration of Swarm satellites (credits to ESA).

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

Vol. 4, January 2015

VarSITI Newsletter

Inside this issue

Project ROSMIC

Article 1:

CASSIOPE Enhanced Polar Outflow Probe (e-POP)

A. W. Yau[1] and H. G. James[1]
[1]Department of Physics and Astronomy, University of Calgary, Calgary, Canada


Andrew Yau


Gordon James

The Enhanced Polar Outflow Probe (e-POP) is sponsored by the Canadian Space Agency (CSA), and it is a part of CASSIOPE, a multi-purpose Canadian small satellite mission. E-POP has three primary scientific objectives: in-situ observations of micro-scale characteristics of plasma outflow and related micro- and meso-scale plasma processes in the polar ionosphere, exploration of the occurrence morphology of neutral escape in the upper atmosphere, and the effects of auroral currents on plasma outflow and of plasma microstructures on radio propagation.

To achieve these objectives, the mission strategy of e-POP focusses on in-situ measurements of small-scale plasma,

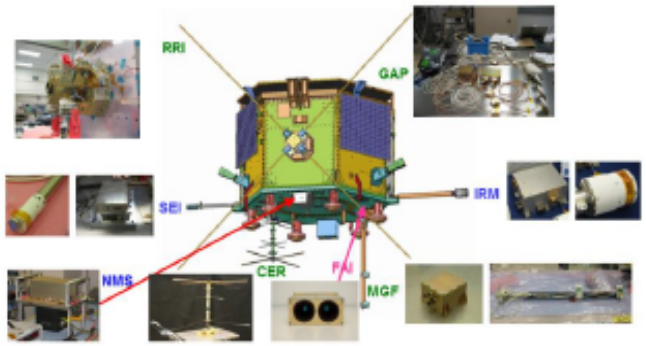


Figure 1. e-POP instrument payload layout on CASSIOPE.

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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				SEE ISEST/Minimax SPeCIMEN ROSMIC ALL

NASA Living with a Star (LWS) Program has Announced Support for SCOSTEP/VarSITI Projects

- Solicitation: NNH14ZDA001N-LWS, Heliophysics Living With a Star Science 2015
- Three-year awards to coincide with the 2014-2018 timeframe of VarSITI
- Proposals need to be relevant to VarSITI themes
- PIs to collaborate and share their models and results with each other and the international VarSITI project leaders
- More details: http://nspires.nasaprs.com/

Scientific Committee on Solar-Terrestrial Physics

In particular, Germany, India, Japan provide substantial funding for VarSITI Research

Initial VarSITI Results to be Published in American Geophysical Union Journal

Editors:

Qiang Hu (USA)
Bernd Funke (Spain)
Martin Kaufmann (Germany)
Olga Khabarova (Russia)
Jean-Pierre Raulin (Brazil)
Craig J. Rodger (New Zealand)
David F. Webb (USA)

- Papers presented at SCOSTEP's 13th Quadrennial Symposium in China (October 2014)
- Related papers from the community
- Peer-reviewed
- Special issue named VarSITI

VarSITI Activities are being Expanded with Cooperation from ICSU/WDS

Summary

- **VarSITI is the new SCOSTEP scientific program to run during 2014-2018 (one year completed)**
- **About 1000 Scientists from all over the world are participating in the VarSITI program to advance Sun-Earth connection studies**
- **Interesting discoveries are being made and the results published**
- **Solar terrestrial science will reach as many developing countries as possible via SCOSTEP's capacity building and outreach activities**