Analysis and Prediction Operations Bulletin No. 71

Operational Upgrade to Predictive Ocean Atmosphere Model for Australia (POAMA)
4 February 2008

1. Introduction:

The first version of Predictive Ocean Atmosphere Model for Australia (POAMA-1) was upgraded to a new version (POAMA-1.5) in NMOC Melbourne on 4 February 2008. POAMA is the Bureau of Meteorology global coupled ocean-atmosphere model for intra-seasonal to seasonal climate prediction (Alves et al. 2003; Zhong et al. 2005; Wang et al. 2008). The POAMA-1 system was developed through collaboration between CSIRO and BMRC with some support from Land and Water Australia. It was mainly designed to predict El Niño/Southern Oscillation (ENSO) and particularly the NINO indices. POAMA-1 has been run in real–time by the National Meteorological and Oceanographic Centre (NMOC) since October 2002 and it is the basis for operational products issued by the National Climate Centre (NCC) early each month.

This new system has been developed by the Seasonal Prediction and Climate Variability Group in the Centre for Australian Weather and Climate Research (CAWCR), that is led by Dr Oscar Alves. This recent upgrade of the coupled system involves the introduction of a new Atmosphere/Land Initialisation (ALI) system (Hudson et al. 2007) and some re-tuning and improvements of physics, for instance, improved wind stress/current coupling, higher coupling frequency (3 hours) and re-tuned ocean vertical mixing (Wang et al. 2008). The new ALI scheme introduces more realistic atmosphere and land initial conditions into the hind-casts and creates the greater consistency between the hind-casts and real-time forecasts, thus allowing better use of the hind-casts to assess the seasonal forecast skill.

A comprehensive set of 10-member monthly ensembles has been completed covering the period 1980-2006. The results suggest that SST skill measured by anomaly correlation from the new system is higher than 0.6 up to a lead time of 9 months over the equatorial Pacific Ocean. Forecasts over the Indian Ocean, however, are skilful only at shorter lead times up to two months. The comparison between POAMA-1.5 with the first version POAMA-1 shows that the skill in the SST predictions is improved and the improvement in the new version at seasonal time scales is likely due to improved atmosphere and land initialization and coupling physics.

2. Model configuration and Hindcasts

The POAMA-1.5 system is comprised of version 3 of the Bureau unified atmospheric model (BAM 3.0d) (Colman et al. 2005) and the version 2 of the Australian Community Ocean Model (ACOM2) (Schiller et al. 2002). Both models interact through an Ocean Atmospheric Sea Ice Soil (OASIS) coupling software and no flux corrections are applied during the forecast integration (Figure 1). The resolution for the atmospheric model is T47 (2.5 deg x 2.5 deg) and vertical resolution is 17 levels. The meridional resolution for the ocean model is 0.5^o between 8^oS to 8^oN, gradually increasing to 1.5^o near the poles and the zonal resolution is 2^o.

The atmospheric initial conditions are provided by a new Atmospheric and Land Initialisation Scheme (Hudson et al., 2007). In this approach, an off-line version of the POAMA atmospheric model is nudged towards the ERA-40 reanalysis for the hind-casts and to the BoM's NWP forecast system (GASP) in real-time. The model's forecast of U and V winds, atmospheric temperature and humidity is compared to the analysis at the six-hour forecast cycle and the fractional difference between the forecast and analysis is added repeatedly to the evolving model atmosphere state. The land surface is initialised indirectly and brought into balance with the atmospheric forcing. This allows the same land and atmospheric model to be used for initialisation and coupled forecasts, which creates greater consistency between real-time forecasts and hind-casts. This overcomes one of the major problems in POAMA-1: the atmosphere and land surface were being initialised directly by GASP, which was not the same model for the coupled hind-casts. ALI introduces a more realistic atmosphere and land surface into the initial conditions including true intra-seasonal atmospheric states, which are important for seasonal forecasting. A detailed description of the advantage of using the ALI scheme can be seen in Hudson et al. (2007).

