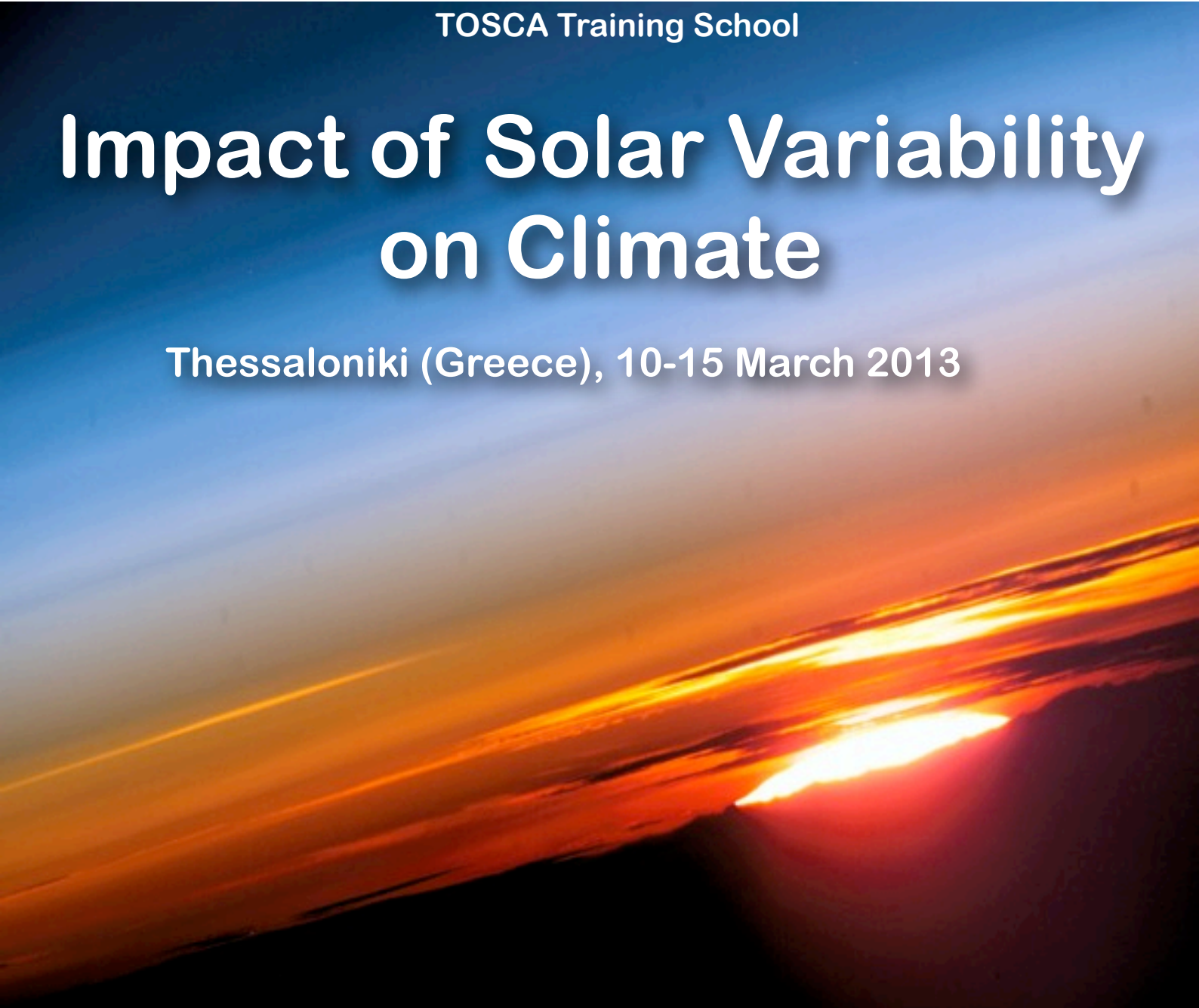
TOSCA Training School

Impact of Solar Variability on Climate

Thessaloniki (Greece), 10-15 March 2013



School booklet

http://sun2climate.sciencesconf.org

Venue : Hotel Santa Beach, Agia Triada, Greece

Conveners :

