THE IONOSPHERE – TROPICAL CYCLONES – EARTHQUAKES INTERACTIONS

L.B. Vanina-Dart (1), T.M.Dart (2)

(1)Space Research Institute, Profsoyznaya str, 84/36Moscow, Russian Federation,
(2) "Seeingear" LTD, Battle Road, 383, St. Leonards on Sea, UK

Abstract

The study of atmospheric–ionospheric interactions is one of the most interesting and perspective applied directions in geophysics. Because of its nature, being a product of ionization of various neutral gas components, the Earth's ionosphere rapidly enough reacts to changes in space radiation and also in the composition of the neutral atmosphere. Respectively, deviations in the behaviour of ionospheric parameters due to atmospheric events (thunderstorms, cyclones, tornados, hurricanes, etc.) are detected. Much attention has been recently paid to such tropospheric events as tropical cyclones (TCs). Really in regions, where TC have been often, earthquakes have been also. It has been proved that processes in the lithosphere have an electrodynamic influence on the ionosphere. In this presentation authors analyze the ionosphere parameters, received in the process of satellite remote sensing above TC (above Australia) and earthquakes from this area in last year's.

1.INTRODUCTION

"There is no doubt that in many cases the damage caused by tropical cyclone winds or storm surge has been incorrectly attributed to earthquakes." (G.J.Bell, 1981)

"Reid (1838) found the residents of the West Indies predisposed to believe that earthquakes accompany hurricanes. Although he conceded that earthquakes may occur with hurricanes he was not convinced that they were necessarily related. Piddington (1864) mentions a number of instances when earthquakes were reported in association with tropical cyclones including the following:- " On the night between the 11th and 12th October, 1737, there happened a furious hurricane at the mouth of the Ganges, which reached sixty leagues up the river. There was at the same time a violent earthquake which threw down a great many houses along the river-side in Colgota (i.e. Calcutta) alone, a port belonging to the English. Two hundred houses were thrown down, and the high and magnificent steeple of the English church sunk into the ground without breaking. It is computed that 20,000 ships, barks, sloops, boats, canoes, &c. have been cast away: of nine English ships then in the Ganges, eight were lost, and most of the crews drowned. Barks of sixty tons were blown two leagues up into land over the tops of high trees; of four Dutch ships in the river, three were lost with their men and cargoes; 300,000 souls are said to have perished. The water rose forty feet higher than usual in the Ganges." (G.J.Bell, 1981)

Present indications are that earthquakes are induced by about one reservoir in 14 among those with maximum depth greater than 100 m and water volume greater than 1 km^3. It is considered that the increase in pore pressure resulting from water penetration is a more important factor than the incremental loud stress. Nevertheless, in most cases the filling of reservoirs has not been accompanied by a significant increase in local or regional seismicity. It is believed, therefore, that special geotechnic or hydrogeological conditions are required in order that storm surges or the impounding of water should be able to trigger earthquakes of significant intensity. (G.J.Bell, 1981)

Two of the possible “TC-Ionosphere” and “Earthquakes – Ionosphere” mechanisms are the Gravity Waves and the electric.

GWs generated at tropospheric altitudes propagate to the F-region. GWs generated from storms break near 100 km and produce secondary waves that continue to propagate upward GWs modulate the E-region plasma producing polarization fields that map to F-region altitudes. Strong convection cells produce a wide spectrum of GWs. GWs increase in amplitude with increasing altitude and may become unstable. Only waves propagating at the certain angles and with the correct amplitude can reach thermospheric altitudes. Once in the thermosphere, only those waves oriented to the magnetic field in a particular manner may produce ionospheric disturbances (dr.Rebecca Bishop, PSL/SSAL, 30 March 2012)

An effect of external electric currents on the global atmosphere-ionosphere el. circuit may be one of possible mechanisms of interaction between atmospheric and ionospheric components. External currents with a horizontal scale of about one hundred of kms may be related to the vertical large - scale convection of the cloudy atmosphere in the zone of a TC and to the charge separation in this region. The electric field disturbance arises due to perturbation in the atmosphere – ionosphere electric circuit generated by the upward transport of charged water drops and aerosols in TC convection zone (Sorokon et al, 2005).

