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ScienceDirect

Procedia - Social and Behavioral Sciences 96 (2013) 1362 – 1365

Procedia
Social and Behavioral Sciences

13th COTA International Conference of Transportation Professionals (CICTP 2013)

A new marine auto-response quantitative wind forecast system

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Abstract

Great waves are usually introduced by and accompanied with strong winds; either of them is dangerous to the vessels on the sea. With the help of quantitative wind speed forecast, a seaman or a self-control system can decide whether to go along the original navigation route or switch to a safer one. A new 24/7 auto-response system was developed with the purpose of providing the future 1-5 days nautical surface wind trend per vessel's request. To lower the satellite communication cost, the messages are formatted in concise and quantitative text-mode (total < 200 bytes). The weather forecast data, retrieved at the nearest half degree grid point from an advanced global weather numerical model stored in a US server, is adjusted by statistical rending method according to the local conditions. The preliminary results were proven to contain great reliability and creditability.

Keywords: quantitative navigation; surface wind, auto system; numerical weather prediction; Inmarsat email communication

1. Introduction

In meteorologist's view, gale (strong wind) represents a wind speed more than 17m/s (scale force 8). But upon maritime safety, vessels are under negligible threat when nautical surface wind speed is greater than 10m/s (scale force 6). High wave is usually introduced by and accompanied with great gale. Usually gale can be observed in the frontal edge of the cold high, low latitude circle of the frontal cyclone, and near-center of the tropical cyclone.

Vessels' robustness against great wind/wave varies greatly with a lot of factors including tonnage, size, age, carrier product, structure, and etc. Generally, near-coastal running vessels have fewer tonnage and less resistant to the strong wind, but they were much closer to the harbor and anchoring area and easier to get the synoptic

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doi:10.1016/j.sbspro.2013.08.154

weather forecast service. Vessels on transoceanic voyages are larger and can resist great wind/wave, but their available hydro-meteorology channels are limited on radio weather report or weather fax map. Sometimes the shipping company would also order the supplemental commercial weather routing service.

However either of the above weather service has some limitations. The weather report in ECG or NAVTEX is described in words while the weather fax map is graphical. All three are carried out by radio signals and free of charge, however neither of them is quantitative. In addition, these weather services could only describe the regional synoptic weather conditions but ship-oriented. As a result, the effect of the self weather-related navigation is highly depending on ship officer's personal experiences. Given the fast development of VTS and AIS and other high-tech navigation techniques, marine accidents due to the adverse weather still occur. One analysis shows more than 80% of marine accidents in the maritime domain are caused by human errors (Cho et al. 2010).

The commercial weather routing navigation service, in contrast, is much professional, digital, and ship-targeted. It could overcome most of the above shortcomings, though also be relative expensive. As a result, weather routing is widely adopted in vessel rental or transoceanic route.

The real-time, objective, quantitative, and most at all, accurate and affordable weather forecast service is a very important problem and majorly concerned by the ship owner and the captain. Supported by Climate Forecast Applications Network (CFAN)[†] research team in Georgia Institute of Technology of USA, a marine system is developed to provide navigation officer the state-of-the-art nautical surface wind speed and direction forecast via Inmarsat satellite email communication.

2. Data and System Design

The raw surface wind information are obtained from European Centre of Medium range Weather Forecast (ECMWF)[‡] global product, one of the most skillful numerical weather prediction model in the world. It is running at TL639 spectral truncation (horizontal resolution ~32km) with 62 vertical levels out to ten days along. To represent the uncertainty in initial conditions, ensemble perturbations are constructed using singular vectors which capture the fastest growing errors in the first 48 hours (Buizza and Palmer 1995). A detailed description can be found at http://www.ecmwf.int/products/data/technical/model_id/index.html The CFAN group has a long term collaboration with ECMWF and agrees to provide the weather forecast data at 0.5*0.5 degree resolution in this study.

