

**Meeting of Theme 3:  
Atmospheric Coupling Processes**

**Paris, 22 July 2004**

**13:00-14:30**

**Room 334, Congress Centre**



# CAWSES: Climate and Weather of the Sun-Earth System

Sunanda Basu  
Chair, Science Steering  
Committee,  
CAWSES

# SCOSTEP

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

## *SCOSTEP Bureau*

- President: M. A. Geller
- Vice-president: S. T. Wu
- Scientific Secretary: J. H. Allen
- S. K. Avery (URSI)
- W. Baumjohann (IAGA)
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- B. Schmieder (IAU)
- F. W. Sluijter (IUPAP)
- T. Tsuda (IAMAS)
- M. Candidi (SCAR)



# CAWSES Meetings – Initial Phase

- First CAWSES SSG Meeting held at Maastricht, The Netherlands in August 2002
- Four themes approved by SCOSTEP Bureau at Rio de Janeiro, Brazil, September 2002
- Theme leaders presented their plans at a Town Hall Meeting in April 2003 during the EGS/AGU Joint Assembly in Nice, France
- CAWSES Program presented at first ILWS Meeting in Nice, France, April 2003
- Special CAWSES Meeting held in July 2003 in conjunction with the IUGG Meeting at Sapporo, Japan
- Election of new SCOSTEP Bureau was held in Sapporo and CAWSES Report was presented to them

# CAWSES

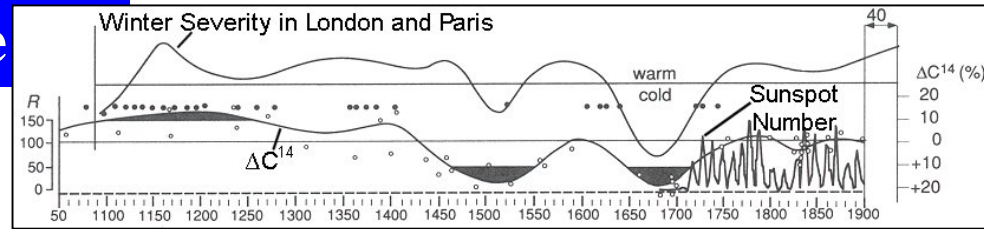
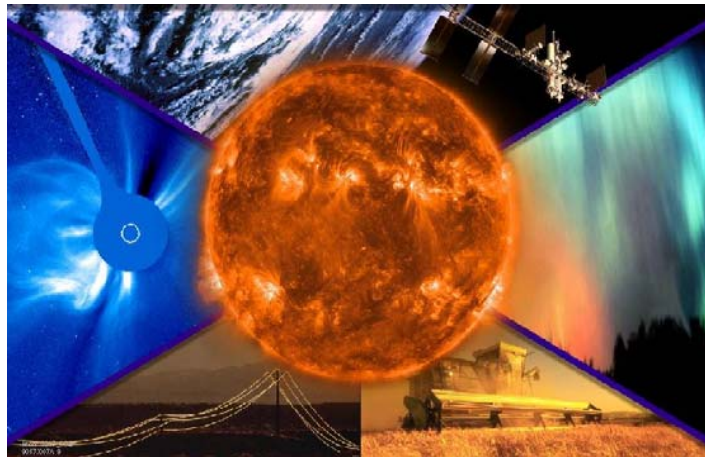
## Scientific Steering Group

- 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
- Secretary – Joe Allen

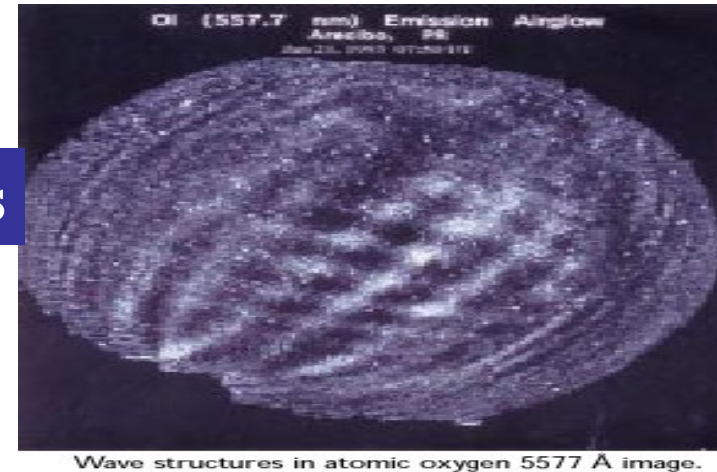


# Four Themes under CAWSES

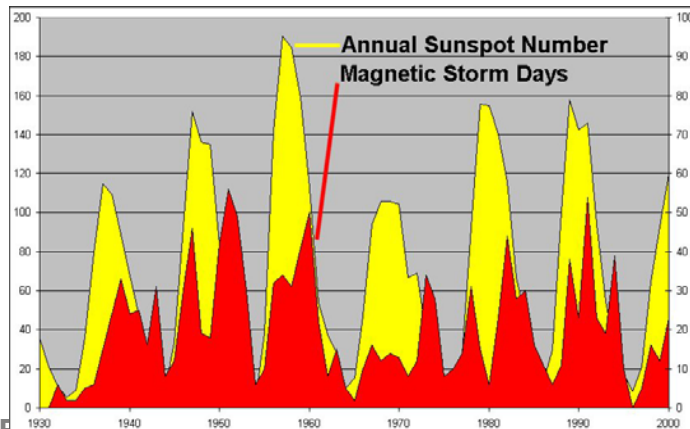
## Solar Influence on Climate



## Space Weather: Science and Applications



## Atmospheric Coupling Processes



## Climatology of the Sun-Earth System

## **Theme 1: Solar Influence on Climate**

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

### **WG 1.1: Assessment of Evidence for Solar Influence on Climate**

*Juerg Beer (Switzerland), William Russow (USA), Ilya Usoskin (Russia), Judith Lean (USA), Gerard Thuillier (France), Gerry North (USA), Peter Stott (UK), Warren White (USA), Lon Hood (USA), Karin Labitzke (Germany), Augusto Mangini (Germany)*