In this paper we did the first attempt to find reply of “TC-Ionosphere-Earthquakes” interaction.

2. DATA

Every 15 minutes ionospheric maps can be obtained from the site of the Australian Ionospheric Prediction Service (IPS). These depict the region 10^0 to 50^0 S and from 110^0 to 180^0 E. The major parameter from these maps is TEC (total electron content in the ionospheric column section 1 m^2). The climatic disturbances TEC map was obtained from the same source. The TEC climate model is based on empirical orthogonal functions (EOF), derived from the analysis of TEC for a 30-day period at 15 minutes intervals. The function is decomposed into basic predictors. Typically, the most significant are the first four EOF, which can decode nearly 95% of the observed variation within 30 days. The TEC deviations map include the time of day, day of the year, the season and the solar cycle.

We used TEC disturbance map in this paper. The near-real-time ionospheric TEC (Total Electron Content) disturbance map is produced at IPS by removing a dynamically updated recent climatology map from the current TEC conditions. It is therefore representative of the deviation of current ionospheric conditions from those expected for the current time/day/season/solar cycle.

Information about earthquakes we took Internet from site http://geofon.gfz-potsdam.de/eqinfo/list.php (GEOFON Program).

Information about TCs we took from Internet site (Australian Severe Weather) http://www.australiasevereweather.com/tropical_cyclones/2012_2013/.

3. RESULTS.

For the “TC&Ionosphere&Earthquakes” interaction analyze we took data for December (2012) period. One of the possible disturbance agents for ionosphere can be the big geomagnetic activity. How we can see in the Figure 1, the geomagnetic activity (planetary magnetic 3-hours-range indeces Kp) was quiet in this time.

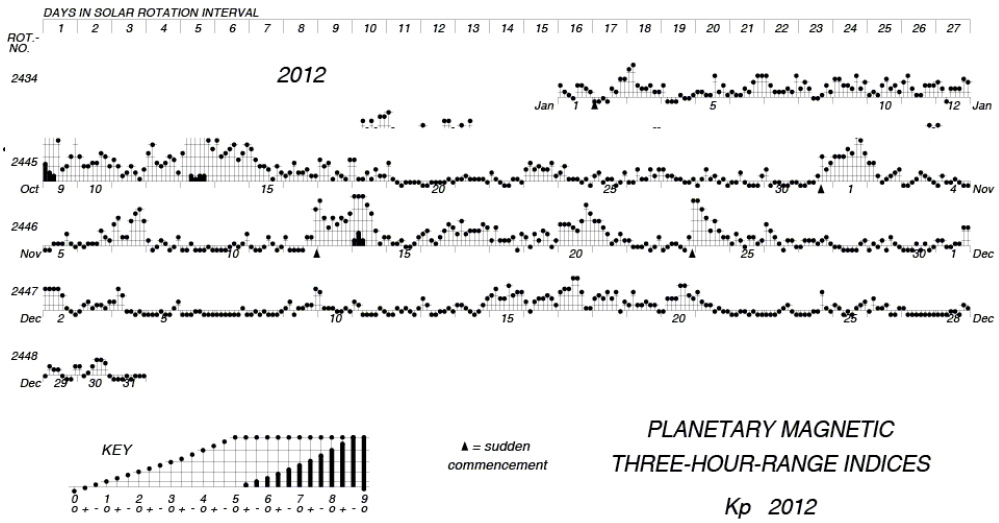


Figure 1: **Planetary magnetic 3-hour-range indices Kp.**

In the Figure 2 we can see the TCs & Earthquakes locations during December 2012.The red spot is the earthquakes location. In the right corner 2 TCs tracks are located very close to earthquakes.

