

Observation of lithospheric-Atmospheric-Ionospheric Variability During Japan Earthquakes

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International Beacon Satellite Symposium-2016

The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy

❑ An unexpected movement of earth surface is called **Earthquake**.

❑ Tremendous amount of **Energy** is release in the form of tremors and vibrations. Earthquake energy radiate in all direction .

❑ An Earthquake create human loss and effect the country **Economy**.

1. Large casualties
2. Millions people are homeless
3. Famous ancient structure, buildings, monuments and houses are collapsed
4. Destruct the world economy



Top 10 Earthquake Ranked Destroyed World Economy

S. No	Name of Earthquake	Magnitude	Property Damage
1	2011, Tohoku earthquake ,Japan	9.0	\$235 billion
2	1995, Great Hanshin earthquake, Japan	6.9	\$100 billion
3	2008, Sichuan earthquake, China	8.0	\$75 billion
4	2010, Chile earthquake, Chile	8.8	\$15–30 billion
5	1994, Northridge earthquake, United States	6.7	\$20 billion
6	2012, Emilia earthquakes, Italy	5.9	\$13.2 billion
7	2011, Christchurch earthquake, New Zealand	6.3	\$12 billion
8	1989, Loma -Prieta earthquake, United States	7.0	\$11 billion
9	1921, earthquake, Taiwan	7.6	\$10 billion
10	1906, San Francisco earthquake, United States	7.7	\$9.5 billion

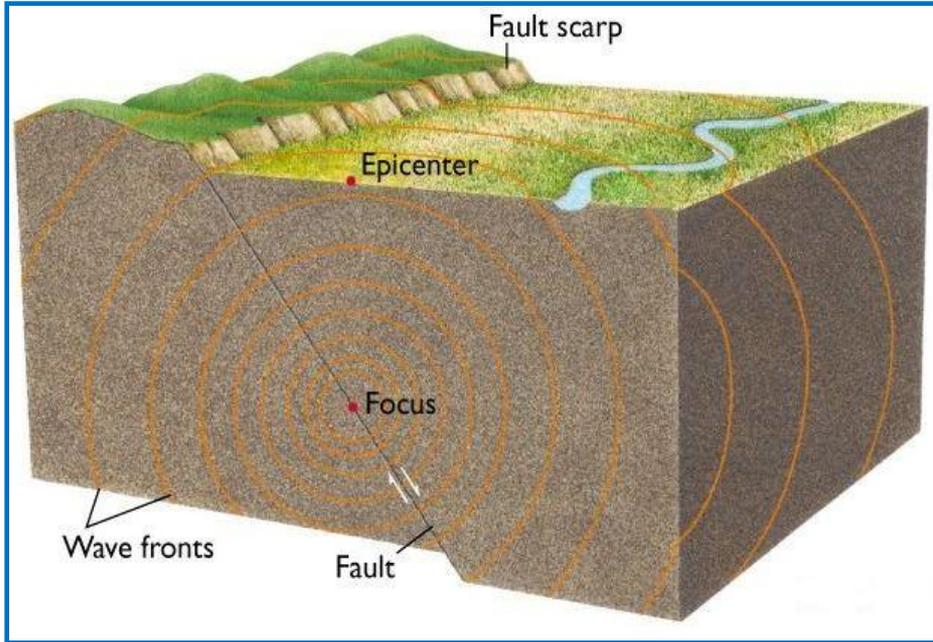
Ring of Fire :- It covers the subduction zones of earth.

1. Japan
2. Indonesia
3. China
4. Chile
5. Turkey
6. North America Plate
7. Australia
8. India



If you live nearby be careful

Physics Behind Earthquakes



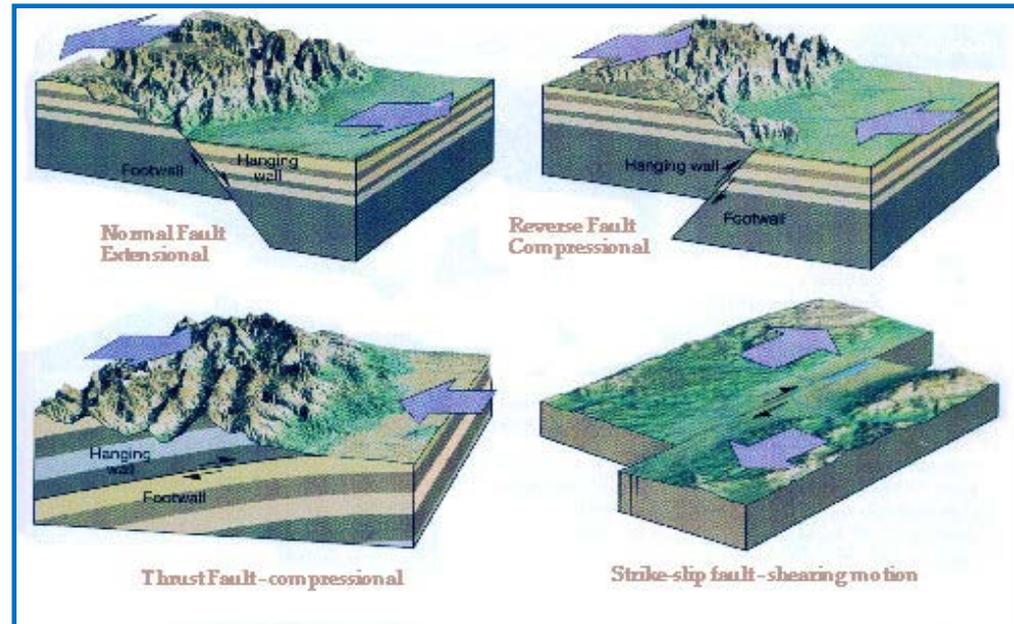
❑ Point of origin of earthquake is called **Focus**.

❑ Point on the earth surface, directly above the focus known as **Epicenter**.

❑ A **Fault** is a planar fracture or discontinuity in a volume of rock.

Types of Fault

- ❖ Normal Fault
- ❖ Reverse Fault
- ❖ Strike-slip Fault
- ❖ Thrust Fault



Physics Behind Earthquakes....

□ Seismic waves are of two types

❖ Body waves

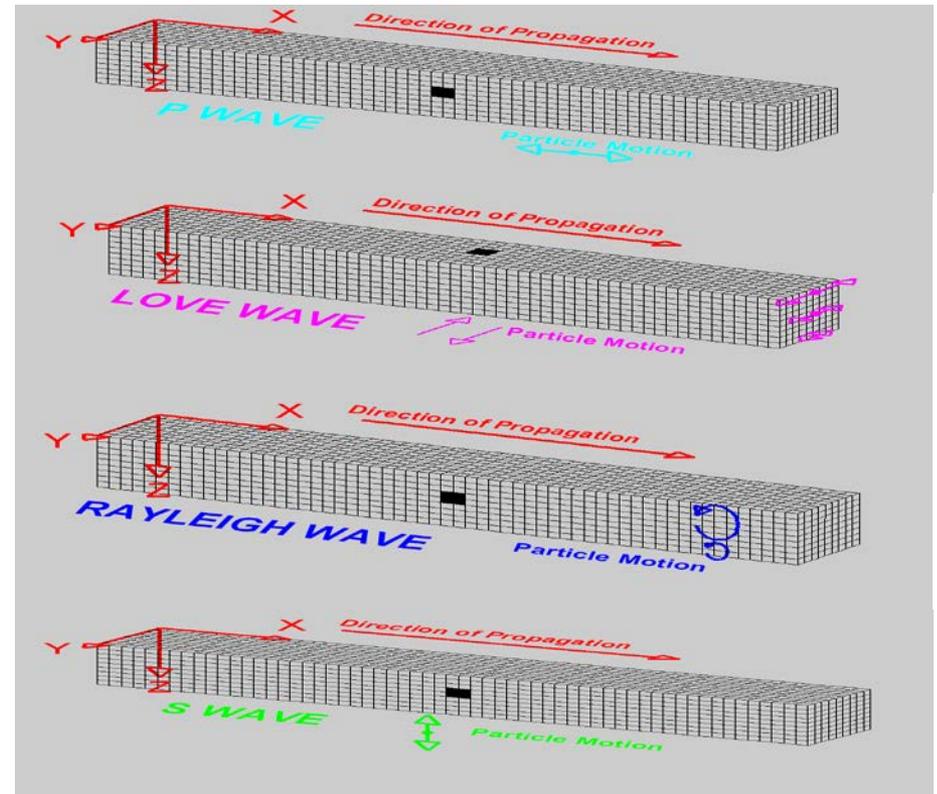
❖ Primary Waves (P-waves)

