# Quasi Simultaneous Tropical Cyclone And Earthquake Action On The Ionosphere

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**&**
**Geodetic Missions Workshop**

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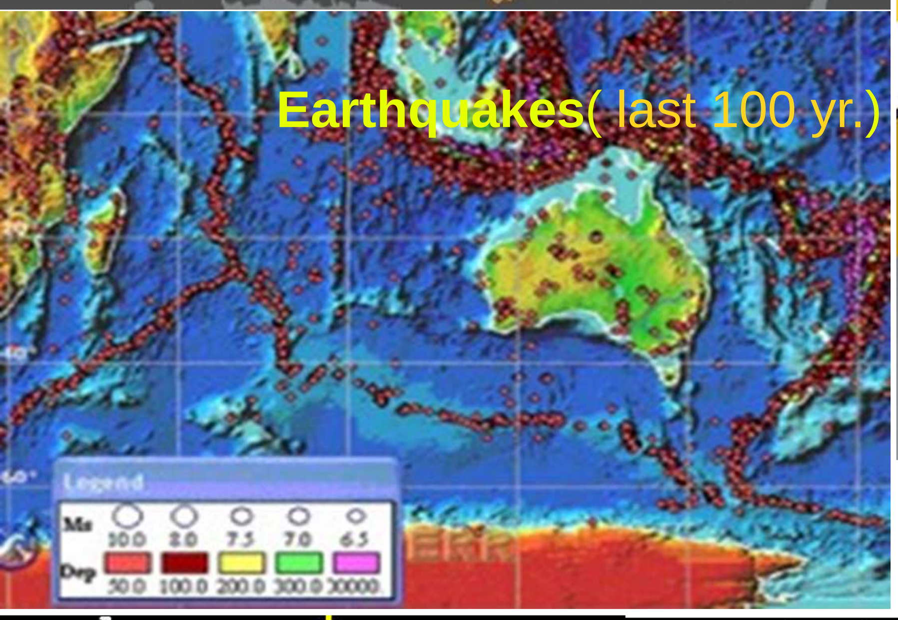
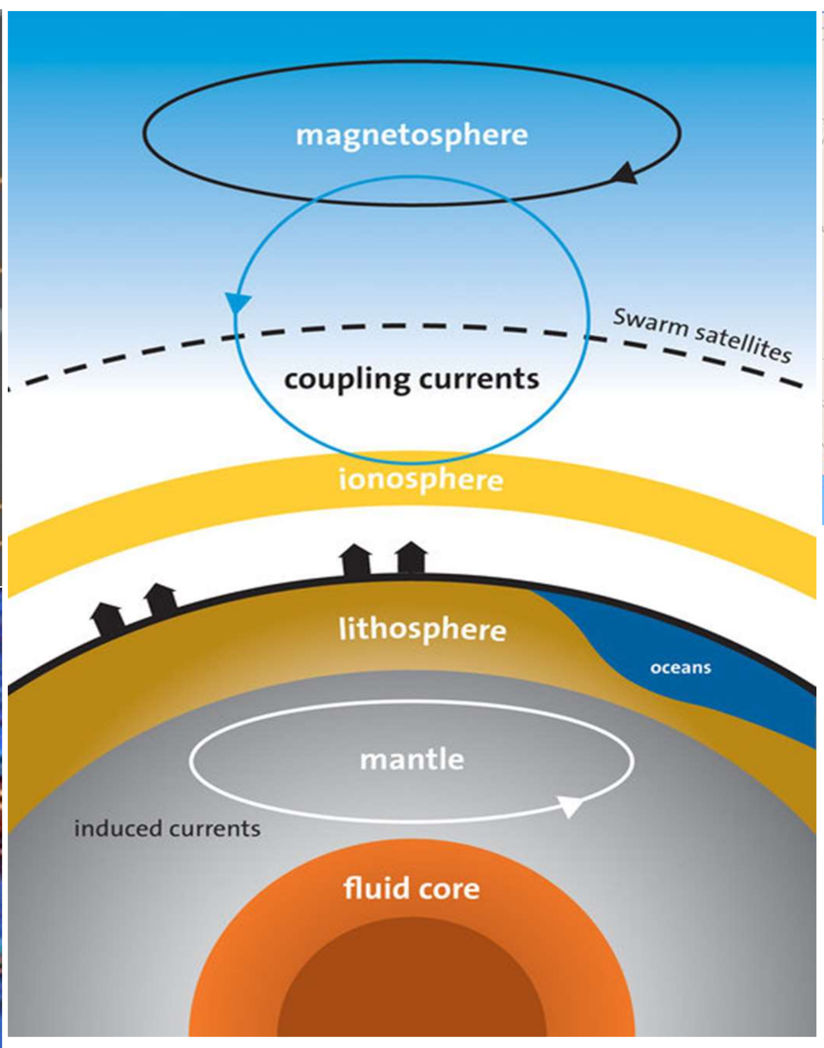
**Rune Floberghagen, ESA's Swarm mission manager, said, "We have very few ways of probing deep into the structure of our planet, but Swarm is making extremely valuable contributions to understanding Earth's interior, which then adds to our knowledge of how Earth works as a whole system." The evidence that our planet works as a whole system could be better demonstrated in extreme situations - global cataclysms or hazards. We use different major characteristics to separate these disasters. But often we have situation when disasters are close to each to others. It's no secret that tropical cyclone often accompanies earthquake during tropical season. Tropical cyclone (TC) is only one of several major natural disasters. There are also earthquakes, floods, fires, volcanic eruptions and many more. It is desirable, where possible, to give advance warning of an impending disaster so that people can take evasive action. An earthquake strikes suddenly and often without specific warning and a lot of scientific research has been devoted to attempting to predict earthquakes. In one sense a TC strikes suddenly; it comes in from the ocean and its damage is (mostly) done where and when it reaches the land. But before it makes landfall it has been tracked for quite a while and it has built up as it has travelled across the ocean, gathering strength as it goes. The problem is on following