Dear Referees,

We are grateful for the thorough analysis of the manuscript, interested review which will be useful for our future studies.

Response to Referee#1:

1. "Page 3 L16-17: "Warming signal moves down from high altitude to low one." and most of the last paragraph. This is not necessarily the case and certainly this is not a conclusion you can make based on the present study. Several of the publications you have cited actually argue that the stratosphere temperature signals are driven by changes in dynamics and are not related to in situ changes in ozone."
After some reflections, we agree with you that we cannot make a conclusion "Warming signal moves down from high altitude to low one" based on the present study. The layer of excited hydroxyl is rather narrow (3-7 km) and located in the upper mesosphere, while the downward movement of heat is found in the stratosphere. Therefore, we tried to remove all phrases concerning "Warming signal moves down…" (P4:L8-L11, P4:L15-L21, P4:L40-L41, P5:L1-L2 in the uncorrected version). Also, we do not refer to Karami et al. paper.

2. "If the amount of OH changes in the mesopause region, is the TOH affected? I think what you are telling me is "No", but I'm still not quite sure. This point would be worth saying clearly.
We do not know for sure, but we think that there is a relationship:
When the internal gravity wave (IGW) passes through the layer of excited hydroxyl, there is a connection between the intensity of radiation and the temperature introduced by Krasovskii: $\Delta I/I = \eta \Delta T/T$. The η parameter, which is called the Krassovskii number, determines the relationship between the relative intensity and temperature variations during adiabatic processes arising in the emission layer when an IGW propagates in it. A similar relation is probably true for waves of any scale. (Khomich et.al.: Airglow as an Indicator of Upper Atmospheric Structure and Dynamics, Springer-Verlag, Berlin, 740 pp., 2008).
The auroral heating also can lead to an adiabatic process and change the amount of the excited hydroxyl.
In recent article Teiser, and von Savigny (J. Atmos. Solar-Ter. Phys., 2017, V. 161, p. 28-42. DOI: 10.1016/j.jastp.2017.04.010), studied the emission rate and altitude of the OH based on spaceborne nightglow measurements with the SCIAMACHY/Envisat. The SCIAMACHY observations cover the time period from August 2002 to April 2012. The analysis focused on low latitudes. They found some evidence for a 11-year solar cycle signature in the emission rate and in the emission altitude. As was mentioned in paper, a solar cycle signature in mesopause temperature was found by many researchers.

3. Talking about the two possible ways geomagnetic activity can modify temperatures in the mesopause region is very useful. What is not clear from the new text is in what timescales these effects work in? If strong geomagnetic events are excluded, does the joule heating effect persist beyond the events? Can we estimate the contributions of the different mechanisms for temperature changes to the TOH observations you report? A sentence or two in the conclusions would be very worth adding.
These questions are difficult to answer. Perhaps we can answer these questions later. We will study proton and energetic electron precipitation events signatures in our data using satellite data.

Response to Referee#2:

The paper has been successfully revised, removing my previous reservations, and is now fully acceptable for publication in ACP. There are only some very minor copy editing details left to repair (as far as I can tell from the "acp-2017-541-manuscript-version5.pdf" file which signals the changes with respect to the previous version, and still has some inconsistencies from leftovers), plus a few text improvements (for clarity) that I suggest in the following list.

The reviewer comments are given on the left column. Our responses are in the right column (pages and line numbers refer to the last corrected manuscript).

