Data Assimilation and Initialization in HWRF

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Tropical Cyclone Operations and Research Forum
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Original HEDAS used wrfout files to start each run. In wrf-nmm, the vertical velocity variable is in the form of 1-dw/dt, but that variable is not in wrfout. Each run was thus starting with a uniform base value of 1-dw/dt at each cycle time.

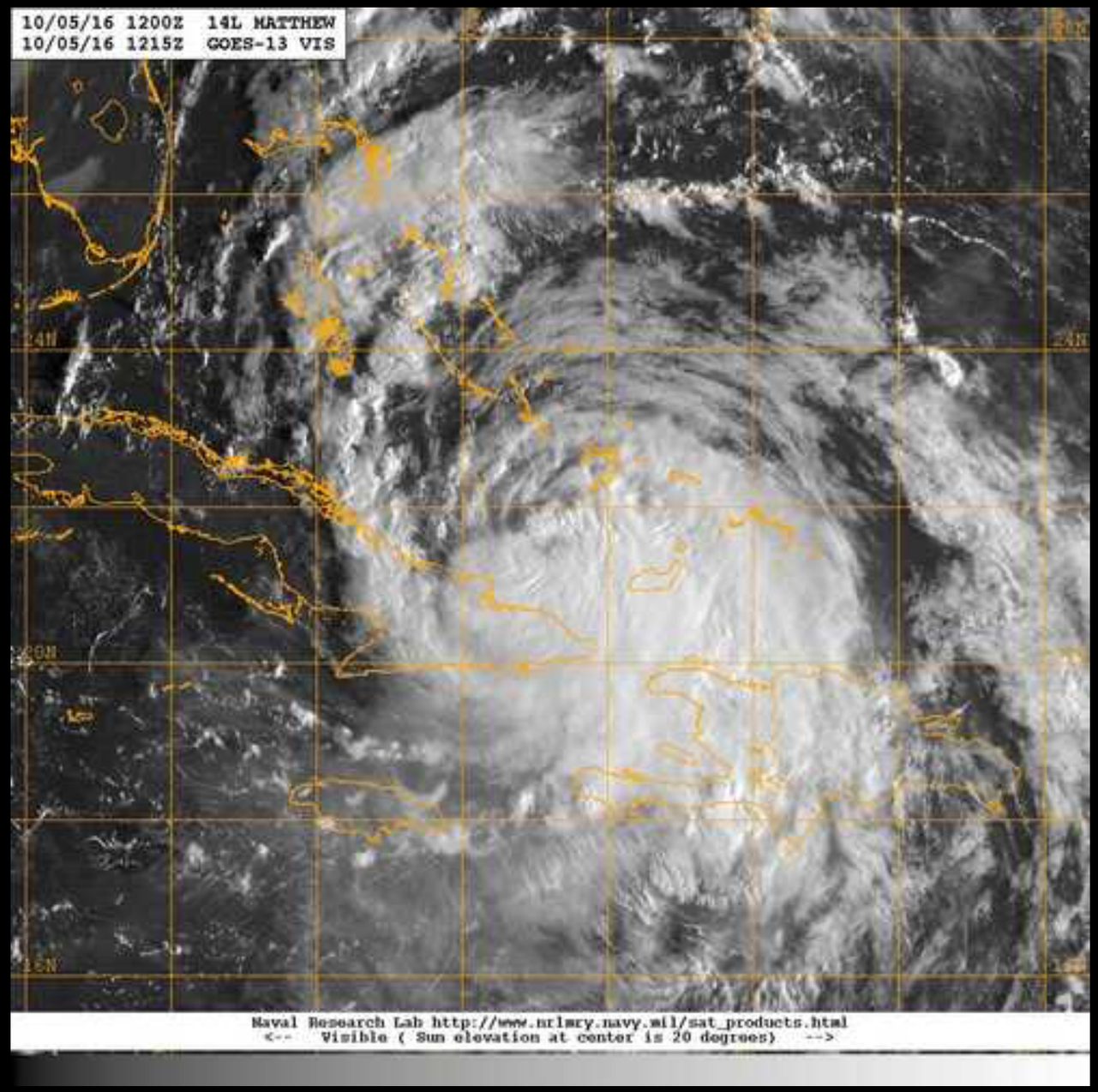
NMM Solver Scientific Documentation, page 19, it states that if there are vigorous convective storms, it takes O(1000s) for the vertical velocity to grow to O(10m/s).

TCs are comprised of “vigorous convective storms,” suggesting that WRF-NMM will take that amount of time to develop sufficient vertical velocity to sustain the secondary circulation.

In discussion with Zavisa Jancic, he stated “For the nonhydrostatic component of motion, it would be useful if you had initial dw/dt, or some approximation of it.”

As a result, HEDAS was upgraded to use wrfrst files which do have 1-dw/dt, and 1-dw/dt is now updated in the HEDAS runs.

What is its impact? What is the impact of other variables (total water content, ice mixing ratio, rain mixing ratio)?

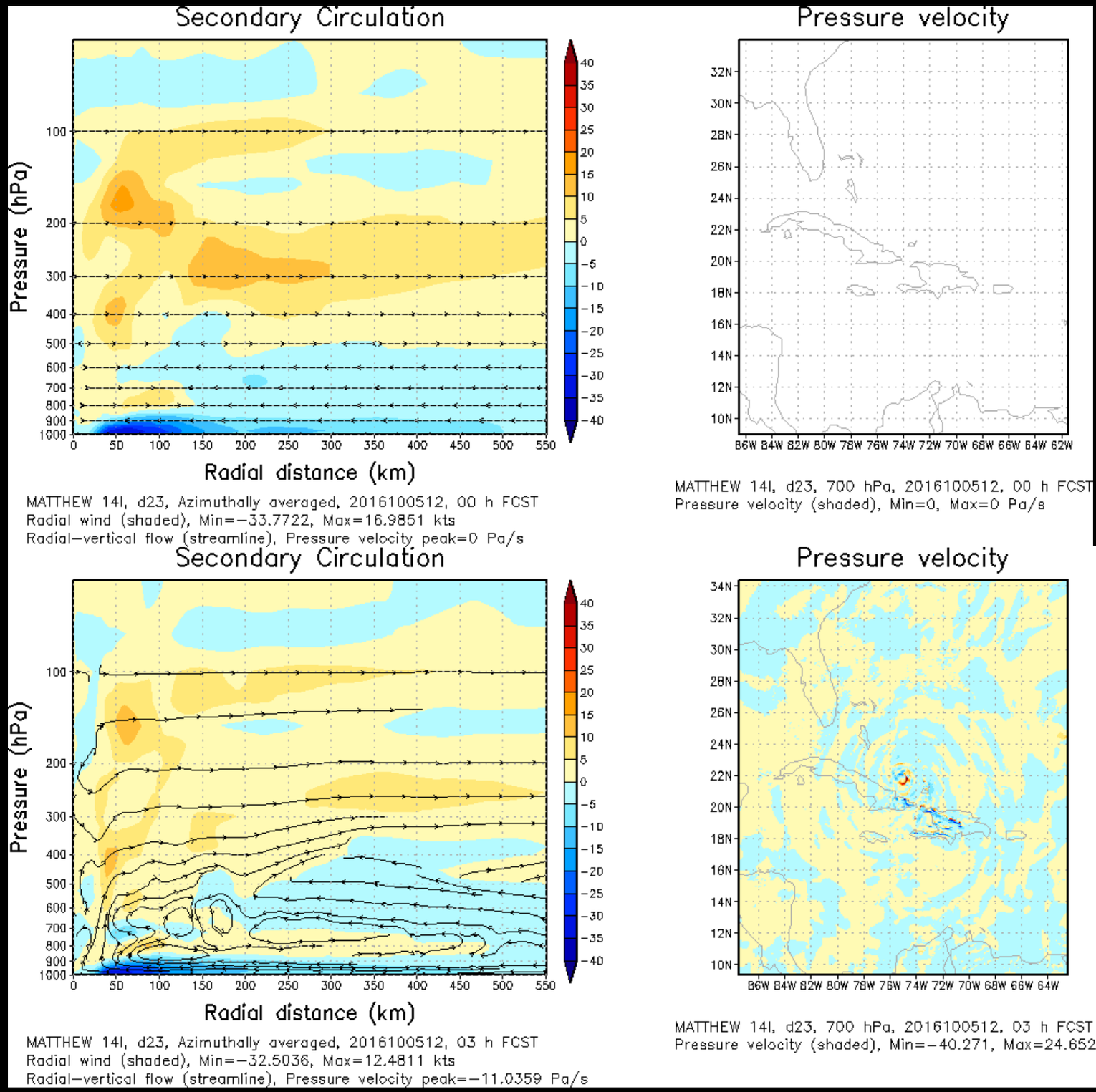


HEDAS has the ability to zero (one) out the values of these variables, to mimic using wrfout/wrfanal files.

The MATTHEW14L.2016100051200 (100 kt/964 mb) run is tested. This case is intense AND intensifying.

