WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR BASIC SYSTEMS
OPEN PROGRAMMME AREA GROUP ON
INTEGRATED OBSERVING SYSTEMS

EXPERT TEAM ON OBSERVATIONAL DATA REQUIREMENTS AND REDESIGN OF THE GLOBAL OBSERVING SYSTEM
SIXTH SESSION

GENEVA, SWITZERLAND, 3-7 NOVEMBER 2003

Dist.: RESTRICTED

CBS/OPAG-IOS (ODRRGOS-6)/ Doc. 6.1
26.IX.2003

ITEM 6

Original: ENGLISH

STATUS AND RESULTS OF OSEs

Observing System Experiments on the impact of AMSU data from 3 satellites

(Submitted by Dr J. Eyre)

Summary and Purpose of Document

This document reports the positive impacts on global NWP performance at two NWP centres when AMSU data from a third NOAA satellite are assimilated. It also reports the positive impact when data from a fourth AMSU-A instrument (on NASA's Aqua satellite) are added.

ACTION PROPOSED

The meeting is invited to take into consideration the information contained in this document when discussing the status and results of OSEs.

DISCUSSION

1. INTRODUCTION

1.1 Polar-orbiting satellites in the NOAA series carry a set of instruments for atmospheric sounding known as ATOVS, the Advanced TIROS-N Operational Vertical Sounder. ATOVS comprises:

- AMSU-A, a microwave sounder primarily for monitoring temperature in the troposphere and stratosphere,
- AMSU-B, a microwave sounder primarily for monitoring tropospheric humidity,
- HIRS, an infra-red sounder primarily for monitoring tropospheric and stratospheric temperature and tropospheric humidity.

1.2 NOAA-15, carrying the first ATOVS instruments, was launched in May 1998. Within a year of launch, NWP centres were reporting substantial improvements in NWP performance resulting from the data provided by these instruments. It also became clear that most of the impact was coming from the AMSU-A data. AMSU-A has proved to be an excellent instrument, with low noise and high stability. It also provides enhanced information on tropospheric temperature in cloudy areas, which appears crucial to the new levels of performance achieved by NWP systems.

1.3 In September 2000, NOAA-16 was launched. For the first time NWP centres were able to demonstrate additional benefits from the presence of the second satellite. (Prior to this, the primary justification for the second satellite was for the robustness of the system, i.e. to ensure that there was always at least one functioning satellite.)

1.4 In June 2002, NOAA-17 was launched. This was primarily intended as a back-up for the aging NOAA-15. However, as ATOVS instruments were now operational simultaneously on 3 satellites, this has provided an opportunity to test the additional impact on global NWP systems of data from the third satellite. Two NWP centres have performed such experiments. This paper summarises their results.

1.5 In addition, data from the AMSU-A instrument on NASA's Aqua satellite have been made available to NWP centres in near real-time. This has allowed investigation of the impact of a fourth satellite, and these results are summarised.

The author acknowledges the contributions of Stephen English (Met Office, UK) and Jean-Noël Thépaut and Graeme Kelly (ECMWF) who supplied the results reported here.

2. OBSERVING SYSTEM EXPERIMENTS

OSEs at the Met Office

Background

2.1 In the operational NWP system at the Met Office, it was originally planned for NOAA-17 ATOVS data simply to replace NOAA-15 data. However, NOAA decided to place NOAA-17 in an orbit between those of NOAA-15 and NOAA-16, and this complicated the plan for a simple replacement. Examination of the coverage of the three satellites showed that a NOAA-16+17 two-satellite system gives roughly one orbit less data per NWP data assimilation cycle than the NOAA-15+16 two-satellite system. Therefore tests had to be run to see if a simple replacement of NOAA-15 by NOAA-17 was acceptable. Further tests were also required to examine the impact of using all three satellites.

