A PROBABILISTIC WIND SPEED FORECAST PRODUCT BLENDING NHC TC-BASED FIELDS WITH A DYNAMICAL MODEL ENSEMBLE

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1. INTRODUCTION

It is often difficult to discriminate the wind circulation associated with a tropical cyclone from the large-scale synoptic environment which can include strong zones of high pressure, or large low pressure systems resulting from extratropical transition. Gale-force winds can often exist well beyond the actual TC circulation, which may not be depicted well by the traditional TC-only wind products issued by the National Hurricane Center. The idea to merge probabilistic wind fields from a large scale dynamical model ensemble with those from the NHC arose from discussions between Richard Knabb and Peter Bowyer at the Interdepartmental Hurricane Conference in New Orleans in 2007. Tropical Storm Ernesto of 2006 spawned the idea since the event proved to be a challenge with regard to defining the storm-only impacts. Over the Eastern U.S. the strongest wind field (near hurricane-force) was well removed from the storm itself and in fact associated with a compacted pressure gradient between Ernesto and a large high pressure area over Maine and Eastern Canada.

In this short paper, we discuss an augmented product that is being explored at the Canadian Hurricane Center which involves the merging of NHC's TC wind "swath" probability fields with fields cast in a similar manner from a dynamical model ensemble covering the large-scale environment. Such a product, if "operationalized", could be particularly useful for interests in the marine community making medium-range decisions that are dependent on wind and waves - *regardless of the weather system generating them*. Here we show some examples from 2009 highlighting the added value of fields generated during extratropical transition (ET) events, including the low-latitude ET of Hurricane Ida in the Gulf of Mexico in November 2009.

2. METHODOLOGY

To construct forecast surface wind speed probability, a number of models must be run and statistics (probabilities) generated from the output at each grid point of the model. There are two separate ensemble systems from which the overall large-scale probability field displays are prepared. The TC-only ensemble is provided by the National Hurricane Center (NHC) and is built from 1000 synthetic (but plausible) storm tracks using a Monte-Carlo style approach (Goerss et al. 2004). The second large-scale ensemble is derived from the 21-member Canadian Meteorological Centre (CMC) Global Ensemble Prediction System (GEPS) (Houtekamer at al. 2005). The horizontal resolution of the CHC ensemble members is 0.9° lat/long.

The NHC ensemble runs on a finer 0.5° lat/long grid, and is used as the grid to which output from the CMC ensemble is mapped. Winds from the lowest computational level of the CMC ensemble are actually representative of the ~55-m level compared to 10 m from the NHC. However, given the coarse resolution of the CMC ensemble members, intensity of lows and pressure gradients are often not modeled as close to reality as would a higher-resolution model. Thus, we use the direct output from the model members as a "proxy" for surface (10 m) winds in computations of probabilities for this approach.

The prototype system simply involves taking the highest probability of 34-, 48- and 64-kt winds from either of the two outputs to construct a combined product covering the tropics and extratropics. This will provide users with an overall expectation of the probability of winds at the key thresholds for various lead times (12, 24, 36, 48…120 hours).

3. CASE EXAMPLES FROM 2009

A recent example of this treatment for Hurricane Ida in the Gulf of Mexico in early November 2009 is shown in Fig. 1. In Fig. 1a the traditional NHC 5-day, tropical storm-force wind probability swath is shown with a characteristic cone shape fanning outward to the north. Since Ida was undergoing interaction with a baroclinic zone to its north over the southern U.S., some characteristics of ET were expected, with expansion of the wind field as described in Evans and Hart (2008). After combining the NHC wind probability field with the CMC ensemble, a wider swath of winds were expected as shown in Fig. 1b. Also note the zone of higher chance of gales off the Carolinas and Virginia (30-50%) at the 5-day lead time. That area was eventually hit with storm-force NE winds with flooding storm surge in parts of Virginia and North Carolina, with a similar synoptic scale pressure pattern to Ernesto (2006). Some information on this storm (dubbed "Nor'Ida") can be found online at http://en.wikipedia.org/wiki/November_2009_Mid-Atlantic_nor'easter .

