Tropical cyclone information processing system (TIPS) of the Hong Kong Observatory

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1. Introduction

An average of 31 tropical cyclones form over the North Western Pacific and the South China Sea every year. About 16 of them enters the Hong Kong area of responsibility for issuing warnings for shipping, while six come close to the south China coast and pose a threat to Hong Kong. The Hong Kong Observatory (HKO) is responsible for monitoring tropical cyclones and issuing related warnings and forecasts.

Over the past decades, HKO automated various aspects of its tropical cyclone operations, such as automatic plotting of forecast tracks, computation of tropical cyclone-related data and preparation and dissemination of warnings to the mariners and general public. However, these programs were developed mostly on UNIX platforms at different times to meet the then prevailing user requirements. The products are therefore presented in various forms, based on different versions of data and are sometimes redundant and inconsistent. This causes forecasters difficulties in assimilating and analysing tropical cyclone information. At the same time, the amount of tropical cyclone-related data from a diversity of local and overseas sources has much increased, which greatly exacerbates the data presentation and analysis problems. The need for an integrated tropical cyclone information processing system based on modern technology is apparent.

Although there have been several previous attempts at the HKO to develop an integrated tropical cyclone information processing system, the results were not entirely successful due primarily to technical limitations. With the advance in computer hardware and software and lessons learned from past experience, the HKO has made initial success in implementing a user-friendly integrated Tropical cyclone Information Processing System (TIPS).

2. System Overview

The development of TIPS began in June 2000 with the first operational version completed in October the same year. The overall design is governed by the following main objectives :

Functionally :

(a) The system should encompass all tropical cyclone related information and acts as a one-stop shop for users;

(b) It should present the multitude of tropical cyclone information in clear and concise graphics and text to facilitate assimilation of the information by forecasters;

(c) It should be interactive and easy to use even for occasional users;

(d) It should cater for both operational and research use; and

(e) It should streamline the process of forecast and warning preparation thereby allowing forecasters to concentrate on the formulation of the forecasts and warnings.

Technically :

(a) The system should be modular in design and expandable;

(b) The system should serve at least 10 PC client workstations running on MS Windows on the HKO Local Area Network;

(c) To secure data consistency, certain clients (e.g. those in the Central Forecasting Office) have the right to modify the data in the database, while others can view the products only;

(d) The PC clients should have quick and reliable access to the data in the database;

(e) The system should be tightly integrated with the HKO's Meteorological INformation Dissemination System (MINDS) for efficient preparation and transmission of tropical cyclone forecasts and warnings to the public and other special users.

Fig. 1 shows the basic structure of TIPS and its inter-relationship with other systems. The Database Interface reads/writes data from/to the HKO Meteorological Database. The Analysis Module analyses the input data and passes the resulting information to the Display Module, which presents the information in various graphical and text formats on the client workstation. The user may modify the displayed data (e.g. a forecast track) through the Graphical User Input Module. The Analysis Module will re-analyse the modified data and, if necessary, update

the records in the database in real time. The Bulletin Generator generates various types of warning bulletins based on the confirmed forecast track and other information provided by the forecaster, and exports the bulletins to MINDS.

The main modules of TIPS are written in Microsoft Visual Basic, which has proved to be a stable and efficient programming language for GUI applications running on MS Windows environment, with easy connection to the UNIX-based database server.

The modular design enables the system to support different types of clients. The Graphical User Input Module will only be installed on PCs that require modification of data in the database.

The first version of TIPS is now in operation. The project is an on-going development. The second major release with most of the planned functionality incorporated is scheduled for the next typhoon season in 2002.

