THE IMPACT OF TROPICAL RADIOSONDE DATA ON THE ARPEGE ANALYSES AND FORECASTS

M. Tounkara[1], P. Caille[2], and J. Pailleux[2]

1. INTRODUCTION

An Observing System Experiment (OSE) has been performed in order to evaluate the impact of the tropical radiosonde data on the meteorological analyses and forecasts. The data assimilation and forecasting system which has been used for this impact study is a particular version of the Météo-France operational ARPEGE system. Two parallel data assimilation suites have been run from 1 to 20 June 2000: one contains all the observations which are normally used operationally; the second one excludes all the TEMP and PILOT messages which are available in the tropical belt (20N-20S). From 00UTC, every day, forecasts are run from the analyses performed with and without the tropical radiosondes. The forecast pairs are then systematically compared over the whole globe through statistical scores as well as through synoptic map evaluation.

The general impact of the global radiosonde network on Numerical Weather Prediction (NWP) has been evaluated through several OSEs in the past (see WMO, 2000). Also, several regional studies have been performed to see the impact of modifications of the radiosonde network over the North Atlantic, Europe or North America. However no radiosonde impact study has been run which is specifically dedicated to the tropics. The atmospheric dynamics inside tropics is very different from mid-latitudes. Wind observations are known to be more important than mass observations near the equator to describe the dynamics, and the radiosonde network (TEMP plus PILOT messages) is the only system providing wind profile observations. In addition, the current radiosonde network is quite sparse between 20N and 20S: during the period 1-20 June 2000, around 70 TEMP observations are available at 00UTC and around 80 at 12UTC; none are available at 06 and 18UTC; 30 to 80 PILOT messages are available at each synoptic time: 00, 06, 12 and 18UTC. Out of the 70 or 90 TEMP observations available in this tropical belt, 50% are actually made on the area between 100E and 160E (South-East Asia to Australia), which represents one sixth of the surface.

The present experiment is one OSE recommended by the WMO Expert Team on the Observation Data Requirements and the Redesign of the Global Observing System. The goals are:

- to understand how the current tropical radiosonde network is important for the tropical analyses and forecasts;
- to understand how this observing system is important for the forecast in mid-latitude areas (i.e. how the information propagates from the tropics to mid-latitudes in the forecast);
- to get ideas for optimising the upper-air conventional network in the tropics.

2. THE ARPEGE ANALYSIS AND FORECASTING SYSTEM

The ARPEGE model is a global spectral model which has been developed in cooperation with ECMWF. In Météo-France operations, it is run with a variable mesh (stretched coordinate). For this OSE, the variable mesh option is not used, and the model is run with a triangular truncation T199 in the horizontal, and 31 levels in the vertical. The corresponding latitude-longitude quadratic grid has a 0.6° resolution.

Since June 2000, the operational data assimilation system at Météo-France has been a 4D Variational Assimilation usually called 4D-VAR (Rabier et al., 1998). Before it was a 3D Variational assimilation (3D-VAR). These schemes are part of the NWP system developed jointly by ECMWF and Météo-France, see Courtier et al. (1998). The computation of the analysis fields is performed through a global minimisation. In 3D-VAR the minimisation does not include the time evolution of the model, consequently it is much less demanding than 4D-VAR in terms of computer resources. For this impact study a 3D-VAR scheme has been chosen: it is performed every 6 hours: 00, 06, 12 and 18 UTC. A 4D-VAR system would have been necessary for testing the impact of observations reporting frequently, but the TEMP and PILOT observations considered in this study report every 6, 12 or 24 hours. The 3D-VAR system works in "incremental" mode, where the analysis increments are evaluated at T127 for correcting the T199 model. Finally a Digital Filter Initialisation (DFI) is performed after the analysis before running the 96h forecast.

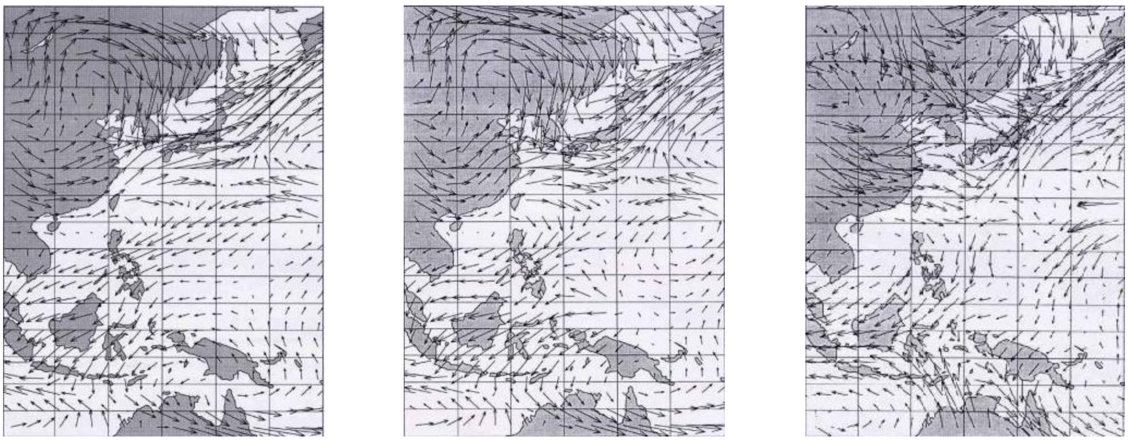
In the control run, all the conventional data are used (surface data including buoys, aircraft reports, radiosondes). The (A)TOVS data (from the NOAA satellites) and the SATOB winds (Atmospheric Motion Winds from geostationary satellites) are also used, but no scatterometer data. In the parallel experimental run, all the radiosonde data are removed, i.e. all the TEMP and PILOT messages, between 20N ans 20S.

