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An introduction to TC forecasting system at NHMS of Viet Nam

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Summary

The current status of tropical cyclone forecasting system at NHCMF of Viet Nam will be reported. In fact, TC forecasting methods at NCHMF is basically based on synoptic charts, satellite and radar images, and NWP products is derived from both of deterministic and ensemble prediction system, both of global and regional modelling system. Final forecasting bulletin is issued by forecaster and broadcast to public media and natural disaster preventing and preparedness units of the Government. At present, the quality of TC forecast and warning at NCHMF only has small error for 24hrs lead time, but still large for higher lead times such as 48hrs and 72hrs. In addition, there are some gaps in forecasting correctly severe weather phenomena in combination with TC such as wind-gust, heavy rainfall, storm surge and flash flood. The challenges, needs and improvement plans at Viet Nam in order to improve the early warning capacity for TC cyclongenesis and the quality (both in track and intensity prediction) of TC forecasting bulletin is reported.

1. Tropical Cyclone Monitoring, Analysis and Forecasting

1.1. Tropical Cyclone Monitoring

.1.1 Tropical Cyclogenesis Monitoring

Monitoring and early warning the cyclogenesis of tropical storm (TS) and tropical depression (TD) are the most important mission of all over centers of Typhoon forecast. In Vietnam, the cyclogenesis warning and monitoring are based on the 3 following methods:

+ Using Drovak method for analyzing cloud patterns which could be developed to TD or TS;

+ Using upper air and surface analysis maps;

+ Using NWP products including regional model running at National Center for Hydro-Meteorological Forecasting (NCHMF) such as HRM and WRF, and global model forecast from international centers (NCEP, ECMWF, JMA, DWD, CMC);

.1.2 Tropical Depression (TD) Warnings

Whenever detecting a low pressure with high potential of being developed to TD, NHMS will make a fixed-form bulletin and issue to NCHMF's official website (www.nchmf.gov.vn) and also send the bulletin to other public media systems such as television, radio, government journals and other important offices of government: Central Committee of Flood and Storm Control (http://www.ccfsc.gov.vn/), Department of Searching and Rescue, Vietnam coastal radio systems, etc;

.1.3 Challenges, Needs and Improvement Plans

In NCHMF, there are two main challenges for forecasters in making final decision of monitoring, warning and forecasting of TD and TS including:

+ How to exactly forecast the time that a low pressure has potential to develop into tropical depression, or a tropical depression has potential to develop into tropical storm;

+ Forecasting detail areas (including land and sea regions) effected by TC or TD;

1.2 Tropical Cyclone Analysis

1.2.1 Parameters and Methods

Parameter	Time (UTC)	Methods	Other sources
Position; intensity; maximum wind; maximum gust wind; motion direction of TC	Normally is every 6 hours at 00, 06, 12 and 18UTC In case of urgent	With satellite images, we have been using Dvorak TC intensity estimation technique for determining intensity of TC every 30 minutes to 1 hours depending on the	Beside the intensity estimation from Dvorak method, we have been using others sources for making TC warning including international

(previous time and next 24, 48 and 72 hours)	situation (TC is going to made landfall in next 24hrs), warning bulletin can be issued every 1hrs	location of TCs effected to Vietnam;	warning bulletins (via GTS, RSMC or internet); TC information extracted from NWP production (both global forecast (NCEP, ECMWF, DWD, JMA) and regional models (HRM, WRF) running at NCHMF, ex.: track forecast, intensity forecast, strike maps from ensemble forecasts ..)

1.2.2 Challenges, Needs and Improvement Plans

At present, we have no specific numerical model for tropical cyclone forecasts, the information of TC has been extracted from forecast fields of deterministic and ensemble forecast. All current forecasters are quite young with limited forecasting experiment. Number of senior forecaster is limited. Therefore we would like to send forecasters to developed international centers (ex. JMA, NOAA, BoM, HKO, etc.) for short and long training in operational environments and the international centers can send their experts for helping us during TC activities.

1.3 Tropical Cyclone Forecasting

1.3.1 Parameter and Method

Parameter	Issuance Time (UTC)	Lead time (hours)	Methods
Position; intensity; maximum wind; maximum gust wind; motion direction of TC	- Normally is every 6 hours at 00, 06, 12 and 18UTC - In case of urgent situation (TC is going to made landfall in next 24hrs),	- 24hrs, 48hrs and 72hrs - up to 24hrs with every 3hrs interval	- Synoptic map analysis - TC information extracted from NWP productions at NCHMF: - Track forecast from international centers: - Track forecast from ensemble forecast of ECMWF: - Track forecast from models: - Forecast maps from Hong Kong center (HKO) - Forecast maps from US Navy - Forecast maps from Japanese

	warning bulletin can be issued every 1hrr		Meteorological Agency (JMA)

1.3.2 Challenges, Needs and Improvement Plans

In fact, TC forecasting methods at NCHMF is basically based on synoptic charts, satellite and radar images, and NWP products is derived from both of deterministic and ensemble prediction system, both of global and regional modeling system. At present, the quality of TC forecast and warning at NCHMF only has small error for 24hrs lead time, but still large for higher lead times such as 48hrs and 72hrs. In addition, there are some gaps in forecasting correctly severe weather phenomena in combination with TC such as wind-gust, heavy rainfall, storm surge and flash flood. Almost forecaster is so young and has a little experiment and they are not familiar to probabilistic products such as strike map, etc. NCHMF's forecaster can access some global and regional NWP products during operation. However, there is no high-resolution NWP products (2-5km) at NCHMF. NCHMF doesn't also has any early cyclongenesis warning system.

In order to improve TC forecast quality, beside of modernizing observation network in which more pay attention to East Sea, the forecasting technology and human resources should be modernizing. For human resources, we need a medium and long training on job related to TC forecasting and analysis. Related to forecasting technology, we need standard operational procedure for TC forecasting. We also need a high-resolution regional modeling system with resolution about 2-5km. In addition, we also need a early warning system for sudden changes in TC track and intensity.

1.4 Tropical Cyclone Products

1.4.1 TC Products

After discussing the forecast of position and intensity of TC, forecasters will use in-house software named TC Aid for plotting official TC forecast map as shown in Fig. 1 in which show out a possible track forecast up to 72hrs with interval of 24hrs. The dark blue area is potential area where the TC center can pass (or error radius), and red area is region where can be affected by strong wind of 10^{th} Cat (beaufort category) or more, and light blue area is region where can be affected by strong wind of 6^{th} Cat (beaufort category) or more. In addition, the detail forecast of the position, intensity (10 minutes maximum wind speed, minimum pressure at center) at interval of 24hrs is also shown out. The forecaster is who make final decision for this TC forecasting map and final forecasting bulletin will broadcast to public media and natural disaster preventing and preparedness units of the Government.