3. Presentation of Tropical Cyclone Information

A major function of TIPS is to display the numerous types of data flexibly and concisely to facilitate analysis by the forecaster. This is done by providing pull-down menus, check boxes and separate toggle buttons for different types of data. The data to be displayed include :

(a) Surface and upper-air observations;

(b) Remote sensing data such as satellite and radar imageries, QuikSCAT, SSM/I data, Doppler radar winds, etc.;

(c) Forecast tracks and intensity parameters derived from NWP model products and a 'super-ensemble track' based on the individual NWP forecast tracks;

(d) Forecast tracks based on objective algorithms, e.g. Climatological-Persistence (CLIPER), space mean, etc;

(e) Track and intensity forecasts issued by other meteorological centres;

(f) Satellite and radar observations made by the HKO and other meteorological centres;

(g) Boundaries of areas for which the HKO are responsible for issuing various types of warnings to the shipping community and the public;

(h) Boundaries of the regions within which the tropical cyclone is likely to cause strong, gale and hurricane force winds locally. Such boundaries are derived from past statistics and are different for tropical cyclones of different intensities;

(i) Range rings centred at the HKO;

(j) Geographical information such as locations of cities.

Fig. 2 shows an example in which the HKO forecast track is overlaid with the satellite image, the 800-km range ring and the boundaries within which the tropical cyclone is expected to cause local strong and gale winds. Fig. 3 shows a sample screen of forecast tracks issued by the HKO, China Meteorological Administration (CMA), Japan Meteorological Agency (JMA) and the US Joint Typhoon Warning Center (JTWC), as well as the one derived from ECMWF global model output.

The system also provides the following features for easy analysis of data and quick access to reference materials :

(a) Zoom and pan with automatic data re-sampling;

(b) Display of tropical cyclone-related GTS messages, sorted and filtered by the type and/or issue time according to user requests;

(c) Plotting of Fujiwara diagram;

(d) Real-time verification of tropical cyclone forecasts by different weather centres and NWP models;

(e) Easy retrieval of tropical cyclone statistics and display of historical storms;

(f) Display of operational forecasting manuals and other reference materials.

4. Formulation of the Operational Forecast Track and Intensity Parameters

After analysing the data mentioned in Section 3, the forecaster needs to determine the operational forecast track and intensity parameters, which form the basis for the issuance of tropical cyclone warnings and the related weather forecasts.

The forecast tracks and intensity parameters derived from NWP models, as well as the 'super-ensemble track', are used as a first guess for formulating the HKO operational forecast track/intensities, making reference to other information (Fig. 4). With the Graphical User Input Module, the user may input and modify a track by manually editing the latitude/longitude of the tropical cyclone position or simply dragging the track with the mouse on screen (Fig. 5). The forecast intensity parameters can also be edited. The modified track will be re-plotted on screen and the related information updated automatically.

5. Information Derived From Forecast Tracks and Intensity Parameters

TIPS automatically computes information that is critical to the issuance of warnings and forecasts based on the forecast tracks. Most of the information is centrally displayed in a summary panel as shown in Fig. 3. Such information includes :

(a) The distance and bearing of the tropical cyclone centre from any reference point, typically major cities near the storm, selected by the forecaster;

(b) The time when the tropical cyclone is expected to enter a specified range from Hong Kong. This information is important because operationally, HKO usually considers hoisting the first local warning signal to alert the public when a tropical cyclone is within 800 km of Hong Kong and poses a threat to the territory;

(c) The time when the tropical cyclone is expected to cause strong, gale or hurricane force winds locally (see Section 3). This information is important because local tropical cyclone warnings are based on expected onset of destructive winds in Hong Kong;

(d) The time and distance of closest approach to Hong Kong;

(e) The expected local rainfall and chance of thunderstorms based on climatology;

(f) The expected timing and magnitude of storm surge in Hong Kong.

The information is automatically updated as soon as the forecast track/intensities are modified by the forecaster.

6. Meteorological Database

HKO has been archiving meteorological data in flat data files for years. These data files were designed many years ago, with the objective of supporting specific applications and minimizing the required disk space. Over the years, the variety, amount and resolution of data have increased many folds. These data files and the related applications have become difficult to maintain. An integrated database to accommodate all meteorological data is therefore required.

