



Climate and Weather of the Sun-Earth System (CAWSES) Science and I*Y Programs

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CAWSES and its Ancestry



- CAWSES is the newest SCOSTEP program for 2004 - 2008
- SCOSTEP had developed and carried out several international programs:

- International Magnetospheric Study (IMS): 1976 – 1979
- Solar Minimum Year (SMY): 1979 – 1981
- Middle Atmospheric Program (MAP): 1982 – 1985
- Solar Terrestrial Energy Program (STEP): 1990 – 1997
- STEP-Results, Applications and Modeling Phase (S-RAMP): 1998 – 2002
- Equatorial Processes Including Coupling (EPIC): 1998 – 2002
- Planetary Scale Mesopause Observing System (PSMOS): 1998 – 2002
- International Solar Cycle Study (ISCS): 1999 – 2002

CAWSES evolved after series of discussions beginning in 2002

→ Combining all the above science issues was the logical next step.





CAWSES



Scientific Steering Group

- Chair: Sunanda Basu, BU, USA
- 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
- D. Pallamraju, Scientific Coordinator

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CAWSES Office at BU**



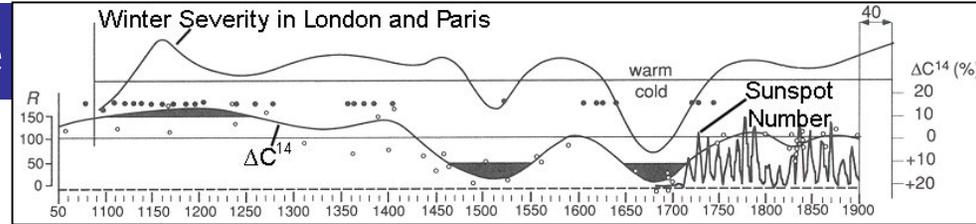
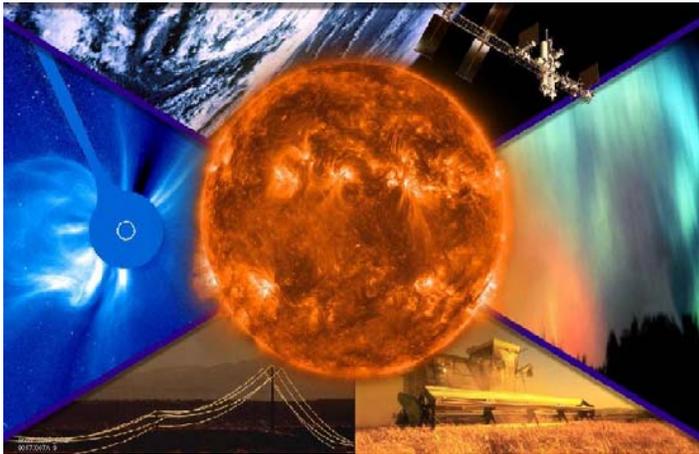


CAWSES Objectives



- Link the end-to-end processes that produce geoeffective CME, facilitate transfer through the heliosphere, magnetosphere, and the geomagnetic storms that affect the atmosphere
- Identify evidence for long-term variations of TSI related to solar activity and resultant impacts on global change compared with other climate change mechanisms
- To what extent are the M-T-I systems modulated by solar activity on long times scales, and how do different variations interact with the dynamical and radiative forcings from below?
- What are the responses of the middle and lower atmosphere to solar activity? Can we identify physical mechanisms with anthropogenic influences and estimate future ozone changes?

Solar Influence on Climate

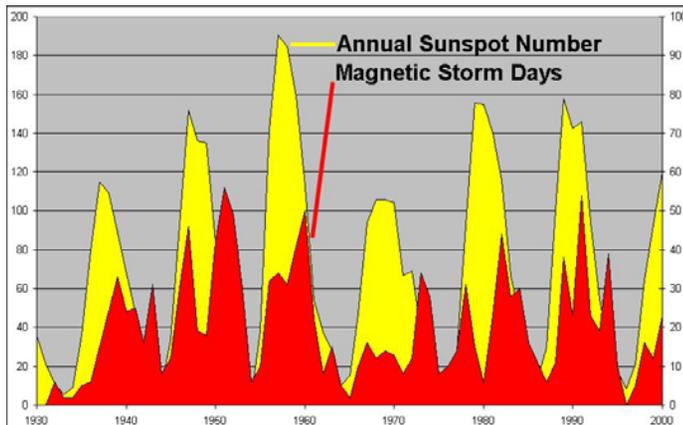


Space Weather: Science and Applications

Atmospheric Coupling Processes



Wave structures in atomic oxygen 5577 Å image.



