

Reoccurrence of transient effects in the atmosphere and ionosphere preceding large events. Case study for 2015 M7.8 and M7.3 Gorkha–Nepal earthquakes

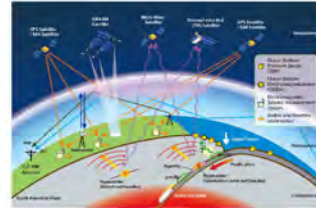
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Outline*

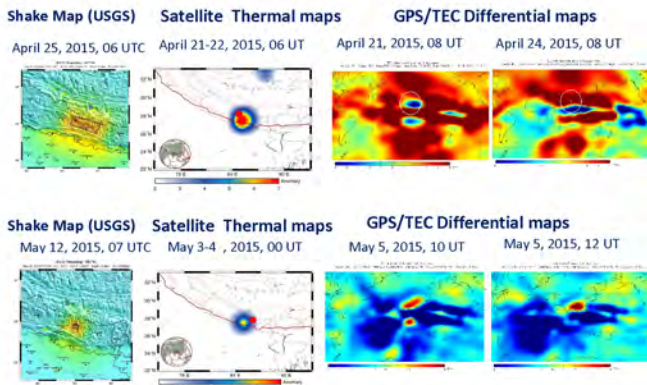
1. M7.8 of April 25th, 2015 – A joint analysis of atmospheric satellite and ground observation observation
2. M7.3 of May 12th, 2015 – A joint analysis of pre-earthquake observations in Nepal
3. Summary



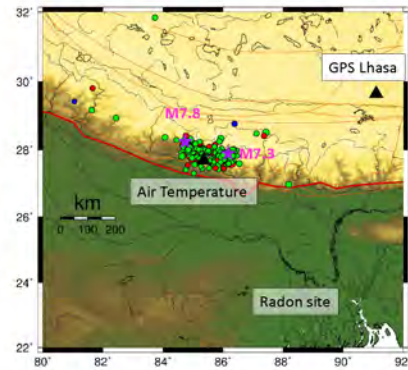
Conceptual diagram for Sensor-web approach for surveying of pre-earthquake signals in Japan (Ouzounov et al, 2018)

* Ouzounov D, Pulnits S, Davidenko D, Rozhnoi A, Solovieva M, Fedun V, Dwivedi BN, Rybin A, Kafatos M and Taylor P (2021) Transient Effects in Atmosphere and Ionosphere Preceding the 2015 M7.8 and M7.3 Gorkha–Nepal Earthquakes. *Front. Earth Sci.* 9:757358. doi: 10.3389/feart.2021.757358

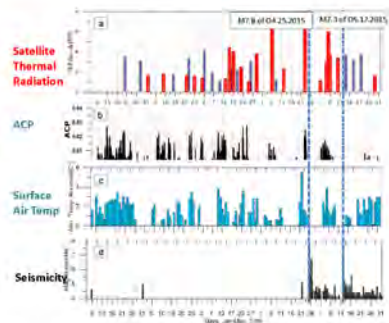
Summary



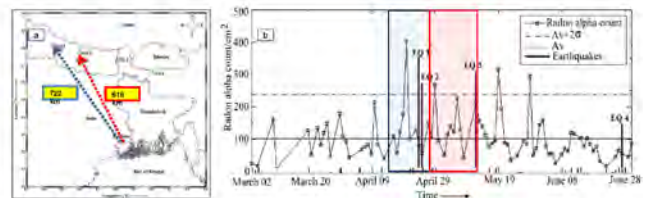
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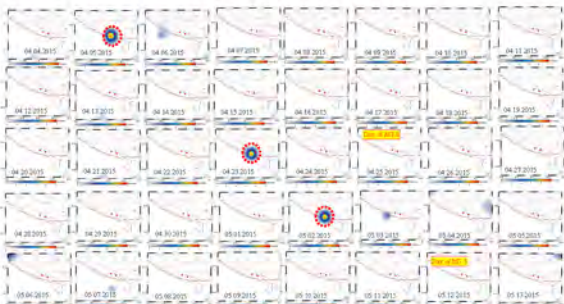
Reference map of Nepal region, with the location of earthquakes >M4 for Jan- May 2015. The location of M7.8 of April 25 and M7.3 of May 12, 2015 are with purple stars. With black triangles are showing the location of the Air Temperature station (Katmandu) and GPS stations (Lhasa), radon site (Kolkata, India)



Time series of atmospheric variability observed within a 200 km radius of the Nepal earthquake (top to bottom): A) Nighttime anomalous OLR over epicentral region from January 1- May 31, 2015 observed from NOAA AVHRR (red). Same location, same period a year before - Jan-May 2014 (black); B) ACP time series over the epicentral areas. With pink color 2015 ACP 6 hourly data. With black the residual of 2015-2014 6 hourly ACP data; C) Air temperature anomaly from station Tribhuvan International Airport (blue) at 0600LT; D) Seismicity (M>4.0), Jan-May 2015 within 200km radius of the M 7.8 epicenter (USGS)

