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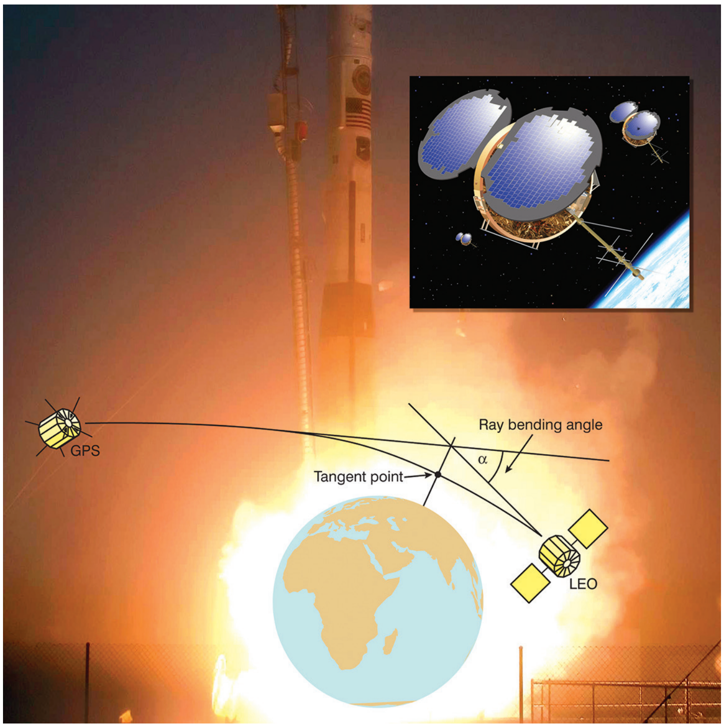

Courtesy of the Orbital Science Corporation.

www.ecmwf.int/en/about/news-centre/media-resources

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New web products for the ECMWF Seasonal Forecast System-3

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With the implementation of the new seasonal Forecast System 3 in March 2007, the set of graphical products available on the ECMWF web site has been improved and expanded. The purpose of this article is to give a brief overview of the new products available, show some examples of what is available on the web site, and provide some guidance for their use.

A summary of the changes recently introduced is as follows.

a) ***Entry page for the ECMWF forecast products***
www.ecmwf.int/products/forecasts

A new entry has been introduced for the System-3 ocean analysis (*Balmaseda et al.,* 2007), including maps from the real-time and the behind-real-time (BRT) analyses; both are used by the monthly forecast system (*Vitart,* 2003) and the latter by the seasonal forecast system (*Anderson et al.,* 2007). The BRT system is referred to as 'Re-Analysis', since it has been used to assimilate ocean data from January 1959 to the present.

b) ***The seasonal forecast index page***
www.ecmwf.int/products/forecasts/d/charts/seasonal/forecasts

This page leads to three different sections devoted to the 'standard' seasonal-range forecast (run every month up to seven months ahead), the annual-range forecasts (run every 3 months up to 13 months ahead), and the EuroSIP multi-model ensemble made up from integrations of the ECMWF, Météo-France and UK Met Office coupled models.

c) ***The seasonal-range forecast page for System-3***
www.ecmwf.int/products/forecasts/d/charts/seasonal/forecasts/seasonal_range_forecast

This includes entries to the same four categories of products as in System 2, namely plumes for El Niño indices, horizontal maps of three-month anomaly statistics (ensemble mean and probabilities), climagrams (i.e. time series of indices representing area-averaged anomalies or teleconnection pattern amplitudes) and tropical-storm indices. However, all these sections have been improved, and forecast products have been extended to seven months following the increased length of the integrations.

Additions include a new 'summary' plot of probabilities for tercile-based categories in the horizontal map section. There is a substantial expansion of the climagram section, now comprising area-averages of two-metre temperature and precipitation over 25 areas, extratropical teleconnection indices and rainfall-based monsoon indices. Tropical storms indices have been revisited, and a measure of forecast uncertainties has been included.

d) ***The annual-range forecast page for System-3***
www.ecmwf.int/products/forecasts/d/charts/seasonal/forecasts/annual_range_forecast

This page includes entries for three categories of products, namely El Niño plumes, spatial maps and tropical storm statistics. At present the annual-range forecasts are only visible to Member State users.

We will now illustrate some of the new products in greater detail.