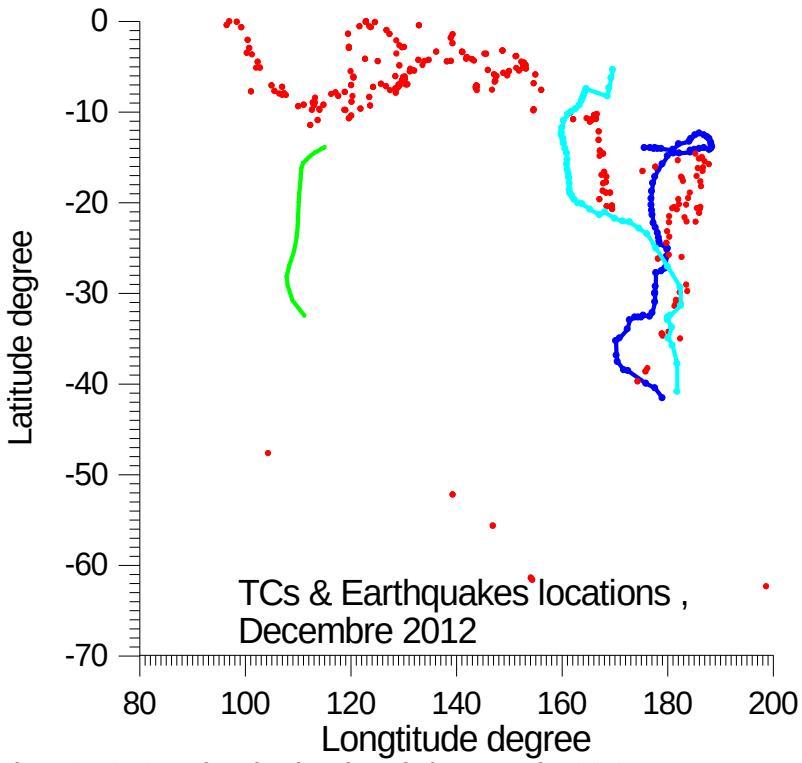


Figure 2. **TCs & Earthquakes locations during December 2012.**

In the Figure 3 we can see the TCs & Earthquakes latitudinal locations during December 2012. The black line is the average earthquakes latitudinal location during some December 2012 intervals. How we can see black lines correlate with latitudinal TCs tracks (10-21 December 2012, 2-8 Jan.2013).

