# The inter-annual and long-term distributions of cloudless days and nights in Abastumani (41.75N; 42.82E): coupling with cosmic factors and climate change


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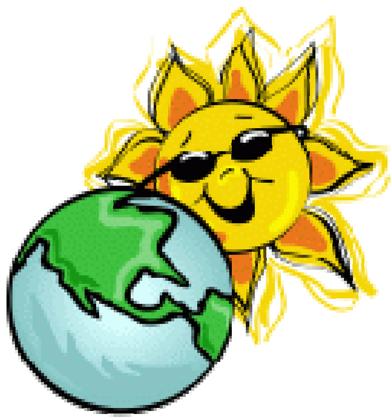


**Solar Influences on the Magnetosphere, Ionosphere and Atmosphere**, ***Sunny Beach, Bulgaria, 26-30 May,***

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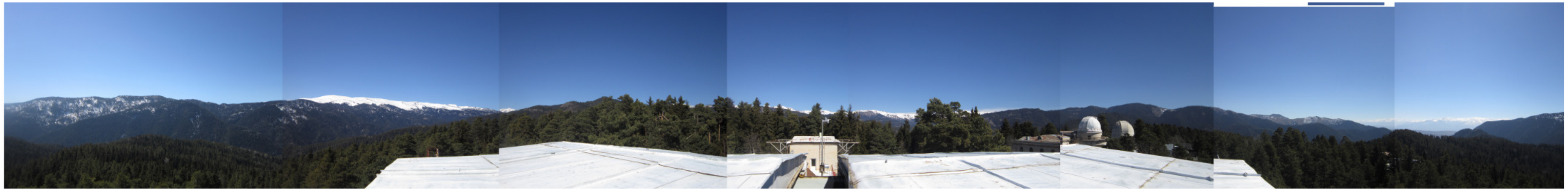
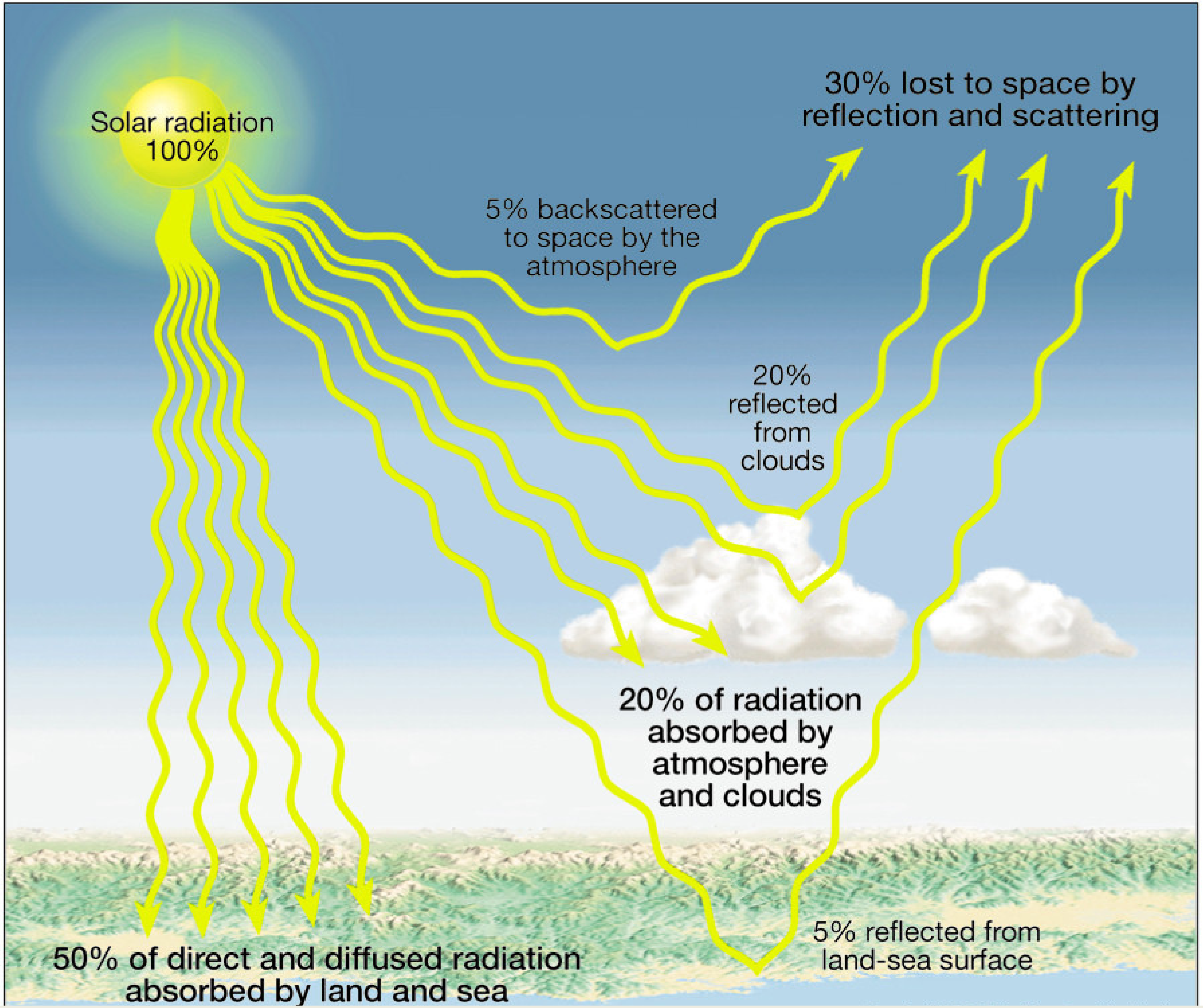


