7th EMS Annual Meeting
8th European Conference on Applications of Meteorology
San Lorenzo de El Escorial, Spain, 01 – 05 October 2007

AW11 Interrelationships between Earth and Space Meteorology

Event Information

The states and evolution of Earth climate and weather are determined by the innumerable degrees of freedom of a complex physical system constituted, in turn, by a set of coupled complex systems subject to physical processes that drive the global states.

For some of these sub-systems the level of scientific understanding allows to confidently quantify the respective roles in concurring to the global state.

Others are less known, as the observed variations cannot apparently account for the observed changes to a significant level, and, to the present knowledge, this requires the existence of relevant amplifying processes for them to be considered as significant drivers.

Space climate and space weather agents belong to this category and certainly deserve a deep analysis in order to define their role as potential concurrent drivers of the Earth climate and weather.

The aim of this session is to provide the state-of-the-art scenario on the knowledge in this framework and to point out the future perspectives for pointing out possible interrelationships between Earth and Space Meteorology by assessing the level of coupling in the acting physical systems and processes.

Authors are invited to submit abstracts with focus on one ore more of the following topics relevant to space sources of potential Earth weather and climate forcing agents, and to the analysis of their time evolution:

1. Solar electromagnetic emission
2. Solar Wind
3. Solar Cosmic Rays
4. Galactic Cosmic Rays
5. Ultra-High Energy Gamma Ray Bursts

The session will be featuring oral and poster presentations.

Convener: Messerotti, M.
Convener(s):

Co-Sponsorship: COST Action 724

Monday, 1 October 2007

Lecture Room: America

Chairperson: MESSEROTTI, M.

☐ 15:00 - 15:15 EMS2007-A-00677
Messerotti, M.
Building a knowledge model for space forcing on Earth weather and climate

☐ 15:15 - 15:45 EMS2007-A-00446
Krivova, N.A.
Variations of solar irradiance on time scales of days to millennia (solicited)

☐ 15:45 - 16:15 EMS2007-A-00182
Rozanov, E.; Fischer, A.; Brönnimann, S.; Egorova, T.; Schmutz, W.
The influence of the UV solar irradiance variability on ozone and climate during the first half of the 20th century (solicited)

☐ 16:15 - 16:45 EMS2007-A-00592
Scherer, K.; Fichtner, H..; Heber, B.
Interstellar-terrestrial relation (solicited)

☐ 16:45 - 16:48 EMS2007-A-00539
Bordás, Á.; Kapor, D.
Performing Milankoviæ's original calculations using modern numerical methods

☐ 16:48 - 16:51 EMS2007-A-00390
Maris, G.; Maris, O.; Dobrica, V.; Demetrescu, C.
Rapid solar wind streams during solar cycle 23 and their geomagnetic imprint

☐ 16:51 - 16:54 EMS2007-A-00440
Todorovich, N.; Vujovic, D.
The relationship between coronal holes and cold air advection in Belgrade region

☐ 16:54 - 16:57 EMS2007-A-00377
Dobrica, V.; Demetrescu, C. ; Maris, G. ; Boroneant, C.
Solar and geomagnetic forcing of climate changes during the instrumental period in Romania

☐ 16:57 - 17:00 EMS2007-A-00372
Demetrescu, C.; Dobrica, V.; Maris, G.
Long-term space climate variations as evidenced by geomagnetic field variations

17:00 Coffee Break

Chairperson: MESSEROTTI, M.