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It is challenging to formally verify a probability product, however the combined QuiKSCAT imagery in Fig. 1c shows that there was a substantial girth to the storm's gale-force wind zone. Areas where the CMC ensemble expanded upon the NHC TC-only field is encircled in Fig. 1a and b, which experienced gale force wind based on the QuikSCAT wind field at the end of the 120-hour verifying period (12Z 09 November 2009).

A second example of Hurricane Bill in August 2009 is shown in Fig. 2 for 5-day gale-force wind speed probability. The familiar NHC wind product is shown in Fig. 2a and again in the Fig. 2b after file conversion. The CMC-only probability field is shown in Fig. 2c with 50%+ probabilities extending farther east of Newfoundland, and showing the presence of unrelated weather systems in the far north and east. In Fig. 2d we show the difference in the probability fields – NHC minus CMC. This allows us to see where the products differ, and hopefully augment each other. Some of the shortcomings of this prototype appear in Fig. 2d in the vicinity of the storm center at the beginning. Note the broader representation of the storm based on the CMC field (blue to purple colors) at a time when it is more likely that the NHC fields are more realistic. This effectively leads to a (potential) "over-warning" of the breadth of gale-force winds. Conversely, the NHC-based probability of gale-force (e.g. TS-force) winds is greater over Nova Scotia than suggested by the CMC dynamical ensemble.

4. QUESTIONS AND FUTURE CONSIDERATIONS

The differences seen for Hurricane Bill may help us to pose questions that need to be answered as part of the scheme development. For instance, were the higher wind probabilities over Nova Scotia to the left of Bill's track warranted? After all, there are many cases of fast-moving ET storms where no evidence of tropical storm-force winds are found left of the track. It turns out that with Bill, the higher probabilities of TS-force winds in the NHC-based ensemble were indeed warranted. Tropical storm conditions did occur over Atlantic coastal Nova Scotia. Was the broader wind field implied by the greater probabilities in the CMC ensemble near Bermuda realistic? We saw for Ida that they were. A closer analysis is required, but it would likely be a function of the stage of ET. Future iterations of this prototype ought to involve a stage-dependent merging approach whereby 'stage' is perhaps inferred from a cyclone phase space (Hart 2003) ensemble.

A *regional* ensemble forecast system has been developed by the Meteorological Service of Canada (at CMC) in support of the 2010 Winter Olympics with a horizontal resolution of ~$1/3^{o}$ lat/long. The domain of the system covers much of North America and an eastward and southward extension is proposed that would include the tropical Atlantic basin. It currently runs out to 48 hours but may be extended to 72 hours in future versions. This could serve as an enhancement to the existing proof-of-concept system discussed here, and would help give a more realistic wind probability distribution in the vicinity of landmasses – a known deficiency of the current 0.9^{-o} lat/long system. Expansion to include the Global Forecast System (GFS) members is also a possibility which is already part of the North American Ensemble Forecast System (NAEFS – Candille 2009).

Ultimately those impacted by strong winds, waves and surge from "tropical-only" or combined systems are not concerned about the classification of the storm, just our predictions with levels of certainty/uncertainty attached to those forecasts. For the insurance and political sectors, the distinctions may be more important but are sometimes difficult to define. Products like this may help quantify these differences.