The recorded numbers of cloudless days - 4323)
and
Cloudless nights – 1534 (under lunarless conditions during 1957-1993) make it possible to investigate their inter-annual/seasonal and long-term variations at various helio-geophysical conditions

# Cloud covering and radiative balance at Earth's surface

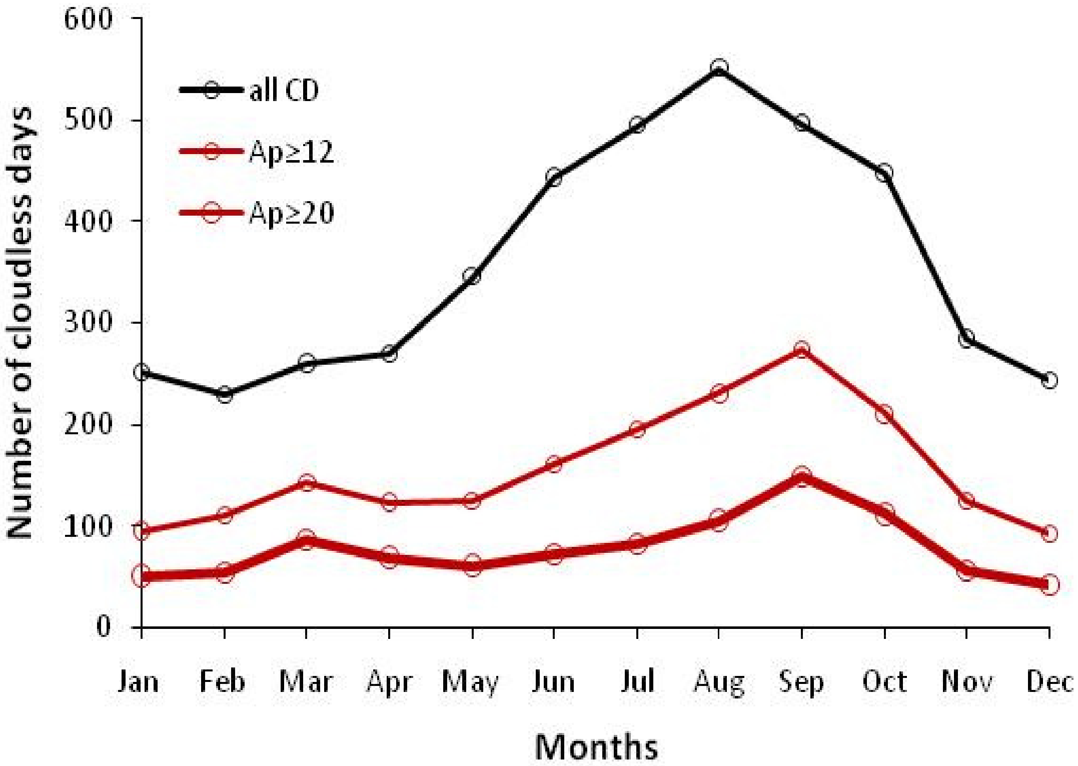


Global cloud covering coupling with cosmic factors (Svensmark, 1997; Marsh and Svensmark, 2000) and problem?!