The initial condition for the ocean model comes from the ocean data assimilation system, which assimilates temperature measurements into the ACOM2 in the top 500m every three days. It makes use of all available real-time subsurface temperature observations including those from the TOGA-TAO moorings, drifters, Ship of Opportunity Program (SOOP) XBT and ARGO floats. Current corrections are calculated by applying the geostrophic relation to the temperature corrections.

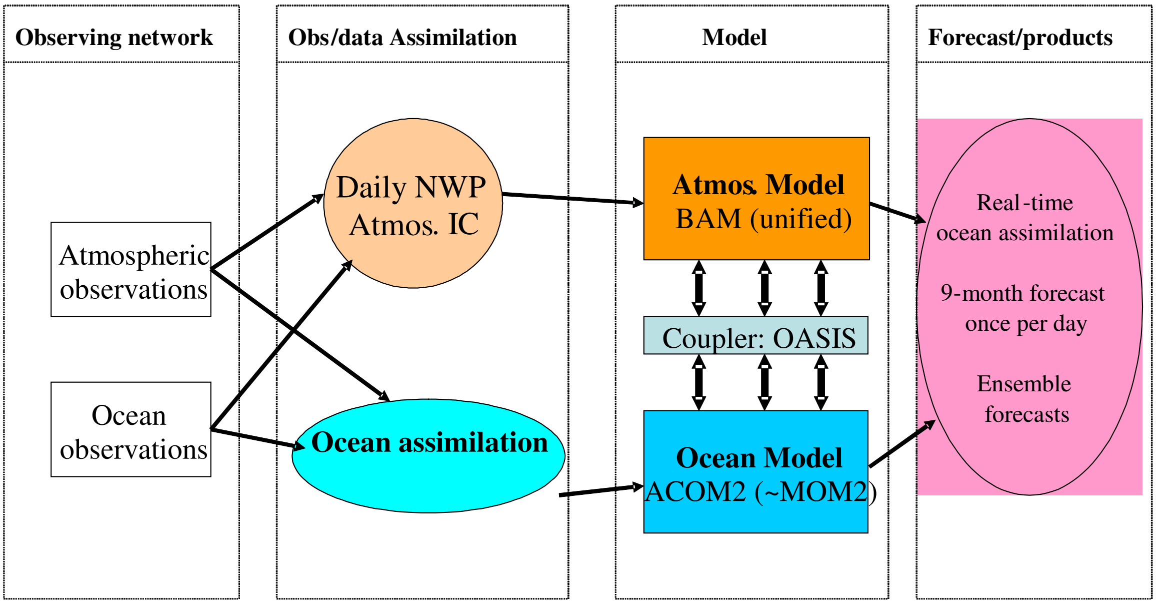

Figure 1: Schematic diagram of introduction of POAMA operating system (Alves et al. 2003)

A comprehensive hind-cast set has been produced for the period of 1980 to 2006. 10-member ensemble forecasts are generated for each month starting at the first day of the month at 00Z UTC. The ocean initial condition is kept the same for the ten members, however the atmospheric initial condition generated from ALI scheme varies every six hours prior to the beginning of each month.

3A. Skill comparison with POAMA-1

Since POAMA-1 has only one member hind-cast for each month and also the hind-cast period is shorter (1987 – 2001), the hind-cast analysis period from POAMA-1.5 is chosen to be from 1987 to 2001 only to make a valid comparison between the POAMA-1.5 and POAMA-1. Figure 2 illustrates the anomaly correlation (ACC) skill for Nino3 SST anomaly from POAMA-1.5 of all ten members and the POAMA-1 single member. It is seen that both the POAMA-1 and POAMA-1.5 forecasts show higher skill than persistence at all lead times with anomaly correlation above 0.6, suggesting that both POAMA systems have robust useful SST prediction skill across central to east

Equatorial Pacific regions for lead times up to nine months. The skill of most members of POAMA-1.5 is higher than that of POAMA-1 at lead times up to nine months. The average skill from the POAMA-1.5 ensembles beats the skill of the single member hind-cast of POAMA-1 (Wang et al. 2008).

