Impact of a large reduction in the number of Russian radiosonde reports

Bruce Ingleby, Mark Rodwell, Lars Isaksen

European Centre for Medium-Range Weather Forecasts (ECMWF); email: bruce.Ingleby@ecmwf.int

Introduction

In early January 2015 the ECMWF automated monitoring system started warning of reductions in the number of Russian radiosonde reports. After some days it was confirmed that, as a result of budget constraints, Russia had cut its radiosonde program from two ascents per day to one. There are 111 radiosonde stations in Russia out of about 800 worldwide, so this constituted a major change. Over Russia radiosondes form the main information source for the lower/mid-troposphere - there are few reports from aircraft ascents/descents and no wind profilers. The uncertainty of surface emissivity over land makes it difficult to use lower/mid-tropospheric satellite sounding channels – some are used in the warmer months, but when snow or ice is present the quality checks generally prevent the use of tropospheric satellite channels. Figure 1 shows mid-tropospheric temperature data usage in winter.

Very quickly ECMWF performed impact studies (using data from 2013/2014) to look at the likely impact. Existing control runs were used for December 2013 – February 2014 (forecast resolution T511) and for April-June 2014 (forecast resolution T639). Both trials used 137 vertical levels, 12 hour 4D-Var and analysis resolution of TL95/TL159/TL255 at successive TL639 outer iterations. Some of the Russian stations ceased their 00 UTC ascent (largely those east of 110°E) and others ceased their 12 UTC ascent, the ECMWF trials mirrored this as closely as possible. The results (right) showed a relatively large impact and ECMWF made representations via WMO about the loss of valuable data.

Results

The 48 hour forecast verification for the cooler months tested (December-February and April) showed 4-10% degradation in 500 hPa geopotential height fields over Russia - as measured by root-mean-squared differences from analyses. Similar signals are also present in temperatures, winds and relative humidities (not shown). At longer lead-times, these degradations first propagate eastwards (Figure 2) and then affect the entire Northern Hemisphere. While the largest effects are centred on Russia and the Pacific stormtrack, the detrimental impact on Northern Hemispheric scores as a whole (~1.5%, Figure 3) amount to ~6 months progress in NWP development (based on upper-air scores over the last 10 years). Figure 4 shows that Russian radiosonde temperature and humidity are somewhat lower quality than some other radiosonde types but the winds have similar RMS statistics (one factor specific to Russian radiosondes is that pressure is derived from radar heights and at low radar elevation angles has large uncertainty, Kats et al, 2005, TECO conference). Despite this, Russian radiosondes provide a very valuable contribution to the global observing system.

