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Behavior of the Total Column Ozone and Temperature above Iraq during 2012 Strong Geomagnetic Storms

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Abstract: ***The aim of this research is to investigate the behavior of the Ozone layer through the total column Ozone (TCO) during the strong geomagnetic storms of the year 2012 and to find the effect of the geomagnetic storms on the variation of the temperature (T2m) two meter above the Earth surface by studying the hourly variations, daily average and monthly average of these two parameters above Iraqi region (38˚- 49˚N; 28˚-38˚E), The data of (TCO) and (T2m) were selected from the ERA satellite for year 2012, in which there are seven strong geomagnetic storms occurred along five months. Drawing the monthly and the daily average (two days before, stormy day, and seven days after the stormy day for three Iraqi cities Muthanna, Baghdad, and Sulaymaniyah). From monthly average the results reveals that the thickness of Ozone layer in North of Iraq wider than the Middle and South of Iraq for all stormy months except in October of 2012 appears that the maximum in Middle of Iraq. About the temperature it is reversely preoperational with Ozone thickness. The maximum values of TCO in spring it reaches 327 DU in April. From the hourly variations of TCO and T2m for three Iraqi cities, it seen that in some events it is decreases and others increases do not depend on storm type, utmost it is increases. The slope of trend line for variation of (TCO) with the variation of (T2m) drawn gives that there is no relationship between them along the three cities taken and for all events.***

Keywords: Total Column Ozone, Temperature, Strong geomagnetic storm.

1. Introduction

Many authers study the effect of the different kinds of geomagnetic storms and solar activities on the atmospheric ozone, they found that there is still some uncertainty whether it is direct effects from solar activity or there are indirect processes. It was find by Labitzke in (1997) that the association between the Sun and the ozone is not a direct. Mlch and Lastovicka in (1995) reveal that 50% of the effect of geomagnetic storm depends principally on solar cycle and quasi-biennial oscillation (QBO) [1]. Lastovicka (1996) he reviewed the effect of geomagnetic storm at heights of about 0-100 km in mid-latitudes (Europe). He found that there are some correlations with geomagnetic storms in the lower stratosphere and troposphere, but these effects are different, they do not understand their mechanisms [2]. Lastovicka and Mlch (1999), they found that for the strong geomagnetic storms effects on total ozone have been observed only in winter [3]. Belinskaya et al. (2001) demonstrated the possible response of (TOC) to the solar and geomagnetic activity for different latitudinal and longitudinal. The influence of the strong geomagnetic storms depends on the solar cycle phases, QBO-phases and longitude [4]. Yordan Tassev et al. (2003) studied the effect of solar Cosmic rays (CR) and the geomagnetic storm on the ozone in the middle atmosphere and the regeneration of the ozone density in the lower stratosphere during night-time [5]. Lastovicka and Kriman Peter (2005) they found that the main results of the effects of geomagnetic storms decreases on the total ozone may be due to sufficiently strong and statistically significant effects of geomagnetic storms and the Forbush decreases of the galactic cosmic ray flux appear to occur in the total ozone at the northern higher middle latitudes only for strong events in winter[6]. Pancheva et al. (2007) they studied the regional responses of the high-latitude of the mesosphere–lower thermosphere (MLT) winds to the very strong geomagnetic storms that occurred on 29 and 30 October 2003. It was found that the response of the MLT dynamics to the first geomagnetic storm occurring in the daytime and accompanied by solar proton fluxes is very different from those to the second and third geomagnetic storms with onsets during the night time [7]. Damiani et al. (2009) they investigated the effects of solar energetic particles on the polar atmosphere in three different seasons, they found that the even events with limited particle flux in the range 15–40 MeV are able to change the abundance of the minor constituents in the mesosphere and upper stratosphere [8]. Cooper et al. (2010) in their study they a strong increase in spring time ozone mixing ratios during 1995–2008 are revealed [9]. In (2012) Saadiyah studied the spatial and temporal structure of the daily total Ozone column (TOC) during years (2004-2011) for various cities in Iraq, which indicated that the daily variation of TOC in Southern part of Iraq lower than the central and Northern parts of Iraq, but the seasonal variation showed that there is a higher diurnal TOC variations in Spring and Summer months than Autumn and Winter months [10]. Marta Zossi de Artigas et al. (2016) they studied the effects of energetic particles precipitation on stratospheric ozone in the Southern Hemisphere statistically significant variation in total ozone content at middle latitudes of the Southern Hemisphere is observed. The variations depend on the intensity of geomagnetic disturbances and the geomagnetic longitude [11]. Mohammed A. and Najat M. Al-Ubaidi (2017) they made a comprehensive study for Iraqi region from (2002-2016) about the variation of Ozone with Temperature, they found that the TCO3 in spring and winter greater than summer and autumn. Also there is an inverse relation between Ozone and temperature in Middle and North of Iraq but in the south the relation fluctuated between direct and inverse along the period study [12]. Najat M. R. Al-Ubaidi and Zahra T. I. in (2018) present in their study the TCO and T2m on Iraqi region for severe and strong geomagnetic storms of year 2015, they found that the thickness of Ozone layer in spring and winter are greater than summer and autumn. Also in the North of Iraq wider than the Middle and South of Iraq for all seasons except in autumn (October 2015), there is anomaly in which the thickness of Ozone is wider in the west and middle than the other Iraqi regions [13]. In this study the effect of strong geomagnetic storms (during year 2012) on the total column ozone (TCO) and temperature (T2m) over Iraqi region are studied.