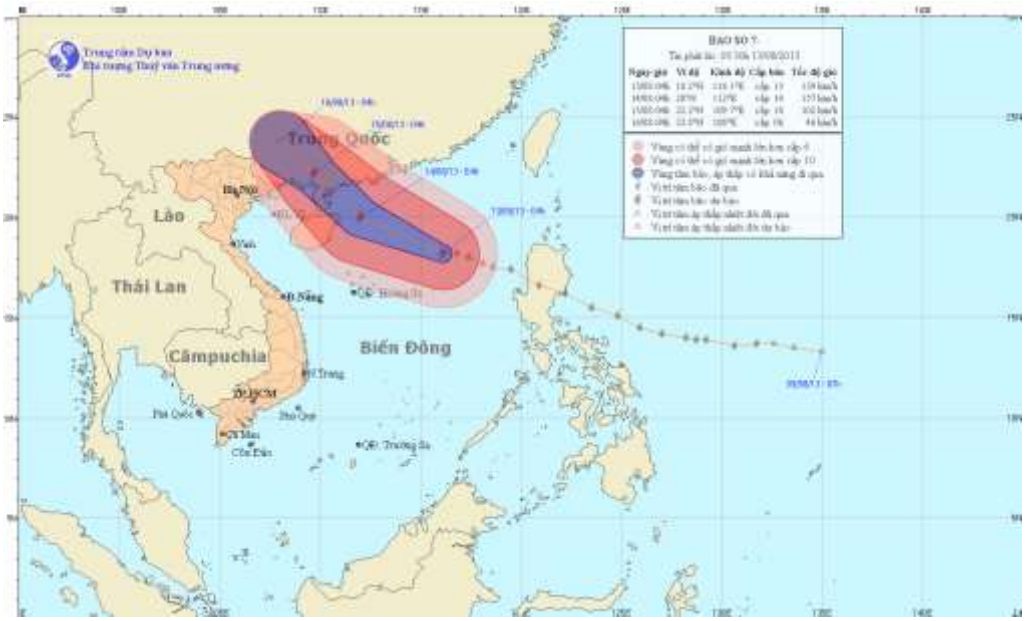

Fig . An example for TC track and intensity forecasting map issued by NCHMF

1.4.2 Challenges, Needs and Improvement Plans

- *Challenges*: At present, the quality of TC forecast and warning at NCHMF only has small error for 24hrs lead time, but still large for higher lead-times such as 48hrs and 72hrs. In addition, it is difficult to correctly predict severe weather phenomena in combination with TC such as wind-gust, heavy rainfall, storm surge and flash flood. The human resource is limited in quantity and meteorological knowledge and especially in TC forecasting experiment and capacity in effectively use probabilistic products such as strike map, etc. NCHMF's forecaster can access some global and regional NWP products during operation. There is no high-resolution NWP products (2-5km) and sudden change warning system for TC track and intensity.

- *Needs*: we need a medium and long training on job related to TC forecasting and analysis. Related to forecasting technology, we need standard operational procedure for TC forecasting. We also need a high-resolution regional modeling system with resolution about 2-5km in order to well capture the thermo-dynamical characteristics of TC. In addition, we also need a early warning system for sudden changes in TC track and intensity.

- *Improvement plans*: we have a big plan to modernize Hydro-Met services at NHMS of Viet Nam. Related to TC forecasting, we will build a standard operational procedure for TC forecasting in which provide more useful products not only for track and intensity prediction but also for forecasting sudden change of track and intensity. The high-resolution regional modeling system will be interpreted soon based on non-hydrostatic model in combination data assimilation in which effectively assimilate local observation and remote sensing data (satellite, radar, wind profiler, etc). The operational tools that support for forecaster will be upgraded according to data integrated, flexible, visualizable, informative

solutions (all in one click).

1.5 Computing Platform (including software)

The current computing and storage systems at the NCHMF with their major characteristics are listed below:

Machine	Quantity	Peak performance	No. of CPU	Memory	Year of Installation
SAN Storage	1	40TB			2010
	1	50TB			2013
Dell HPC 6 nodes	1	1.2 TFLOPS	48	88 GB	2011
IBM HPC 16 nodes	1	200 GFLOPS	64	32 GB	2008
IBM HPC 8 nodes	1	28 GFLOPS	16	32 GB	2006

The SAN storage is used to store all kind of dataset such as conventional observations (synop, temp, pilot, etc), non-conventional data (satellite, radar, AMV, ASCAT, etc), global NWP data (GFS, GEM, GSM, NOGAPS, etc) and regional NWP data (SREPS, LEPS).

The HPC cluster system of 16 nodes is used to run operational short-range ensemble forecast system (SREPS) including 20 members based on multiple model - multiple analysis approach.

The HPC cluster system of 8 nodes is used to run operational local ensemble prediction system (LEPS) for 3-5 days ahead including 21 members (integration of HRM model with 21 input from global ensemble prediction system of NCEP based on GFS model).

The HPC cluster system of 6 nodes is used to run non-hydro static model such as NHM, WRF along with regional data assimilation (3DVAR) in research mode only.

For Satellite imagery, NHMS of Vietnam uses version GMSLPD for window. This program support analyzing a 3-dimensional structure of cloud system and weather conditions through applying the cloud image clipped data from MTSAT. Figure 2 below show the interface of GMSLPD. The software is provided by JMA.

For creating typhoon track maps, NHMS use TCAid. TCAid is a tool that facilitates typhoon forecasters in operational forecast. It support typhoon forecasters in creating track map including all information related to a certain typhoon such as position, maximum wind speed, direction of movement or areas of strong wind, etc…(Figure 3 is the interface of TCAid, Figure 4 is a TC forecasting product of TCAid). The tool is developed at NCHMF.

When tropical cyclones approach close to the coastline, NHMS of Vietnam will operate all the stations within the effect of tropical cyclone every hour or 30 minutes. The

data will be shown in a tool called TYPH. This tool facilitates typhoon forecasters in visualizing data in details. Figure 5 below is the interface of TYPH.