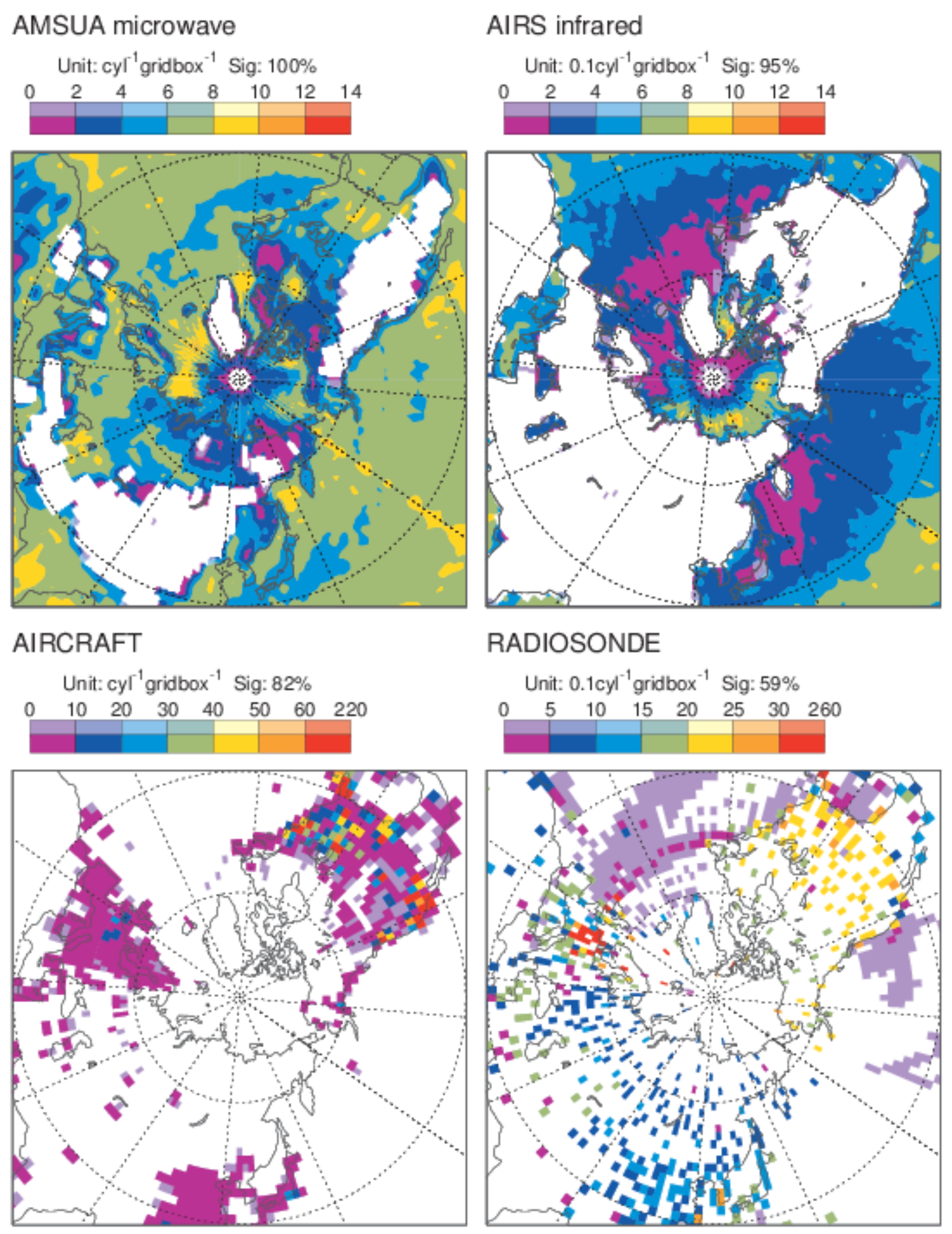

Figure 1. Observation counts for temperature at ~500 hPa per 12hr cycle per 2° gridbox. Based on actively assimilated data during DJF 2014/15. Note the satellite gaps over Russia and the lack of aircraft data, except near a few airports.