Kleareti Tourpali	Aristotle University, Thessaloniki
Jean Lilensten	IPAG, Grenoble
Thierry Dudok de Wit	University of Orléans

Lecturers :

Ilaria Ermolli	INAF, Rome
Katya Georgieva	Bulgarian Academy of Sciences, Sofia
Jón-Egill Kristjánsson	University of Oslo
Jean Lilensten	IPAG, Grenoble
Katja Matthes	GEOMAR, Kiel
Colin Price	Tel Aviv University
Eugene Rozanov	PMOD/WRC, Davos
Hauke Schmidt	Max-Planck Institute for Meteorology, Hamburg
Claudia Stubenrauch	LMD, Paris
Kleareti Tourpali	Aristotle University, Thessaloniki
Ilya Usoskin	University of Oulu

Sponsors :

Cooperation in Science and Technology (COST action ES1005)
Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)
International Union of Geodesy and Geophysics (IUGG)
Committee for Space Research (COSPAR)
Aristotle University at Thessaloniki (AUTH)

http://sun2climate.sciencesconf.org

Introduction

One of the key issues in global climate change is the role of natural climate variability, whose quantification has remained a major challenge. There is strong evidence that it is related to man-made increasing greenhouse gas levels. However, many uncertainties remain regarding the actual contribution of natural climate variability. The role of solar variability, in particular, is a topic of major scientific and societal importance. This is also a highly multidisciplinary issue for which progress has been slowed down by the lack of interactions between different communities.

The prime objective of this training school is to give young scientists a global understanding the Sun-climate connection, so that they get more easily engaged in multidisciplinary interactions during their career. This school will be held under the auspices of the COST (Cooperation in Science and Technology in Europe). All lecturers are scientists who are involved in COST action TOSCA *"Towards a more complete assessment of the impact of solar variability on climate"*, which is a multidisciplinary European network of scientists from 18 countries. This action aims at assessing the various contributions of solar variability to the Earth's climate by bringing together solar physicists, space scientists, plasma physicists, atmospheric scientists, climate modellers, and more.

There is no restriction in the number of scientists who can be involved in TOSCA, so you are welcome to join the action as well. We organise periodic workshops and also offer dedicated funding for allowing young scientists to do short-term scientific missions between countries that are involved in the action. For more information, see: http://www.tosca-cost.eu

We wish you a very pleasant stay in Thessaloniki and hope that this workshop will provide you with new opportunities for interacting with the international science community.

K. Tourpali, J. Lilensten and T. Dudok de Wit
March 2013

Practical information

Venue : The meeting will be held at

Hotel Santa Beach (formerly Galaxias Hotel)
2 Lambraki Street, Agia Triada 57019
Tel +30 2392 022 291, Email info@santahotel.gr
Coordinates: N 40.502191, E 22.896173