Data quality and data coverage

2.2 Comparison of statistics of differences between measured brightness temperatures and those computed from short-range forecast fields showed that, for most channels, the statistics for NOAA-17 ATOVS were very similar to NOAA-15 and NOAA-16. Therefore there is no reason to conclude that any difference in impact comes from a difference in data quality, with the following provisos. At the time of the experiments described below, NOAA-17 data were newly available and two problems existed which were not addressed until later: the HIRS scan pattern was misaligned, and the radiance bias tuning was only provisional. Therefore, the NOAA-17 data were not being used to full advantage in these experiments, which can only have affected their impact adversely.

2.3 The data coverage for NOAA-15, 16 and 17 is shown in Figure 1. There is considerable overlap between NOAA-15 and NOAA-17, and between NOAA-16 and NOAA-17. However, NOAA-17 fills in some of the gaps between NOAA-15 and NOAA-16 and significantly improves the overall coverage.

Forecast impact in global NWP system

2.4 A set of experiments was run assimilating data from:

1. NOAA-15+16
2. NOAA-15+16+17
3. NOAA-16+17

2.5 Results were studied for different forecast variables, regions, height levels and forecast ranges. Figure 2 shows an example: the Southern Hemisphere T+72 forecasts for a range of heights. For these fields, replacing NOAA-16 by NOAA-17 gave a small negative impact, whereas adding NOAA-17 gave a positive impact.

2.7 Results for other fields are not uniformly positive; many are broadly neutral. The Met Office measures overall impact using a “global NWP index”, which is a weighted “basket” of skill scores for several fields of different variables, regions, heights and ranges. For this index, using forecasts verified against analyses, the effect of changes in ATOVS data assimilated is as follows:

from no satellites to 1 satellite (NOAA-15):	+13.8
from 1 satellite to 2 satellites (adding NOAA-16):	+1.9
from 2 satellites to 3 satellites (adding NOAA-17)	+ 0.9

2.8 To give meaning to these figures, this index has historically risen by between 2 and 3 points on average each year as a result of all improvements in NWP science, computer power and observations. Therefore, the third satellite has an impact equal to about 4-6 months worth of NWP improvements, whereas losing two satellites has an impact equivalent to about 1 year of NWP improvements. Although, the majority of the impact (roughly three quarters) of ATOVS data on NWP performance comes from the first satellite, it is clear that the substantial benefits are also derived from the second and third satellites, in this configuration of satellites, and using the Met Office global NWP system.