the TC over a matter of a few days before it makes landfall and predicting exactly where and when it will strike the land. We do not know the real reason for TC's birth. We cannot predict the life length of a tropical cyclone. We know how to classify TC. We can observe its birth, progress and death. We know the area where hurricanes can appear. For example, it is common for TC's to appear in areas where earthquakes are active. But we don't know why. Do we know all about TC's? Answer is "Of course, not". What is a possible mechanism for the interaction of different layers like lithosphere, atmosphere and ionosphere during hurricane action? It has been proved that processes in the lithosphere have an electrodynamic influence on the ionosphere. Two of the possible "Earthquakes – Ionosphere" and "TC-Ionosphere" interaction mechanisms are the Gravity Waves and the electric. The ionosphere is important element in the "Earthquakes - TCs" interaction. It is extremely difficult to establish the precisely effect that the presiding earthquake has had on the TC by measuring ionospheric parameters. With new opened SWARM data the author has possibilities to discuss a possible electrodynamic influence on the ionosphere during TC action. In this presentation the author analyses the dynamic ocean parameters, earthquake and ionospheric parameters, received in the process of satellite remote sensing above TC (above Australia) in the last years in the south-eastern area of the East hemisphere. The aim of this topic to assess the contribution of both possible "Earthquakes – Ionosphere" and "TC-Ionosphere" mechanisms during quasi simultaneous TC and earthquake action on the ionosphere.**