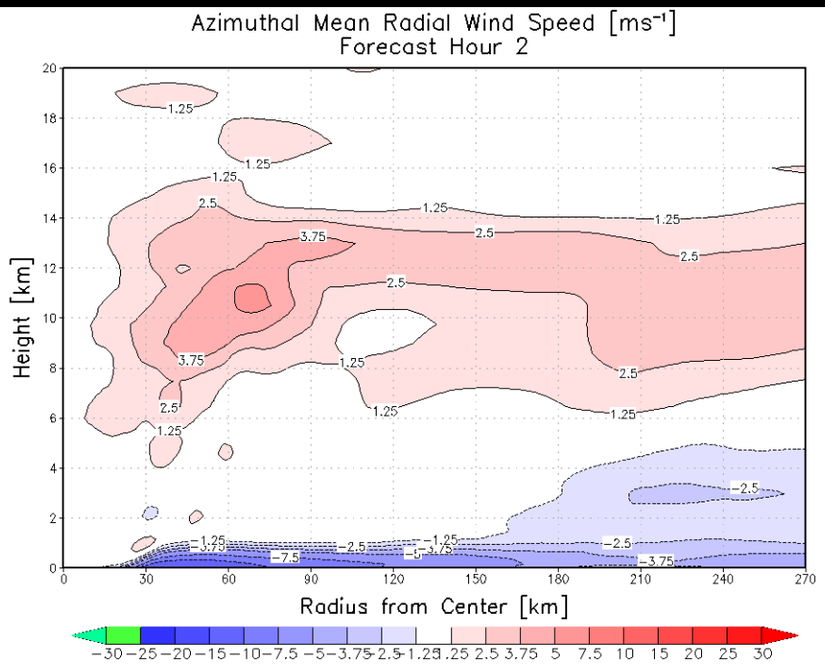
Operational HWRF secondary circulation

Initial

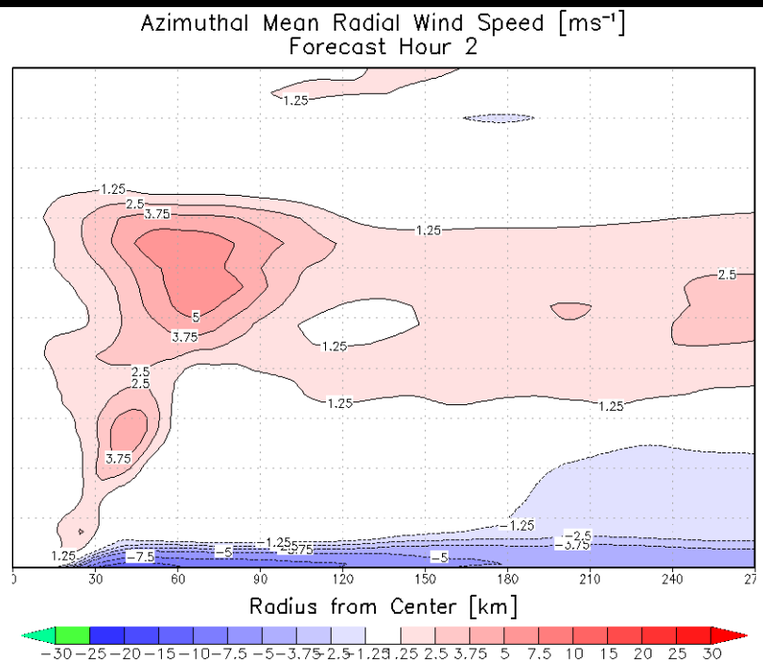


3-h

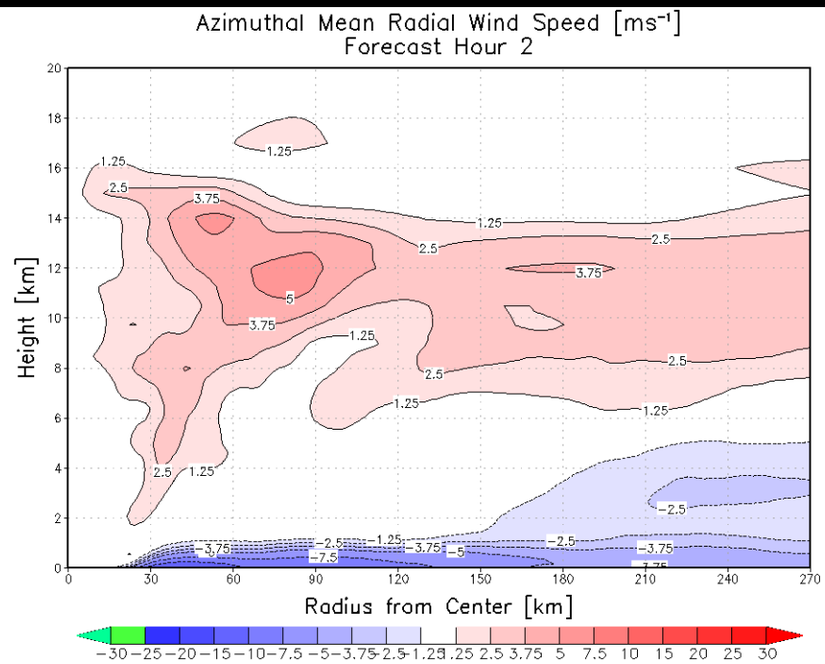
Initial azimuthal mean radial wind



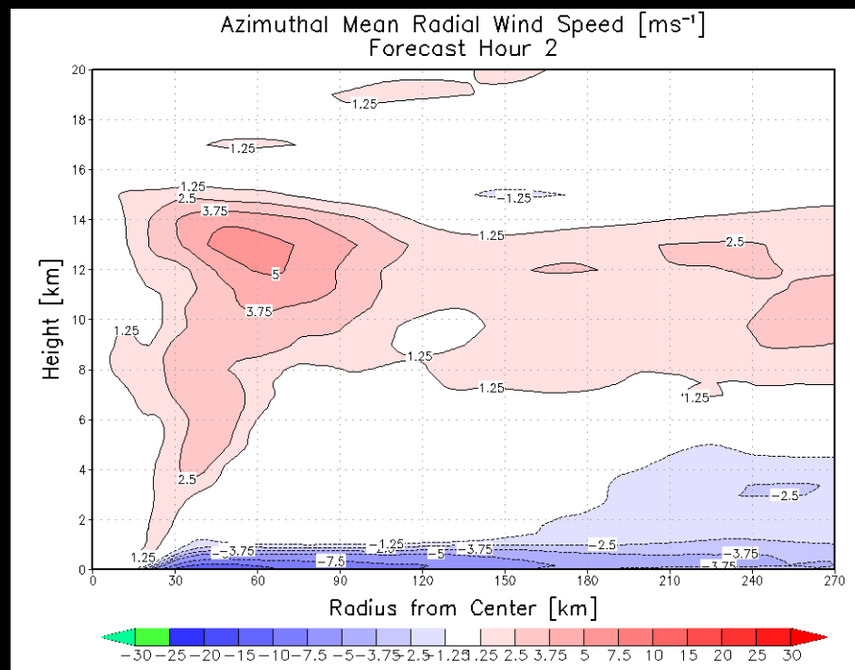
All



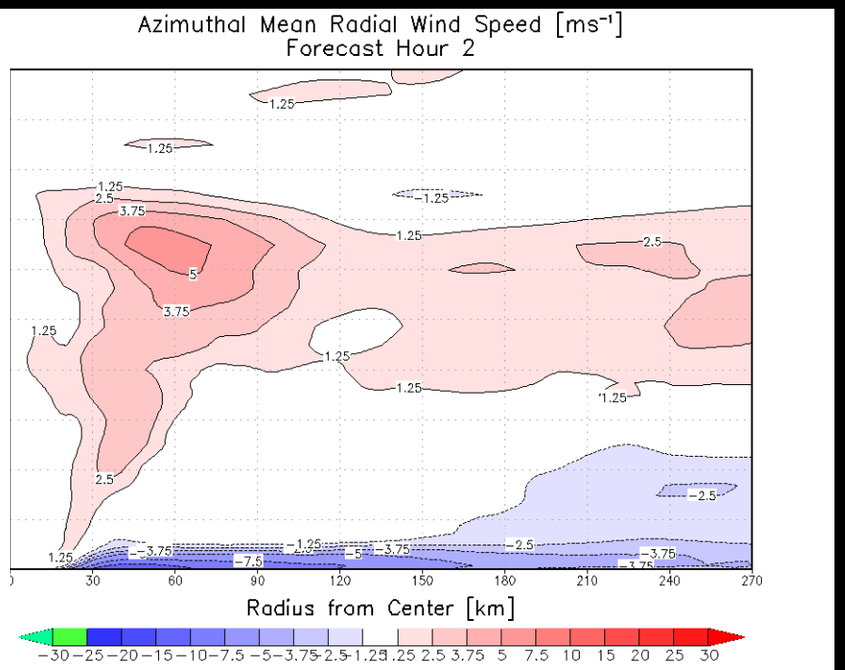
No total condensate



No vertical acceleration

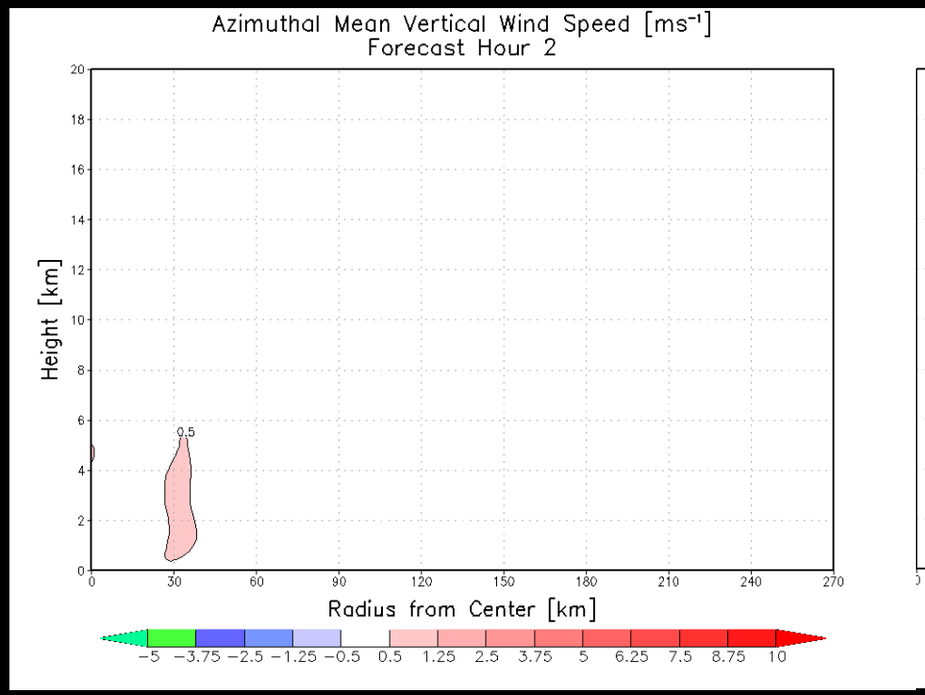


No ice mixing ratio

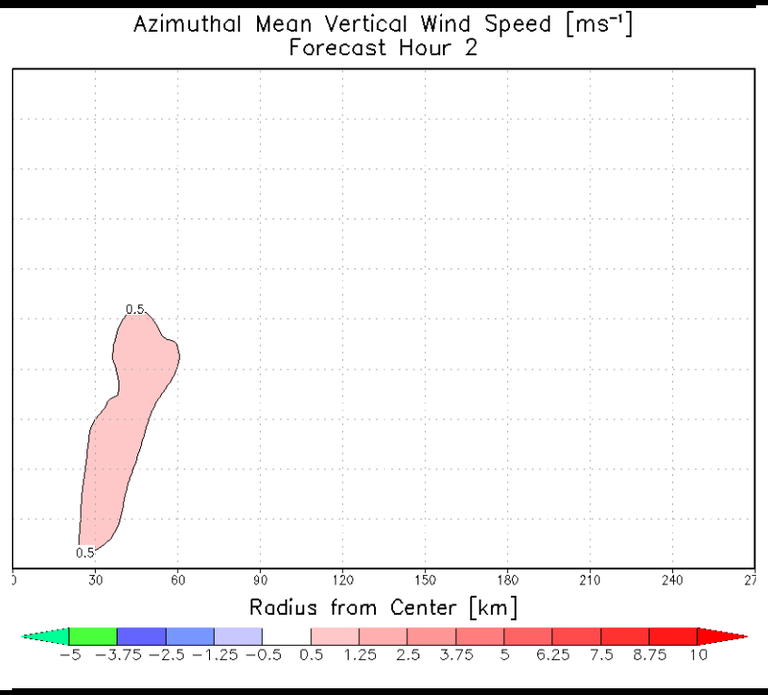


No rain mixing ratio

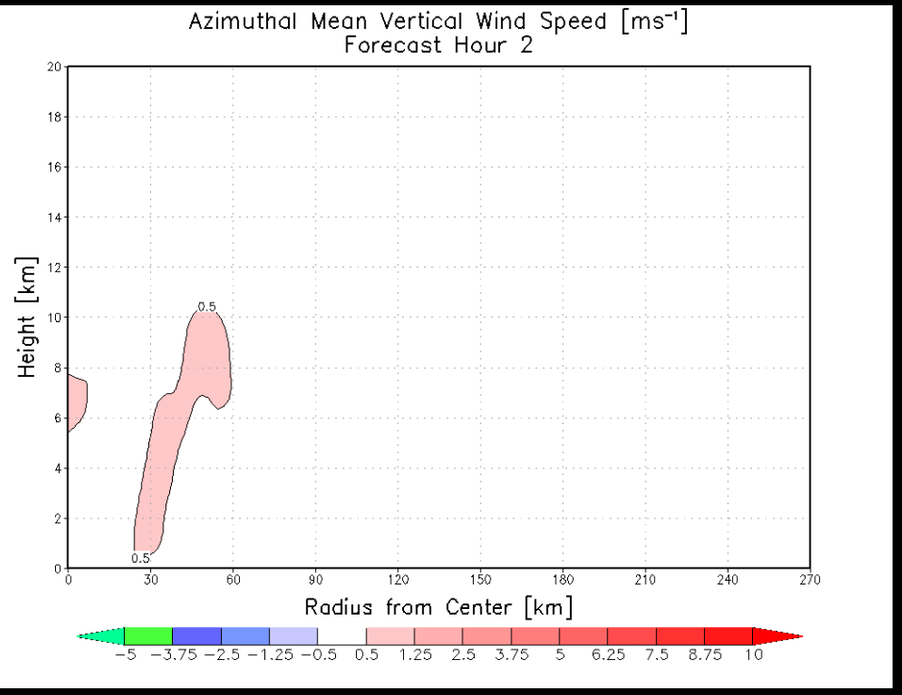
initial azimuthal mean vertical wind



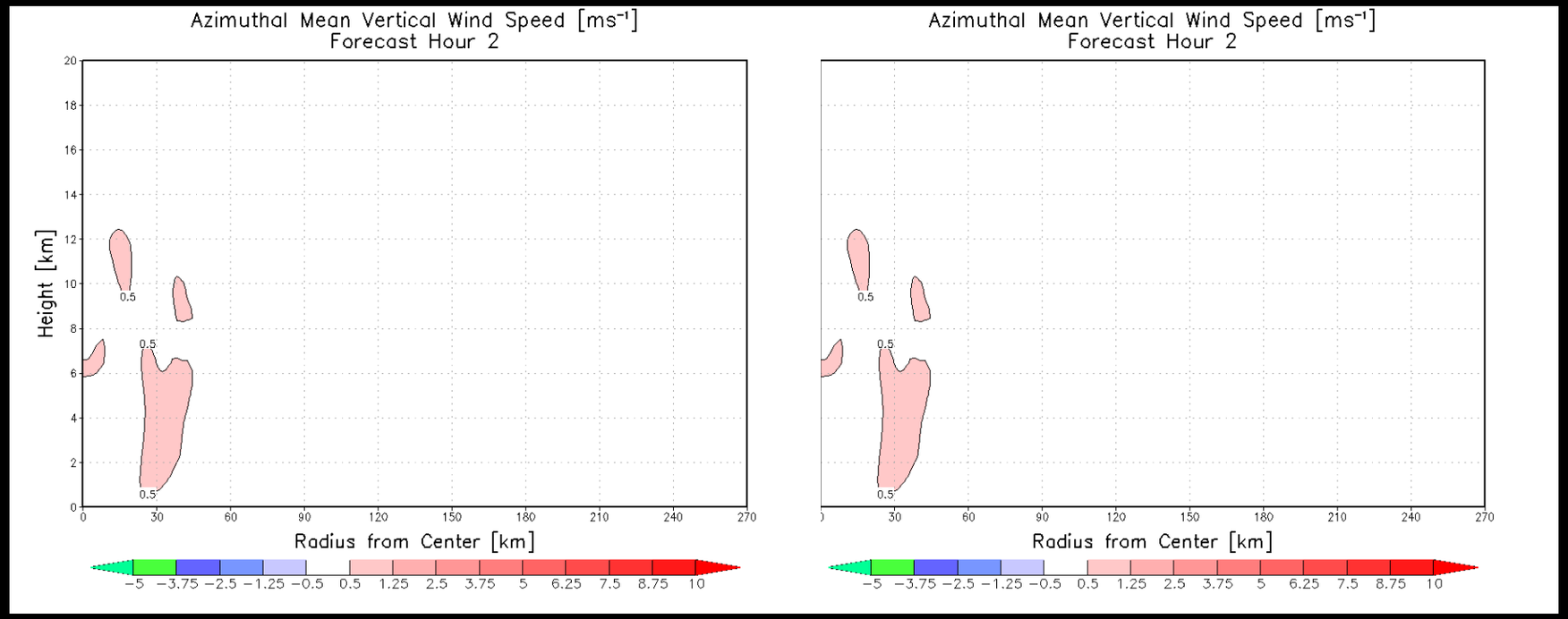
All