The System-3 ocean analysis products

The System 3 (S3) operational ocean analysis consists of two analysis streams: (a) a historical reanalysis from 1 January 1959 which is continuously updated (with a delay of 11 days) and is used to initialize seasonal forecasts, and (b) a real-time ocean analysis, used to initialize the monthly forecasts. The S3 ocean analysis has several innovative features, including an on-line bias correction algorithm, the assimilation of salinity data on temperature surfaces, and assimilation of altimeter-derived sea level anomalies and global trends. The S3 ocean analysis has been running since August 2006, and became fully operational in March 2007.

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The new ocean web pages (**www.ecmwf.int/products/forecasts/d/charts/ocean**) offer, for the first time, products from both the real-time stream and from the historical reanalysis. Online documentation of the ocean analysis system is also available, with information on the observations used, the ocean archive and a guide to the ocean products. The selection of ocean products can be summarized as follows.

- ***Horizontal maps*** of sea surface temperature (SST), sea level (SL), depth of 20°C isotherm (D20), sea surface salinity (SSS), zonal wind stress (Tau-x), and temperature and salinity averaged over the upper 300 m (T300 and S300 respectively). T300 and S300 are proxies for the upper ocean heat and salt content, and D20 is a proxy for the depth of the thermocline.
- ***Zonal sections*** of temperature along the equator.
- ***Meridional sections*** of temperature at 165°E, 140°W and 30°W.
- ***Time-Longitude*** sections along the equator of SST, sea level, depth of 20°C isotherm and zonal wind stress.
- ***Observation coverage maps*** and quality control decisions for subsurface observations. The maps include information about number of profiles, observation type (mooring, ARGO floats, or XBTs), and whether the profile has been fully accepted, rejected, partially rejected or "super-obbed" (a super-observation is the average of several observations correlated in time and space that is given extra weight).

Both full fields and anomalies are displayed. The anomalies have been calculated respect the 1981–2005 climatology, which is the same period used for the hindcast integrations of the S3 seasonal forecasts. The maps represent daily fields from the real-time analysis, and weekly and monthly fields from the reanalysis stream. The monthly fields go back to 1959 and the weekly fields have only been displayed since January 2007. Table 1 offers a summary of the ocean products on the web. The products only available for the reanalysis are in blue, those that exist only for the real-time stream are in red, and the products common for both streams (although at different timings) are in black. The new products are in bold.

Figure 1 shows longitude-depth sections of temperature along the equator for eight months during the reanalysis period, illustrating the transition from warm to cold conditions in four ENSO events. While normally transitions from warm to cold phases occur on a time scale of one year, the transition during the recent winter (see panels for December 2006 and March 2007) was anomalously rapid.

Sections				
Spatial attributes	Parameter	Time attributes		
		Average	Updated / delay	Record
Horizontal **Global** / Tropical	SST, **SSS**, SL, D20, **T300**, **S300**, Tau-x	**Daily**	**Every day No delay**	Last 30 days
Zonal Equatorial	Temperature	Weekly	Sundays. 11 days delay	From January 2007
Meridional 165°E / 140°W / 30°W	Temperature	**Monthly**	**End of each month. 11 days delay**	**From 1959**
		Span		
Hovmoller Equatorial	SST, SL, D20, Tau-x	Last 6 months	**Every day No delay**	**Latest**
		6 / **12** months	End of each month. 11 days delay	**From 1959**
Observation coverage maps and quality control				
Global maps	**Temperature and salinity profiles**	**10-days assimilation window**	**Every day**	**Last 30 days**
			Every 10 days. 11 days delay	**From 1959**

Table 1 Summary of the ocean analysis products available in the web. Blue indicates products only available from the reanalysis stream, and red products are only available from the real-time stream. Common products are in black. New products are in bold. The abbreviations used for the Parameter are defined in the section on the S3 ocean analysis products.

