Third Joint Session
Panel on Tropical Cyclones | Typhoon Committee
(42nd Session of PTC and 47th Session of TC)
9- 13 February 2015
ESCAP - UN Conference Center
Bangkok, Thailand

FOR PARTICIPANTS ONLY
WRD/TC.47/6.2
06 February 2015
ENGLISH ONLY

The Experiment on Typhoon Intensity Change in Coastal Area (EXOTICA) ANNUAL REPORT 2014

(Submitted by TC WGM Chair)

ACTION PROPOSED:

The Committee is invited:

(a) To take note of the major progress and issues in implementing the project in 2014 as reported

(b) To encourage TC and PTC Members to participate the field campaign and the share the observational data related to the target typhoon

The Experiment on Typhoon Intensity Change in Coastal Area (EXOTICA)

(WGM of TC)

1. Background (context)

With the significant advances in numerical prediction modeling of typhoon, there has been significant improvement in typhoon track forecast. The current 48-hour track forecast error incidence is equivalent to the 24-hour forecast error incidence 15 years ago; in other words, the accuracy for the typhoon track forecasts has been improved (advanced) approximately one day in 15 years. However, no significant progress has been made in typhoon intensity forecast. In recent decades, the intensity forecasts of numerical prediction models still remain challenging, which may not yet fully meet the need in operation, while operational forecasting of typhoon intensity still mainly relies on statistical methods.

In Northwest Pacific region, the core issue that impedes more in-depth analysis and improvements in forecasting capabilities is the lack of observations of structure and intensity changes of tropical cyclones. Since the USA has stopped the reconnaissance flights in 1987, the primary technique for tropical cyclone intensity analysis widely used by operational forecast centres is the Dvorak technique. The tropical cyclone intensity estimated in warnings may vary across different Centers due to the subjectivity of the Dvorak technique. In recent years, though on-board microwave sensors in satellites have gained wide application, they still cannot provide a significant improvement in this situation.

During the 45th Session of the UNESCAP/WMO Typhoon Committee (TC), held in Hong Kong, China from 29 January to 1 February 2013, the Working Group on Meteorology (WGM) proposed a regional field experiment to be implemented with the cooperation and joint efforts of the TC Members. Similar in scale to the “SPECTRUM-90” Typhoon Research Experiment, this experiment will focus on resolving the difficulties of operational typhoon forecasting and identifying the key scientific issues of tropical cyclone related disaster prevention and mitigation. The proposed project's concept was generally well received by TC Members.

2. Experimental objectives

To conduct field campaigns on the intensity and the structural characteristics of the target offshore and landfalling tropical cyclones by employing integrated aircraft drop-sonde, vehicle/boat on-board GPS automatic sounding, offshore and island tower observation, and novel tropical cyclone observation techniques such as rocket drop-sonde, to retrieve such parameters as wind-temp vertical profile, cloud walls, dimensional scale of the tropical cyclones, sea surface temperature, and air-sea flux. It is planned to observe 3 – 5 target tropical cyclones per year.

To conduct demonstration research on the utilization of the synergized field observation data with the aim of deepening the understanding of the mechanism of structure and intensity changes of offshore and landfalling tropical cyclones; to improve key techniques of intensity analysis and the regional tropical cyclone prediction model; to enhance the performance of tropical cyclone intensity forecasts from NWP models; to develop a more reliable storm surge model for the coastal cities in the Asia Pacific region; and to develop the flooding and associated risk assessment techniques and systems for the inland flood plains.

3. Target typhoon's observation

3.1 Observation period and region

In the Asia Pacific region, the two major observation regions will be the South China Sea and the East Asian Sea (Western Asian Pacific). The observation period is planned to cover the period from June to October, the peak tropical cyclone activity period, of 2014 – 2017 in the Asia Pacific Region.