❖ Secondary Waves (S-waves)

❖ Surface waves

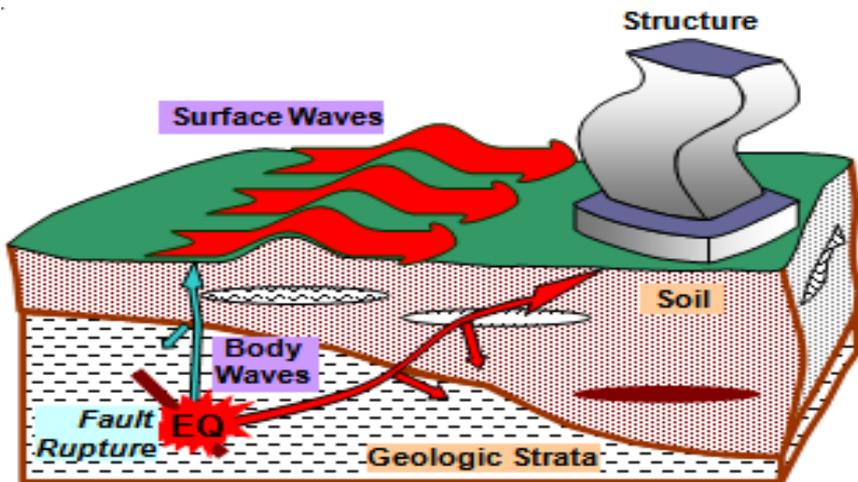
❖ Love waves

❖ Rayleigh waves



□ P-waves is fastest, followed by S, Love and Rayleigh waves.

□ We detect an epicenter by triangulation method by using these P & S waves



Earthquake Prediction

Earthquake prediction, as a branch of seismology, but it is an **Immature science**.

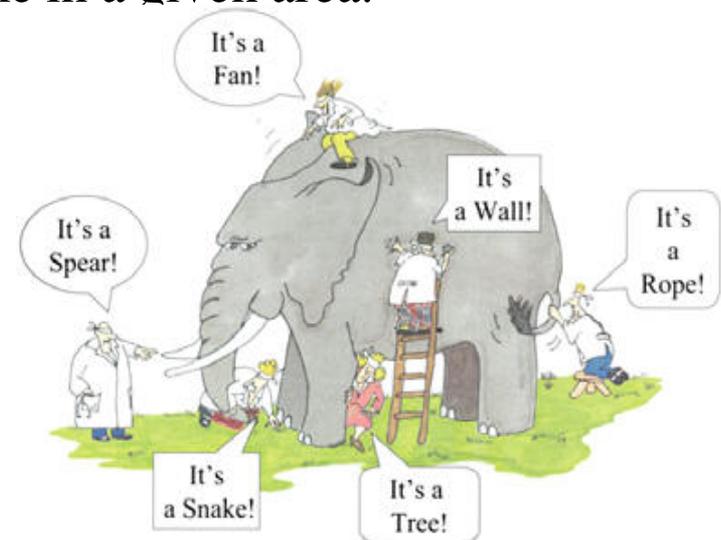
- ❖ Long term (10 to 100 years)
- ❖ Intermediate term (1 to 10 years)
- ❖ Short term (hours/day/weeks/month)



Earthquake Precursors

An **Earthquake Precursor** could be any anomalous phenomena that can give effective warning of the severity of an impending earthquake in a given area.

- ❖ Ground Based Electromagnetic Field
- ❖ Radon Concentrations
- ❖ Thermal Infrared
- ❖ Ionospheric Precursors
- ❖ Abnormal Animal Behaviors



Can we predict the Earthquake ?

Recent Advances—Make the routine prediction of earthquakes seem predictable

Stuart Crampin.....

British Geological Survey, U.K.

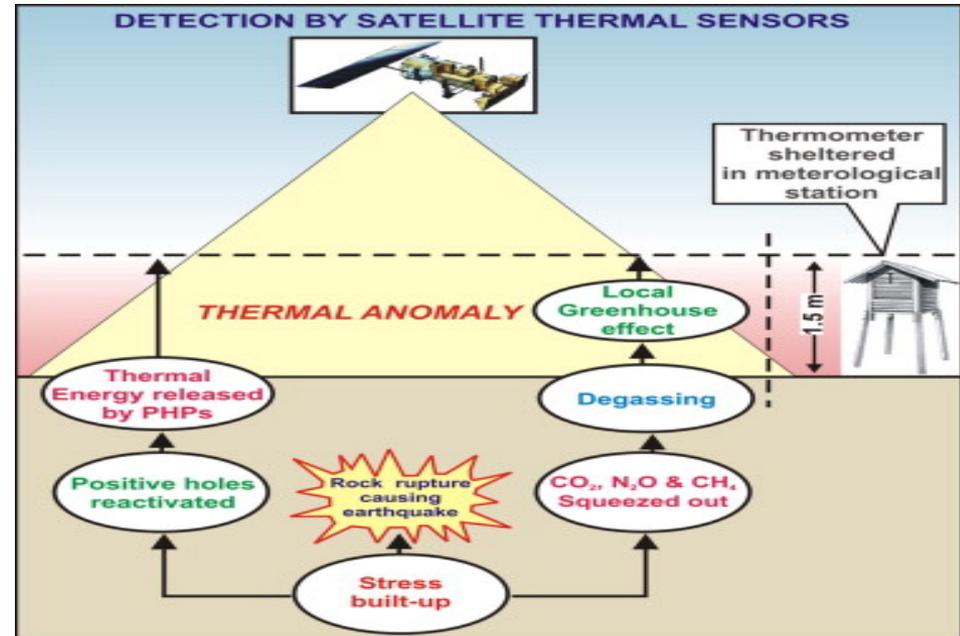
How can Scientists Predict the Earthquake ?

- 1. Laser Beam (Putting Laser Beam Across the fault to measure the small movement)**
- 2. Radon Gas (Monitoring Release of any Radon Gas)**
- 3. Water levels (Monitoring water levels)**
- 4. Movement of the ground (By Seismometers)**
- 5. Strange Animal Behaviour**

Investigation of Earthquake by Multi-Parameteric Approach

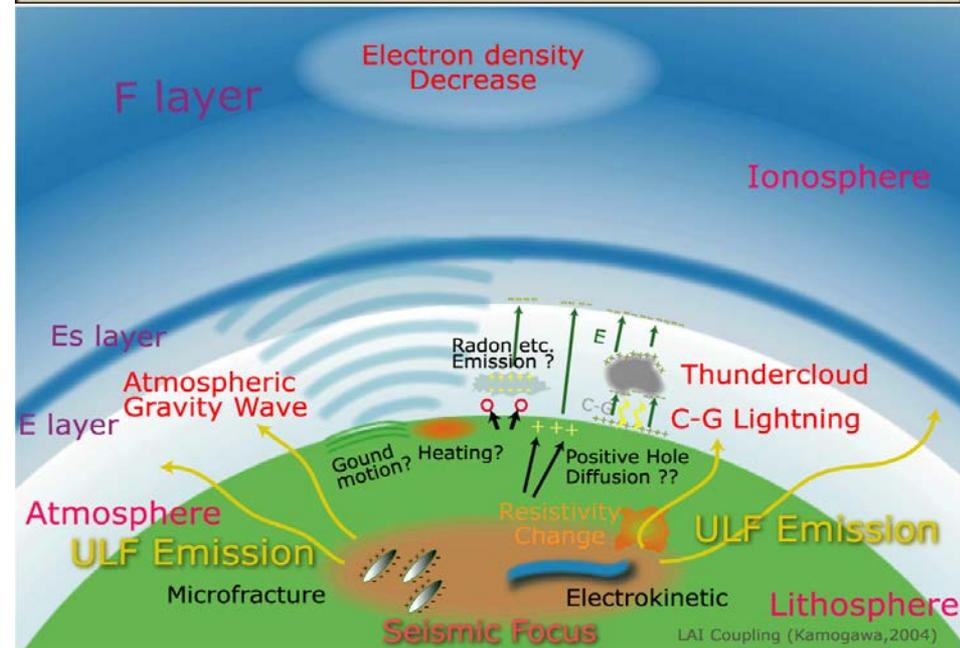
□ Dynamics changes may occur on the earth environment during the processes of earthquake.

- ❖ Land Surface Temperature(LST)
- ❖ Sea Surface Temperature (SST)
- ❖ Soil Moisture
- ❖ Ground Water Level Changes
- ❖ Outgoing Long-wave Radiation(OLR)
- ❖ foF2 (Critical frequency)



□ Two leading theory can explain the Atmosphere-Ionosphere coupling

- ❖ Earth Degassing theory
- ❖ P-hole activation theory



Correlation and Interaction Mechanisms

□ Electromagnetic waves related to earthquake can disturb the earth atmospheric system and significant changes may occur on some atmospheric parameters.

