3B.5 TC-IDV A New Tool for Tropical Cyclone Forecasting and Research

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1. INTRODUCTION

Visualizing the track of a tropical cyclone, its processes, and its evolution through time is a fundamental aspect of tropical weather forecasting and research. The newly developed Tropical Cyclone version of the Integrated Data Viewer (TC-IDV) provides an integrated system for tropical cyclone research and operational application. TC-IDV is under joint development by the Unidata Program Center and the Shanghai Typhoon Institute and includes capabilities to visualize tropical cyclone tracks, to compare the position and intensity among different forecasting ways, and to integrate this information with other types of data (satellite, radar, model, etc). In this paper, we discuss the development and the use of this new tool.

2. TC-IDV

1.1 Data Model

TC-IDV data comes from both observations and numerical model output. The input data can be stored in a relational database, as text files or as other storage formats which represent a collection of geo-located storm track points. To easily compare these features, we defined a TC-IDV data model to provide an abstract representation of the relationship between one data value and another. The data model is independent of data storage format. The design and implementation of the data model provides efficient access to the different datasets, regardless of the storage format. The TC-IDV data model contains three major modules: the Storm Track Collection, the Storm Track and the Storm Track Point. We consider a tropical cyclone as a collection of storm tracks, and a storm track as a collection of track points, and a track point includes the scalar latitude, longitude, time, storm ID and other parameters.

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1.2 TC-IDV functionalities

Detailed information of the tropical cyclones is constructed using the TC-IDV data model, and a fully interactive display of storm tracks, quantitative analysis, and storm data. Exploration is implemented in the TC-IDV. So, it is not only a tool for visualization, it is also an application for the forecasting and researching of tropical weather.

With the TC-IDV we can:

- Display the storm track interactively with time animation control. When a storm is loaded, both observation track and multiple forecast tracks can be selected and shown in the view window. If there are a large number of forecast ways? Users can pare down the number through a properties panel. The layout model of storm track point and the color of each track can be changed. If there are Beaufort scale radius and forecast probability radius associated with each storm track point, they can be display as a ring and/or the cone. The animation mode of the forecast track can also be turned off.

- Do computation and analysis. TC-IDV can display charts of a single or multiple parameters, and calculate the difference between the observation and forecasts. In our near future plan we will implement the Dvorak technique using infrared and visible satellite imagery to quantitatively estimate the intensity of a tropical system.

- Explore data from multiple data sources. Tropical cyclone related radar data; surface observations, satellite imagery and model output can be visualized and analyzed.

3. CASE STUDY

Typhoon Sinlaku was the13th tropical storm and the ninth typhoon in the east Pacific in 2008. The track of its life cycle is shown in a view window of the TC-IDV (Fig. 1). It started out as a tropical disturbance northeast of Manila in the Philippines, near latitude 17.1N and longitude 125.5E on September 9. As it moved slowly northwest, it rapidly grew into a tropical depression and reached typhoon strength within nine hours. By September 10, at 17Z, Sinlaku had intensified into a strong typhoon, and in late afternoon of September 11, it was classified as a super typhoon (wind speeds > 52 m/s). On September 13, Sinlaku made landfall in coastal Ilan County (Taiwan). It then passed over Taiwan at a northwest direction and turned towards the northeast and moved back into the sea. After spiraling off Taiwan's northeastern coast for several hours, it made a northeast turn away from mainland China towards Japan. In the early morning of September 16, Sinlaku had weakened from a typhoon to a tropical storm as it moved closer to Japan. On September 21, it was downgraded to an extra tropical low as it moved further away from Japan.