### **WG 1.2: Investigation of Mechanisms for Solar Influence on Climate**

*Ulrich Cubasch (Germany), Gerry Meehl (USA), Kuni Kodera (Japan), Garcia (USA), David Rind (USA), Mark Baldwin (USA), Charles Jackman (USA), Jon Kristjansson (Norway) and Giles Harrison (UK)*

## **Theme 2: Space Weather Science & Applications**

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

*Santimay Basu (USA), Walter Gonzalez (Brazil), Nat Gopalswamy (USA), A. T. Koba (Ivory Coast), Anatoly Petrukovich (Russia), Rainer Schwenn (Germany), Wei Feng Si (China) and R. Sridharan (India)*

# Theme 3: Atmospheric Coupling Processes

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

## WG 3.1: Dynamical Coupling and its Role in the Energy and Momentum Budget of the Middle Atmosphere

*Martin Mlynczak (USA), William Ward (Canada), David Fritts (USA), Nikolai Gavrilov (Russia), S. Gurubaran (India), Maura Hagan (USA), J. Y. Liu (Taiwan), Alan Manson (Canada), Dora Pancheva (UK), Kauro Sato (Japan), Kazuo Shiokawa (Japan), Hisao Takahashi (Brazil), Robert Vincent (Australia) and Yi Fan (China)*

## WG 3.2: Coupling via Photochemical Effects on Particles and Minor Constituents in the Upper Atmosphere

*Charles Jackman (USA), Ulf Hoppe (Norway), Manuel Lopez-Puertas (Spain), Daniel Marsh (USA), James Russell (USA), David Siskind (USA)*

## WG 3.3: Coupling by Electrodynamics including Ionospheric Magnetospheric Processes

*Steve Cummer (USA), Peter L. Dyson (Australia), Inez S. Batista (Brazil), Archana Bhattacharya (India), Jorge Chau (Peru), Martin Fullekrug (Germany), Gang Lu (USA), Roland Tsunoda (USA), and M. Yamamoto (Japan)*

## WG 3.4: Long-Term Trends in Coupling Processes (*inter-connected with 4.4*)

## **Theme 4: Space Climatology**

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

### **WG 4.1: Solar Irradiance Variability**

*Judit Pap (USA) and Gerard Thuillier (France)*

### **WG 4.2: Heliosphere Near Earth**

*Leif Svalgaard (USA)*

### **WG 4.3: Radiation Belt Climatology**

*Takahiro Obara (Japan)*

### **WG 4.4: Long-Term trends in Ionospheric and Upper-Atmospheric Variability (*inter-connected with 3.4*)**

*M. Jarvis (UK) and John Emmert (USA)*

# 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
- ICSU Grant Application made for such activities



# CAWSES Moves Forward

- CAWSES Office established at Boston University, Jan 16, 2004
  - D. Pallamraju (Raju) appointed Scientific Coordinator
- First Newsletter published in March, 2004
- Many Working Group members have been chosen
- First CAWSES Campaign organized in March –April, 2004 in conjunction with CPEA Campaign
- Proposal submitted by L. Gray (as PI ) for Workshop on Solar Influences on Climate at ISSI in Bern, Switzerland
- Special all–day CAWSES Meeting at Observatoire de Paris, July 17, 2004
- CAWSES presentation at ILWS Session, COSPAR Meeting, Paris, July 19, 2004
- Solar Irradiance Variability Session at COSPAR, 2004
- Atmospheric Coupling Group Meeting on July 22, 2004 at COSPAR

# CAWSES – National and Regional Programs

- CAWSES–India has been approved by ISRO
  - Workshop held in April, 2004
- CAWSES has been approved as a priority program by DFG in Germany
- CAWSES–Japan is having its inaugural Workshop near Nagoya, Japan, June 16–18, 2004
- CAWSES–AOPR (Asia Oceania and Pacific Rim) Center will be discussed in Taipei on June 18, 2004
- Early Recognition for CAWSES: IAGA and URSI have both invited S. Basu to give CAWSES–related General Lectures at their General Assemblies in Toulouse and New Delhi in 2005

# 1st CAWSES Campaign

> 40 participating international space & ground-based programs & growing. In collaboration with:

- **ISR World Days, MI-coupling campaign, 29 March - 3 April 2004**

- Focus:

- Coupling between the high- and low-latitude ionospheres
- Coordinated observations by incoherent scatter radars worldwide
  - Sonderstrom, EISCAT, Svalbard, Millstone Hill, Arecibo, Jicamarca, Irkutsk (Russia), and Kharkov (Ukraine)

- Led by Chao-Song Huang (MIT/Haystack)

- **CPEA (Coupling Processes in the Equatorial Atmosphere) Campaign, March - April 2004**

- Focus:

- Coupling troposphere up through thermosphere
- strong convective region over Indonesia