Contact : During the workshop, you may contact us at

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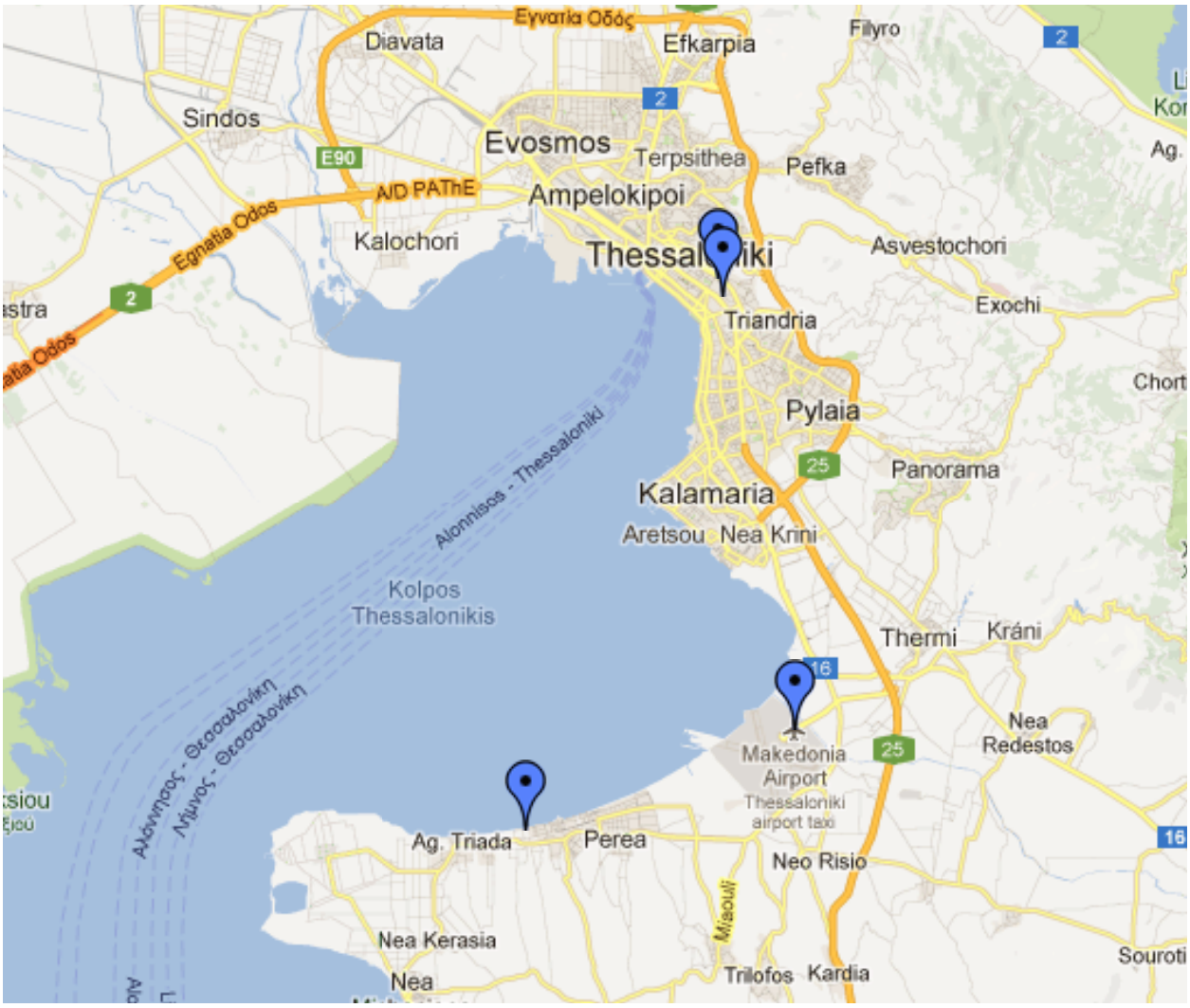
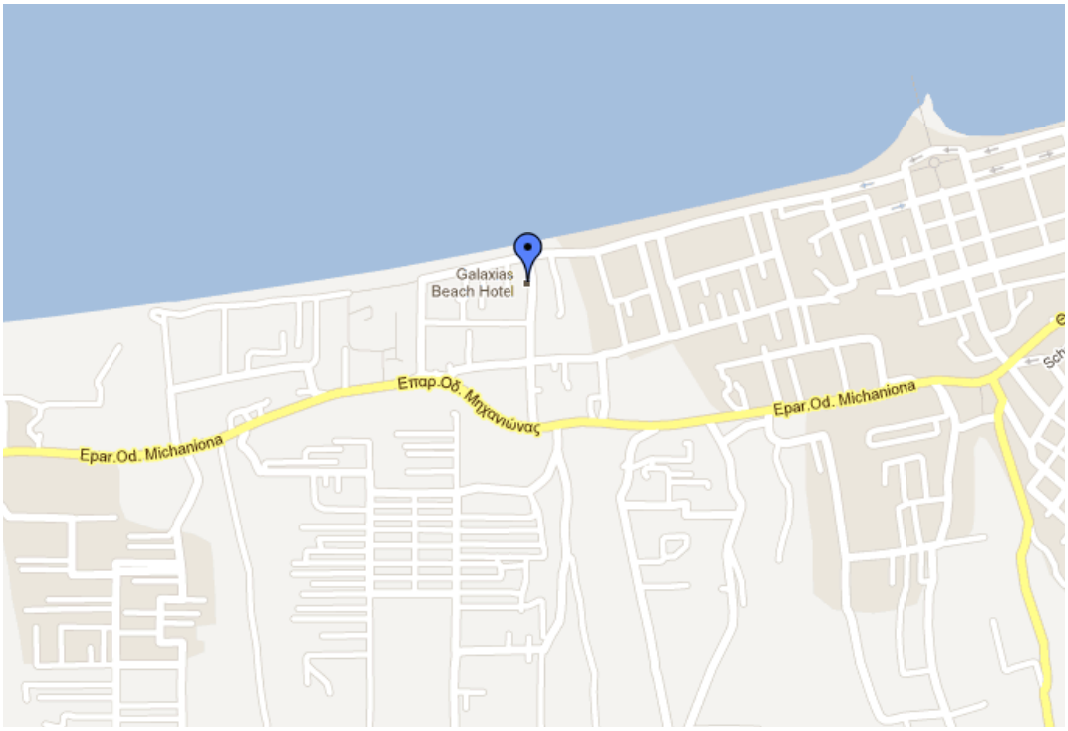
