CLIMATE AND WEATHER OF THE SUN EARTH SYSTEM: CAWSES

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ABSTRACT

During 2004-2008, CAWSES (Climate and Weather of the Sun-Earth System), SCOSTEP's new international scientific program, will link the world's scientists in a cooperative effort to study the entire interactive Sun-Earth system. This new program seeks to mobilize the international solar-terrestrial science community to fully utilize past, present and future data; to produce improvements in space weather forecasting, design of space- and Earth-based technological systems, and understanding the role of solar-terrestrial influence on Global Change. The CAWSES Science Steering Group with its 7 members (chairman: S.Basu) has organized around four themes: Solar Influence on Climate (chairman: M.Lockwood) Space Weather: Science and applications (chairmen: J. Kozyra, T.Shibata) Atmospheric Coupling Processes (chairman: F.J.Luebken) Space Climatology (chairman: C.Frolich) A forum is open on the web site for all comments and discussions about the different projects of CAWSES.

Key words: Sun Earth system.

1. INTRODUCTION

Research in the past decade has produced significant improvements in understanding the physical processes within each of the Sun-Earth domains, and enabled cross-disciplinary progress in understanding the domain as a whole. Examples include:

* The launch of satellites such as Yohkoh, SOHO and UARS have resulted in unprecedented improvements in our understanding of physical processes on the Sun and in the solar wind that generate the variable solar energies impacting Earth. These new observations and models developed from them, have facilitated progress in predicting potential geospace perturbations (from helicity signatures, halo events, backside imaging), the impact of CME driven shocks on interplanetary magnetic fields and the magnetosphere (coordinated observations with ACE, etc.),

* The new technique of energetic neutral atom (ENA) imaging, as conducted by the IMAGE mission, together with coincident EUV remote sensing, reveals for the first time the global distribution of particles of the inner magnetosphere and plasmasphere. The simultaneous solar and heliospheric observations are enabling physical interpretations of the observed global variations, e.g., the Bastille-day (14th July 2000) explosive event on the Sun was seen to cause enhancements in IMAGE global maps.

* The development of self-consistent, three-dimensional, time-dependent numerical models of the thermosphere - ionosphere system allow the effects of coupling from above and below, and interactions of the neutral and ionized layers to be investigated in increasing detail. Future progress requires reliable observations, such as TIMED and COSMIC will provide, to validate the models.

2. SPATIAL DOMAIN CONCEPTS OF THE SOLAR-TERRESTRIAL SYSTEM

The various domains of the solar-terrestrial system studied by STEP were the Sun, the heliosphere, the magnetosphere, the thermosphere and ionosphere, the middle atmosphere, the lower atmosphere and the climate. CAWSES seeks a new paradigm - that of a system in which the study of scientific "problems" from end-to-end supercedes focused research within these somewhat arbitrary spatial distinctions.

3. TEMPORAL VARIATIONS WITHIN THE COUPLED SOLAR-TERRESTRIAL SYSTEM

Physical processes on the Sun, the Earth, and the environment in between, all vary continuously. Chang-
ing magnetic fields in the solar atmosphere, driven by an interior dynamo, cause solar variability. The resultant alterations of energy output, in the form of electromagnetic and particle radiation, and solar wind plasma, induce terrestrial variability, in the form of temperature, composition and particle populations at altitudes from the Earth’s surface to the near-earth space environment. Within and among the Earth’s atmosphere, ionosphere and magnetosphere, internal oscillations and instabilities are further sources of variability.

Figure 3 lists typical changes in different regions of the sun-earth system. Time-scales range from minutes over weeks and years to decades and centuries. Terrestrial changes can result directly from the 11-year cycle modulation of the Sun’s energy output, and also from the cumulative effects of shorter term variations associated with eruptive events and solar rotation that occur at different rates and have different amplitudes at different phases of the activity cycle.

4. OBJECTIVES

CAWSES project would take a role of:

* Articulate timely outstanding questions in the connected Sun-Earth system.

* Coordinate international aspects of specific national programs when the participating national programs find this desirable.

* Provide a forum to bring together the international solar-terrestrial science community to help define future programs.

* Continue to help developing nations to participate meaningfully in international solar-terrestrial programs.

* Provide scientific inputs for the purpose of specifying the environment for technological systems whose performance critically depends on solar-terrestrial variations.

* Provide scientific inputs that help ensure human safety in space since humans will be spending increasing amounts of time there.

* Contribute solar-terrestrial information to the international Global Change community.

* Take an active role in helping international science education by providing solar-terrestrial information to the international educational community.