☐ 17:30 - 18:00 EMS2007-A-00370
Usoskin, I.G.
Atmospheric Effects of Cosmic Rays (solicited)

☐ 18:00 - 18:15 EMS2007-A-00191
Tinsley, B.
Models of electrical effects on clouds, linking solar activity with weather and climate change (solicited)

- 18:15 - 18:30 EMS2007-A-00192
  Tinsley, B.
  Observations of electrical effects on clouds, linking solar activity with weather and climate change (solicited)
- 18:30 - 18:45 EMS2007-A-00070
  Avakyan, S.; Voronin, N.
  Potential Earth weather controlling agent in the solar-terrestrial physics (solicited)
- 18:45 - 19:00 EMS2007-A-00462
  Veizer, J.
  Climate, water and carbon cycles: terrestrial records across a hierarchy of time scales (solicited)
- 19:00 - 19:15 EMS2007-A-00466
  Ferguson, P.R.; **Veizer, J.**
  Coupling of water vapor and carbon dioxide fluxes via the terrestrial biosphere: regional-scale estimates of evaporation and plant transpiration (solicited)

19:15 END OF SESSION

EMS7/ECAM8 Abstracts,
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Building a knowledge model for space forcing on Earth weather and climate

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Space forcing of Earth weather and climate is a debated issue due to the still controversial experimental evidences. In order to clearly identify and to properly define the various agents and their potential role in this framework, it is quite useful to organize the related existing knowledge in a knowledge model, based on the most updated models and observations. In this work, we describe a prototype knowledge model for space forcing of Earth weather and climate, built by means of Concept Maps which code the topical knowledge as graphs where concepts and their interrelationships are shown to provide an intuitive understanding at a glance.

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Variations of solar irradiance on time scales of days to millennia

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Determining the exact level of warming due to greenhouse gases requires a good understanding of the natural causes of climate change and the magnitude of their influence. The most obvious one is related to the Sun, which is the source of almost all external energy input into the climate system. Both solar total energy reaching the Earth and its spectral distribution vary with time. Measurements and models suggest that these variations occur at all time scales ranging from seconds to millennia (and even longer). Here a review of recent models of solar irradiance on time scales longer than a day will be given.

EMS7/ECAM8 Abstracts,
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The influence of the UV solar irradiance variability on ozone and climate during the first half of the 20th century

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During the first half of the 20th century the solar activity had been continuously increasing. It was suggested that the UV and total solar irradiance had similar behavior. General Circulation models driven solely by the changes in the total solar irradiance underestimated the climate response in comparison with observations. To estimate the influence of the UV solar irradiance variability on the global climate and ozone evolution during the first half of the 20th century we have carried out transient ensemble run with the Chemistry-Climate Model SOCOL covering 1900-1960 driven by the time evolving solar spectral irradiance, sea surface temperature, sea ice, land use, sulfate aerosol loading, greenhouse gases and ozone destroying substances. In the paper we present the solar signal in the atmosphere extracted from these transient runs using multiple regression analysis technique. We also define the contribution of the imposed solar irradiance changes to the time evolution of the simulated quantities and estimate their sensitivity to the long-term and decadal scale solar irradiance variability. The model results are compared with the solar signal obtained from the transient simulation covering 1975-2004 and with the solar signal in the land surface temperature extracted from the observational records.

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Interstellar-terrestrial relation

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There is increasing evidence that there exist interstellar-terrestrial relations and that the heliosphere's effectivity to serve as a protecting shield for the Earth, specifically against cosmic rays, is varying in time. Nonetheless, a debate is going on whether, amongst other drivers, the Sun or the cosmic rays are influencing the terrestrial climate, particularly on periods of hundred years and shorter. On very long time scales, e.g. millions to hundred of millions years, varying cosmic rays intensities are in accordance with temperature indices.

As the modeling of the transport of cosmic rays in the heliosphere has evolved from pure test particle simulations to far more consistent treatments, one can explain varyious correlations within the framework of physical models and one can make quantitative predictions regarding terrestrial indicators of interstellar-terrestrial relations.

Recently, also the connection between the ionization and the cloud condensation nuclei are under investigation. First results indicate such a relation. Therefore, varying cosmic ray fluxes causing changing ionization rates can act as an additional climate driver.

Here we will present the physical concepts of the cosmic ray transport, its variation with time in the heliosphere, magnetosphere and atmosphere and its possible imprints in Earth's archives.

