PAOBs in the Bureau ; past, present and future

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Origin

In the early 1970s, when the Australian Bureau of Meteorology had just started its numerical prediction operations, the observational data base was vastly different from the present day. There were no quantitative radiometric data from satellites to sense the thermal structure of the atmosphere, no drifting or moored buoys to measure pressure, no cloud drift winds at several levels in the atmosphere, and no scatterometer winds just above the ocean surface. Indeed, in the early seventies, the only information over vast tracts of the southern hemisphere oceans was pictorial, in the form of visual or infra-red satellite imagery. The human skills of picture interpretation and manual analysis were necessary to translate such pictorial information into the quantitative form needed by numerical prediction models. Guymer (1978) provides a comprehensive account of the tools available. Several overheads will be shown to illustrate the preceding points.

This was the background against which PAOBs, and the closely related THKLs, came into being. The PAOBs (pronounced "payob", and short for "paid observations") and THKLs (pronounced "thick-el", and short for "lower thickness") were respectively point values of sea level pressure, and 1000-500 hPa geopotential thicknesses, extracted from manual analyses, and used for subsequent numerical analysis and prediction. When first used, the PAOBs and THKLs were extracted from manual analyses done in pencil on paper charts. The production of PAOBs is now streamlined by means of an interactive computer workstation, but the PAOBs so produced still reflect the human skills that go into manual analysis and satellite image interpretation.

The idea behind PAOBs and THKLs is usually attributed to Bob Falconer and Jack Langford, two prominent Bureau meteorologists at the time. The PAOBs were fitted closely by the numerical analysis scheme then in operation, hence the name "paid observation". The PAOBs and THKLs provided a framework within which the multi-level analyses for input to a numerical prediction model were constructed, using such other quantitative data as were then available. It was found by hard-won experience that analyses needed to be done in this way, in order to maintain a stable analysis-prediction cycle.

Not only were PAOBs and THKLs an essential component of the Bureau's numerical analysis and prediction operations in the seventies. Their impacts on prediction skill over the Australian region were also clear. The Bureau used to do two NWP runs, at each of 1100 UTC and 2300 UTC, for its regional system; the so-called operational and archive runs. The idea of the archive run was to update the analysis with late data that was received after the operational data cut-off time. That late data consisted mainly of extra orbits of satellite imagery, from which corresponding additional PAOBs and THKLs were prepared.

A table to be shown during the presentation will illustrate the positive impact of the extra PAOB and THKL data over the Australian area. The statistics are based on over 1000 cases, and are therefore quite reliable. The improvements in the S1 skill scores are substantial.

So, in the mid-1970s, as well as being essential to maintain a stable analysis-forecast cycle, PAOBs and THKLs had a clear positive impact on prediction skill. But what has happened since then ?

Evolution

The evolution in the use of PAOBs over the years has been driven by two factors. The first is obvious, namely the vast increase in the largely satellite-based quantitative (as opposed to pictorial) observational data base, which occurred as the data mentioned in the opening paragraph progressively became available. No longer can one speak of the "data-sparse oceanic areas" in the way one did in the seventies. The use of THKLs was phased out in the 1990s, as advanced radiometric sounders provide similar information to THKLs , and much more.

A second factor in the evolution of PAOBs has been the ever-increasing sophistication of data assimilation systems, ranging from statistical interpolation methods during the 1980s, to three- and four-dimensional variational methods currently. These newest systems now typically combine observational data with short-range forecast information. Unlike the analysis systems used in the seventies, today's systems do not try to "pay", or fit, observations very closely. They seek to combine observational and short range forecast data according to their respective reliabilities. As a result, PAOBs have much less influence on analyses now than they did in the seventies. The main effect of PAOBs now is to make small adjustments to 6-hour forecast background fields poleward of about latitude 40, particularly in areas where pressure data from buoys and ships are sparse.

So, does the use of PAOBs still improve numerical predictions ? The short answer is yes, but not by as much as they did in the seventies. This will be illustrated during the presentation. However, an interesting aspect of PAOB impact on predictions, is that despite the ever-increasing volumes of quantitative data from other sources, the PAOB impact on predictions, which diminished during the 1980s, hasn't changed much since the early 1990s.

