4.6 TOWARD IMPROVED USE OF GOES SATELLITE-DERIVED WINDS AT THE NCEP ENVIRONMENTAL MODELLING CENTER (EMC)

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1. INTRODUCTION

Two types of GOES satellite-derived winds, cloud-drift infrared and cloud-top water vapor, are now used operationally at NCEP. These winds provide valuable information for initializing numerical model over regions where conventional observations are unavailable. These satellite-derived winds which use clouds as a tracer are believed to have significant correlated errors. To reduce the effect of the spatial correlations, the data can be thinned. The impacts of various thinning algorithms are tested by examining their effects on skill of the T62 version of the NCEP global forecast and data assimilation system.

2. THE THINNING ALGORITHMS AND EXPERIMENTS

The tested thinning algorithms take all the wind observations in a box and replace them by a single observation. For our test, we used 2^0x2^0 boxes with tops and bottoms at 100, 150, 200, 250, 300, 350, 400, 500, 600, 700, 750, 800, 850 mb. The tested thinning algorithms are (1) random thinning which selects one observation randomly, (2) average thinning which averages all the observations in a box, (3) the recursive filter flag (RFF)-thinning which picks the observation with highest RFF value (Hayden et al. 1995), which is distributed with GOES winds) (4) the quality indicator (QI)-thinning which picks the observation with highest QI value (Holmlund, 1998); and (5) QI+RFF thinning which chooses the wind with highest QI+RFF value. The fraction of observations that are filtered out depends on the distribution of data, generally, thinning reduced the number of satellite observations about 65%.

The experiments were conducted on the version of T62 (192x94 horizontal grid and 28 vertical levels) NCEP global forecast model. The forecasts were run twice daily during the August 1-31, 2000 period. The thinning algorithms were tested on various versions of the global forecast and data assimilation system (not all combinations were tested). The first model is the older version of the T62 operational model (circa October, 2000), the second is the next upgrade to the operational model. The primary difference between the two versions is a change to the convective parameterization and the assimilation of cloud liquid water in the second version. These changes have resulted in the significant improvement in the tropical wind field. Results are presented here for the two versions of forecast and assimilation system.

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3. THE RESULTS

The results of experiments are presented in Table 1 and Table 2.

Table 1. The test scores the first mode

		2-day	3-day	4-day	5-day
	CONT	0.947	0.886	0.794	0.670
	RAND	0.947	0.886	0.793	0.668
	AVER	0.947	0.886	0.794	0.670
NH-500	RFF	0.947	0.886	0.793	0.667
	QI	0.947	0.886	0.793	0.671
	RFF+QI	0.946	0.884	0.790	0.661
	NOSAT	0.947	0.886	0.797	0.681
	CONT	0.950	0.890	0.830	0.752
	RAND	0.950	0.892	0.831	0.750
	AVER	0.950	0.891	0.829	0.749
SH-500	RFF	0.950	0.892	0.832	0.752
	QI	0.950	0.892	0.832	0.751
	RFF+QI	0.949	0.891	0.828	0.744
	NOSAT	0.950	0.894	0.828	0.739
	CONT	3.910	4.560	5.051	
	RAND	3.916	4.583	5.068	
	AVER	3.911	4.571	5.052	
TR-850	RFF	3.903	4.567	5.049	
	QI	3.882	4.541	5.033	
	RFF+QI	3.884	4.556	5.028	
	NOSAT	3.952	4.627	5.151	
	CONT	7.066	8.348	9.373	
	RAND	7.019	8.352	9.297	
	AVER	7.040	8.368	9.327	
TR-200	RFF	7.005	8.304	9.290	
	QI	6.971	8.358	9.327	
	RFF+QI	6.952	8.287	9.263	
	NOSAT	7.105	8.452	9.394	

In the Table 1, CONT and NOSAT represent the experiments with all and none of the satellite winds, respectively. RAND, AVER, RFF, QI, RFF+QI represent the five thinning algorithms. NH-500 and SH-500 represent the North Hemisphere (20^0 -80^0 N) and the South Hemisphere (20^0 -80^0S) forecast 500 mb geopotential height anomaly correlation score compared with its own analysis, respectively. TR-850 and TR-200 represent the tropical (20^0 N -80^0 S) wind vector RMS error using its own analysis at 850mb and 200mb, respectively. Note that the comparison of forecast wind field with rawinsonde observation produced consistent results with Table 1.

The results (CONT vs. NOSAT) show that the satellite winds have a little impact on the forecast skill for the mid-latitude 500 mb heights (the impact is in the third decimal place). However, the satellite winds did slightly improve the tropical wind forecasts. The difference between with and without satellite winds on the 850mb and 200mb wind vector RMS at tropics is less than 2% averaged over experiment period (August 1-31, 2000). For the five thinning algorithms, there are only small differences for both 500mb geopotential height anomaly correlation scores and tropical RMS. The largest differences for the 500mb geopotential height anomaly correlation scores and wind vector RMS at tropics is 3% (between AVERAGE and RFF on forecast day-5 South Hemisphere) and 2% (between RANDOM and QI on day-3 forecast at 850mb tropics). The QI-thinning, on average, performed best in our tests. However, the impacts were small with the effects negligible in the mid-latitude heights and only up to a 2% improvement the tropical RMS error.

The experiments using second version of model and assimilation system focus on the impacts of satellite winds and QI thinning. Table 2 summarizes the results for the new model for the same period (August 1-31, 2000). All symbols have same meaning as in Table 1.

Table 2. The test scores for the second model

		2-day	3-day	4-day	5-day
	CONT	0.954	0.901	0.816	0.701
NH-500	QI	0.954	0.900	0.814	0.699
	NOSAT	0.954	0.899	0.812	0.699
	CONT	0.951	0.894	0.834	0.758
SH-500	QI	0.951	0.895	0.834	0.756
	NOSAT	0.951	0.896	0.838	0.767
	CONT	3.824	4.270	4.558	
TR-850	QI	3.845	4.301	4.596	
	NOSAT	3.798	4.255	4.575	
	CONT	7.158	8.157	8.903	
TR-200	QI	7.152	8.135	8.888	
	NOSAT	7.266	8.278	8.955	

The results for the new model show that the impacts of using all satellite winds are much smaller on the tropical wind vector RMS at 200mb with a negative impact on the tropical wind vector RMS at 850mb for the second and third day forecast. The impact of satellite wind on the geopotential height forecasts, if any, is also in the third of decimal place, except for the South Hemisphere at forecast day 5 (0.758 (control) vs. 0.767 (no satellite winds)). For the upgraded model/data assimilation system, the impact of the satellite wind is much smaller than in the older systems.

The impact of thinning is more complicated in the new model. The thinning almost has no impact on the geopotential height forecast field, negative impact on the 850mb tropical wind vector RMS, and slightly positive impact of the 200mb tropical wind vector RMS (Table 2). However, generally the results for the new model are still superior to those from the old model.

4. CONCLUSIONS

The impacts of using satellite-derived winds in a forecast/data assimilation system are complicated and system dependent. The NCEP assimilation system usually assumes that observations are spatially uncorrelated which is not appropriate for satellite winds. Hence we have tested different thinning methods in order to reduce the spatial correlation of the satellite winds. Our results are mixed. For example, the thinning improves on the higher level (200mb) tropical wind vector forecasts (RMS), but degrades it for the lower levels (850mb) when used in the NCEP's new forecast/data assimilation system. This differs from the older and current operational system. Further analyses are needed to explore the problem of improving the use of satellite winds by the operational forecast systems. Future improvements in the use satellite winds are expected to be the results of improved satellite wind quality and improved data assimilation methods.

References

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