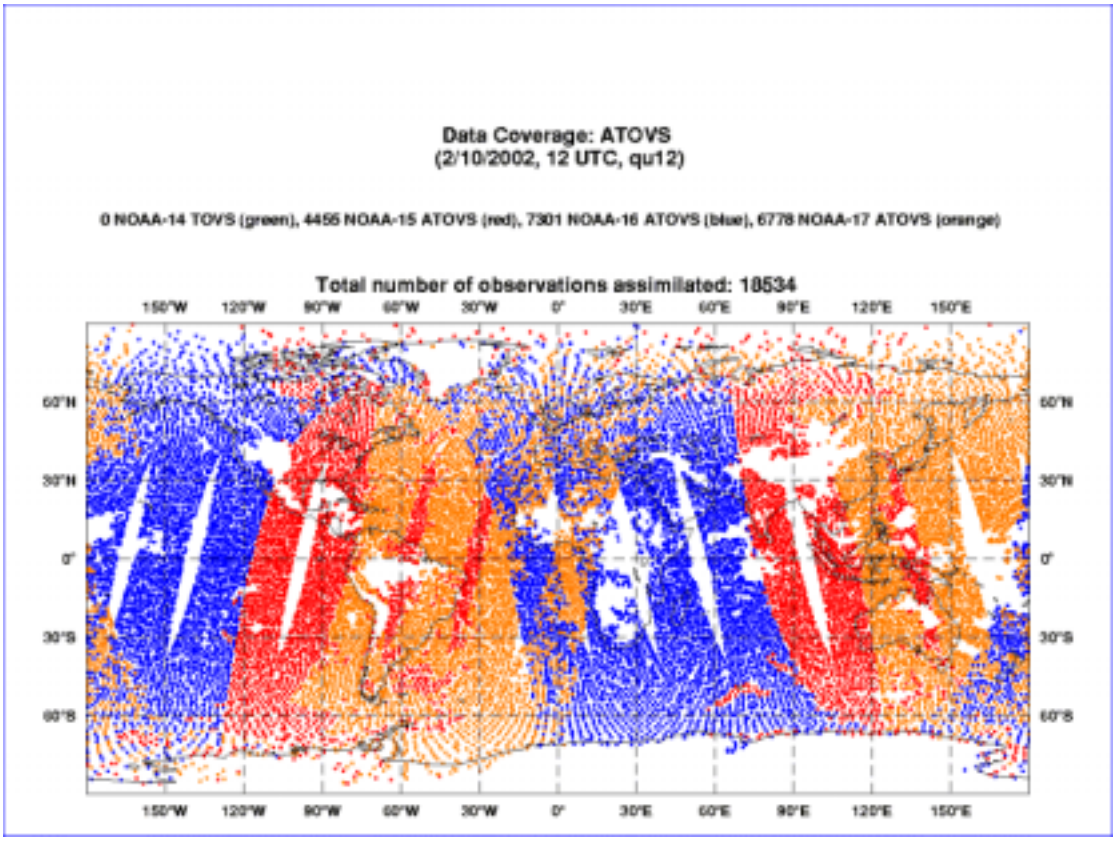

Figure 1. Coverage of ATOVS data from NOAA-15, -16 and -17 for the 6-hour period 0900-1500 UTC, 2 October 2002.