Currently, TIPS is still working with flat data files and data manually input by forecasters. A comprehensive meteorological database system subsuming tropical cyclone data will be implemented on the HKO's main processing server, an IBM Scalable PowerParallel (SP) System. To ensure high availability, the database system will run on one node of the server with automatic fail-over to another node under the control of the High Availability Cluster Multi-Processing (HACMP) Software. TIPS will be modified to interface with the new meteorological database when it is ready.

7. Interaction with the Meteorological INformation Dissemination System (MINDS)

A main task of the HKO during tropical cyclone situations is to issue timely warnings and forecasts to the public, the shipping community and other special users. The Bulletin Generator of the TIPS automatically generates the required warning bulletins based on the HKO operational forecast track and other information input by the forecaster. The bulletin is then fed into the HKO's existing Meteorological INformation Dissemination System (MINDS) for onward transmission to the media, general public or the special users. Fig. 6 shows the work flow and sample bulletins generated by the Bulletin Generator.

8. Trial Operation

The first version of TIPS has been in trial operation in the HKO Central Forecasting Office since October 2000. The system retrieves the forecast tracks from data files in a UNIX server or accepts manual input by forecasters. The Bulletin Generator is partially implemented and the Summary Panel is providing some of the operational information. Although the system is still in development stage, it is well received by the forecasters, particularly in providing much better presentation of the tropical cyclone information and in saving their time and effort in manually plotting the tracks and computing the required information.

9. Looking Ahead

The second version of TIPS, which will include most of the planned features and connection to the meteorological database of the HKO's main processing server, is scheduled to be completed before the typhoon season in 2002.

Past experience tells us that user feedback is important and should be regularly incorporated in the design of the system during the development stage. We have therefore taken the approach of modular design and rapid upgrading of the operational version as soon as a few features are added or enhanced to obtain feedback from users. After going through multi-iterations with the users, the system would have a better chance of satisfying the operational requirements and getting a better reception by the users.

TIPS is expected to provide forecasters with a user-friendly integrated system for quick assimilation and analysis of tropical cyclone data. It will also help reduce manual labour of the forecaster, streamline the operational procedures in tropical cyclone situations and ensure the timely issuance of tropical cyclone warnings and forecasts to the public.

10. Acknowledgment

We would like to extend our appreciation to Messrs T K Wong and Y F Tong of the TIPS development team for their assistance in the preparation of this paper, and Mr C Y Lam for his valuable comments on the manuscript.

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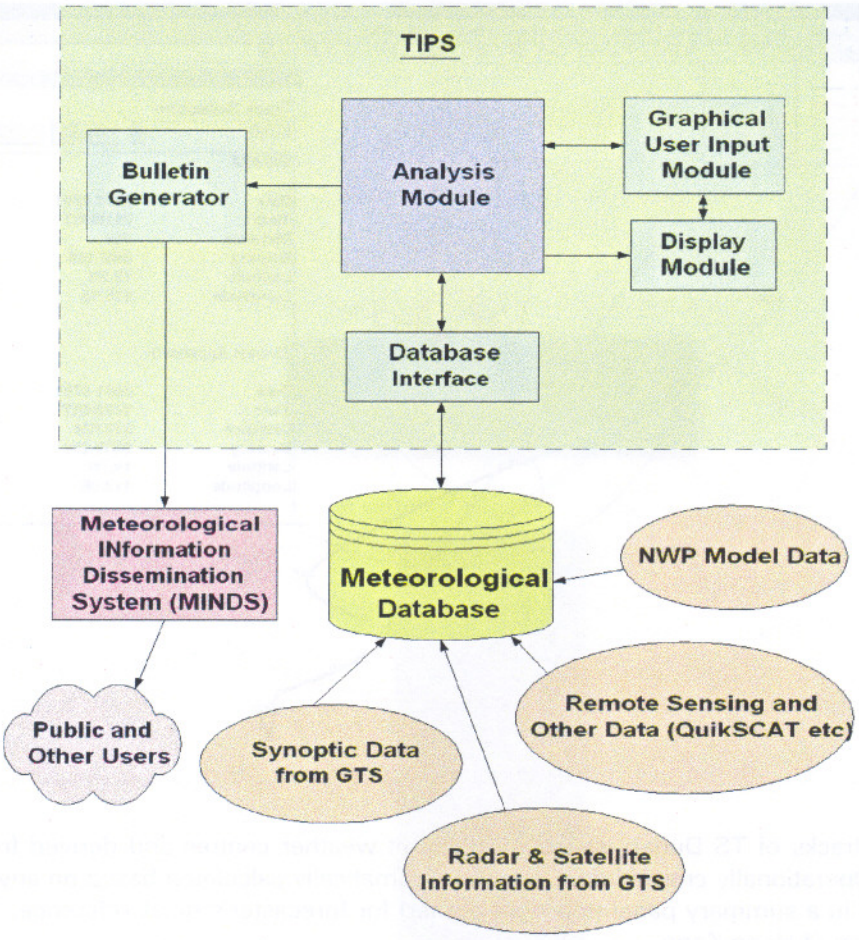