No total condensate



No vertical acceleration

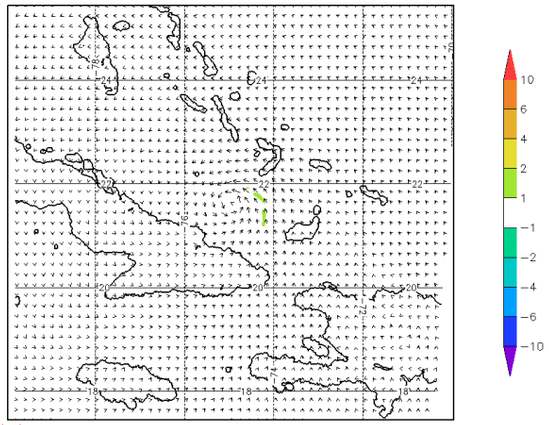


No ice mixing ratio

No rain mixing ratio

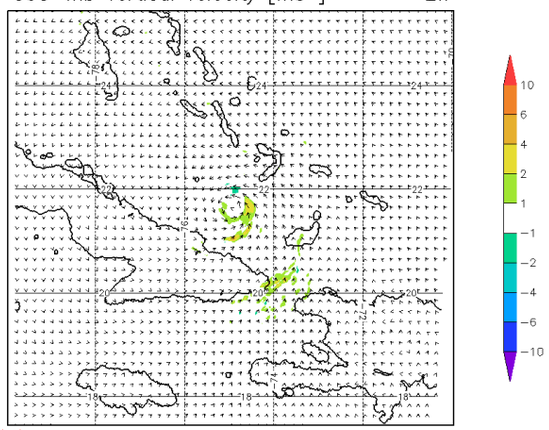
Experimental Product

200−mb vertical velocity [ms⁻¹] 2h



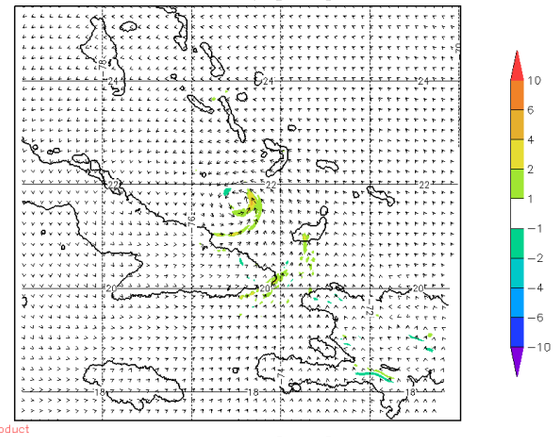
Experimental Product

500−mb vertical velocity [ms⁻¹] 2h



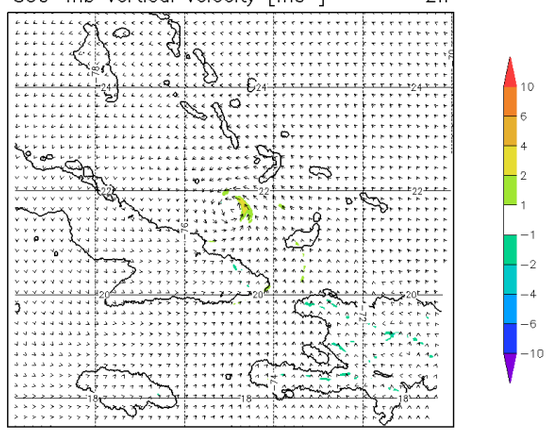
Experimental Product

700−mb vertical velocity [ms⁻¹] 2h



Experimental Product

850−mb vertical velocity [ms⁻¹] 2h



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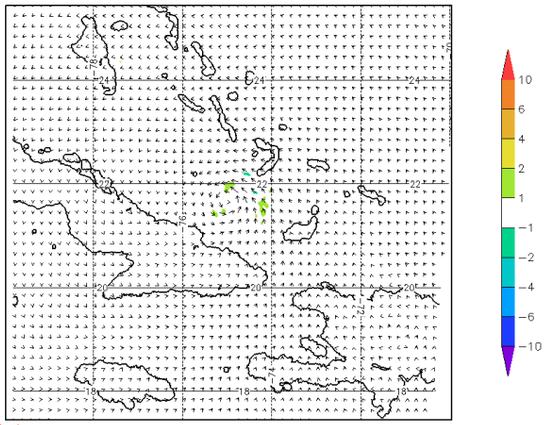
Initial date: 2016100512