2. Data Selection

The year 2012 was chosen in this research basis on that it was the year in which seven strong geomagnetic storms occurred during four months represented in table (1), so we were able to take three seasons, spring (March and April), the summer (July), and autumn (October and November), which helped us to take a comprehensive study of the impact of storms with Seasons and Latitude. In this research the data for total column ozone (TCO) and temperature (T2m) at height (2m) above the surface of the Earth were selected for Iraqi region (38˚- 49˚N; 28˚-38˚E) from the site (http://apps.ecmwf.int/datasets).

3. Data Analysis

From data selected above Iraqi region for the year 2012, there is only five months (March, April, July, October and November) in which the strong storms occurred. Figure (1) reveals the hourly (Dst-index) which gives the type and strength of the geomagnetic storm [14], it found that there is seven strong storms (-200 nT<Dst< -100nT) in year 2012.

Drawing contour maps for the monthly average figure (2) for (TCO) in Dobson Unite (DU) and figure (3) for (T2m) in (K), also contour maps daily average of (TCO) and (T2m) which are represented in figures (4 and 5, a, b, c) for five events selected in 2012. These five events are occurred in (9th March, 24 April, 15 July, 1th October and 14 November 2012) respectively, where a) two days before the geomagnetic storm, b) for the stormy day, and c) seven days after the geomagnetic storm.

To reveals the changes of TCO and T2m during the geomagnetic storms, to illustrate this more easily, Iraqi region divided into three categories South represented by Muthanna (latitude, 30oN; longitude, 45oE), Middle Baghdad (latitude, 33oN; longitude, 44oE), and North Sulaymaniyah (latitude, 35oN; longitude, 45oE). Figure (6), represented the daily variation of TCO and the T2m (represented by only eight hours 0, 3, 6, 9, 12, 15, 18, and 21 in universal time) through the day to the five events chosen, for three days two days before storm, day of geomagnetic storm and seven days after the geomagnetic storm.

To find the relationship between the thickness of Ozone layer (TCO) and temperature change (T2m) during the geomagnetic storm, figure (7) reveals the hourly (eight hours during the stormy day) variation of (TCO) with respect to hourly variation of (T2m) for five events occurred from year 2012 for three Iraqi cities chosen in this research. The curve fitting of this drawing gives the trend line equation in which the slopes are represented in table (2).

4. Results and Discussion

From results above for the monthly average contour maps of (TCO) and (T2m) it reveals that, in general the thickness of Ozone layer in spring are greater than summer and autumn. Also in the north of Iraq wider than the middle and south of Iraq for all seasons except in month 10 from year 2012, there is anomaly in which the thickness of Ozone is wider in the west and middle of Iraq than the other Iraqi regions. About the temperature in the middle and south of Iraq greater than the north and for all stormy months and there is an inverse relation between (TCO) and (T2m).

From the daily average of TCO for the two days before the geomagnetic storm, stormy day, and seven days after the geomagnetic storm, it is seen that for spring and autumn for over the three cities chosen the TCO seems increases during the stormy days except in April it is decreases than the days before for all cities chosen, but it is still the maximum values of TCO in spring utmost in April it reaches 327 DU. About the temperature in north of Iraq lower than middle and south, seems increases during the stormy days in spring and summer, also it is decreases in autumn (October and November) during the stormy days. The maximum value of T2m reaches 310 K in July.

For more comprehensive study, eight hours from the day taking for two days before the storm, stormy day and seven days after, to see the impact of storms on total column Ozone and temperature with Seasons and Latitude. From comparing between the stormy day and two days before, the results shown that during the geomagnetic storms the TCO increases for all seasons and latitudes chosen with respect to two days before the stormy day, except in summer for all cities and in spring for south (Muthana) it is decreases. About the temperature it is increases for all seasons and latitudes except in the November for all cities chosen and October in the south only it is decreases. To compare between the TCO in stormy hours and after seven days, it seen that the TCO increases for all seasons and latitudes except in October and November for all latitudes chosen, in April (middle) and July (north) after the storm it is decreases. Concerning the temperature it is increases in all seasons except in October (middle and north) and November (south) it is decreases also it is decreases in March compared to the stormy day.

To find if there is any relationship between the TCO and T2m, which gives the climate change during the geomagnetic storms for year 2012, Figure (8) and table (2) reveals that, there is a fluctuation between direct and inverse relation in all seasons and latitudes. There is no clear relationship that can be deduced in this study, which requires consideration of other factors that have an effect on changes in temperature which are not included in this study.

5. Conclusion

From the result and discussion above, it appears that, the thickness of Ozone layer in spring is greater than summer and autumn. Also in the north of Iraq wider than the middle and south of Iraq for all seasons except in autumn (month 10 from year 2012), there is anomaly in which the thickness of Ozone is wider in the west and middle of Iraq than the other countries. About the temperature in the middle and south of Iraq greater than the north and for all stormy months and there is an inverse relation between (TCO) and (T2m). The seasonal and latitude variation between TCO and T2m by taking the relative comparisons between days before and after with stormy day, it seems that there is an inverse relation between TCO and T2m for all seasons and latitudes taken in this research, but there is a fluctuation between direct and inverse relation between TCO and T2m for the stormy day in all seasons and latitudes. There is no clear relationship that can be deduced in this study.