Space Climatology



Theme 1: Solar Influence on Climate

Co-Chairs: Michael Lockwood (UK) and Lesley Gray (UK)

- Sun is the fundamental source of energy.
 - Essential to monitor how sun's energy output varies
 - How do these variations affect Earth's climate
- Separate changes caused by human activity from the changes caused by natural variations.
- Reconstruct TSI over long time scales based on proxy solar parameters.
- Understand the 27-day solar rotation on the stratospheric chemistry
- Investigate effect of solar influences on QBO, ENSO, NAO, etc.



Theme 2: Space Weather Science & Applications

Co-Chairs: Janet Kozyra (USA) and Kazunari Shibata (Japan)



- Identify critical inputs to specify the geospace environment to minimize impacts on technology, human society and life
- Support the development worldwide of dependable, robust models that predict conditions in the geospace based on quantitative understanding of the Sun-Earth system and all of its interacting components.
- Organize international observational campaigns to
 - Obtain comprehensive Sun-to-Earth geophysical data sets
 - coordinate analysis efforts to utilize these datasets
 - initiate global modeling efforts based on the data



Theme 3: Atmospheric Coupling Processes

Co-Chairs: Franz-Josef Luebken (Germany) and Joan Alexander (USA)

- Coupling via dynamics (planetary waves, gravity waves, tides, turbulence) and its role in the energy and momentum budget of the middle atmosphere
- Coupling via photochemical effects on particles and minor constituents in the upper atmosphere
- Coupling via electrodynamics including ionospheric/magnetospheric processes



Theme 4: Space Climatology

Co-Chairs: Claus Froehlich (Switzerland) and Jan Sojka (USA)



- Solar Irradiance variability
- Heliosphere near the Earth
- Radiation belt climatology
- Climatological variations of the ionosphere and the upper atmosphere