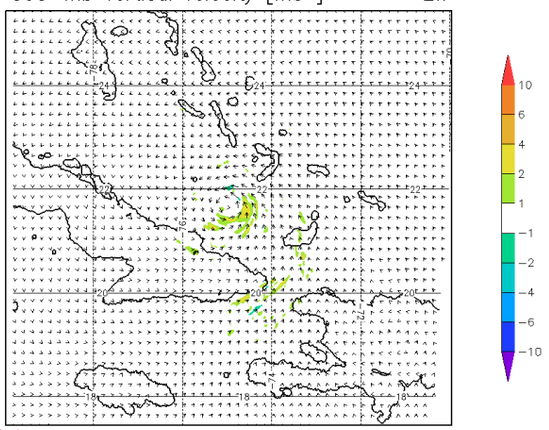
Experimental Product

200−mb vertical velocity [ms⁻¹] 2h



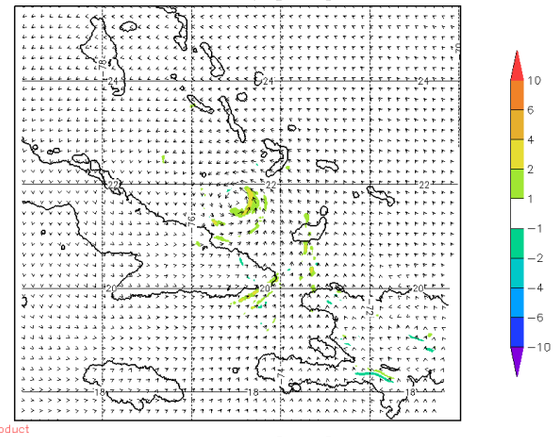
Experimental Product

500−mb vertical velocity [ms⁻¹] 2h



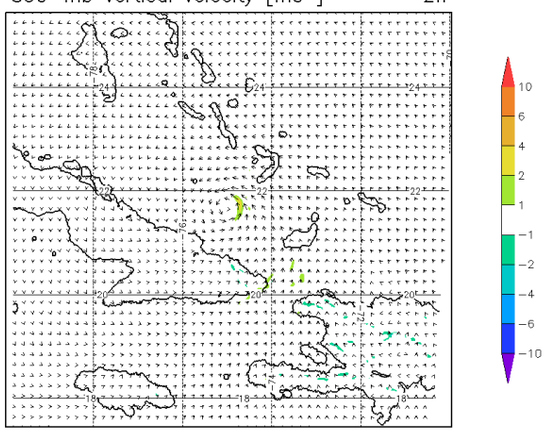
Experimental Product

700−mb vertical velocity [ms⁻¹] 2h



Experimental Product

850−mb vertical velocity [ms⁻¹] 2h



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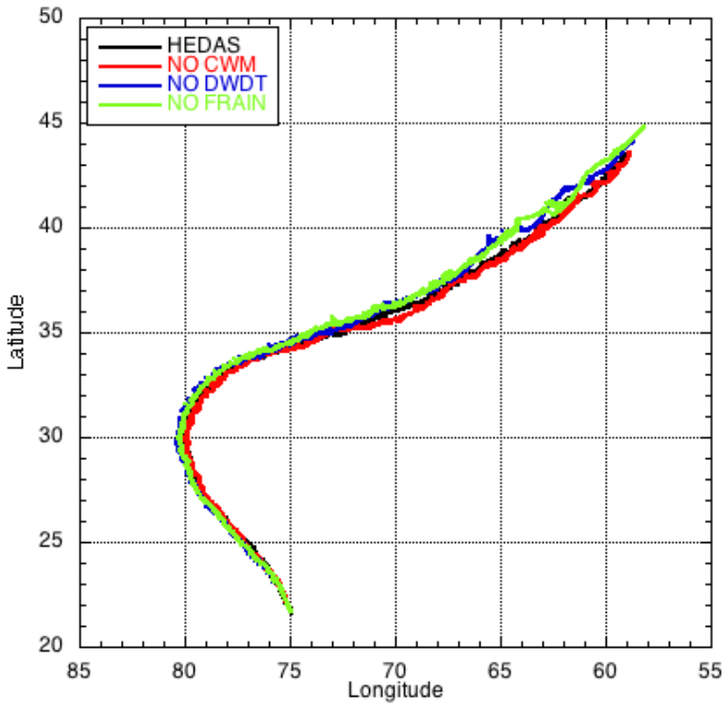
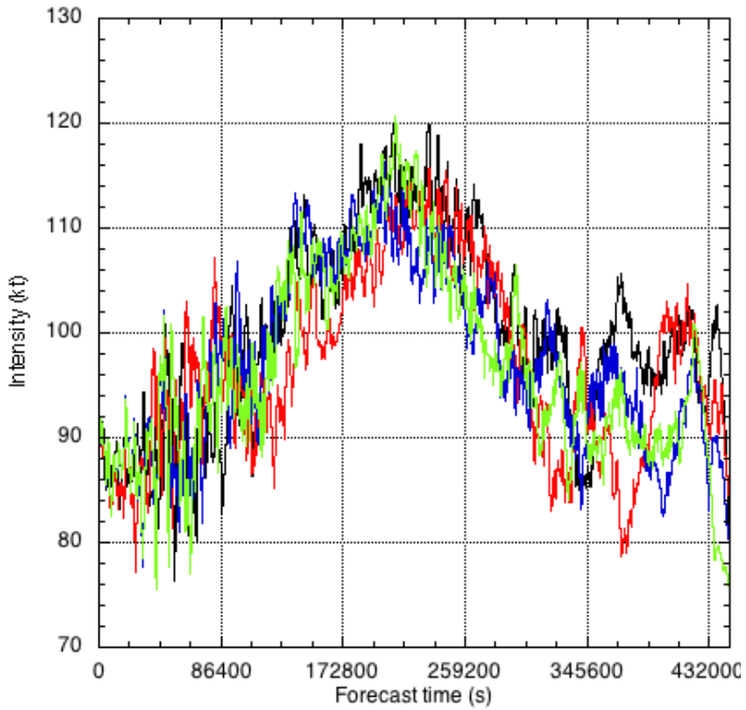
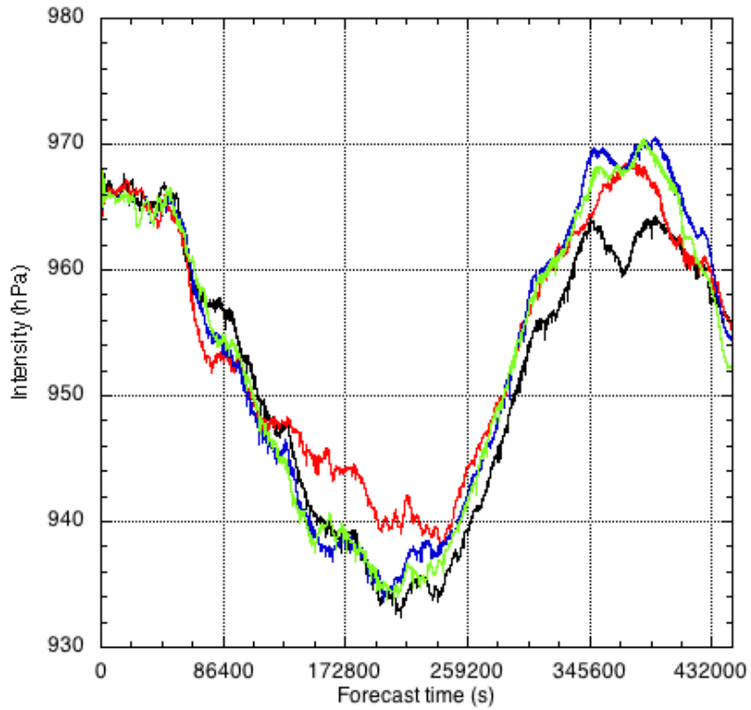
Initial date: 2016100512