❖ **Air Temperature**

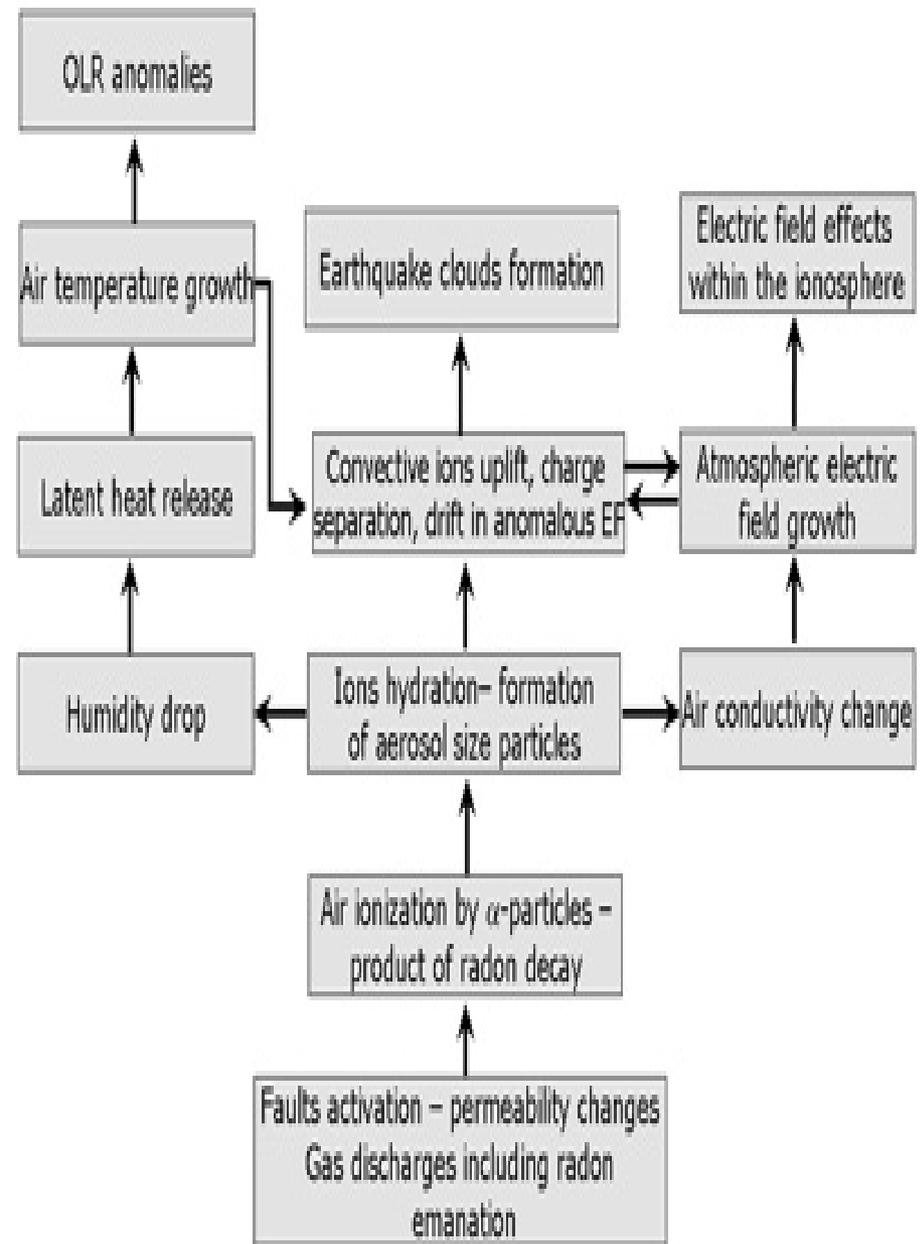
❖ **Surface Latent Heat Flux(SLHF)**

❖ **Outgoing Long-wave Radiations(OLR)**

❖ **Wind**

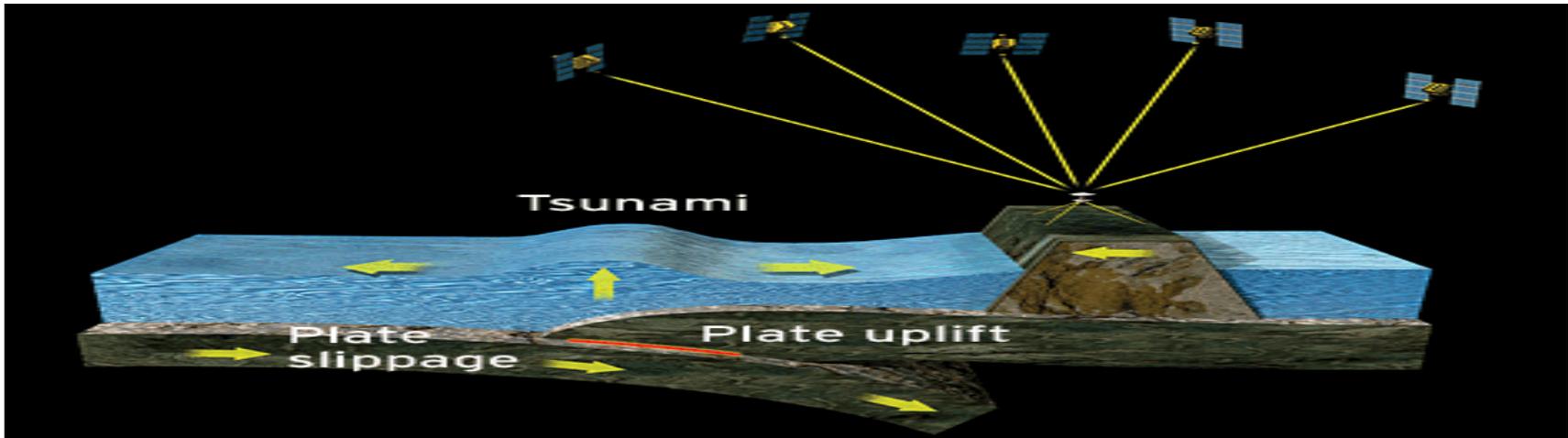
❖ **Water Vapour**

❖ **Chlorophyll Concentrations**



Space Satellite Approach for Earthquake Prediction

- ❑ Space Satellite based Earthquake prediction research had been started since 1970.
- ❑ Major characteristics of the onboard sensor which facilitate target discrimination
 - ❑ Spectral
 - ❑ Spatial
 - ❑ Temporal
 - ❑ Polarization
- ❑ In seismology geophysical method is widely used for the following technique
 - ❖ Global Positioning System(GPS)



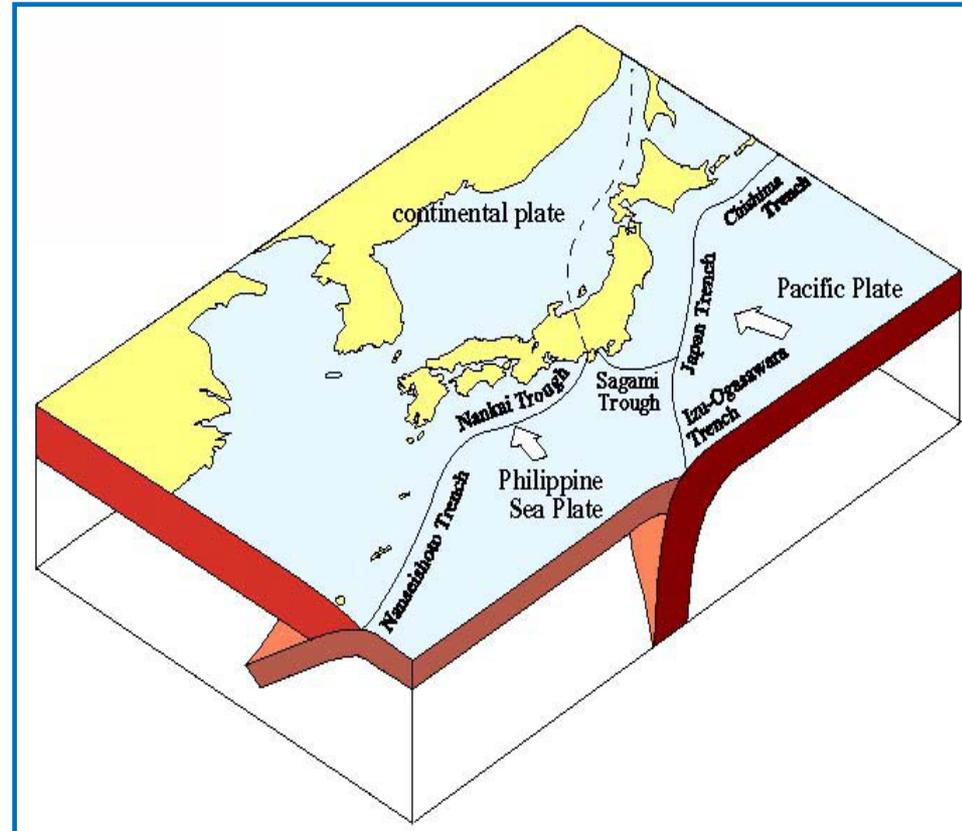
- ❖ Inter-ferometry Synthetic Aperture Radar (InSAR)

- ❑ Newly emerging technique for earthquake prediction.