EMS7/ECAM8 Abstracts,
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Performing Milankoviæ's original oalculations using modern numerical methods

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The mathematical climate of the Earth, the theoretically computed Earth's climate changes, is the masterpiece of M. Milankoviæ published in "Canon of Insolation and the Ice Age Problem (Kanon der Erdbestrahlung und seine Anvendung auf das Eiszeitenproblem, 1941)". In his work Milankoviæ defined the fundamental parameters which govern the variations and march path of insolation of the Earth, the nature of climate and climate feedbacks. These parameters are the eccentricity (measure of the Earth's orbit deviation from circular) with adequately described characteristic period of 100-kyr, the obliquity (tilt of the Earth's rotation axis with respect to the plane of ecliptic) with a period of 41-kyr and the precession (variation in the direction of the tilt at the Earth's closest approach to the Sun) with characteristic periods of 23- and 18-kyr. The records of climate changes in the deep sea sediments and ice cores prove Milankoviæ's theory.

In the development of any mathematical theory, some simplifying presuppositions had to be made in order to investigate the natural phenomena described by means of differential equations, and to be able to integrate these equations. Our aim is to make closer to public Milankoviæ's calculations of the mathematical climate of the Earth performing them numerically and avoid complicated series convolutions. In this contribution we will compare analytical and numerical solutions for the Earth's insolation during the last 600 millennia with an idea to better understand the connection between isolation and the temperature of the Earth and its atmosphere, the displacement of the snow limit caused by march of insolation, the mechanism, complete structure and chronology of ice age and the ice age history the quarternary's great climatic oscillations, this time not "blurred" by complicated series expansions.

EMS7/ECAM8 Abstracts,
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Rapid solar wind streams during solar cycle 23 and their geomagnetic imprint

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The paper sets a catalogue of high speed streams in the solar wind for the last solar cycle, namely during the 1996-2006 interval. We have used the same identification and calculation criteria of the streams as the authors of the similar catalogues for solar cycles 20-22 (Lindblad and Lundstedt: 1981, 1983, 1989; Mavromichalaki et al.: 1988, 1998). The source data consist of OMNI Data - an hourly resolution multi-source data set - and SOHO data. Our catalogue lists the basic parameters of the rapid streams: the time of start (calendar year, month, and day as well as the corresponding day in Bartels Rotation), the initial and maximum velocities (in km/sec), and the duration (in days). The solar source of each stream, such as coronal holes or solar eruptive phenomena, as well as the interplanetary magnetic field dominant polarity are also mentioned. The statistical analysis of the high speed streams (by year, by duration, by velocity and, by intensity) is discussed in comparison with the results for the previous solar cycles (nos. 20-22). An analysis of the high speed stream impact on the variability of the terrestrial magnetic field is also done. The geoeffectiveness of the streams in respect to their solar origin (flares or coronal holes) is discussed.

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The relationship between coronal holes and cold air advection in Belgrade region

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In this paper we investigated the relationship between the solar activity and weather on the Earth, especially coronal hole impact. The investigation is based on the assumption that every energy ejection from Sun by the Solar wind has direct effect on weather on the Earth. The Solar wind particles move along the magnetic field lines. After the reconnection among interplanetary and Earth magnetic fields, the particles come in the atmosphere, mostly through polar magnetic funnel. The particles impel the air masses to move by the hydrodynamic pressure in lower and denser layers of atmosphere. Because of Earth magnetic field characteristics, the particles start to eddy like cyclone circulation. There are only a few sunspots in the last year of 23rd Solar cycle so in that period it is easier to notice impact of coronal holes and their opened magnetic field. There was relatively good coronal holes repetitiveness in the period of 27 days of Sun rotation in the first part of 2007. Solar wind characteristics, synoptic situation over the Europe, cold fronts inflow over Belgrade and daily maximum temperatures in Belgrade were analyzed. Results of this analysis showed that there is lawfulness in the appearance of similar synoptic situations and cold air inflow while the same dominated coronal hole exist in a few Sun rotation. Using the noticed lawfulness it can be possible to forecast date, intensity and lasting significant cold air inflow at the quiet Sun. Forecast is possible in the period of active Sun too.