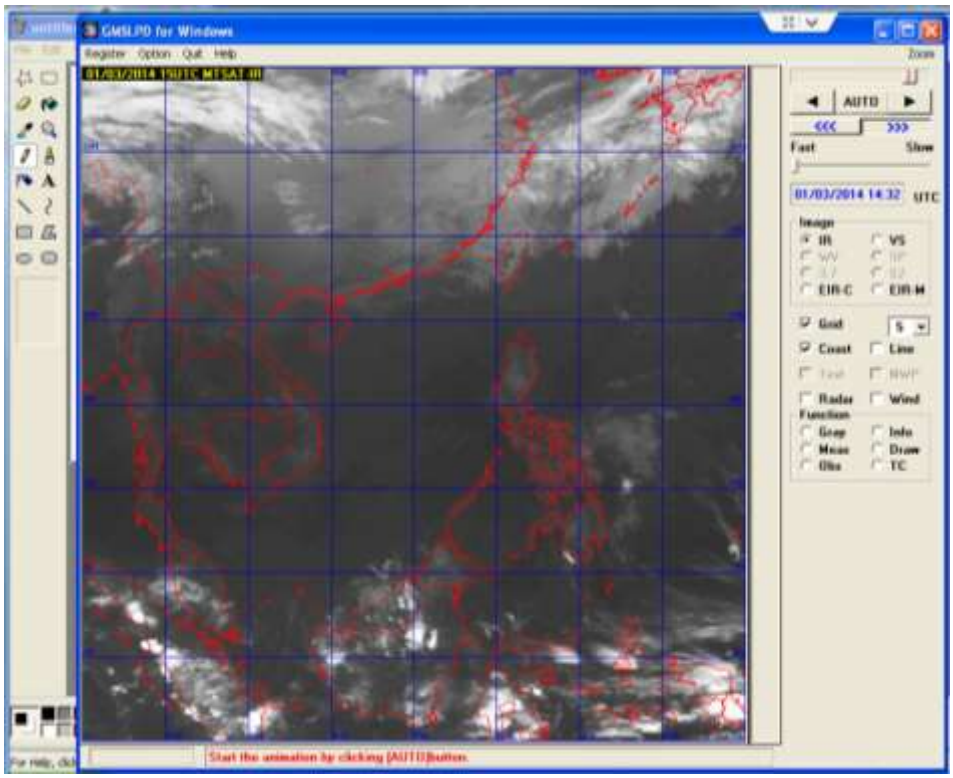

Fig. 2: Interface of GMSLPD

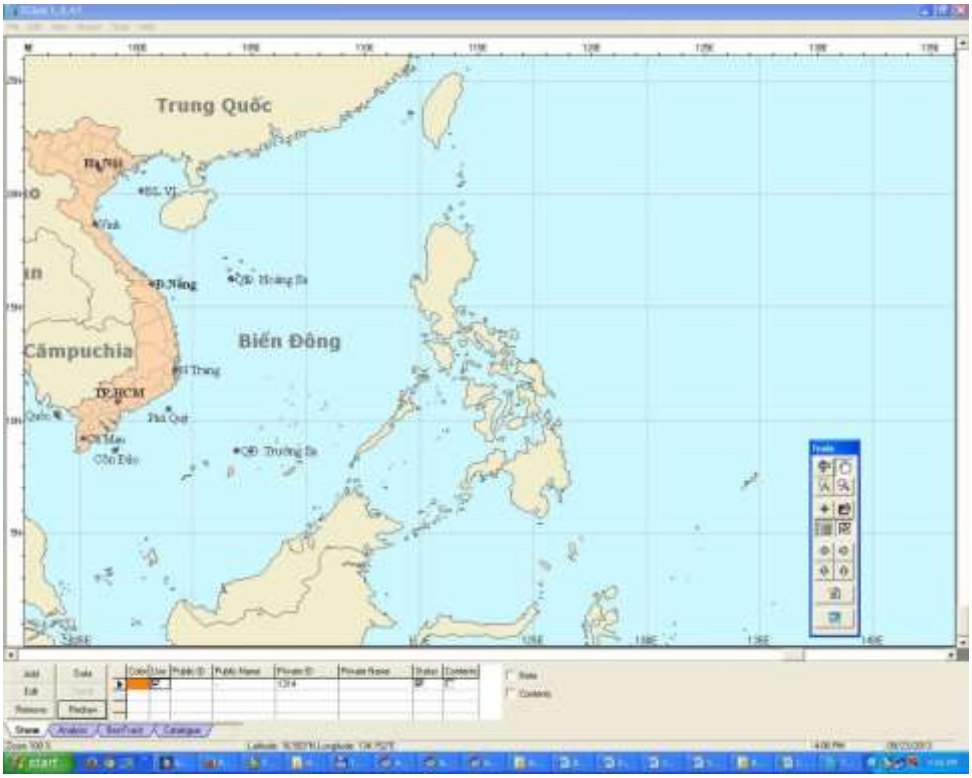

Fig. 3: TcAid's interface

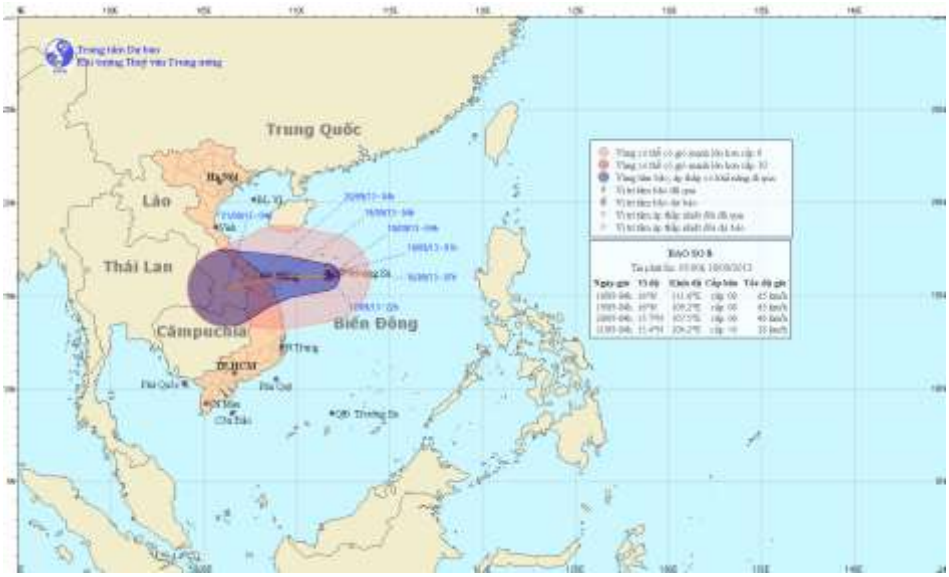

Fig. 4: Track map created by TcAid

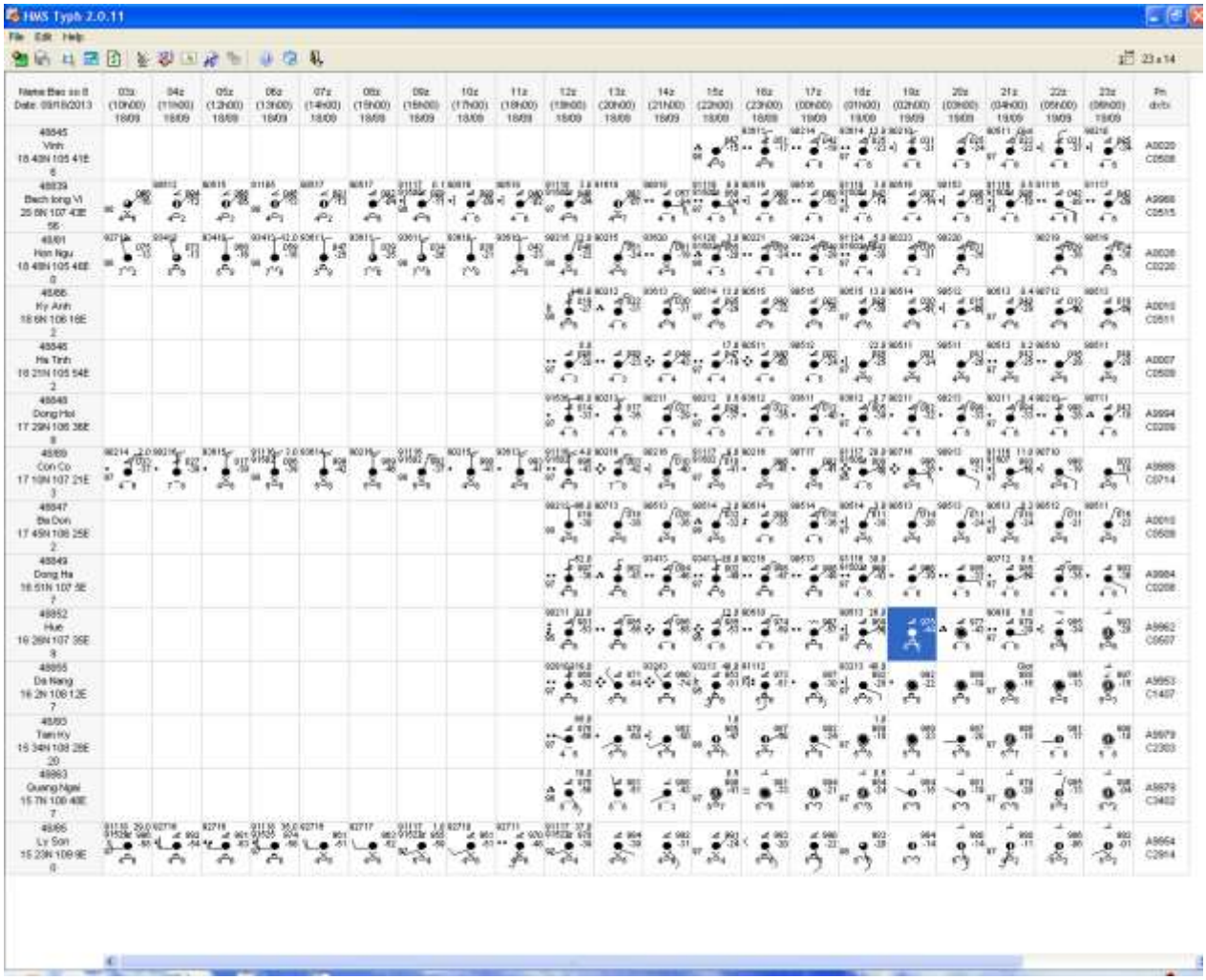

Fig. 5: TYPH's interface

2. Numerical Weather Prediction Status for Effective Warning

The SREPS consists of 20 members by running 4 regional models including HRM, WRF-ARW, WRF-NMM, BoLAM in hydrostatic mode with initial and boundary conditions from 5 global forecasts (GEM, GFS, GME, GSM, NOGAPS). The forecast range is 3 days ahead with every 3 hours output. The model runs operationally 4 times a day at 00Z, 06Z, 12Z and 18Z. The resolution is 0.15^0 x 0.15^0, 201 x 161 grid points, 31 levels. The forecasting domain is shown in Fig. 6. The Operationally available EPS products from SREPS include:

+ Ensemble mean and stamp map
+ Probability maps for severe weather phenomena
+ EPS diagrams
+ Input data for wave and hydrological models

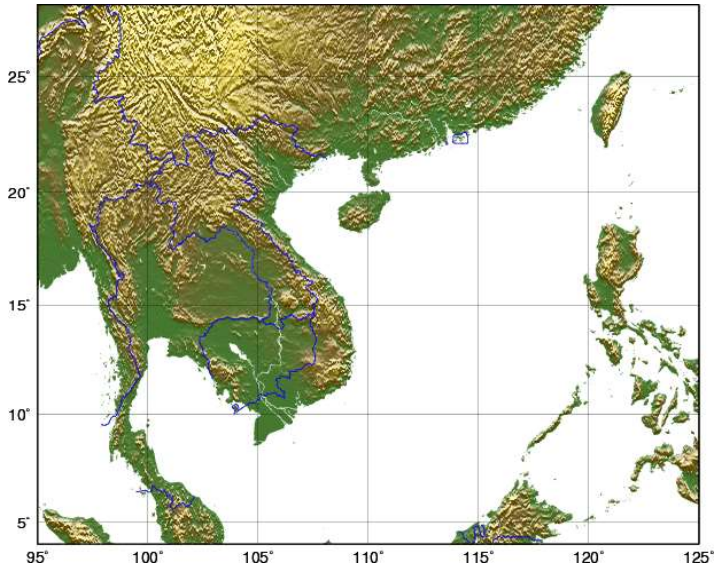

Fig. 6: Integrating domain of SREPS

The LEPS consists of 21 members (by running HRM model with ICs and BCs from 21 members of GEFS) with resolution of 0.2^0 x 0.2^0, 201 x 161 grid points, 31 levels, 3-hour interval output. This system operates 4 times per day (00Z, 06Z, 12Z and 18Z) and forecast 5 days ahead. The forecasting domain of LEPS is shown in Fig. 7. The Operationally available EPS products from LEPS include:

+ Ensemble mean and stamp map
+ Probability maps for severe weather phenomena
+ EPS diagrams

The NAEFS is a combination of the two global ensemble forecast systems: GEFS from NCEP and CEFS from CMC with resolution of 1^0 x 1^0 for first week and 2.5^0 x 2.5^0 for second week. The product is provided 2 times a day (00UTC and 12UTC) up to 10 days ahead. The NAEFS is also used for early warning of cyclone-genesis.

Tropical Cyclone Track System: A tropical cyclone (TC) tracker is developed to track TC movement from model forecasts. TC tracks are detected from global products and regional ensemble systems.

Tropical Cyclone Track Ensemble System: an ensemble mean track from all track predictions from global models, operationally regional NWP systems and operational track forecasts of international centres such as JMA, HKO, CMA, Guam, US Navy, etc.