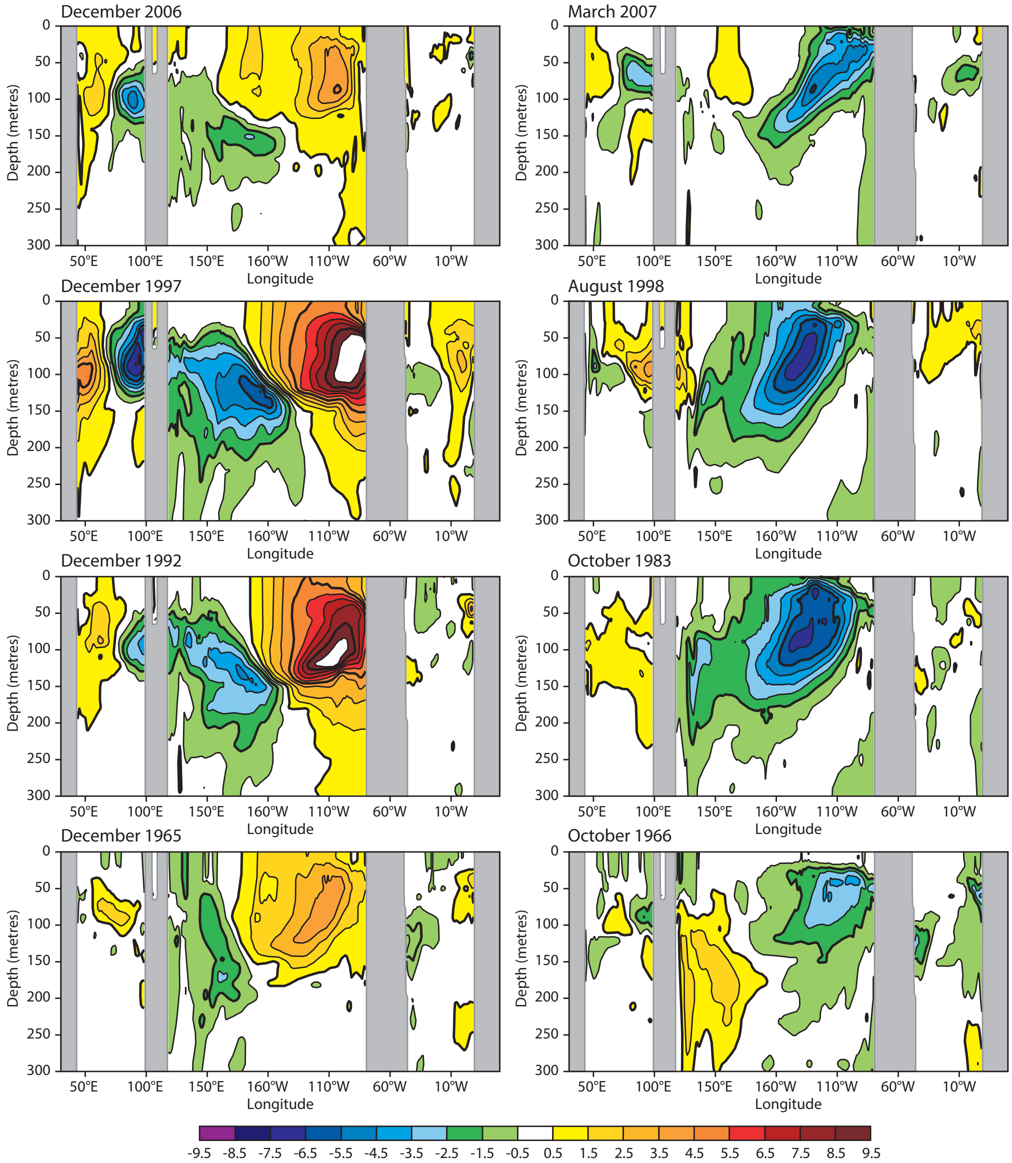

Figure 1 Longitude-depth sections of temperature along the equator for eight months during the S3 ocean reanalysis period, illustrating the transition from warm to cold conditions in four ENSO events. Left column, top to bottom: December 2006, December 1997, December 1982, December 1965. Right column, top to bottom: March 2007, August 1998, October 1983, October 1966.

The 'tercile summary' probability plot

Probabilities of tercile-based categories for three-month mean anomalies have been produced since the introduction of the first operational seasonal forecast system at ECMWF. So far three different maps have been available for individual categories, corresponding to the lower, middle and upper third of the anomaly distribution. To have a proper assessment of the distribution it is necessary to examine at least two of these maps. Alternatively, the user could consult the map for the probability of anomalies being above (or, by difference, below) the median value to get a single-map overview. However, using such a product one must be careful not to confuse high/low probabilities with large positive/negative anomalies!