Fig. 1 Block diagram of the TIPS and its interactions with other HKO systems

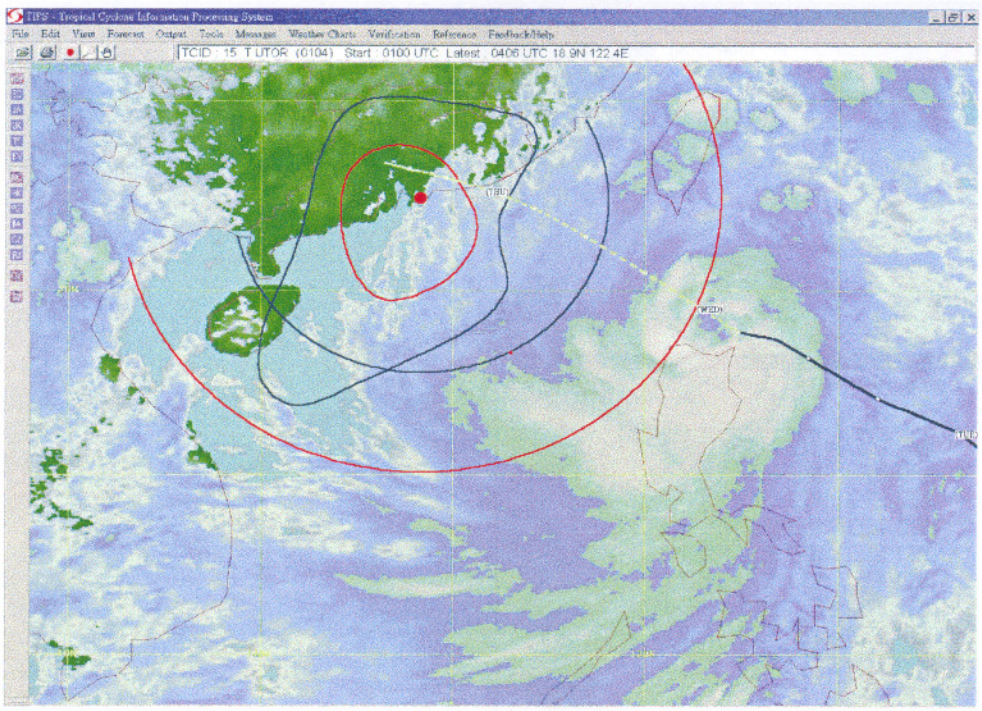

Fig. 2 The forecast track of Typhoon Utor at 06 UTC, 4 July 2001, overlaid with the infrared satellite image at the same time. Also plotted are range rings at 500 and 800 km from Hong Kong and the boundaries within which the storm is likely to cause strong and gale winds at Hong Kong. The red dot marks the location of Hong Kong.

