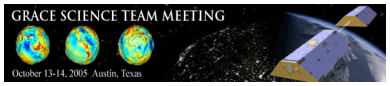

Uncertainties in atmospheric surface pressure fields from global analyses

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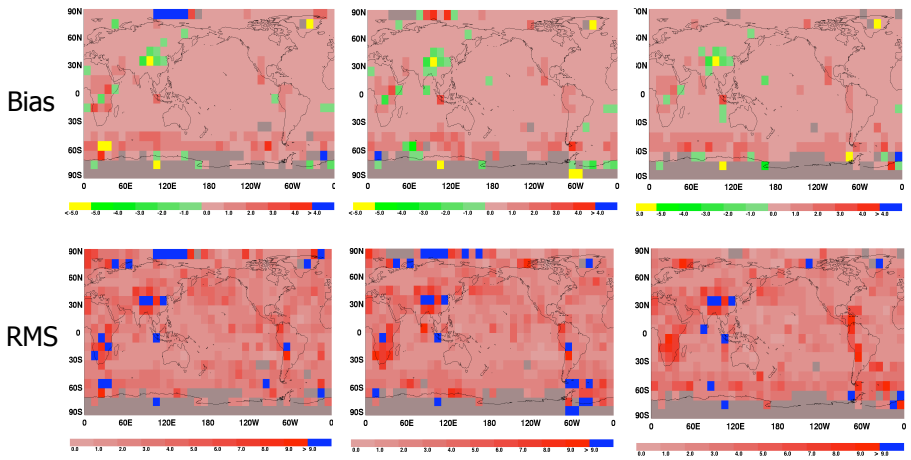
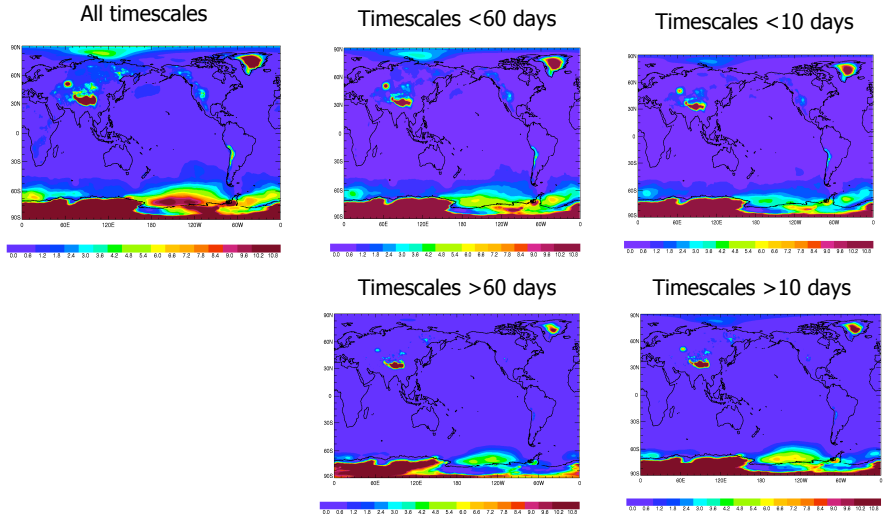
Two operational analyses, those from the U.S. National Centers for Environmental Prediction (NCEP) and the European Centre for Medium-Range Weather Forecasts (ECMWF), provide, among other quantities, atmospheric pressure at the Earth's surface. Because these analyses are derived from combining observational data with forecast fields from atmospheric models, their characteristics depend upon the type of observation available, the assimilation technique, and the characteristics of the model itself, all of which have changed over the course of time. To help assess error levels in analyses of surface pressure, we compare their values to surface barometric observations (OBS); to do so, the former are interpolated spatially and temporally to the observation location and time. Over land, surface observations are typically taken at fixed stations, but those over the ocean are determined from a set of ship-based measurements. The largest differences are found over the high latitudes of both hemispheres, particularly over Antarctica. During our study period of 2001-2003 we observe larger biases between the analysis fields and the observations, sometimes up to 4 hPa over the southern oceans, and high altitude regions of the continents. Full root mean square differences indicate larger values that occur on all time scales. Considering the mean differences between the NCEP and ECMWF values, we note that they have generally decreased in time. For the difference between analyses, variances of this difference are also separated into temporal bands. For variance of 30-day smoothed data (scales >60 days), related closely to the time scale of GRACE, we note the largest differences over the Antarctic Ice sheet, oceans in the high southern latitudes particularly near 120 W – 180, the Himalayan region, and Greenland; these are larger in their respective winter seasons. Surface pressure errors can affect both dealiasing efforts as well as interpretation of monthly gravity anomalies.

