TEC anomalies preceding large earthquakes: Review and perspective

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An increasing number of Global Navigation Satellite System (GNSS) receivers continuously operating worldwide, makes it possible to observe changes in the ionospheric total electron content (TEC) associated with large earthquakes, e.g. coseismic ionospheric disturbances ~10 minutes after earthquakes by acoustic disturbances (Cahyadi & Heki, 2015). Heki (2011) also found TEC enhancement starting ~40 min before the 2011 Mw9.0 Tohoku-oki earthquake. He also confirmed similar TEC enhancements occurred before all the earthquakes in this century with Mw 8.5 or more (Cahyadi & Heki, 2013; Heki & Enomoto, 2015).
Several papers critical to Heki (2011) have been published during 2013-2015. They claim that (1) the preseismic increase is an artifact popped up by defining the reference curves using the data after earthquakes, and (2) the anomalies originate from geomagnetic activities rather than earthquakes. In our rebuttals papers (Heki & Enomoto, 2013; 2014; 2015), we demonstrated statistical significance of the preseismic increases of vertical TEC rates. We also counted the occurrences of similar changes in TEC caused by space weather during times of no earthquakes and demonstrated it statistically unrealistic to attribute all the observed preseismic anomalies to space weather.
Recently, He and Heki (2016) analyzed the spatial distribution of preseismic ionospheric anomalies of 3 large earthquakes in Chile, i.e. the 2010 Maule, the 2014 Iquique, and the 2015 Illapel earthquakes. There, both positive and negative anomalies started simultaneously at altitudes of ~200 km and ~400 km, respectively, with 3-D structure similar to Kuo et al. (2014) predicted as the ionospheric response to positive electric charges on the ground.
We found three different kinds of Mw dependence of the anomalies so far. At first, Heki and Enomoto (2015) found that the amount of the preseismic VTEC rate changes depend on Mw and background VTEC, i.e. larger precursors occur before larger earthquakes under similar background VTEC. Secondly, Heki and Enomoto (2015) found that earthquakes with larger Mw tend to have longer precursor times (i.e. tend to start earlier). Third, He and Heki (2016) showed that the anomalies of larger earthquakes have larger spatial dimensions. In the latest work, He and Heki (submitted) studied 32 earthquakes with Mw7.0-8.0 in this century, and found that 8 earthquakes showed possible preseismic changes starting 20-10 minutes before earthquakes. We could observe them before Mw7.0-8.0 earthquakes when background VTEC are large, say over 50 TECU.

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Keywords: earthquake precursor, TEC, GNSS, GPS

An Automatic Landslide Detection Technique Using Deep Convolutional Neural Networks and Orthophoto

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Deep learning machine algorithms learn representations of data with multiple levels of abstraction; have recently gained significant attentions in machine learning and geoscience communities. Yet their strengths have not been broadly explored in natural hazard mapping and modeling. In particular, deep convolutional neural networks (DCNN) is a category of deep learning that is suitable for object detection and can achieve reliable accuracy. This paper presents an automatic landslide detection in tropical regions using DCNN trained on a manually prepared dataset from a grayscale orthophoto acquired over Cameron Highlands, Malaysia. The proposed model has a simple architecture including an input layer with (28 ×28) nodes, two convolution and two pooling layers, followed by two fully connected layers. The probabilities of the classes were calculated with a Softmax layer. To apply the DCNN, a number of proposals (i.e. probable targets) were first selected from the input image using a baseline technique called sliding window method. Then, low level features were extracted from each selected proposal and sent out to the deep network. After that, high-level features were learned by the deep network and used to classify the proposals and detect landslide objects in the input image. Experimental results show that the proposed landslide detection based on DCNN can achieve an overall accuracy of 78%. In addition, a comparative study with one-layer neural network (NN), support vector machine (SVM), and logistic regression (LR), showed that the proposed model outperforms NN (57%) and LR (77%) and achieves accuracy comparable to that achieved by SVM (78%) method. Overall, this study successfully applied deep learning algorithm in landslide mapping and modelling as well as to creating standard large-scale landslide inventory datasets that can help advancing this field by further research.

Keywords: landslide detection, LiDAR, Deep Convolutional Neural Networks , Orthophoto, GIS

A Syncro Floodwater Index for Flood Risk Mapping using Multiple Satellite Data: A Case Study of 2015 Bangladesh Flood

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In January 2015, the Government of Japan addressed the new space policy, "Basic Plan for Space Policy," which emphasizes the development and utilization of outer space in recognition of increasing demands for safety and security including recovery from the Great East Japan Earthquake. In this context, remote sensing technology is expected to play a central role in more effective and accurate disaster risk reduction and restoration.

The purpose of this study was to provide a rapid and accurate flood mapping of temporal changes in the extent of annual flooding for a transboundary river basin. We proposed the Syncro Floodwater Index (SfWI) to detect widespread inundation extent in a transboundary river basin using the different sensors obtained by NASA's Moderate Resolution Imaging Spectrometer (MODIS MOD09A1), JAXA's new L-band SAR satellite ALOS-2 (PALSAR-2), and JMA's Multi-functional Transport Satellite series (HIMAWARI-8). After removing clouds using the White-object Index (WOI), the SFwI coupled with land surface temperature (LST: MOD11A1) data and in-situ water level data was applied to the 2015 Bangladesh flood for near-real-time nationwide rapid flood monitoring.