Track



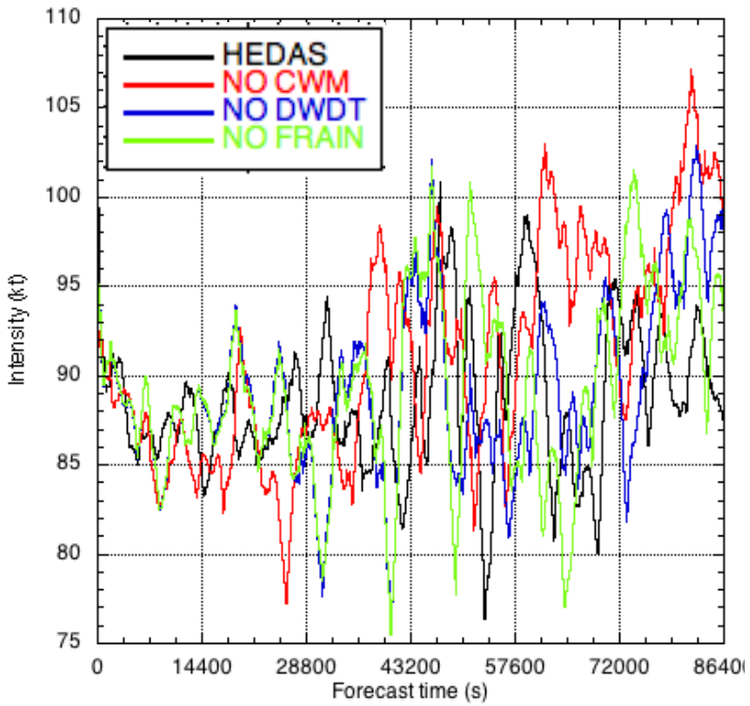
Intensity

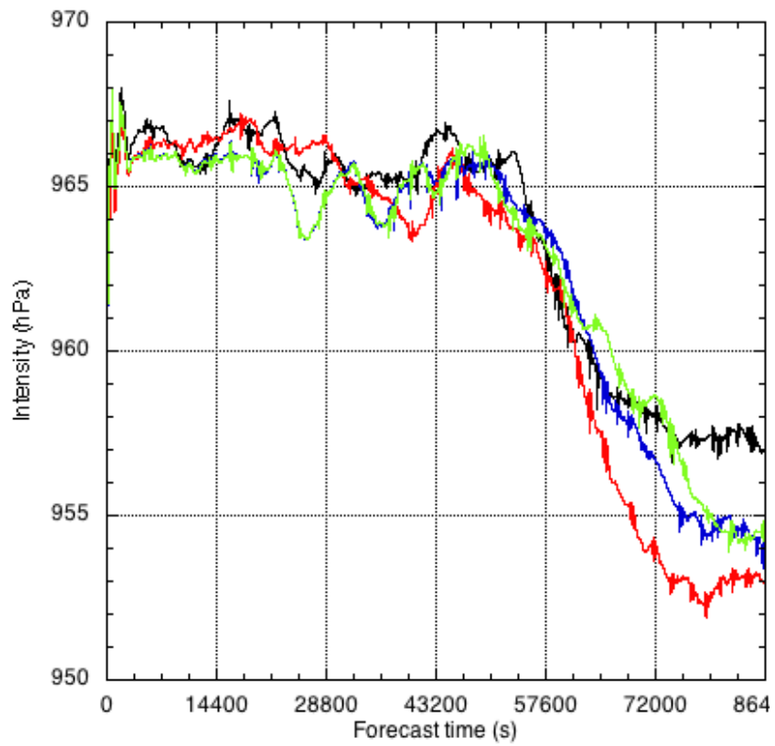




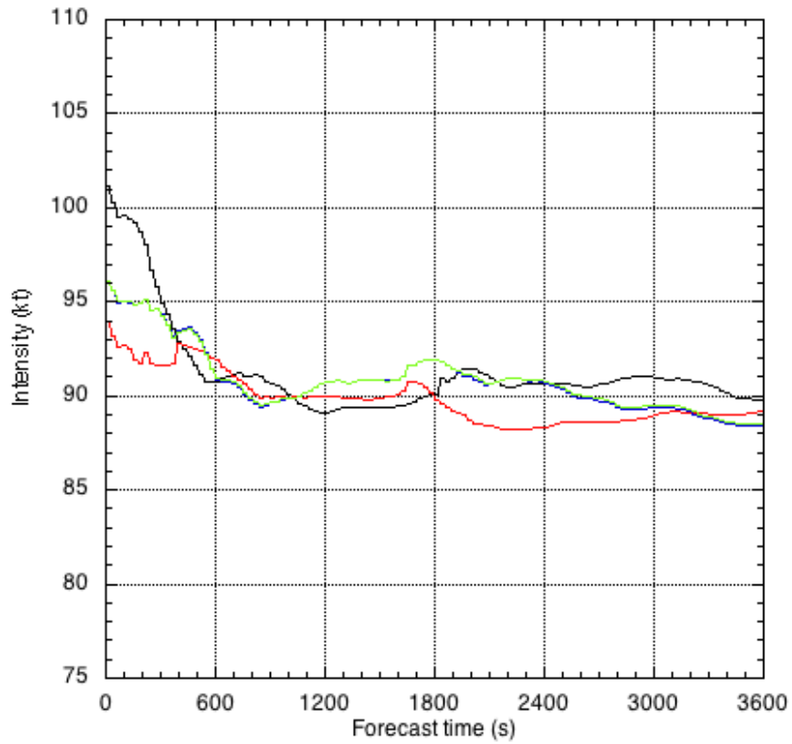
Intensity

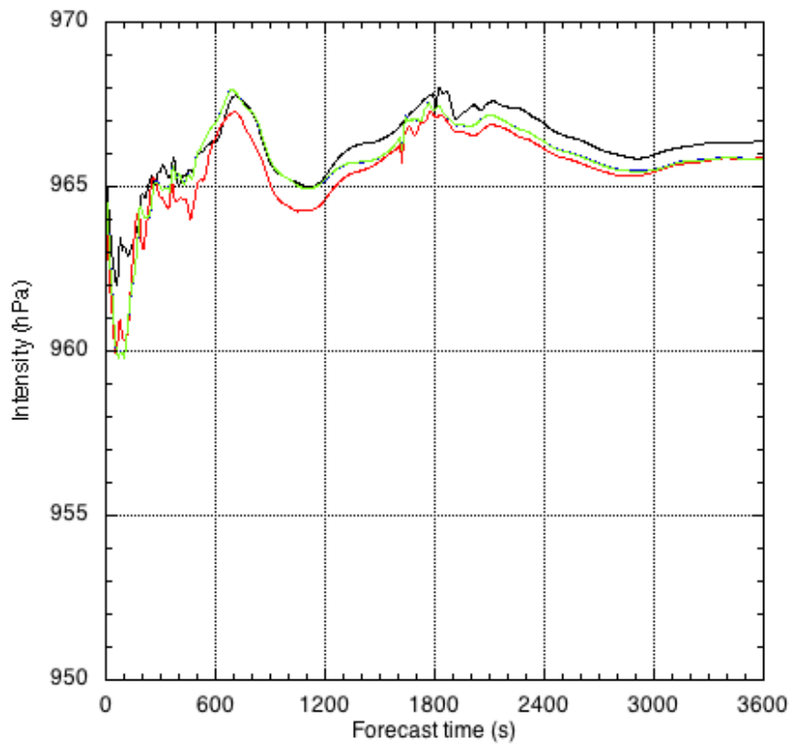
First 24 h



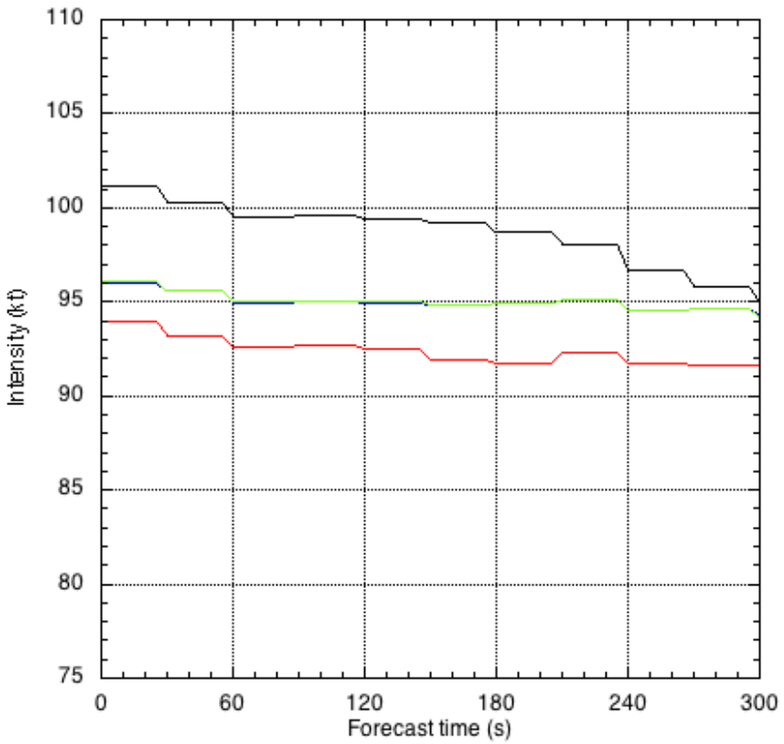


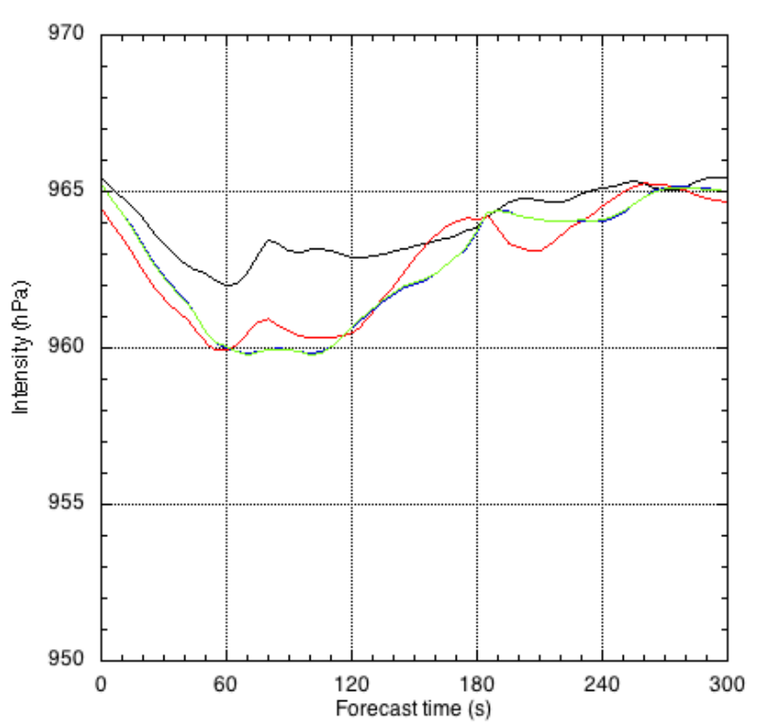
First 1 h





First 5 min





In TEMPDROP, the release time and location are available to the nearest hour and 0.1 degrees latitude and longitude, respectively.

As model resolution increases, this can lead to large errors in location for data assimilation.

NOAA (and all other agencies) have turned off hurricane core dropwindsonde assimilation since this was identified as a problem in 2008.

Large Forecast Degradations due to Synoptic Surveillance during the 2004 and 2005 Hurricane Seasons

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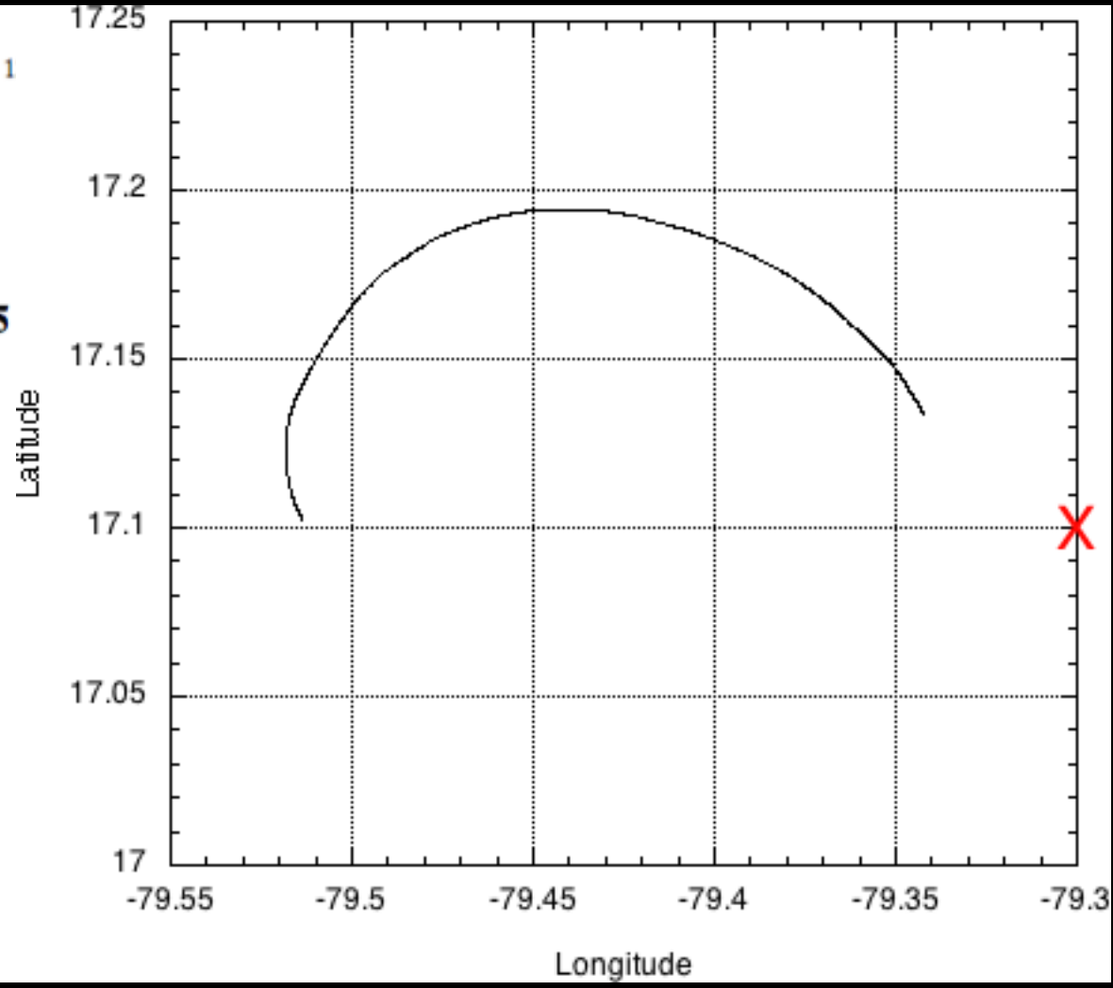
(Manuscript received 6 March 2007, in final form 18 October 2007)

ABSTRACT

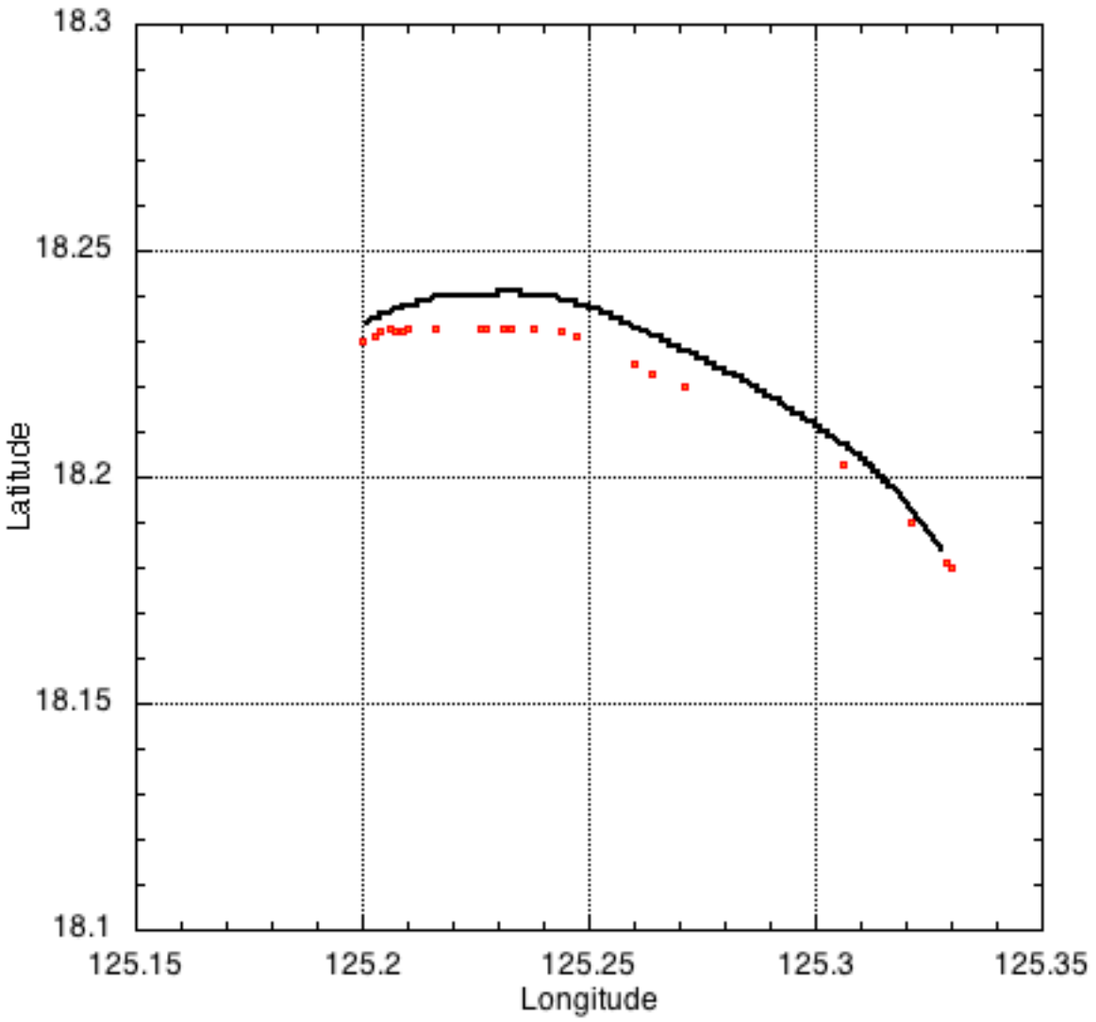
Though operational tropical cyclone synoptic surveillance generally leads to smaller track forecast errors in the National Oceanic and Atmospheric Administration Global Forecasting System (GFS) than would occur otherwise, not every case is improved. Very large GFS forecast degradations due to surveillance are investigated. Small perturbations to model initial conditions may have a large impact locally or downstream in a short time. In these cases, the perturbations are due either to erroneous data assimilated into the models or to issues with the complex data assimilation system itself, and may have caused the forecast degradations. Investigation of forecast and observing system failures can lead to procedural changes that may eliminate some causes of future large forecast errors.