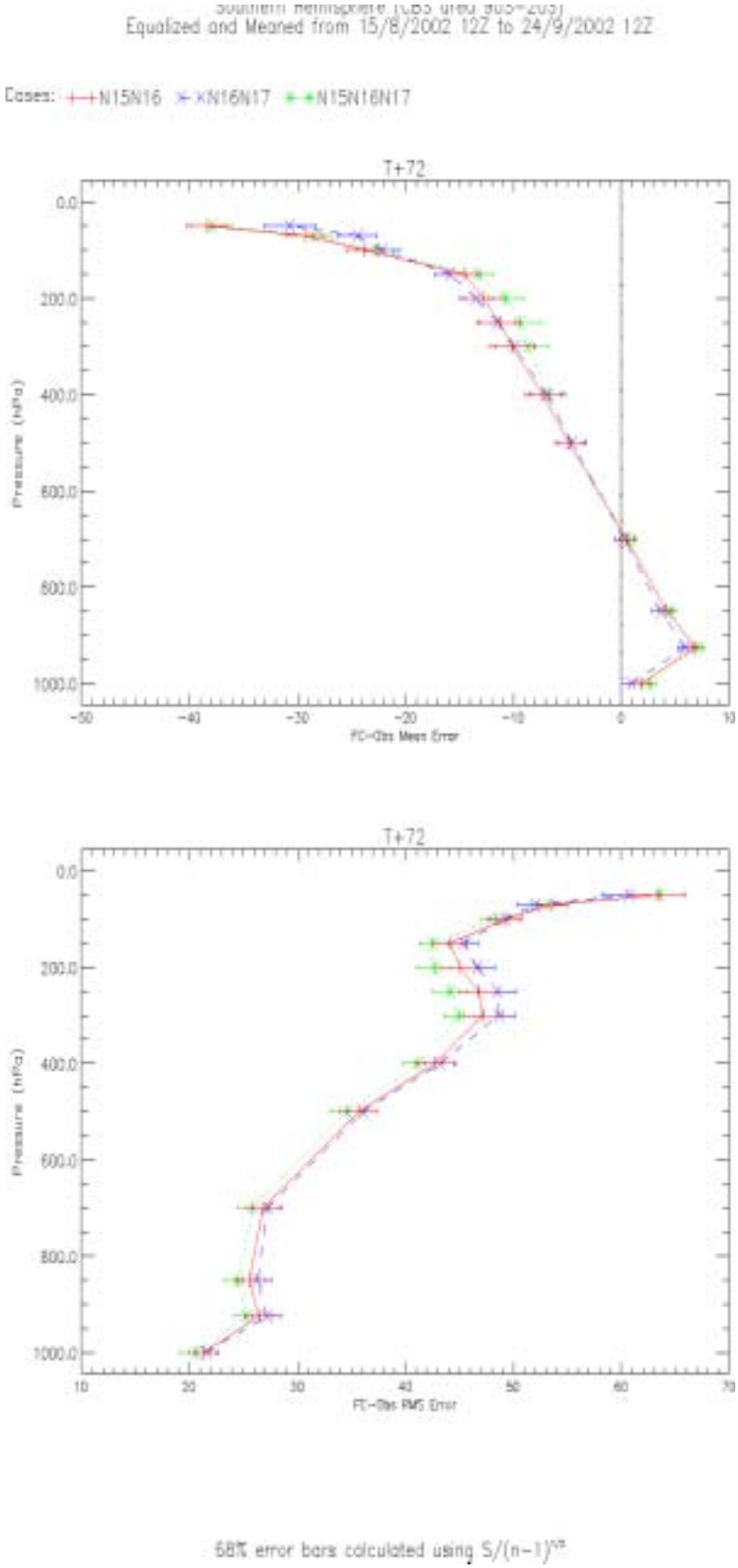

Figure 2. Mean difference (upper) and r.m.s. difference (lower) between T+72 forecast and radiosonde heights for the 3 experiments:
red = N15+N16, blue = N16+N17, green = N15+N16+N17.

OSEs at ECMWF

Data quality and data coverage

2.9 Data monitoring at ECMWF has confirmed that:

- ATOVS data from 3 satellites (NOAA-15, -16 and –17) represent a homogeneous data source.
- The third satellite leads to improved coverage, filling important gaps in each 6-hour observation window in critical ocean areas.
- The 3-satellite system is more robust against failure, and this is particularly important as one of the operational satellites starts to experience partial failures.

Forecast impact in global NWP system

2.10 40 days of assimilation experimentation have been run comparing the impact of ATOVS data from 3 satellites (NOAA-15, 16 and –17) with 2 satellites (NOAA-15 and –16). Also NOAA-15+16 has been compared with NOAA-16+17 for 26 days.

2.11 Some illustrative results are shown in figures 3 and 4. The addition of the third satellite led to positive impacts on forecast scores overall. Notably, there were small improvements in both N.Hemisphere and S.Hemisphere extra-tropics and substantial improvements over N.America.

2.12 In addition ECMWF has studied the impact of adding a 4th satellite: AMSU-A data from NASA's Aqua satellite. These data gave improvements in forecast scores in all regions, particularly in the medium-range and over the Pacific, Asia and the S.Hemisphere extra-tropics.

3. CONCLUSIONS

3.1 ATOVS data from a third satellite has improved both the data coverage and the robustness of the system against failure. Moreover, measurable positive impact on global NWP performance has been shown both at the Met Office (UK) and at ECMWF.

3.2 AMSU-A data from a fourth satellite (Aqua) has also been shown to lead to an additional positive impact within the ECMWF system.

