URSI GASS 2020,Rome, Italy,29 August- 5 September 2020

RESEARCH ON REGIONAL EXTREME RAINFALL FORECASTING FOR WATER RESOURCE MANAGEMENT AND WARNING OPERATIONS

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Abstract

The regional extreme weatherforecast system with early warning and decision-making functionsdeveloped in this paper aims to use air-space data(satellite, ground observation, GIS, and hydrological information) as well as numerical weather forecast models and hydrological modelsin order to realize accurate rainfall forecasting.By fusing ground multi-source data, regional forecast data and reanalysis data, high-resolution assimilation system can be run with coupled ground-sky-space information. According to the regional characteristics, this study develops an intelligent human-computer interaction system based on assimilation modelfor meteorological and hydrological applicationsduringextreme weather events. In addition, an advanced radiativetransfer model with accurate calculation of hydrometric states andbackground error covariance with flow-dependent is incorporated in this research. This system has the ability of effectively simulating and forecasting storms and floods, including all the lake and reservoir features in the selected study region.Based on the real-time analyses, early warning and decision-making guidance willbe providedfor relevant userswith intuitive, accurate and quantitative products for heavy rainfall and floods.

1 Introduction

The formation, development, and evolution of tropical cyclones are the result of energy coupling and material exchange in different layers of the atmosphere, ocean, and land.The changes in the state of hydrometer play a decisive role in extreme weather. Research on extreme weather processes such as typhoons and torrential rains based on systematic observations is a major scientific issue in atmospheric and marine sciences, and it also has urgent hydrological application requirements.

Microwaves and millimeter-wave can penetrate the cloud and rain in the atmosphere and provide three-dimensional structure information of the cloud. Thus, it is potential to effectively monitor the large-scale structure of typhoon and its process of occurrence, development and extinction in real time, using such remote sensors.

Previousapplication results based on observations indicate that it is still challenging to accurately forecast extreme weather such as tropical cyclones and heavy rain. As the most conservative requirement, the time resolution must be in the order of minutes and the spatial resolution must be within kilometers in magnitude.This study aims to develop a regional extreme weather forecast system with early warning and decision-making functions using a combination of observations and numerical models.

2 Forecast system and framework

The flowchart of the designed regional extreme weather forecasting system is shown in Figure 1, which is a meteorological-hydrological coupled model. The keytechnique is rainfall forecasting with multi-source data, including satellite and ground-based observations. After rainfall forecasting, parametersare adjusted according to the historical rainfall, runoff and evapotranspiration [1-3]. The surface information is complex and fast changing in small scale, while satellite data hascoarse spatial resolution. In this framework, how to couple the atmospheric and surface model with tempo-spatial resolution and meteorological and hydrological information is investigated [4-5].Combining with satellite infrared and microwave data, surface GIS information such as ponds, reservoir, lake, river network, we can feature thisregional extreme rainfall forecastingsystem with typhoon track and forecast of precipitation amount and intensity. The results will be used in hydrological applications such as waterlevel warning and decision for rivers, lakes, and ponds operations.

In particular, basedon the WRF model, WRF-Hydro model and 3D variation technology, fast assimilation system with an update period of 3hhas been developedas shown in Figure 1. The observation datasets include soundings, regional precipitation data, conventional ground observations and regional automatic station data, combined with satellites, so that it can enrich the detail characteristics of medium-scale systems with strong convection, promoting the development of numerical models and enhancing the ability of strong convective weather forecasting.The rainfall terminal of the forecasting system is shown in Figure 2, with intensity and path validation of rainfall during typhoon event. It has the ability of simulation, 1~72h forecasting and analysiscomparison with the results forecasted by other models [6].

The WRF-Hydro coupled model can well simulate and forecast the hydrological process under complex terrain conditions and is of great significance for regional flood forecasting. Based on this, this system can provide timely and effective regional hydrological forecast by using meteorological forecasting products.

Overall, this system involves 1) WRF-RTFDDA: assimilate various meteorological observations into WRF, and produce four-dimensional continuous clouds, precipitation, radiation and various types of ground meteorological elements. 2) Multi-Sensor-QPE: Precise ground rainfall estimation based on rain gauges, radars, etc. 3) WRF-Hydro: Simulate land surface, soil physical processes, groundwater flow, and water and reservoir logging processes.

The specific method for quantitative rainfall estimation is based on radar, rain gauge, laser rain spectrometer, and lightning location. Regional WRF-RTFDDA-Hydro coupled flood forecasting is carried out, and the measured data is used for verification analysis.