Capacity Building & Education

Co-Chairs: Marv Geller, S. T. Wu and Joe Allen

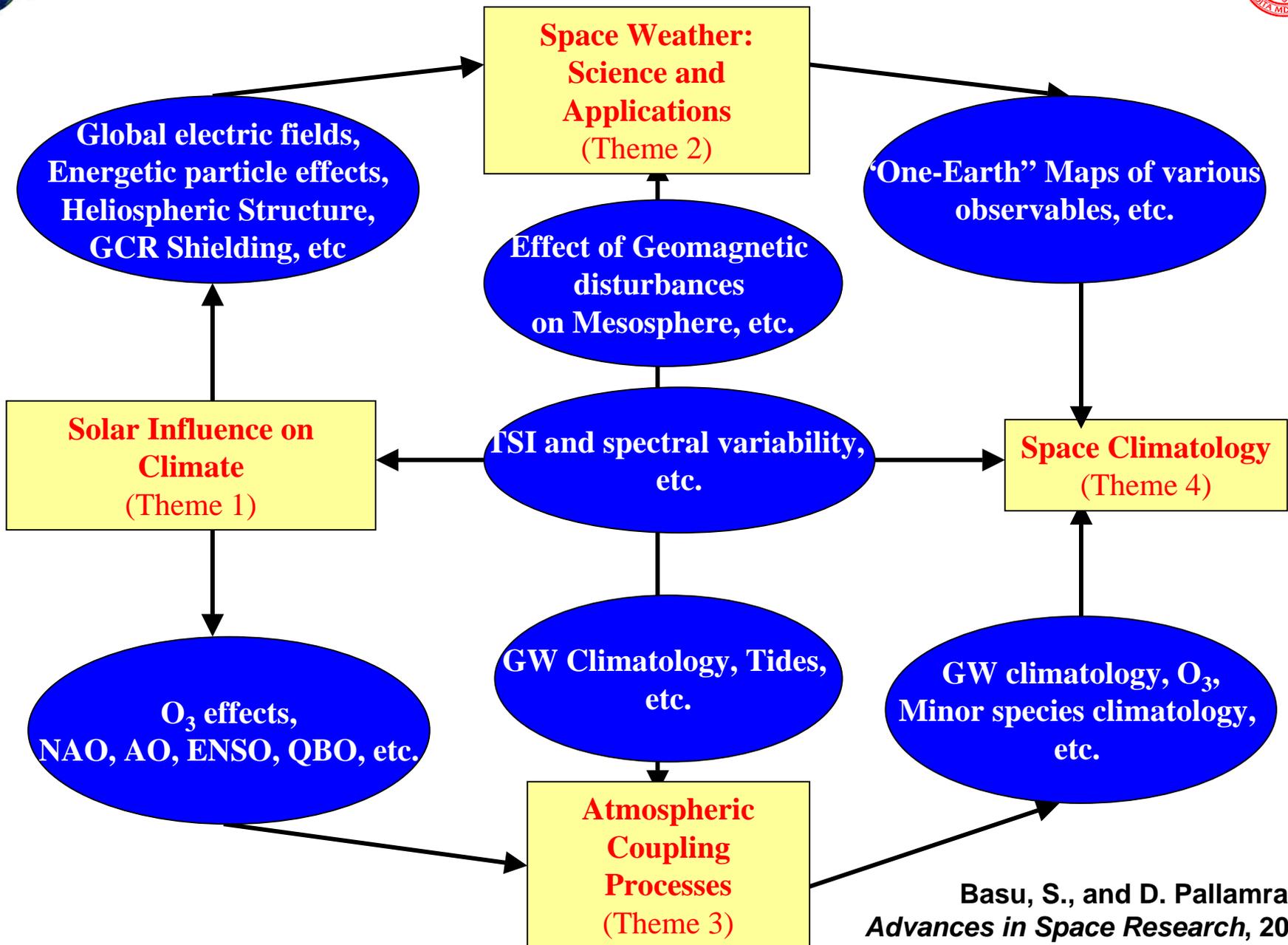


- CAWSES will hold meetings and provide specialized training courses for scientists from developing nations and help with computational and data resources
- Establish partnerships between developing & industrialized nations
- CAWSES – AOPR Center in Taipei will facilitate such activities





Coupling between different CAWSES Themes



Basu, S., and D. Pallamraju,
Advances in Space Research, 2005
(in press).



Value of CAWSES to IHY, eGY, IPY

- Progressively develop a set of new international data analysis tools
 - Valuable asset for space research
 - Combined with satellite data they give new ways of investigating important science questions
 - Lasting legacy after I*Y celebrations
- Collect & preserve comprehensive sets of international sun-to-Earth observations
 - Valuable for developing assimilative space weather models
 - Important for testing understanding and predictive capabilities of sun-to-Earth models
 - Worldwide resource for sun-Earth system science during and after I*Y
- Build up an international community familiar with campaign tools & collaborative analysis ready to participate in the I*Y
- Help refine science questions and needs for worldwide campaigns over the next 2 years in preparation for the I*Y celebration.



Science Plans & Activities for Different Themes

Theme 1



- **Team Meeting on Influence of Solar Variability (Lesley Gray, PI) held at ISSI, Bern, June 6-10, 2005**
 - Review observational evidence for impacts of solar variations on climate and weather
 - Assess mechanisms for transfer and amplification of solar variations by the atmosphere
 - One or more review papers are expected as the outcome



Themes 2 and 3 Joint Activity: 1st CAWSES Campaign



Purpose to investigate:

- **Space Weather Sun-to-Earth (27 March - 6 April 2004)**
 - Collect a sun-to-Earth data set which includes the lower atmosphere
 - Provide first testbed for CAWSES worldwide maps - new international research tools.
- **Equinox State of the Middle Atmosphere & Coupling between Atmospheric Regions (March - April 2004)**
 - By collecting worldwide information on the equinox middle atmosphere.
 - By serving as test bed (where possible) for global integrated maps of middle atmosphere parameters - (i.e., gravity waves, temperature, winds, etc).