- ❖ Thermal Remote Sensing

Area of Interest

- ❑ Japan endures 20% of the world powerful earthquakes.
- ❑ Japan is one of the most active seismic and volcanic zones in the world.
- ❑ Japan island lies on the pacific ring of fire
- ❑ Japan lies at the crossing of four tectonic plates.
- ❑ Japan tectonic setting is very complicated due to various faults and their interaction with the third plate.



S.No	Earthquake	Date	Location	Magnitude	Depth
1	Kuril Island,(Japan)	15/11/2006	46.6°N, 153.3°E	8.3	30.3 km
2	Izu Island ,(Japan)	09/08/2009	33.1°N, 138.0°E	7.1	29 km
3	Ryukyu Island ,(Japan)	26/02/2010	25.9°N, 128.4°E	7.0	22 km
4	Tohoku,(Japan)	11/03/2011	38.2°N, 142.3°E	9.0	30 km

Data & Methodology

❑ The National Oceanic and Atmospheric Administration (NOAA) Climate Prediction centre (<http://www.cdc.noaa.gov/>).

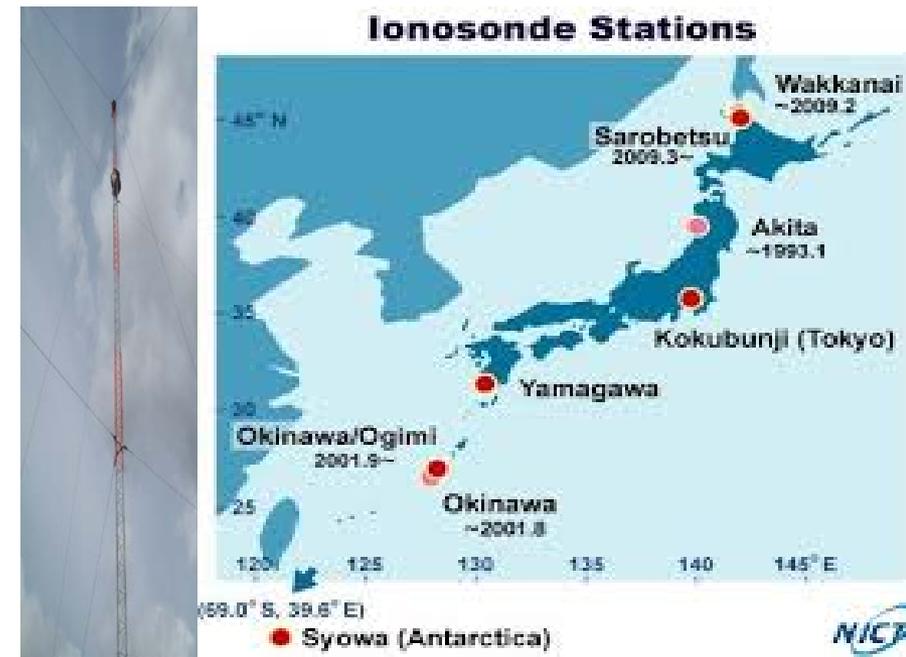
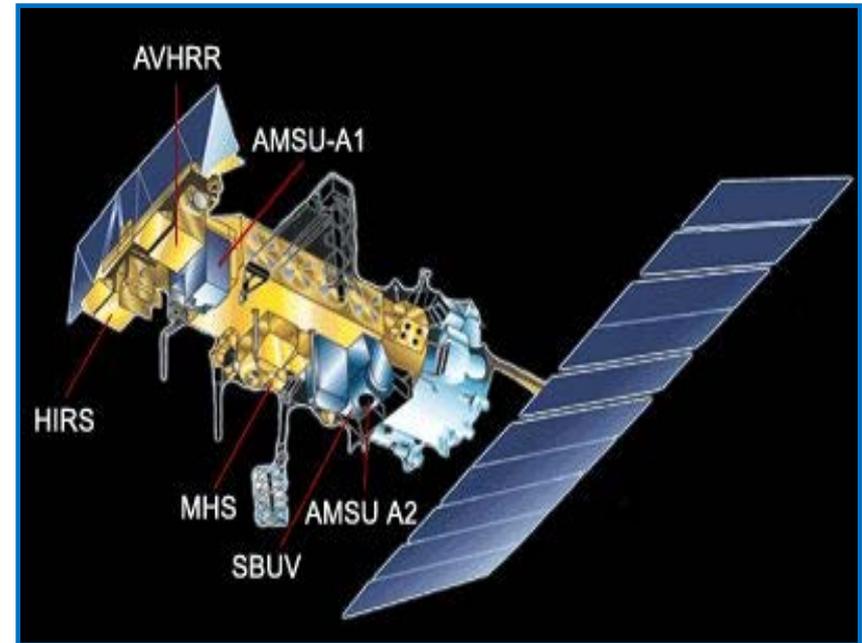
❑ It provides daily and monthly OLR/SST data. It is a **Sun-Synchronous orbit** with altitude 854 km above the earth.

❑ Spatial Resolution is $2.5^{\circ} \times 2.5^{\circ}$ km.

❑ The OLR algorithm for analyzing the Advanced Very High Resolution Radiometer (**AVHRR**) data.

❑ It integrates the IR measurements between 10 and 13 μm .

❑ National Institute of Information and Communication Technology (NICT), Japan provides the daily hourly values of f_oF_2 by using the various Ionosonde Instruments



Data & Methodology

□ **Eddy Field calculation mean method** is applied to calculate the atmospheric disturbances associated with selected earthquake.

$$S_d^*(x_{ij}, y_{ij}) = 4.S(x_{ij}, y_{ij}) - [S(x_{i-1}, y_{ij}) + S(x_{ij}, y_{j-1}) + S(x_{i+1}, y_{ij}) + S(x_{ij}, y_{j+1})]$$

Where,

$S_d^*(x_{ij}, y_{ij})$ - Daily OLR value

$s(x_{i-1}, y_{ij})$ - Daily Mean OLR value

x - Latitude; y - Longitude

i, j - Any number of grid point

□ I have analyzed the OLR data of **60 days before and 10 days** after the earthquake .