Bias and RMS difference of ECMWF surface pressures from OBS set



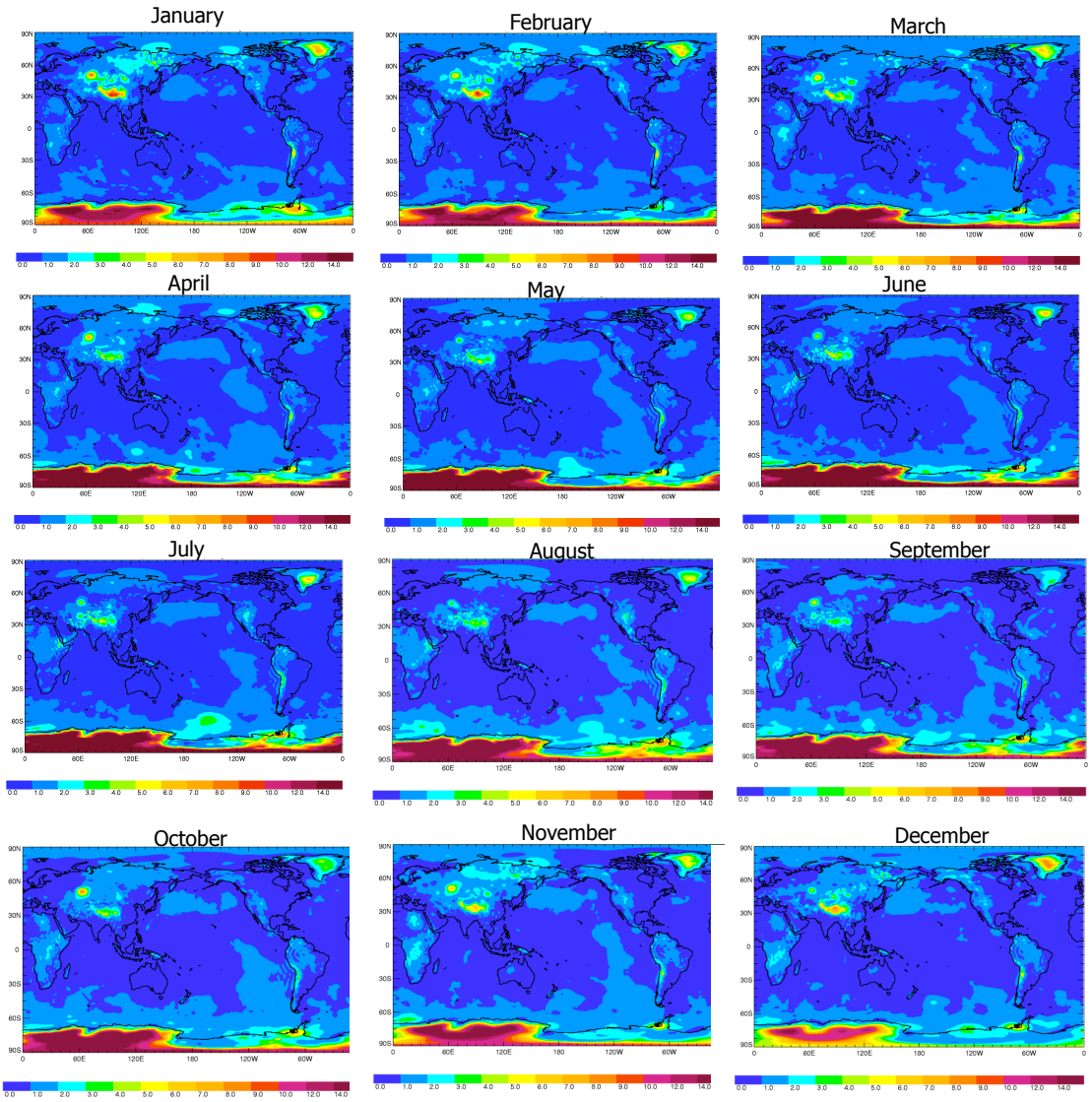
For the ECMWF analysis system, in use for the GRACE project, we assess the changing accuracy in terms of bias and root-mean-square errors in surface pressure, defined as differences from the surface observation set. (Here the OBS set is given as a ground truth, though it has errors of its own.) The bias and RMS between the ECMWF and OBS is given for 2001, 2002, and 2003; the last year, being entirely since the launch of GRACE, has somewhat smaller differences. Results of NCEP surface pressures are reasonably similar (not shown) though the differences from the OBS set were somewhat larger than those of ECMWF in the earlier two years. The bias of the analyses values relative to observations is typically positive over most areas.

Variance of difference between NCEP and ECMWF analyses, 2001-2003



The highest overall variability at all scales is above Antarctica, the high southern latitude oceans, Greenland, and the central Asian mountain regions. When separated into time scales, by an averaging-based analysis, we find that these same regions appear to be centers of variance at high and low pass bands. Over the southern oceans, the amount of variance at time scales longer and shorter than 60 days appears to be comparable.

Seasonal variation of NCEP and ECMWF differences (2003)



Above is a sample annual cycle, by calendar month, of the root-mean-square differences in surface pressure between the NCEP-NCAR and ECMWF series, taken for the year 2003. The areas of larger differences are in fact largest in the winter months of those hemispheres, with, for example, the differences over Central Asia and Greenland peaking in December-January-February, and those over the Antarctica and its surrounding seas largest in June-July-August.