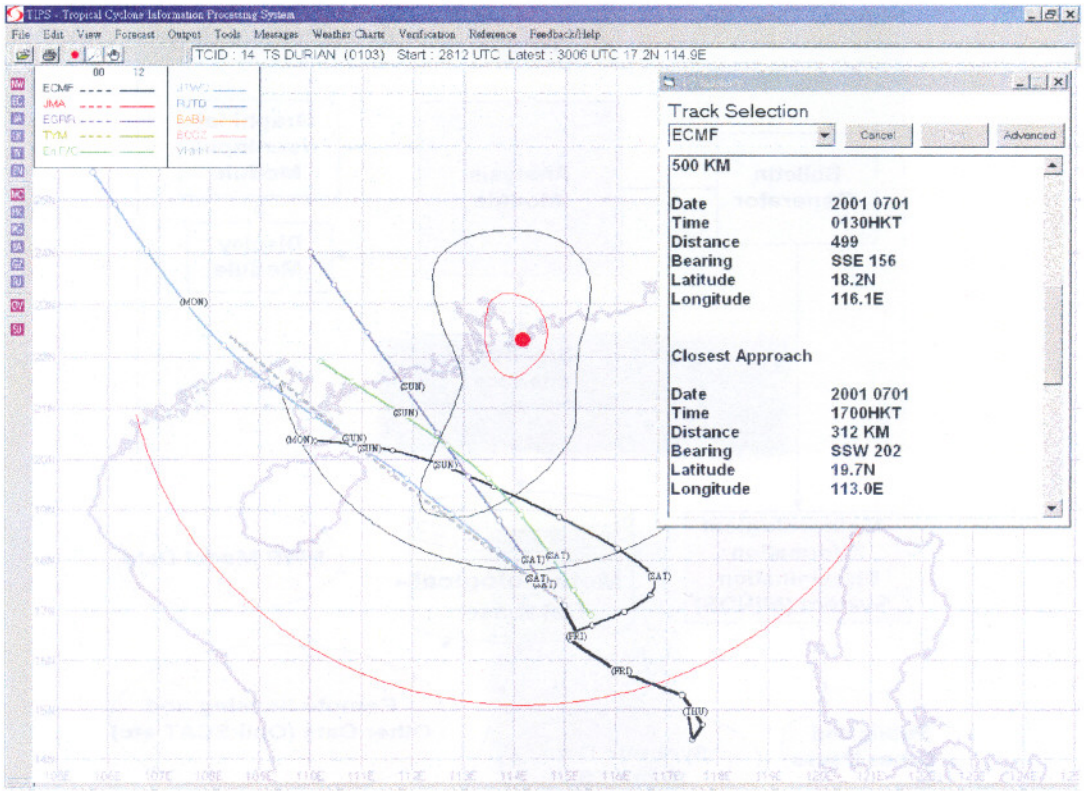

Fig. 3 Forecast tracks of TS Durian issued by different weather centres and derived from ECMWF global model. Operationally critical information is automatically calculated based on any selected track and displayed in a summary panel (top-right corner) for forecaster's quick reference. The red dot marks the location of Hong Kong.