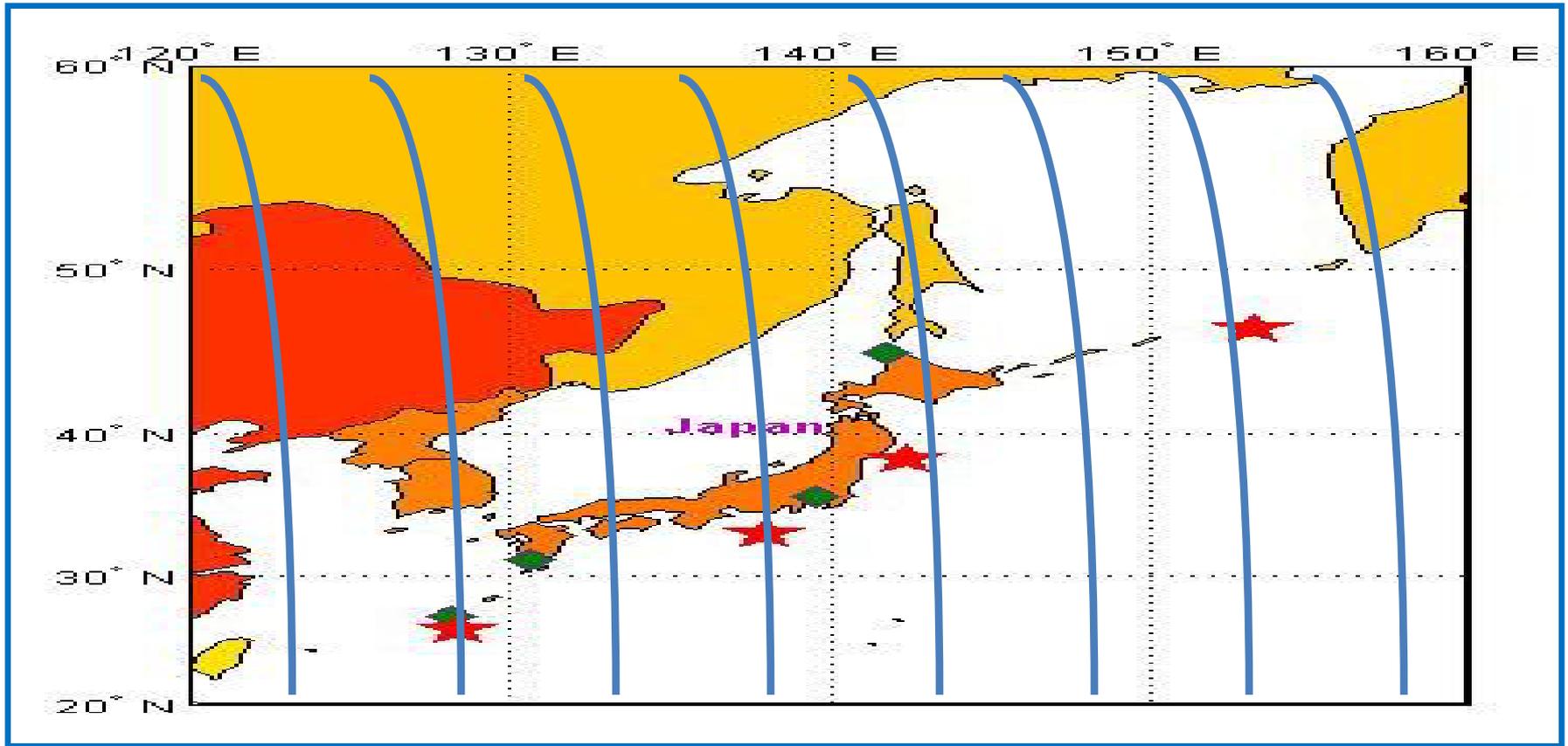
$$k\text{-index} = \frac{\text{OLR current value} - \text{Multi year mean data}}{\text{Standard Deviation}}$$

□ Calculation of SST data for Optimum Interpolation (OI) technique (since 1971-2011).

□ Calculated SST Anomaly.

□ Observation of foF2 critical frequency by NICT Japan.

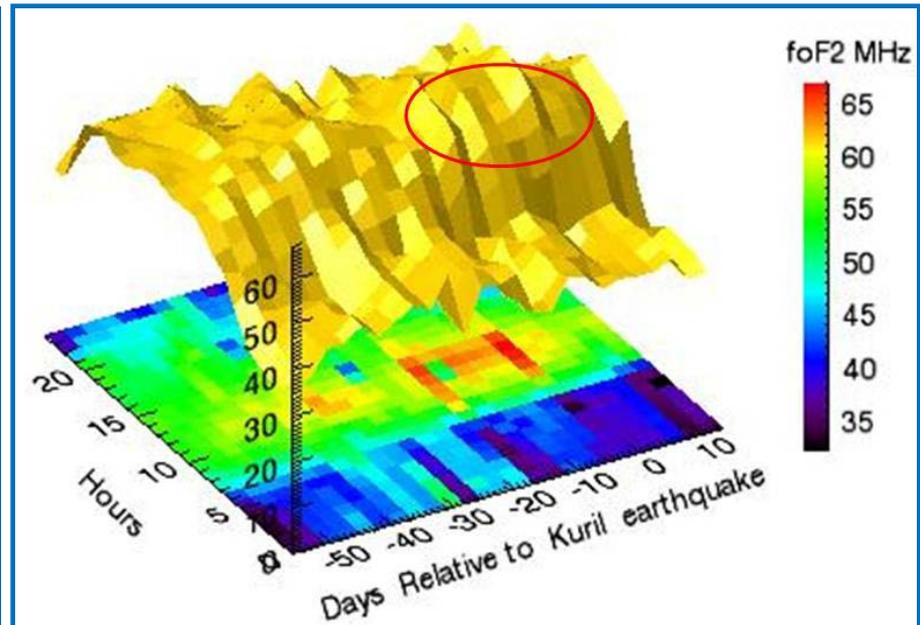
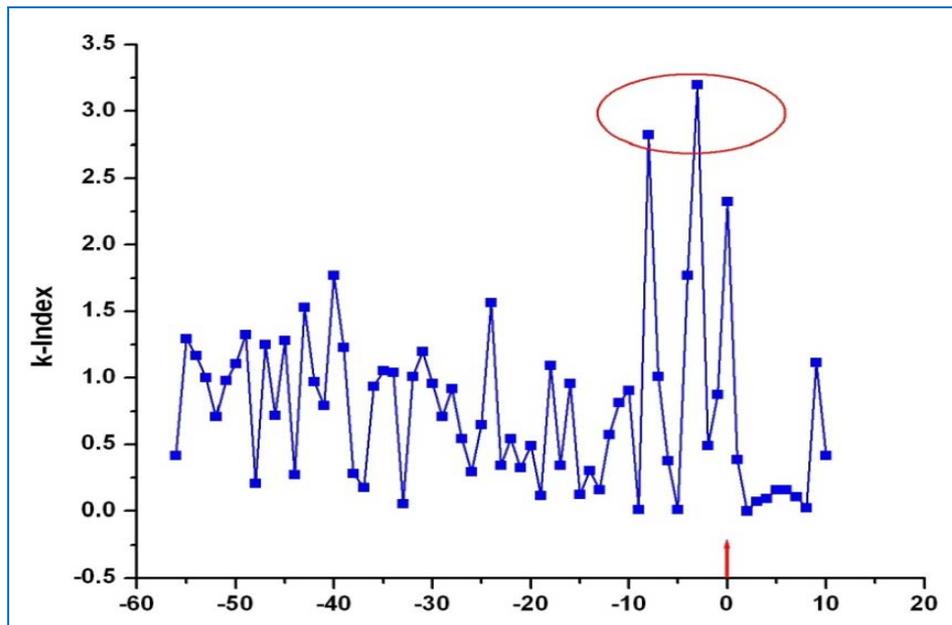
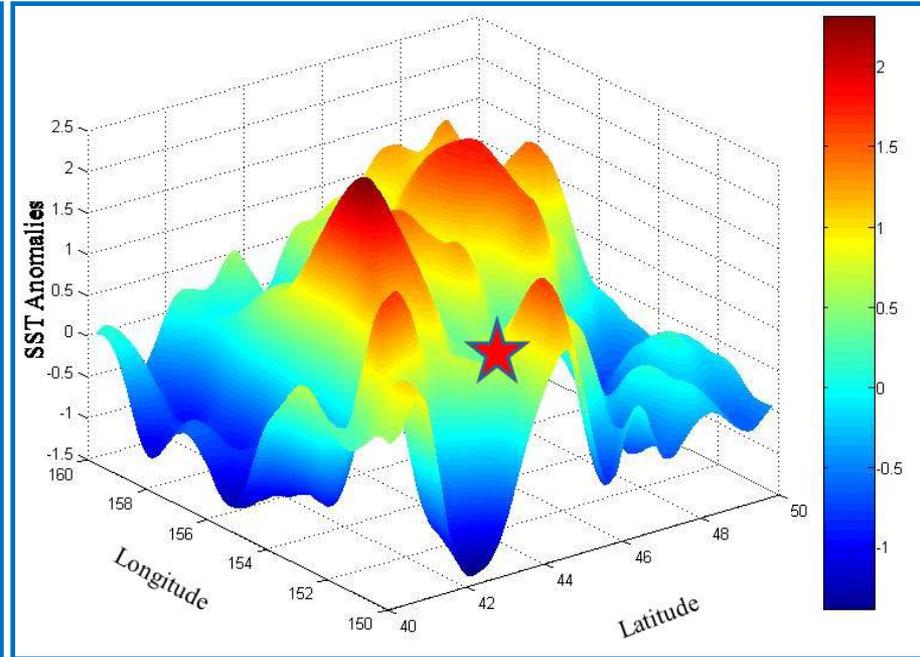
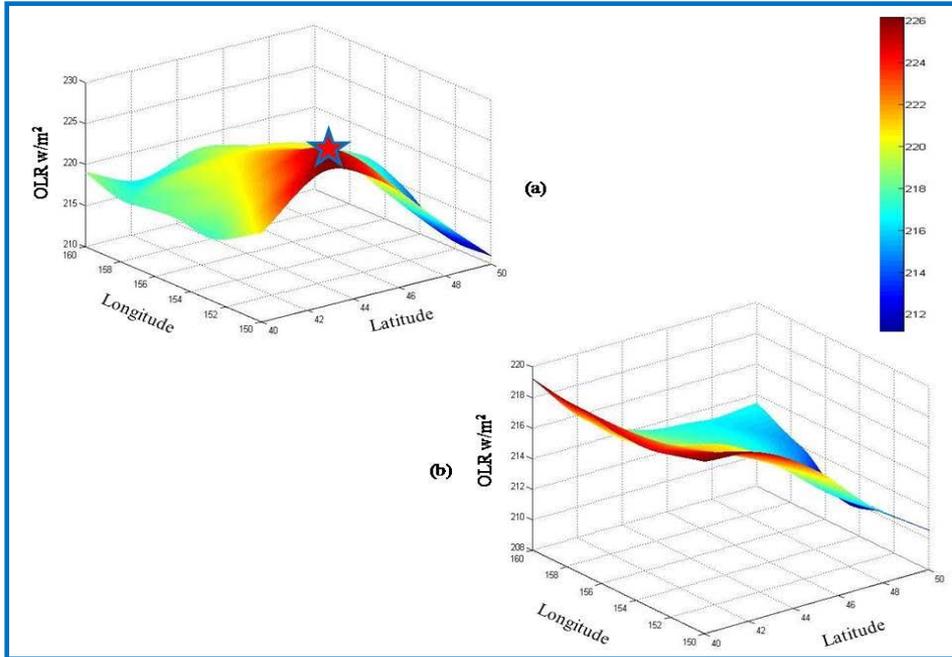
Data & Methodology