- Led by Prof. Shoichiro Fukao, Dr. Mamoru Yamamoto (Kyoto Univ)

# Purpose to investigate:

- **Space Weather Sun-to-Earth (27 March - 6 April 2004)**
  - Collect a sun-to-Earth data set which dips down into the lower atmosphere
  - Provide first testbed for a CAWSES/GEM/IAGA effort to combine international magnetometer chains & produce global maps of ULF wave index and magnetospheric density.
- **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). Looking for gaps to fill.
- **Post-Event Analysis Led Jointly by CAWSES Space Weather & Atmospheric Coupling Panels & CPEA Group**

# CEDAR/CAWSES Workshop

- Take a first look at ITM observations during space weather (25 March - 6 April) & atmospheric coupling (March - April 2004) portions of the CAWSES campaign
- Provide forum for initiating & developing collaborations
- Collect science issues on which to focus community efforts
- Discuss the value of initiating campaign efforts in:
  - assimilative modeling
  - one-atmosphere modeling
  - worldwide maps of atmospheric quantities (e.g., gravity waves, mesospheric winds, etc.)
  - worldwide maps of ionosphere/thermosphere quantities (in addition to ULF wave parameters)

# CEDAR/CAWSES Workshop

Evolving list of presentations & topics:

## Space Weather

- Jan Sojka -- GAIM assimilative ionospheric model results
- John Foster & Chaosong Huang -- Millstone Hill radar observations of positive storm effects
- Larry Paxton -- Unusual auroral forms during the 3 April and 5 April 2004 magnetic storms from TIMED/GUVI
- Dave Anderson -- Observations of Penetration Electric Fields
- Mike Ruohoniemi -- SuperDARN radar observations
- Rick Niciejewski -- TIMED/TIDI and FPI observations during CAWSES
- TBD -- Update on efforts to create worldwide maps of ULF wave quantities

## Atmospheric Coupling

- TBD -- Update on the Whole Atmosphere WACCM Model
- Jim Russell -- Perturbations in NO<sub>x</sub> & Ozone in April 2004 seen by UARS
- Marty Mlynczak -- SABER NO observations during March-April 2004
- Larry Paxton -- Thermospheric O/N<sub>2</sub> Changes during March-April 2004

**Meeting of Theme 3:  
„Atmospheric Coupling  
Processes“**

**Paris, 22 July 2004**

3 working groups:

- 3.1 Dynamical coupling (planetary waves, gravity waves, tides, turbulence) and its role in the energy and momentum budget of the middle atmosphere
  - 3.2 Particles and minor constituents in the upper atmosphere: solar/terrestrial influences and their role in climate
  - 3.3 Coupling by electrodynamics including ionospheric/magnetospheric processes
- (plus “trends” together with other themes)

### WG 3.1 Dynamics....

Fritts  
Gavrilov  
Gurubaran  
Hagan  
Liu  
Luebken  
Manson  
Mlynczak  
Pancheva  
Sato  
Shiokawa  
Takahashi  
Vincent  
Ward  
Yi

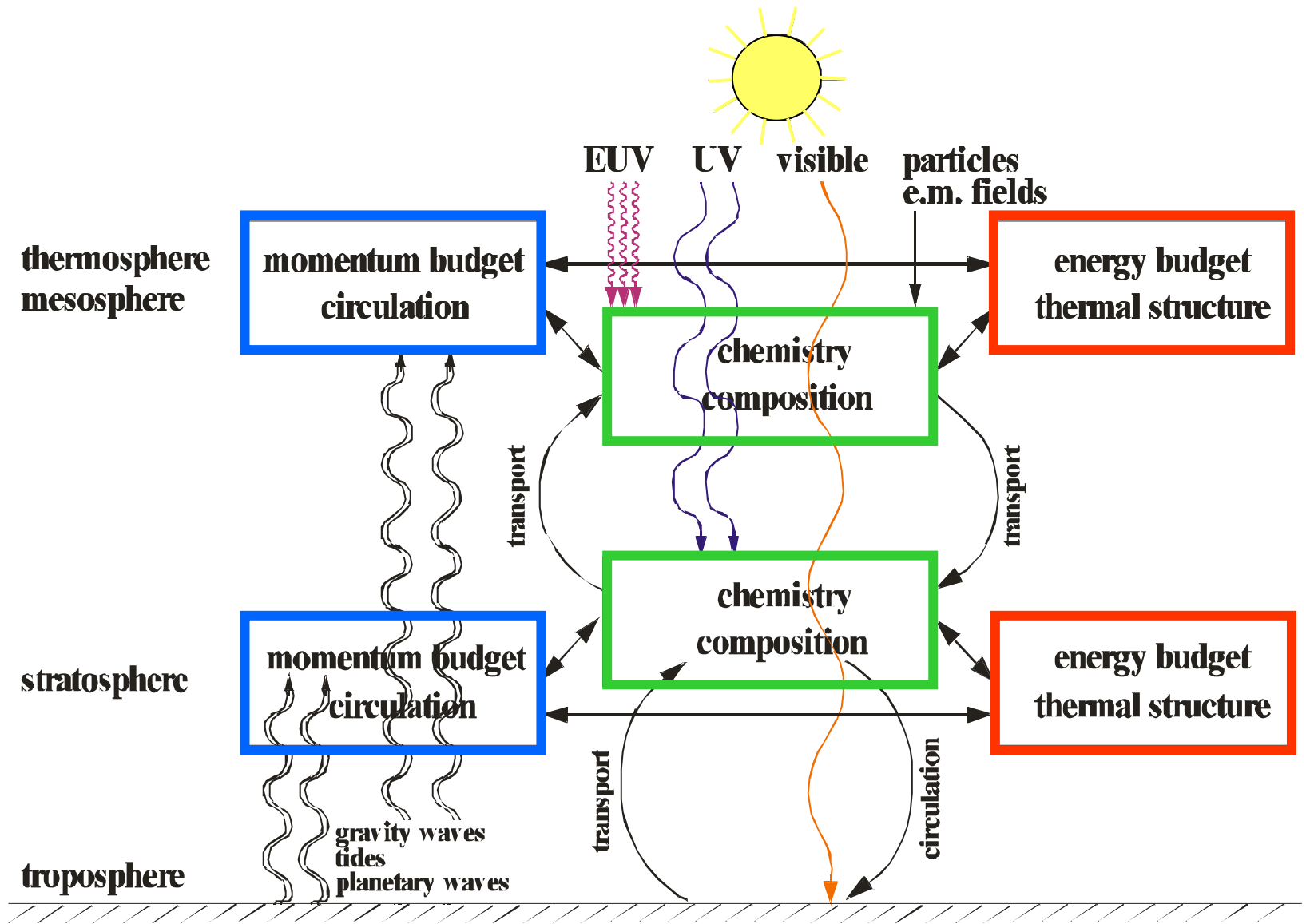
### WG 3.2 Constituents ...