All dropwindsonde data are also sent with information to calculate the time and location of each level's data within 0.5 km and 30 s. Only data available in realtime are necessary for this calculation. Average fall speed of sonde is assumed.

```
UZPA13 KBIX 121814
XXAA  67118 99180 11251 06085 99/// ///// ///// 00/// ///// /////
92/// 24802 22669 85/// 21405 27664 70/// ///// 88999 77999
31313 09608 81122
61616 AF100 WXWXA TRAIN        OB 99
62626 AEV 32172 REL 1796N12509E 112328 SPG 1794N12524E 112659 =
XXBB  67118 99180 11251 06085 00/// ///// 11926 25002 22850 21405
33810 20809 44767 17601 55755 19003 66738 16601 77720 17202 88717
16001 99706 140// 11703 150//
21212 00/// ///// 11926 22667 22923 22676 33921 23177 44914 24160
55913 23674 66911 23677 77908 24163 88903 24170 99901 24668 11897
25176 22892 25664 33887 26669 44878 27162 55857 27667 66850 27664
77747 30148 88712 31164
31313 09608 81122
61616 AF100 WXWXA TRAIN        OB 99
62626 AEV 32172 REL 1796N12509E 112328 SPG 1794N12524E 112659 =
```

Location and time of first and last wind to nearest 0.01 degrees and 1 sec



Red - calculated mandatory- and significant-level locations

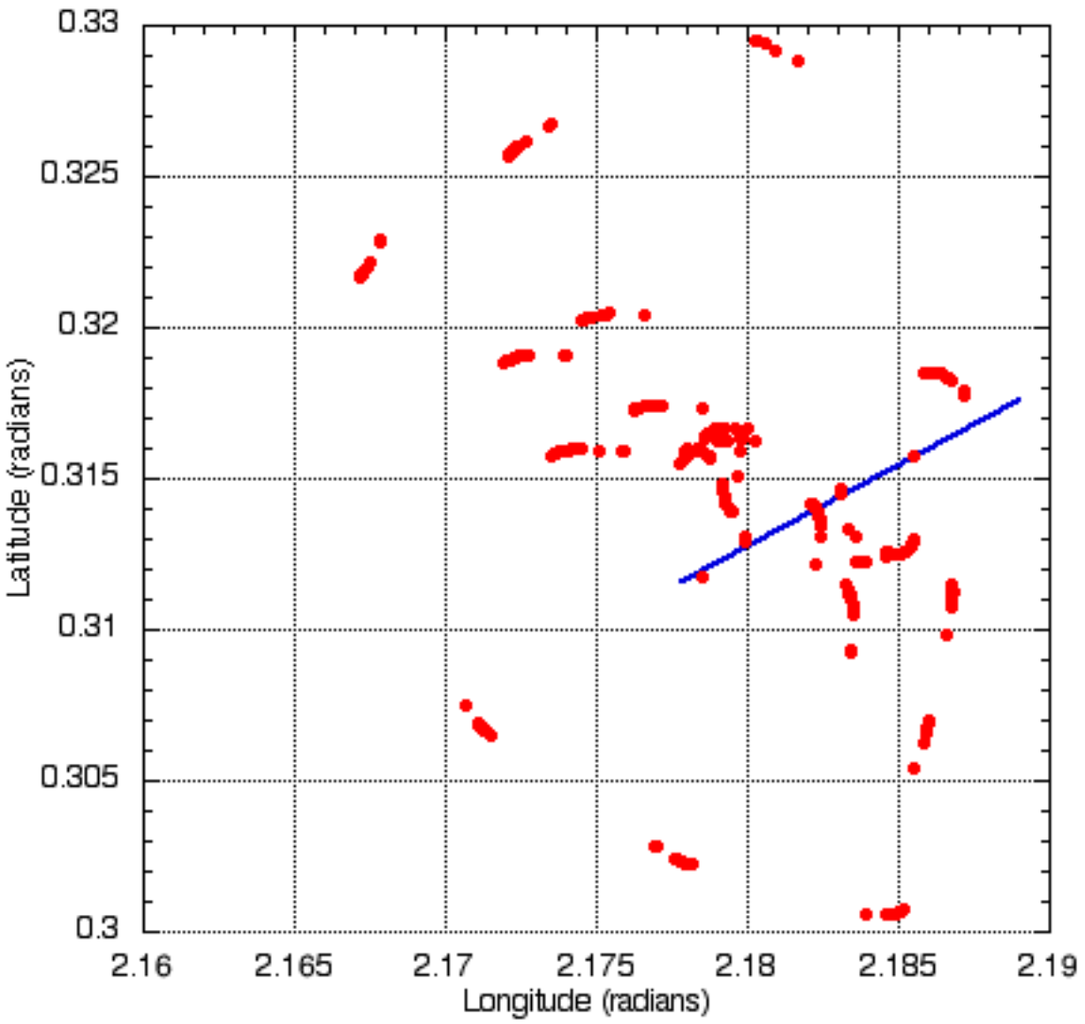
Black - actual location (.frd file)

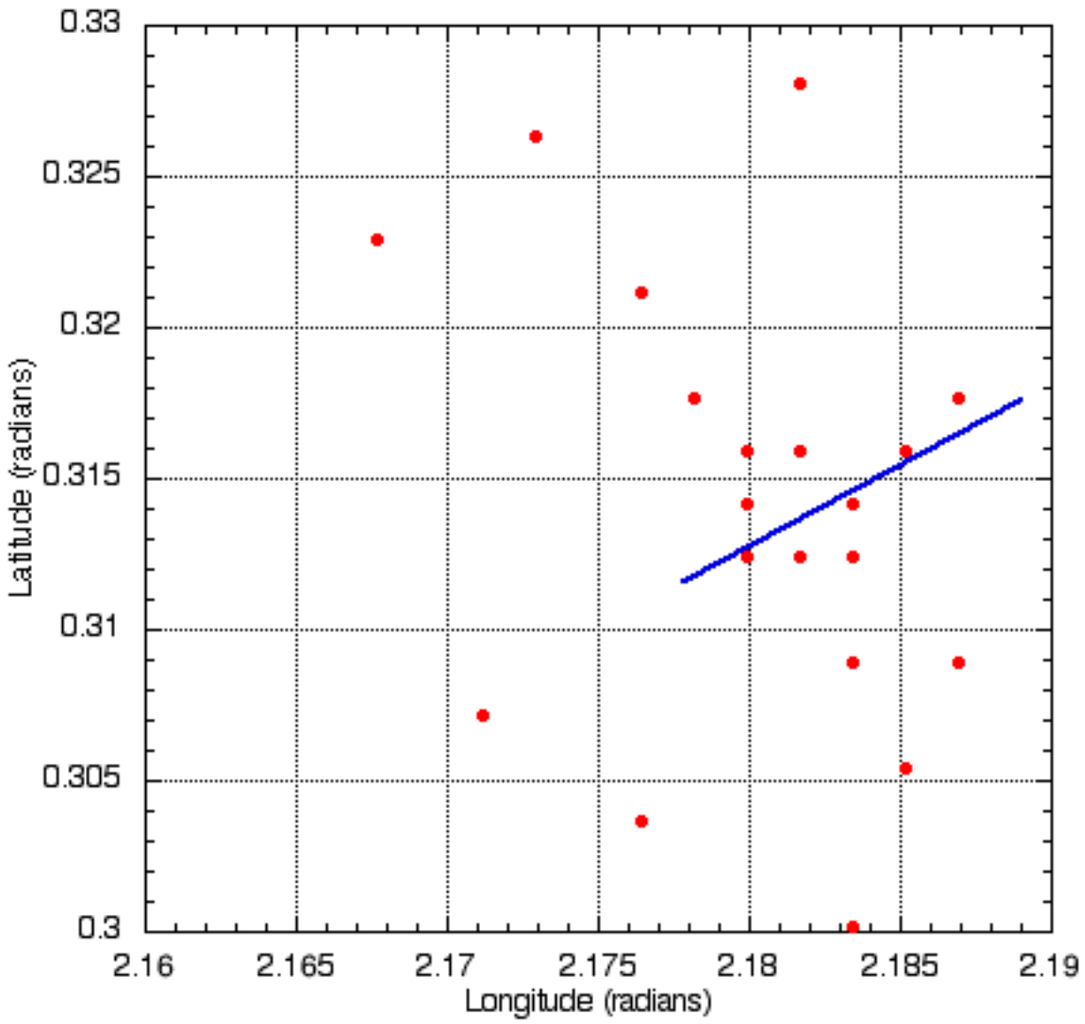
Accuracy of method

	P3 TEMP DROP	P3 calculated	G-IV TEMP DROP	G-IV calculated
Mean time error (min)	15.9338	0.105	16.2711	0.2697
σ time error (min)	8.6934	0.3108	10.7611	0.4537
Mean distance error (km)	5.1571	0.4256	5.57432	0.4139
σ distance error (km)	2.6824	0.3723	3.5386	0.2068
Maximum time error (min)	34.0	2.0	46.0	3.0
Maximum distance error (km)	20.0134	5.7953	29.3802	1.6102
Number of comparisons	2383	2383	18076	18076

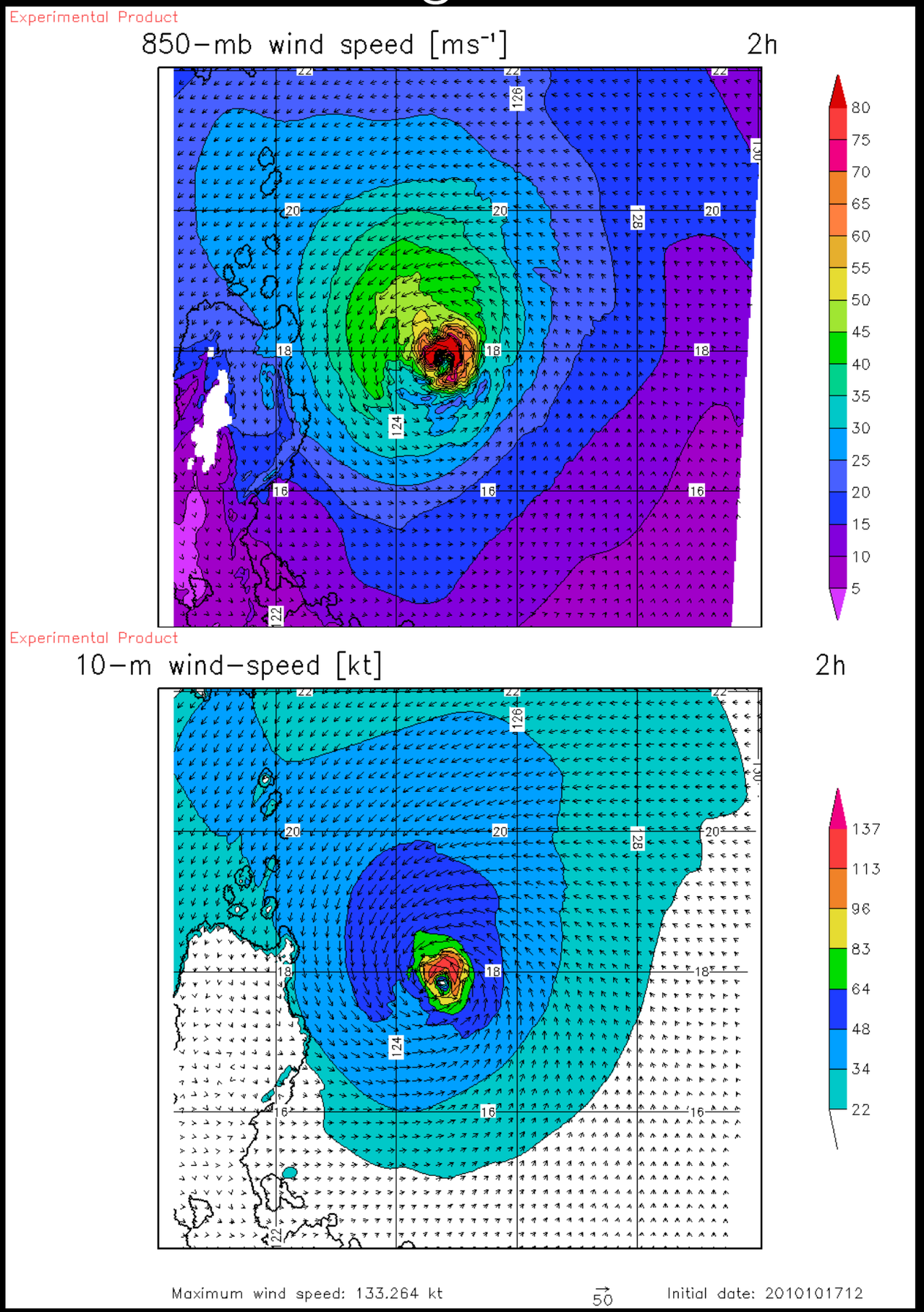
Table 1: Differences between observation times and locations as reported in the TEMP DROP messages and as calculated using the current technique.