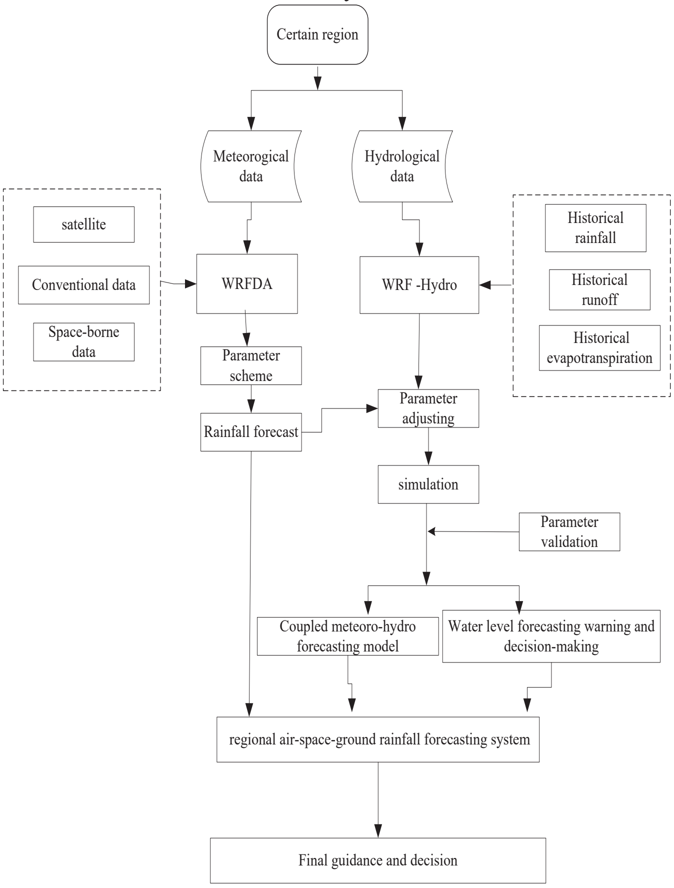

Fig. 1 Flowchart of the designed regional extreme rainfall forecasting system.

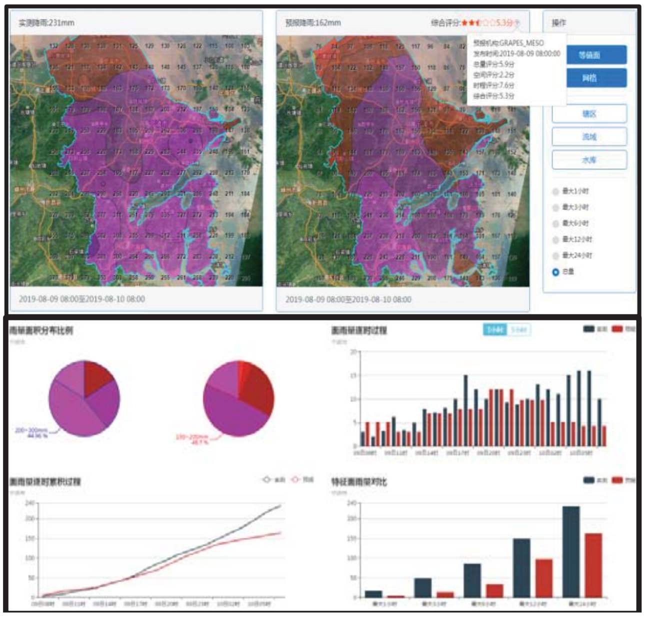

Fig. 2 The rainfall terminal of the forecasting system.

3 Further applications on warning and guidance

Water raising in small tributaries in cities plays an important role in hydrological prediction model.The designed system is regionally operated for forecasting rainfall, track and intensity of typhoons [7]. It also has lake-pool-pond-river water level forecasting, early-warning, guidance and decision-making functions. According to the specific terrain, it corresponds to the lower terrain area, and reflects the process of rainfall lowering into the river channel. When the level of river water is high, the surface water cannot enter the river quickly, so the early warning of flood disasters is critical and will be issued depending on the water levels.

According to the results of typhoon and heavy precipitation path and intensity forecast, an ensemble of Monte Carlo algorithm and a suite of machine learning techniques are used to find the optimal hydrological network parameter thresholds based on the measured values of river and lake reservoir, ponds and their respective geographical locations and hydrological conditions.

As part of the forecast system, we have also built a set of interfaces for comprehensive water level forecasting, early warning and intelligent decision guidance. The terminal has the ability of showing the real-time changes (15 mins) and related response of the river, lake and ponds during extreme events.

4 Summary

A regional extreme rainfall forecasting system was developed with early warning and decision support functions. Therein, multi-source data combined with weather research and forecast models as well ashydrological models are used to realize rainfall forecasting and warning and issue subsequent decision-making guidance. The data include air, space and ground-based observations and hydrological/GIS information. The operations and experimental results of this system have been verified using Ningbo Yongjiang River Basin as an example during the development stage. The flood disaster forecasting products and warningguidance are used by hydrological managers for water resource management. Future work will focus on large-scale meteorological and hydrological applications ofthis coupled system.

7 References

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