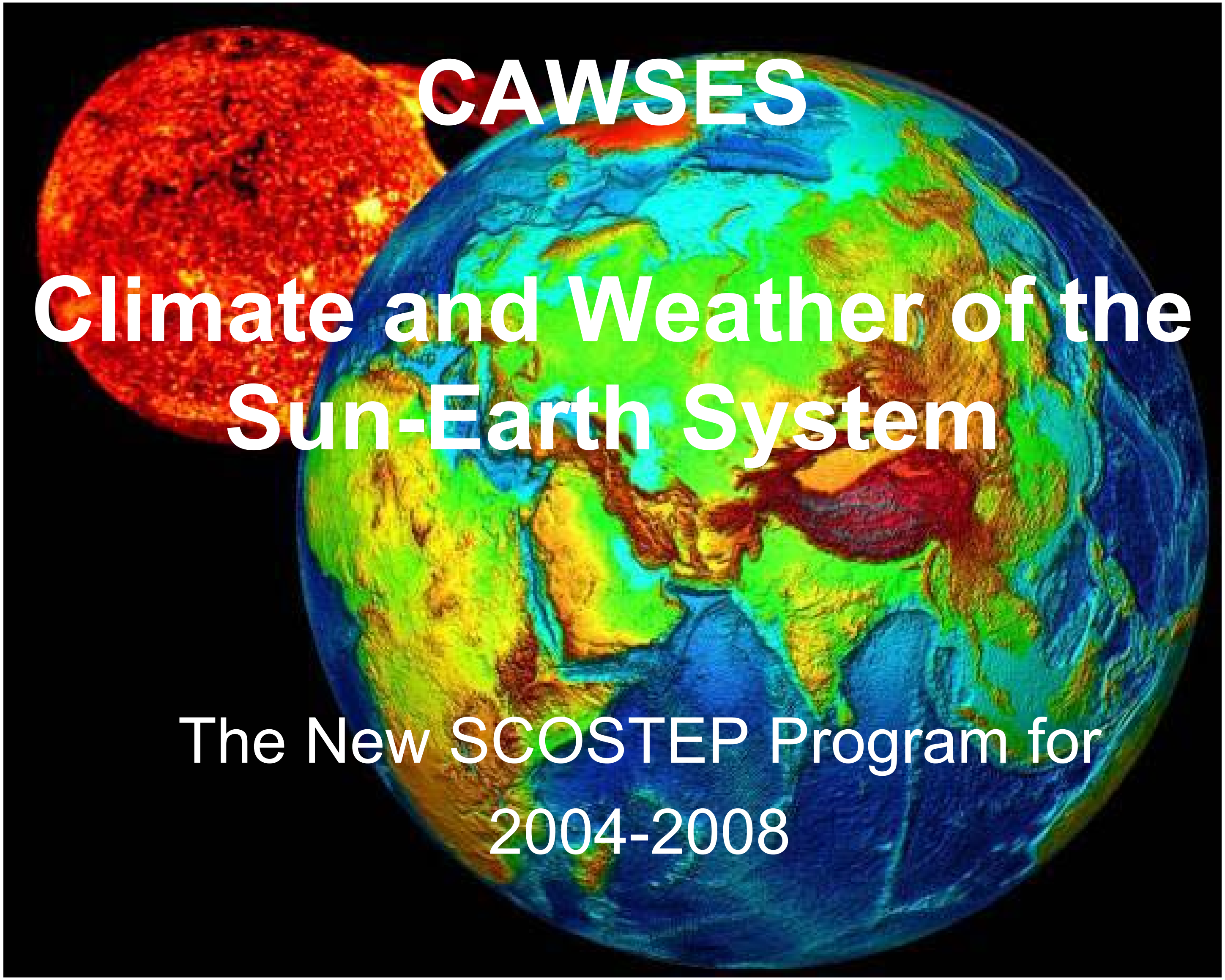
CAWSES

Climate and Weather of the Sun-Earth System

The New SCOSTEP Program for 2004-2008



Composite picture created at NOAA-NGDC by Dr. Peter Sloss from SKYLAB solar X-ray telescope picture by Naval Research Laboratory and bathymetry and topography databases archived at NGDC.

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Introduction

- SCOSTEP's mission: to implement research programs in solar-terrestrial physics that benefit from international participation and that involve at least two ICSU bodies.

- Some past SCOSTEP programs have been comprehensive, such that virtually all of SCOSTEP's energy was dedicated to the implementation of one large program.
  - STEP in 1990-97
  - MAP in 1982-85
  - IMS in 1976-79

- This sets forth the case for a major future SCOSTEP program called "CAWSES" (Climate and Weather of the Sun-Earth System), to be implemented from 2004-2008.

Scientific Motivations for CAWSES

- Quest to apply research and technological tools to better understand human space.
- Understanding our solar-terrestrial environment has practical significance.
- The solar-terrestrial environment is a physical system whose state at any given time and at any specific location results from a combination of multiple physical processes that occur simultaneously or sequentially across many domains.

Timeliness of the CAWSES Program

- Several countries now propose to implement substantial national programs in solar-terrestrial physics. CAWSES would help mobilize action on those proposals and offer an opportunity for voluntary coordination between their programs.
- Properly defined, an international SCOSTEP program would help science communities in nations without space programs, who have difficulty implementing solar-terrestrial programs. Progress in Internet technology now facilitates effective international collaborations that will benefit CAWSES.
- A properly posed SCOSTEP program would articulate new directions for future solar-terrestrial research involving observations, modeling and applications. CAWSES would help coordinate national activities in all these areas.
- New technology offers unprecedented opportunity to involve scientists in developed and developing countries, and to provide educational opportunities for students at all levels.