The consideration of **cloudless days (CD) and cloudless nights (CN) inter-annual and long-term changes** gives possibility more easily detect the presence of cosmic factors effect in cloud-covering.

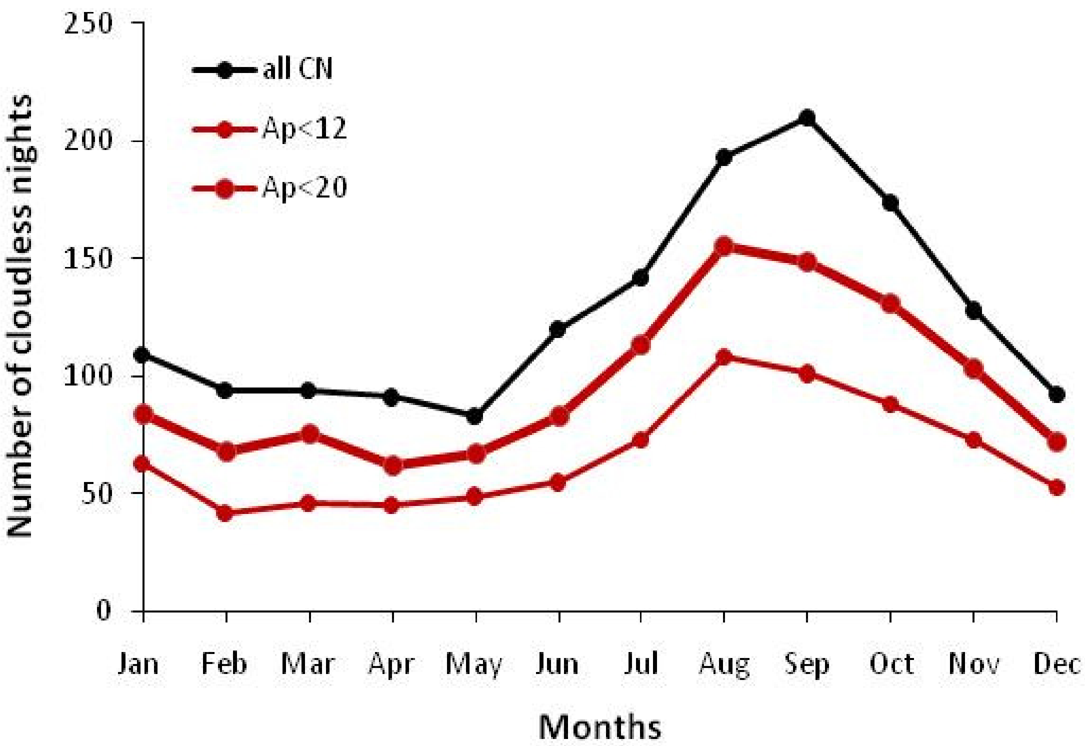
The inter-annual and long-term distribution of CD and CN under various helio-geophysical conditions also can show us about **cosmic factors influence on cloud covering and regional climate changes**.