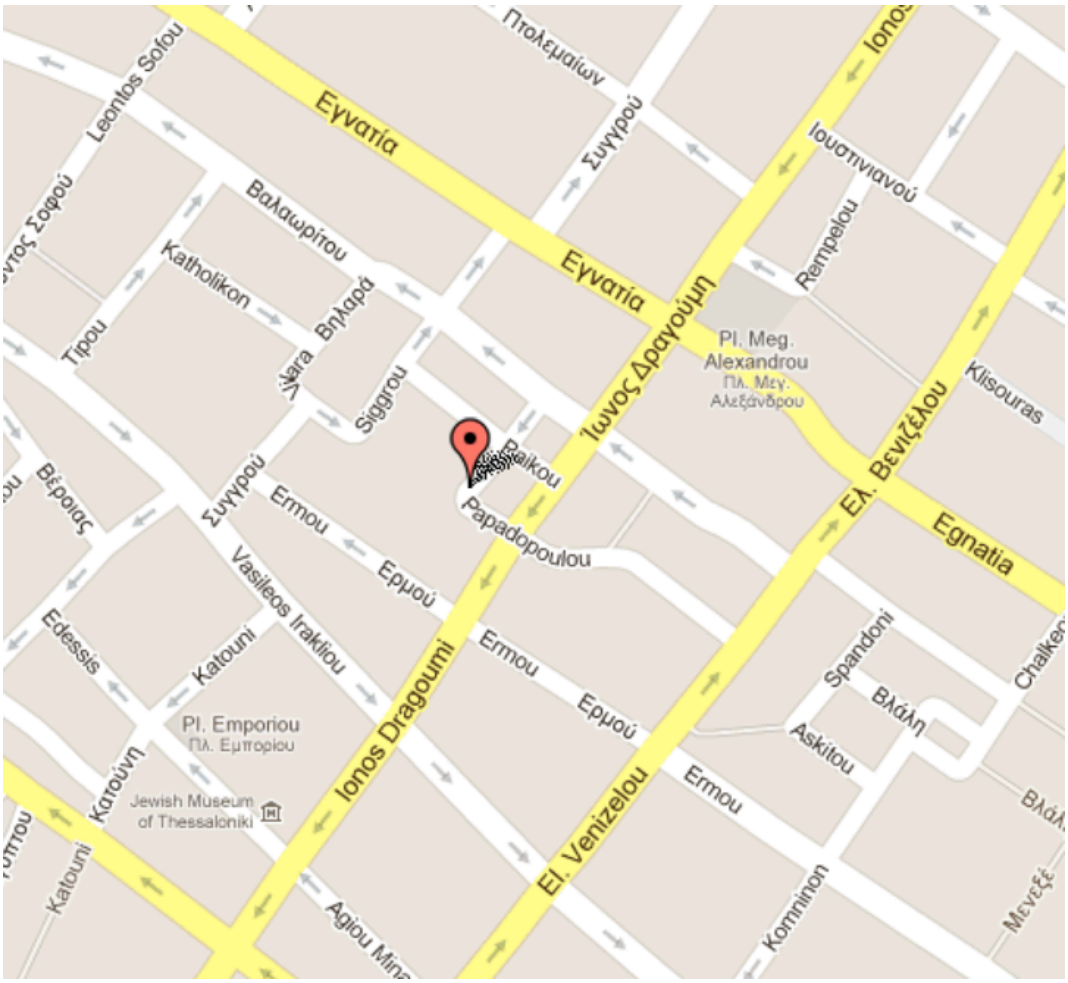
On Thursday evening we shall have dinner at AGORA, Kapodistriou 5 (Καποδιστριου 5), in Thessaloniki. See http://bit.ly/XXS7aW for a map with walking directions.