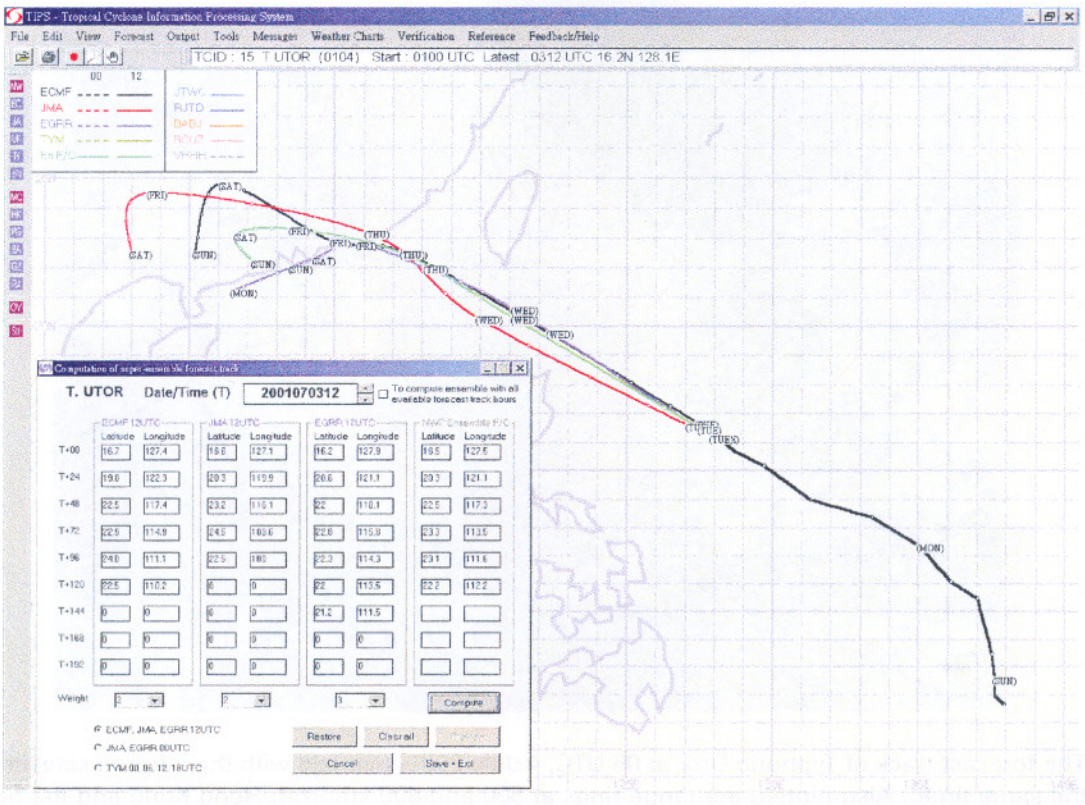

Fig. 4 The TIPS function for formulating the super-ensemble track based on different NWP models

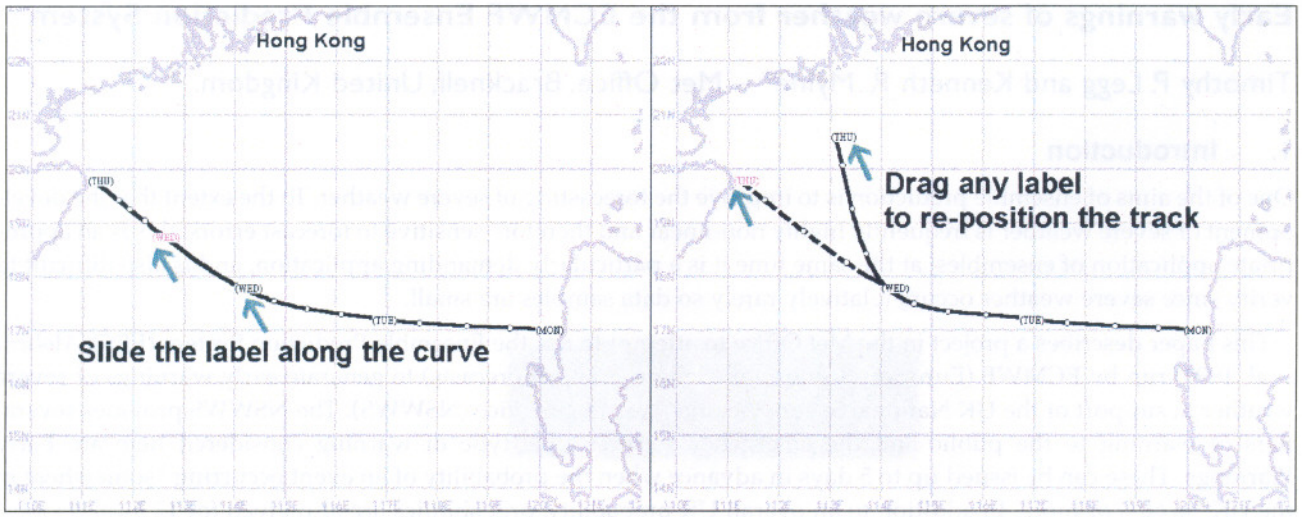

Fig. 5 The TIPS provides a user-friendly drag-and-slide graphical interface for easy modification of the forecast track.