Example: Typhoon Megi

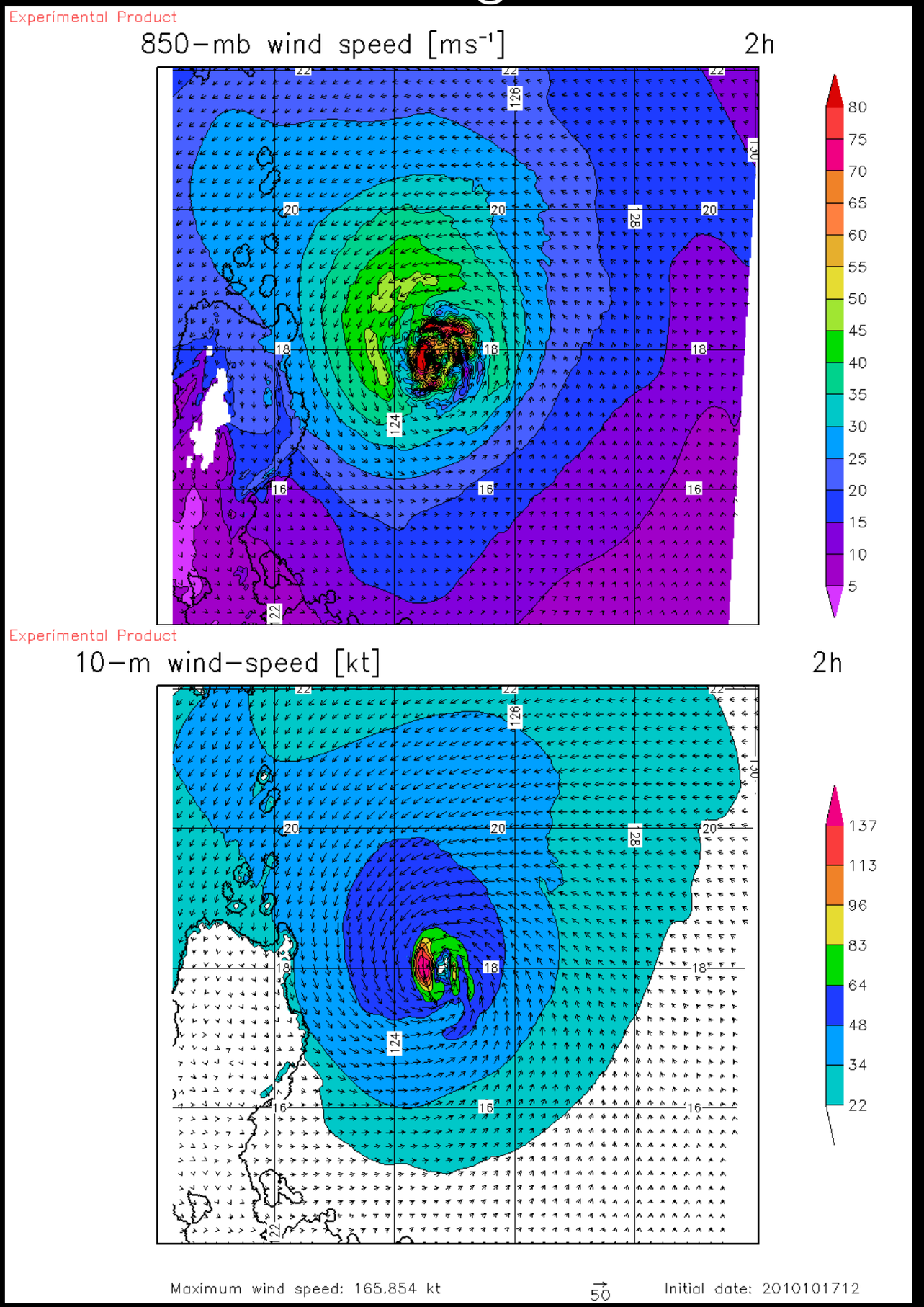




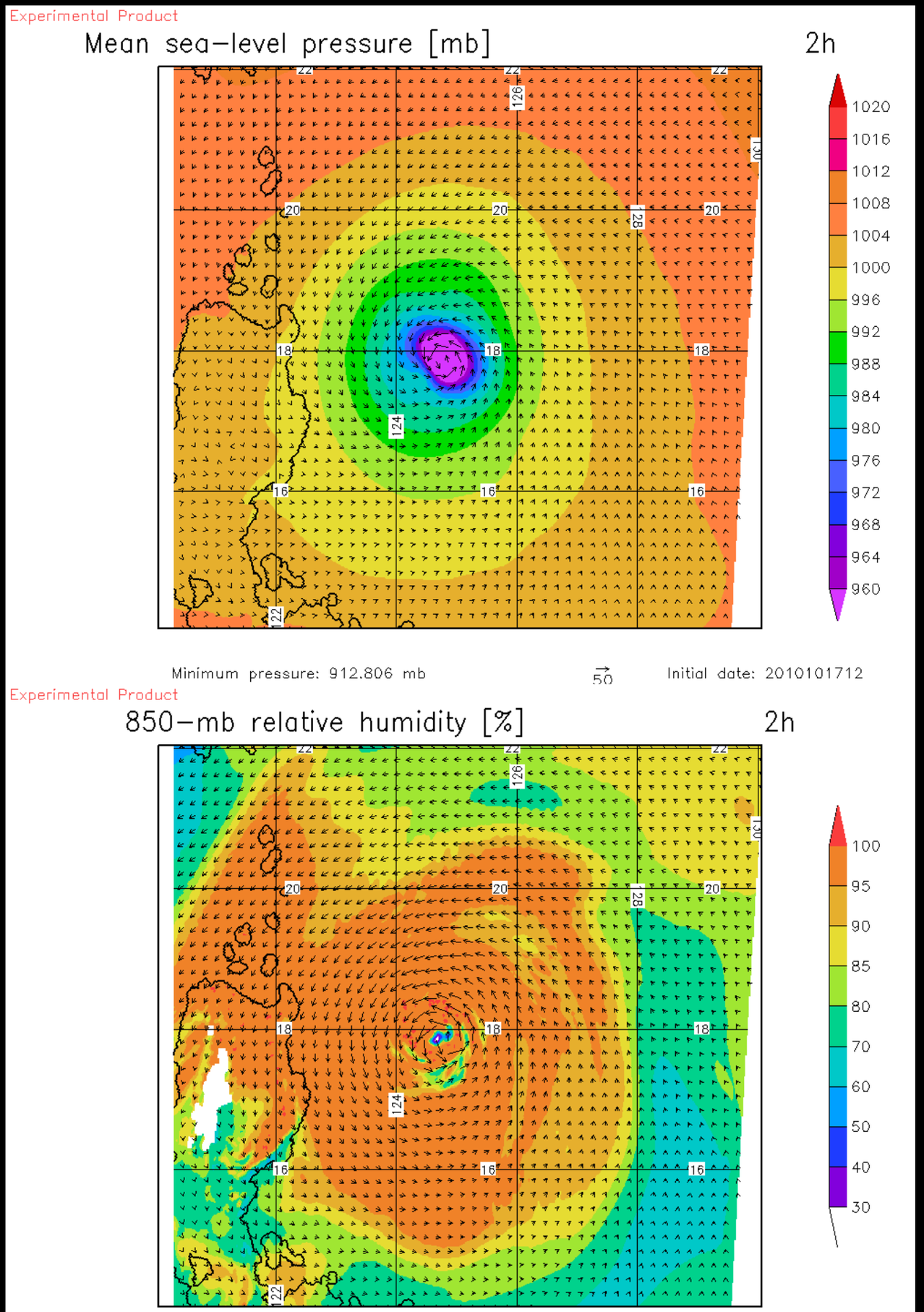
Accounting for location



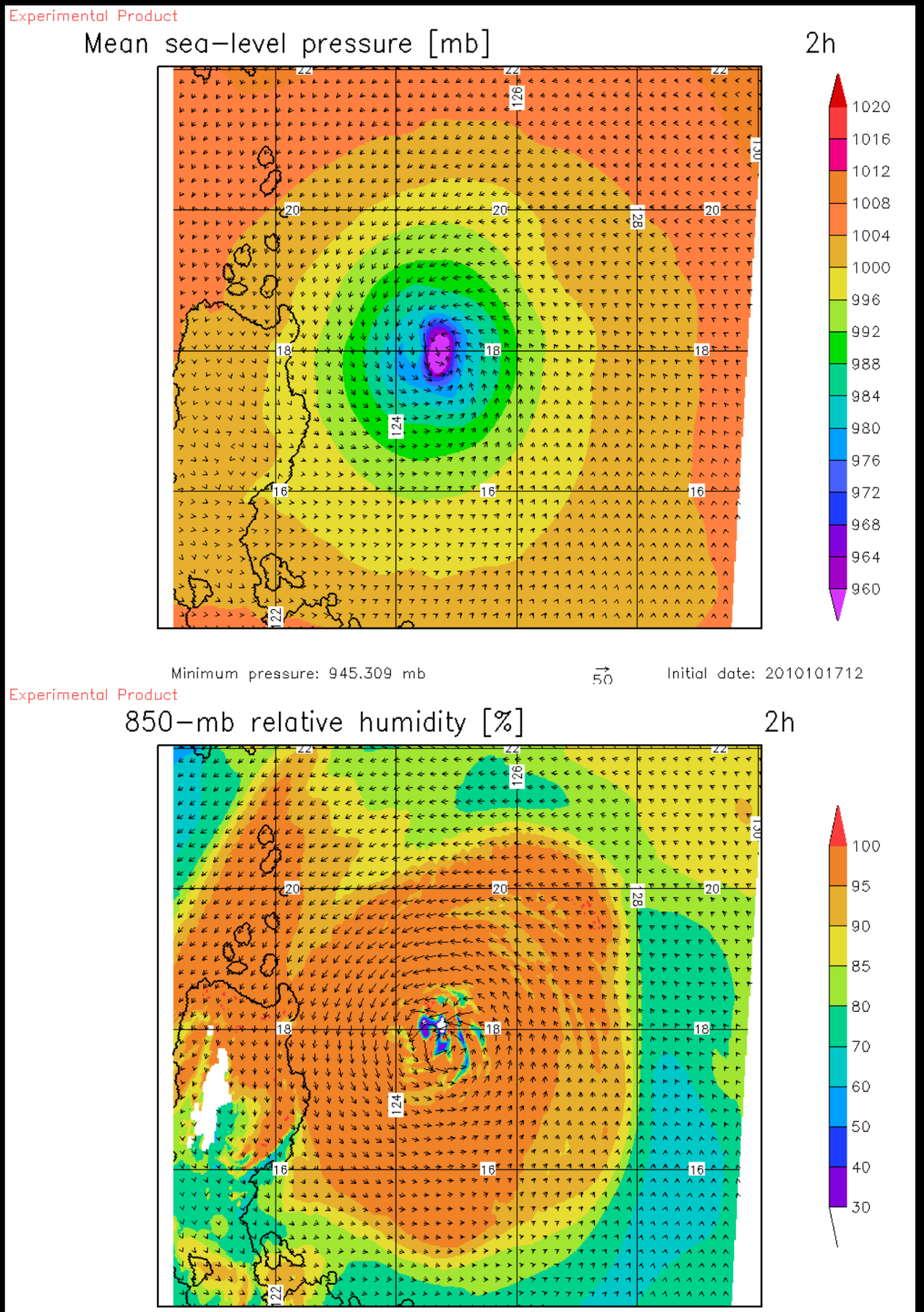
Not accounting for location



Accounting for location



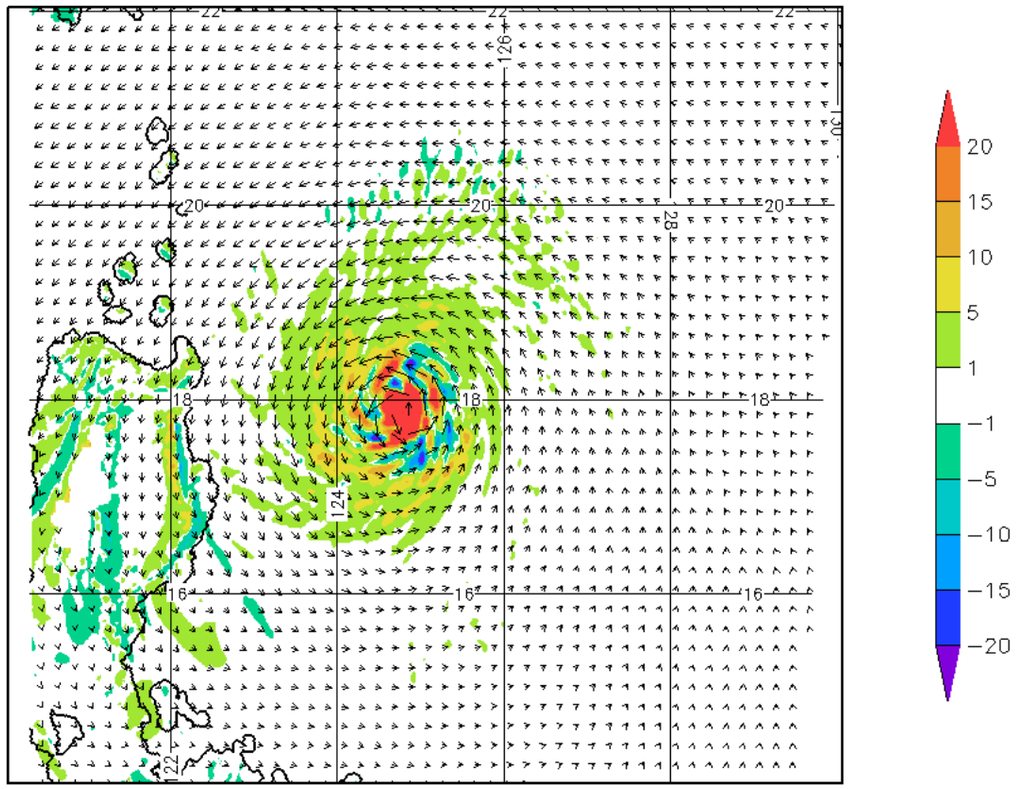
Not accounting for location



Accounting for location

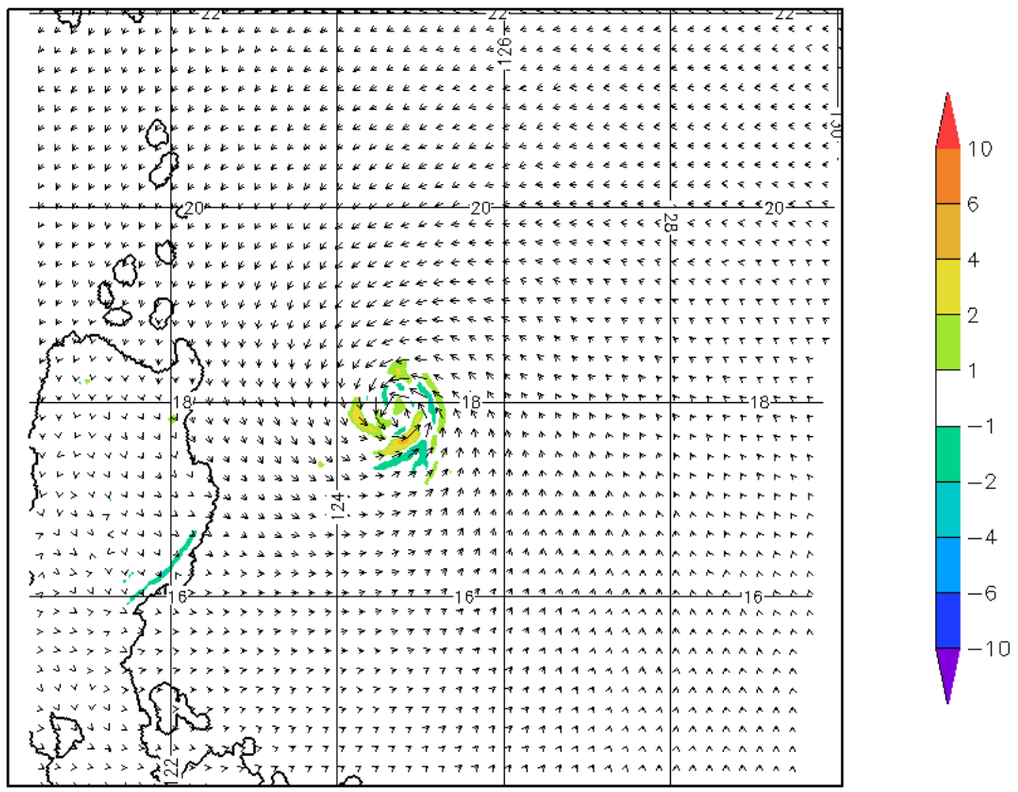
Experimental Product

850−mb relative vorticity [$10^{-4}s^{-1}$] 2h



Experimental Product

850−mb vertical velocity [ms^{-1}] 2h



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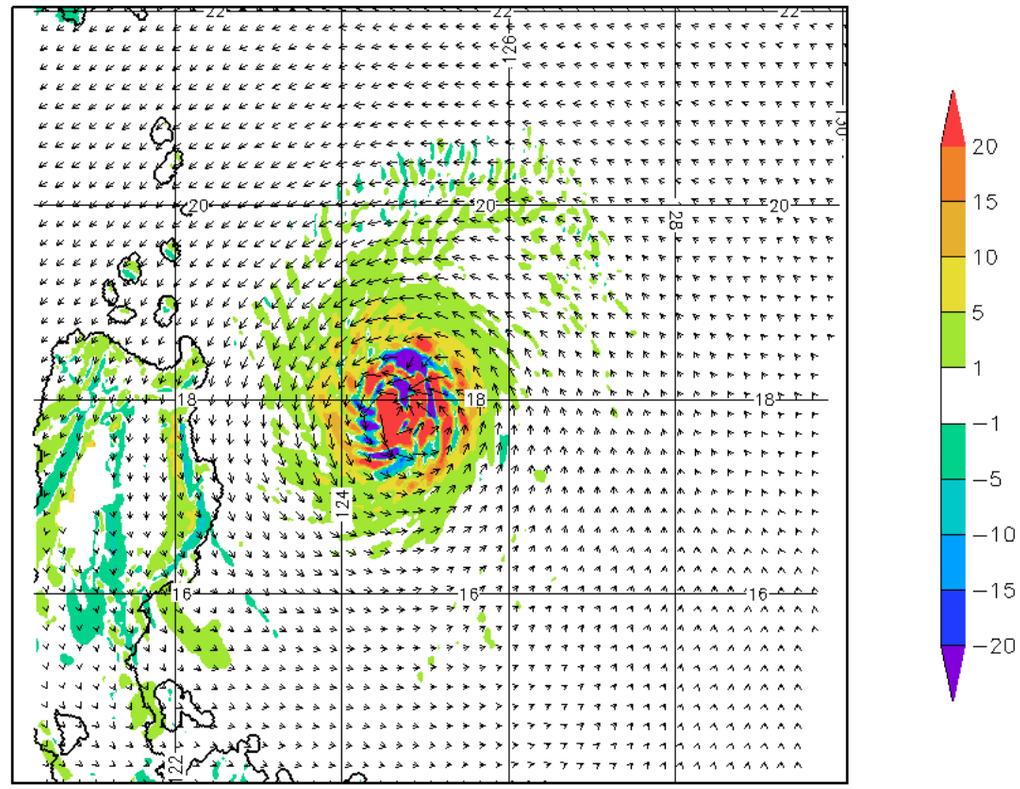
Initial date: 2010101712

Not accounting for location