Reviewer comment	Responses
P1: L9: -> "at the altitude of"	P1: L9: corrected
L15: is the dot before "10 K higher" real?	P1:L14: corrected
L16: that should read "at the 95% level"	P1:L16: corrected
L20: is "of changes" before "in solar activity" really necessary? If solar activity were constant, we would not call it a cycle...	P1:L16: "of changes" deleted
L26: could be shortened to read "to the change in F10.7 flux", because it is clearly defined above	P1:L24: corrected
L29: better, change to "That study only used..." to remove any doubt that the 2002 paper is referred to, not the present manuscript.	P1:L27: changed
L35: better, change order to read "The changes of F10.7 radio flux and the Ap index of magnetic disturbance over the last...", to make clear that both parameters change (if emphasis on the change is really necessary). However, the Ap index is explained in the following sentence, so the order of presentation should be changed	P1:L32-L35: Corrected "In this study as a measure of geomagnetic activity, the widely available index Ap was used. The changes of F10.7 radio flux and the Ap index of magnetic disturbance over the last 4 cycles of solar activity is shown in Figure 1."
P2:L3: correct "upper latitude atmosphere" (deleting "latitude"?), and "through the of energetic..."	P2:L3-L4: corrected
L5: As individual papers are mentioned only some lines later, "In these papers" is not helpful, here. Better, concatenate with previous sentence "... energies, discussing the influence of geomagnetic activity on atmospheric temperature in two different ways".	P2:L5-L6: corrected
L7: "The first way [or, maybe, "process"] is a direct effect...".	P2:L8: replaced by "One process is..."
L9: avoid "evidences", since it's used as not countable -> "There is some evidence..."	P2:L10: corrected
L10: put instrument/satellite in same order "SABER/TIMED and MIPAS/Envisat";	P2:L11: corrected
L13: -> "The authors suggested..."	P2:L14: corrected
L14: At start of sentence, -> "Von Savigny...", or rearrange so the reference appears later in the sentence. L15: no need of plural in "the noctilucent cloud occurrence rate", or change to read "... in the occurrence rate of noctilucent clouds"; "made	P2:L18-L21: A significant decrease in the occurrence rate of noctilucent clouds in the southern polar mesopause region was observed immediately after the onset of the enhanced solar particle precipitation in SCIAMACHY (an imaging

with SCIAMACHY" is misplaced here, and sentence needs reordering (author X observed something in satellite data after onset of EPP (?) event, or something was observed after onset of EPP in satellite data by author X). And, the next sentence refers to the same finding (?).	spectrometer installed on satellite Envisat) data on January 16, 2005 by von Savigny et al., (2007). Yes
L21: there should also be "by" before "Jiang et al.", because they are two different and independent papers.	P2:L25: corrected
L22: "low thermosphere temperature" -> "temperature of the lower [!] thermosphere", to avoid the misunderstanding of the temperature being low.	P2:L26: corrected
L23: is this the "second way" (or, process)? Then, you should say so (or replace "the first way" by "one way [or process]. What does "whose energy" refer to? "the energy of precipitating particles that is deposited mainly..."	P2:L27: ", whose energy is deposited mainly… " is changed to ". The energy of precipitating particles is deposited mainly..."
L31 (also L33): there should be no article before "hydroxyl", or even reorder -> "hydroxyl rotational temperature"	P2:L37: corrected P2:L39: corrected
L32: replace "height of its radiation" by "mean emission height", "emission centroid height", or "at about 87 km".	P2:L38: replaced by "mean emission height"
L36: avoid repetition of "widely available index".	P2:L41: "As a measure of geomagnetic activity, the widely available index Ap was used." - deleted
L38: "The mesopause", strictly speaking, is not a region but the precise altitude where the vertical temperature gradient is zero (the height of which varies). Change to refer to the mesopause region (80 - 100 km).	P3:L1: changed
L39: Avoid repetition; see above, L32.	P3:L5: "at the radiation height" - deleted
L42: I think that "see, e.g., " is needed before the Khomich reference to avoid misleading readers about since when the OH temperature is used to diagnose mesopause region temperature. And, avoid misleading term "radiation height".	P3:L5: corrected
P3:L1: better, change "the presented paper" to "this paper", or "the present paper". And, better add "described by Ammosov and Gavrilyeva (2000), so that the definite article before "infrared spectrograph" makes sence (or else, change to read "with an infrared spectrograph (Ammosov...)").	P3:L6-L7: corrected
L5: -> "on the OH(6-2) spectrum	P3:L10: corrected
L24: -> "The mean values of...", but averaged over what? Aha, the same averages as in 2a! Better, reformulate to make this clear, and that the same TOH data are repeated in 2a and 2b.	P3:L26: Replaced by "The same TOH and Ap, averaged over the same years, are shown in Figure 2a."
P4:L33: -> "et al."; "geopotential" (lower case!)	P4:L12: corrected