3.2 Observation parameters

These include the WMO conventional observational network and, during the observation period of the target typhoon, enhanced with conventional observation of the atmosphere such as weather radar and satellite surveillance, upper air sounding, and ARGO buoy observation. In addition, the following non-conventional observational techniques will also be employed:

- **The aircraft observations**: Upper-air observations of the inner-core structure of tropical cyclones over northern part of the South China Sea could be available by using dropsondes and data probe on a fixed-wing aircraft from Hong Kong, China. The unmanned aerial vehicle (UAV) developed by China is another means to make the low altitude observation of the wind field and boundary layer of the inner core of typhoons.
- **Rocket launch through the target typhoon:** Improved rocket drop sounding to observe the target typhoons in the East Asian Sea and South China Sea observation regions in order to collect the vertical profile of the wind, temperature, and humidity around the center of the typhoons.
- **Wind chasing/mobile vehicle sounding:** Making use of the vehicles from STI/CMA and TC Members, equipped with mobile observation systems (e.g. microware radiometer, wind profiler, and GPS sounding), to make mobile observations of the target offshore or lanfalling typhoons, to collect the essential meteorological parameters under the various underlying surface conditions.
- **Offshore tower observation:** Using the observation towers set up on the coast and the offshore islands within the observation regions to carry out the boundary layer observation to collect the near surface (about 100m altitude) wind, vertical profiles of temperature and humidity as well as the essential oceanic parameters from sea surface to bottom.
- **Buoy observation:** Using the satellite-linked buoy(s) to carry out buoy observation, with the aim to obtaining the essential atmospheric and oceanic parameters under typhoon conditions (including the air-sea flux).
- **Wind profiling radar and ground-based GPS/MET water vapor remote monitoring station:** Making use of the wind profiling radar to make observations on horizontal wind speed and direction, vertical winds, and atmospheric refractive index at different altitudes, as well as using the related equipment to observe atmospheric water vapor column quantity.

4. Demonstration of the integrated application of the field observation data of the

target typhoons in research

Research on key techniques of operational typhoon structure and intensity analysis: To develop the objective analysis of wind speed and direction based on the multi-source observation and typhoon intensity analysis techniques. To provide the techniques support for the improvement of operation in locating typhoons and structure.

Research on structure and intensity change mechanisms of offshore and landfalling typhoons: To reveal the structural changes of the typhoons and the offshore ocean-air interaction and to analyze factors contributing to genesis and dissipation, intensification and weakening of tropical cyclones.

Research on the offshore and landfalling typhoon numerical prediction model via inter-comparison studies: To compare the performance of NWP models in the prediction of the intensity of offshore and landfalling typhoons; to investigate the impact of field observations on the performance of NWP models; and to conduct research on the improvement of physical parameterization in NWP model intensity forecasts based on the observations of vortex structure and boundary layer characteristics.

Research on the effect of intensity changes on storm surge and the flood forecasting of landfalling typhoons: To evaluate and improve the storm surge and the inundation models of the pilot coastal cities, and the inland flooding model.

Research on the effect of the intensity changes on typhoon disasters: To analyze the typhoon disaster risk vulnerability in the Asia Pacific Region, in particular analysis of the sensitivity and vulnerability to super typhoons and weak tropical cyclones with intense precipitation, rapid intensity/weakening tropical cyclones, as well as the relationship between the total estimated precipitation and the damages caused.

5. Implementation of the project and safeguard measures

5.1 Organizational structure

(1) Scientific Steering Committee: The Scientific Steering Committee (SSC) will be established to provide guidance on the design and implementation of this field experiment. SSC will comprise the renowned typhoon experts. All the members of the SSC are will be nominated by the AWG of Typhoon Committee. The ToRs of SSC:

- Providing overall guidance and advice on the project activities
- Reviewing the status, scope of work and performance of the different project implementation teams
- Regular monitoring and evaluation of the project activities and
- Fulfill other functions as emerging needs are identified.

(2) Organizing Committee: The Organizing Committee (OC) will be established to direct the implementation of this project, and to coordinate TC Members and working groups in their project activities. OC will comprised the AWG members and the chief representatives of the participating Members of Typhoon Committee.

(3) Chief Scientists and Research Groups: One or two chief and vice-chief scientists, nominated by OC, under the guidance of the SSC and led by the OC, will be responsible for the implementation of the project and the work planning of the OC. In addition, five research groups (RGs) will be established: "Field Campaign", "Research on Mechanism", "Model Comparison", "Inundation Early Warning" and "Disaster Assessment". These five groups will be responsible for carrying out the respective research. Members of each group will comprise the experts nominated by participating Members of Typhoon Committee and will be led by the Chief of the Research Group.

