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Impact Assessment of a Doppler Wind Lidar for OSSE/NPOESS

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1. INTRODUCTION

The future National POES System (NPOESS) is scheduled to fly during the 2007-2010 period. For the next 10 years, a considerable amount of effort must take place to define, develop and build the suite of instruments which will comprise the NPOESS. The forecast impact of current instruments can be assessed by Observing System Experiments (OSEs), in which already existing observations are denied or added to observations from a standard data base. However, the impact of future instruments must be assessed with experiments using simulated observations. These experiments are known as Observing System Simulation Experiments (OSSEs) (Lord et al. 1997).

For each OSSE, a long integration of an atmospheric general circulation model (GCM) is required to provide a "true atmosphere" for the experiment. This is called the "nature run" (NR). The nature run needs to be sufficiently representative of the actual atmosphere but different from the model used for the data assimilation. The observational data for existing and future instruments is simulated from NR and impact tests are performed for both real and simulated data. The nature run, the data assimilation system and forecast model used in these experiments are described in Masutani et al (2002a).

Among various candidate instruments Doppler wind lidar (DWL, Baker 1995) data are produced as line-of-sight (LOS) winds by SWA using their Lidar Simulation Model (LSM). Bracketing sensitivity experiments are being performed for various DWL technology-neutral concepts to bound the potential impact (Emmitt 1999, Emimtt et al. 2001b). Scanning, and various data sampling strategies, are being tested with these experiments. Analysis impact of DWL are presented in Lord et al. (2002). In this paper, the forecast impact is presented for selected cases. Mainly, the focus is on the impact of scanning.

2. SIMULATION OF DWL DATA

The details of procedures to simulate observational data are described in Atlas and Terry (2002) and references of Lord (2002) and Masutani et al. (2002a, 2002b). In this paper the impact of DWL is assessed with existing instruments. However, it is important that the assessment is also done with the more advanced instruments expected when DWL would be actually launched. Higher density cloud motion vectors (CMVs) and more advanced sounders, such as Atmospheric Infrared Sounder (AIRS), will be included in impact the assessment.

2.1 Simulation of DWL data

The simulation of DWL data includes efforts with DWL performance models, atmospheric circulation models and atmospheric optical models (Emmitt 1999, Emmitt et al. 2001b). The instrument parameters are provided by the engineering community. Scanning and sampling requirements are provided by the science community and define various instrument scenarios. These scenarios are tested initially by examining the sensitivity of analyses to the various scenarios. A candidate DWL concept is then chosen for a full OSSE, and an impact study is conducted and evaluated by a technology-neutral group.

The bracketing OSSEs are being performed for various DWL concepts to bound the potential impact. Later OSSEs will be performed for more specific instruments. The following “technology-neutral” observation coverage and measurement error

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characterizations will be explored.

EXP 1(Best): Ultimate DWL that provides full tropospheric LOS soundings, clouds permitting.

EXP 2 (PBL+cloud): An instrument that provides only wind observations from clouds and the PBL.

EXP 3 (Upper): An instrument that provides mid- and upper- tropospheric winds only down to the levels of significant cloud coverage.

Exp 4 (Non-Scan): A non-scanning instrument that provides full tropospheric LOS soundings, clouds permitting, along a single line that parallels the ground track.

Targeted Resolution Volume (TRV) : 200km x 200km x T

T: Thickness of the TRV
0.25 km if z < 2km, 1km if z > 2km
0.25 km for cloud return

Swath width: 2000 km except for EXP4 (non-scanning)

No measurement error is assigned for the initial test. Strategies for systematic errors are discussed by Emmitt (2000a). One measurement is an average of many shots. Data products based upon clustered and distributed shots are generated for each experiment. The clustered data product is based upon averaging the observations associated with shots clustered within an area that is very small compared to the base area of the TRV. The distributed data product is based upon averaging the observations of shots distributed throughout the TRV as would result from continuous conical scanning.

Distributed shots for the non-scan experiment (EXP4) are not realistic. However, it is used to test the penetration through cloud. In the real atmosphere, cloud has porosity which is not described in the NR archive. Cloud porosity lets some DWL shots pass through the cloud. This not possible for the NR cloud as the clouds are uniform within a grid in the NR. Distributed measurements collect many shots within the TRV and there is more chance of penetrating the atmosphere. This does not exactly model the porosity of the cloud but it is used to check the penetration due to porosity.

EXP2 and EXP3 are simulated to test various wave lengths and instruments. They are tested but not presented in this paper.

3. IMPACT ASSESSMENT FOR DWL WINDS

Prior to testing future instruments, data impact tests of existing instruments are performed to calibrate OSSEs (Masutani et al. 2002a). The results show that there are reasonable agreements between simulated and real data impact but the interpretation needs caution.

Among many candidate instruments for the OSSE, DWL winds are simulated by SWA. According to the strategy for bracketing sensitivity experiments (Lord et al. 2001a, Lord et al. 2001b, Masutani et al. 2001), scanning or non-scanning, various wave lengths, numbers of LOS per measurement, are being tested. Sensitivity to weight in the data assimilation has been tested.