L36: repetion of emission height "The hydroxyl radiating ... (~ 87 km)" has been removed in new text, L37 etc. Delete repeated lines of text.	These lines are deleted.
P5:L9: "data" is plural, so -> "are necessary to separate..." (also, delete "because")	P4:L31-32: corrected
L22: -> "in search for a geomag..."	P5:L35: corrected
L27: -> "explained by the altitude difference between the mesopause..."	The sentence is deleted
L29: -> "The warming signal..."; hmmm, and "to low one" is not informative ("moves down" says it all).	The sentence is deleted
several refs: missing hyphen in "J.Atmos.Solar-Terr.Phys."	corrected
L24: missing hyphens in "9-day" and "13.5-day"	P5:L34: corrected
Caption Figure 3: "-black columns, grey columns-": confusing change of order (after/before main explanation). If at all necessary (the symbols are explained in the figure, clearly enough), "black columns", "grey columns" should be included in the parenteses "(Ap>8; black columns)", "(Ap<=8; grey columns)".	Changed to: Figure 3: The number of measurements per month during the geomagnetic activity years (Ap > 8) and quiet years (Ap <= 8).
Caption Figure 4: -> "Monthly mean TOH..."	Corrected
Caption Figure 5: -> "F10.7 and Ap-index averages for January...", because the fact that they vary is obvious from the figure.	Corrected

Influence of geomagnetic activity on mesopause temperature over Yakutia

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Abstract. The long-term temperature changes of the mesopause region at the hydroxyl molecule OH (6-2) nighttime height and its connection with the geomagnetic activity during the 23rd and beginning of the 24th solar cycles are presented. Measurements were conducted with an infrared digital spectrograph at the Maimaga station (63°N, 129.5°E). The hydroxyl rotational temperature (TOH) is assumed to be equal to the neutral atmosphere temperature at the altitude of ~87 km. The

10   average temperatures obtained for the period 1999 to 2015 are considered. The season of observations starts at the beginning of August and lasts until the middle of May. The maximum of the seasonally averaged temperatures is delayed by 2 years relative to the maximum of solar radio emission flux (wavelength of 10.7 cm), and correlates with a change in geomagnetic activity (Ap-index). Temperature grouping in accordance with the geomagnetic activity level showed that in years with high activity (Ap> 8), the mesopause temperature from October to February is about 10 K higher than in years with low activity

15   (Ap <= 8). Cross-correlation analysis showed no temporal shift between geomagnetic activity and temperature. The correlation coefficient is equal 0.51 at the 95% level.

Introduction

Long-term changes in the state of the mesopause, such as the linear trend and the fluctuations associated with the 11-year cycle of changes in solar activity, are investigated by different methods. In the review Beig et al. (2008) lists numerous studies

20   showing that the response of the mesosphere/low thermosphere temperature to the change in solar activity reaches 4-5 K / 100SFU, where SFU is the solar radio flux at a wavelength of 10.7 cm in $10^{-22}\,W\,M^{-2}\,Hz^{-1}$ (F10.7). Tang et al. (2016) estimated the change in the temperature of the mesopause from 2002 to 2015 using the measurements of the SABER radiometer onboard the TIMED satellite. They showed that the average global response is about 5 K / 100 SFU, in agreement with the results given in the review of Beig et al. (2008). The response of the temperature to the change in the flux of radio emission F10.7 flux at

25   high latitudes is greater than at the middle latitudes and reaches up to 7-10 K / 100SFU.

Previously, according to data obtained from 1997 to 2000 at the Maimaga station, we found the temperature response equal to 11 K / 100SFU (Gavrilyeva and Ammosov, 2002). ThisThat study only used a very short period of observations which coincided with the maximum of solar activity. Further, Ammosov et al. (2014) presented the results of data analysis obtained in a time interval comparable to the solar cycle duration from 1999 to 2013. Analysis showed that the temperature change

30   follows the solar activity change with 25 months delay. The temperature response at the delay of 25 months reaches 7 K/100 SFU.

It is known that the geomagnetic activity maximum lags behind the solar radiation maximum including the index F10.7. In this study as a measure of geomagnetic activity, the widely available index Ap was used. The radio emission flux F10.7 and Ap index of magnetic disturbance changes over the lastThe changes of F10.7 radio flux and the Ap index of magnetic

35   disturbance over the last 4 cycles of solar activity is shown in Figure 1. As a measure of geomagnetic activity, the widely available index Ap was used. Both indices were acquired from the National Geophysical Data Center, NGDC (ftp://ftp.ngdc.noaa.gov/STP). As can be seen from the Figure 1 Ap-index changes follow the F10.7 changes with a lag of 2-3

years. As this is similar in scale to the observed delay of 25 months, it was logical to assume that the long-term temperature fluctuation of the subauroral mesopause correlates with the change in geomagnetic activity.