In most cases, users are interested in spotting regions where significant deviations from climatological values may occur. To provide such information in a synthetic form, a new plot has been introduced with probabilities only plotted in those areas where (a) the highest probability among the three tercile-bounded categories is predicted for one of the two extreme categories and (b) such a probability exceeds 40%. An example of the 'tercile-summary' for the prediction of two-metre temperature in the January–March 2007 period, derived from the pre-operational System-3 forecast started on 1 December 2006, in shown in Figure 2. The prevalence of orange/red colours indicates a moderate to high chance of anomalously warm temperatures over most of the tropics, North Atlantic, Europe and western Asia.

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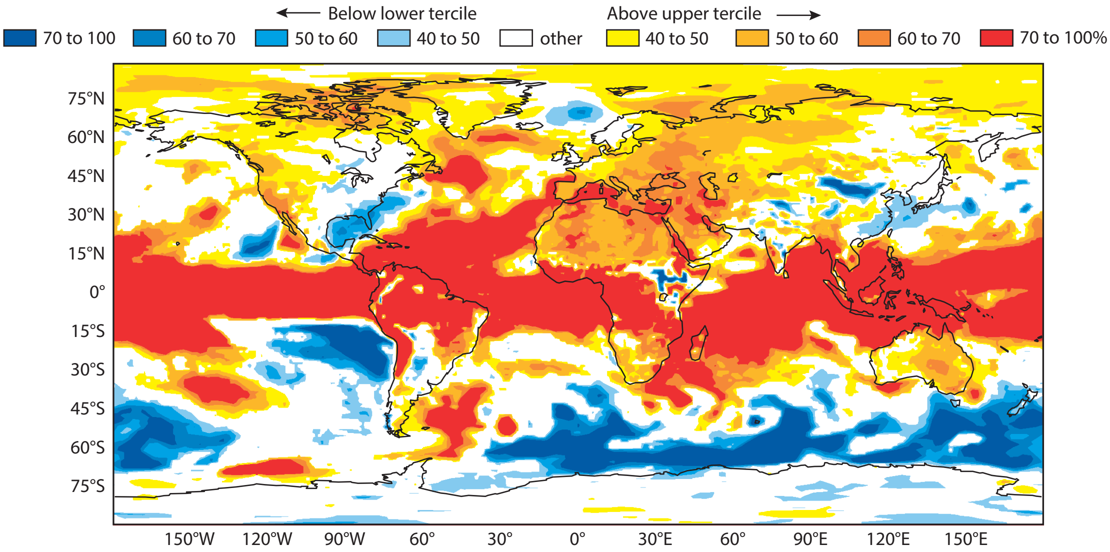

Figure 2 Example of the 'tercile summary' plot for the probabilities of two-metre temperature categories, from the S3 forecast started in December 2006.

Climagrams: new graphical display for an extended set of indices

As mentioned in the introduction, climagrams are graphical products representing the evolution of the ensemble distribution of monthly-mean anomalies for a specific atmospheric parameter throughout the seasonal forecast range. At the time of writing, four categories of parameters are displayed.

- Area averages of two-metre temperature anomalies.
- Area averages of precipitation anomalies.
- Teleconnection indices based on mean-sea-level pressure or geopotential height anomalies.
- Monsoon indices based on rainfall anomalies.

Climagrams for SST indices are going to be introduced in the near future.

The new graphical display of the climagrams is illustrated in Figure 3 by two examples. Figure 3(a) shows the predicted distribution of the Equatorial Southern Oscillation Index (ESOI) from a pre-operational forecast started in November 2006, while Figure 3(b) shows the distribution of two-metre temperature anomalies averaged over the Southern European region (35–50°N, 10°W– 30°E) from the October 2006 pre-operational forecast.

For each index and each month in the seven-month forecast range, the climagram compares the following three distributions.

- The distribution derived from observational datasets (ERA-40, operational analysis or GPCP data) during the S3 hindcast period (1981–2005).
- The distribution corresponding to the model climatology computed from the hindcast dataset.
- The distribution from the 41-member ensemble forecast started at the beginning of the first month in the graph.

