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Title: Observing system simulation experiments for the Laser Atmospheric Wind Sounder using a global spectral model

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Introduction: Fundamental to improving the understanding of the total Earth system are increased and improved observations. In the coming decade several space borne instrumented platforms will be constructed and implemented. These platforms will, in large, be housing the NASA Earth Observing System (EOS) instrument suite.

One of the proposed instruments is a wind profiling system which is currently referred to as the Laser Atmospheric Wind Sounder (LAWS). This instrument will use a CO_2 Doppler lidar wind profiler to give wind measurements with a vertical and horizontal resolution which has yet to be seen globally. The LAWS instrument is now a candidate for launch on a NASA EOS–B platform and is fundamental to increasing our understanding of Earth System Science.

The importance of these improved wind data sets from LAWS should not be sold short. These data sets will form an integral component of the temporally continuous data base needed for research of the coupled climate systems. This instruments observations will aid in giving an improved description of the atmospheric circulation including the transports of energy, momentum, moisture, trace gases, and aerosols. Also, the wind data will be assimilated and used as the initial state for many global forecast models at various operational centers. Improvements in the forecast skill should be seen as well as enabling a forward progression of model development. In addition to the EOS–A platform instruments and the other proposed EOS–B instruments, LAWS wind measurements should help to advance our view and understanding of the total Earth system immensely.

Significant Accomplishments: Within the last year our group has worked toward assessing the impact the LAWS instrument will have on numerical weather prediction. This task has its limitations due to the lack of real LAWS wind observations. Therefore, observing systems simulation experiments (OSSE's) must be run so as to examine the impact. In these experiments one simulates a data set which is considered to be what the LAWS instrument would provide given that it was actually operational. This data set should idealistically be constructed so that it reflects the errors and inconsistencies that the instrument will have once it has been launched and is collecting wind measurements.

We have chosen to begin with the fundamentals and continuously improve upon them. Since few space borne platform OSSE's have been documented, a great deal of care and understanding is required to accurately attack such an important problem. We have chosen to begin with identical twin OSSE's using perfect winds for our LAWS observations. This is unrealistic in a sense, however, these early experiments have enabled a benchmark to be set showing the best case scenario for LAWS. These experiments have also aided in improving our understanding of how certain orbital parameters would affect global forecasts out to five days. A large amount of resources has gone into testing and development of the OSSE's. This includes the development of a multivariate optimal interpolation (OI) scheme and cloud obscuration techniques since LAWS is unable to see below clouds accurately.

An identical twin OSSE is run as follows: A numerical forecast model is integrated for a long period of time, generally 7 days or longer. This is considered the "nature" run and supposedly fully describes the atmosphere as 100% truth. As an example, from day five of the nature run, the u and v components of the wind field are interpolated to the latitude and longitude of the LAWS shot locations thus giving LAWS wind observations. The temperature, relative humidity, and height fields along with winds are interpolated to the positions of the World Weather Watch observations. These include rawindsonde, satellite drift winds, and commercial aircraft observations for a typical day's operational global coverage. Now having simulated these observations three dimensionally, a multivariate OI is used to create analyzed fields of height and u,v components. A univairate OI is used to do the temperature and relative humidity analyses. This routine is completed every six hours for a 24 hour period thus providing a full four dimensional data assimilation. The global spectral model is then run for five days to get the forecasts which had the LAWS data included in the assimilation. This entire process is duplicated except the LAWS observations are left out of the assimilation. The resulting forecast then shows the effects of only using the WWW data. This global spectral model run is termed the "control" experiment due to the exclusion of any LAWS observations. The impact of the LAWS instrument for a given set of orbital parameters can be seen by comparing the control run and the LAWS included run to the nature run.

These experiments show the differences in coverage which occur by varying the orbital parameters. Our group has found that there are large improvements in the forecasts especially over the oceans and in the southern hemisphere where there is a notable lack of wind observations. The polar orbit exhibits the most improvement globally, but repeatedly duplicates coverage in the polar region which can be considered a waste of resources. The 55° inclination angle orbit does not over sample the poles and provides more information from the tropical belt without greatly compromising the forecast skill as can be seen synoptically in figures 1a,b.

Future Experiments: Our plans for future work include doing some improvements to the identical twin OSSE's. Simpson Weather Associates, a fellow LAWS team member, is in the process of providing our group with data sets that add reality to the pseudo LAWS observations. The effects of aerosols, attenuation, backscatter and the inclusion of subvisible cirrus will be the most notable improvements in these data sets.

Also planned are fraternal twin OSSE's. These experiments will be done in the same fashion as the identical twin experiments except that one forecast model will be used for the nature run and to create the pseudo observations while a different model will be used to do the control and LAWS included forecasts. This type of OSSE is regarded to remove model biases and delete the effects of model climate drift.