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Table 1: Date and type (Dst) of Geomagnetic storms during year 2012

ent no.	Day	Month	Year	Hour Begin	Hour End	Dst (nT)	Type
1	9	3	2012	8	16	-131	Strong
2	24	4	2012	4	6	-108	Strong
3	15	7	2012	10	22	-127	Strong
4	16	7	2012	1	8	-102	Strong
5	1	10	2012	3	7	-119	Strong
6	9	10	2012	6	10	-105	Strong
7	14	11	2012	6	9	-108	Strong

Table 2: Trend line slope for hourly variation of (TCO) with respect to hourly variation of (T2m) for five events from year 2012 and for three Iraqi cities

Event	Muthanna	Baghdad	Sulaymaniyah
9/3/2012	-0.0975	-0.9719	-0.9097
24/4/2012	0.7643	1.2205	-0.0954
15/7/2012	-0.1345	-0.3917	0.0125
1/10/2012	-0.0658	-0.0089	0.059
14/11/2012	-0.6264	-0.3815	-0.7415

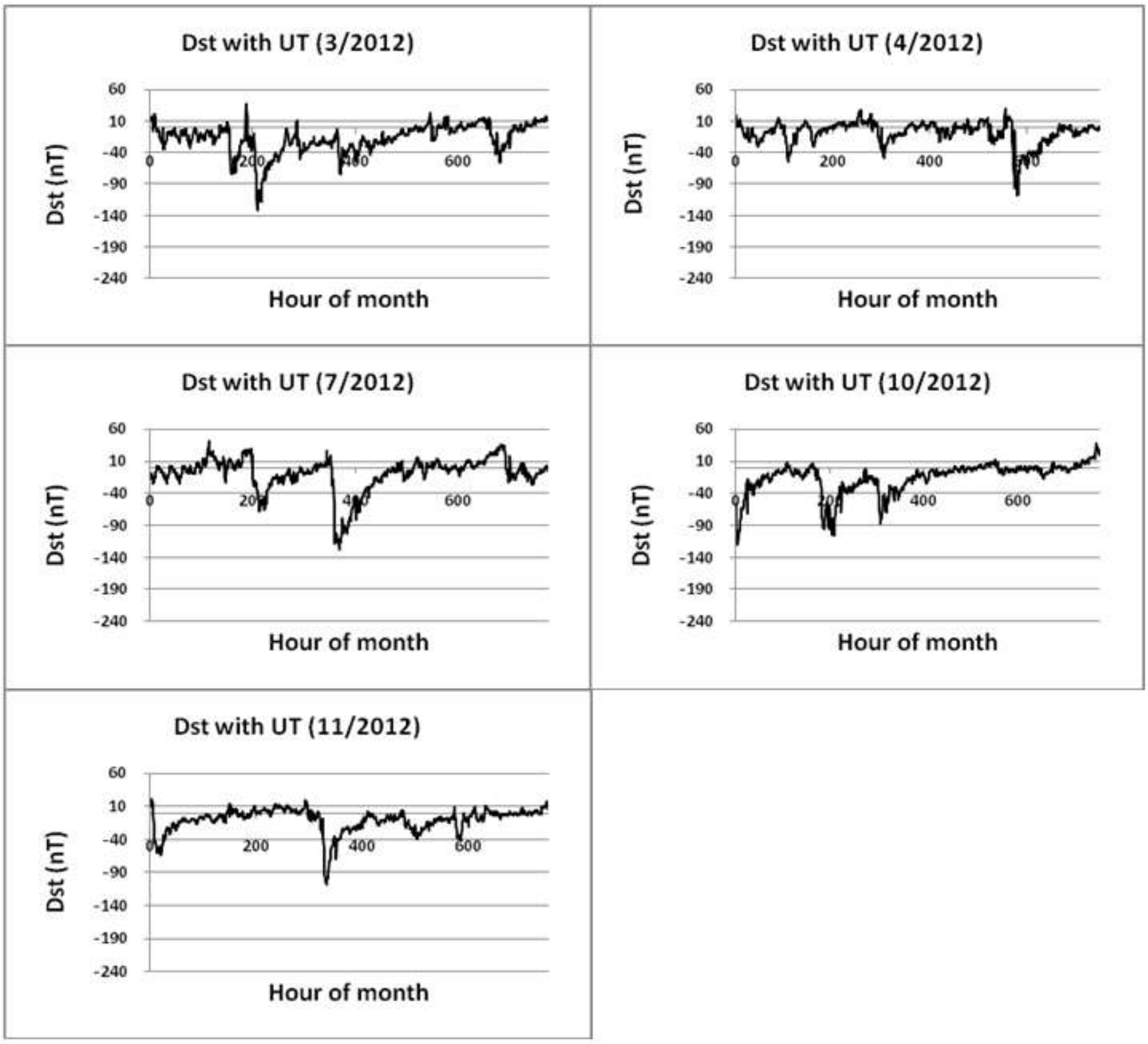

Figure 1: Dst (nT) index of geomagnetic storms for five months from year 2012

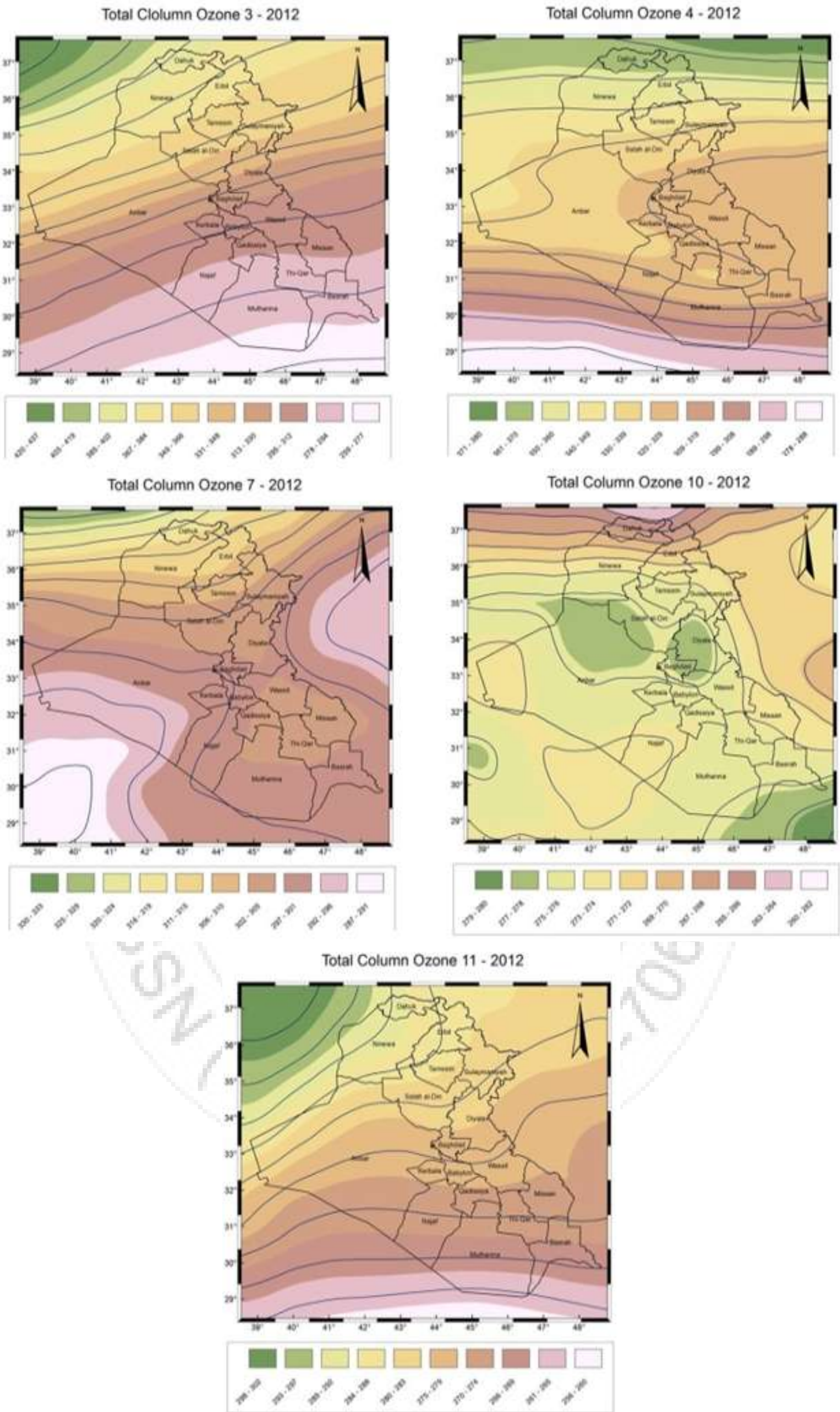

Figure 2: monthly average contour maps of total column Ozone (TCO)

