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GENESIS POTENTIAL ESTIMATION OF HIGH-IMPACT WEATHER BY TIGGE ENSEMBLE DATA

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ABSTRACT

A prototype of a warning potential system for high-impact weather events is proposed, based on the THORPEX Interactive Global Grand Ensemble (TIGGE) data sets. The main events we are interested in are heavy precipitation, tropical cyclone track, heat wave, flooding, drought etc. The basic concept and some examples will be presented; the Northern Vietnam flooding in November 2008 and a sand storm event in Gobi Desert in April 2007.

1. INTRODUCTION

THORPEX (http://www.wmo.int/thorpex) is the international research program under the World Meteorological Organization, to accelerate improvements in the accuracy of 1-day to 2-week high-impact weather forecasts for the benefit of humanity.

THORPEX Interactive Global Grand Ensemble (TIGGE) is a key component of THORPEX. It accumulates global ensemble forecasts, generated by a number of major operational forecast centers in real time and delivers the data to the scientific community for research and education with 48-hour delay through three TIGGE Archie Centers (ECMWF, NCAR and CMA). The data is accumulating at a daily rate of approximately 500 GB from ten data providers around the world. The data accumulation started in October 2006 in some data providers. Total forecast members in a day are now close to 500.

The objective of this study is to show the feasibility of warning potential of high-impact weather events using the global ensemble forecast data. ECMWF operates the index, called Extreme Forecast Index (EFI) (Lalaurette, 2002), based on the ECMWF ensemble dataset. This study tries to extend the EFI into the TIGGE dataset.

2. METHODOLOGY

First we need the climatological global meteorological data. For this purpose we use the JRA-25 (Onogi et al., 2008) reanalysis data and JCDAS data, which cover from 1979 through 2008. We get the climatological PDF of meteorological parameter from the data and set a climatological PDF threshold (such as 90, 95, 99 percentile), f_{90}, f_{95} or f_{99}, as shown in Fig. 1.

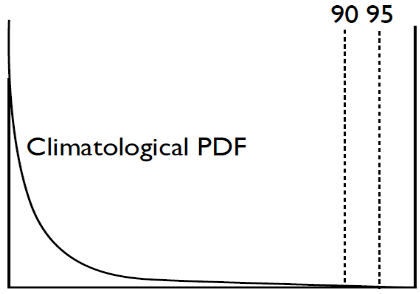

Fig. 1. Schematic diagram to get a 90/95 percentile from a climatological PDF.

The global PDF of the surface wind speed of the JRA-25 /JCDAS in 30-years (1979-2008) is shown in Fig. 2. The PDF of surfaced wind speed should follow the Weibull distribution as follows.

$$f(t) = \frac{m}{\eta}\left(\frac{t}{\eta}\right)^{m-1} \exp\left\{-\left(\frac{t}{\eta}\right)^{m}\right\},$$

m: Weibull parameter, which represents the skewness, η: scale parameter as the variance.

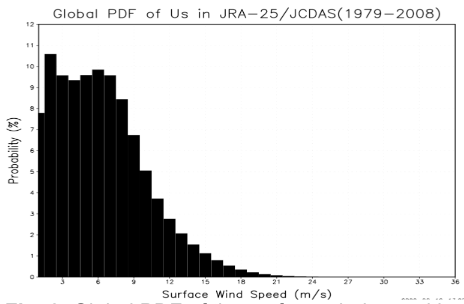

Fig. 2. Global PDF of the surface wind speed in the JRA-25/JCDAS.

Figure 3 shows the percentage of the occurrence of the surface wind speed greater than 15 m/s in 30-year JRA-25/JCDAS data. There are regions with stronger wind speeds over the circum Antarctica between 40 ˚S and 60 ˚S, and over the north Pacific.

The occurrence of high-impact weather events is verified by the disaster databases, such as EM-DAT (http://www.emdat.be/database), ADRC (http://www.adrc.asia/) or IRIN (http://www.irinnews.org/).

We will choose the right parameters for the target disasters. The following list describes the candidates of appropriate meteorological parameters, used to estimate the genesis potential.

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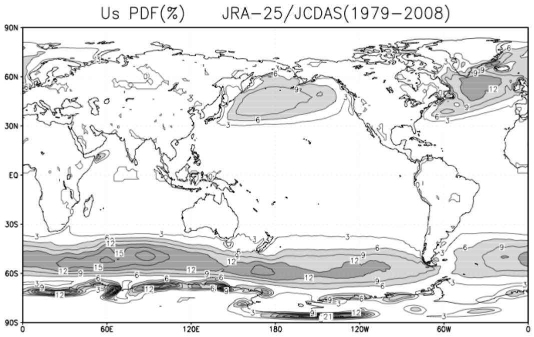

Fig. 3. Percentage of the occurrence of the surface wind speed, greater than 15 m/s in the 30-year JRA-25/JCDAS data. Dark (light) shading denotes the area greater than 12 (6) %.