Dameris  
Hoppe  
Jackman  
Lopez-Puertas  
Marsh  
Russel  
Siskind

### WG 3.3 Electrodynamics ...

Batista  
Bhattacharyya  
Chau  
Cummer  
Dyson  
Fuellekrug  
Lu  
Tsunoda  
Yamamoto

**+ interdisciplinary panel on specific topics**



## **Aims for this meeting:**

- **Identify most relevant scientific topics with good chances for success in the near future**
- **Define specific campaigns/projects/cooperations: scientific goals, time line, coordinators, etc.**
- **Aim for first report during the next meeting (when? where?)**

input received by Email from:

**Archana Bhattacharya**

**Jorge Chau**

**Nikolai Gavrilov**

**Subramanian Gurubaran**

**Maura Hagan**

**Charles Jackman**

**Franz-Josef Lübken**

**Alan Manson**

**Dan Marsh**

**Marty Mlynczak**

**Kaoru Sato**

**Hisao Takahashi**

**William Ward**

**Ulf-Peter Hoppe**

**Dave Siskind**

***Specific scientific topics,  
projects, campaigns***

## Archana Bhattacharya:

- Equatorial and low-latitude ionosphere: coupling between the equatorial F region and conjugate E regions
- Shielding of the low latitude ionosphere against prompt penetration of magnetospheric electric fields
- Quantitative understanding of low-latitude/high-latitude ionospheric variability and coupling

## Takahashi/Gurubaran:

- Atmospheric coupling from troposphere to ionosphere in the equatorial region
  - vertical energy and momentum transport and their zonal distribution
  - generation of waves in tropical deep convection (including migrating and non-migrating tides)
  - equatorial QBO and SAO and their lateral and vertical links to distant regions
  - coordinated observations by satellites (TIMED, C/NOFS, COSMIC, EQUARS, GPS), ground based (radar, lidar, optical), insitu (balloons, rockets from India)
  - 3 regions: (1) South America (Amazon forest), (2) Eastern Pacific (Indonesia and Australia), (3) India

## Charles Jackman:

Quantify the influence of the upper atmosphere on the lower atmosphere over a solar cycle

- development of usable models that determine quantitatively the impact of the upper atmosphere on the lower atmosphere over a solar cycle.
- Quantitative validation using observations from satellite instruments observing the atmosphere, especially the mesosphere and stratosphere
- provide the understanding that is necessary for the development of a predictive capability for the dynamic Sun-Earth system.

## ???? Together with Theme 2

- Study end-to-end processes: coronal mass ejection, transfer through heliosphere, interaction with magnetosphere, production of geomagnetic storms, effects in the atmosphere

## Dan Marsh:

- Certain scenarios for GCMs should be defined for intercomparison (e.g. at solar maximum conditions)

## Maura Hagan:

# Proposal for a 2007 IHY Dynamical Coupling Project

## ▪ Overarching Objectives

- ← quantify magnitudes & sources of **global** quiescent thermosphere-ionosphere variations
- ← develop improved capabilities for studies of space weather effects (i.e., better knowledge of **global** "natural" variability and/or "pre"conditioning)

## ▪ Project Components

- ← 1- to 3-month observational campaign(s); global  $T_n$ ,  $U_n$ ,  $V_n$ ,  $\rho$ ,  $N_e$ ,  $T_i$ ,  $U_i$ ,  $V_i$ ,  $W_i$ ,  $\Delta H$ ,  $\Delta D$ ,  $\Delta Z$ , etc (?)
- ← correlative analyses to quantify tidal & planetary wave signatures (quiescent parts of campaigns)
- ← develop/assess data assimilation models (e.g., GAIM; GSWM-DA); use DA to quantify optimum data requirements (quality-location-cadence) for fielding new instruments
- ← correlative/interpretive numerical modeling efforts

## ▪ Strategy

- ← leverage efforts & skills of previous and/or existing teams (e.g., SCOSTEP PSMOS; EPIC; CAWSES WG3)