MAGNETIC FIELD SOURCES

http://www.esa.int/spaceinimages/Images/2012/10/Magnetic_field_sources


**Countries most affected by the tsunami, with the earthquake's epicentre 26.12.2004**

It is estimated that only 10 percent or less of an earthquake's total energy is radiated as seismic energy. Most of the earthquake's energy is used to power the earthquake fracture growth or is converted into heat generated by friction. Therefore, earthquakes lower the Earth's available elastic potential energy and raise its temperature, though these changes are negligible compared to the conductive and convective flow of heat out from the Earth's deep interior.

An earthquake (also known as a quake, tremor or temblor) is the perceptible shaking of the surface of the Earth, which can be violent enough to destroy major buildings and kill thousands of people. The severity of the shaking can range from barely felt to violent enough to toss people around. Earthquakes have destroyed whole cities. They result from the sudden release of energy in the Earth's crust that creates seismic waves. The seismicity, seismism or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time.

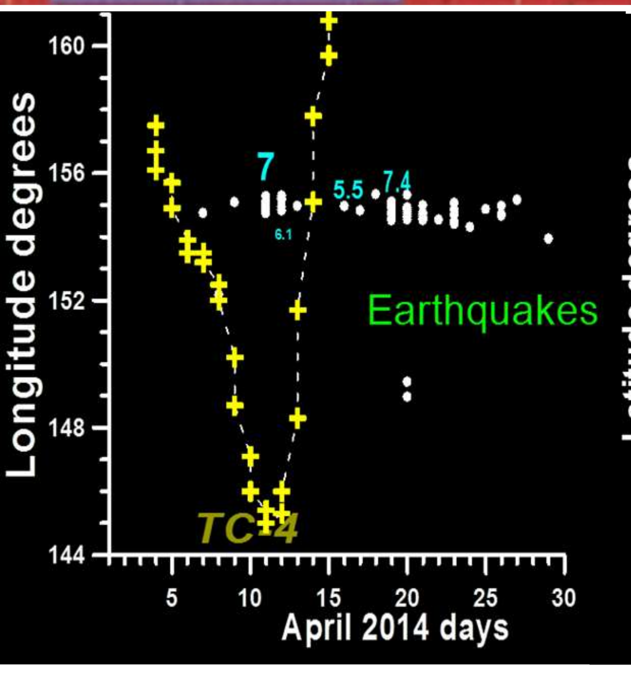
"We find that slow-slip phenomena are not unique to the depths (tens of kilometres) of subduction zone plate interfaces. They occur on faults in many settings, at numerous scales and owing to various loading processes, including landslides and glaciers. Taken together, the observations indicate that slowly slipping fault surfaces relax most of the accrued stresses through aseismic slip. Aseismic motion can trigger more rapid slip elsewhere on the fault that is sufficiently fast to generate seismic waves. We conclude that instead, slip modes span a continuum and are of common occurrence." "Slow earthquakes triggered by typhoons"//ChiChing Liu, Alan T. Linde & I. Selwyn Sacks,Nature 459, 833-836 (11 June 2009) | doi:10.1038/nature08042

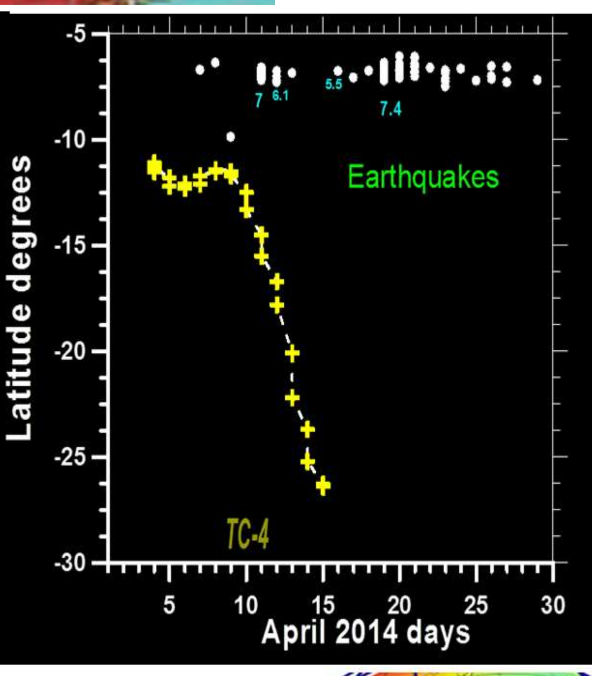
*"There are several reasons why the probability of an earthquake at some sensitive localities could increase when TC's are at hand.*