The preliminary results showed that the estimated maximum inundation area from MODIS-derived SfWI was smaller than the area from the solo use of modified land surface water index (MLSWI) that was 32% (29,900 km^2) of the total area of Bangladesh. We also addressed that the new hybrid approach based on SfWI has showed the possibility of a major contributor in international flood monitoring by means of the integration of multiple satellite data, despite different time and spatial resolutions. The SfWI was particularly designed to enhance advantages of SAR data to overcome disadvantages of the multiple optical satellite images by the hybrid image fusion for integration of SAR and optical satellite.

With recent advances in satellite data, this scheme for a rapid flood mapping will help provide stakeholders with important information to support not only the development of a national policy but also the implementation of international cooperation for disaster risk management. At the same time, these results are important to evaluate for validation of hydrological model simulation output such as flood inundation area in the national-level flood risk.

Keywords: flood mapping, Syncro-floodwater index, MODIS, ALOS-2, Himawari-8

Variability of Meteorological Parameters and Their Association with the Vegetation Stress during 2001-2016 in Brazil Using Satellite Data

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With growing populations, hydrological cycles are severely impacting megacities. Water collection systems in these cities are being affected by extensive population growth. In general, increasing atmospheric pollution is directly and indirectly related to population growth. In mega cities, due to increasing pollution, the meteorological parameters, surface and air temperature, water vapor and rainfall are severely affected which also correlates with vegetation growth and crop yield. We have carried out a detailed analysis of multiple satellite data sets between 2001-2016 and studied surface, atmospheric, meteorological parameters, and water vapor from GPS stations deployed in various locations throughout Brazil. Our detailed analysis of satellite data in varying regions in the north-east, north-west and mid regions of Brazil show dramatic changes in meteorological parameters. These changes have one to one correspondence with the vegetation index during period 2001-2016. The meteorological conditions (relative humidity, water vapor, surface and air temperature) are found to be very dynamic over the years, the pronounced changes in these parameters show the cause of drought in different regions of Brazil especially in Sao Paulo and north-eastern parts of Brazil. We have also analyzed LANDSAT images over the past years that show pronounced changes in water reservoirs throughout the drought affected regions. Our detailed analysis shows shift in the climate patterns, thus, cities face new challenges in regards to their sustainable water management practices. We have also analyzed sea surface temperature of the adjacent ocean and found pronounced relations between the sea surface temperature and vegetation growth which could be associated with a strong El-Nino between 2015-2016. Additional analysis of Vegetation Health (VH) data derived from observations of NOAA operational polar-orbiting satellites during a strong 2015-2016 El Nino indicated that northern Brazil was under intensive vegetation stress. A similar situation was observed during two other strong El Nino cases in 1997-98 and 1982-83. During La Nina, northern Brazil was normally wet.

Keywords: Hydrology, Satellite Data, Water Storage, Vegetation Index

Detection and simulation of long-term land-air changes induced by wildfires in the United States

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Wildfire is a severe natural hazard in the United States. One of the damages from wildfires is removal of vegetation. This can further lead to anomalies in local and regional climate. This study investigates the changes in the land-air system caused by some large wildfires in the United States using data analysis and modeling technique. Satellite remote sensing was used to quantitatively evaluate the land-surface changes. It was found that the changes in land-surface properties induced by mega-fires are very complex, depending on vegetation type and coverage, climate type, season and year after fires. The changes in LAI (and NDVI to a less degree) are remarkable only if the actual values meet a threshold. Large albedo changes occur in winter for fires in cool climate regions. The signs are opposite between the first post-fire year and the following years. Large increases in day-time temperature are found, mainly in summer, while nigh-time temperature changes have various patterns. The changes are larger in magnitude in forested lands than shrub / grassland lands. A parameterization scheme was developed based on the detected post-fire changes. The changes were decomposed into trend and fluctuation. The trend was described using a natural exponential function. The fluctuation included periodic variations determined by the Fourier analysis with their amplitudes determined by natural exponential functions. The final algorithm was a combination of the trend, period, and amplitude functions. This scheme was further used with climate and earth system modeling to simulate the local and regional climate effects of wildfires.

Keywords: wildfire, land-surface , climate, remte sensing, modeling

Tropical Cyclone Risk Mapping Using Remote Sensing and Spatial Analysis: Application to a Coastal Upazila in Bangladesh

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Tropical cyclones are a common and devastating natural disasters for tropical coastal regions globally. The intensity and extent of damage by tropical cyclones are very high. An appropriate mapping approach is essential for producing risk assessments to reduce the impacts of cyclones on people, property and the environment. The present study developed and tested a risk mapping approach for tropical cyclone impacts in Sarankhola Upazila, a 151 km^2 local government area in coastal Bangladesh. The approach incorporated remote sensing and spatial analysis, field data and multi-criteria evaluation. Fourteen criteria under three risk components: hazard, vulnerability and mitigation capacity were assessed. Thematic raster map layers quantifying the level of risk were prepared for every criteria using Analytical Hierarchy Process (AHP) approach. A weighted overlay technique was used for overlaying standardized criteria maps under each risk components with their weights to produce the individual risk components maps and then finally risk map. Our results indicated that 6% of the study area was located in the very high risk zone, mostly close to the coastal river, with 16 % area as high risk zone and around 28 % area was at moderate risk zone. The area was classified as low and very low hazard zone accounts the 26% and 23%, respectively, mostly towards inland from the coast. Our results were validated by comparison to a map of previous cyclone impacts. Critical assessment of our findings demonstrate the approach may have more widespread applicability for assessing tropical cyclone risks in similar coastal environments for the purposes of disaster planning and management.

Keywords: Tropical cyclone, Vulnerability, Hazard, Remote sensing, Spatial analysis, Analytical hierarchy process