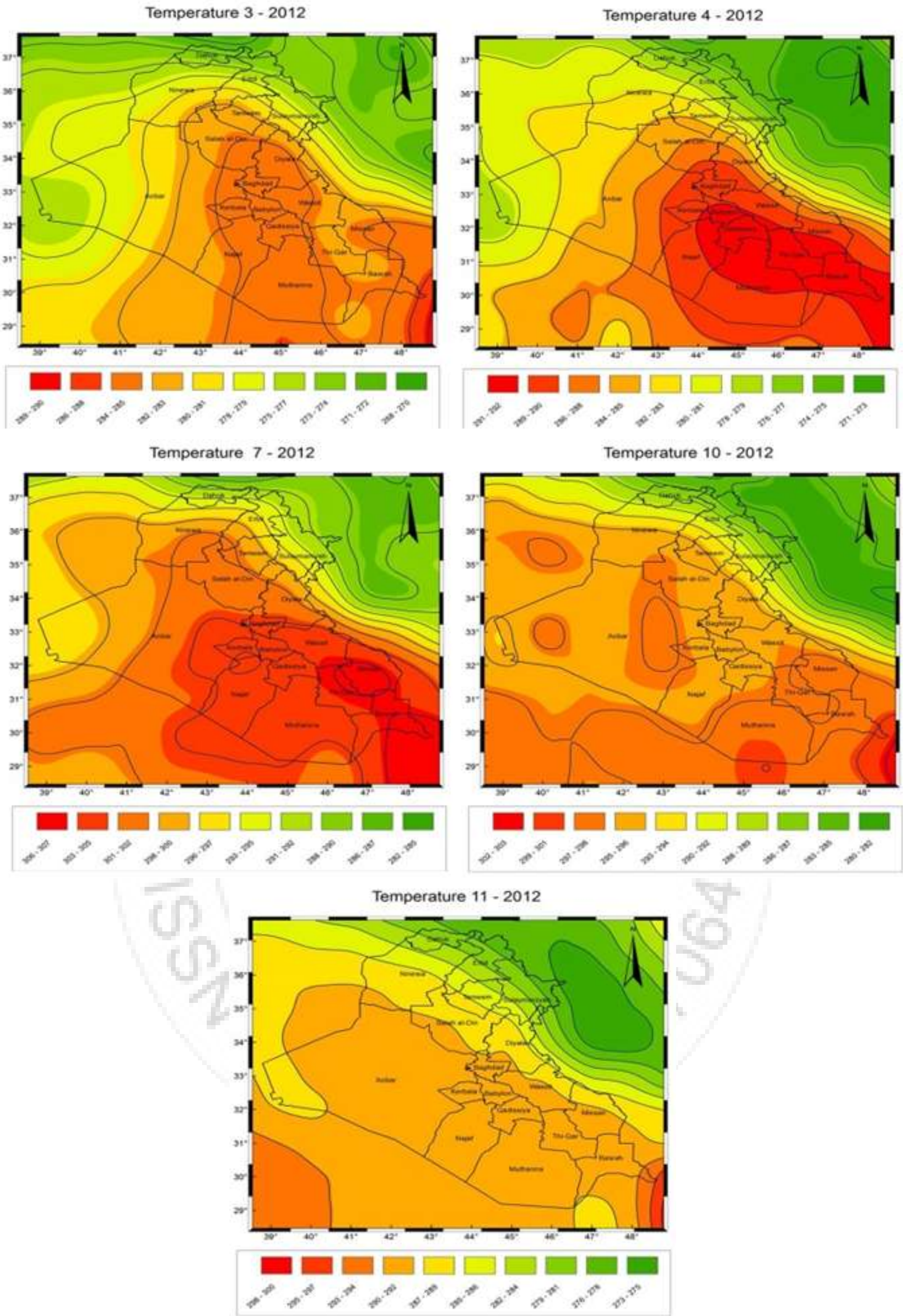

Figure 3: monthly average contour maps of the temperature (T2m)

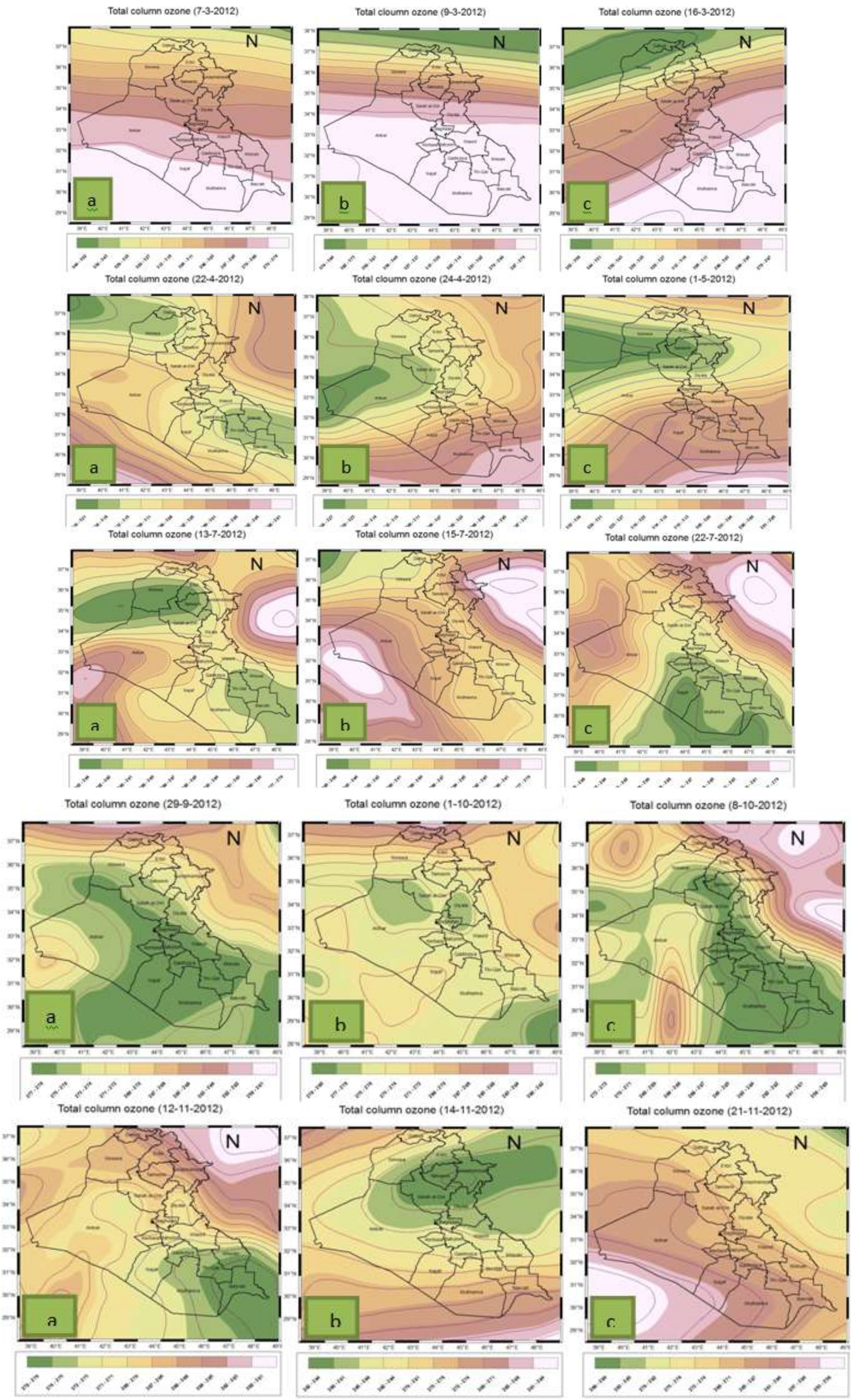

Figure 4: daily average contour maps of the TCO, a) two days before the geomagnetic storm, b) day of the geomagnetic storm, c) seven days after the geomagnetic storm