- **Field campaign (FC):** Led by WGM of Typhoon Committee, in cooperation with WGH and WGDRR, to be tasked with the operation of the observations in the two experimental regions.
- **Research on Mechanism (RM) and Model Comparison (MC):** Led by WGM and to be tasked with research on key techniques in typhoon intensity analysis, impact of observation in data assimilation of NWP models for tropical cyclone structure and intensity analysis and forecasting, the mechanism behind the structure and intensity changes of the offshore and landfalling typhoons, the comparison of the NWP models on offshore and landfalling typhoons structure and intensity changes, and the development of physical parametrization in NWP models to improve tropical cyclone intensity forecasts.
- **Inundation Early Warning (IEW) and Disaster Assessment (DA):** Led by WGH and WGDRR of Typhoon Committee respectively, to be tasked with

research on the effect of the intensity changes of typhoons on the storm surge and the flood forecasting of the landfalling typhoons, as well as studying the effect of the intensity changes of the typhoons on disaster impact.

5.2 Contributions from TC members

(1) Management participation: Each participating Members' responsible person in charge of the Typhoon Committee's affairs will be the OC member, who will participate in the organization of this project and coordinate the members' domestic activities related to this project (promotion, linkage with existing projects, and resource mobilization).

(2) Establishing appropriate domestic projects: As per the assigned task, members are advised to set up corresponding domestic projects in order to facilitate project implementation.

(3) Participation in field campaign of the target typhoons: To implement meteorological and hydrological observation of typhoons, to organize domestic observation, and to select appropriate experts to participate in other members' observations during the passage of the target typhoons.

(4) Participation in the application of the observed data research demonstration project: Participating Members will select meteorologists, hydrologists and DRR experts to participate in the five research groups and to carry out the corresponding research.

5.3 Logistics and funding support

(1) Funding field campaign: Participating Members will be responsible for funding the operational costs and the acquisition of the equipment required for the intense and non-conventional observation of the target typhoons.

(2) Funding research demonstration research: WGM, WGH and WGDRR of Typhoon Committee will establish the appropriate AOPs to link with this project and to allocate TCTF funding support for relevant activities. Members should consider inviting experts from TC Members to carry out research via their fellowship scheme.

(3) Funding the meeting of the Scientific Steering Committee and Organizing Committee: Allocation from the TCS and AWG budget and funding support from WMO, will fund the meeting of the SSC, OC and the principal scientists, while contributions from the WGs (e.g. WGM and TRCG) budget will cover travel expenses for the chiefs of the 5 research groups to attend the IWS.

(4) Logistics: TCS will be responsible for the correspondence and logistics of the SSC and OC, the coordination of the TC Members and WGM, WGH and WGDRR, as well as providing assistance on the logistics of the implementation of this project.

5.4 International cooperation

(1) Cooperation among Members: This project will enhance cooperation among TC Members and the collaborating Typhoon Committee Working Groups through its implementation, and will also promote linkage between the Members' research activities and the Typhoon Committee's.

(2) Cooperation with WMO demonstration project: The project will work closely with WMO SCMREX in conducting joint observation in the South China Sea Observation Region. Data and research outcomes will be shared between these two projects. The outcome of this project will also be shared to TC Members and other regions through the two WMO demonstration projects: "Typhoon Landfall Forecast Demonstration Project (WMO-TLFDP)" And "Tropical Cyclone Ensemble Forecast Project (WMO-TCEFP)".

(3) Cooperation with international organizations: This project will promote cooperation between the Typhoon Committee and ESCAP in the area of disaster risk reduction, and close cooperation is expected with PTC through ESCAP. Further cooperation with WMO/TCP and WMO/WWRP will be made during research in observation technique and numerical simulation and evaluation, and with the WMO/WWRP/WGTRM typhoon panel in relation to the work on the mechanisms behind the intensity changes of typhoons.

(4) Application for the WMO Demonstration Project: This will be made based on the design and the goal of this project taking into consideration the focus of important research works of TC Members, WMO/TCP and WMO/WWRP. The target is to make parts

of this project as the WMO demonstration projects, such as “Typhoon Intensity Forecasting Demonstration Project (FDP)”, “Typhoon numerical model comparison research demonstration project (RDP)” and “Typhoon Catastrophic Risk Assessment and Prevention technique research demonstration project (RDP)”.