Geomagnetic activity can change the composition, dynamics and thermal state of the ~~upper~~ high latitude atmosphere through the ~~of~~ energetic particles precipitation (EPP). In the last decade, many papers have been published on the atmosphere response

5 to the proton and electron fluxes with various energies, discussing the influence of geomagnetic activity on atmospheric temperature in two different ways. ~~. In these papers, two ways of the geomagnetic activity influence to the atmosphere temperature were discussed.~~

~~First~~ One process~~way~~ is direct effect on the temperature and dynamics. The geomagnetic storm is followed in the atmosphere by ionization, excitation, Joule heating and dissociation processes (Lastovicka, 1996, Burns et al., 2014, Xu et al., 2013). There

10 ~~are~~ is some evidence~~s~~ of the upper atmosphere temperature change during EPP. Xu et al., (2013) investigated the longitudinal temperature structure in the lower thermosphere using the SABER / TIMED and MIPAS / Envisat ~~/ MIPAS~~ (Michelson Interferometer for Passive Atmospheric Sounding) data obtained from 2008 to 2009. Study of satellite measurements reveals that the maximum of the diurnally averaged temperature in the lower thermosphere is near the longitude of the magnetic pole in both the Northern and Southern Hemispheres. The A~~a~~uthors suggested that this structure of the diurnally averaged

15 temperature in the lower thermosphere is most likely related to auroral heating, which occurs in the auroral region near the magnetic poles. ~~von Savigny et al., (2007) observed a significant decrease in the noctilucent clouds occurrence rate in the southern polar mesopause region made with SCIAMACHY (an imaging spectrometer installed on satellite Envisat), immediately after the onset of the enhanced solar particle precipitation on January 16, 2005.~~ A significant decrease in the occurrence rate of noctilucent clouds in the southern polar mesopause region was observed immediately after the onset of the

20 enhanced solar particle precipitation in SCIAMACHY (an imaging spectrometer installed on satellite Envisat) data on January 16, 2005 by von Savigny et al., (2007). Simultaneously, the instrument Microwave Limb Sounder (MLS) on board of NASA's satellite AURA registered the atmosphere temperature increase at an altitude of 85 km. Hocke (2017) studied the temperature measurement with the MLS on AURA during the proton event on November 7-10, 2004. He found the temperature increasing of the polar mesosphere by 5-10 K while the polar stratosphere temperature decreased. Analyses of SABER / TIMED

25 temperature data made by Chang et al., (2009), and by Jiang et al., (2014) showed that periodic oscillations of the temperature of the low~~er~~ thermosphere ~~temperature~~ had good correlations with oscillations in geomagnetic activity.

As well as the direct effect of EPP, there is also an indirect effect on the atmosphere from particle penetration, ~~.~~ The energy of precipitating particles is deposited mainly ~~whose energy is deposited mainly~~ in the thermosphere and upper mesosphere. Studies showed that particle precipitations through a cascade of dissociation, ionization and recombination processes create

30 odd nitrogen (NO_x) and odd hydrogen (HO_x) in the high latitude thermosphere and mesosphere. HO_x is relatively short-lived (of the order of days) leading mostly to local effects, while NOx can be transported by polar downwelling into the winter polar stratosphere, where it can lead to both short and long term (order of months) catalytic ozone destruction.~~while NO_x can lead to both short and long term (order of months) catalytic ozone destruction in the stratosphere~~. These effects may further couple to atmospheric dynamics and propagate downwards by changing polar winds and atmospheric wave propagation through

35 wave—mean flow interaction (Krivolutsky et al., 2006, Baumgaertner et al., 2009, 2011, Semenuk et al., 2011, Arsenovic et al., 2016, Karami et al., 2015, Randall et al., 2007).