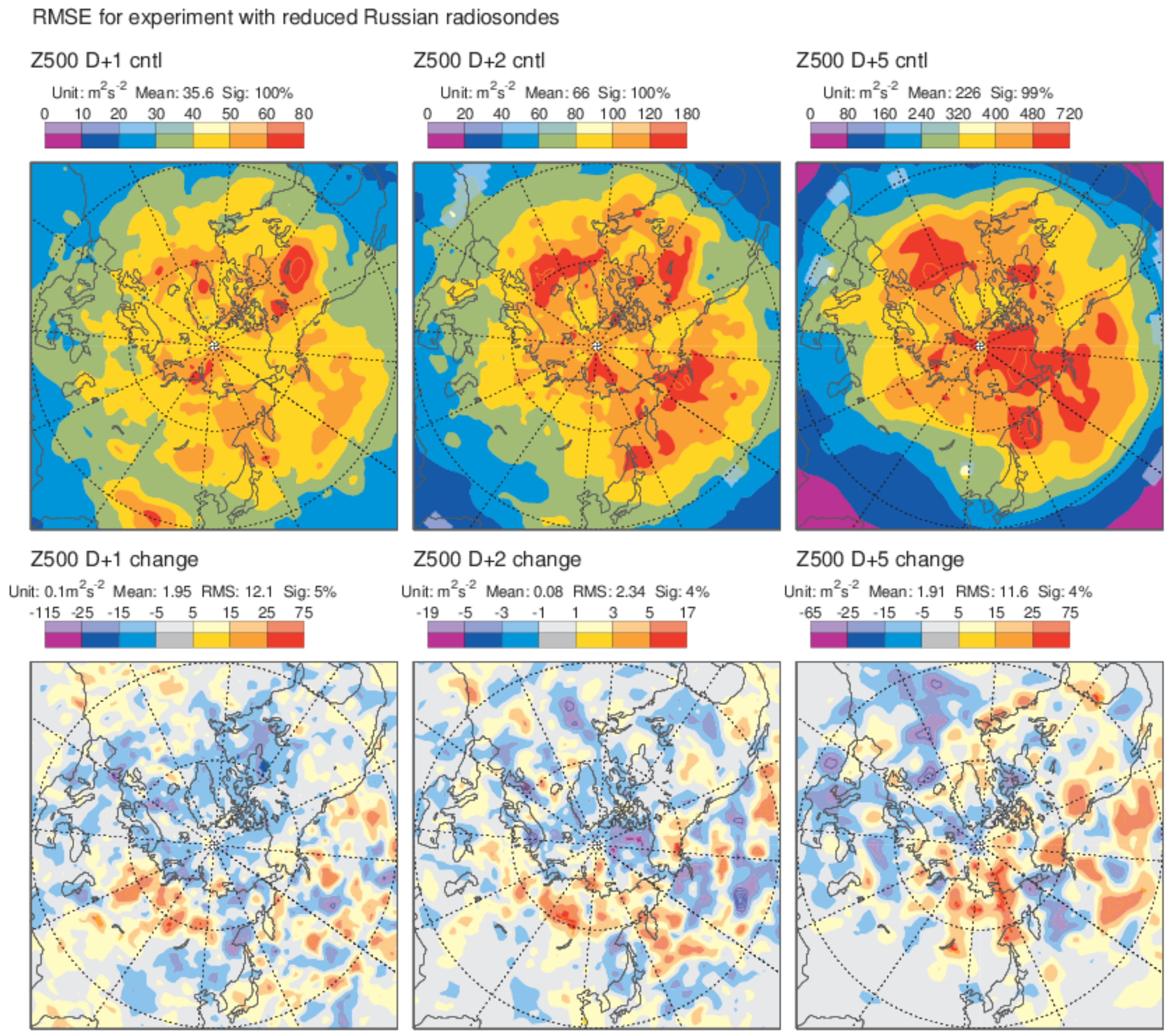

Figure 2. (*Top*) Control RMSE values for Z500 at D+1, D+2 and D+5. (*Bottom*) The effect of the radiosonde cuts, positive (yellow/red) values imply deterioration. There seems to be a gradual deterioration over the North Pacific with lead-time. Nevertheless, the changes at D+1 are not negligible and presumably reflect the cumulative effect of reduction in Russian radiosondes over several analysis cycles. December 2013 – February 2014 and April 2014 combined.