For first few days, more than 20 cases are tested with various combinations and selected cases are completed for the whole OSSE period (00z February 13-00z March 7, 1993). Analysis impacts for the whole period are evaluated for 13 cases (Lord et al. 2002). In this paper the forecast impact of eight experiments is presented. Experiments discussed in this paper are listed in Table 1. The distributed data for the non-scanning scenario is not realistic. However, it is used to test the effect of penetration. Because of the averaging of each 200 Km square area, more DWL shots penetrate to lower levels for distributed shots. The amount of penetration is still an unknown quantity and needs to be investigated. For clustered shots, representativeness error 7m/s is assigned while 1m/s is assigned to distributed shots. This is to model that about 50 time shots are involved in distributed shots compared to clustered shots. In the analysis impact, the impact with representativeness error 7 m/s is about 10-20% less than that of 1m/s, but the geographical distribution of the impact does not change.

In Table 2, the correlation between NR and 72 hour forecast fields are presented. Compared to control experiments, any DWL data improved the wind fields globally at all levels for all experiments. The forecast impact is similar to the analysis impact. Major improvements are over the tropics if T1B is included in CTL. Marseille et al. (2001) showed major impact in SH, because in their experiment CTL does not include T1B. If T1B are included, the major improvement in SH has already been achieved by T1B and the major improvements due to DWL occurs in the tropics instead. However without T1B, significant improvement is achieved in the SH even in the worst case of DWL (Dex4cr7) . Although T1B and Dex4cr7 show similar magnitude of impact in SH and minimum impact in NH, there are significant differences between experiments with T1B and experiment with Dex4cr7 (Lord 2002). Therefore, both T1B and Dex4cr7 together allow a further improvement to be achieved. In NH neither the T1B nor Dex4cr7 produce significant impact. Significant impact, which is comparative to RAOB winds, is achieved in the best case of DWL with scanning distributed data.

4. COMMENTS AND FURTHER PLANS FOR DWL IMPACT TEST

DWL is evaluated with the 1993 data distribution. However, DWL winds also needs to be evaluated with both the current data distribution and the future data distribution corresponding to when the DWL data will be actually used.

In this paper no measurement error is included in the DWL. Systematic errors are discussed by Emmitt (2000a) and other large-scale correlated error need to be designed and added to the assessment. Various sampling strategies such as the separation between forward and backward scan, and adaptive observations need to be tested.

In this paper only results from U are presented.

The impact on meridional wind (V) is similar to that on U. Impact in temperature fields is more sensitive and complicated. Impact on temperature from radiance data and R-Temp involve many procedures that alter the results, such as the bias correction. Impact on temperature from DWL wind is even more complicated because balance between temperature and winds in the data assimilation system is imvolved.

It is found that surface data are too optimistic in simulation experiments because NR surface characteristics are too simple compared to the real surface data. Therefore, impact of other data, including T1B and DWL, are underestimated in this OSSE. More realistic error for surface data are being evaluated.

Exp2 and Exp3 are also being tested to evaluate different types of instruments. The OSSE data assimilation system will be upgraded to 2002 operational system. With new system, AIRS data and high density CMV will be analyzed with the DWL data. More details of the future planning are discussed in Masutani et al. (2002b). AIRS data is being simulated (Goldberg et al. 2001) and simulation of CMV is in the process of final adjustment (O'Handley 2001 and Atlasand Terry 2002).

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Experiment Name	TIB	RAOB WIND	DWL	DWL SHOT	DWL Rep. error	DWL SCAN	
1B	Y	Y	N				All existing data including T1B
NTV	N	Y	N				Deny T1B from 1B
1BNWIN	Y	N	N				Deny RAOB wind from 1B
1BNTMP	Y	Y	N				Deny RAOB temp from 1B
1BDex1dr1	Y	Y	Y	D	1	Y	Best in scan
1BDex1cr7	Y	Y	Y	C	7	Y	Worst in scan
1BDex4dr1	Y	Y	Y	D	1	N	Best in non scan
1BDex4cr7	Y	Y	Y	C	7	N	Worst in non-scan
Dex4cr7	N	Y	Y	C	7	N	Worst case of DWL added to NTV (No T1B)

Table 1. Experiments described in this paper. All other conventional data including RAOB temperature, ACAR data, cloud motion vector, etc are included in all experiments.

	NH U500	SH U500	TRU200	TRU850
1B (Control)	85.6	77.4	80.6	64.9
NTV	85.9	69.9	79.6	64.9
1BNWIN	83.5	76.1	78.6	62.9
1BNTMP	84.8	76.9	81.1	66.4
1BDex1dr1	86.8	81.6	84.1	70.1
1BDex1xr7	86.4	81.6	83.8	67.9
1BDex4dr1	85.9	78.8	81.6	67.2
1BDex4cr7	85.8	78.3	81.3	65.7
Dex4cr7	86.1	77.0	81.3	65.8

Table 2.
Anomaly correlation with the nature run for 72 hour forecast fields. For NH values are averaged over 20N to 80N. For tropics 20S to 20N; For SH 80S to 20S. Values are averaged from 00Z 16 February 1993 to 12 Z February 28, 1993. For every 12 hours. They are presented as percent.