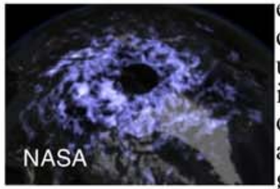
The Science of CAWSES-II

CAWSES-II focuses on the fundamental processes of the Sun-Earth system during the rising phase of solar cycle 24. These processes interact in nonlinear ways to produce effects that impact life and society. To address these topics, CAWSES-II uses a research strategy that includes comparisons with other stellar and planetary environments to inform investigations into solar-terrestrial science.

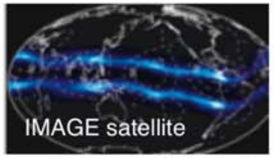
1. What are the solar influences on the Earth's climate? Solar variability drives geospace and the atmosphere on time scales ranging from minutes to millennia. Feedbacks are inherent in the Earth system and may amplify the direct forcing effects from the Sun. The influence of this solar variability on Earth's climate is a key issue of the Intergovernmental Panel on Climate Change, and one that continues to be highlighted by policy makers, climate change skeptics, and the media.

2. How will geospace respond to an altered climate? Radiative, chemical, and dynamical forcing from below contributes to disturbances of the upper atmosphere. In response to rising greenhouse gas concentrations, cooling in the middle atmosphere will alter the complex physical and chemical processes of this region. Patterns of cooling and contraction of the upper atmosphere are emerging from model studies and observations, consistent with a strong connection to changes in the lower atmosphere. Recent changes in noctilucent cloud distributions, now observed on a global scale by the AIM satellite (see figure above), are thought to be symptomatic of cooling temperatures in the upper atmosphere. Rising greenhouse gas concentrations alter the ionosphere in a variety of ways and could be transmitted to the magnetosphere. These changes may have unforeseen consequences for space-related technologies and societal infrastructures.



3. How does short-term solar variability affect the geospace environment? Solar variations such as solar flares, energetic particle bursts, coronal mass ejections, and high-speed solar wind streams directly alter space weather on short time scales. Electromagnetic radiation drives the ionosphere, while solar particulate outputs penetrate through space, interact with the magnetosphere and upper-middle atmospheres, and even produce disturbances at Earth's surface. A systems approach is crucial to understand and forecast space weather.

4. What is the geospace response to variable waves from the lower atmosphere? A variety of new evidence suggests that tropospheric weather is an important ingredient in space weather. Equatorial ionospheric densities are modulated by atmospheric waves driven by persistent tropical rainstorms. The figure (right) shows enhanced airglow from these regions of elevated density. Radio waves generated by lightning strokes in the rainstorms interact with radiation belt particles to clear a "safe" zone between the inner and outer belts in the magnetosphere. Gravity waves generated by hurricanes and typhoons may seed plasma bubbles in the low latitude ionosphere. The extent to which the effects of this quiescent atmospheric variability are transmitted to the magnetosphere is yet to be resolved.



Capacity Building and Education

CAWSES-II will continue and expand the capacity building and educational efforts developed in CAWSES. In collaboration with the Solar-Terrestrial Environment Laboratory of Nagoya University in Japan, a series of educational comic books was developed to communicate solar-terrestrial science to the general public in many languages. New comics that address CAWSES-II science topics will be developed. CAWSES-II will continue to organize and cosponsor international science meetings and workshops. Particular emphasis will be placed on the support of scientists from developing nations as well as graduate students and young scientists. CAWSES-II will work with scientists in the developing nations to provide access to data and research tools, and will develop an international network of graduate students and early-career scientists.