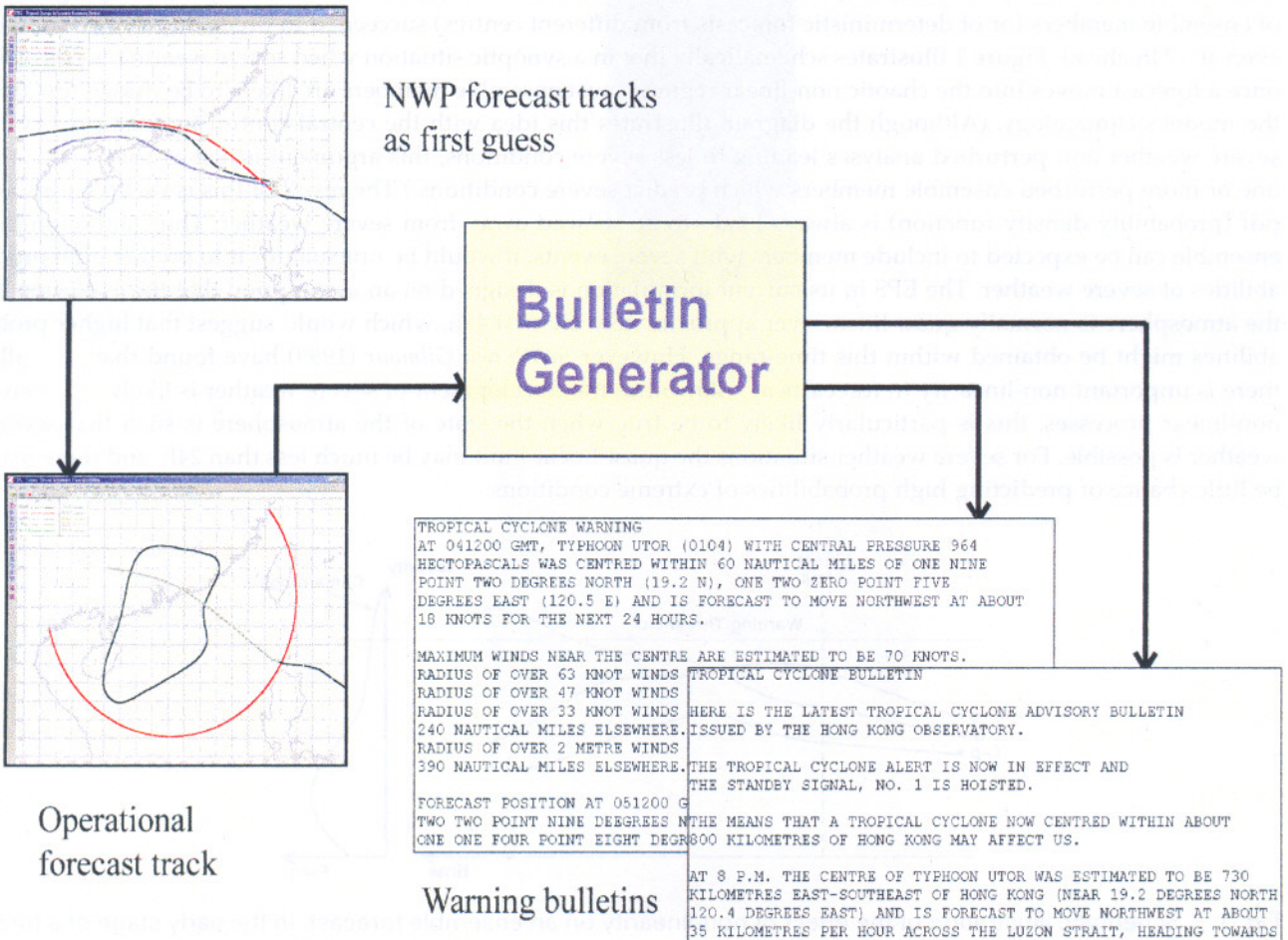

Fig. 6 Workflow for the generation of tropical cyclone warning bulletins through the use of the Bulletin Generator.