# Inter-annual didtribution of cloudless days and cloudless nights



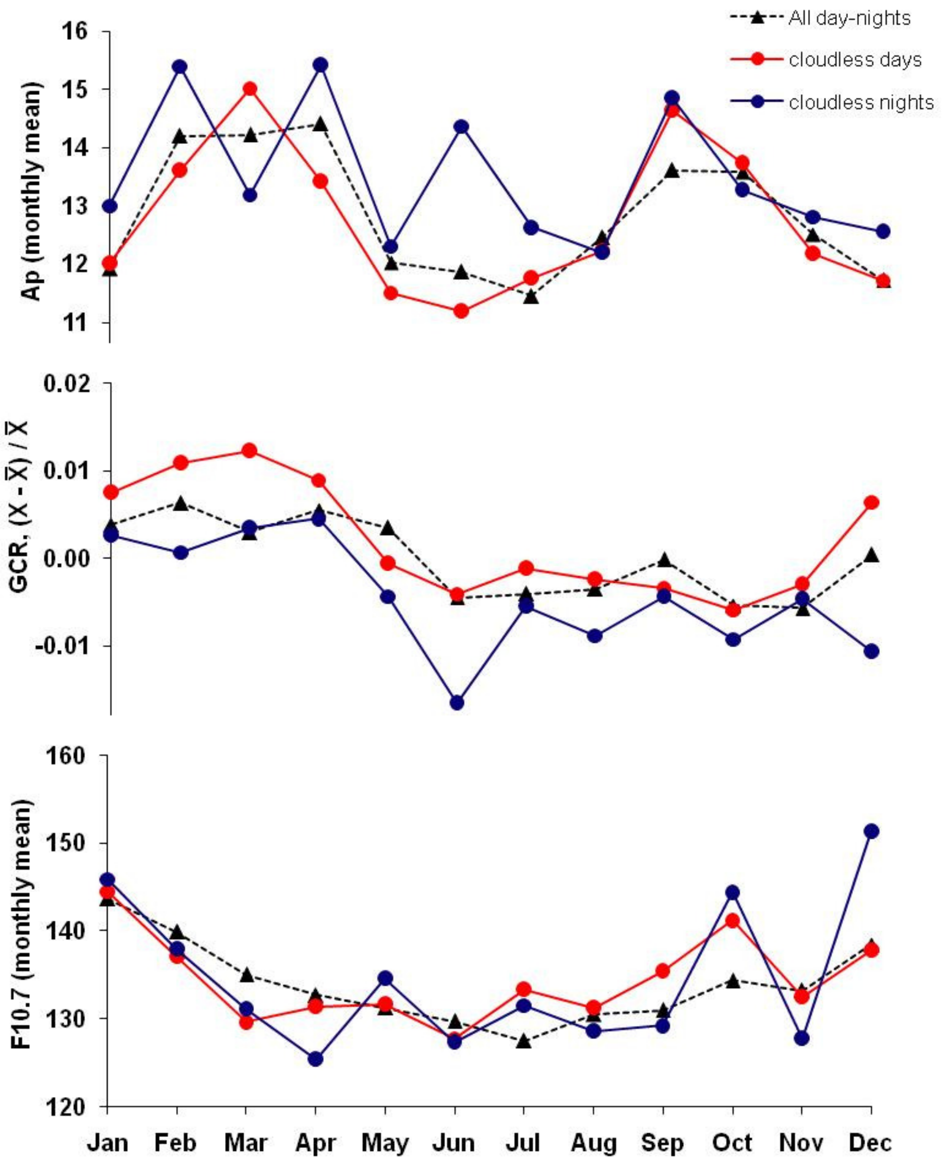

The inter-annual distributions of monthly numbers of cloudless days: all CD (black line), at geomagnetic disturbances with planetary geomagnetic index Ap≥12 (thin red line) and stronger disturbances Ap≥20 (thick red line) in Abastumani during 1957-1993.