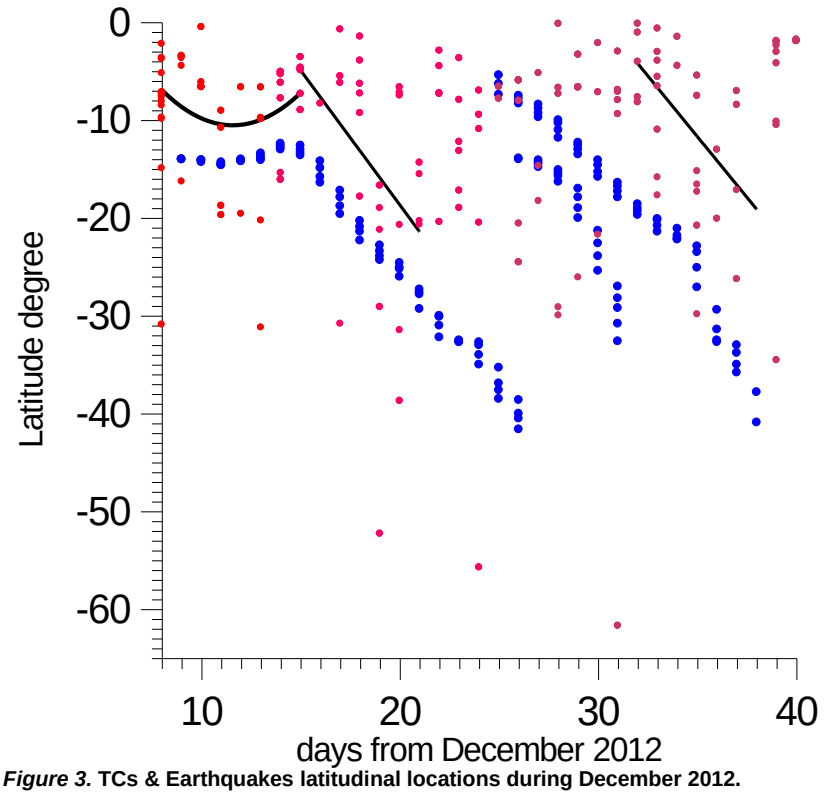


Figure 3. **TCs & Earthquakes latitudinal locations during December 2012.**

Figures 4 and 5 demonstrate some closed TCs & Earthquakes locations during December 2012 (the right corner of the Figure 2 with bigger scale). Numbers at the pictures are the data of December (if more than 31 – data of January). We think that it is difficult to say now about predictor in "TC-Ionosphere-Earthquakes" interaction. But both of the possible mechanisms of "TC-Ionosphere" and "Earthquakes – Ionosphere" interactions are the same. But some information can give conclusion that TCs proceeded by earthquakes by 5-10 days (Figure 4 and 5), because days data of earthquakes (red numbers) were days data of TC (blue numbers) mostly.