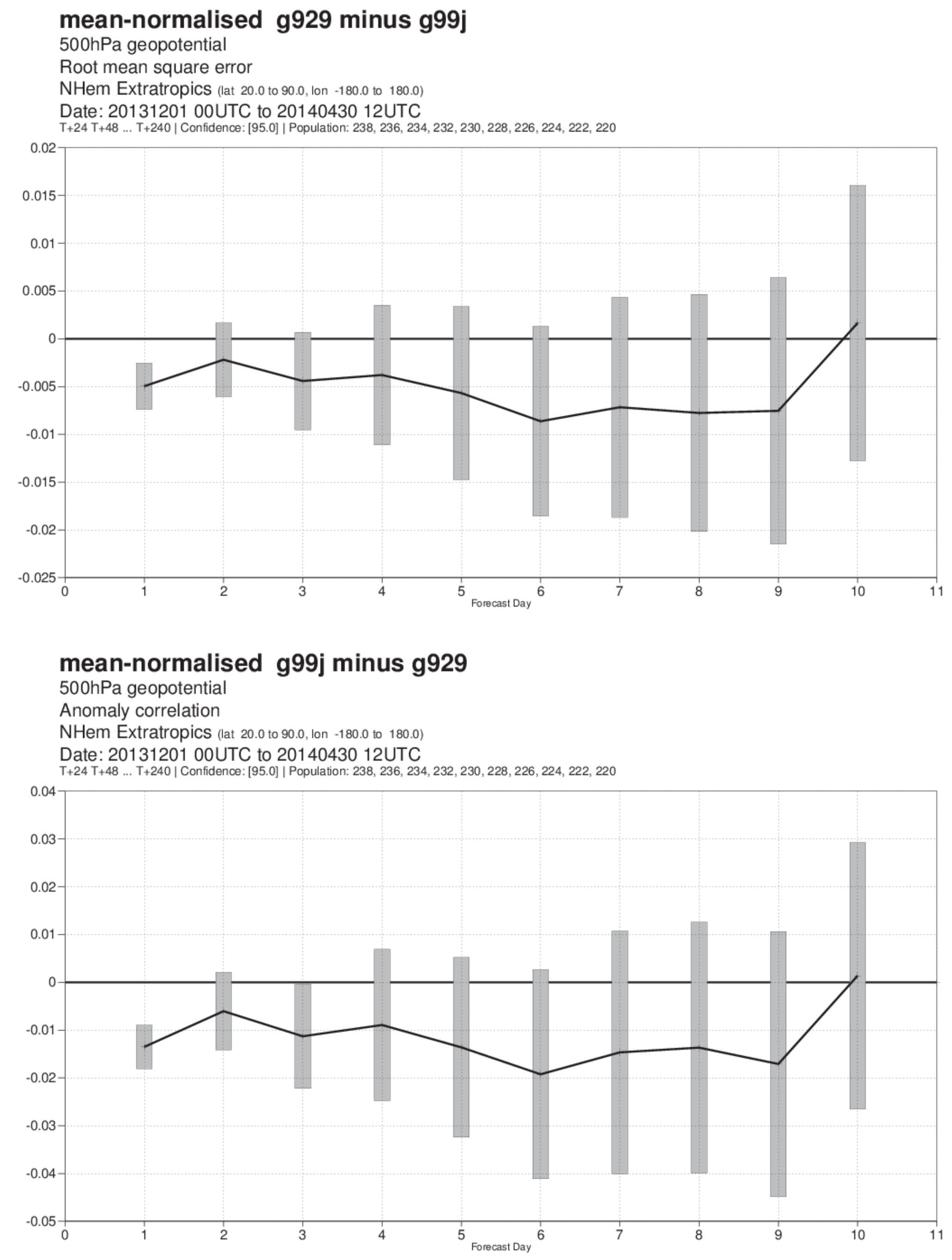

Figure 3. Differences in Z500 RMS (*top*) and anomaly correlation (*bottom*) for 20-90°N vs forecast range (bars give a measure of the uncertainty). Negative values indicate that the control was better than the trial with fewer radiosonde reports.