We are now gathering information on other EOS platform instruments with the hope of including them with LAWS for some impact experiments on numerical weather prediction. Instruments which we are now considering include the Tropical Rainfall Measuring Mission (TRMM) rain radar, the Special Sensor Microwave Imager (SSM/I), the Atmospheric Infrared Sounder (AIRS) which will provide atmospheric temperature profiles, and the Stick Scatterometer (STIKSCAT) thus giving surface wind speed and direction over global oceans. These instruments along with LAWS will be used in OSSE's to examine their effect on global forecasting as well as on different model parameters. We are hoping to see improvements in the transports of moisture and momentem as well as improving the prediction and affects of boundary layer fluxes such as sensible and latent heat and moisture. Together these instruments should provide a better defined initial state which will in turn improve forecast skill.

As our understanding of OSSE's continues to improve and develop, a switch to higher resolution models will be warranted. The future for OSSE's is to see how increased observations will aid in the forecasting of synoptic and especially mesoscale meteorological phenomena. For example, hurricane and typhoon forecasting as well as the overall structure of the smaller scale systems should become better defined.

Publications:

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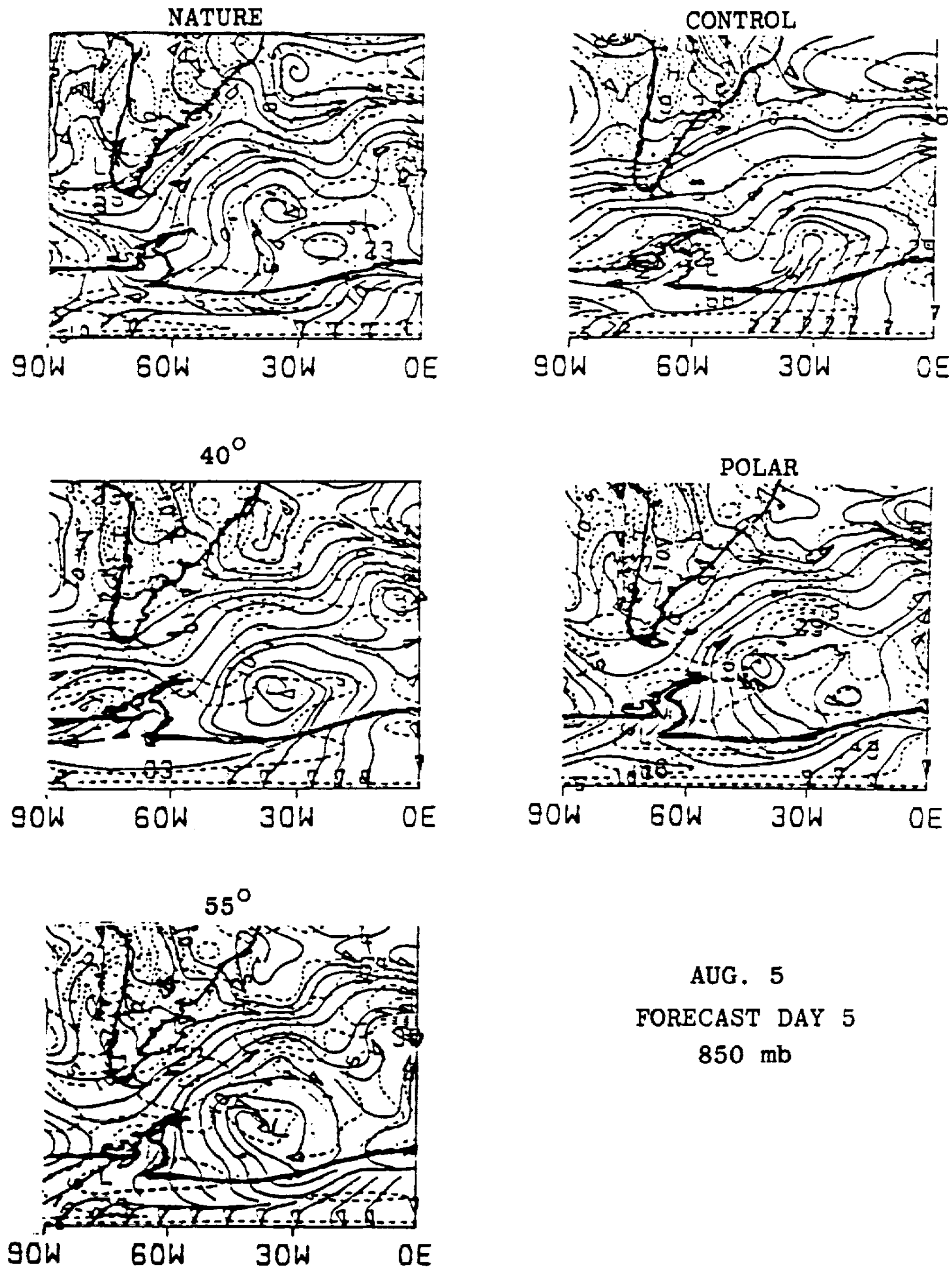

Figure 1a. The nature run shows a complex flow around the southern tip of South America. The control run, which contains WWW data only, shows a much too zonal wind field. This is due primarily to the lack of the WWW data over the South Pacific and Atlantic Oceans as well as the Scotia Sea. The other figures illustrate how different orbital inclinations affect the day five forecasts in this region. For the 40° and 55° inclination angle forecasts, the low pressure area is too large. The polar orbit shows a major improvement in the forecast of the low pressure area and the flow around it.