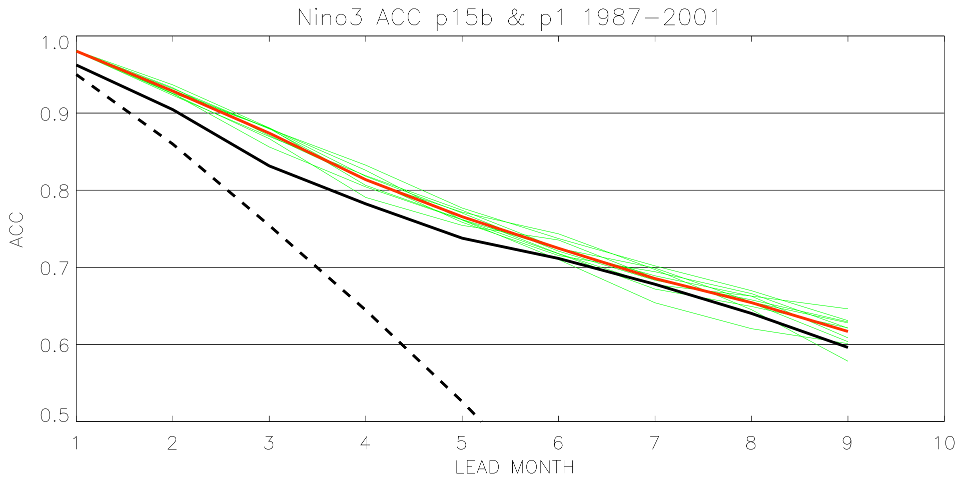

Figure 2: Nino3 SST anomaly correlation for POAMA-1 (black solid) and POAMA-1.5 each member (green) and mean of the skill of the individual ensembles (red). Persistence is in dashed black (Wang et al. 2008)

Figure 3 shows the spatial distribution of SST ACC skill at the lead time of three months for a single member of POAMA-1.5 and POAMA-1 hind-casts. Generally the skill from both models over the tropical and subtropical Pacific is high with the ACC well above 0.5-0.6 at the three month lead time. However, both models' skill drops dramatically over the Indian Ocean compared with the Pacific Ocean, like many other models. The possible causes for low skill over the Indian Ocean are summarized in Wang et al. (2008). One of the important factors could be due to the lack of reliable observations, which impacts the quality of ocean data assimilation.

Comparison between POAMA-1.5 and POAMA-1 shows a slight improvement of SST skill almost everywhere in the new version, in particular over the northwest and northern Australia. Even though the skill improvement in POAMA-1.5 is marginal and possibly not statistically significant, the improvement may be due to more realistic atmospheric initial conditions through the use of the ALI scheme (Wang et al. 2008).

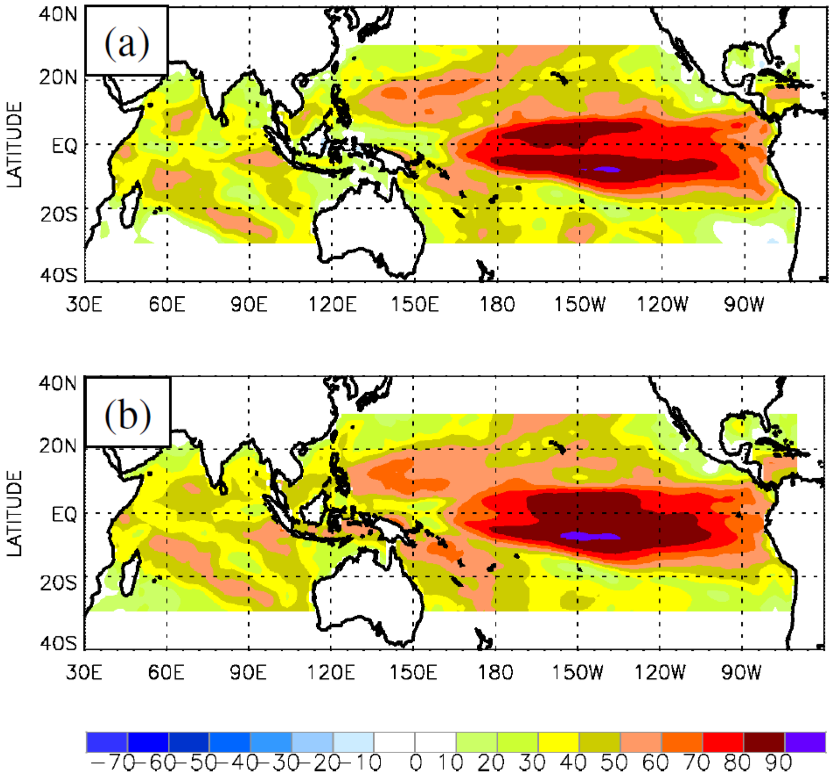

Figure 3: SST anomaly correlation skill at three month lead time for (a) POAMA-1.0 forecasts and (b) POAMA-1.5 (Wang et al. 2008).