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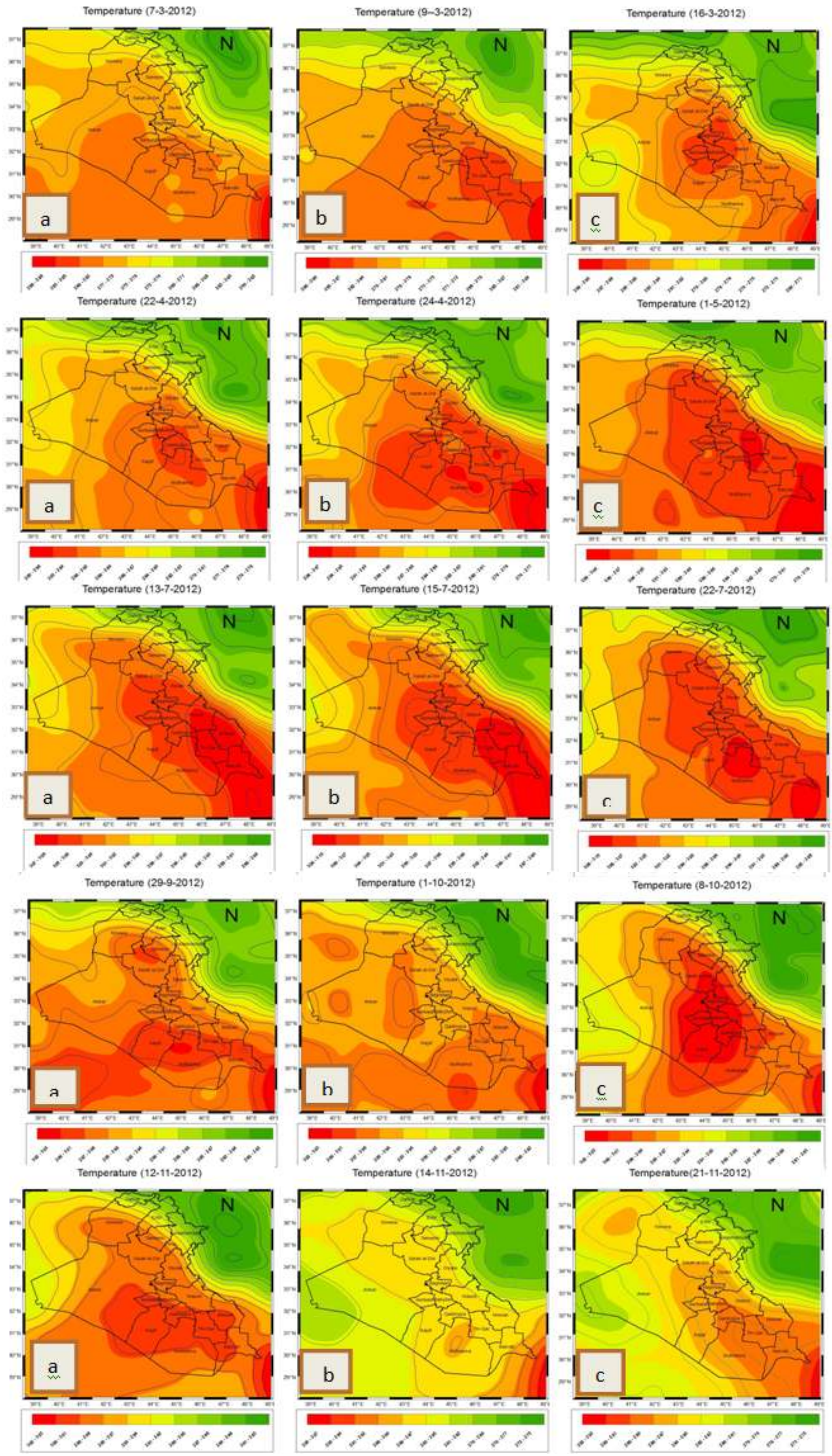

Figure 5: daily average contour maps of the T2m, a) two days before the geomagnetic storm, b) day of the geomagnetic storm, c) seven days after the geomagnetic storm