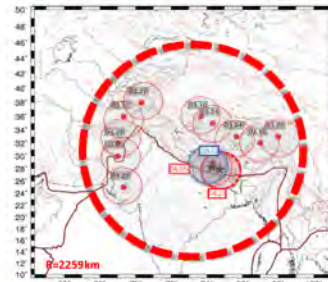


Radon observation in Kolkata, India a) Map indicating the monitoring sites in Kolkata and the M5+ earthquakes within 1000 km region. b) Combined graph for radon-222 anomalies at location A and the corresponding earthquakes during the observation period from March 1 to June 30, 2015. EQ1 -M7.8 of 04.25.2015; EQ2- M6.9 of 04.26.2015 and EQ3- M7.3 of 05.12.2015. [Deb et al, 2016]



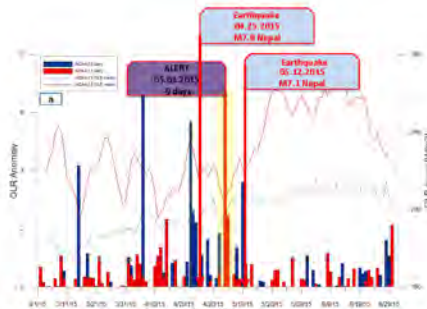
Time series of nighttime TRA observed from NOAA/AVHRR, April 4-May 13, 2015. Tectonic plate boundaries are indicated with red lines and major faults by brown ones and earthquake location by red circles. Red circles show the spatial location of TRA within vicinity of M7.8 and M7.3.

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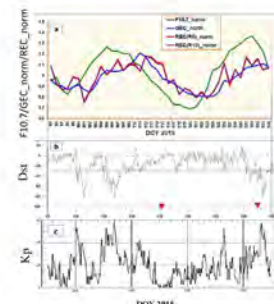
Spatial distribution of Thermal Radiation Anomalies (TRA) March-May 2015 and Dobrovolsky estimated area for the earthquake preparation zone (red dash circle). With red shadowed circles 04.03 and 04.23 anomalies. With a blue shadowed circle 05.03.2015 anomaly. With red dots - the centers of TRA anomalies, with dash red circles, the confidence area of TRA. With black stars the epicenters of M7.8 04.25.2015 and M7.3 of 05.12.2015.

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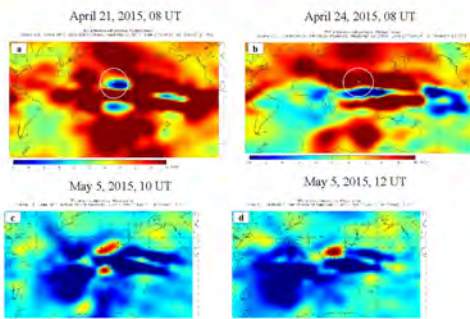
TRA time series for March 2015- June 2015 over the Nepal Gorkha epicentral area. On April 5, 2015 and April 23, were revealed transient anomalies (by retrospective analysis of satellite radiation) 21 and 3 days in advance to the M7.8 mainshock of April 25, 2015, earthquake. On May 3, 2015, the ongoing prospective analysis of satellite radiation revealed transient anomaly (9 days in advance, with yellow), associated with the M7.3 of May 12, 2015, earthquake.

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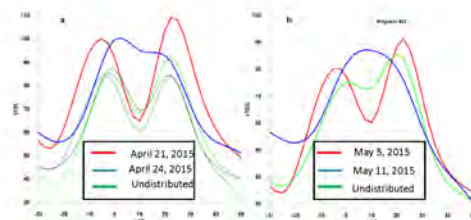
Solar-geophysical conditions during April- May 2015. A/ Normalized values of F10.7 - Solar electromagnetic radiation on the Wavelength 10.7 cm, GEC - Global ionospheric content - sum of all values in the IONEX table, REC (R5) - the Regional Ionospheric Content - within the 500 km radius circle, REC (R10) - it is the Regional Ionospheric Content - Within the 1000 km radius circle, D/ Dst equatorial geomagnetic index, C/ Planetary K-index (Kp*10, OMNI WEB Plus)