It is known that the rotational temperature of ~~the~~ hydroxyl corresponds to the temperature of the neutral atmosphere at the mean emission height ~~height of its radiation~~ (~ 87 km). Consequently, the effect of geomagnetic activity on the temperature of the atmosphere can be investigated from the change in the rotational temperature of ~~the~~ hydroxyl. The purpose of this paper

40 is to find geomagnetic signatures in night measurements of OH rotational temperature obtained for the period August 1999 to May 2015. ~~As a measure of geomagnetic activity, the widely available index Ap was used.~~

Instrumentation and measurement technique

Mesopause region (80-100 km) is the atmosphere region where the mesosphere borders on a thermosphere. The radiating layer of excited hydroxyl (OH) is located ~~at about 87 km~~ in mesopause region.

The exited hydroxyl molecule experiences $2 \cdot 10^4$ s^{-1} collisions before radiation, which is sufficient for thermalization with the surrounding medium. Therefore, the OH rotational temperature calculated from the night sky spectra indicate the neutral atmosphere temperature ~~at the radiation height~~ (see, e.g., Khomich et al., 2008).

The OH(6-2) rotational temperature data (TOH) for the ~~presented~~ this paper were obtained with the infrared spectrograph described by Ammosov and Gavrilyeva (2000)~~(Ammosov and Gavrilyeva, 2000)~~. The spectrograph was installed at optical station of Maimaga (geographic coordinates are 63° N, 129.5° E, geomagnetic coordinates are 58° N, 202° E) located about 120 km north of Yakutsk, Russia. Observations were carried out in cloudless and moonless nights, with the sun at least 9° below the horizon. The atomic oxygen line which arises at high auroral activity superimposes on the OH(6-2) spectrum. To avoid systematic errors in evaluating the temperature because of this, the data obtained in the absence of aurora were selected for the analysis. The location of the observation station makes it possible to perform measurements only from the beginning of August to the middle of May since the summer mesopause is constantly sunlit at the Maimaga latitude.

The method for estimating the rotational temperature of molecular emissions is based on the least squares fit of model spectra constructed with regard to the instrument function for different previously specified temperatures to an actually measured spectrum (Ammosov and Gavrilyeva, 2000). The temperature corresponding to that model spectrum, which deviates least from the real spectrum, by not more than the registration noise, is considered as a best fit to the real hydroxyl rotational temperature. The random errors in measuring the temperature are typically 2-10 K, depending on signal-to-noise ratio. Since different published transition probabilities lead to temperature differences up to 12 K (Turnbull and Lowe, 1989; Greet et al., 1998) all the data are analyzed using the same Einstein coefficients by Mies (1974), for consistency.

Results

The rotational temperature data set comprises 2864 nightly average temperatures obtained from August 1999 to May 2015. The measurements of the nightglow spectrum are conducted from the beginning of August to the beginning of May. The longest night data series are registered in the winter. The number of measurements per month varies from 10 to 25 nights. The TOH and F10.7 index average values for the measurement season (from August to May) for 1999-2015 are plotted in Figure 2a. ~~The TOH and Ap index mean values are shown in Figure 2b.~~ The same TOH and Ap, averaged over the same years, are shown in Figure 2a. The average values of the F10.7 index and Ap-index were calculated in the days that coincided with the TOH measurements at the Maimaga station. As can be seen from the Figure 2, the TOH inter annual variation is delayed relative to the F10.7 change and is more consistent with the Ap-index variation. The correlation coefficient of TOH and Ap-index is 0.51. The significance of correlation coefficient was tested with 14 degrees of freedom T-test. The critical value of correlation coefficient is 0.46 at the 0.05 level of significance. TOH is not significantly correlate with F10.7, because correlation coefficient 0.36 is less than critical value. The correlation coefficient increases to 0.65 when F10.7 leads the temperature by 2 years.

The night temperature means were divided into two groups for further analysis. The average AP in the observation interval of about 8 was chosen as the transition value. The first group includes the measurements which were conducted at the season with high geomagnetic activity when average Ap-index > 8. The second group consists of night TOH measured during the season with Ap-index <= 8. The number of observations per month in two groups is shown in Figure 3. The seasonal distribution of measurements is approximately similar. A monthly mean TOH in geomagnetically active years (Ap> 8) and in geomagnetic quiet years (Ap <= 8) are plotted in Figure 4. The results show higher monthly mean OH temperature with high Ap (>8) than with lower Ap (<=8) from October through January. The difference is about 10 K (i.e. 10.5K±1.4K, or 9.6K±1.4K, if Feb is included). There is no dependence of the TOH on the level of geomagnetic activity in autumn and spring. However, it should be noted that at this period the number of observations is not large.