Disaster	Parameters
Typhoon:	Ps, Precip, Us, Vor850
Flood:	Precip, Us, CAPE, Vor850
Wind, Dust Storm:	Us, Vor850
Draught:	Ts, qs, Precip
Cold Surge:	Ts, Us
Heat Wave:	Ts, qs

3. THORPEX Interactive Global Grand Ensemble (TIGGE)

The data of the TIGGE database is over 500 GB a day with about 500 members. The detailed datasets in the TIGGE database are listed in Table. 1.

(as of Nov. 2009)

Centre	Ensemble members	Output data resolution	Forecast length	Forecasts per day	Fields (out of 73)	Start date
BOM	33	1.50° x 1.50°	10 day	2	55	3 Sep 07
CMA	15	0.56° x 0.56°	10 day	2	60	15 May 07
CMC	21	1.00° x 1.00°	16 day	2	56	3 Oct 07
CPTEC	15	1.00° x 1.00°	15 day	2	55	1 Feb 08
ECMWF	51	N200 (Reduced Gaussian) N128 after day 10	15 day	2	70	1 Oct 06
JMA	51	1.25° x 1.25°	9 day	1	61	1 Oct 06
KMA	17	1.00° x 1.00°	10 day	2	46	28 Dec 07
Météo-France	11	1.50° x 1.50°	2.5 day	1	62	25 Oct 07
NCEP	21	1.00° x 1.00°	16 day	4	69	5 Mar 07
UKMO	24	1.25° x 0.83°	15 day	2	70	1 Oct 06

Table 1. Current available global ensemble data in the TIGGE database, as of Nov. 2009.

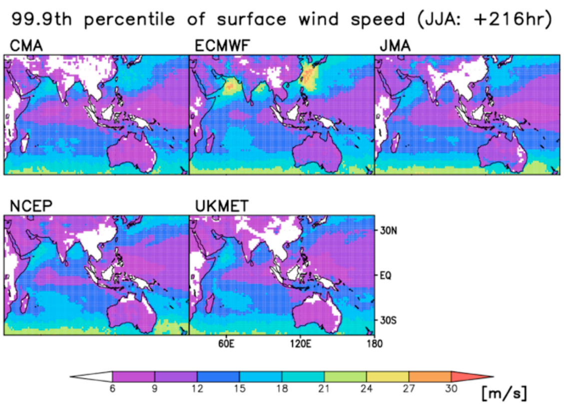

Fig. 4. The 99.9 percentile of the surface wind in 216-hr forecast data in the boreal summer (June-July-August), 2007-2009 in several forecast centers.

Figure 4 represents an example of the TIGGE database, showing the 99.9 percentile of the surface wind in 216-hr forecast data in the boreal summer (June-July-August), 2007-2009 in several forecast centers.

Now we utilize the TIGGE global ensemble data to see how many members exceed the threshold of f90, f95 or f99, as shown in Fig. 5. When a percentage of the members in the ensemble forecasts becomes higher, we suspect that there would be a high genesis potential of an extreme event with enough leading time of several days to mitigate disaster.

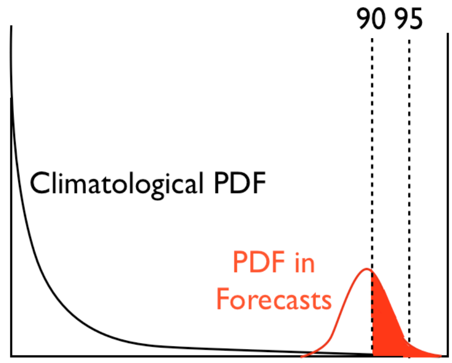

Fig. 5. Same as Fig. 1, except for including the PDF of many members of global ensemble forecasts for computing the percentage of the members greater than the 90 percentile (red area).

4. RESULTS

4.1 *Typhoon Morakot Forecast*

The first example is for Typhoon Morakot, which gave severe and destructive damage in Taiwan in August 2009. The accumulated precipitation during the passage of Morakot exceeded 3,000 mm. Figure 6 shows the accumulated precipitation in all 51 members by the ECMWF ensemble forecasts for Southern Taiwan (22-24 ˚N, 120-121 ˚E). Even though the track forecast is perfect, it is very common to predict underestimated precipitation amount in the global models. Although the accumulated precipitation is between 150 mm and 800 mm and far below the observation, it is encouraging that some members in the global model are capable to forecast such a heavy rainfall, due to tropical cyclone.