One way of quantifying the impact of a particular type of observation, such as PAOBs, is to run an experiment with two parallel data assimilation cycles, one with and the other without PAOBs, and then perform predictions from the analyses generated by each of the two cycles. This methodology is often called a "data denial" experiment. The Bureau has run such experiments with PAOBs every few years since the early 1990s. The impact of data denial may be quantified by loss of predictability. This is done by comparing the time range at which a measure of skill drops to a pre-specified level, with and without the data of interest (in this instance, PAOBs).

The results of the data denial experiments on PAOBs, from 1992 up to the present, will be illustrated during the presentation. They are based upon predictions from the Bureau's prediction model known as GASP (global assimilation and prediction). The gain in predictability using PAOBs (or conversely, the loss in predictability without PAOBs), is based upon the time range at which the anomaly correlation for the extratropical southern hemisphere (20 to 60 south) drops to 0.6 with and without PAOBs. The gains in predictability attributable to PAOBs vary somewhat between the years, but in terms of monthly averages there is always a small positive impact, with no systematic trend up or down. This has been the case, despite both changes in model resolution, and changes in data assimilation methods.

Of course, a gain in predictability of a couple of hours on average is not large, and impacts of this size may be difficult to discern synoptically. It is rather the fact that the impact is consistently positive in terms of monthly averages, and is apparently not changing much, that is the point to note.

The PAOBs originated by the meteorologists in the Bureau's National Meteorological and Oceanographic Centre are disseminated on the Global Telecommunications System. They are used in several other countries, and some of these countries have done PAOB impact tests, too. Such tests are reported in Atlas(1997), Butterworth and Dalby (1999), Bouttier and Kelly (2001), Cress (2002) and Langland and Baker (2004). The prediction models, data assimilation methods and impact assessment methods all vary from country to country. It is encouraging that their results are broadly consistent with the Bureau's, namely a small positive impact in southern hemisphere mid-latitudes.

The future

Finally, what of the future for PAOBs ? There is not much doubt that they still do help numerical predictions, to a small extent. But conversely, if the Bureau stopped preparing them, the loss of numerical prediction skill would also be small, and not readily noticeable most of the time. So, two questions are likely to be asked, by two rather different groups of people.

The first, from those of a managerial bent is, given that the incremental benefit of PAOBs is rather small, is the effort to produce them justified by the benefit ? The second question, from both manual analysts and researchers is, can we improve the way in which we utilise the skills of manual synoptic analysis and image interpretation, by using PAOB-like manual interaction in a better way ?

On the first question, that of cost-effectiveness, I am not well placed to comment, as I am not sure how costly is the effort to produce the PAOBs, or whether the skills of the people that produce them might be better used doing other things. I simply warn that the cost-effectiveness question may loom larger in years to come; forewarned is forearmed !

On the second question, namely can we make better use of the human skills of manual analysis and image interpretation, the challenge is ahead of us. The evidence is there, from the impact tests discussed earlier, that the skills of manual analysis and imagery interpretation do provide something different and useful, over and above what all the other data do. Can we use that "something" better than we do now ? The experiences of Davidson and Weber (2000), using a manual tropical cyclone bogus within the Bureau's tropical analysis and prediction system suggest the importance of information that a manual analyst can provide at the mesoscale. Several other researchers illustrate how incorporating satellite imagery information through modification of fields such as potential vorticity, can improve the numerical forecast in some baroclinic situations. Hello and Arbogast (2004) is a recent example. And manual analysts will probably tell you that it is the pattern of the isobars, rather than the absolute value, that they can interpret best from satellite imagery. So, some clues are there. But talk is cheap. The resources, the expertise and the motivation are all needed to tackle the problem in a serious way.

So the outlook for PAOBs remains cloudy. If we persist with business as usual, there is a danger that hard-headed cost-effectiveness considerations may sooner or later lead to their demise. To one who analysed many charts using pencil and paper some 40-odd years ago, this would be sad. But if the commitment is there, both from those with the relevant skills, and from those who prioritise resources, we may well prolong the PAOBs' life expectancy.

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