Location of Agia Triada (bottom) and the University campus (top).



Location of the hotel in Agia Triada.



Location of AGORA restaurant.

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Programme

Sunday, March 10

19:00–22:30	*welcome reception at the hotel, with buffet*	Hotel restaurant

Monday, March 11

8:30– 9:15	I. Ermolli: The Sun as a star	Conference room
9:15–10:00	K. Georgieva: The solar dynamo	Conference room
10:00–10:30	*coffee break*	Conference room
10:30–11:15	I. Ermolli: Solar irradiance	Conference room
11:15–12:00	K. Georgieva: Other manifestations of solar activity	Conference room
12:00–13:30	*lunch*	Hotel restaurant
13:30–14:15	I. Ermolli: Solar data bases	Conference room
14:15–15:00	K. Georgieva: Solar wind and geomagnetic data bases	Conference room
15:00–15:30	*coffee break*	Conference room
15:30–17:00	J. Lilensten: the space environment I	Conference room
17:00–17:30	*break* and assessment of the day	Conference room
17:30–19:00	Projection of the movie "An inconvenient truth"	Conference room
19:15	*dinner*	Hotel restaurant

Tuesday, March 12

8:30–10:00	K. Tourpali: The Earth's atmosphere: a brief introduction	Conference room
10:00–10:30	*coffee break*	Conference room
10:30–12:00	J. Lilensten: the space environment II	Conference room
12:00–13:30	*lunch*	Hotel restaurant
13:30–15:30	E. Rozanov: Physics and chemistry of the stratosphere and the mesosphere I	Conference room
15:00–15:30	*coffee break*	Conference room
15:30–17:00	poster session	Conference room
17:00–17:30	*break* and assessment of the day	Conference room
17:30–19:00	Projection of the movie "The great global warming swindle"	Conference room
19:15	*dinner*	Hotel restaurant

Wednesday, March 13

8:30–10:00	E. Rozanov: Physics and chemistry of the stratosphere and the mesosphere II	Conference room
10:00–10:30	*coffee break*	Conference room
10:30–12:00	C. Stubenrauch: Climatic studies from space observations	Conference room
12:00–13:30	*lunch*	Hotel restaurant
13:30–15:00	J.-E. Kristjánsson: Climate impacts of energetic particles	Conference room
15:00–15:30	*coffee break*	Conference room
15:30–17:00	H. Schmidt: Climate impacts of solar radiation I	Conference room
17:00–17:30	*break* and assessment of the day	Conference room
17:30–19:00	Debate on the two movies	Conference room
19:15	*dinner*	Hotel restaurant