## Lübken:

- Modification of trace gases by solar activity and feed back mechanisms on energy budget and dynamics. What is the role of precipitating particles on the production of minor constituents (e. g. NO<sub>x</sub>).
- Study mean state and solar induced variability on trace gases and on layered phenomena in the high latitude summer mesosphere (H<sub>2</sub>O, NLC, PMSE)
- Model solar cycle effect on water vapor and effect on NLC/PMSE
- compare with measurements:
  - H<sub>2</sub>O from ENVISAT, ODIN, microwave, etc
  - NLC/PMSE/PMC from lidars/radars/satellites

## Nakamura et al.

- characterize variability of tides (day-to-day ; inter-annual)
- coordinated effort of ground based and satellite measurements
- plus modeling

# ***Specific Measurements and Instruments***

- New contributions from Jicamarca:
  - Regular measurements of daytime mesospheric winds and turbulence with excellent height/time resolution
  - daytime electric fields in the lower thermosphere on 100 days/year
- Specific observations from MIPAS (ENVISAT) and SABER (TIMED) are used to study
  - interaction between mesosphere and stratosphere in the polar region mainly using NO<sub>x</sub> and CO
  - effects of Oct/Nov 2003 solar storm
  - non-LTE effects in CO<sub>2</sub>, NO<sub>x</sub>, O<sub>3</sub>, H<sub>2</sub>O and CO
- ENVISAT high altitude mode: few available today, but more will hopefully be made soon.
- Detailed ozone data available from TIMED from 0-100 km
- Antarctic MF radar network (Rothera, Davis, Syowa)
- New: SuperDARN HF radar network (Arctic, Antarctic) will be used to estimate winds in the thermosphere

# General aspects: science issues

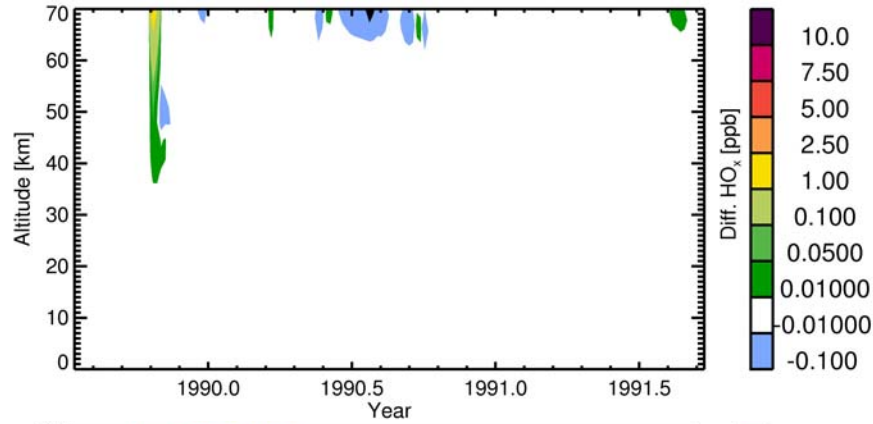
## General ; open questions

- Mesosphere/lower thermosphere (MLT): energy, momentum, constituent budget are not understood in a self-consistent manner (mostly considered separately).  
Questions: input from below/above ?; coupling between dynamics, radiation, composition ? ; details of physical processes, e.g. wave breaking ?
- Role of waves in coupling ? Sources ? Impact on circulation and mixing ?  
In particular: tides ; Non-linear interactions, e.g. between tides and PW ?
- Tides are not understood (observations and models often do not agree)
- Gravity wave observations/climatologies are essential
- Interaction of the solar signal with tropospheric/stratospheric circulation patterns (NAO, AO, ENSO, QBO, stratospheric warming) **(Fig.!)**
- Impact of variability on energy budget, for example through non-linear dependence of chemical reactions on temperature.
- Influence of MLT on the thermosphere/ionosphere ?
- What is the response of the middle atmosphere to solar activity changes and what are the relevant physical mechanisms involved (in comparison with anthropogenic influences).  
How deep into the atmosphere do solar disturbances and variability penetrate ?

## (general ; open questions , continued)

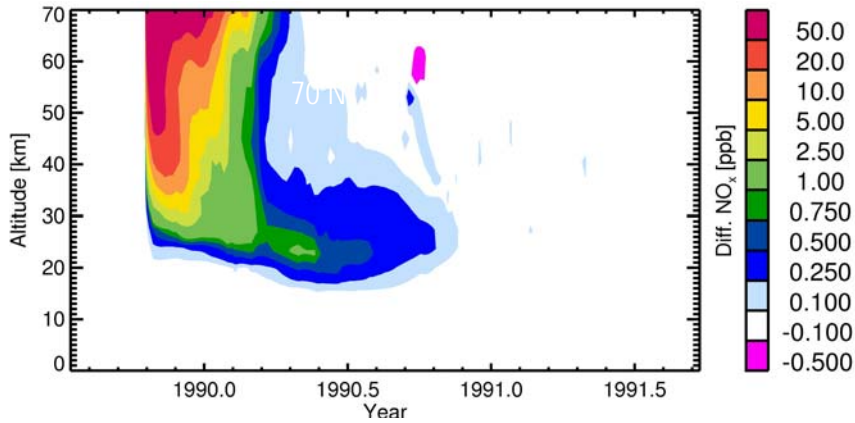
- What is the response of stratospheric ozone to changes in solar input. Ozone will be studied in the entire altitude range from the surface to 100 km.
- Modification of trace gases by solar activity and feed back mechanisms on energy budget and dynamics. What is the role of precipitating particles on the production of minor constituents (e. g. NO<sub>x</sub>). **(Fig.!)**
- Study mean state and solar induced variability on trace gases and on layered phenomena in the high latitude summer mesosphere (H<sub>2</sub>O, NLC, PMSE) **(Fig.!)**
- Identify solar variability signature in various atmospheric parameters (winds, temperatures, composition) at various time scales and different heights. More specific: quantify the influence of the upper atmosphere on the lower atmosphere over a solar cycle (e.g. downward transport of chemically active species)
- Inter-hemisphere differences must be considered (we live on `two planets') **(Fig.!)**
- Some basic physical processes need to be investigated since they are highly relevant for coupling (e.g. transition of wave instability to turbulence ; non-LTE processes).