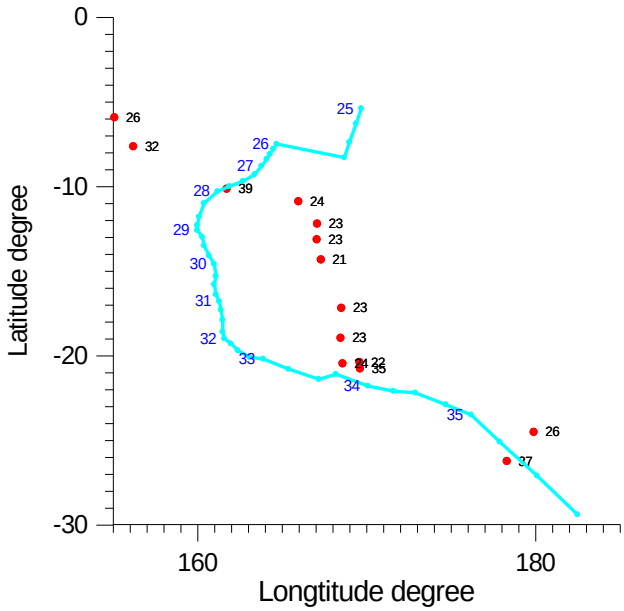


Figure 4. **Some closed TCs & Earthquakes locations during December 2012.**