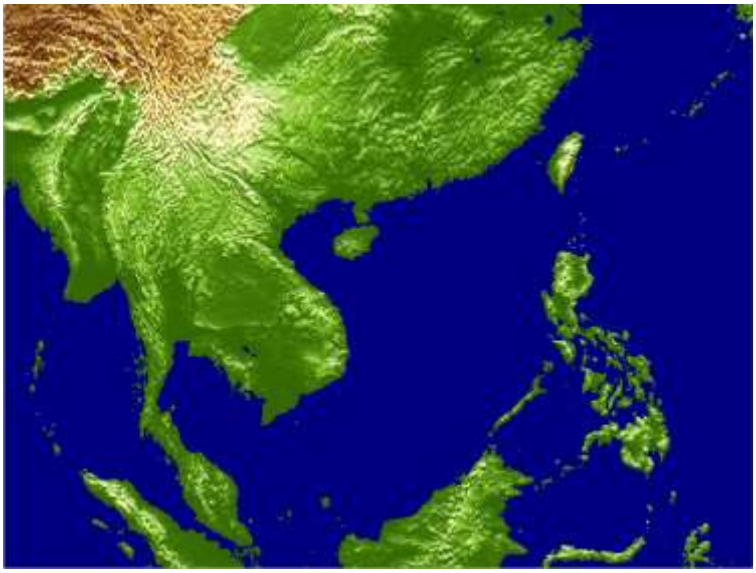

Fig. 7: Integrating domain of SREPS

2.1 NWP in Operational Use

The raw data of global NWP models received through the Internet (mainly is via TEIN III network) is given Table 1 as following:

Table 1: Global NWP products in operational use at NCHMF

Model	**Domain (square degree)**	**Resolution (horizontal & vertical)**	**Initial Time**	**Forecast Range (hours)**	**Run by (own/foreign centers)**
GEM	79.8^0E-145.2^0E; 10.2^0S-40.2N	0.6^0 x 0.6^0, 28 pressure levels	00UTC and 12UTC	72hrs with 3hr interval	CMC (Canadian Meteorological Center)
GFS	60^0E - 155^0E; 15^0S - 60^0N	0.5^0 x 0.5^0, 26 pressure levels	00UTC, 06UTC, 12UTC and 12UTC	72hrs with 3hr interval	NCEP
GME	80.25^0E - 130.2^0E;	30km, 60	(00 and	72hrs with	DWD (Deutscher

	5^0S - 35^0N	model levels	12UTC) & (06 and 18UTC),	3hrs interval 48hrs, 3hrs interval	Wetterdienst)
GSM	60^0E - 155^0E; 5^0S - 60^0N	0.5^0 x 0.5^0, 21 pressure levels	00UTC and 12UTC	72hrs with 3hr interval	JMA
NOGAPS	80^0E - 145^0E; 10^0S - 40^0N	1.0^0 x 1.0^0, 29 pressure levels	00UTC and 12UTC	72hrs with 6hr interval	US Navy
UM	78.875^0E - 145.125^0E; 10.125^0S - 40.125^0N	0.5625^0 x 0.375^0, 10 pressure levels	00UTC and 12UTC	72hrs with 6hr interval	KMA
IFS	80^0E - 140^0E; 20^0S - 40^0N	0.125^0 x 0.125^0, 25 pressure levels	00UTC and 12UTC	240hrs with 6hr interval	ECMWF
GEFS	80^0E - 145^0E; 10^0S - 40^0N	1.0^0x1.0^0, 26 pressure levels	00UTC, 06UTC, 12UTC and 12UTC	6 days with 6-hour interval	Global EPS of NCEP (21 members)
VarEPS	80^0E - 140^0E; 20^0S - 40^0N	0.25^0 x 0.25^0, 8 pressure levels	00UTC and 12UTC	240hrs with 6hr interval	Global EPS of ECMWF (51 members)

Beside of global NWP products, NCHMF only has their own regional deterministic and ensemble modeling system as shown in Table 2 as following:

Table 2: Regional NWP products in operational use at NCHMF

Model	**Domain (square degree)**	**Resolution (horizontal & vertical)**	**Initial Time**	**Forecast Range (hours)**	**Run by (own/foreign centers)**
WRF	96^0E - 124^0E; 5^0S - 27^0N	15km x 15km and 40 vertical levels	00UTC and 12UTC	72hrs with 3hr interval	NCHMF (deterministic modeling system

					in combination with 3DVAR)
WRF	96^0E - 124^0E; 5^0S - 27^0N	5km x 5km and 60 vertical levels	00UTC and 12UTC	48hrs with 1hr interval	NCHMF (in research mode, inputs from WRF 15km)
SREFS	0^0-28^0N; 95^0E-128^0E	0.15^0 x 0.15^0, 201 x 161 grid points, 31 levels.	00UTC, 06UTC, 12UTC and 12UTC	72hrs with 3hr interval	NCHMF (Regional EPS)
LEPS	0^0-32^0N; 91^0E-131^0E	0.2^0 x 0.2^0, 201 x 161 grid points, 31 levels	00UTC, 06UTC, 12UTC and 12UTC	120hrs with 6hrs interval	NCHMF (Regional EPS)

2.2 Application Techniques of NWP Products for Operational Forecasts

The global and regional NWP products of deterministic and ensemble system is display as weather chart including surface maps (rainfall, wind speed and direction, pmsl, tmax, tmin, specific and relative humidity, etc) and upper air maps (i.e. geopotential height, wind, divergence, convergence, stream line, potential vorticity, relative vorticity, etc). For some speicial location, the crossing section diagram, Skew-T diagram, Meteogram and EPSgram is displayed. For EPS products, the probability maps is displayed for special atmospheric variables such as heavy rainfall, strong wind, track, etc.

2.3 Challenges, Needs and Improvement Plans

In fact, NCHMF use a lot of global and regional NWP products in operational TC prediction. However, there still aren't any information about quality of these NWP system. This caused a lot difficult for forecaster during the operational forecast. In addition, most of forecaster is well training in synoptic method and has a little knowledge in NWP. Hence, they sometime misunderstand the true meaning of NWP products, specially for probabilistic products. We really need some short and medium training course for NCHMF's forecaster so that they could more pay attention to how to understand and interpret NWP products.

Major changes in NWP system which are expected in the next year

+ Purchase new HPC system that peak performance can be up to 60TFlops
+ Operational real time verification system for all NWP products

+ Operationally regional data assimilation system based on 3DVAR technique
+ Operational MOS system based on UMOS, Kalman Filter and GMOS methods for all stations. The predictands consist of precipitation, temperature at 2 meters, dew-point temperature at 2 meters, maximum and minimum temperature, wind direction and speed at 10 meters, cloud amount and visibility.
+ Operational Ensemble MOS for SREPS and LEPS systems
+ Operational EMOS for SREPS and LEPS systems

Major changes in the operational deterministic forecasting system which are envisaged within the next 4 years