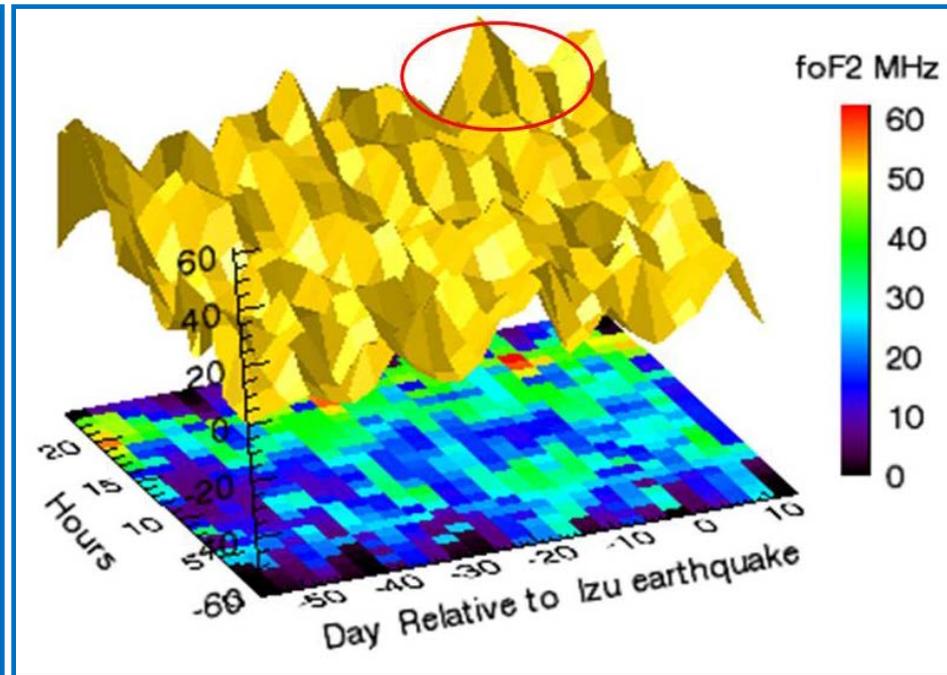
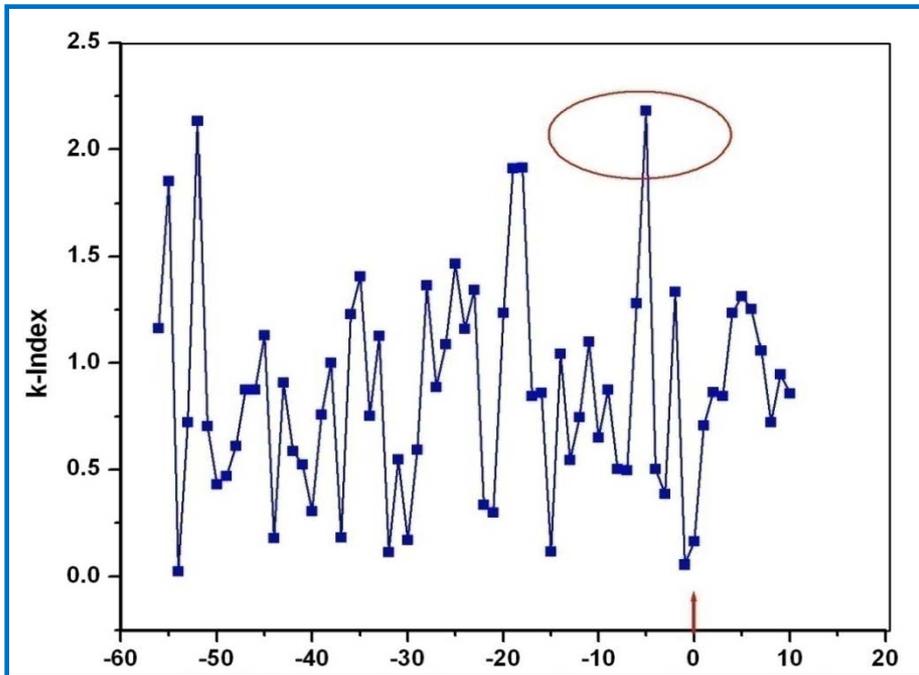
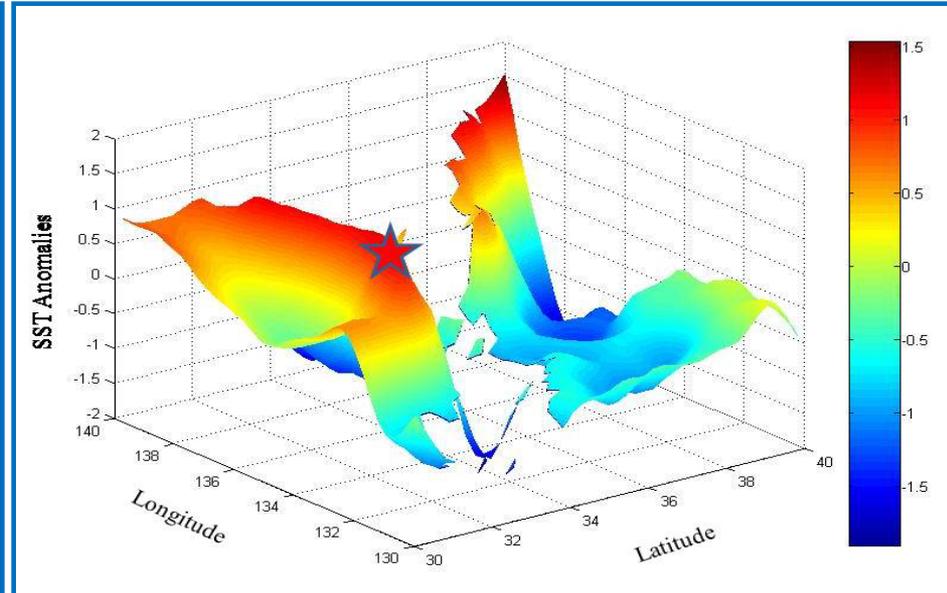
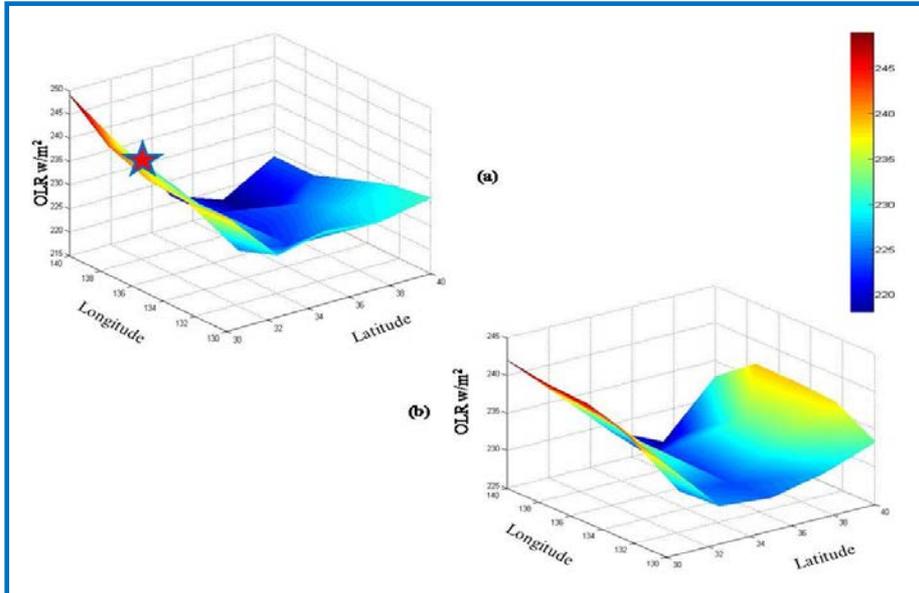