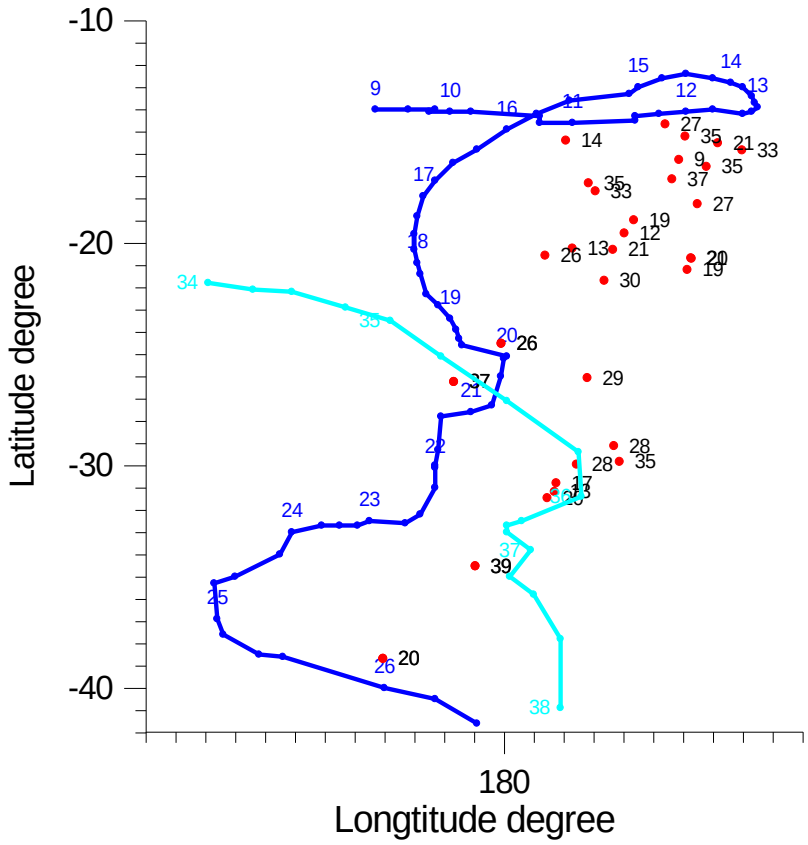
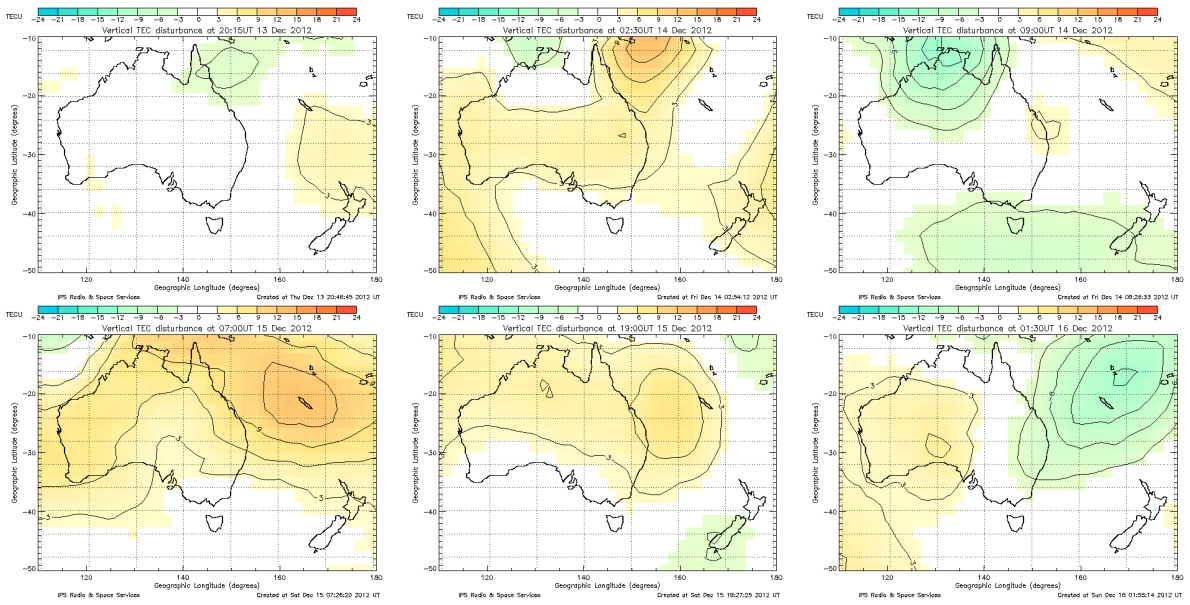
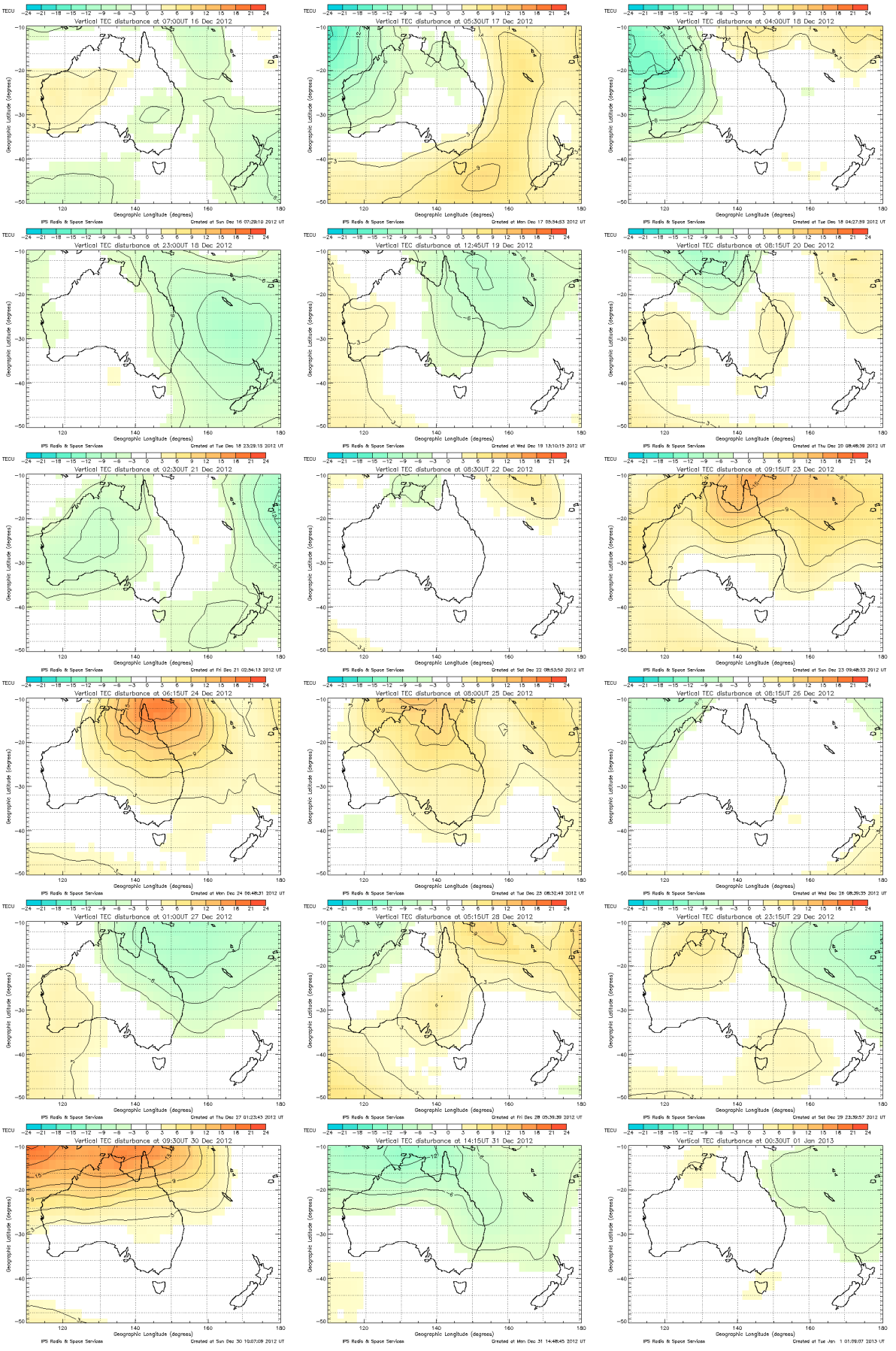