+ Operational data assimilation based 4DVAR or EnKF technique in which all conventional and non-conventional data sources will be used.
+ A new deterministic forecast system: The Fig. 8 show the proposal for future NWP system that based on nonhydrostatic modeling system (ex. WRF model). The WRF model will be used to run for 4 domains as following:
    - ***Region grid*** (abbreviation of **R**) will cover graphical domain from 10^0S-50^0N; 65^0-150^0E. The WRFARW model will be run with 12km resolution and up to 72 hour. The initial and boundary conditions can be from IFS (ECMWF) or GSM (JMA) global model (we are going to purchase all products of ECMWF). The boundary condition updating cycle is 3 or 6 hours. The data assimilation system will be used is 3DVAR with every 6 hour cycle. The local data is used for 3DVAR as shown in table 1 except for TCBOGUS source.
    - ***Viet Nam grid*** (abbreviation of **VN)** will cover graphical domain from 0^0-30^0N; 95^0-135^0E. The WRFARW model will be run with 4km resolution and up to 48 hour. The initial and boundary conditions is get from analysis and forecast of **R** grid (nesting one way). The boundary condition updating cycle is 3 hours. The data assimilation system will be used is one of following scheme (3DVAR/4DVAR/EnKF) with every 6 hour cycle. The local data is used for data assimilation system as shown in table 1 except for TCBOGUS source and along with humidity data from analysis of cloud based on LAPS scheme (this scheme is using in Hong Kong Observatory)
    - ***City grid*** (abbreviation of **C)** has integrating domain depend on size of city will be chosen to nowcasting. The WRFARW model will be run with 2km resolution and up to 12 hour. The initial and boundary conditions is get from analysis and forecast of **VN** grid (nesting one way). The boundary condition updating cycle is 1 hour. The data assimilation system will be used is one of following scheme (3DVAR/4DVAR/EnKF) with every 3

hour cycle. The local data is used for data assimilation system as shown in table 1 except for TCBOGUS source and along with humidity data from analysis of cloud based on LAPS scheme. If don't have enough computing resources, the forecast for this domain can be get from **VN** grid by applying dynamic downscaling method.

- ***TC grid*** (abbreviation of **TC**) will cover a domain has size of 10^0 x 10^0 with the present TC center locate at domain center. The HWRF model will be run with 12km or more higher depending on computing resources and up to 72 hour. The initial and boundary conditions can be from IFS (ECMWF) or GSM (JMA) global model (we are going to purchase all products of ECMWF). The boundary condition updating cycle is 3 hours. The data assimilation system will be used is 3DVAR with every 6 hour cycle. The local data is used for 3DVAR as shown in table 1 that including TCBOGUS source. The intergrating domain will move according to analyzed TC center with the same size (10^0 x 10^0).

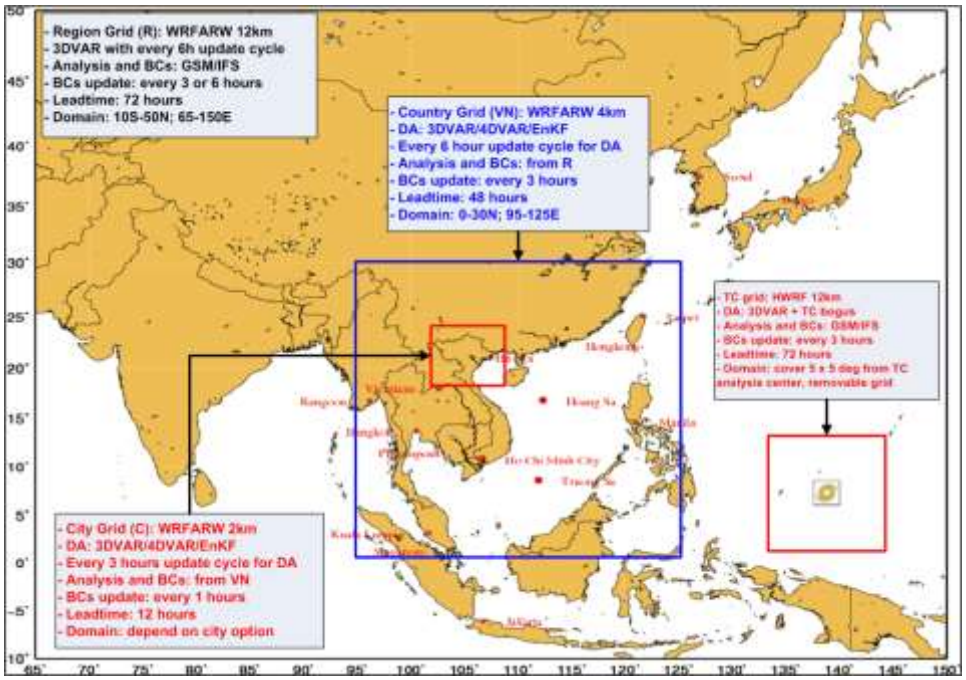

Fig. 8: Schematic diagram for proposal NWP system

Planned Research Activities in NWP

+ Research techniques to use nonconventional data sources (radar, satellite, etc) to put into data assimilation scheme
+ Apply 4DVAR or EnKF technique for regional data assimilation system
+ Apply 2-5km non-hydrostatiscal NWP model and take into the operation
+ High-resolution regional ensemble prediction modeling system for nowcasting and short-range forecast.

+ Develop real-time QC system for conventional and nonconventional data
+ Develop real-time verification system based on state of the art verifying methods
+ Regional forecasting system for seasonal prediction

Planned Research Activities in Nowcasting

+ Develop a complete nowcasting system (such as SWIRL of HKO)
+ Forecasting the movement of thunderstorm cloud based on MTSAT satellite data: using variational echo technique (VET) in combination with Semi-Largrange scheme

Planned Research Activities in Long-range Forecasting

+ Apply regional climate model such as RegCM, REMO, etc and take into the operation.

3. Storm Surge

1) Storm Surge Information
   a. Issuing
2) How the information is issued?
   a. Independent storm surge information
   b. Included in TC information
   c. Included in tide information
3) What products (observations /forecasts) are referred to?
   We usually refer to JMA storm surge forecasting products
4) If your Service runs a storm surge model by yourself, please describe the way in detail.

Model	**Domain and resolution**	**Forecast Range (hours)**	**Frequency**	**Considered factors (Tide/ensemble/ inundation, etc.)**
JMA	Model area cover: 8-22°N and 105 - 120°E -Grid type: Rectilinear. - Grid solution: two minutes.	48hrs with 6hrs interval	4 forecasts/day	
CTS	Model area cover: 8-23°N and 104 - 120°E -Grid type: Rectilinear. -Grid solution: two minutes. 1/4degree	48hrs with 6hrs interval	4 forecasts/day	
Delfd3D	Model area cover: 8-22°N and 105 - 120°E -Grid type: Curvilinear.	48hrs with 6hrs interval	In research mode	Tidal

5) In case your Service issue storm surge forecast without your own model, please briefly explain the operational procedure.

Based on empirical formula of storm surge height with, maximum wind speed, angle between the wind direction and the normal to the shoreline, fetch length and mean water deep of the location.

4. Effective Warnings

4.1 Emergency Response for TC Disasters

4.1.1 Legal Framework for TC Disaster Management

+ Reference Code: 172/2007/NĐ-CP: National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020 (published on 16 Nov 2007)
+ Implementation plan for the National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020 (published on 29 Sep 2009)
+ The Community-Based Disaster Risk Management (CBDRM) action plan (Issued with Decision No. 1002/QD-TTg dated 13/07/2009)

All these legal framework can be referred at the address:
http://www.ccfsc.gov.vn/KW34707D/Legal-Documents.aspx

4.1.2 Emergency Response Mechanism

The Emergency Response Mechanism is described more detail in the above mentioned legal documents.