Unresolved Questions for the CAWSES Program

There are many unresolved questions about the sun-earth system, and its contribution to global change and space weather. Some are related to shorter-term variation (space storms), others to longer time scale modulations (space environment and climate). CAWSES program will provide significant progress of understanding to resolve these fundamental questions. Among them are:

* Can we link the end-to-end processes that produce geoeffective coronal mass ejections, facilitate their transfer through the heliosphere, their interaction with the magnetosphere, and the production of geomagnetic storms that affect the atmosphere?

* Can we identify evidence for long-term variations of solar luminosity related to solar activity and resultant impacts on global change, compared with other climate change mechanisms?

Can we reconcile apparent responses of the middle and lower atmosphere to solar activity, identify the physical mechanisms, in comparison with anthropogenic influences, and estimate future ozone changes?

* To what extent are the magnetosphere and ionosphere-thermosphere systems modulated by solar activity on long time scales, including the solar cycle, and how do variations driven by different processes interact with dynamical and radiative forcing processes from below?

CAWSES Implementation

The SCOSTEP Bureau charges a CAWSES Science Steering Group (SSG) with overseeing the planning and organization of the CAWSES program. The Bureau will establish the bi-yearly budget for the CAWSES SSG. The budget will support the activities of the SSG plus those of the CAWSES Steering Groups. The SSG will determine the budgets for the CSGs and review their activities on a yearly basis. The terms of appointment of the SSG members by
Figure 1. Time evolution of a coronal mass ejection observed with SOHO/LASCO (Courtesy of G. Aulanier)

Figure 3. Time variation of the Sun Earth effects
the Bureau will be for three years with reappointment possible. The CSFs will be established for an initial period of two years, with renewal possible.

A unique opportunity for celebrating and communicating solar terrestrial physics exists within the time frame of CAWSES, namely the anniversary of the 50th IGY. Effort should be addressed to commemorating progress in the field.

The members of the SSG are: S. Basu (chairman), J.L. Bougeret, J. Haigh, Y. Kamide, A. Richmond, C.H. Liu, Zelenyi L., Allen J. (secretary). They meet for the first time in Maastricht on August 24-25 2002 and defined the four following programs:

5. CAWSES THEMES

1. Solar influence on Climate
Chairman: Michael Lockwood

- Interpretation of past climate change during the Holocene (historic observations)
- Modeling of century-scale climate change (total solar irradiance, prediction)
- Detection and interpretation of solar cycle signal in recent climate data (statistical methods, calibration)
- Development and testing of mechanisms for the amplification of solar influence (cosmic ray effects)

2. Space Weather: science and applications
Chairman T. Shibata, and Janet Kozyra

The principal objective of this theme is to create the “One-Earth Space Weather Observatory” a facility with virtual instruments built on worldwide collaboration (integration of ground based observations into global maps). The other activity should be to identify and initiate Space Weather campaigns.

3. Atmospheric Coupling Processes
Chairman: Franz-Josef Luebken

- Atmospheric coupling by gravity waves, tides and planetary waves: source, sinks and transfer
- Coupling by electrodynamics and ionospheric/magnetospheric processes
- Variability of energy and momentum budgets of the middle atmosphere

- Particles and minor constituents in the upper atmosphere: solar/terrestrial influences and their role in the climate

4. Climatology of the Sun-Earth System
Chairman: Klaus Fröhlich and Jan Sojka

- Ionospheric and upper atmospheric variations (Long term variation in the F region height, upper atmospheric trends)
- Radiation belt climatology, long term cosmic ray variability and solar activity, long term variations in magnetic activity
- Total solar irradiance variability (secular trends and short term variability)

6. CONCLUSION

CAWSES will facilitate compilation of climatology of the Sun, interplanetary medium, magnetosphere, ionosphere/thermosphere, and upper and middle atmosphere; it will assess long-term trends in these system components; and it will seek to understand the underlying processes that influence the climate. It will assemble and evaluate relevant data sets and help make them available to solar-terrestrial scientists worldwide. It will assess the characteristics of each data type (accuracy, precision, etc.) and bring them onto a common space-time domain so that individual variations may be interpreted in terms of different causes.

For each component of the Sun-Earth system, this project will represent the average conditions, the regular variations, the long term trends, and the statistical properties of irregular variations with the aid of models. It will quantify the probabilities of extreme events. It will analyse relations among the variables of the system components. It will carry out a critical assessment of long-term trends in the system, joining with SPARC for the assessment of middle- and upper-atmosphere trends. It will interact closely with the other CAWSES project in achieving its goals.

It is SCOSTEP intention to reach out to involve Developing Nations of the Word in CAWSES and to disseminate material to educate the public about solar-terrestrial science that CAWSES will be addressing. More detailed of the CAWSES project is available on internet

http://www.ngdc.noaa.gov/stp/SCOSTEP/scostep.html

A forum is open on the web site for all comments and discussions about the different projects of CAWSES.