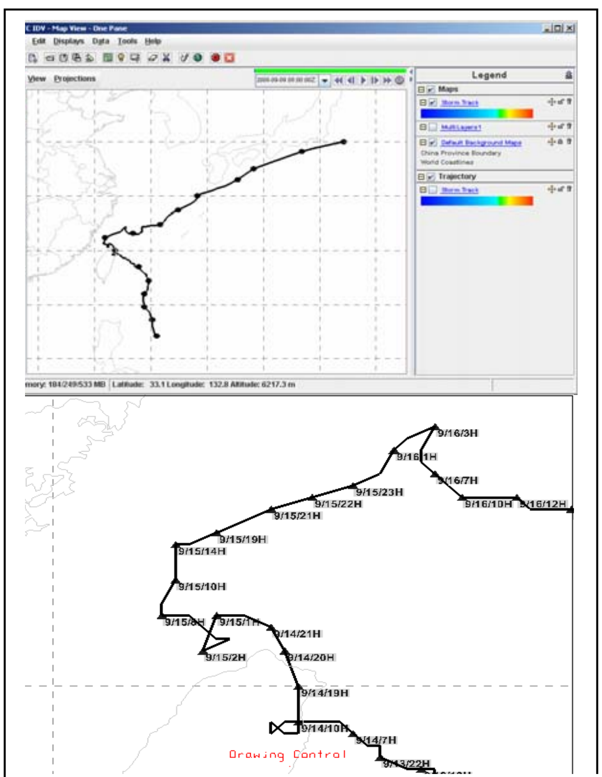

Figure 1, the observation track positions for typhoon Sinlaku

Many factors influence typhoon development and intensification. In this case study, the guiding flow and the subtropical high are considered to be the important factors. The guiding flow is the average flow field between 400hPa and 600hPa and is computed in the TC-IDV using formulas written in Jython. The changes of the guiding flow and 500hPa height at 02Z, 08Z and 14Z of September 14 are shown in Figure 2. When Sinlaku landed in Taiwan at 02Z, its center was between two subtropical highs. The ridge of the subtropical high was near longitude 128.0ºE, the guiding flow was a dominant south flow on its right side; at 08Z, the ocean side subtropical high intensified and expanded, and its ridge was near 126.9ºE. Between 02Z and 08Z, although there was little change in the guiding flow, Sinlaku moved southwest and looped due to the intensified and expanded westward movement of the subtropical high. After 14Z, the subtropical high was weakening and contracting, and the guiding flow led Sinlaku moving northeast. Between 17Z and 20Z, Sinlaku once again looped after it swept through Taiwan; it was in a similar changing pattern of the subtropical high and the guiding flow. The guiding flow field and the 500hPa height field demonstrated the connection of the abnormal changes of Sinlaku track and the subtropical high. Whenever the subtropical high is stable, the typhoon is moved by the guiding flow; however, any changes to the locations and strengths of the subtropical high will cause the typhoon to go off this original course.

The intensity of a tropical cyclone is classified by the maximum sustained wind according to the WMO. To compare the forecast results of the intensity of Sinlaku, Figure 4 shows the time series of maximum wind speed of the observation and the forecasts at two different starting times. The rapid increase of the intensity of Sinlaku at the beginning of its life cycle was underestimated. By the end of Sinlaku's life cycle, two of the forecast ways had generated better forecasts of maximum wind speed. In the TC-IDV the parameter charting can also be used to compute and display the difference between the observation and the forecasts.

Figure 4 shows the observation track and the forecast tracks from five different forecasting ways at 08Z on September 9. The black line is the observation track; we selected a solid color to distinguish each forecast track. In the TC-IDV the track color can be used to indicate the maximum wind speed and other parameters associated each storm track point. In Figure 4 all five forecast tracks inclined to the east; this is because these models did not correctly forecast the changes of the subtropical high in the region.