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Solar and geomagnetic forcing of climate changes during the instrumental period in Romania

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The climate is influenced by various forcing factors, the main ones being solar, geomagnetic, volcanism and greenhouse gases. We analyze the influence of solar and geomagnetic activities on the climatic variations in Romania, in the context of European and global data. Long-term trends in solar and geomagnetic activities inferred from the sunspot number and aa index time-series are compared to the long-term variations of mean temperature and precipitation over the study area. The discussion is based on yearly and monthly means of the temperature and precipitation recorded at 14 stations in Romania in the instrumental period (1850 - present). The comparison at interdecadal and centennial time-scales of solar and geomagnetic parameters with the mean temperature shows positive correlation coefficients, while the comparison with the mean precipitation shows negative correlation coefficients. The correlation of climatic parameters seems to be stronger in case of geomagnetic activity than in case of solar activity. The relationship with the most important source of climatic variability over Romania, the North Atlantic Oscillation (NAO), is addressed as well.

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Long-term space climate variations as evidenced by geomagnetic field variations

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The solar magnetic and Gleissberg cycles signatures in the observed variations of the geomagnetic field are presented and discussed. Long time series of geomagnetic indices describing both the regular (SR) and the irregular (geomagnetic activity) variations are used for this purpose. The role of the long-term main geomagnetic field variations in the observed geomagnetic activity is explored as well. The relationship between the solar activity and various aspects of the variability of the geomagnetic field implies that at both the 22-year scale and the Gleissberg cycle scale, the coronal source field (as reflected by general heliospheric conditions at 1 AU - IMF strength, solar wind speed and density, described in turn by the aa index of geomagnetic activity, and/or as reflected by the IMF strength at 1 AU, described in turn by the IDV index), the photospheric magnetic field (as reflected by the R index), and the solar radiative output (as reflected by x, y, z, r, and S) have a similar behavior, being subject to similar long-term variations caused by processes developing in the Sun.

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Atmospheric Effects of Cosmic Rays

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An important factor affecting the terrestrial environment is the flux of cosmic rays permanently impinging on Earth. Energetic cosmic rays initiate a nucleonic-muon-electromagnetic cascade in the atmosphere, affecting its physical-chemical properties. In particular, cosmic rays form the dominant source of ionization in the atmosphere, especially in the troposphere. Therefore, a detailed knowledge of processes leading to the cosmic ray induced ionization makes a solid basis for a quantitative study of the outer space influence upon Earth. We present here a review of atmospheric effects of cosmic rays, including both physical modeling and phenomenological relations to the climate changes, on different time scales.

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Models of electrical effects on clouds, linking solar activity with weather and climate change

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Models of the global electric circuit and its downward current density Jz show responses to solar wind and cosmic ray flux changes that affect the deposition of electric charge at the boundaries of layer clouds. Models of the effect of such charge on the microphysics of the clouds suggest small but significant effects on precipitation rates and cloud lifetimes. These affect weather and climate through latent heat transfer and changes in the atmospheric radiation balance.

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Observations of electrical effects on clouds, linking solar activity with weather and climate change

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Observations show meteorological responses to short term changes in Jz, due to both solar and internal forcing. On the day-to-day timescale the responses agree in onset time, duration, and amplitude with the Jz changes, and exclude total solar irradiance and UV irradiance changes as causes. On the century and millennial timescales larger Jz changes and larger climate responses are to be expected.