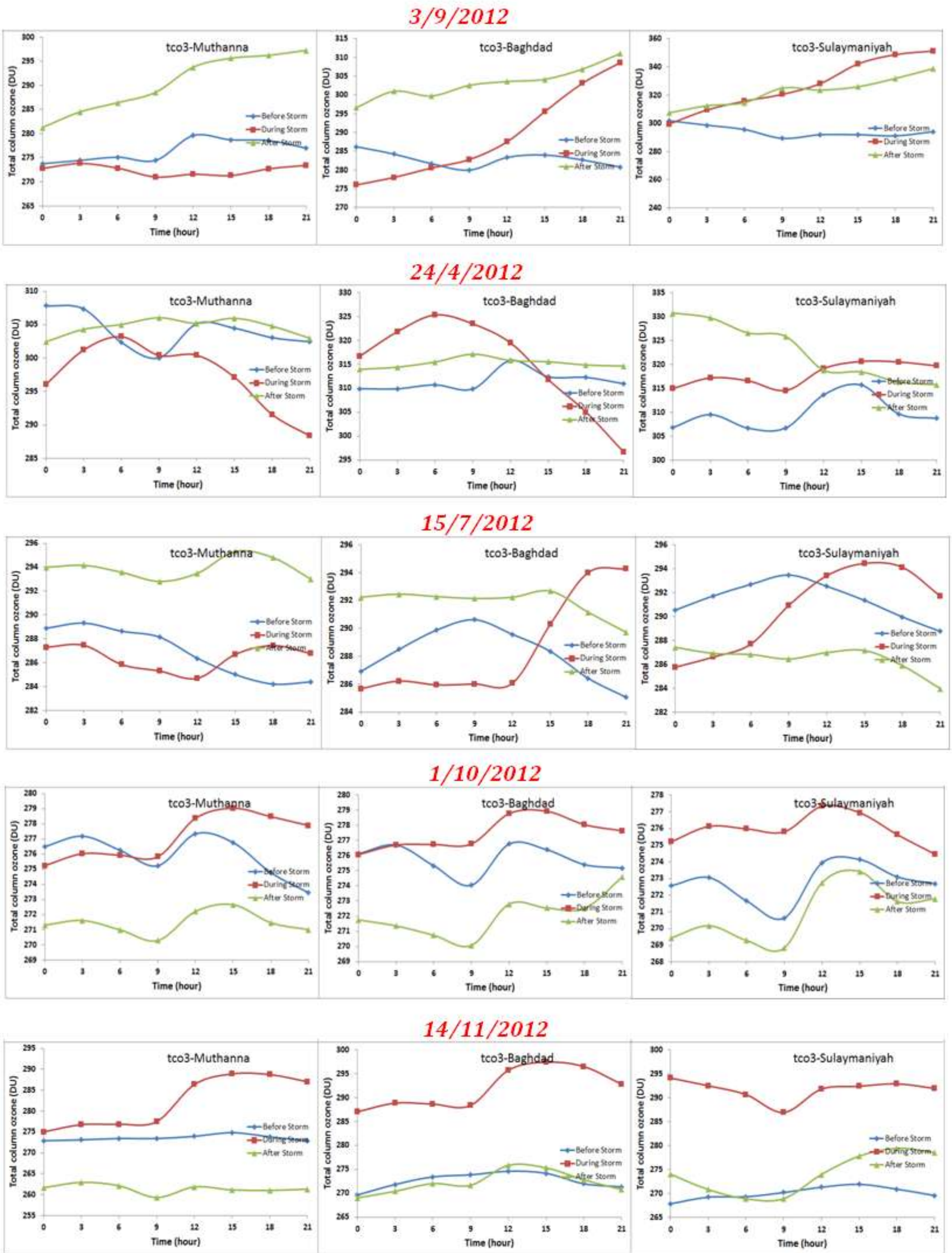

Figure 6: daily variation of the TCO for three days two days before storm, day of geomagnetic storm and seven days after the geomagnetic storm. For five events occurred from year 2012 and for three Iraqi cities