# Inter-annual didtribution of cloudless nights



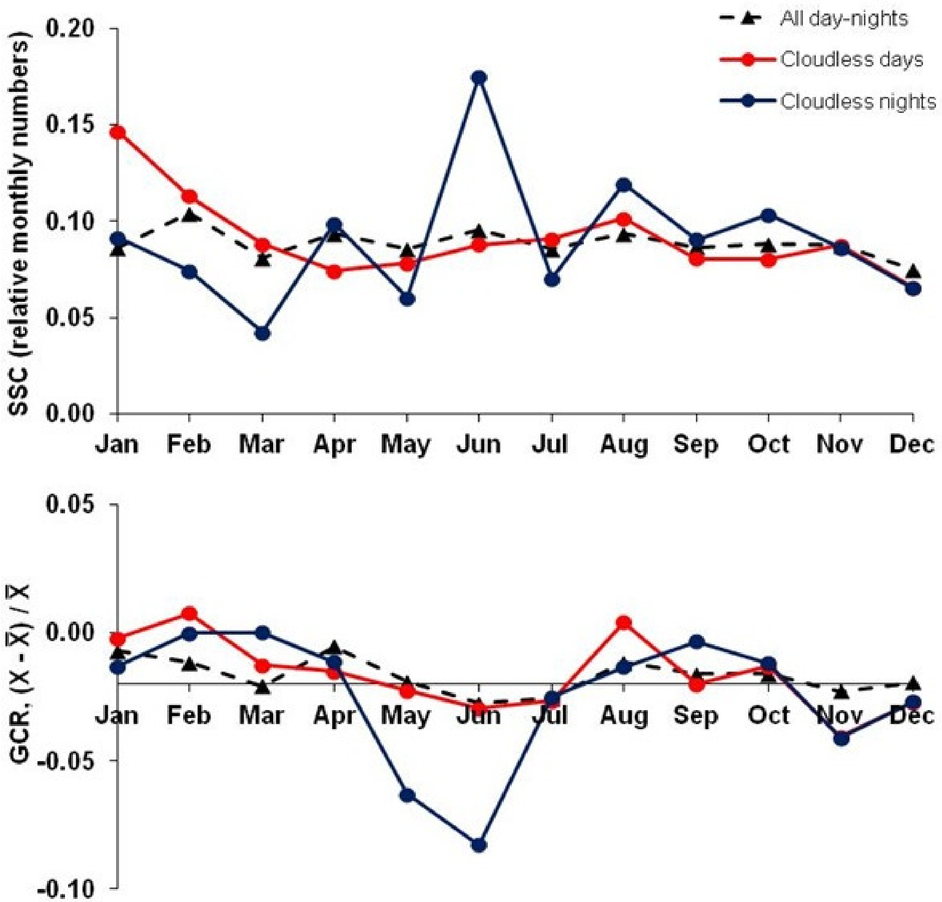

The inter-annual distributions of monthly numbers of CN for all days (black line and full circles), geomagnetically quiet Ap<12 (thin red line and full circles) and including weak disturbances Ap<20 (thick red lines and full circles).

# Inter-annual didtribution of the Ap index, GCRs and F10.7 solar radio flux fo cloudless days and nights



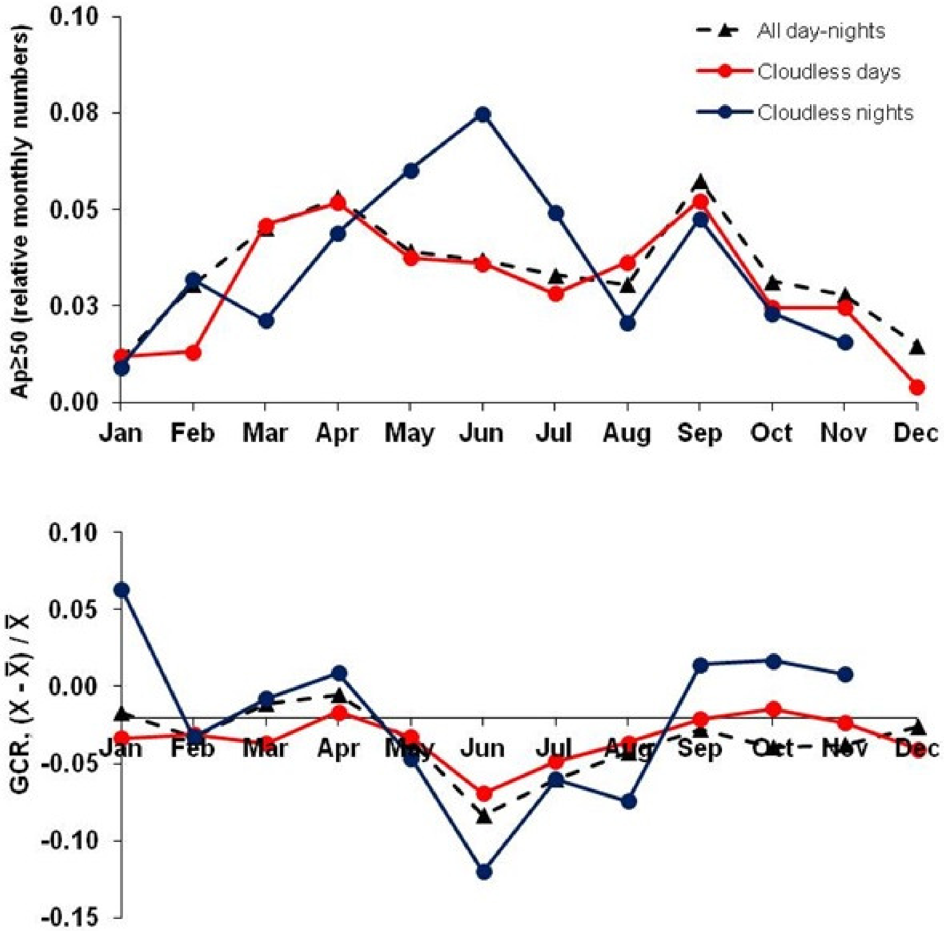

*The inter-annual distributions of monthly mean values of the following quantities for the planetary geomagnetic Ap≤49: (upper panel) Ap index; (middle panel) the normalized GCR flux observed by Tbilisi neutron monitor during 1964-1993 and (bottom panel) solar radio flux $F_{10.7}$. Dashed black line and squares are for all day-night periods, red line and circles – for cloudless days, and blue line and circles – for cloudless nights at Abastumani.*