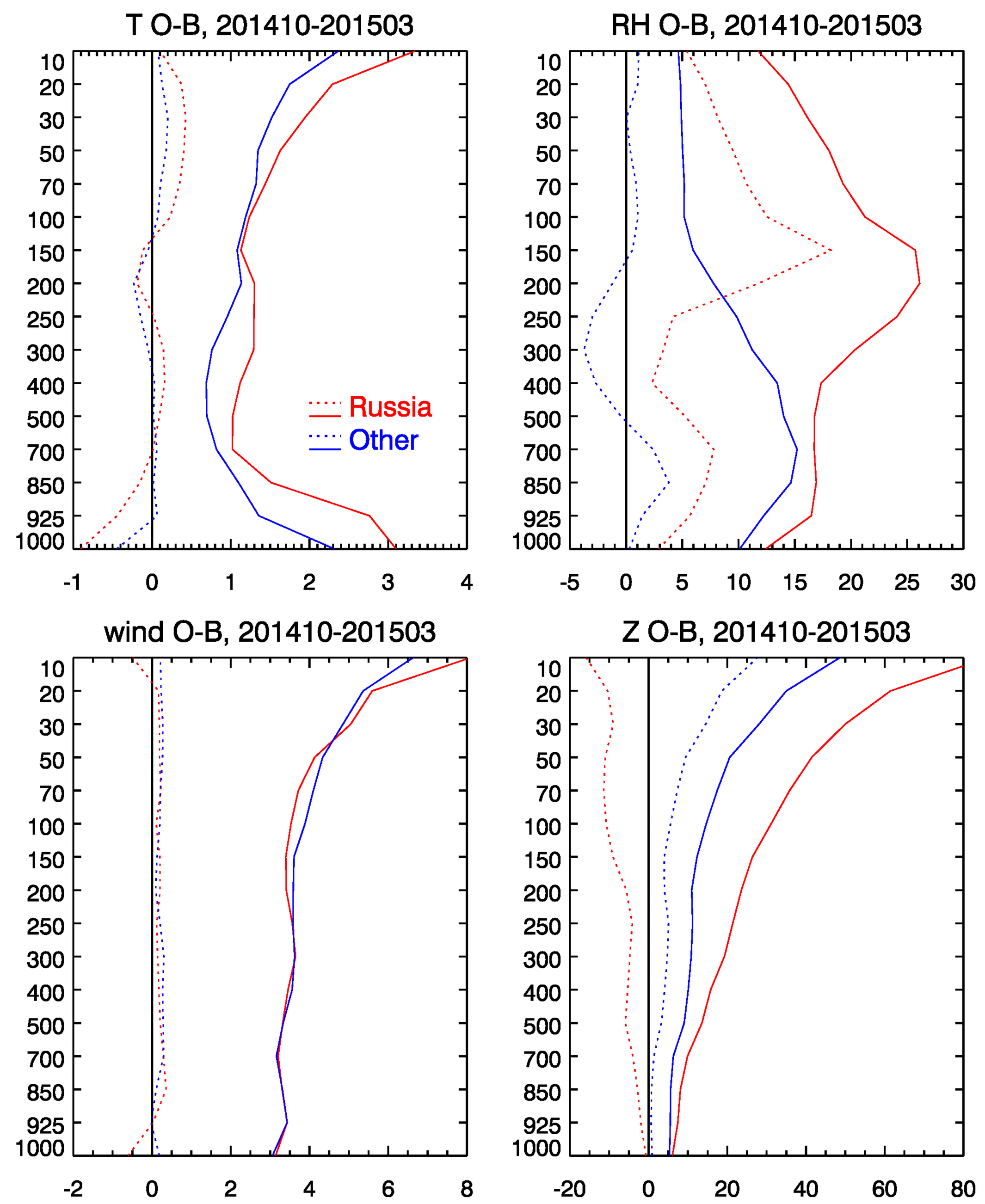

Figure 4. Observation minus background (12h forecast) statistics for Russian radiosondes (red) and other radiosondes North of 50°N (blue): mean (dotted) and RMS (solid). Standard level data that passed the operational first guess check, October 2014 – March 2015. For wind the mean speed difference and the RMS vector difference are shown. Note that upper-tropospheric humidity from Russian radiosondes is not assimilated in the ECMWF system. The very large near-surface temperature differences are partly because the forecast model has difficulty representing the very sharp low-level inversions that occur in Winter over Russia (and to a lesser extent over the other land areas).

Discussion

<u>In April 2015 the decision was reversed and the Russian radiosondes went back to two ascents per day</u>. We understand that the representations from ECMWF played a role in this and we welcome the return to two reports per day. A similar study at the Met Office also showed large impact from the reduction in Russian reports – a larger impact than in the ECMWF system especially in summer (Reid, pers. comm., 2015). The large number of Russian radiosonde stations involved makes it easier to get a clear signal – it is much more difficult to assess the impact of a few radiosonde stations when smaller changes to the observing system are contemplated.

A separate issue affecting radiosonde data is the migration from alphanumeric TEMP/PILOT code to binary BUFR code. The BUFR code allows reporting of high-vertical resolution data, including the position of each level and also enables higher-precision reporting (Ingleby *et al*., 2016, “Progress towards high-resolution, real-time radiosonde reports”, BAMS, under revision). Users should be starting to process BUFR data because alphanumeric will progressively be withdrawn (see **https://software.ecmwf.int/wiki/display/TCBUF/** and links).