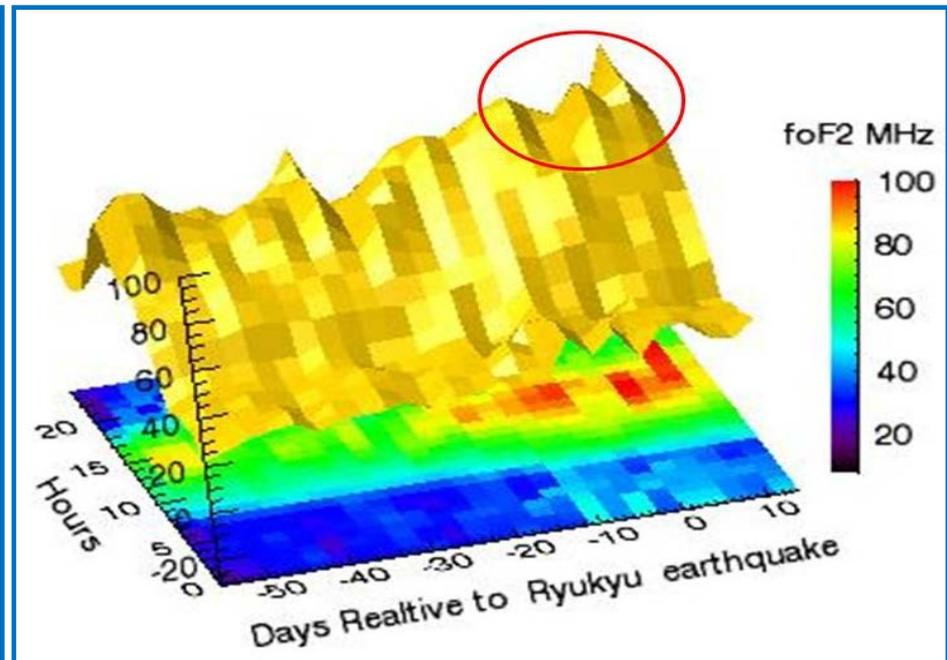
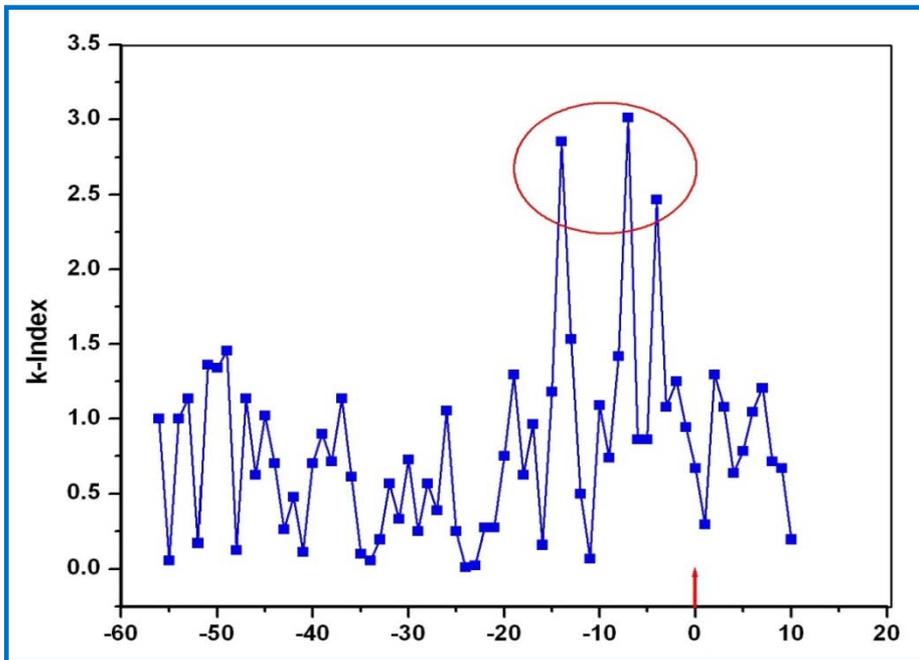
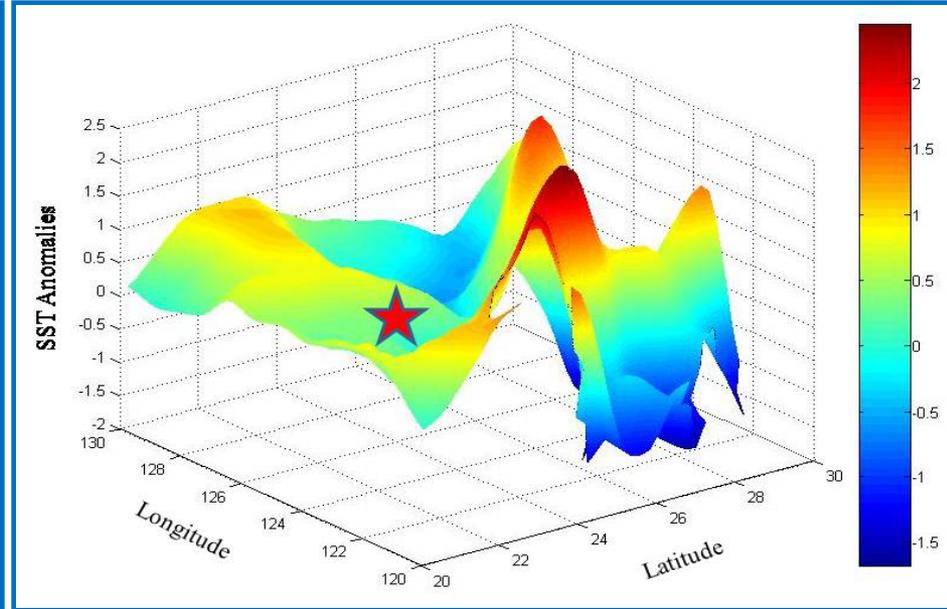
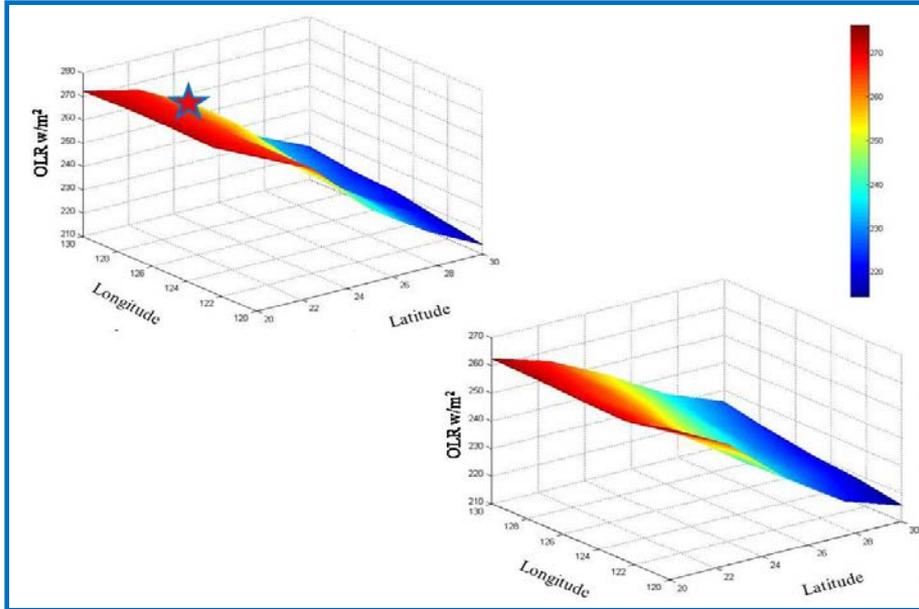
- ❑ Calculate the **Radius of Earthquake Preparation Zone**. (Dobrovolsky et al.,).