EMS7/ECAM8 Abstracts,
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Potential Earth weather controlling agent in the solar-terrestrial physics

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Microwave radiation of the Earth ionosphere during solar flares and geomagnetic storms as well as microwave bursts from the Sun are supposed to control the condensation processes in the low atmosphere and thus influence the weather. This hypothesis is based on taking into account the excitation of Rydberg states of atoms and molecules in generation of the ionospheric microwave radiation and in realization of the three body dissotiative recombination of cluster ions in low atmosphere. The main basis for this study is the following positions: - during the weather observations was found that some weather characteristics correlate with the bursts of solar microwave radiation; - investigations of low atmosphere transparency and of water vapor concentration has shown that microwave radiation has an influence on clusterisation of the water vapor during the condensation process; - sporadic increase of the intensity of the ionospheric microwave radiation in SHF and UHF ranges during solar flares and magnetic storms was registered. Coefficients of the rates of the water cluster dissociation depend strongly on the orbital quantum moment of Rydberg electron excited at the initial stage of the three body collisional dissociative recombination. Probability of the dissociation of the cluster ions decreases for the high values of the orbital quantum number. Therefore in the periods of bursts of microwave radiation of the Sun as well as sporadic microwave radiation of the ionosphere the induced population of the high orbital quantum numbers would be going on and as a result the rate of dissociation of the cluster ions in the low atmosphere would decrease. All these phenomena would change the atmosphere transparency and thus the weather characteristics (temperature, relative humidity and atmospheric pressure).

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Climate, water and carbon cycles: terrestrial records across a hierarchy of time scales

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The observed temperature increase of ~ 0.6ºC over the last century has been attributed (IPCC) by $\sim$ 2/3 to greenhouse gases (GHG) and $\sim$ 1/3 to an increase in solar irradiance (TSI). Such relative attribution reflected the general consensus that no credible amplifier to muted changes in TSI was known. Recently, however, a spate of empirical observations demonstrates that sun-climate connections are apparent in a plethora of high-fidelity climate indicators, suggesting that "solar influence on climate is greater than would be anticipated from radiative forcing estimates" (Hadley Centre technical note 62). The most likely amplification candidates are high-energy particles such as cosmic rays and solar protons, via their potential role in cloud formation. Juxtaposition of empirical records of paleoclimate with proxies for atmospheric CO_2 levels vs. celestial (solar and cosmic rays) intensities, across a 10^8 – 10^1 hierarchy of time scales, indeed favours a reversal of the relative impact of the above climate "drivers", the last few decades being the focal point of the ongoing controversy. In the above scenario, the celestially modulated planetary energy balance drives the hydrological cycle, with the carbon cycle "piggy-backing" on the water cycle "thermostat"

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Coupling of water vapor and carbon dioxide fluxes via the terrestrial biosphere: regional-scale estimates of evaporation and plant transpiration

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The distribution and vitality of terrestrial ecosystems is largely determined by water availability, although the fluxes of moisture from the biosphere may, in turn, affect regional patterns of precipitation. Despite the significance of terrestrial moisture fluxes, which represent one of the largest movements of mass and energy in the Earth's outer spheres, the relative contributions of abiotic water vapor fluxes and fluxes regulated by the physiology of plants remains a contentious and poorly constrained issue. These estimates, derived from the closure of the annual water balance for fifteen large watersheds in North America, South America, Africa, Australia, and New Guinea, indicate that approximately two-thirds of the annual water flux from water-limited ecosystems typical of high latitude regions could be attributed to plant transpiration. In contrast, in high-rainfall regions of the tropics, the transpiration flux is relatively stable and independent of the amount of precipitation. Further, these regional estimates of transpiration co-vary with annual water input by precipitation in a manner similar to that observed for primary productivity, implying that water vapor and carbon dioxide fluxes are coupled. Although the estimates are admittedly first-order, they offer a broadly conceptual perspective on the dynamics of energy exchange between terrestrial systems and the atmosphere, where the carbon cycle is essentially driven by solar energy via the water cycle intermediary.