CAWSES World Maps - New International Research Tools

First Results:

- CAWSES Hi-Res GPS TEC World Maps [Leads: Anthea Coster (USA) & M. Hernandez Pajares (Spain)]
- CAWSES/GAIM Assimilative Worldwide Maps of the Ionosphere [Lead: Jan Sojka, Utah State University]
- CAWSES/IAGA/GEM Worldwide ULF Wave Parameters [Leads: Ian Mann, Paul Loto'aniu, University of Alberta, CA]



Future Plans – to come!



- **Two virtual worldwide poster sessions in planning for the analysis of the 1st CAWSES campaign**
 - Data exchange
 - Science issues raised by the data
- **30 day campaign in September 2005**
 - All 8 worldwide ISR radars will operate on best effort basis
 - Investigate global ionospheric variability
 - Special focus on modeling of this variability
 - Extend observations sun-to-Earth to look at solar drivers and geospace responses
 - Collaborate, if possible, with CPEA again



New Theme 3 Projects



- **Planetary and gravity wave influence on winter polar vortices – A. Manson**
- **Global observing campaign to characterize tides from troposphere - thermosphere – W. Ward**
- **Gravity waves and turbulence – D. Fritts**
- **Solar influence on minor constituents & layers at the extra-tropical summer mesopause – F.-J. Luebken, U.-P. Hoppe, S. Bailey**
- **Ozone: how well do we understand it? – M. Mlynczak**
- **Coupling processes in the equatorial atmosphere (CPEA) – M. Yamamoto**
- **Magnetosphere-ionosphere electrodynamic coupling – G. Lu**



Theme 4 Activities

- **WG 4.1 (J.Pap & G. Thuillier) – Special CAWSES session at “Solar Variability and Climate” Meeting in Rome, June 27-July 2, 2005 will consider:**
 - Possible secular change in TSI over 30 years
 - Role of solar variability in climate change
 - Solar feature recognition
 - Establish best archival data products for the community



Theme 4 Activities (continued)



- **WG 4.3 (T. Obara) – Radiation Belt Climatology**
 - Climatology of radiation belts and impact of extreme events
 - Compile long-term database over four decades
 - Create next generation radiation belt model based on improved knowledge of climatology.
- **WG 4.4 (M. Jarvis and J. Emmert) -Climatological variations of the ionosphere and upper atmosphere**
 - Scope and mission document formulated
 - Determination of long-term trends in climatology is of high priority
 - Sessions at AGU Spring Meeting and IAGA to address the topic of “Long-term trends”



Summary: Suggestions for CAWSES and I*Y 2007 Collaborations



Means And Ends...

- Joint development of data environment & worldwide campaign analysis tools
- Collaborative effort to collect and archive comprehensive sun-to-Earth data sets during I*Y.
 - NSF contribution: Request to run all ISR radars opportunistically during magnetic activity throughout 2007
 - International Space Agency contributions: Request to make available relevant satellite data during as many magnetically active periods as possible in 2007
 - CAWSES, ICESTAR, CEDAR and other programs: Recruit & coordinate worldwide ground-based contributions
 - CAWSES: Make available the set of new global ground-based analysis tools during magnetically active periods
 - I*Y/CAWSES: Recruit large-scale model outputs & assimilative models as part of the archived data sets



Summary: Suggestions for CAWSES and I*Y 2007 Collaborations



- Comprehensive Sun-to-Earth data sets would be an important worldwide resource and lasting legacy, freely available during and after the I*Y for research efforts aimed at:
 - Focused science question within the global context
 - Sun-to-earth system science research issues
 - Design of new space missions
 - Identifying important gaps in ground-based arrays
 - Testing of design concepts for ground-based instrument arrays
 - Assimilative space weather modeling efforts
 - Verification of sun-to-Earth and large-scale space weather models
 - Testing of predictive capabilities of space weather models
- Joint CAWSES/ICESTAR session on July 1 at 08 – 10 AM (Anasazi)**



Join the movement in these exciting times
for Space Research ...

For more information on CAWSES,
Please visit:

<http://www.bu.edu/cawses>

THANK YOU