# Inter-annual didtribution of the frequency of occurrence SSC and GCRs flux changes

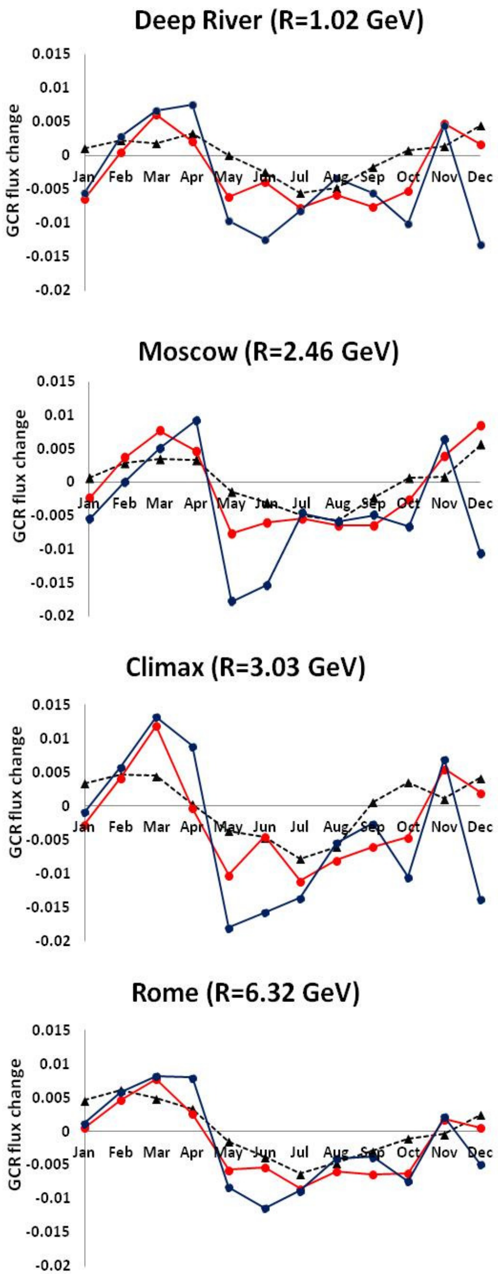



*The inter-annual distributions of monthly mean values of the following quantities: (top panel) mean monthly frequency of Sudden Storm Commencement; (bottom panel) mean GCRs flux changes observed by Tbilisi neutron monitor during 1964-1993. Dashed lines with triangles represent the values for all day-night periods, solid lines with white circles – for cloudless days, and solid lines with black circles – for cloudless nights at Abastumani in 1957-1993.*