Thursday, March 14

8:15– 9:00	travel by bus to the university	Bus
9:00–12:00	E. Tanskanen: Introduction to the substorm zoo	Computer room
12:00–13:30	*buffet lunch*	Physics department
13:30–15:00	Colin Price: global circuit and atmospheric electricity	Physics department
15:00–15:30	*coffee break*	Physics department
15:30–17:00	K. Matthes: Climate impacts of solar radiation II	Physics department
17:00–19:30	*free time in downtown Thessaloniki*	
19:30–22:30	*dinner*	Agora Restaurant
22:30	travel by bus back to the hotel	Bus

Friday, March 15

8:30–10:00	I. Usoskin: Cosmic rays in the Earth's atmosphere	Conference room
10:00–10:30	*coffee break*	Conference room
10:30–12:00	Round table on the IPCC and the current science view	Conference room
12:00–13:30	*lunch (optional)*	Hotel restaurant
13:30–18:00	departure from hotel	Hotel

Abstracts of the lectures

The Sun as a star and solar irradiance
Ilaria Ermolli (INAF, Rome, Italy)

The Sun is just one middle-aged member of the vast family of stars, but it is our nearest star. Its proximity provides heat and light to maintain life on Earth, as well as a unique laboratory to test our theories of stellar evolution, fluid dynamics, plasma physics, seismology, particle physics, atomic physics, nuclear physics, spectroscopy, radiative transfer, ...

The lecture will begin with a description of the Sun as a star in the Milky Way. What do we gain and what do we lose by studying the Sun with respect to other stars? The basics of solar physics will then be introduced, by describing the solar structure, from the core to the corona, and the physical processes behind this. The Sun is a magnetically active star. The solar magnetic field leads to many phenomena that are collectively called solar activity. The lecture will describe the properties and the physical principles of magnetic regions in the solar atmosphere. Why are sunspots dark? The solar magnetic field changes over time. Are we living in special solar times? The radiative emission of the Sun varies as well. The last part of the lecture will focus on this topic. Which measurements are available today? How do we explain solar irradiance variations?

Solar databases

The lecture will begin with an introduction to different ways to observe the Sun and to the space-born and ground-based telescopes in operation. Then, it will continue with a presentation of the main features of a few solar databases, e.g. HELIOVIEWER, NOAA/NGDC, SIDC, LISIRD.

Solar dynamo and manifestations of solar activity
Katya Georgieva (Bulgarian Academy of Sciences, Sofia, Bulgaria)

I will first present the observations of sunspots including cycles, Spörer's law, Hale's polarity law, etc. pointing what observational facts any solar dynamo theory has to explain. Then I will present the flux-transport solar dynamo theory and how it explains all thèse observations. I will next demonstrate how proxy data can be used to derive the long-term variations of the solar dynamo, and what can be the sources of long-term variations of the solar dynamo. I will then illustrate the different manifestations of solar activity, and their effects on the Earth.

Solar wind and geomagnetic data bases

I will provide links to recommended data bases useful for investigating solar-terrestrial influences, along with a description of the data provided.

Climate impact of energetic particles
Jón-Egill Kristjánsson (University of Oslo, Norway)

Despite recent advances in climate research, there is still a large uncertainty concerning the role of solar activity for climate variations. In addition to variations in total solar irradiance (TSI) or solar ultraviolet (UV) radiation, consideration needs to be given to possible mechanisms involving energetic particles, such as galactic cosmic rays (GCR) and solar energetic particles (SEP). For instance, it has been suggested that GCR may modulate clouds, either via cosmic ray induced ionization (CRII) and subsequent particle formation or via electrical charges on the surfaces of clouds. Since clouds strongly influence the Earth's radiation budget through reflection of solar radiation and trapping of thermal infrared radiation, variations in cloud properties might exert a strong signal on the climate system. Global aerosol models and even some global climate models have recently started accounting for CRII as a possible catalyst for aerosol formation in the presence of supersaturated precursor gases, e.g. sulphuric acid (H2SO4). In the case of SEP, there is emerging evidence of links between energetic particle precipitation (EPP) and the dynamics of the middle atmosphere via NOx, ozone and planetary waves. To what extent there is a detectable influence of these events at the Earth's surface is still highly uncertain.