To reduce the high communication cost via Inmarsat satellite service, most computing and downloading jobs were set in the ground servers. The request might be initialized at anytime by one of the vessel high-rank officers, who would send out a formatted email with latitude/longitude information, to a particular address. The successful arrival of this email will trigger a set of jobs which will read the near-to-date high-volume ECMWF product from the US server, generate the future weather elements change trend near the target location, compress them, and then deliver the package to the server located in Dalian Maritime University, China. The Chinese server will apply a bias-correction algorithm to adjust the raw data according to water depth, season of the year, wind direction, and grid distance to the nearest land. Finally the future surface wind trend will be stated in a concise way and sent back to the ship's satellite receiver. Fig. 1 illustrates the brief flow chart of how system

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† http://www.cfanclimate.com

‡ http://www.ecmwf.int

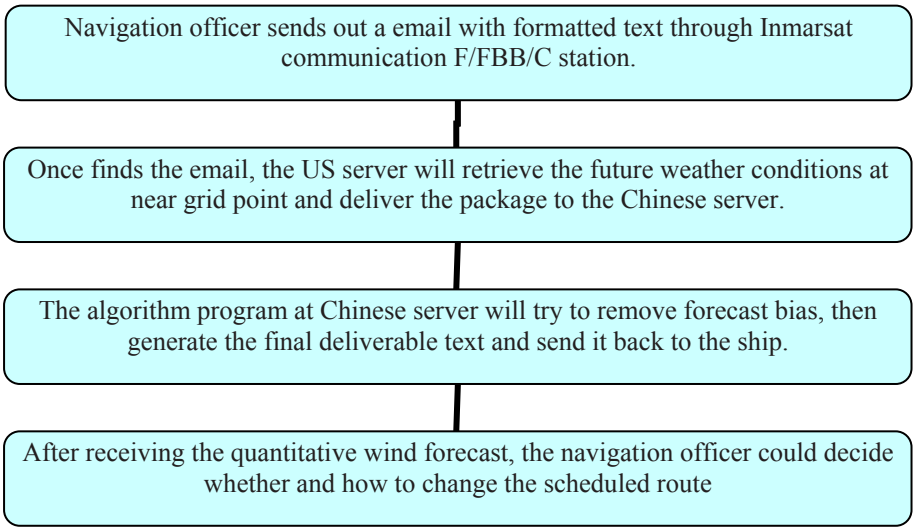

Fig. 1. Flow chart of the system

3. Input and output of the system

The system is designed to simplify the operation without installing any new instruments on the ship. For example, if any crew sends out a request including the following phrase "/LAT/30.5/LON/123/", he will receive below message within 10 (or 25) minutes via F (or C) station:

```
LON123.0/LAT30.5/.5deg
052912Z/8NW/5SW/
053000Z/14S/12S/10SW/15W/
060100Z/10NW/6NW/7W/10SW/
060200Z/11SW/9W/6W/6SW/
060300Z/8S/8N/9N/10N/
```

The first line notes the nearest grid's latitude and longitude and the model's horizontal resolution. In the other lines, the first value on the left marks the starting date and hour in GMT (e.g. 052912Z means 1200Z at May 29th), the other values indicates the surface wind speed (m/s) and direction (eight position) by the increment of six hours (e.g. /5SW/ means a southwest wind of 5 m/s would be expected at 1800Z on that day).

4. Advantages of this Newly Developed Marine System

- Auto-response and 24/7.
  All the works are processed by routinely executed programs in the high-speed servers. Though messages were being transferred transoceanically, the system has been on nonstop working since Jan 2012.

- Quantitative and concise.

  According to the preliminary examination in "Yukun" training ship and several bulk vessels, the total communication of one round is limited to less than 200 bytes.

- Captain objective.
  The ship owner and the captain concern the adverse weather mostly since they are the major responsible person. This system could work as a new navigation technique between the weather Fax-based self navigation and commercial weather routing service.

- High accuracy.
  The forecast is based on EMWF product, which is from the most advanced skillful model.

5. Conclusion

A new 24/7 auto-response system was developed with the purpose of providing the future 1-5 days nautical surface wind trend per vessel's request. To lower the satellite communication cost, the messages are formatted in concise and quantitative text-mode. The weather forecast data, retrieved at the nearest half degree grid point from an advanced global weather numerical model, are adjusted by bias-correction programs according to the local conditions. The first one-year preliminary results show great reliability and creditability. We are keen to assimilate our products into more sophisticated transportation system like Intelligent Transportation Systems (ITS) or Geographic Information System for Transportation (GIS-T) to benefit the shipping economy and improve marine transportation safety.

Acknowledgements

This research is supported by the Fundamental Research Funds for the Central Universities and open fund of State Key Laboratory of Numerical Modeling for Atmospheric Sciences and Geophysical Fluid Dynamics. The ECMWF global weather model data applied in this paper are received under the agreement between CFAN and ECMWF.

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