3B: Skill for ensemble mean

Ten member ensemble mean anomalies for the period of 1980 to 2006 are available for assessing POAMA-1.5 SST skill. The model anomalies are calculated by subtracting model climatology from the individual hind-casts. The model climatology is defined as the mean over all ten ensemble members and over twenty-seven years for each initial month. The detailed documentation of SST skill in this full hind-cast set can be found in Wang et al (2008).

Figure 4 compares the anomaly correlation skill for Nino3 SST and Indian Ocean dipole mode index from POAMA-1.5 and persistence. POAMA-1.5 Nino3 forecasts beat persistence at all lead times and the skill is well above 0.6 which is often used as a threshold value for a useful forecast, indicating that the POAMA-1.5 has robust SST prediction skill across central to east Equatorial regions. It is worthy noting that the skill from the POAMA-1.5 10-member ensemble mean (Figure 4 left panel) is slightly higher than the averaged skill from the individual ensemble members (Figure 2) for all lead times. Skill over the tropical Indian Oceans is much lower than in the tropical Pacific and the skill for DPI drops quickly after first two months.

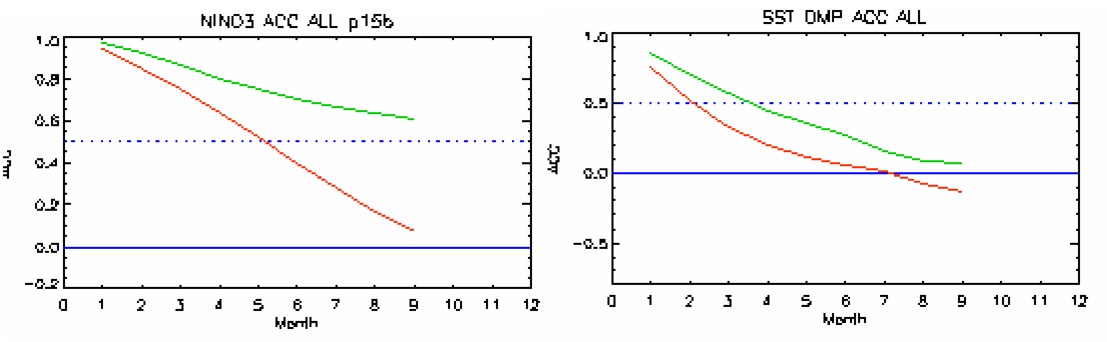

Figure 4: Nino3 anomaly correlation (left panel) and Indian Ocean Dipole Mode Index anomaly correlation (right panel) based on ensemble mean of 10-member hind-casts. Hind-casts skill is in green and persistence is in red (Wang et al. 2008)

SST skill from the POAMA-1.5 forecasts and persistence at lead time 6 months are displayed in Figure 5. It is clear that the POAMA skill beats the persistence almost everywhere within the tropical and subtropical Pacific and Indian Oceans. The skill level is higher over the northwest Pacific and central and east tropical Pacific and lower in the tropical Indian Oceans.