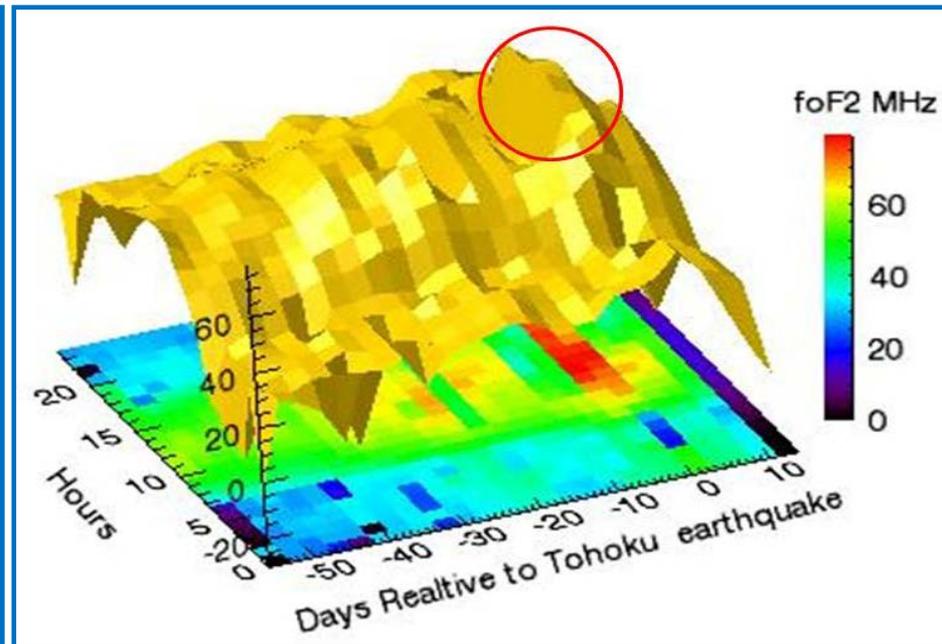
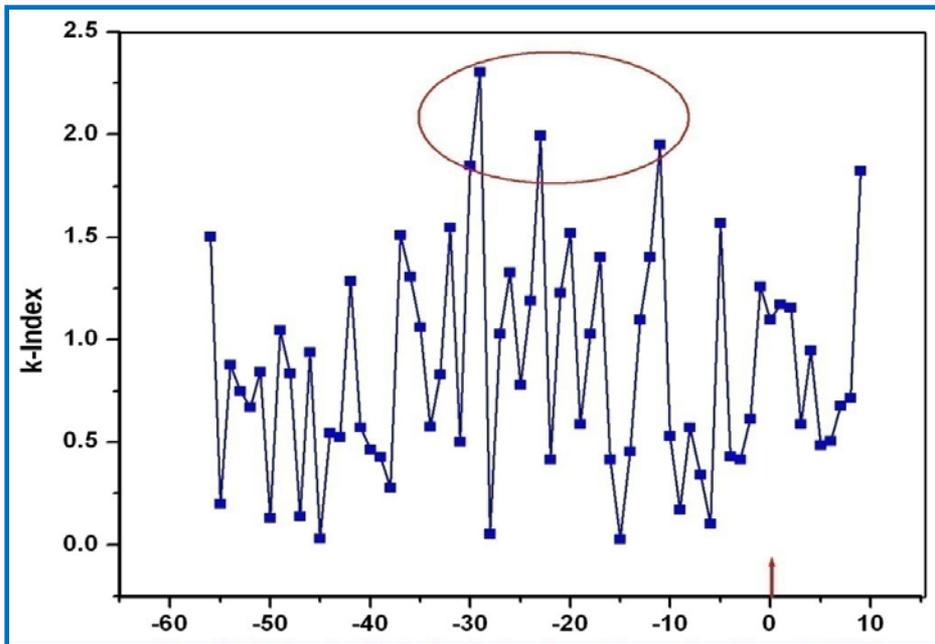
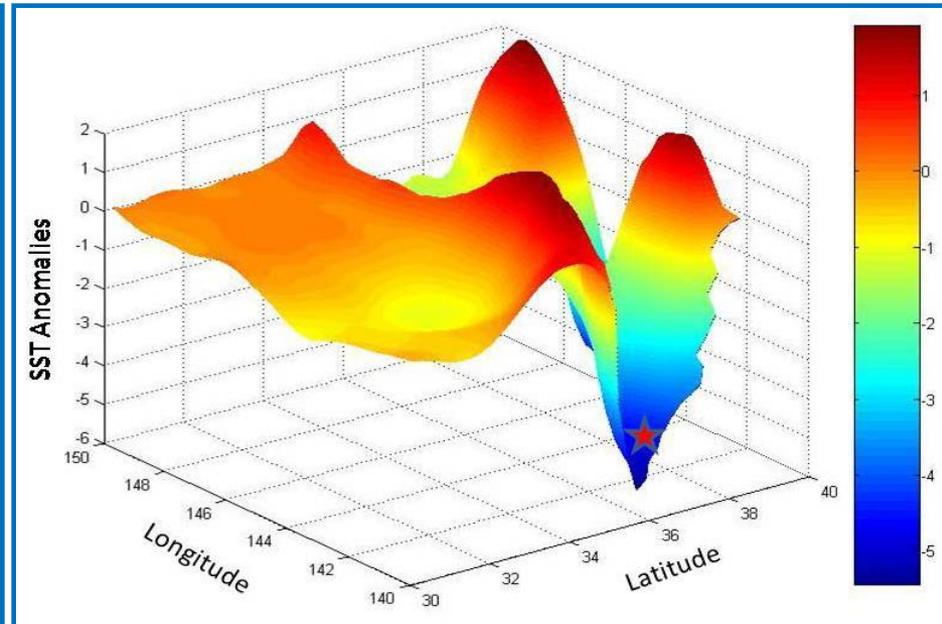
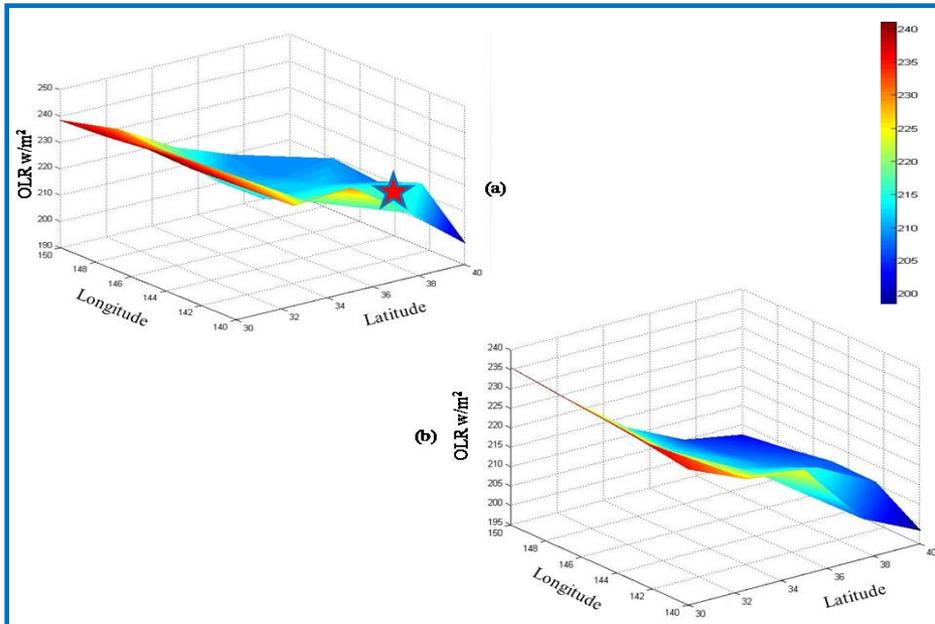
$$\rho = 10^{0.43M}, \text{ Where } M \text{ is the magnitude of earthquake}$$

- ❑ Select the **Area of Interest**.
- ❑ Select the **Ionosonde Station** which comes under the radius of earthquake preparation zone.
- ❑ Keep remember always that the data should be in **same time period**.









Summary

- ✓ Stress energy in the earthquake preparation zone may be operating some tectonic force.
- ✓ Releasing warm gases (radon) create atmospheric disturbances.
- ✓ During disturbances emissions may create the coupling between Lithospheric-Atmosphere-Ionospheric.
- ✓ Ionization is the possible cause for this Coupling.
- ✓ Multi-Parametric approach is only possible method for predict the earthquake.
- ✓ Continuous monitoring of radon gases in the nearby seismic zone.
- ✓ Explore more atmospheric parameters.

**Thanks For Your Kind
Attention !**

**Earth Sending Some Signal Before the Natural
Disaster !**