Recent Smaller Programs Pertaining to Individual Disciplines: 1998-2002

- ISCS: Solar physics
- PSMOS: Middle atmosphere physics
- EPIC: Equatorial regions
- S-RAMP: Further the objectives of STEP. An event-oriented multi-regional study, Space Weather Month (September 1999), was conducted by S-RAMP and used the array of ISTP satellites still operational.

CAWSES Scientific Steering Group

- Chair: Sunanda Basu
- Jean-Louis Bougeret, CNRS, France
- Joanna Haigh, Imperial College, UK
- Yohsuke Kamide, STEL, Japan
- Arthur Richmond, NCAR, USA
- C.-H. Liu, NCU, Taiwan
- Lev Zelenyi, IKI, Russia
- Secretary – Joe Allen

CAWSES Meetings - Past & Future

- First CAWSES SSG Meeting held at Maastricht, The Netherlands on August 24-25, 2002
- Four themes approved by SCOSTEP Bureau at Rio de Janeiro Meeting, Sept 28-30, 2002
- Theme leaders presented their plans at a Town Hall Meeting on April 8, 2003 during the EGS/AGU Meeting in Nice, France
- Membership of the thematic groups to be finalized by IUGG Meeting in Sapporo in July 2003
- A special CAWSES Meeting is being planned for July 5, 2003 at Sapporo

Four Themes under CAWSES

Solar Influence on Climate

- **Chair- Mike Lockwood, Rutherford-Appleton Lab, UK**

Space Weather: Science and Applications

- **Co-Chair- Janet Kozyra, U. of Michigan, USA**
- **Co-Chair - K. Shibata, Kyoto University, Japan**

Climatology of the Sun-Earth System

- **Co-Chair - J. Sojka, Utah State University, USA**
- **Co-Chair - C. Frohlich, World Radiation Center, Switzerland**

Atmospheric Coupling Processes

- **Chair- Franz-Josef Luebken, IAP, Kuehlungsborn, Germany**

Solar Influence on Climate

- Effects of solar variability on middle and lower atmosphere
- Variability of spectral irradiance, energetic particles & cosmic rays
- Study of paleoclimates
- Study of extreme environments in the Sun-Earth system

Space Weather: Science and Applications

- Impacts on Space Technology and Operations
- Effects on Humans in space
- Telecommunications interruptions
- Vulnerability of Earth- surface systems
- Navigation upsets during magnetically quiet (at low latitudes) & disturbed times
- Effects on high-altitude aircraft passengers and crew
- Model development through quantitative understanding of multi-scale coupling in the Sun-Earth system

Space Climatology

- Study regular variations, long-term trends and statistical properties of irregular variations with help of models
  - Temporal scales from mins/hours to centuries/millennia
- Quantify probabilities of extreme events
- Understand processes that influence the climate
- Critical assessment of long-term trends, joining SPARC for assessment of middle & upper atmosphere trends

Temporal Variations Within the Coupled Solar-Terrestrial System

Examples of time-sorted phenomena with linkage between traditional STP science:

Minutes-Hours	Days-Weeks	Months-Years	Decades-Centuries
Solar Flares CMEs Geomagnetic Storms Substorms Ionospheric Currents and Structure Gravity Waves Turbulence Reconnection Radiation Belt Enhancement	Solar Rotation Emerging Flux Features Trapped Particles Magnetic Clouds Geomagnetic Storms Radiation Belt Dynamics	Solar Cycle Solar Dynamo Solar Wind Variance Cosmic Rays Middle Atmosphere Composition, Dynamics, Temperature SAO & QBO	Solar Irradiance Changes Earth Surface Temperature Ozone Changes Galactic Cosmic Rays Maunder Minimum Climate Change

Atmospheric Coupling Processes

- Coupling of spatial domains through dynamic, radiative and/or electrodynamic processes
- Coupling through transport of atmospheric constituents
- Observations, theory and modeling to be utilized for understanding coupling processes
- Coupling processes important for understanding of Space Weather, Space Climatology and Solar Influence on Climate

Spatial Domain Concepts of the Solar-Terrestrial System

- Sun
- Heliosphere
- Magnetosphere
- Thermosphere/Ionosphere
- Middle Atmosphere
- Lower Atmosphere and Climate
- Limits/Extreme Cases of Variability

Unresolved Questions for the CAWSES Program

- 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?
- 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?
- 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?

Strategy

- Collect data records to document with increasing fidelity various aspects of the Sun-Earth system.
- Use physically based models for assimilating observed data and deriving enhanced outputs for segments of the solar-terrestrial system.
- Mobilize SCOSTEP researchers to work together to understand variability throughout the entire solar-terrestrial system.

Capacity Building & Education

- **CAWSES will hold meetings and provide specialized training courses for scientists from developing nations and help with computational and data resources**
- **Establish partnerships between developing & industrialized nations**
- **Develop material to educate the public about solar-terrestrial science, its impact on technology & the global environment**

Implementation

- **Must have the enthusiastic participation of the entire SCOSTEP community.**
- **Must have an appropriate management structure.**
- **Must have a realistic budget, the capacity building components that promote meaningful participation of SCOSTEP scientists from all countries, and educational components that communicate the excitement and usefulness of the CAWSES science to the public.**

Perspectives on CAWSES

- CAWSES is an ambitious program that builds on and leverages the broad SCOSTEP programs STEP and S-RAMP and more specialized Post-STEP programs.
- CAWSES is particularly timely.
- Successful implementation of CAWSES will provide an integrated scientific framework for solar-terrestrial research in the future, and provide an informed basis for guiding later programs under different solar conditions and changing anthropogenic influences and as made necessary by new human institutions and technological advances.