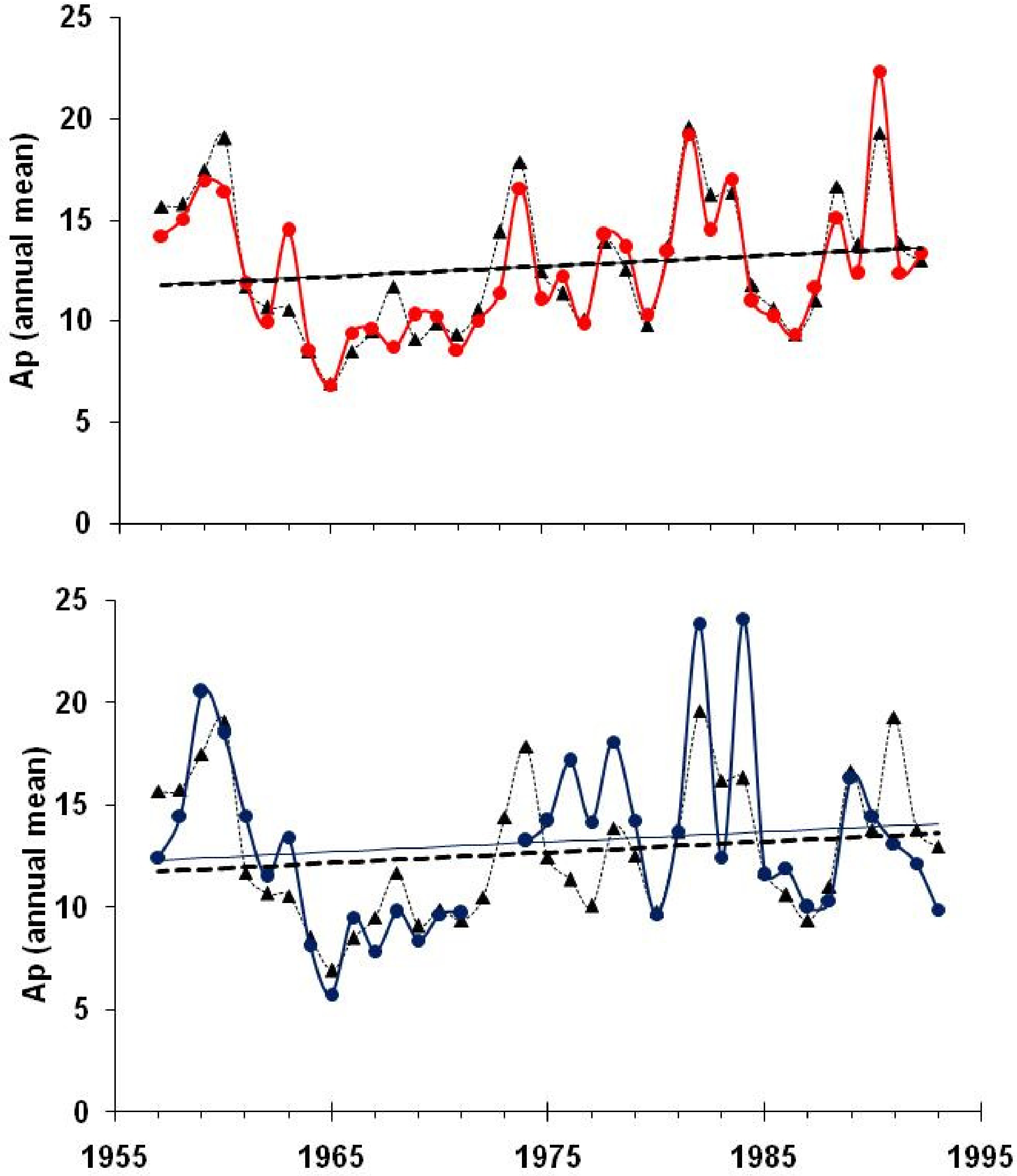
# Inter-annual didtribution of the frequency of occurrence strong geomagnetic events (Ap≥50) SSC and GCRs flux changes




*The inter-annual distributions of monthly mean values of the following quantities: (top panel) mean monthly frequency of strong geomagnetic disturbances with Ap ≥ 50; (bottom panel) mean GCRs flux changes observed by Tbilisi neutron monitor during 1964-1993. Dashed lines with triangles represent the values for all day-night periods, solid lines with red circles – for cloudless days, and solid lines with blue circles – for cloudless nights at Abastumani in 1957-1993.*