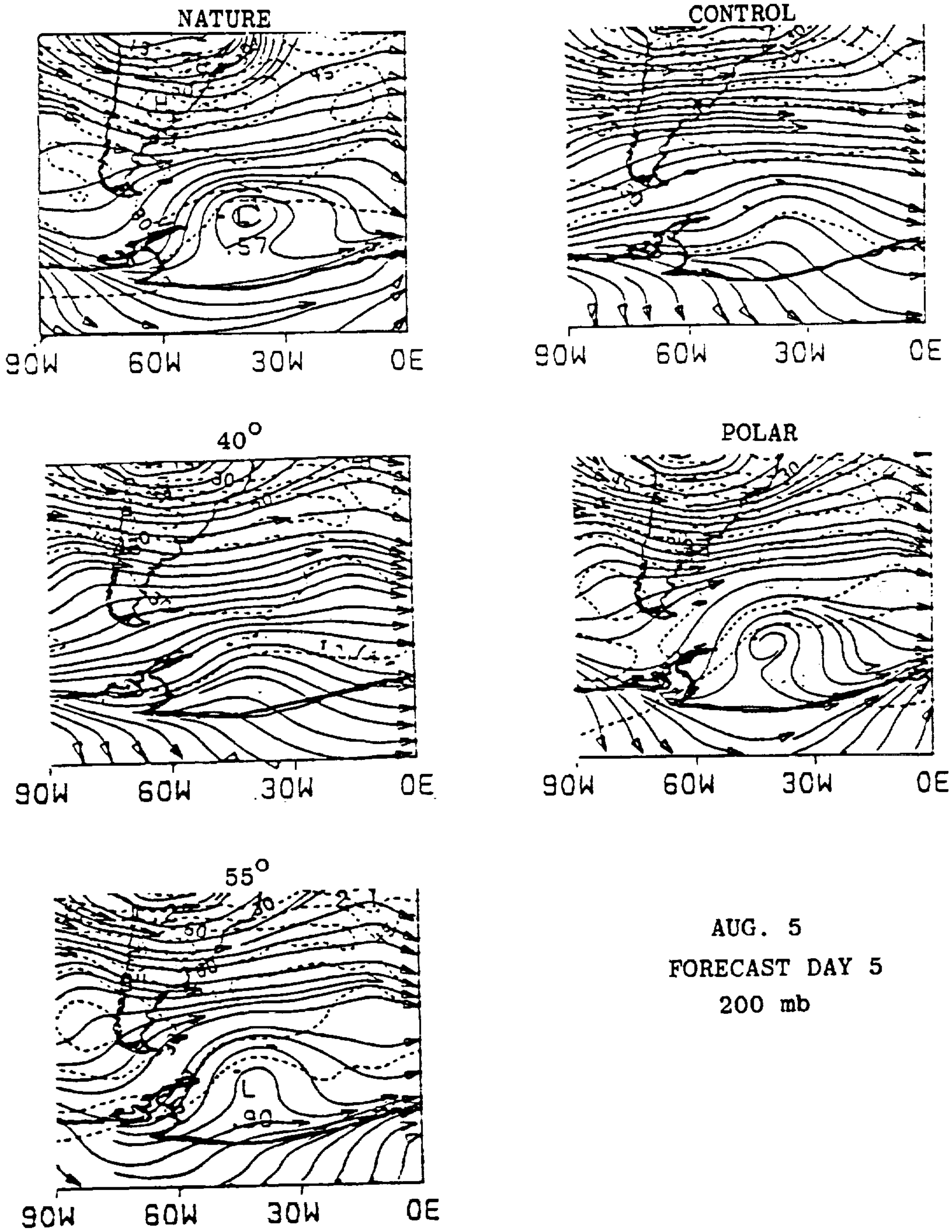

Figure 1b. The nature run shows a large upper level closed low. This feature is absent in the control run which gives a flow field which is too zonal. The 40° run does not contain enough information to better define the low pressure area. The 55° run begins to better pick up the wind field and makes the low much more pronounced. The polar orbit provides a wind field which looks much more like the nature and shows how this orbit will seemingly improve forecasting in the polar region.