For each distribution, the graph shows the median, the interval between the lower and upper terciles, and the interval between the 5th and 95th percentiles. For the observational data, the two intervals are represented respectively by orange and yellow bands, with a solid line indicating the median. For forecast data, the two intervals are shown by a box and whiskers of different colour and width: grey and wider for the model climatology, purple and thinner for the actual seasonal forecast. Again, a solid line within the tercile box indicates the median of the distribution. Verification data available *a posteriori* are shown by a red square.

Contrary to the spatial maps for probabilities illustrated in the previous section, climagrams do not classify forecast anomalies in pre-defined categories, but rather compare the forecast and climatological distributions in graphical form. This gives the user a visual impression of the difference between the forecast distribution and its climatology, and therefore of the significance of the predicted anomalies. Also, by comparing the model climatological distribution with the observed one, a user gets information about the ability of the forecast model to reproduce the observed anomaly range.

One may wonder whether there is any predictive information in the monthly values displayed in the climagrams, or whether one should only consider three-month means as in the categorical probability maps. If one thinks in terms of, say, correlations of anomalies for a specific month across the 25-year hindcast range, in the large majority of cases such a correlation turns out to be lower than the correlation for three-month means centred on that specific month. However, if one considers the relative variations of monthly anomalies within the seven-month period, it is found that, in a number of cases, such variations had a counterpart in the observations. For example, the recent transition from a warm to a cold ENSO phase in the eastern tropical Pacific (corresponding to the decrease and eventual reversal of ESOI anomalies in Figure 3(a)) caused significant intra-seasonal variations in the northern hemisphere circulation, which were often captured by the seasonal forecast. In Figure 3(b), not only the overall positive sign of the temperature anomaly over Southern Europe in the last autumn/winter was predicted by the October forecast, but also some of the intraseasonal fluctuations (although with a lower degree of consistency between successive forecasts).

Finally, we wish to point out that the number of areas for which two-metre temperature and rainfall anomalies are displayed in the climagrams has been substantially increased with respect to the previous seasonal forecast system, with a more extensive coverage of tropical and southern mid-latitude regions. The full set of areas is illustrated in Figure 4.

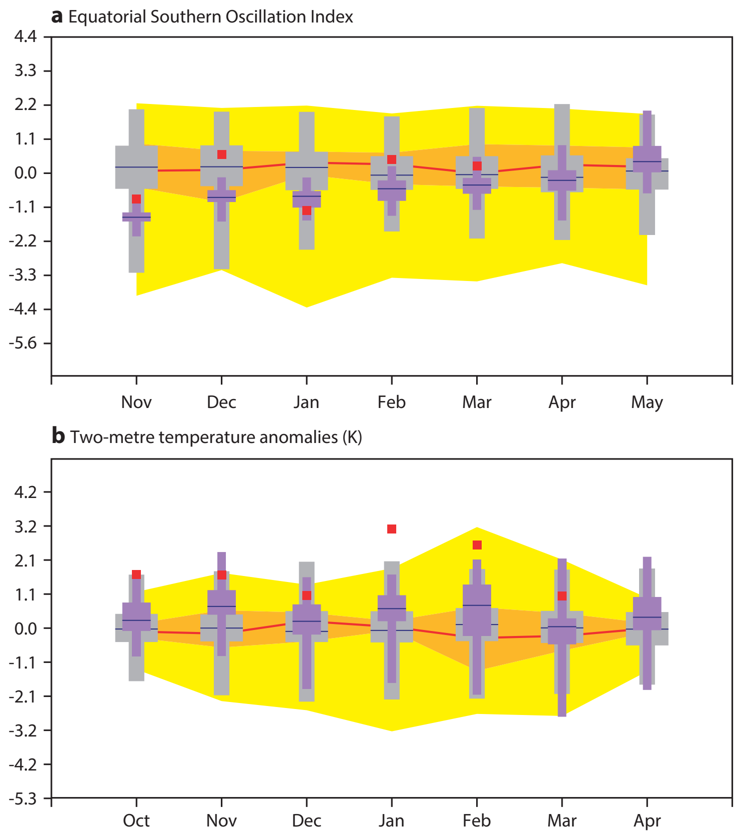

Figure 3 Examples of climagrams for the Equatorial Southern Oscillation Index (top) and the two-metre temperature anomaly averaged over Southern Europe (35°N–50°N, 10°W–30°E; bottom). See the main text for the explanation of the graphical elements.