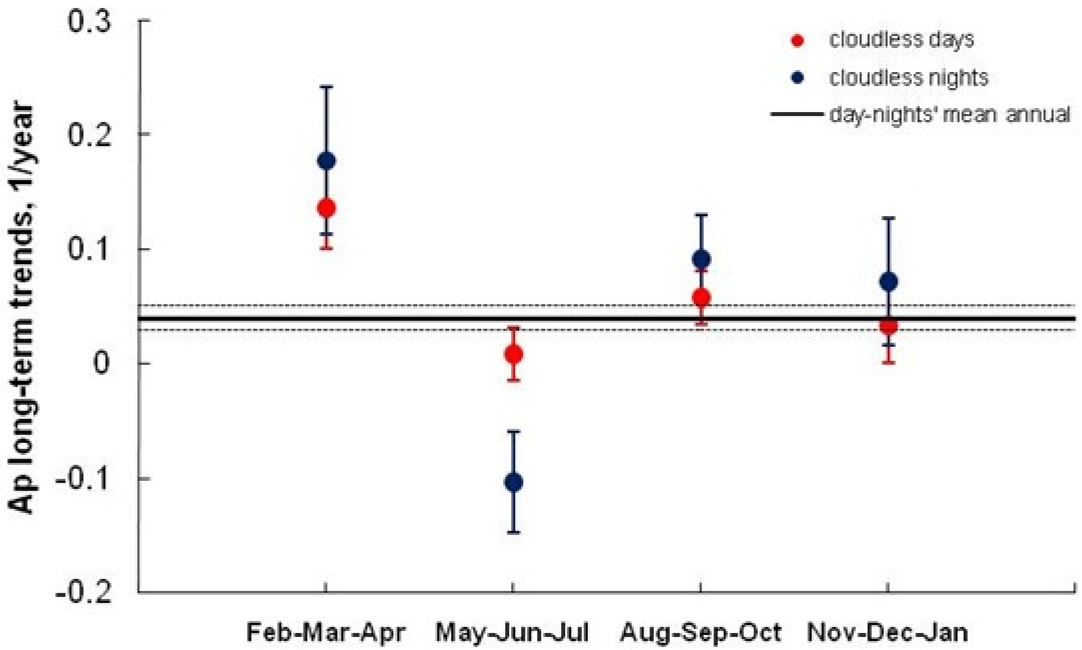



*The inter-annual distributions of monthly mean values of the GCRs flux changes during strong geomagnetic disturbances, Ap ≥ 50 at Deep River, Moscow, Climax and Rome for all day-nights (dashed black lines), CD (red lines), CN (blue line) at Abastumani*




*Long-term variations of the mean annual planetary geomagnetic Ap index with Ap<50 for all day-nights (black lines and triangles), cloudless days (red line and circles), cloudless nights (blue lines and circles) and their linear long-term trends during 1957-1993*

# The seasonal trends in the Ap index for cloudless days and cloudless nights




*Long-term trends of the Ap≤49 index (three months average around equinoxes and solstices) for cloudless days (red circles) and nights (blue circles), with corresponding error-bars. The horizontal solid line corresponds to all day-night long-term trend, dashed lines - to its standard error (estimated for yearly mean value)*

For cloudless days and nights these trend values are significantly different in summer (May-Jun-Jul)**: 0.008±0.046** and **-0.104±0.088**

# Conclusions

The different inter-annual distributions of cloudless days (CD) and cloudless nights (CN) in Abastumani Astrophysical Observatory (41.75N; 42.82E) have been observed,.
The number of CD is greatest in August when daily mean temperature at the Earth's surface is the highest in this region. For geomagnetically disturbed conditions, when planetary geomagnetic index Ap≥12, the greatest number of CD shifts to September. Such a coupling between the observed inter-annual distribution of CD and occurrence of geomagnetic disturbances indicates a possible link between cloud covering processes and cosmic factors. Unlike CD, the biggest number of CN occurs in September and moves to August for geomagnetically quiet conditions (Ap<12).

The day-night differences have been found for inter-annual distributions of monthly mean Ap index as well. Besides the highest frequencies of occurrence of geomagnetic disturbances at equinoctial months (in March and September), an additional maximum for CN was observed in June (for nights with Ap<50, strong geomagnetic disturbances Ap≥50 and SSC), while for all day-nights and CD the Ap values are close to minima.

The inter-annual variations of galactic cosmic rays (GCRs) flux are also different for CD and CN. The maximal decrease in GCRs flux occurs in June for CN at Ap<50, becoming even deeper at SSC and strong geomagnetic disturbances with Ap≥50 (in May-June). Such a coupling of occurrence of CN and decrease of GCRs flux may indicate their influence on cloud covering processes, when night-time atmospheric conditions in June in the region may appear more suitable for CCN production, stimulating cloud formation.
We assume that the obtained different sensitivity of day- and night-time cloud covering to the influence of cosmic factors is considerable for climate changes. This fact is also supported by the significant negative long-term trend observed in Ap index for CN for May-June-July period (exhibiting the decrease of magnetically disturbed CN causing reduction of infrared radiation of the Earth's surface), which is accompanied by the positive trend in CD (showing the increase of magnetically disturbed CD causing increase in absorbtion of solar elecromagnetic radiation during day). These features can influence long-term changes of the radiative balance at the Earth's surface and be reflected in the regional peculiarities of the development of global warming in the lower atmosphere

Thanks for your attention!