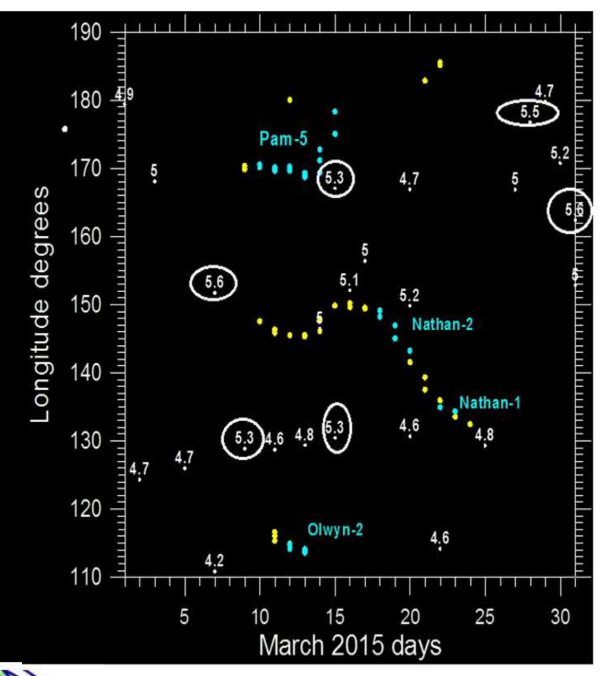
*A. The huge mass of water brought to the coast and possibly inland by the storm surge will cause changed loading and strains in the earth's surface layers. Flooding to a depth of 3 m adds 3*109 kg to each km2 but this could be lessened by about 25% because of the reduced barometric pressure - a 70 mb drop decreases the air load on each square kilometre by about 0.7 106million tonnes.*

*B. Flooding by rain and/or storm surge usually causes water to penetrate below ground where it may "lubricate" faults permitting sliding to occur earlier than would otherwise be the case.*

*C. The heavy microseismic activity which accompanies tropical cyclones could be the "last straw" to trigger a local earthquake."*



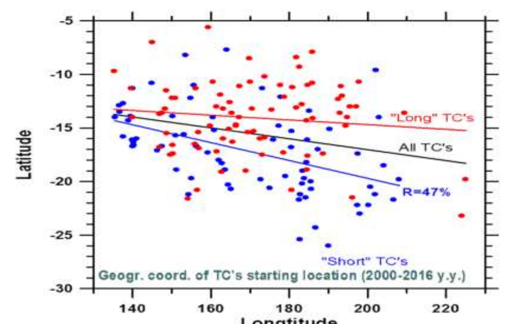



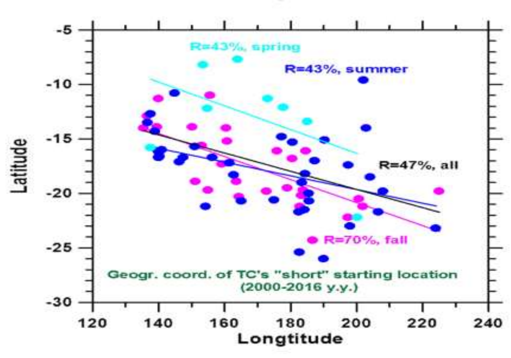

Possible ways TC-ionosphere interactions

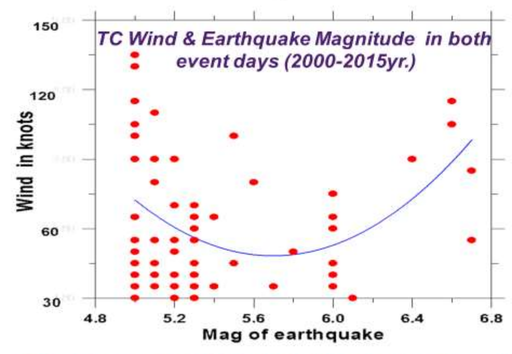
1.The atmospheric GWs from their strong convective towers & the associated synoptic-scale motions in the stratosphere and ionosphere (J.Bell,1986) 2. An effect of external electric currents on the global atmosphere-ionosphere electric Circuit. External currents with a horizontal scale of about one hundred 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 (Isaev et al, 2006).

