**Very Severe Cyclonic Storm (VSCS), Phailin over the Bay of Bengal during 08-14 October 2013 : A Demonstration of Early Warning Capability of India Meteorological Department**

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A Very Severe Cyclonic Storm (VSCS), Phailin over the Bay of Bengal originated from a remnant cyclonic circulation from the South China Sea, moved northwestward and crossed east coast of India near Gopalpur (Odisha) around 1700 UTC of 12th October 2013 with maximum sustained surface wind speed of about 115 knots, estimated central pressure of 940 hPa and pressure drop of 66 hPa. It was the most intense tropical cyclone that crossed India coast after Odisha Super Cyclone of 29th October 1999. It caused very heavy to extremely heavy rainfall over Odisha leading to floods, and strong gale wind leading to large scale structural damage and storm surge of 2-2.5 meters leading to coastal inundation. The VSCS, Phailin was monitored & predicted continuously from 08th October with the formation of depression over the north Andaman Sea. The 4 to 5 days in advance early warning during cyclone, Phailin with minimum error (landfall point forecast errorof 3-13 km and landfall time forecast error of 1-3 hrs for 12-72 hr forecasts) helped the disaster managers to maximize the effect of the early warning system for management of cyclone and hence to minimise the human deaths to 21 only. However, the success in early warning of cyclone, Phailin is not an isolated case. The average track forecast error has decreased at the rate of about 7 km per year and the skill in forecasting has increased by about 5% per year during 2003-13 resulting in confidence building of disaster managers and reducing the cost towards evacuation during cyclone. The average track forecast error of India Meteorological Department (IMD) is about 124, 202 and 268 km and landfall point forecast error is about 75, 98 and 124 km for 24, 48 and 72 hr forecasts respectively during 2009-2013. The intensity forecast has also improved significantly in recent years, though the rate of improvement is less compared to that of track forecast.

The improvement in early warning of cyclone has been possible due to several initiatives taken by IMD, Ministry of Earth Sciences (MoES), Government of India, in recent years. Curerntly, the cyclone analysis, prediction and decision-making process is made by blending scientifically based conceptual models, dynamical & statistical models, meteorological datasets (including observations from conventional observational network, automatic weather stations (AWS), buoy & ship observations, Doppler weather radars and satellites), technology and human expertise. A number of national & international global and regional models including IMD’s global forecast system (GFS), weather research and forecast (WRF), Hurricane WRF (HWRF), multi-model ensemble (MME) technique, global ensemble forecasting systems (GEFS) of National Centre for Medium Range Weather Forecasting (NCMRWF) are utilized for cyclogenesis, track, intensity and associated wind and rainfall prediction. IMD’s Dynamical statistical models are also utilized for cyclogenesis and intensity prediction. For prediction of storm surge, the dynamical model of IIT Delhi & Indian National Centre for Ocean Information Services (INCOIS), Hyderabad is utilised. A special tropical cyclone module is utilized as a decision support system (DSS). Consensus cyclone forecasts that gather all or part of the numerical forecast and uses synoptic and statistical guidance are utilised to issue official forecast. There is still scope for further improvement in cyclone forecast through improvement in initial condition using observations from aircraft reconnaissance and deployment of more buoys, assimilation of more observational data from satellite and radars in NWP models, implementation of high resolution meso-scale ocean–atmosphere coupled model, implementation of ensemble prediction system (EPS) for global and mesoscale models etc. IMD is already taking up all these aspects through its continuous upgradation programme.