4.1.3 Organs Responsible for Warnings and Evacuation Orders

Severe Weather Phenomena	Organs responsible for Warnings	Organs responsible for Evacuation Orders
Tropical Cyclone	National center of Hydro-Meteorological Forecasting (NCHMF)	Central Committee of Flood and Storm Control at national and provincial level (CCFSCs)
Heavy Rain	NCHMF	CCFSCs
Strong Wind	NCHMF	CCFSCs
River Flood	NCHMF	CCFSCs
Storm Surge	NCHMF	CCFSCs

4.2 Warnings/Advisories for Severe Weather Phenomena

4.2.1 Tropical Cyclone

Warnings/Advisories and corresponding emergency responses	Warning for strong wind, heavy rainfall, flash flood and landslide, thunderstorm, storm surge, etc

Potential Disaster Risks	Strong wind, heavy rainfall, Flash flood, flood, inundation, thunderstorms, hails, etc… will be damaged to human lives and properties of people
Target (warning areas)	All of high potential effected areas will be warned
Meteorological variables/indices used for criteria/thresholds for warnings/advisories	Distance of current TC center in comparison with the coastal line or specific point, category of strong wind, 24hrs accumulated heavy rainfall, influenced radius of strong wind and heavy rainfall
Criteria/Thresholds	Based on climatology (rare events) and dangerous levels (has very high potential in order to cause lost of human and properties)
Contents of Warning/Advisory Message	The warning includes the position, intensity and its effects to specific area about strong wind and heavy rain situation. In addition, the warning related to land slide, flash flood, storm surge and high wave is sometime included in TC warning bulletin or advisories

Sample Warning/Advisory Message	No: BGB14-17/ DBKT *Hanoi, Day 09 Month 11 Year 2013* **TYPHOON WARNING** **(No 14 – Haiyan)** At 090600Z, Typhoon Haiyan located near 13.5N – 114.8E, approximately 240km North of Song Tu Tay Island (Sparatly Islands). Maximum sustained wind speed near the center is estimated to be 14 – 15 Beaufort (150 to 183 km/h), gust 16 – 17 (184 to 220 km/h). Forecast to move West – Northwest at about 30 km per hour for the next 24 hours. At 100600Z, the position located near 16.7N – 108.3E. Maximum sustained wind speed near the center is estimated to be 13 – 14 Beaufort (134 to 166 km/h), gust 15 – 16 (167 to 201 km/h). Forecast to move Northwest at about 20 - 25 km per hour for the next 24 - 48 hours and downgrade into a Tropical depression. At 110600Z, the position is located near 20.8N – 103.8E, over the boundary of Vietnam-Lao. Maximum sustained wind speed near the center is estimated to be 6 – 7 Beaufort (39 to 61 km/h), gust 8 (62 – 74 km/h). Forecast to move North at about 15km per hour and downgrade into a Low for the next 48 - 72 hours. Next warnings will be issued at 091030Z.

4.2.2 Heavy Rain

Warnings/Advisories and corresponding emergency responses	- There are two kinds of heavy rain bulletins, one is from heavy rains occur over large area due to large scale environmental circulations, the another comes from heavy rains accompany with thunderstorms which are the result of local factors. - Once relevant authorities receive heavy rain bulletins from NHMS, they will immediately announce the content to people for better preparedness
Potential Disaster Risks	Flash flood, flood, inundation, thunderstorms, hails, etc… will be damaged to human lives and properties of people
Target (warning areas)	All of high potential affected areas will be warned
Meteorological variables/indices used for criteria/thresholds for warnings/advisories	The rainfall amount and high potential of thunderstorms will be used to be thresholds

Criteria/Thresholds	- For heavy rains due to large scale environmental circulations, the rainfall amount must be at least 16mm within 24 hours. - For heavy rains due to local factors, the rainfall amounts must be at least 25mm. Also, the thunderstorms must be high potential
Contents of Warning/Advisory Message	All warnings include the exact areas will be affected by heavy rain. The time of occurrence and the amount of rainfall are also mentioned. In addition, if heavy rains accompany with thunderstorms or hails, they must be included in the bulletins. Beside, the potential of flash flood, flood and inundation should be mentioned.
Sample Warning/Advisory Message	According to a Low is prevailing over red river delta area from surface up to 5000m high, there could be heavy rain from 11 of August. The areas will be affected including the whole red river delta areas, provinces from Thanh Hoa to Ha Tinh. This occurrence could be ranged from 11 to 15 of August. All the mountainous areas should aware flood as well as flash flood. Next warnings will be issued at 0906Z.

4.2.3 Strong Wind

Warnings/Advisories and corresponding emergency responses	- Strong wind bulletins are normally issued for territorial waters. The bulletins will be issued when strong wind coming from Northeast monsoon and Southwest monsoon. - Once relevant authorities receive strong wind bulletins from NHMS, they will immediately announce the content to people for better preparedness
Potential Disaster Risks	Strong wind over Seas will be severely damage to fishery, especially damage to human lives.
Target (warning areas)	All of high potential affected areas will be warned.
Meteorological variables/indices used for criteria/thresholds for warnings/advisories	Beaufort wind scale will be used for thresholds for warnings

Criteria/Thresholds	Wind speed over 6 category of Beaufort wind scale (strong wind over 11m/s) will be used as criteria for issuing the strong wind bulletins
Contents of Warning/Advisory Message	All warnings include the exact areas will be affected by strong wind. The time of occurrence and the category of strong wind are also mentioned.
Sample Warning/Advisory Message	According to Northeast monsoon is extending to the south to the Biendong sea, there could be strong wind with category ranged from 11 to 17m/s over the North Biendong sea (including Paracel Islands) from 11 of August. The areas of strong wind will be enlarged to the Spratly Islands from 12 of August. Next warnings will be issued at 0906Z.