"From 2002 to 2007 we monitored deformation in eastern Taiwan using three highly sensitive borehole strainmeters installed 650 to 870 feet (200-270 ms) deep. These devices detect otherwise imperceptible movements and distortions of rock," explained coauthor Selwyn Sacks of Carnegie's Department of Terr. Magnetism. "We also measured atm. pressure changes, because they usually produce proportional changes in strain, which we can then remove." Taiwan has frequent TC's in the second half of each year but is TC's free during the first 4 months. During the five-year study period, the researchers, including lead author *Chiching Liu, identified 20 slow earthquakes that each lasted from hours to more than a day. The scientists did not detect any slow events during the TC's-free season. 11 of the 20 slow earth-es coincided with TC's. Those 11 were also stronger and characterized by more complex waveforms than the other slow events. "These data are unequivocal in identifying TSC's as triggers of these slow quakes. The probability that they coincide by chance is vanishingly small," remarked coauthor Alan Linde, also of Carnegie."*

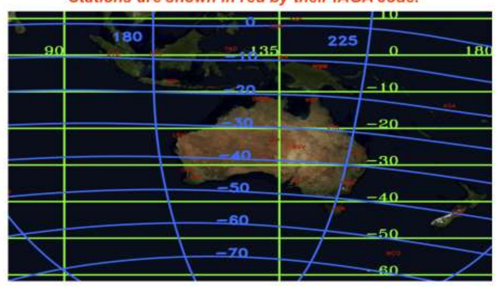
https://carnegiescience.edu/news/surprise-typhoons-trigger-slow- Earthquakes

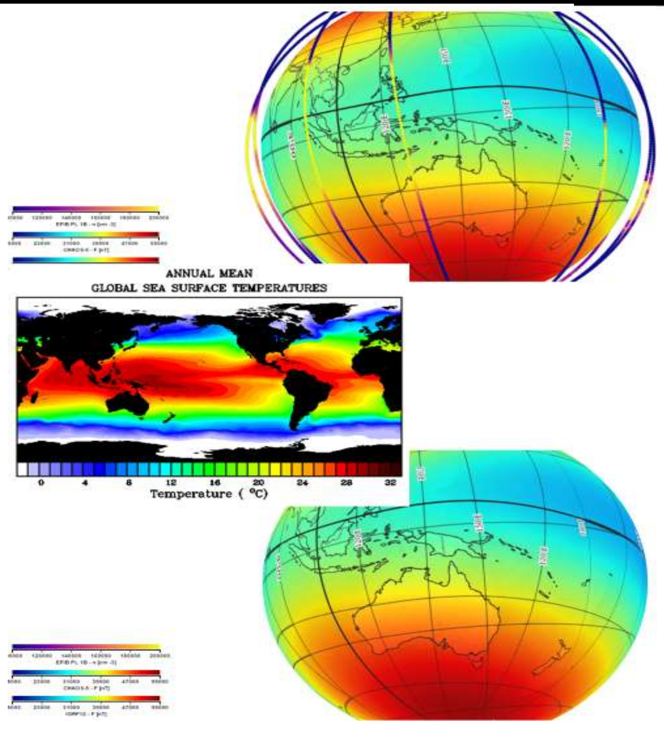


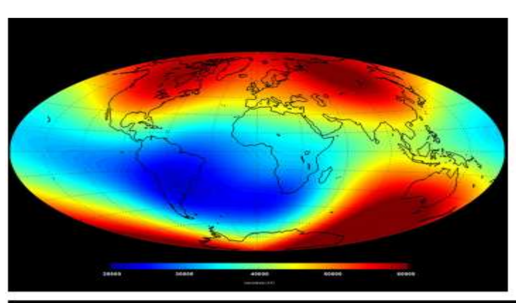



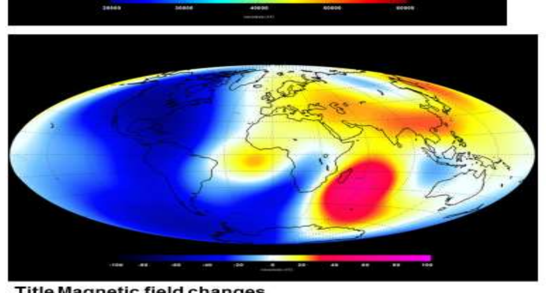




Geographic map (isotropic projection). Blue lines are Geomagnetic coordinates while green lines are geographic coordinates. Stations are shown in red by their IAGA code.