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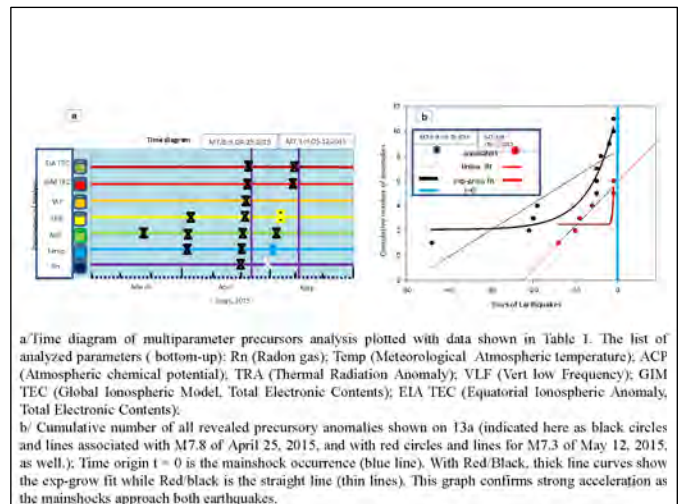
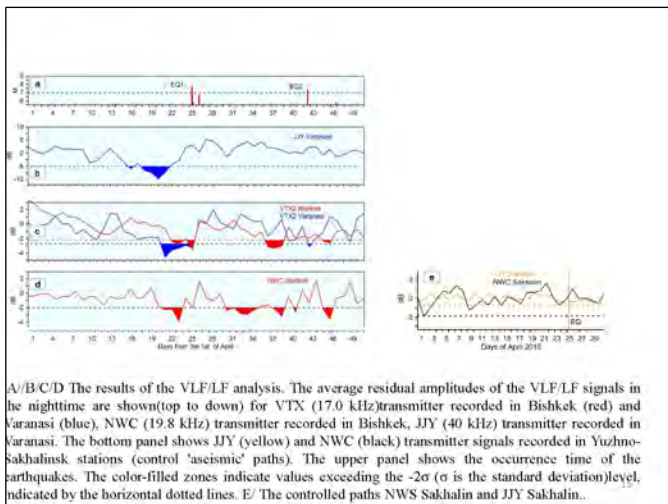
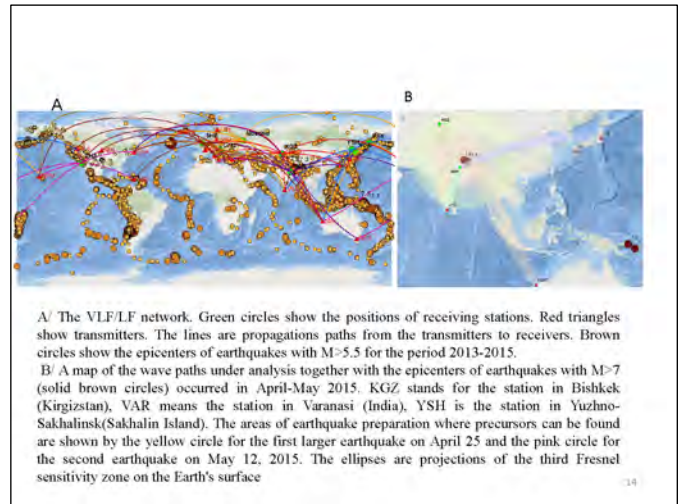
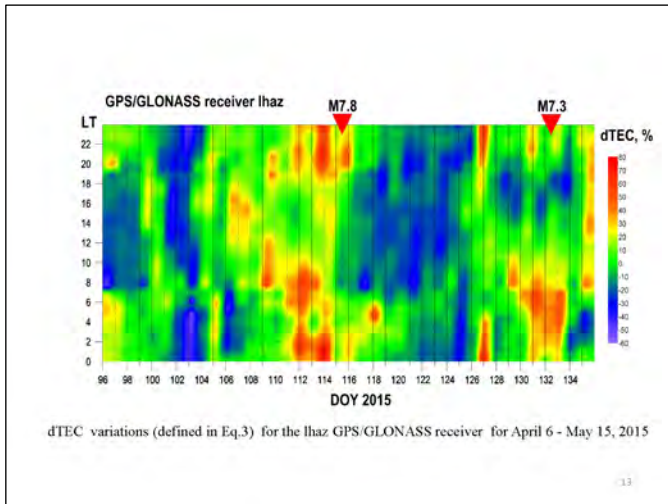
GIM GPS/TEC spatial analysis. (A) Differential TEC map of April 21, 2015, (-4 days) 09UT and (B) April 24, 2015, 08UT (-1 day)(C) Differential TEC map of May 5, 2015, (-7 days) 10UT and (D) May 5, 2015, 12UT (-7 day)

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Equatorial Ionospheric Anomalies a/ Nepal, April 25 2015, M7.8: Red - April 21, Blue April -24 , 08 UT; b/ Nepal, May 12, 2015, M7.3: Green - undisturbed, Red- 5 of May Blue 11 of May, 08 UT

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Takeaways

- ❑ The multiparameter measurements show the presence of anomalies in the atmosphere and ionosphere occurring consistently over the region near the 2015 Nepal earthquake epicenter.
- ❑ Results also show evolutionally and recurrence patterns in the appearance of pre-earthquake transient effects in the atmosphere and ionosphere, with a short time-lag from hours up to a few days and scalable with a magnitude estimate at their unusually far distance from the epicenter.
- ❑ The spatial characteristics of pre-earthquake anomalies were associated with the larger area but always inside the preparation-activation region estimated by Dobrovolsky-Bowman.