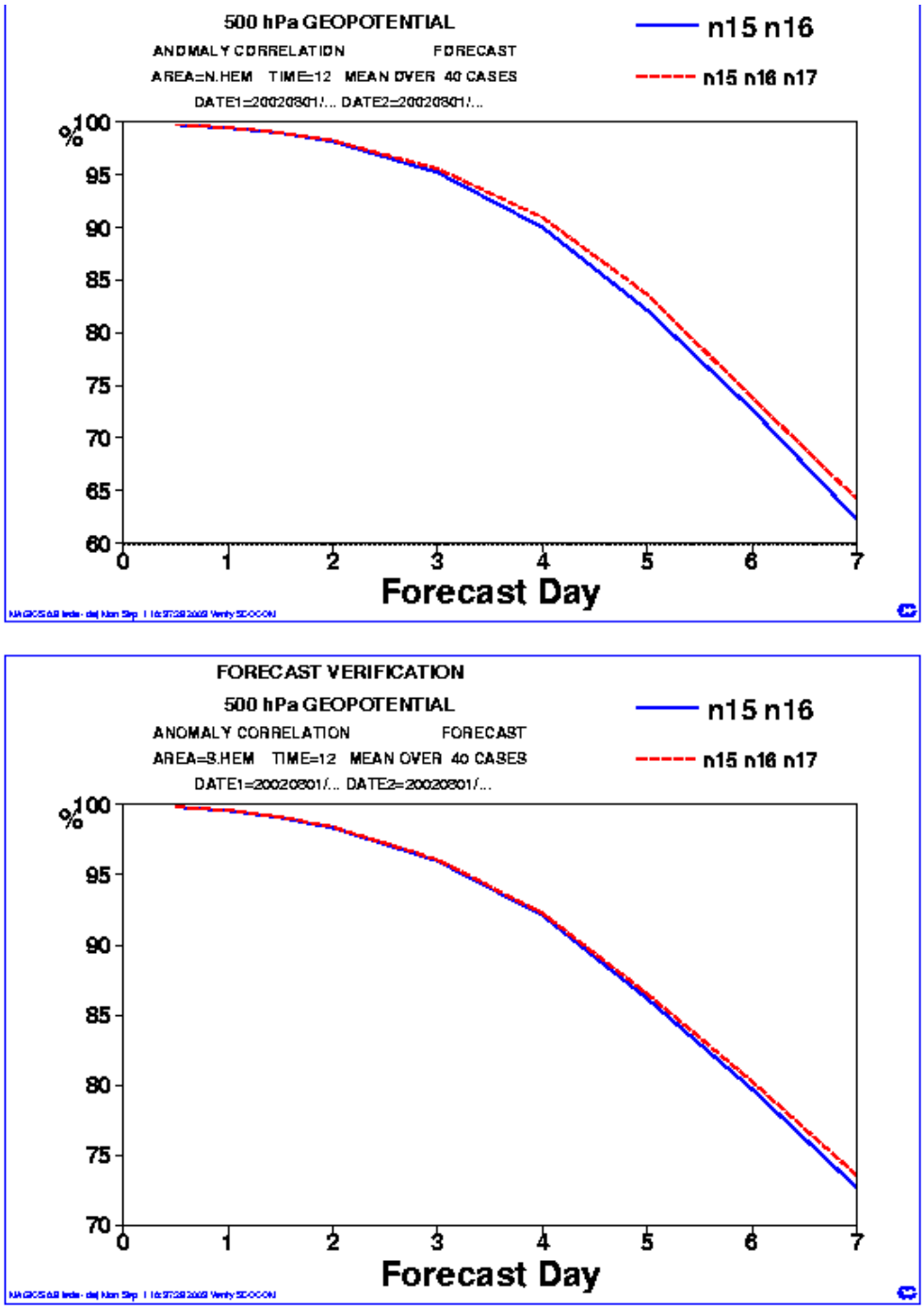

Figure 3. Anomaly correlation of 500hPa height forecast (verified against analysis) for 3 satellites (n15n16n17) and 2 satellite (n15n16), for N.Hemisphere extra-tropics (upper) and S.Hemisphere extra-tropics (lower).