5. ACKNOWLEDGEMENTS

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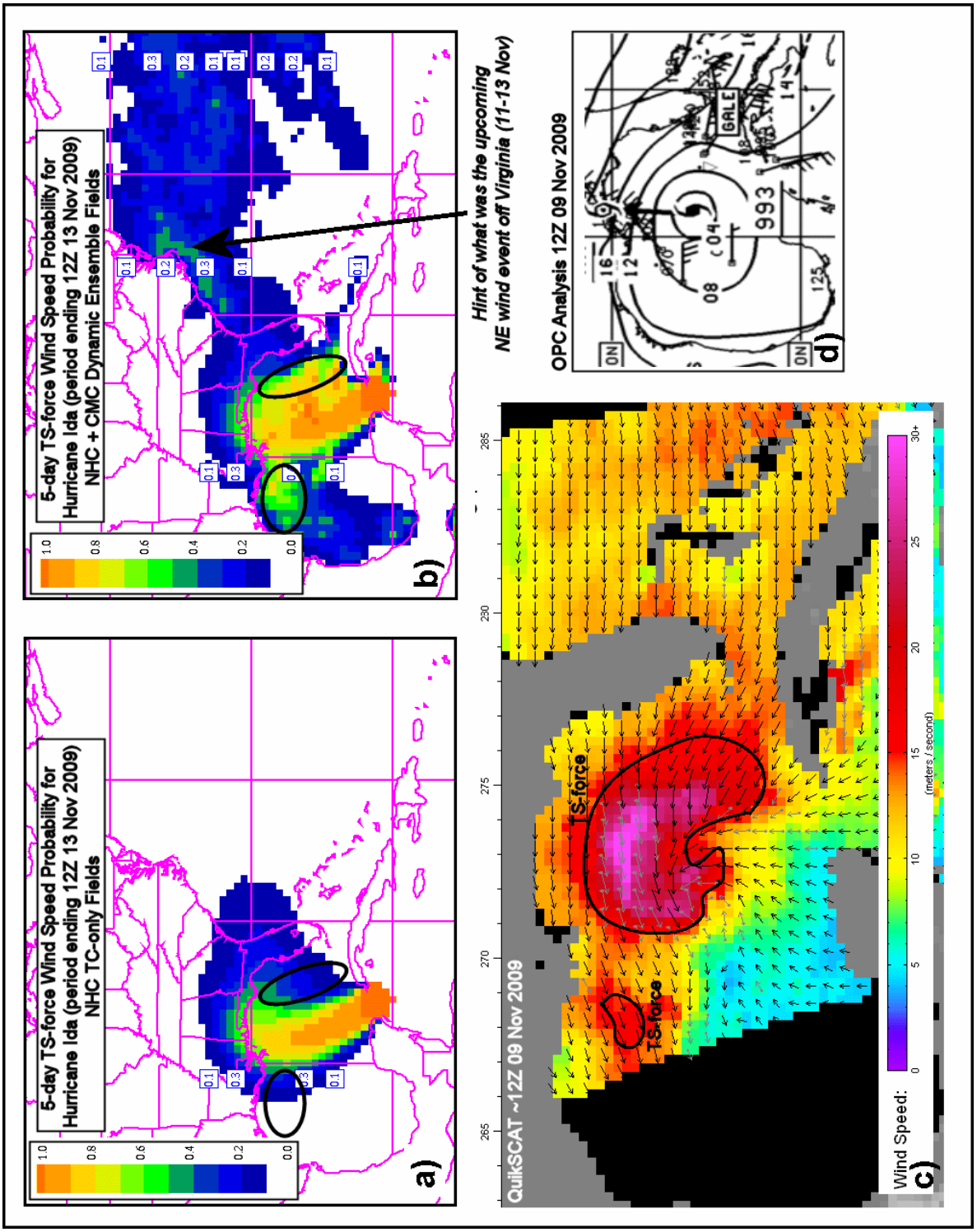

Fig. 1. Composite of model output and observations during Hurricane Ida's extratropical transition in the Gulf of Mexico. (a) 5-day TS-force wind speed probability ending 12Z 13 November 2009 from the NHC expressed in fractional terms (1=100%), (b) combined NHC and CMC ensembles showing probability for the same period (same scale as (a)), (c) QuikSCAT surface winds near 12Z 09 November 2009 showing the extent of TS-force winds in m s^{-1}, and (d) 12Z 09 November 2009 sea level pressure analysis from the Ocean Prediction Center in Washington.