6. The major progress

Soon after the 45th Session, the WGM drafted the project proposal (first draft). In March 2013, former TC Chair JIAO Meiyan (Deputy Administrator of CMA), at the request of the current TC Chair, organized a thematic symposium with the participation of the WGM Chair, the Chief Scientist of SCMREX (LUO Yali, the professor of Chinese Academy of Meteorological Sciences) and the WMO/WGTMR Chair (DUAN Yihong, President of Chinese Academy of Meteorological Sciences). The proposal (first draft) was then submitted to TRCG Chair (AWG member) for feedback.

Based on discussions during the symposium and recommendations from the AWG, the proposal was then revised into a second draft, which was submitted for discussion at the AWG Meeting in Bangkok on May 10, 2013.

Based on the input from AWG meeting, WGDRR and WGH workshop in 2013, the proposal was then revised again into the third draft, which was submitted for discussion at the 8th IWS in Macao, China on December2-7, 2013. Based on the proposed amendments at the WGM parallel meeting during 8th IWS and the input after the meeting from Japan Meteorology Agency (JMA) and Hong Kong Observatory (HKO), the proposal was then revised a third time into the fourth draft, which was submitted for endorsement at the 46th session of ESCAP/WMO Typhoon Committee in Bangkok, Thailand on February 10-13, 2014.

After all year prepare, the proposal of this project has been endorsed in 46th Typhoon Committee Session, held on 10-13 February 2014 in Bangkok.

The Organizing Committee (OC) Meeting, which was expected to be held in June 2014, was not been able to be realized due to the time conflict of the OC Members with their own commitments during the typhoon season. Nevertheless, the field campaign conducted by CMA and HKO in 2014, which including:

- The reconnaissance flights were conducted by HKO, in collaboration with the Hong Kong Government Flying Service (GFS), to collect meteorological observations (wind) for tropical cyclones over the South China Sea continued in 2014.
- The contract for the supply of a dropsonde system to be installed on the new GFS fixed-wing aircraft for obtaining vertical atmospheric profiles in 2014.
- The mobile sounding was conducted by STI/CMA to collect vertical atmospheric profiles for typhoon landfalling in East China region continued in 2014.
- The satellite buoy array (including 5 buoys) established successfully in South China Sea. Two tropical cyclones (Rammasun and Kalmaegi) path over the buoy array in 2014, the essential atmospheric and oceanic parameters under typhoon conditions (including the air-sea flux) obtained.
- The technique of rocket rounding developed by CMA as well as the unmanned aerial vehicle (UAV) in 2014.

The following research project related to the EXOTICA, on the air-sea interaction and its influence on tropical cyclone intensity change (National basic research programme) and the High Resolution Model (WGM-PP) were carrying out by CMA in 2014 and beyond.

7. Future planning and implementation schedule

The project is scheduled to be implemented from 2014 to 2017. The detailed schedule in 2015 and beyond is as follows:

(1) 2015:

- To hold the OC meeting in 2015 for preparing the implementation (field campaign in 2015) of the experiment, including establishing the Scientific Steering Committee and the Research Groups (Field Campaign, Basic Research and Typhoon Modelling) and confirm the tasks of participating TC Members on the field Campaign in 2015.
- To pilot the field campaign include trial target observations for 1-2 tropical cyclones and testing of new instrument (UAV, aircraft and rocket drop-sound) as

well as the mobile GPS rise-sound.

- Demonstration research on tropical cyclone intensity change by using target typhoon data from the field campaign (to be included in the TC Fellowship Scheme) with the focus on target typhoon data assimilation technique development.

(2) 2016:

- Implementing the field campaigns for 3-5 target typhoons from June to October.
- Demonstration research on tropical cyclone intensity change by using target typhoon data from the field campaign (to be included in the TC Fellowship Scheme) with the focus on the mechanism of target typhoon structure/ intensity change and tropical cyclone model system development.

(3) 2017:

- Joint scientific demonstration research on the effect of intensity changes on storm surge and the flood forecasting of landfalling typhoon and its related disasters risk.
- Consolidating the outcomes of the project and submitting the project summary report to the Typhoon Committee Session in 2018.