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Upper and Lower Atmosphere interaction during Tropical Cyclones

Tropical Cyclones (TCs) are one of the most significant weather phenomena in the Earth's lower atmosphere that causes a variety of damages and large scale destruction to lives and property due to violent winds, heavy rain (torrential rainfall) and storm surges. TCs, also referred to as hurricanes in the Atlantic Ocean and eastern Pacific Ocean and typhoons in the western Pacific, is a low pressure system which is caused by atmospheric disturbances over the tropical ocean with a sea surface temperature (SST) greater than 26℃. Technically they are defined as an intense low pressure system with organized convection that originates over tropical or subtropical waters circulating either anti-clockwise (in the northern hemisphere) or clockwise (in the southern hemisphere). Bay of Bengal (BoB) is one of the most vulnerable regions for the development of some of the strongest and deadliest tropical cyclones. India and Bangladesh are the highly affected countries by BoB cyclones which occur usually during pre-monsoon (April and May) and post-monsoon (October to November) seasons. Because of its unique geo-climatic conditions and densely populated coastal region, the Indian subcontinent is considered to be the worst affected area of the world with regard to TCs.

The favorable conditions for TC formation include six major parameters, three dynamical: low-level relative vorticity, coriolis parameter and tropospheric vertical wind shear, and three thermodynamics: sea surface temperature, conditional instability, and mid tropospheric relative humidity. These parameters are analysed to examine the effect of four different types of cyclones: Super cyclonic storm - Gonu (1st June, 2007 to 8th June, 2007), Extremely severe cyclonic storm - Hudhud (7th October, 2014 to 14th October, 2014), Severe cyclonic storm - Mora (28th May, 2017 to 31st May, 2017) and Very severe cyclonic storm - Ockhi (29th November, 2017 to 4th December, 2017). In this study the International GPS Service (IGS) scintillation data at 15-min interval is taken from website ftp://cddis.gsfc. nasa.gov/pub/gps/data/daily/ for the locations on the tracks of the cyclones. To validate the observation from ground receiver (bottomside) the TEC data from SWARM satellite (topmside) is also investigated. The tropospheric parameters data is extracted from Giovanni Model (Merra-2).

The noticeable variations in wind speed, potential vorticity, relative humidity and outgoing long wave radiations in the troposphere have been observed during all the four cyclones. For the upper atmosphere, day to day vertical TEC (Total Electron Content) over the locations along the path of the cyclones is evaluated, which exhibit significant variations. The upward propagating waves from lower atmosphere carry energy and momentum capable of affecting the TEC dynamics. Anomalous depression in VTEC is noticed during the landfall of the cyclone (12th October to 14th October, 2014) under the geomagnetic quiet condition (Dst ≤ ±50). The decrease in VTEC might be the result of combined effect of TC-inspired gravity waves, ejection of neutral particles from the terminator of TC, and lightning electric fields that redistribute the chemical constituents of the ionosphere by increasing the number of neutral particles at different ionospheric heights. These upper and lower atmospheric responses during pre cyclonic and cyclonic periods can be an added parameter to be used in forecasting cyclones.

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