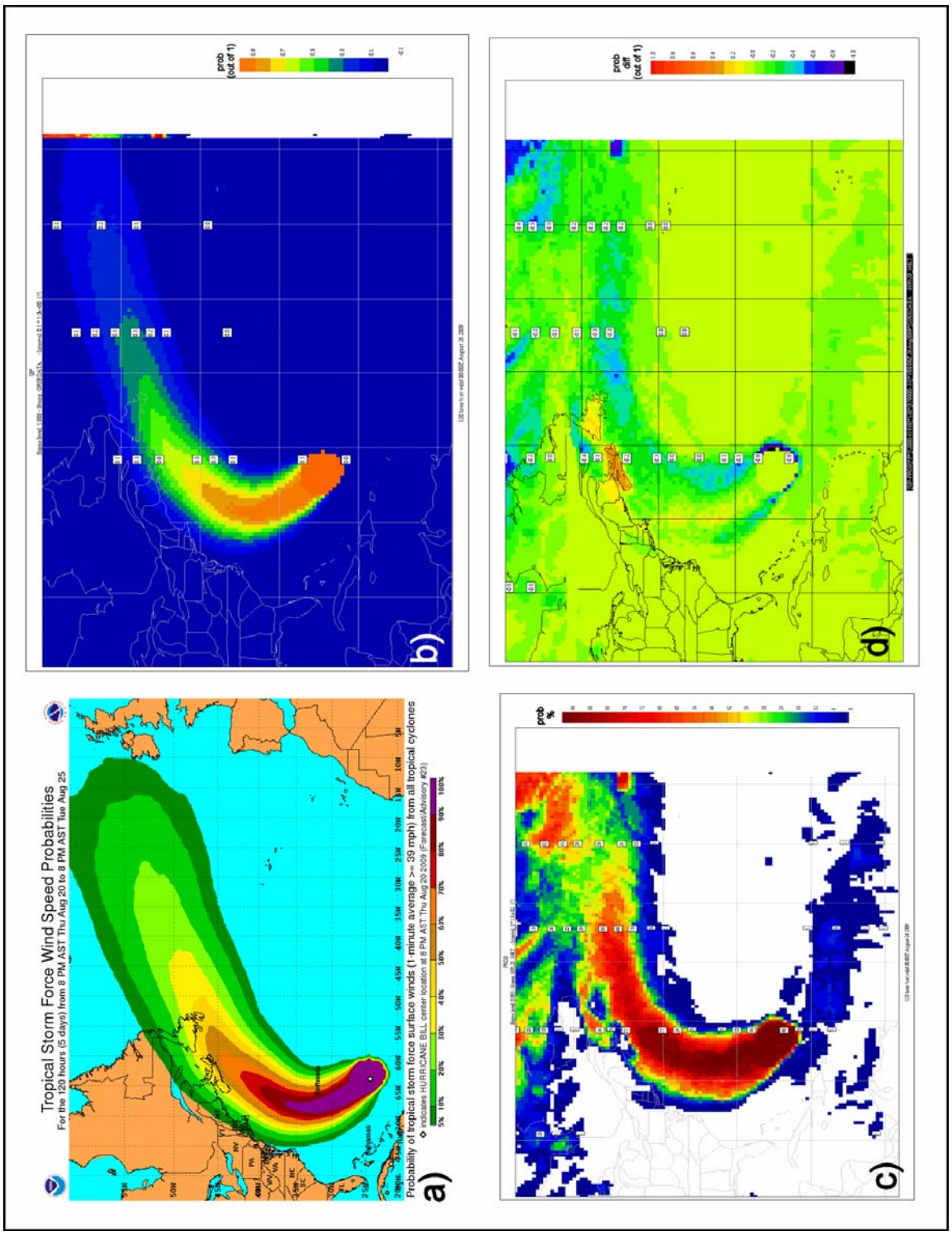

Fig. 2. Composite of ensemble-based wind probability fields for Hurricane Bill (2009). (a) Traditional 5-day TS-force wind probability from the NHC for the period ending 00Z 26 August 2009, (b) same field after file format conversion needed for merging with the CMC output, (c) CMC wind probabilities for the same 5-day period, and (d) difference between the NHC and CMC ensemble outputs (NHC minus CMC) expressed in fractional terms (1=100%).