[1] Service météorologique de Guinée, Conakri, Guinée
[2] Météo France (CNRM), 42 av. G. Coriolis, 31057 Toulouse Cedex, France - philippe.caille@meteo.fr

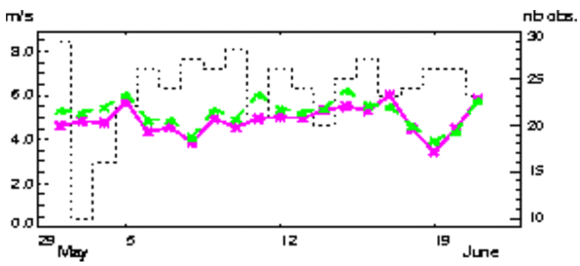
3. SUMMARY OF THE RESULTS

Comparing the analyses with and without radiosonde data, the biggest differences can be seen on the wind field on the South-East Asia and Australian region mentioned before, where the analysis differences often reach 5 m/s. Outside the tropics the analysis differences are always small, which means that the radiosonde signal does not propagate to mid-latitudes in the data assimilation.

For comparing the forecasts with and without radiosonde data, RMS scores have been computed against the radiosonde observations for different variables, different pressure levels (250, 500 and 850 hPa), and different areas of the globe. Also, for some cases (fig.1), a systematic synoptic evaluation has been performed on the forecast maps, forecast error maps, and forecast differences. The 24h wind score at 500 hPa is almost systematically improved by 0.5 to 1m/s inside the tropics (fig.2): this means that on average the signal coming from the tropical radiosondes is kept for 24h at least. Not much of this positive impact is left at 96h on similar diagrams. However, the signal can occasionally propagate to mid-latitude areas like Asia and affect forecasts up to 96h and up to 50 or 60 degrees of latitude. On one case (runs based on 11 June 2000, 00UTC), the tropical analysis differences on Indonesia and Australia affect a wave pattern moving from China to Kamtchamka. The 96h forecast is improved by the use of tropical radiosondes both on a mid-latitude wave pattern over Japan and on a tropical system inside the tropics (over New-Guinea, fig.1).



⇧ **figure1** : *an example of positive impact of the tropical radiosondes spreading to high latitudes in the 96h forecast*
250 hPa wind fields from the 96h forecast run from 11 June 2000, 0 UTC, with all the observations (middle), without the tropical radiosondes (left) and from the verification analysis of 15 June 2000, 0 UTC (right).



⇨ **figure 2** : *time series of the wind forecast scores computed daily by verification against the radiosonde wind observations. 24h forecast at 500 hPa over the tropical belt (20N-20S).*
The curves are the RMS errors in m/s. The full lines are for the forecast using all the observations, the dashed lines are for the forecasts without tropical radiosonde data. The dotted line is the number of radiosonde wind data used for the verification (vertical scale plotted to the right hand side of the diagram). The verification day is plotted on the horizontal axis (to get the day of the initial state, substract the forecast range).

REFERENCES

♦ Courtier, P., E. Andersson, W. Heckley, J. Pailleux, D. Vasiljevic, M. Hamrud, A. Hollingsworth, F. Rabier and M. Fisher, 1998: The ECMWF implementation of three dimensional variational assimilation (3D-VAR). Part I: Formulation. Q.J.R.M.S.,124, 1783-1807.

♦ Rabier, F., J.N. Thépaut and P. Courtier, 1998: Extended assimilation and forecast experiments with a four-dimensional variational assimilation system. Q. J. R. Meteorol. Soc., 124, 1861-1887.

♦ WMO, 2000: Proceedings of “Second CGC/WMO workshop on the impact of various observing systems on Numerical Weather Prediction”. Toulouse, France, 6-8 March 2000. WWW Technical Report 19. WMO/TD N°1034 (available from WMO, Geneva).