Figure 5. **Some closed TCs & Earthquakes latitudinal locations during December 2012.**

Figure 6 demonstrates the some TEC disturbance maps during December 2012. How we can see in the area of 180^0 E: some spots of the arising or decreasing of the total electron content. We will not try to predict how Ionosphere can play the role of the "connecting agent" between TC and earthquakes. But we can see the reflection of it.




TECU
−24 −21 −18 −15 −12 −9 −6 −3 0 3 6 9 12 15 18 21 24
Vertical TEC disturbance at 07:30UT 16 Dec 2012
Vertical TEC disturbance at 05:30UT 17 Dec 2012
Vertical TEC disturbance at 04:30UT 18 Dec 2012
Vertical TEC disturbance at 23:30UT 18 Dec 2012
Vertical TEC disturbance at 12:45UT 19 Dec 2012
Vertical TEC disturbance at 08:15UT 20 Dec 2012
Vertical TEC disturbance at 02:30UT 21 Dec 2012
Vertical TEC disturbance at 08:30UT 22 Dec 2012
Vertical TEC disturbance at 09:15UT 23 Dec 2012
Vertical TEC disturbance at 06:15UT 24 Dec 2012
Vertical TEC disturbance at 08:00UT 25 Dec 2012
Vertical TEC disturbance at 08:15UT 26 Dec 2012
Vertical TEC disturbance at 01:30UT 27 Dec 2012
Vertical TEC disturbance at 05:15UT 28 Dec 2012
Vertical TEC disturbance at 23:15UT 29 Dec 2012
Vertical TEC disturbance at 09:30UT 30 Dec 2012
Vertical TEC disturbance at 14:15UT 31 Dec 2012
Vertical TEC disturbance at 00:30UT 01 Jan 2013
Geographic Latitude (degrees)
Geographic Longitude (degrees)
IPS Radio & Space Services

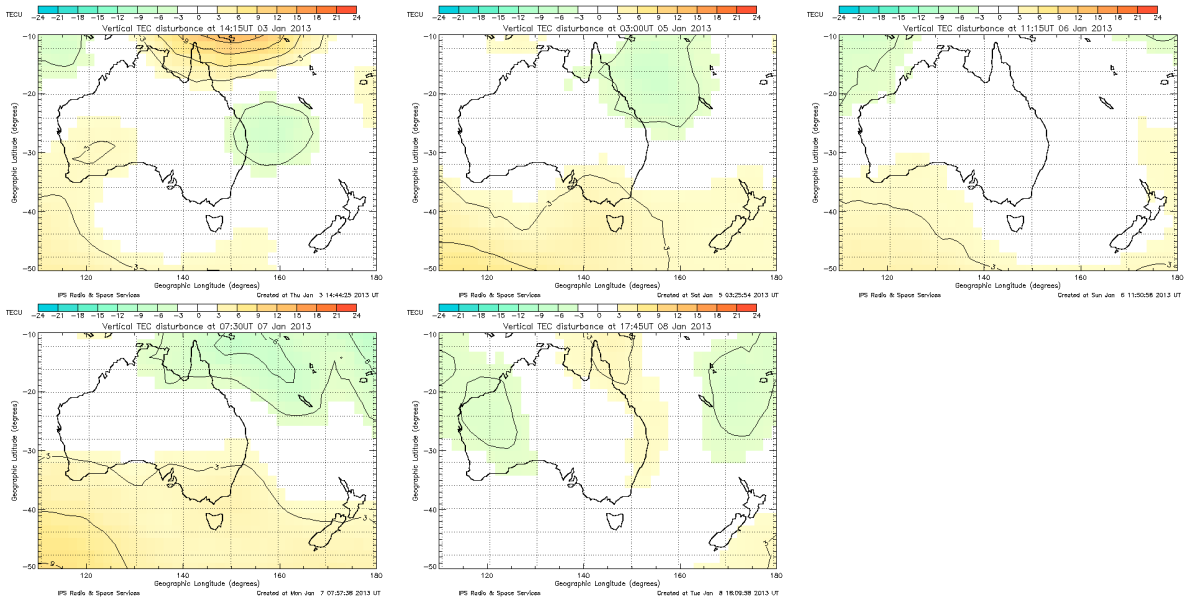


Figure 6. **TEC disturbances maps (13, 14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31 December 2012 and 1,3,5,6,7,8 January 2013).**

4.CONCLUSIONS.

In this paper authors try to morphologically demonstrate the “TCs-Ionosphere-Earthquakes” interaction for the first time**.** The ionosphere is important element in "Earthquakes - Tropical cyclones“ interaction.It is extremely difficult to establish the precisely effect that the presiding earthquake has had on the TC by measuring ionospheric parameters. But some information can give conclusion that TCs preceded by earthquakes by 5-10 days (Figure 4 and 5).

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