We will present an overview, in which we seek to clarify what is well known, as well as what the remaining uncertainties are. We will review statistical studies of possible GCR - cloud - climate links using satellite retrievals, as well as model studies in which the physical processes linking GCR to aerosol formation are parameterized and their climate impact assessed. Recent modeling studies of EPP-atmosphere interactions will also be reviewed.

The space environment (thermosphere, ionosphere, magnetosphere)
Jean Lilensten (IPAG, Grenoble, France)

A. The solar energetic inputs

- The electromagnetic flux
  - Description of the flux, values for the Irradiance at Earth
  - Computation of the solar constant
  - Description of the solar emission variability
  - Review of the proxies used to characterize the solar activity

- The particle flux
  - Short description of the particle fluxes
  - Short description of the magnetosphere (but short since it is fully addressed in the lecture on Magnetic reconnection) review of the proxies used to characterize the geomagnetic activity

B. The Earth's atmosphere

- the atmosphere: a simple approach ...
  - Description of the upper atmosphere.
  - Presentation of the absorption cross sections
  - Demo (on the blackboard) of the hydrostatic equilibrium and the scale height. Typical values
  - Demo (same) of the absorption law (Beer Lambert approach)
  - The Chapman layers
  - Limitations of this approach
- Kinetic and fluid theory
  - The kinetic theory (demo on the board too)
  - Presentation of the impact cross sections
  - Presentation of the collision frequency concept
  - Presentation of the true upper atmosphere layers (production, heating rate?)
  - De-excitation processes and airglow, including auroras
  - Fluid mechanics (blackboard)
  - From Production / Heating to Densities / Temperatures
- the atmosphere : more ...
  - Presentation of the true upper atmosphere layers (densities, temperature?) and its variability
  - Presentation of the TEC

Climate impacts of solar radiation
Katja Matthes (GEOMAR, Kiel, Germany) and *Hauke Schmidt (Max-Planck Institute for Meteorology, Hamburg, Germany)*

Solar irradiance is by far the most important source of energy for Earth's weather and climate. But this irradiance is not constant. The total energy output of the sun varies on climate-relevant time scales from days to billions of years. This lecture is intended to discuss the basic climate impacts of the variable Sun.

The first part starts with a short presentation of spectral and time dependence of solar radiation. Methods to study impacts of solar variability are discussed with a focus on the role of numerical models in climate research. Basic energy balance considerations are then used to estimate the response of near surface air temperature to a change of total solar irradiance (TSI) by

about 0.1%, a magnitude that is typical for the variation of TSI within the 11-year sunspot cycle. Observations and numerical results of global mean and regional surface temperature effects both on the 11-year and the millennium time scale are presented to conclude the first part.

The second part deals with the 11-year solar cycle effects in the stratosphere and the dynamical mechanisms for a downward transfer to the Earth's surface and the ocean. Besides the so-called "top-down" stratospheric UV mechanism in which UV radiation and ozone photolysis as well as dynamical interactions with the QBO play an important role, the "bottom-up" coupled air-sea mechanism is also discussed. Finally, the potential role of the solar cycle for climate predictions is examined and an overview of other existing mechanisms for solar influence on climate is given.

Global circuit and atmospheric electricity
Colin Price (Tel Aviv University, Israel)

Atmospheric electricity is one of the oldest fields of research in the geophysical sciences, dating back to the 1700s when the first electric fields were detected in the atmosphere. In the 1920s the Carnegie research vessel made many measurements of the potential gradient above the oceans, and found a universal diurnal variation in the fields, independent of location and local time. It was proposed that these fields were related to global thunderstorm activity. With the discovery of ions in the atmosphere, atmospheric currents were also detected flowing to the Earth. Then with the discovery of the ionosphere, a schematic model was developed describing the Earth-ionosphere system as a spherical capacitor, with a leaky dielectric between the plates of the capacitor. The atmospheric electric system could be compared with an electric circuit (with batteries, resistors, capacitors, currents, voltages, etc.). The global circuit is now known to be influenced by phenomena on many different spatial and temporal scales. Observations show that parts of the global circuit are also influenced by solar variability, solar storms, and the solar cycle. What is being impacted by the Sun? The resistance of the circuit, the batteries, or something else?