Kallenrode & Sinnhuber,  
Private communication,  
2004

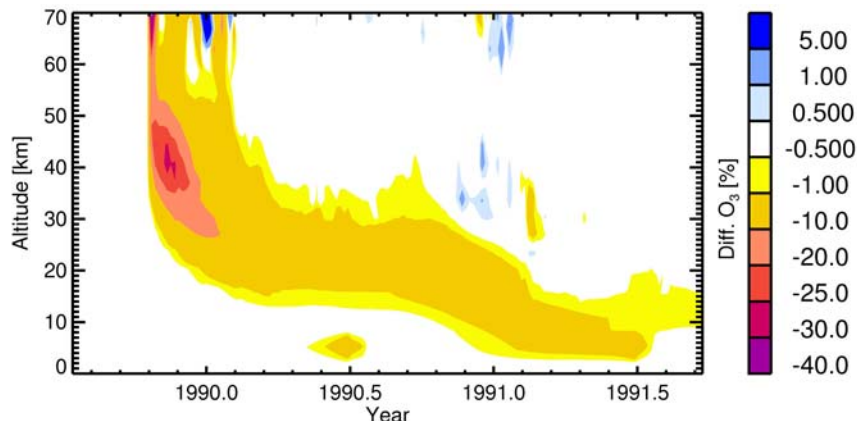


Effect of solar storm  
(October 1989) on:

HO<sub>x</sub>



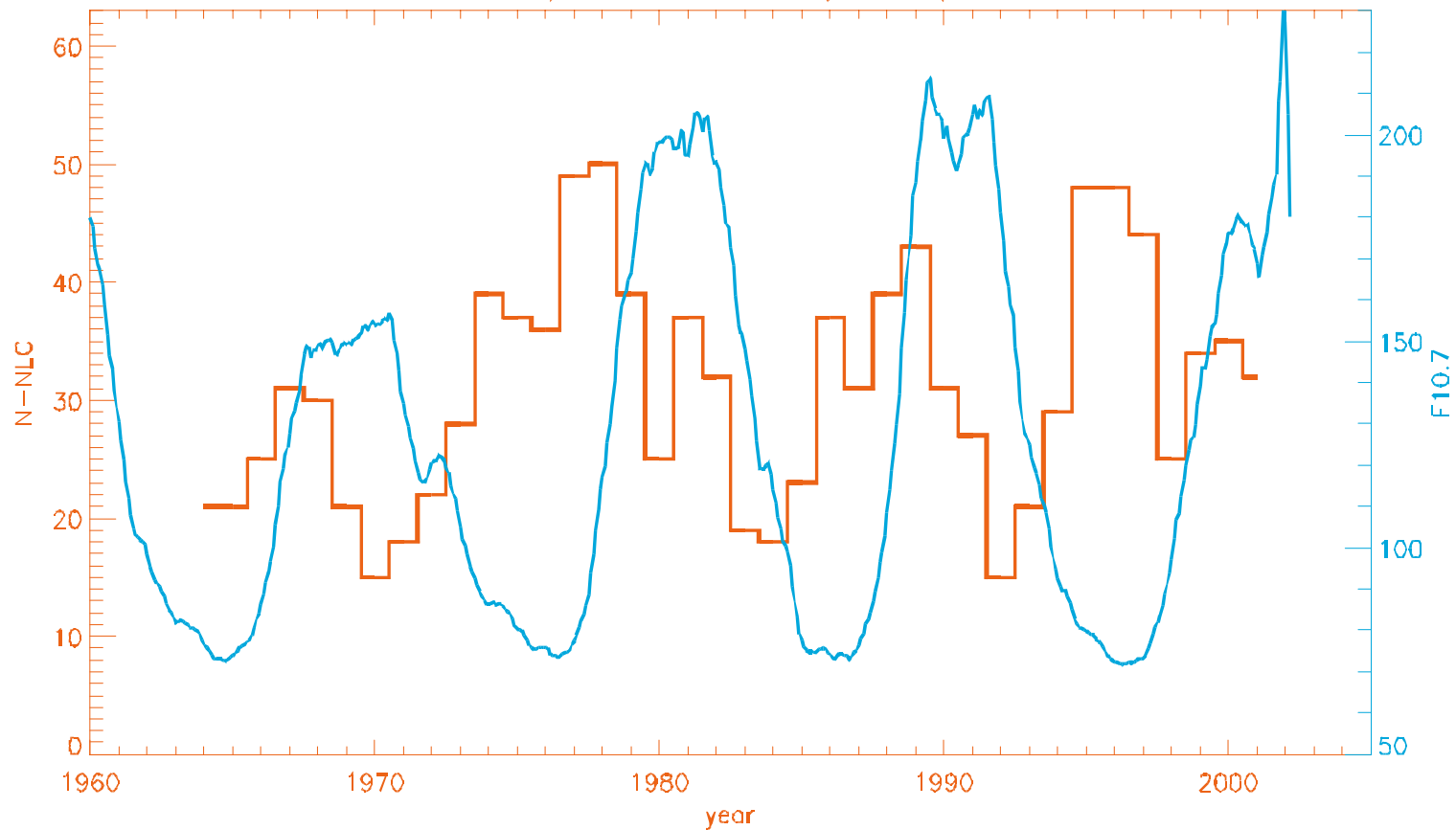
NO<sub>x</sub>



O<sub>3</sub>

Particle flux from GOES,  
Model results from  
TOMCAT/SLIMCAT

Gadsden, Brit. Astron. Ass., Vol.45, 2002



## Instrumental:

- Several satellites are (or will soon be) in orbit:  
TIMED, ENVISAT, Odin, SNOE, UARS, ACE, AURA, AQUA, EQUARS etc.
- Data in the lower atmosphere (ECMWF) are required to be available more frequently (for example to study tides) and up to 50 km
- Resonance lidars can now measure day and night (important for tides!). **(Fig.!)**  
RMR-Lidars: t.b.d.
- Optical systems (lidars, air glow) should be co-located with radars
- Coordinated campaigns with satellite and ground based observations are needed
- Chains of ground based instruments (radars, lidars etc) need to be complemented according to scientific needs (e.g. to study non-migrating tides and/or PW).  
For example: some longitudinal gaps in the radar network need to be filled
- Dedicated field campaigns and/or laboratory work are required to solve specific scientific problems.

## Models:

- GCM models with coupled chemistry now extend from the ground to the thermosphere. They require intercomparison, and also validation by comparison with observations and with mechanistic models.
- Most models are still not `wave-specific'
- Improved GW parameterizations are required
- Data assimilation in the MA is challenging but important

## Trends etc.:

- Is there evidence for long term variations of solar luminosity and impact on global change ?
- Can we make an assessment of long term changes in the upper atmosphere (similar to stratosphere?)
- Is there a tie between aeronomical activity (cosmic rays) and clouds in the troposphere ?

# **Miscellaneous:**

- **Close interaction between working groups is required, e. g. between WG 3.1 and 3.2 (because of transport of chemically active species)**
- **Interaction with the other CAWSES themes is essential**
- **Question: topics in working groups too broad ? Some more specific subprojects should be organized, e.g. `gravity waves and turbulence' or `tides'**
- **What about International Polar Year and International Heliophysical Year 2007?**

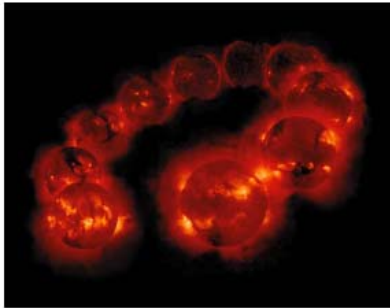
# German DFG has approved CAWSES as a „priority programme“

Proposal for a DFG priority programme entitled:

## Climate And Weather of the Sun-Earth System (CAWSES)

presented by Franz-Josef Lübken (speaker), May-Brit Kallenrode,  
Ulrike Langematz, Paul Hartogh, and Christoph Jacobi

11. February 2004



The Solar Cycle: a montage of ten years worth of soft X-ray images demonstrating the variation in solar activity during the sunspot cycle (source: solar.physics.montana.edu).



Noctilucent clouds (NLC) observed in Kählingsborn in summer 2003. NLC occurrence frequency varies with solar cycle but the physical mechanism is not understood (photo courtesy of IAP).

1



- **appr. 25 institutions**
- **appr. 2-3 Mio Euro per year**
- **2 (+4) years**
- **in operation: April 2005**

Nikolai Gavrilov has generated a website for NIS scientists interested in CAWSES:

<http://lmupa.phys.spbu.ru/cawsesnis/>

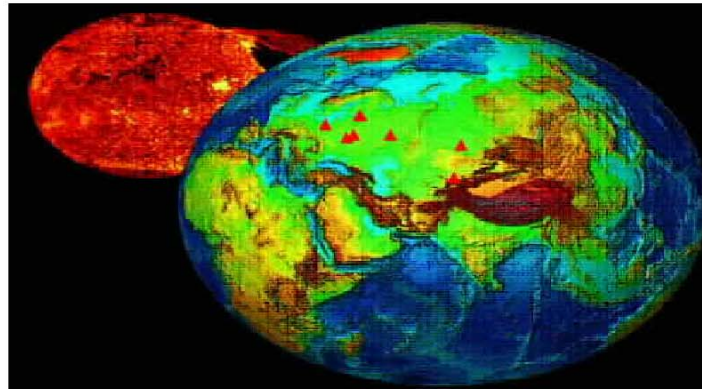
# Atmospheric Coupling Processes

studies in NIS countries according to Theme 3 of CAWSES

(Climate and Weather of the Sun-Earth System)

A new SCOSTEP Program for 2004-2008

[Russian – Русская версия](#)



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. Red triangles show sites of NIS participants.