4.2.4 River Flood

Warnings/Advisories and corresponding emergency responses	- Flood Warning; prepare for possible flood situation - Flood Bulletin; - Urgent Flood Bulletin; all resources mobilized for flood response
Potential Disaster Risks	- Possibility of flood occurrence - High level of damages caused by flood - Very high risk and emergency of big flood
Target (warning areas)	-Central Committee of Flood and Storm Control -Provincial Committee of Flood and Storm Control
Meteorological variables/indices used for criteria/thresholds for warnings/advisories	Tropical storm, cold surge, ICTZ, heavy rain
Criteria/Thresholds	Flood warning stages (Level) I, II, III
Contents of Warning/Advisory Message	- Briefing on last 24 hours flood situation on affected area/basin - Forecasting on possible flood warning level for next 24-48 hours. - Possible risk, damage caused by upcoming flood

Sample Warning/Advisory Message	**FLOOD INFORMATION** **ON THE THAO, CAU, THUONG, LUC NAM RIVERS** **I. Remark** In the past 36 hours, moderate to heavy rain occurred in the North of Vietnam due to the affects of storm No. 5. The mean precipitation were recorded between 70 to 150 mm in which high amount of rainfall at Thanh Son (Phu Tho): 217mm; Tam Dao (Vinh Phuc): 274mm, Son Duong (Tuyen Quang): 208mm; Van Chan (Yen Bai): 186mm; Viet Yen (Bac Giang): 167mm; Pho Du (Thai Nguyen): 170mm; Cha (Bac Can): 176mm; Luc Nam (Bac Giang): 161mm Water levels on the Thao, Cau, Thuong and Luc Nam is sharp rising. Water levels at main stations at 19PM 18/8 is detailed as below: • On the Thao river at Yen Bai: 30.52m, above Alarm level (AL) 1: 0.52m; at Phu Tho: 16.9m, below AL 1: 0.6m. • On the Cau river at Đap Cau: 4.08m, below AL 1: 0.22m • On the Thuong river at Phu Lang Thuong: 3.9m, below AL 1: 0.4m. • On the Luc Nam tai Luc Nam: 4.85m, below 2: 0.45m. **II. Forecast** Water level on the Thao river will continue rising. Tomorrow (19/8), WL on the Thao at Yen Bai will be able to reach 31.3m at 7AM (over AL 2: 0.3m), and 31.7m at 19PM (below AL 2: 0.3m) ; at Phu Tho will be able to reach 18.0m at 19PM (below AL 3: 0.3m). During tonigh and early morning of tomorrow, WL on the Cau, Thuong, Luc Nam river will be able to reach a peak. Peaks of flood on the Cau at Dap Cau will reach 4.6m (over AL1: 0.3m); on Thuong river at Phu Lang Thuong : 4.3m (AL 1); on the Luc Nam river at Luc Nam: 5.0m (below AL2: 0.3m). Flash flood, landslide will be able to occur on streams, small rivers in moutainous areas of provinces as Cao Bang, Bac Giang, Bac Can, Thai Nguyen, Tuyen Quang, Ha Giang, Lao Cai, Yen Bai, Phu Tho… Flood stituation will be complecated, please following next flood information at 10AM on 19/8.

4.2.5 Storm Surge

Warnings/Advisories and corresponding emergency responses	- storm surge height; total water height and time of storm tide
Potential Disaster Risks	- Possibility of maxium storm surge height and total water height, possible of inundation due to storm surge plus tide
Target (warning areas)	- All of high potential effected areas will be warned;
Meteorological variables/indices used for criteria/thresholds for warnings/advisories	Not used
Criteria/Thresholds	Not yes, future make storm tide level (I, II, III)

<table>
<tr><td>Contents of Warning/Advisory Message</td><td>- Forecasting on maximum surge height, storm tidel height and times.
- Possible risk by upcoming maximum surge height, storm tidel height</td></tr>
<tr><td>Sample Warning/Advisory Message</td><td>
Storm surge forecasting (issue in NCHMF-Website)
Typhoon name:
<table>
<tr><th rowspan="2">N°</th><th rowspan="2">Town</th><th rowspan="2">Province</th><th colspan="4">Period forecasts:
(12 or 24 or 36)</th></tr>
<tr><th>Tidel height (m)</th><th>Storm surge height (m)</th><th>Total water level height (m)</th><th>Time of maximum surge height</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Quang Ninh</td><td>Bai Chay</td><td>3.2</td><td>1.5</td><td>4.7</td><td>15h/20/08</td></tr>
<tr><td>Honggai</td><td>3.1</td><td>1.7</td><td>4.8</td><td>14h/20/08</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Hai Phong</td><td>Yen Hung</td><td>3.0</td><td>2.1</td><td>5.1</td><td>13h/20/08</td></tr>
<tr><td>Do Son</td><td>2.9</td><td>2.0</td><td>4.9</td><td>13h/20/08</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Thai Binh</td><td>Diem Dien</td><td>2.8</td><td>1.7</td><td>4.5</td><td>14h/20/08</td></tr>
<tr><td>Tien Hai</td><td>2.7</td><td>1.5</td><td>4.2</td><td>14h/20/08</td></tr>
</table>
Warning : Maximum storm surge can be reach up to 5 m in the Hai Phong Coastal area

Check: Bui Manh Ha Forecaster: Nguyen Manh Dung
</td></tr>
</table>

4.3 Supporting Meteorological Information for Warning/Advisory Messages

Name of Information	Potential Disaster Risks	Target (areas)	Issuance (update) Time	Contents
Detail information about weather phenomena like strong wind, strong wave, heavy rainfall, hot weather (heat wave), cold surge	Large forecast error in some rare weather phenomena and unpredictable	- Central Committee of Flood and Storm Control at national and provincial levels; - Regional and provincial hydro-meteorological services	Depending on severe weather phenomena, the timing of issuance is twice, forth, eighth per day or even updated every hour	Information of severe weather phenomena usually include: - The forecast of given severe weather in detail - The spatial and temporal changes of given and related weather phenomena - where and when given severe weather phenomena will affect to specific area;

4.4 Institutional Coordination

4.4.1 Coordination with Disaster Management Authorities

Warning Coordination	In severe weather conditions; the Center will issue report and send to important address and make a phone-call for directly advisory;
Needs from Disaster Management Authorities	All offices need more detail, correct and clear forecasting information and longer range forecasts

4.4.2 Partnership and Coordination with Media

Warning Coordination	In severe weather conditions, we immediately send forecasting warning or bulletins to mass media and also help them in preparing weather forecast movie clips via direct calling or nominating our experts to their studio.
Needs from Media	All public media and warning offices always want to know detail and correct forecasting information and longer forecast range. They also need to know what exactly phenomena is in

	understandable way. All forecasting bulletins must be written in easy words for easy understanding without specific meteorological terms;

4.5 Challenges (and Future Plan)

The public and emergency responses by relevant authorities always want to know detail and correct forecasting information not only 1-3 days ahead but also more longer range (5-10 days to seasonal range). They also need to know what exactly phenomena are in understandable way. All forecasting bulletins must be written in easy words for easy understanding without specific meteorological terms. The most challenges are the demands of social are higher than the capabilities of forecasting and responding offices.

In order to improve these gaps, NCHMF has a significant plan to modernize observation network, TC forecasting technology, analysis and forecasting support tools, human resources (forecaster and modeller). The operational TC prediction procedures will be revised and improved according to increasing capacity of early warning and prediction of cyclongenesis and sudden changes in track and intensity. In addition, the public education about meteorology and TC affects will be implemented. The TC warning and forecast bulletin disseminating system will be improved in the way increasing both of quality and quantity. The content of bulletin will be changed to capture the requirements of the public.