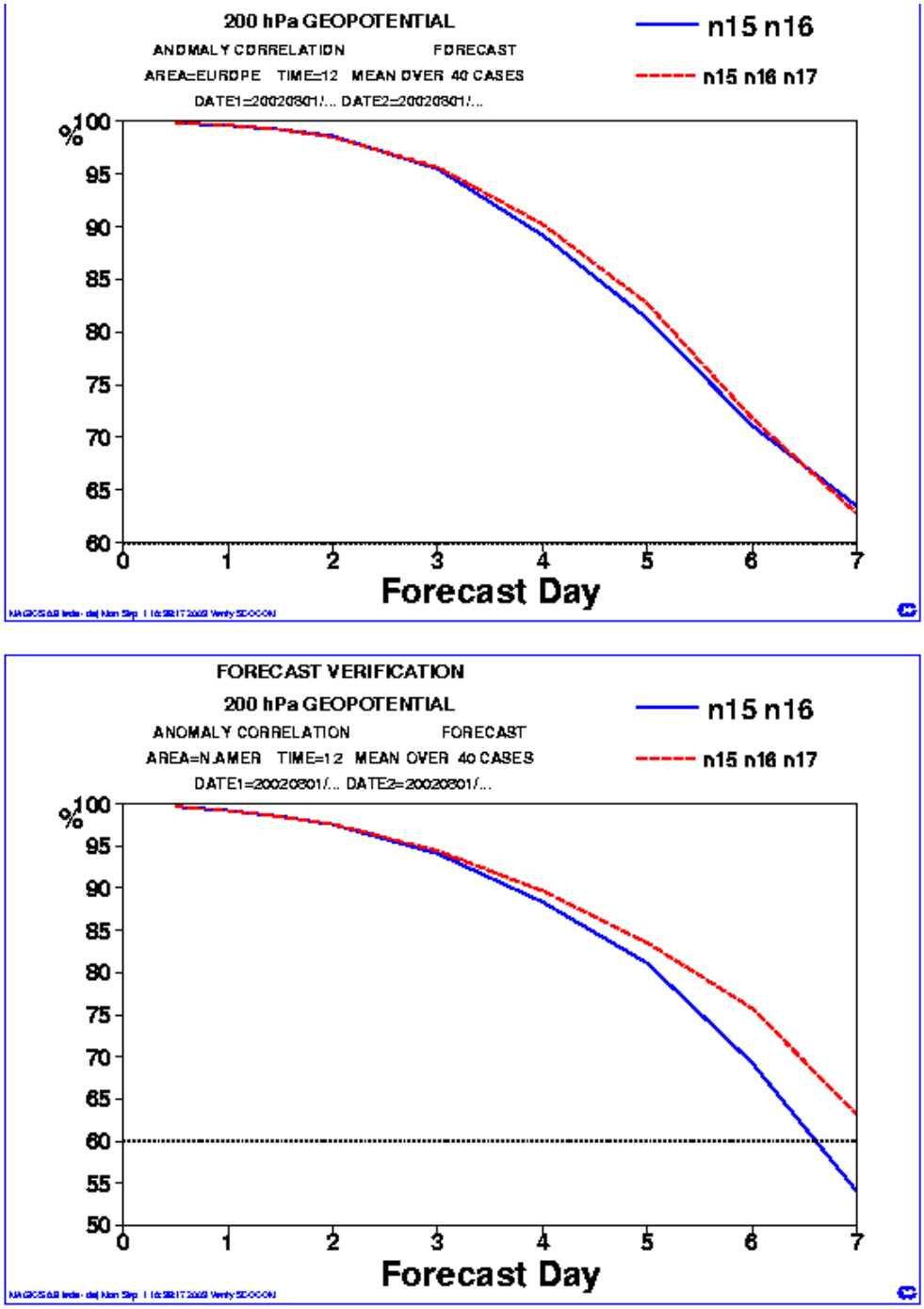

Figure 4. Anomaly correlation of 200hPa height forecast (verified against analysis) for 3 satellites (n15n16n17) and 2 satellite (n15n16), for Europe (upper) and N.America (lower).