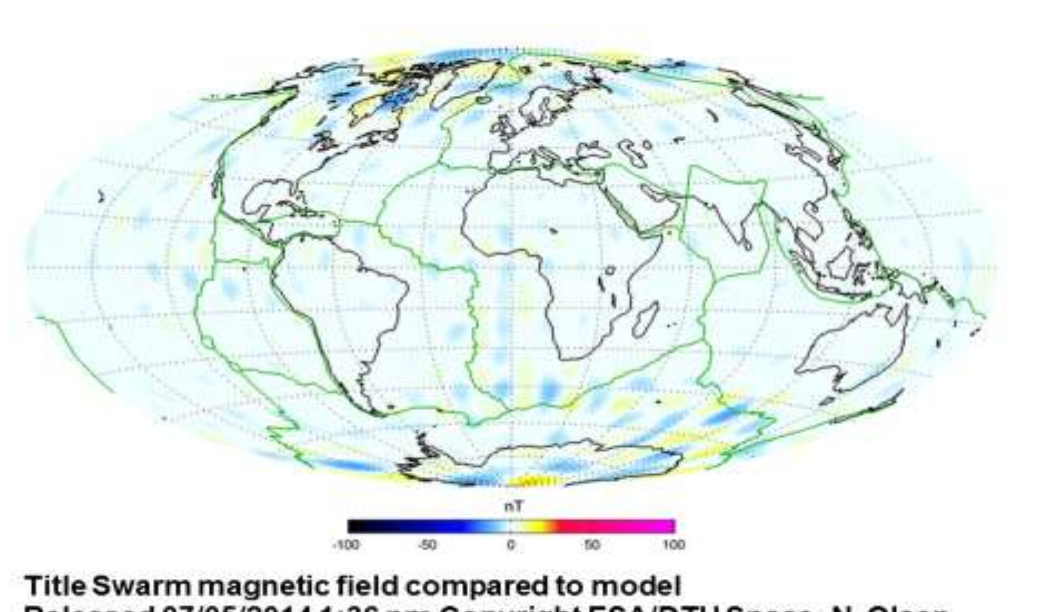




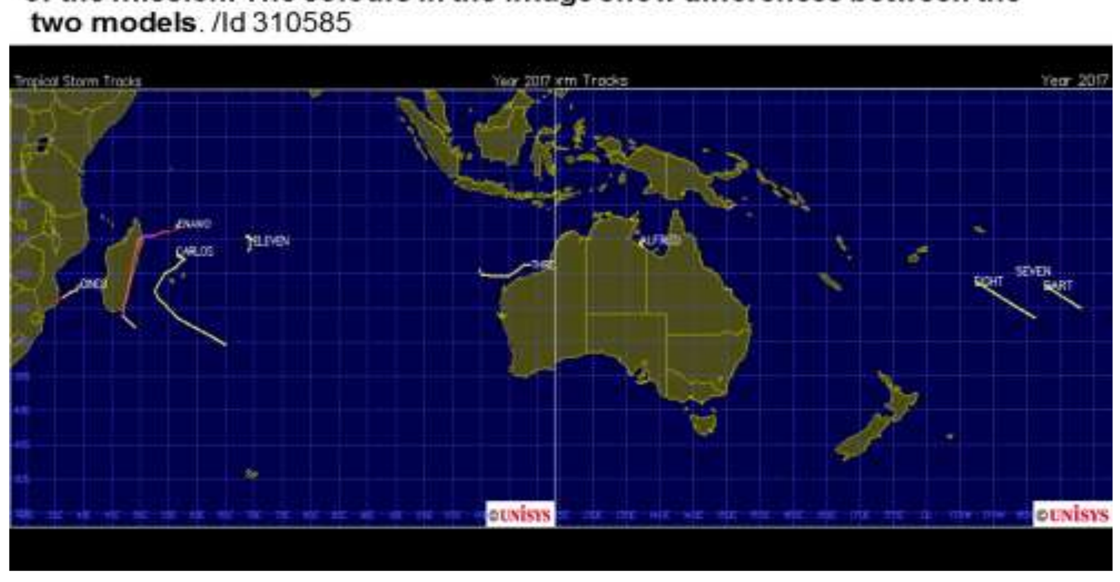



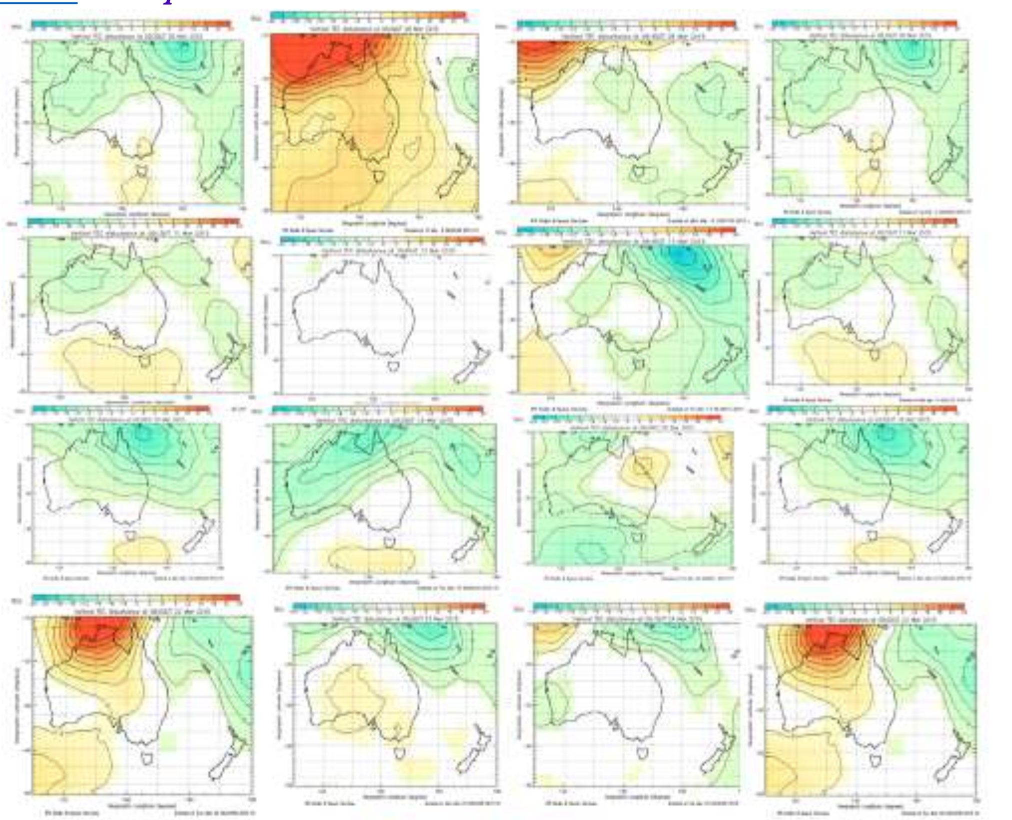


Title Magnetic field changes
Released 19/06/2014 10:13 am // Copyright ESA/DTU Space
Description. Changes in Earth's magnetic field from January to June 2014 as measured by the Swarm constellation of satellites. These changes are based on the magnetic signals that stem from Earth's core. Shades of red represent areas of strengthening, while blues show areas of weakening over the 6-month period.




**Title Swarm magnetic field compared to model**
**Released 07/05/2014 1:36 pm Copyright ESA/DTU Space–N. Olsen**
**Description. Data from Swarm were used to generate a model of the magnetic field from Earth's lithosphere. The image compares the Swarm model with the Chaos-4 model and shows good agreement, especially considering Swarm is still only in the calibration and validation phase of the mission. The colours in the image show differences between the two models**. /Id 310585



### Conclusions

*1.We do not know the real "first step" of TC's birth. We can not predict the life length of a tropical cyclone. We know how to classify TC. We can observe the it's birth, progress and death . We know the area where cyclones are possible. For example, it is common for TC's to arise in areas where earthquakes are active. But we don't know why. Do we know all about TC's?*

*2.The Ocean has a dual role – in hazard generation and hazard protection.*