~~Discussion~~

There are several publications (Lu et al., 2008, Seppälä et al., 2009, Seppälä et al., 2013), where the authors investigated the geomagnetic activity effect in the atmosphere based on the meteorological measurements ERA-40 and ERA interim data set. The authors studied the atmosphere climatology from 1000 hPa to 1 hPa separately in the years with high and low

5 geomagnetic activity. They found that high geomagnetic activity can drive a strengthening of the Northern Hemisphere polar vortex, with warming in the polar upper stratosphere and cooling below. Meteorological data analysis shows that the upper stratosphere warming starts in beginning of December and lasts until March (Seppälä et al., 2013). The heating descends downwards during winter. ~~Karami et al. (2015) investigated the thermal and dynamic response of the middle atmosphere to ozone concentration losses due to EPP using the chemistry-climate general circulation model EMAC. The results of~~

10 ~~simulations show that as winter progresses the temperature anomaly moves downward with time from the mesosphere/upper stratosphere to the lower stratosphere.~~ A similar downwards descending signal (in the same model) is already demonstrated by Baumgaertner et al (2011) using G~~g~~eopotential height anomalies~~.~~

The temperature difference in the geomagnetic active years in comparison with the geomagnetic quiet years has been observed since October to February in our measurements. The heating signal appears in mesopause region about 1-2 month earlier and

15 has approximately the same duration as in the upper stratosphere. ~~It should be noted that model and experimental researches of meteorological parameters are limited to a height of 80 km. The hydroxyl radiating layer is located in the mesopause region (~ 87 km). As indicated above, the temperature difference in the geomagnetic active years in comparison with the geomagnetic quiet years has been observed since October to February in our measurements. It should be noted that model and experimental researches of meteorological parameters are limited to a height below ~ 80 km. The hydroxyl radiating layer is located 7 km~~

20 ~~higher. Stratwarm effects are known to propagate downward, so that the OH temperature effect should be expected to occur earlier than model results obtained for 80 km, and below.~~ However, one cannot be sure that the observed temperature difference is the result of an indirect impact. The temperature signal can be related to auroral heating, or in situ ozone depletion caused short-time HO_x enhancement. Unfortunately, we cannot investigate the direct effect of precipitating particles, since a line of atomic oxygen is superimposed on the hydroxyl spectrum in geomagnetic active days. Such spectra are excluded from the

25 analysis.

The EPP changes temperature and dynamics in the winter polar atmosphere as shown in the above studies. Also, most of the measurement of the mesopause region temperature at our latitude is carried out in the winter. Figure 5 shows the F10.7 and Ap-index averages variations in January from 1975 to 2016. The regular measurements of the mesopause region temperature began approximately in these years. Unlike the previous solar cycles, it is clearly seen that F10.7 maximum leads Ap-index

30 maximum by about 2-3 years in the 23rd solar cycle. It should be noted, that in our research the influence of the solar irradiance and the long-term linear trend on the mesopause temperature is not studied. The data of several solar cycles ~~is~~are necessary ~~because~~ to separate correctly the influence of these components.

Conclusions

The data set of the hydroxyl emission airglow comprises 2864 nightly average temperature values obtained from August 1999

35 to May 2015 at the subauroral Maimaga station are considered. The measurements of rotational temperature of OH(6-2) were studied in search for a geomagnetic activity effect. Correlation between seasonally averaged TOH and geomagnetic activity index Ap is statistically significant and is equal to 0.51.

The winter polar mesopause is approximately 10 K warmer in the years with high geomagnetic activity (Ap>8), than in the years with low geomagnetic activity (Ap<=8). Warming of the mesopause starts in October and lasts until February, which is

40 about 1-2 months earlier than the warming in the stratosphere. ~~It can be explained by altitude difference between mesopause (87 km) and 1 hPa (50 km) level where the average onset of stratospheric warmings is observed (Seppälä et al., 2013). Warming~~

~~signal moves down from high altitude to low one. Nevertheless, it cannot be ruled out that the temperature rise of the upper mesosphere in geomagnetically active years is due to the in situ effect of EPP.~~