<a href="#">CAWSES homepage</a>	<a href="#">Science in</a>
<a href="#">Theme 3 of CAWSES</a>	<a href="#">NIS Participan</a>
<a href="#">To join the list of NIS Participants e-mail to <a href="mailto:gavrilov@pobo">gavrilov@pobo</a></a>	

## Aims for this meeting:

- **Identify most relevant scientific topics with good chances for success in the near future**
- **Define specific campaigns/projects: scientific goals, time line, coordinators, etc.**
- **Aim for first report during the next meeting (when? where?)**

# CAWSES sessions and workshops:

- **During international meetings:**

**AGU, San Francisco, Dec. 2004**

**EGU, Nice, spring 2005**

**IAGA+ICMA, Toulouse, 18-29 July 2005**

**IAMAS+IUGG, Beijing, 2-11 August 2005**

**COSPAR, Beijing, 2006**

**SCOSTEP, Rio de Janeiro, March 2006**

**and more ...**

- **Specific workshops: t.b.d.**

Suggestions for a session in C2 (COSPAR, Beijing, 2006)

Solar (and extraterrestrial ?) influence in the middle atmosphere and coupling mechanisms through dynamics, composition, and electrodynamics

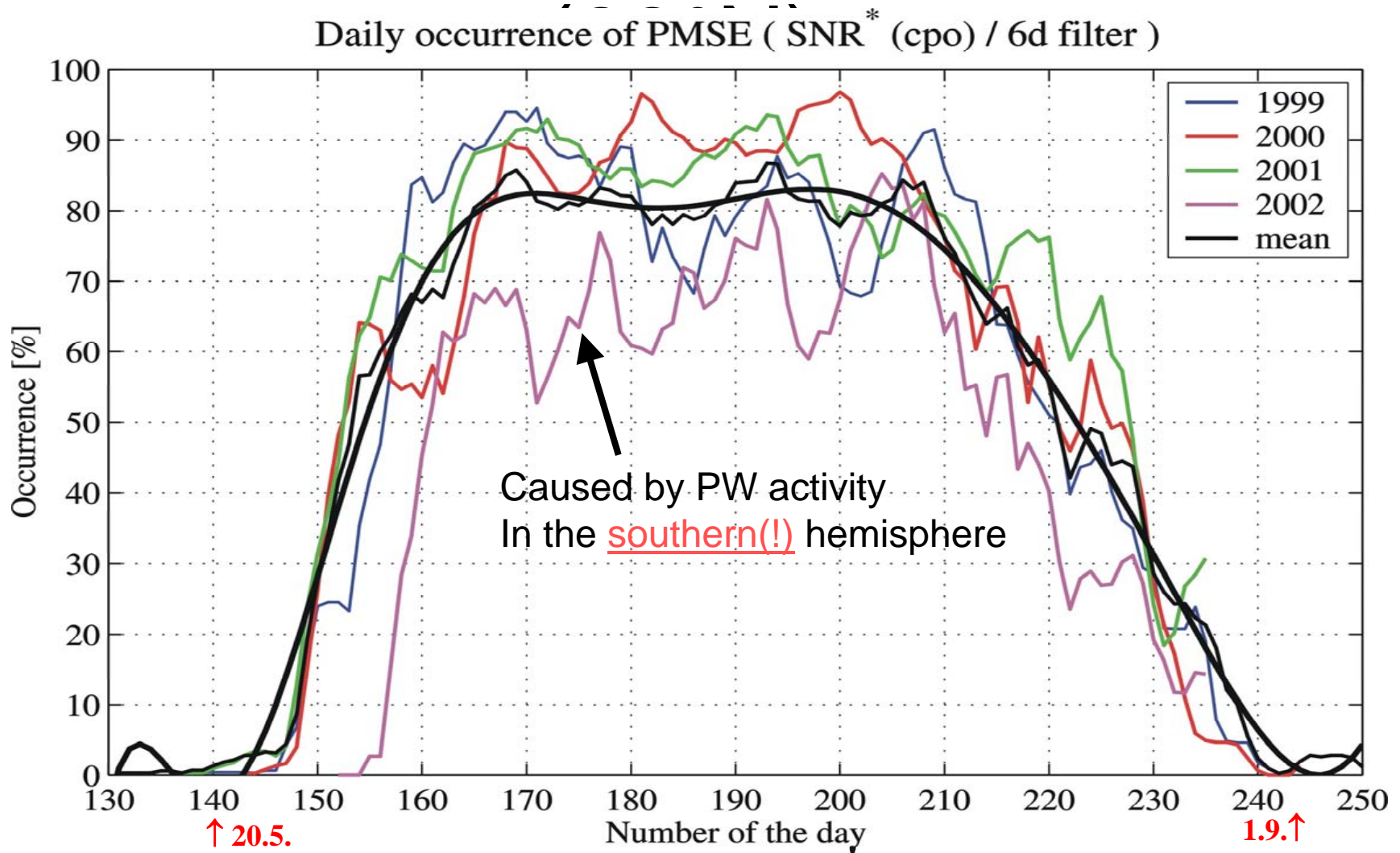
- effects of energetic particles on composition (including aerosols)
- modification of minor constituents by solar e.m. radiation (H<sub>2</sub>O, O<sub>3</sub>, ...) and feedback mechanisms on dynamics (including waves) and energy budget
- (electrodynamics?)
- response of MLT (including lower ionosphere) to solar disturbances
- observations (ground based, satellites, etc.) and modelling

MSO/scientific editor: Krivolutsky/Ward

DSO: Chakrabarty, Gupta, Lübken, (TIMED team)

**Spare:**

# PMSE occurrence at ALWIN



Latteck (IAP), private communication, 2003.

# GW climatology at 54°N from various lidars