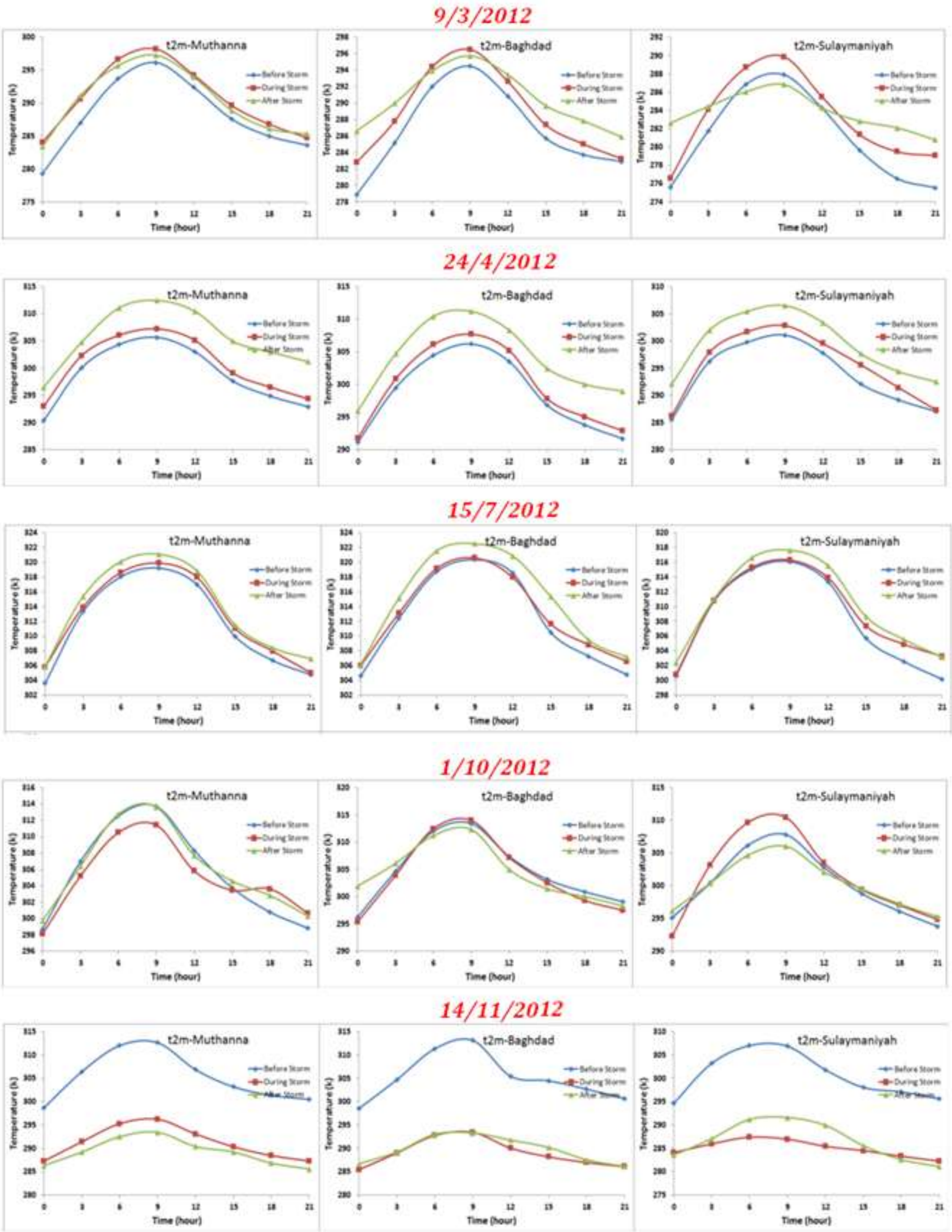

Figure 7: daily variation of the T2m for three days two days before storm, day of geomagnetic storm and seven days after the geomagnetic storm. For five events occurred from year 2012 and for three Iraqi cities

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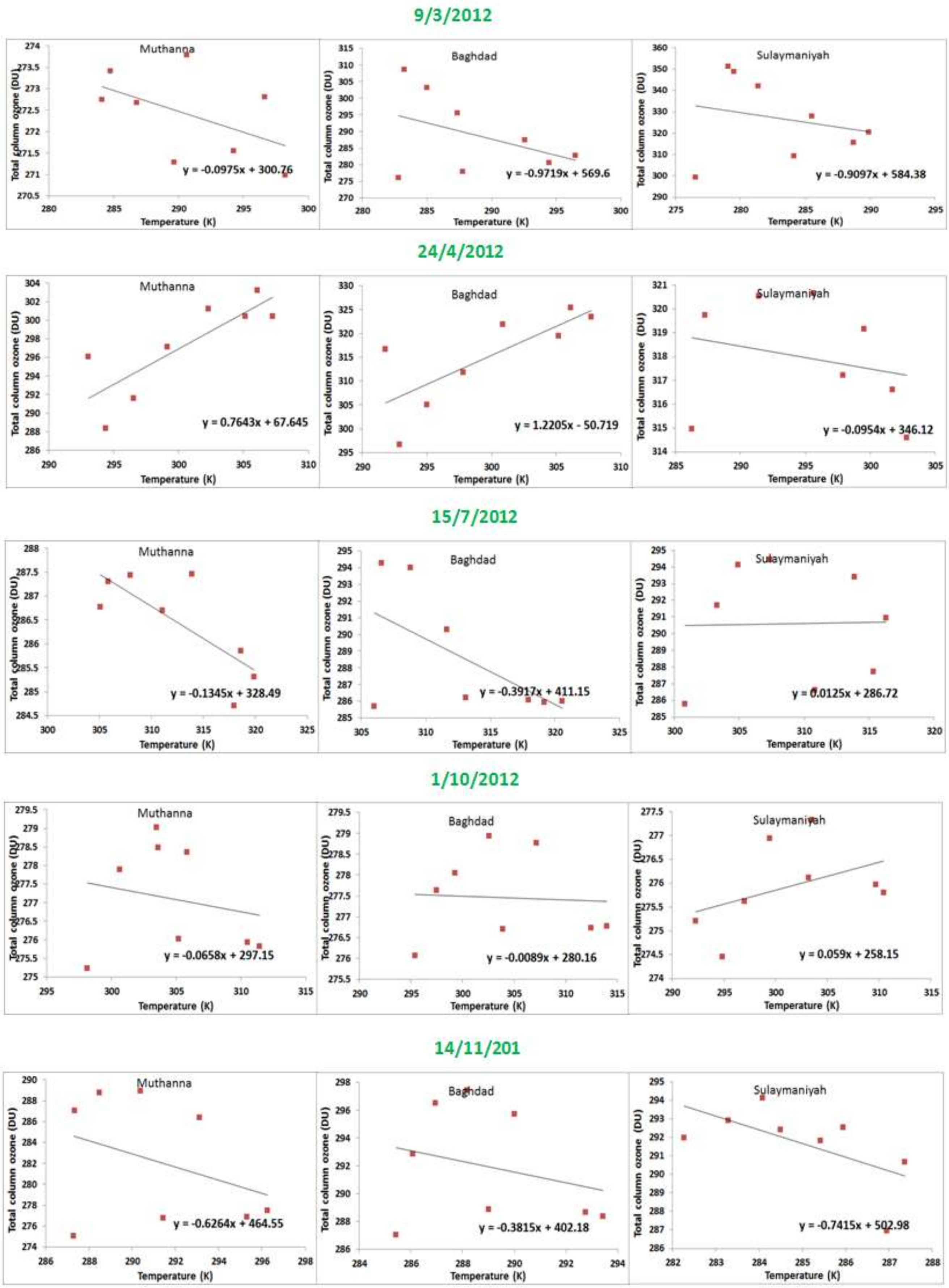

Figure 8: hourly variation of (TCO) with respect to hourly variation of (T2m) for five events occurred from year 2012 and for three Iraqi cities