P4.5 IMPACT OF LOST RUSSIAN RAOBS ON NUMERICAL WEATHER PREDICTION SKILL

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1. BACKGROUND

The number of sites in the Russian Federation taking upper air observations using radiosondes (RAOBs) decreased by 65% to 70% from January 1994 to December 1999, largely as a function of budget restrictions. Such a decrease might be expected to affect the skill of Numerical Weather Prediction forecasts. To address this issue, the Open Program Area Group on Data Processing and Forecast Systems of the WMO formed an Expert Team whose mission was to assess the possibility of using routine verification statistics as an alternative to conducting the more costly and time consuming Observing System Experiments (OSEs). The Expert Team adopted the following working hypothesis:

"*It is possible to establish meaningful impact in the radiosonde network in Russia through evaluation of readily available verification scores of global and/or regional scale operational forecast models".*

The results of this investigation are documented in the WMO publication, "Study of the Impact of the Loss of Russian Federation RAOBS on NWP Verification Statistics in the Northern Hemisphere" (available at http://www.wmo.ch/web/www/reports.html). In summary, those results neither proved nor disproved the hypothesis. No clear signal in the verification statistics was found, except possibly some degradation in skill over Asia and North America. Given changes in NWP systems over the years and likely natural variations in predictability (e.g., associated with circulation regime, seasonal trends), it is very difficult to detect a real signal and equally difficult to assign any change to a particular cause. One cannot conclude from this study that the loss of Russian Federation RAOBs does result in a meaningful loss of skill in NWP, only that the approach used in the investigation was not adequate to uncover a signal in the noise of the several factors which might lead to a change in routine verification scores.

To investigate further whether loss of the Russian data does have a meaningful impact on NWP skill, NCEP agreed to conducted an OSE using its Reanalysis system and data set.

2. EXPERIMENTAL DESIGN

The OSE was run using the NCEP Reanalysis data assimilation system and data set. The system includes the NCEP global spectral model operational ("MRF") in 1995 with T62 (~210 km) horizontal resolution and a three-dimensional variational (3DVAR) analysis scheme. The data set includes RAOBs, TOVS temperature soundings, cloud-tracked winds, aircraft observations, land and ocean surface reports, etc. Further details can be found in Kistler, et al. (February, 2001 BAMS). The experiment period selected was January, 1994, a month where subjectively (based on appraisal of circulation patterns and weather systems) it appeared loss of the RUSSIAN RAOBs could have a notable impact upon NWP forecasts.

Three experiments were run:

EXP1: the control - all available observations

EXP 2: all observations, except those Russian RAOBS available in January, 1994, but NOT available in January, 2000 (nearly identical to the comparison between January, 1994 and December 1999 shown in Figs. 1 and 2, respectively, in the WMO report)

EXP 3: all RUSSIAN RAOBS removed

EXP3 was run as a baseline sensitivity test to assess the effect of removing all Russian Federation radiosonde reports. The relevant data sets were assimilated starting Dec. 1, 1993 and continued through Jan. 31, 1994 (December provided a one month "spinup"). Forecasts to 8 days were run from the 00Z analyses of each experiment for each day of January, 1994. Verifications were in the form of anomaly correlation (AC) scores and RMSE of forecasts with respect to the control set of analyses over the Northern Hemisphere and selected subregions thereof. Subjective case study evaluation was also performed to confirm and complement these objective verifications. Also, the subjective appraisal suggests that additional objective verifications against radiosonde observations likely would not change the results.

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3. RESULTS[2]

Verification statistics indicate that at shorter ranges a small, but systematic negative impact is felt in the Asian and JMA (centered about Japan) domains. The E1 errors on average over the period (20.25/25.06 for JMA/Asia) are slightly smaller than for EXP2 (20.89/25.72). More importantly, as seen clearly in plots of EXP1-EXP2 scores, the negative impact occurs in most cases. Meteorological significance from subjective evaluation, however, is dubious. Over Alaska and Northern Canada, where there are no separate objective verifications, it appears qualitatively that forecast differences are larger than over Asia and the JMA regions. At day 2, and to a limited extent at day 3, there is a tendency generally for the EXP2 to have larger errors than EXP1.