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CAWSES-II

2009-2013

Climate and Weather of the Sun-Earth System - II: Towards Solar Maximum

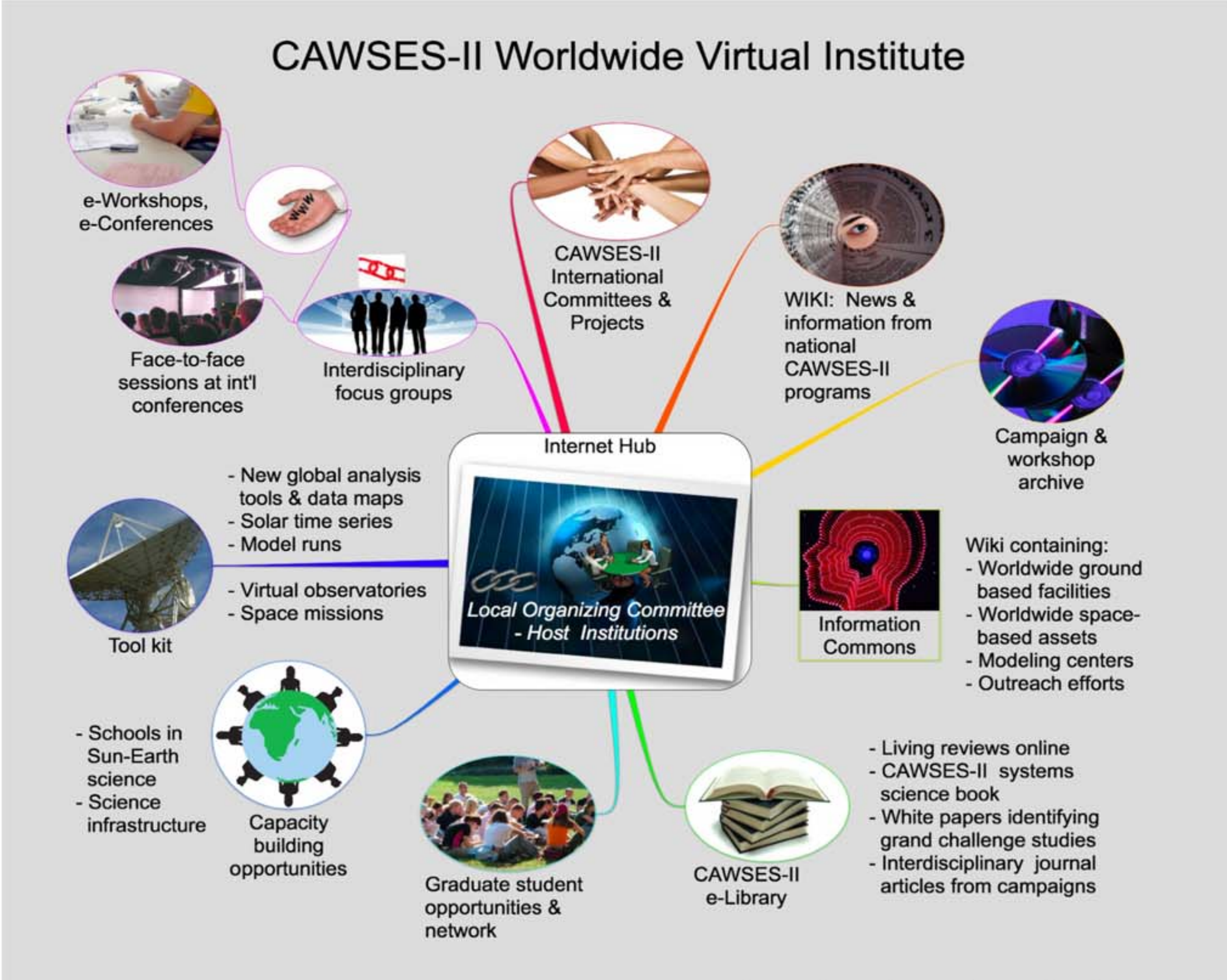
SCOSTEP's Program for 2009-2013

Climate And Weather of the Sun-Earth System- (CAWSES) - II: *Towards Solar Maximum*

The Scientific Need: We are poised on the brink of discovering the important processes that connect changes at the solar surface with features in the geospace environment and ultimately with climate variability. These connections are key to understanding complex planetary environments, and the general elements that enable planets to sustain life. Scientific breakthroughs in all these areas await advances in cyberinfrastructure that will allow the worldwide research community to access international data sets, distributed sensor networks, virtual observatories, advanced computational and visualization facilities, the most sophisticated Sun-to-Earth community models available, and to communicate with each other across discipline and national boundaries. No single organization is poised to make these breakthroughs, operate these instruments, construct these models, develop and maintain research support facilities. This is a worldwide endeavor with diverse participation and stakeholders. At issue is the ability to address the frontiers of system-level science.

Why Now? The past decade has seen the creation of a remarkable new capability to observe conditions simultaneously in regions from Sun-to-Earth using combinations of worldwide space and ground-based observing platforms. Simultaneously, new models of the solar dynamo that enable physics-based predictions of solar magnetic variability, suites of cutting-edge Sun-to-Earth coupled models, and "whole atmosphere" models that simulate tropospheric climate with linkages all the way to the upper atmosphere and space weather have become available along with the necessary advances in computer hardware and software. Open data policies and a developing system of virtual observatories are making diverse data sets widely available to the research community. The availability of data by itself, however, is not enough.

Transformative Science: CAWSES-II will add value to this effort by supporting the construction of a framework for sustaining international and interdisciplinary collaborations. This framework leverages the full potential for scientific discovery and learning inherent in past investments in instrumentation and facilities. CAWSES-II focuses coordination efforts on "grand challenge" questions that can only be addressed through interdisciplinary research and international collaboration. It supports the development of a virtual community that will produce the scientific breakthroughs enabled by advances in cyber infrastructure and in the process, will help to revolutionize the very way in which collaborative scientific research is done.



CAWSES-II Virtual Institute: Based on a successful pilot study that utilized cyber infrastructure to organize and conduct science, CAWSES-II will create an International Virtual Institute. This institute will be organized around the principles that progress in system-level investigations requires: researchers committed to the value of pursuing science at the interface between disciplines, strongly-focused science topics that provide a common theme around which disciplines are able to interact, means of educating researchers about the key scientific issues in other disciplines and the connections between disciplines, access to scientific publications in other discipline areas, new forms of scholarly publishing, and the structure needed to bring researchers into contact with data sets, models, and each other, across disciplines and national boundaries.