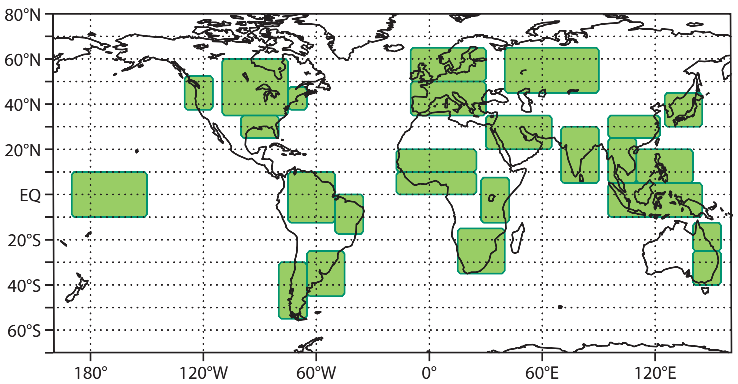

Figure 4 Distributions of areas covered by the climagrams for two-metre temperature and precipitation anomalies.

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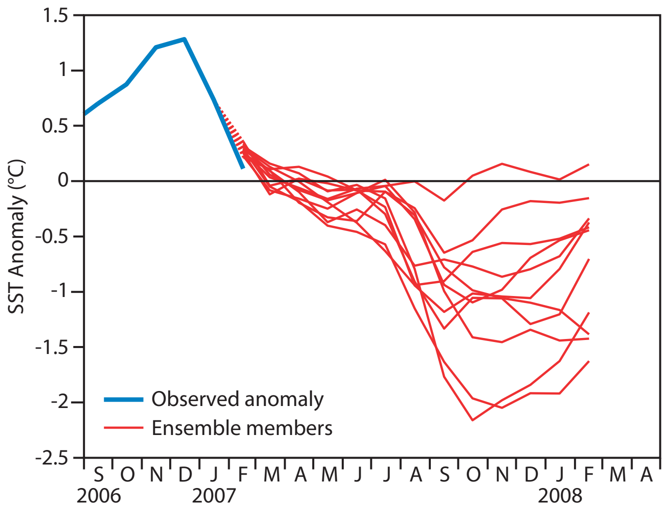

Figure 5 Niño 3.4 (120°W–170°W, 5°N–5°S) SST anomaly from the annual-range forecast starting on the 1 February 2007. Red lines are the individual forecast ensemble members and the blue line is the observed anomaly to date.

The annual range forecasts

An example of a Nino 3.4 SST forecast plume from the latest annual range forecast is given in Figure 5. The reduced ensemble size of the annual range forecasts (11 members) limits the usefulness of forecasts of noisy fields such as precipitation, but is sufficient to look at the evolution of El Niño. Here the forecast shows that a “La Niña” event (East Pacific SSTs colder than normal) is likely in the second half of this year, but that its amplitude is uncertain at this stage.

What next?

ECMWF has been issuing global seasonal predictions every month since 1997. In 2000 the seasonal forecasts became part of the operational products, and by mid-2000 some of those products became available to all WMO Members. Recently ECMWF has been recognized by the WMO as one of the Global Producing Centres for Long-Range Forecasts (GPCs). Consistent with the role of a GPC, we hope that the new products available from the ECMWF website may be of benefit not only to the ECMWF Member States, but also to international organizations involved in providing guidance on climate-sensitive applications for developing countries.

The set of products described in this article may be further expanded in the future according to users’ needs. Also, a set of verification statistics will soon be made available on the web site. We wish to point out that some of these new products (particularly those from the annual-range forecast) should be considered as experimental, and may be modified according to operational experience. In order to progress with the product development, we believe that feedbacks from both operational and research communities are essential, and we encourage all seasonal forecast users to share with us their experience regarding the products described in this article.

Further Reading

Anderson, D., T. Stockdale, M. Balmaseda, L. Ferranti, F. Vitart, F. Molteni, F. Doblas-Reyes, K. Mogensen & **A. Vidard,** 2007: Development of the ECMWF Seasonal Forecast System-3. *ECMWF Tech. Memo. No. 503.*

Balmaseda, M., A. Vidard & **D. Anderson,** 2007: The ECMWF System-3 ocean analysis system. *ECMWF Tech. Memo. No. 508.*

Vitart, F., 2003: Monthly forecasting system. *ECMWF Tech. Memo. No. 424.*