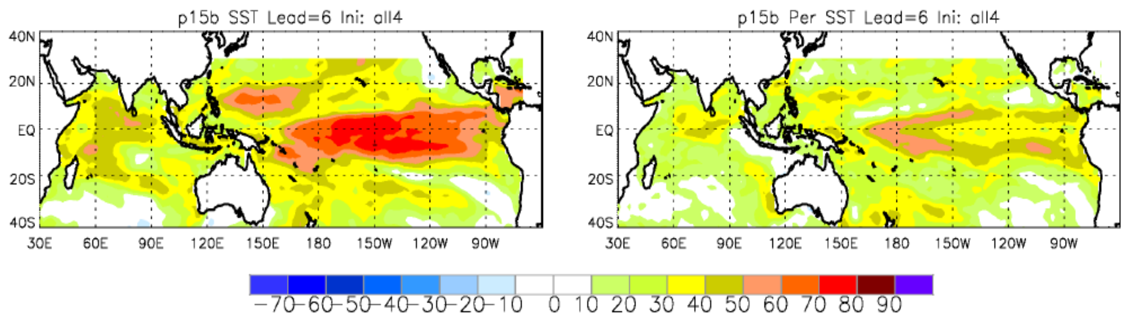

Figure 5: SST anomaly correlation skill at 6 month lead time for mean of ensembles (left) and persistence (right) (Wang et al. 2008)

4. Real Time Forecast Products

SST plumes:

The real-time ensemble forecasts are produced differently from the past twenty-seven year hind-casts. POAMA-1.5 system is run every day at 00Z UTC to give forecasts out to nine months ahead. There are approximately 30 ensemble members produced every month. The atmospheric initial condition comes from ALI nudging scheme. The main ocean assimilation system forced by fluxes from real-time GASP system is run 10 days behind the real-time that allows maximum coverage of observations to be included. 10-day catch up ocean assimilation including latest arrival of observations then produces initial condition for the ocean model.

The bureau official forecasts are accessed through the National Climate Centre (NCC) website: http://www.bom.gov.au/climate/coupled_model/poama.shtml. The website for real time experimental products is at: http://poama.bom.gov.au. This website is experimental and only for research purposes, but contains a broader range of experimental products.

One of the main products from POAMA-1.5 is the forecast NINO3 SST anomalies, which can be seen on both the research and NCC website. Figure 6 shows the POAMA-1.5 forecast NINO3 anomaly plumes for the next 9 months. Probabilities are based on the range of predictions from the most 30 recent daily forecasts of POAMA. The spread of plumes shown here provides a range of possible developments in sea surface temperature (SST) in the equatorial Pacific Ocean. The model maintains moderate La Nina conditions for the next few months, gradually warming to weak cold conditions in the medium term and neutral conditions by the end of the forecast.

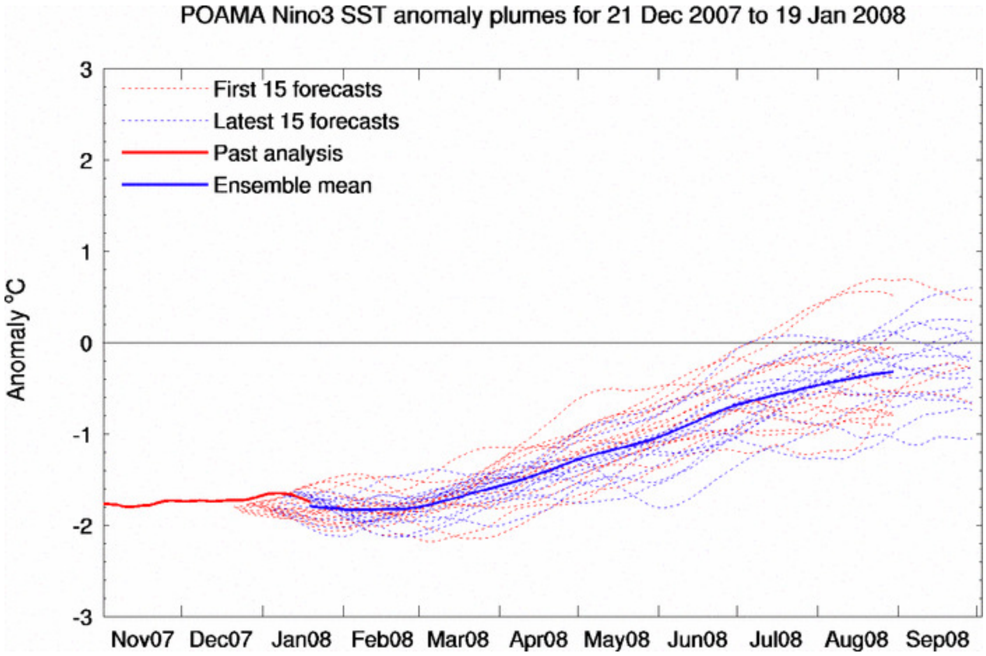

Figure 6: Forecast NINO3 (150^{o}W-90^{o}W, 5^{o}N-5^{o}S) SST anomalies for the next 9 months. Solid red line is the past analysis, dotted blue lines are latest 15 forecasts and dotted red lines are previous 15 forecasts and solid blue line is the 30 member ensemble mean.