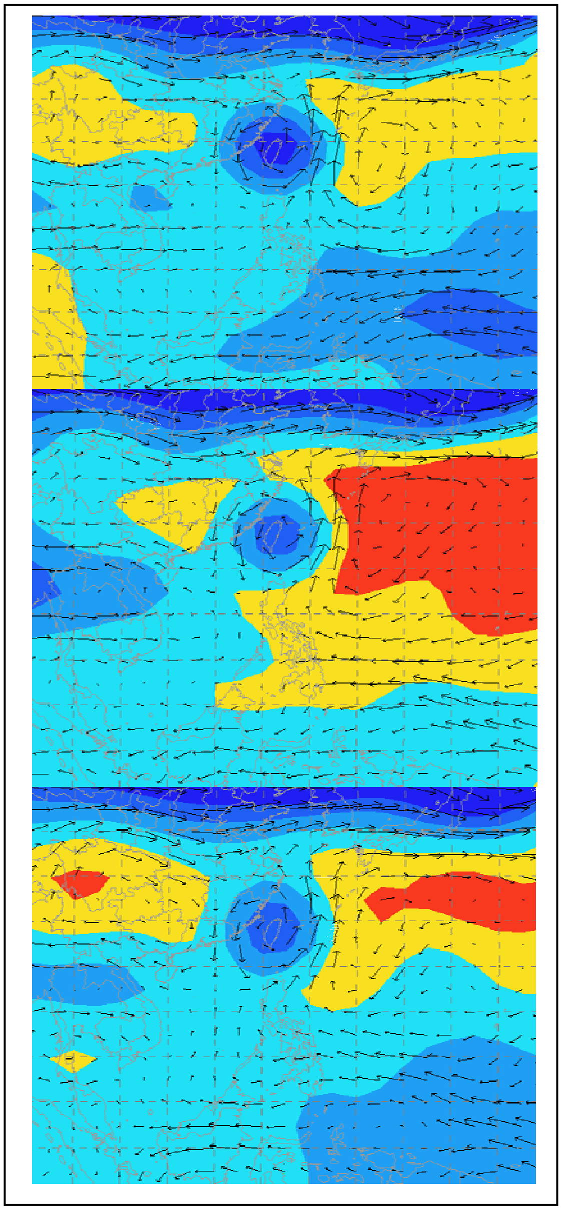

Figure 2 2008/09/14 at 02Z (top), 08Z (center), and 14Z (bottom) the guiding flow and 500hPa height (yellow region is 5880m)

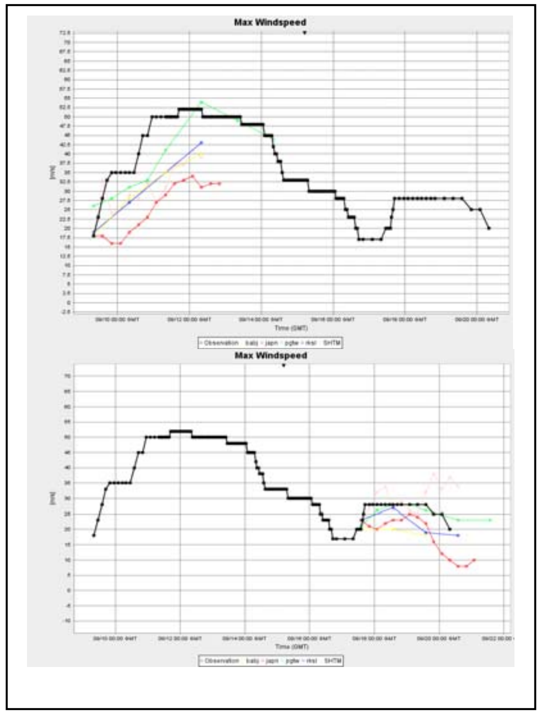

Figure 3 Time series of maximum wind speed

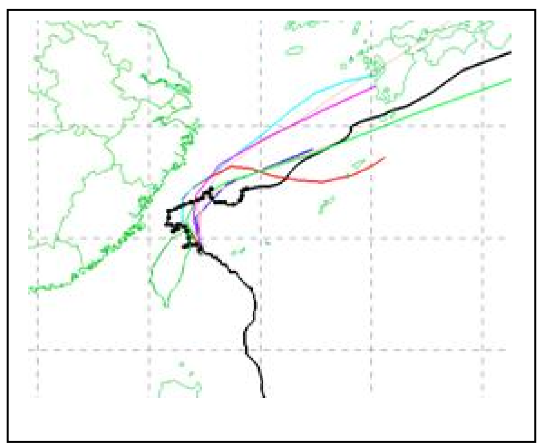

Figure 4 Sinlaku tracking map

4. CONCLUSION

The TC-IDV is being designed and implemented as a visualization and research tool for both researchers and weather forecasters. The strength of the TC-IDV is its ability to provide its end users an interactive tool, and to access different types of datasets. In its trial usage during the 2008 typhoon season, researchers in the Shanghai Typhoon Institute had been able to run the TC-IDV as a supplemental tool and generate many analysis results; many features from the IDV made it very easy for them to customize the user interfaces and to enable the data integration; they also provided valuable feedback to the developers. The planning of the TC-IDV in the coming year will evolve it into a more powerful tool. Some of the functionalities of the TC-IDV are integrated into the general IDV framework, providing similar functionality to the whole user community.

5. REFERENCES

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