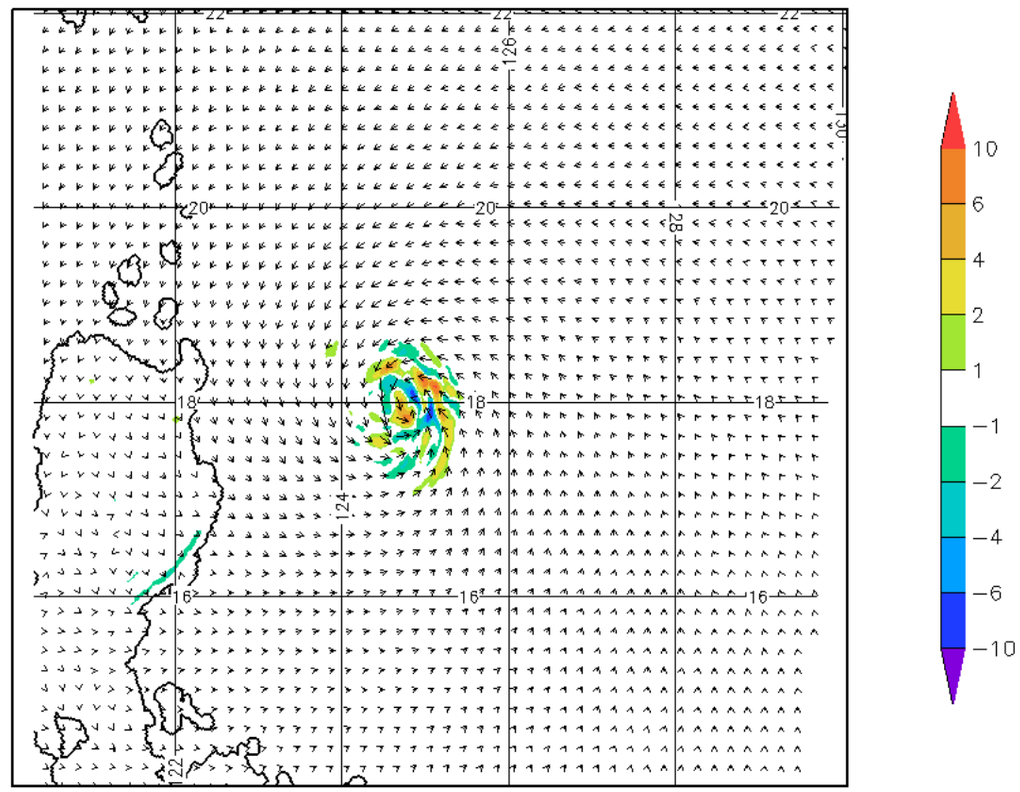
Experimental Product

850−mb relative vorticity [$10^{-4}s^{-1}$] 2h



Experimental Product

850−mb vertical velocity [ms^{-1}] 2h



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Initial date: 2010101712

This will not be an issue with transmission of dropwindsonde data in BUFR, but ASPEN is not yet ready for this, and this also requires time and money to upgrade systems, especially on Air Force aircraft.

Aberson, S. D., K. J. Sellwood, and P. A. Leighton, 2017: Calculating dropwindsonde location and time from TEMP DROP messages for accurate assimilation and analysis. Submitted to JTECH.