5. Future Developments

Some new products will be added to POAMA experimental web site including the new skill score maps (e.g. mean square skill scores, ROC scores and reliability graphs) for SST, 2 metre air temperature and precipitation from POAMA hind-casts. These skill scores are standard products for each WMO global producing centre for dynamical seasonal forecasts. At this stage, operational rainfall products are currently being assessed, but not issued. An operations bulletin will be produced for new rainfall products in the near future.

A major new version, POAMA-2 is under development by CAWCR. POAMA-2 will use a new higher-resolution version of the atmospheric model (T63), a new ocean data assimilation system and an enhanced version of the atmosphere/land initialisation systems. A time-table for the development of different versions of the POAMA system is shown in Figure 7. The diagram also shows the development of the POAMA-3 system, which will be built from new modules developed as part of Australian Community Climate and Earth System Simulator (ACCESS) projects. The atmospheric model will be the UKMO unified atmospheric model and the CSIRO Atmosphere Biosphere Land Exchange (CABLE) land-surface model. The model configuration is yet to be decided.

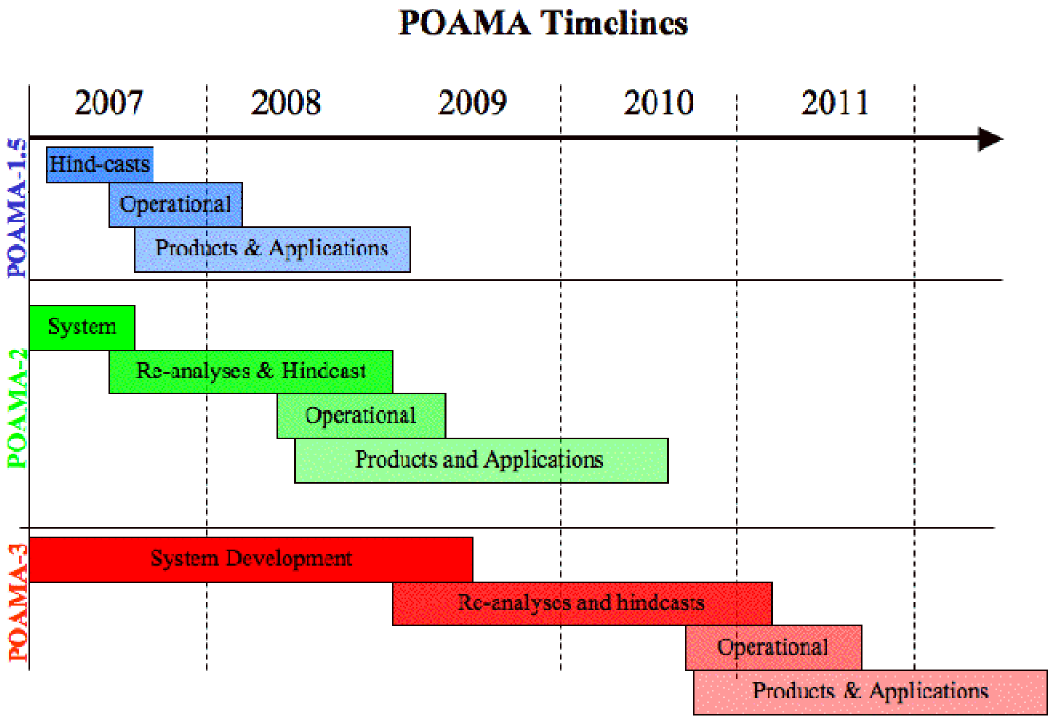

Figure 7: POAMA time lines (O. Alves)

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6. References

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