Experiments with regional models would have to be performed to assess more thoroughly the significance of the loss of data on short term forecasting over regions in relatively close proximity to the differences in analyses due to the decline in Russian RAOBs. In that context, before serious non linearities develop and other sources of error become dominant, the sense of the analysis differences (presumed to be negative) is more likely to be felt. Finally here, it should be noted that the negative impact which would occur from removal of all Russian RAOBs is considerably larger.

At medium ranges AC scores of 5-day forecasts computed for the Northern Hemisphere north of 20° show that there is a mix of positive and negative impacts with the difference in the mean between EXP1 and EXP2 very small (E2 actually better) and certainly not statistically significant. The same conclusion is drawn from the corresponding set of RMS errors. And, the same result applies to each of the verification sub regions and for the most part to day 3 forecasts as well.

The lack of significant effect on verification scores does not mean that the loss of the Russian RAOBS does not have an impact on the forecasts. This can be seen from the initial through 5- day EXP2-EXP1 difference fields in individual cases. The relatively small differences that exist between analyses (day 0) in the polar regions over and to the north of Siberia evolve (via translation and downstream amplification/propagation) to seemingly very significant levels both in magnitude and areal coverage. But, beyond 2-3 days those differences are generally small compared to the corresponding forecast error charts, whether they be for EXP1 or EXP2. In effect, the signal of forecast impact due to loss of the Russian RAOBs is essentially noise in the context of the total forecast error. Or in the vernacular of NWP, the forecasts are much more alike than either is to the real atmosphere. From one case to the next or within one case from region to region subjective appraisal shows that, when it is possible to judge that one forecast is better than the other in some respect, there is no systematic preference for EXP1 or EXP2. By no later than days 2- 3, non-linear interactions dominate and the sense of forecast differences is essentially random.

4. SUMMARY AND DISCUSSION

The OSE was designed explicitly to isolate the effect of the loss of Russian RAOBs. Unlike the earlier study based on evaluation of routine verification scores, the impact is not obscured by before and after differences in atmospheric predictability (e.g., related to circulation regime), changes in the global observing system, or differences between models and data assimilation schemes. It was a perfectly "clean", but limited, experiment.

The results indicated a small, but systematic loss of skill at short ranges (< 3days) in the regions most local to the areas affected by the loss of data (Asia, JMA, Alaska and Northern Canada). In the medium range (3-8 days), results were remarkably comparable to those arrived at by the Expert Team - no degradation in forecast skill as a result of deterioration in the Russian Federation RAOB network. Beyond day 3, the loss of data does have a notable impact, but the differences between the with and without experiments (EXP1 and EXP2) are small and not systematic relative to the total error of either EXP1 or EXP2 predictions. The loss in skill associated with loss of the RAOBs over Russia is essentially noise in the context of other sources of error, i.e., analysis errors exclusive of the Russian data and inadequacies in the data assimilation system and forecast model.

It is worthwhile to note that the objective verifications and subjective evaluation of EXP3 does indicate a fairly large and more or less systematic degradation in forecast skill even at medium ranges as a result of removing all Russian Federation RAOBS. In most instances the result is making a bad forecast even worse. But in some, the loss of data clearly renders a reasonably good prediction less useful. In the context of this experiment, by chance or design, it appears the decrease, but not elimination, in Russian RAOBS was such as to minimize the impact on global NWP.

Of course, the principal caveat of this OSE is that it applies only to the particular numerical and analysis forecast system used (NCEP, 1995 vintage) and only for the particular period selected. To adequately generalize would require using the latest state-of-the art system (more than one) applied to several independent sample periods. That would be exceedingly costly in human and computer resources (and beyond anything currently planned at NCEP). And, if later studies, in fact, did demonstratea clear and meteorologically significant loss in skill from the dedine in Russian RAOBs, one likely would have to address the cost effectiveness of alternative observing systems (e.g.,aircraft ascent/decent soundings) in comparison to reconstituting the Russian RAOB network.

[2] For further details and supporting figures see: http://www.emc.ncep.noaa.gov/projects/index.html (link to NAOS)