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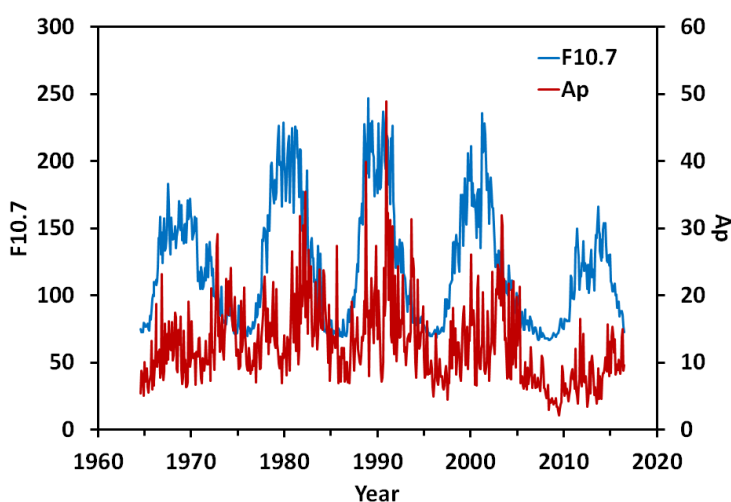
Figure1: Monthly mean F10.7 and Ap for 1965-2016. Both indices were acquired from the National Geophysical Data Center, NGDC (ftp://ftp.ngdc.noaa.gov/STP).
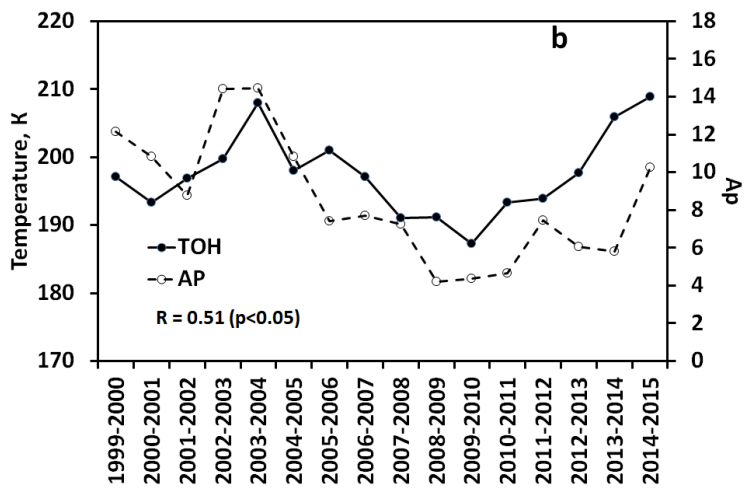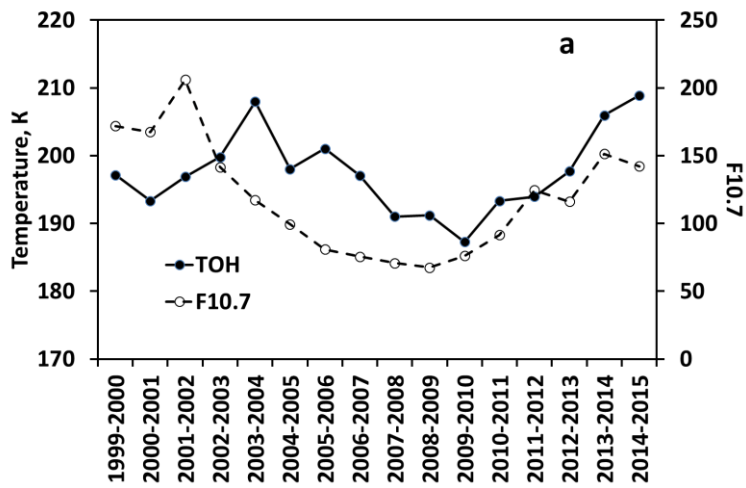
Figure 2: (a) Seasonally averaged TOH and F10.7 index (from August to May) for 1999-2015. (b) The TOH and Ap-index mean values for 1999-2015. The average values of the F10.7 index and Ap-index were calculated in the days that coincided with the TOH measurements at the Maimaga station.
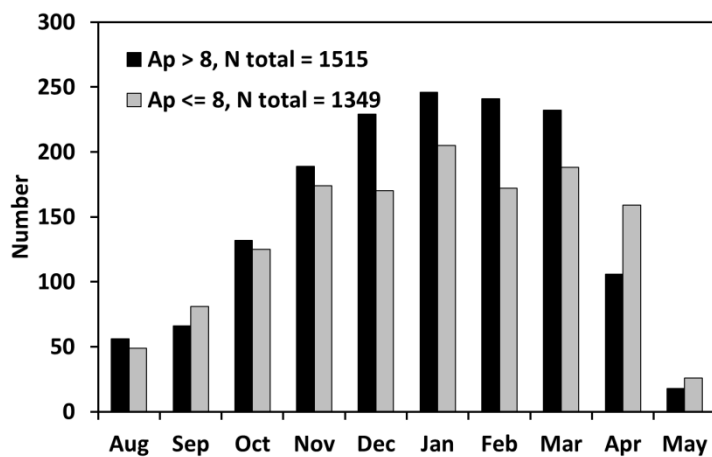