Physics and chemistry of the stratosphere and the mesosphere
Eugene Rozanov (PMOD, Davos, Switzerland)

The distributions of the trace gases, temperature and wind in the stratosphere and mesosphere depend on a number of physical and chemical processes. The knowledge of these processes is necessary to understand what is happening in the atmosphere and how it will react to some changes of the external forcings such as solar activity. In the lecture I will talk about the processes which are the most important and relevant for the study of the solar-climate connection.

The lecture will be divided into three 60-minute long parts devoted to radiation, chemical and dynamical processes. The radiation part will cover the main features of the solar and terrestrial radiation, the main absorbers in the atmosphere, radiation transfer, as well as practical aspects of the heating and photolysis rate calculations. The chemical part will be devoted to the classification of trace gases, description of their production and loss terms, main chemical cycles as well as practical aspects of the chemical calculations. In the third part I will present basic equations of the atmospheric motions, structure of the general circulation, atmospheric waves, Brewer-Dobson circulation, as well as different variability modes observed in the stratosphere/mesosphere (like QBO, SAO, AO, SSW and so on).

Climatic studies from space observations
Claudia Stubenrauch (LMD, Paris, France)

After an introduction on climate definition, its drivers and components, the construction of global datasets of essential climate variables is discussed. The principles of satellite remote sensing, based on radiative transfer, are addressed. Then satellite retrievals, assessments and selected results of greenhouse gas concentrations, radiative fluxes, cloud properties and aerosol properties are presented. Finally an example of using the synergy of different variables in a climate study is shown.

Hands-on computer session with the Substorm zoo
Eija Tanskanen (Finnish Meteorological Institute, Helsinki, Finland)

Hands-on-data session introduces measurements from the Sun, solar wind, magnetosphere and ionosphere together with simple-to-use tools for basic and advanced data analysis. The browser-based system called Substorm Zoo (http://www.substormzoo.org) with the lists of pre-identified events will be used for studying different aspects of the Sun-Earth interaction: geomagnetic activity, heliospheric disturbances and different measures for the solar activity.

The tools that will be introduced include spectral analysis, wavelet analysis, dashboard for real-time operative use, measuring and commenting tools and many more. We will use the discussion groups inside the Substorm Zoo for delivering the questions and for discussions during and after the session. The labnotebook tool will record the tasks proceed during the session and that will be used to deliver the answers to the questions.

The Earth's atmosphere: a brief introduction
Kleareti Tourpali (Aristotle University, Thessaloniki, Greece)

During my lecture I will discuss: Composition of the atmosphere (major/minor constituents, evolution, whatever else) Vertical structure (temperature, pressure, density distributions: what is the troposphere, stratosphere (incl. ozone layer, of course, but not many details!), mesosphere, above ...) Horizontal structure (general characteristics, seasonal variations, and a bit on large scale variations, such as ENSO, QBO, etc)

Cosmic rays in the Earth's atmosphere
Ilya Usoskin (University of Oulu, Finland)

An important factor affecting the terrestrial environment is the flux of cosmic rays permanently impinging on Earth. Energetic cosmic rays initiate a nucleonic-electromagnetic cascade in the atmosphere, affecting its physical-chemical properties. In particular, cosmic rays form the dominant source of ionization in the lower and middle atmosphere. Via the variable heliospheric modulation of cosmic rays, this provides an indirect solar-terrestrial link.

A review of atmospheric effects of cosmic rays is presented, that includes the description of what are cosmic rays, their modulation by solar activity, and their effects in the Earth atmosphere.

Map of downtown Thessaloniki (for Thursday)