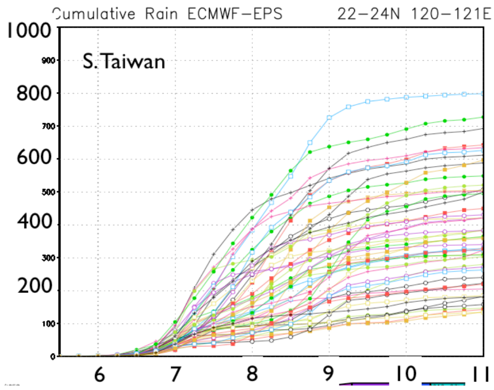

Fig. 6. Accumulated rainfall (mm) in all 51 members of the ECMWF ensemble forecasts over the Southern Taiwan during the passage of Morakot from August 6 to 11 in 2009.

4.2 *Vietnam Flood in October 2008*

Flooding is also one of the major disasters in Asia. Using the global ensemble data, we checked the feasibility of flood genesis potential for the case in Northern Vietnam in October 2008.

Figure 7 represents the result. The arrows are the ensemble forecast mean surface wind in 192 hr (left) and 216 hr (right), initialized at 12 UTC, October 23, 2008. The shades denote the percentage of the number of members, which exceed the 90 percentile in climatological October. The flood in Hanoi was related with the development of a tropical disturbance in the South China Sea, and occurred around October 31 and November 1, which correspond well with Fig. 7. A multi-model ensemble forecast data could detect a flooding with a long leading time.

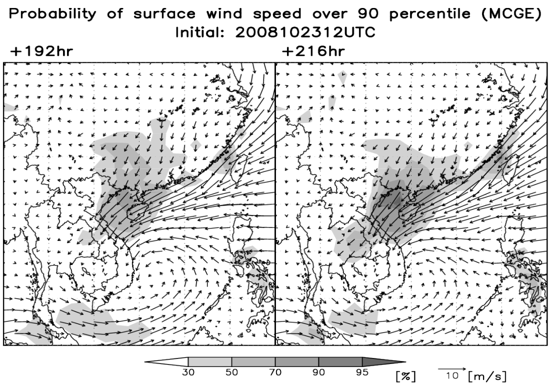

Fig. 7. The arrows are the ensemble forecast mean surface wind in 192 hr (left) and 216 hr (right), initialized at 12 UTC, October 23, 2008. The shades denote the percentage of the number of members, which exceed the 90 percentile in climatological October.

4.3 *Dust Storm initiated at Gobi Desert*

The last example is for the dust storm, which was initiated at Gobi Desert in March 2007.

Although the genesis of dust storm is not only related with the surface wind speed, but also several other parameters, such as surface moisture, particle size distribution, etc., we would like to evaluate the importance of the forecast of surface wind speed to warn the occurrence of dust storm.

Figure 8 is the same as Fig. 7, except for the 95 percentile in 96 hr forecast, initiated at 12 UTC, March 26, 2007.

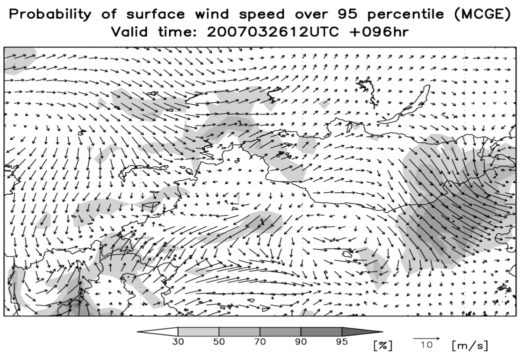

Fig. 8. Same as Fig. 7, except for the 95 percentile in 96 hr forecast, initiated at 12 UTC, March 26, 2007.

5. Summary

- A prototype of a high-impact weather warning system will be developed for flood, heavy precipitation, tropical cyclone etc., using the global model ensemble forecast datasets.
- Preliminary results show capability of ensemble forecast datasets for potential detection of high-impact weather events with a leading time of several days.
- The system will be expandable, for other high-impact weather events and applicable in more quantitative manner by combining with regional NHM models.

References

Lalaurette, F., 2002: Early Detection of abnormal weather conditions using a probabilistic extreme forecast index. *Quart. J. Roy. Meteor. Soc.*, 129, 3037-3057.

Onogi, K. and coauthors, 2007: The JRA-25 Reanalysis. *J. Meteor. Soc. Japan.*, 85, 369-432. (http://www.jstage.jst.go.jp/article/jmsj/85/3/369/_pdf/)