Figure 3: The number of measurements per month during the geomagnetic activity years (Ap > 8) —black columns, grey columns - the monthly distribution of measurements during geomagnetic and quiet years (Ap <= 8).
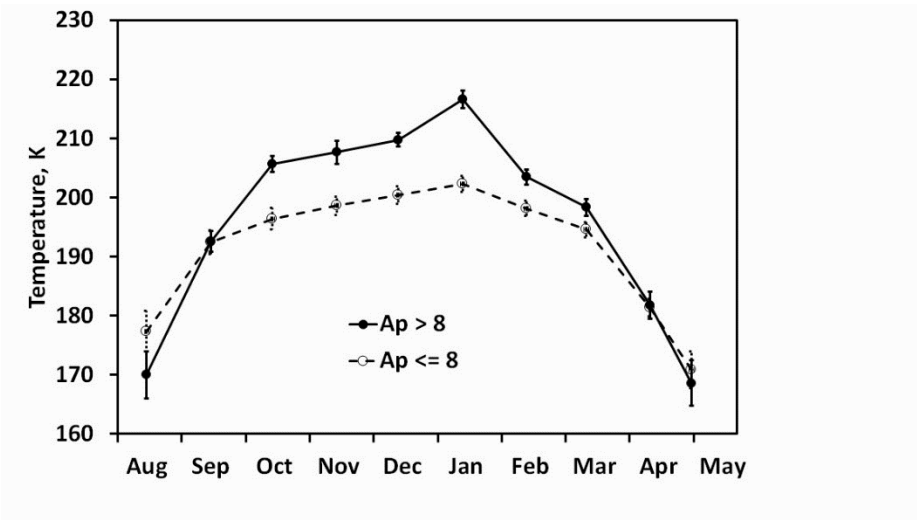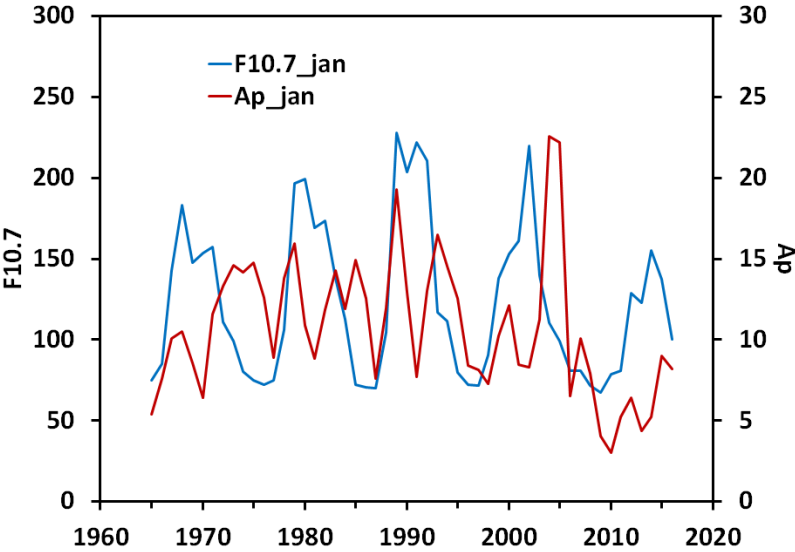
Figure 4: A mMonthly mean TOH in geomagnetic active years (Ap> 8) and in geomagnetic quiet years (Ap ≤ 8). Vertical bars correspond the standard deviations.

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Figure 5: The F10.7 and Ap-index averages variations infor January from 1975 to 2016.