Simple Ocean Data Assimilation (SODA) reanalysis: Beta23

Overview: The SODA reanalysis project, which began in the mid-1990s, is an ongoing effort to reconstruct historical ocean climate variability on space and time-scales similar to those captured by the atmospheric reanalysis projects (e.g. *Kalnay, et al., 1996*). Our guiding philosophy is to begin with an algorithmically straightforward approach, to identify the worst errors and address them WOF (worst one first). We currently think the worst errors are associated with time-mean and seasonally varying bias in the forecast model. Beta23 represents our latest and greatest moderate resolution renalaysis. A high resolution reanalysis, SODA1.2, should be available shortly.

Funding: Support for this project has been provided primarily by the National Science Foundation with additional help from the National Aeronautics and Space Administration and the National Oceanic and Atmospheric Administration (for which we are extremely grateful) through a series of individual grants to the participants.

Collaborators: This project has been made possible by loose affiliation of interested volunteers who have contributed in a variety of ways, most importantly in identifying problems with previous versions. The core of the effort remains at University of Maryland (Carton, Chepurin, Cao) and recently Texas A&M (Giese).

Evolution of algorithm: The algorithms explored in SODA are sequential estimation with empirically modeled error covariances. The basic algorithm is described in two papers (*Carton et al., 2000a,b*: see http://www.meto.umd.edu/~carton/carton/ref.html)[1]. We have recently implemented an improved two-stage bias correction algorithm (*Chepurin et al., 2004*; submitted, see http://www.atmos.umd.edu/~carton/bias). The latest release of the MOM2-based moderate resolution version is beta23, for which a brief description is provided below.

We are now exploring an eddy-permitting reanalysis based on the Parallel Ocean Program POP-1.4 model with 40 levels in the vertical and a 0.4x0.25 degree displaced pole grid (25 km resolution in the western North Atlantic). The first version of this we will release is SODA1.2, a reanalysis driven by ERA-40 winds covering the period 1958-2001 (extended to the current year using available altimetry).

Access: The beta23 release of the SODA ocean reanalysis (1950-2003 monthly) is available directly from us at: http://dods.atmos.umd.edu/SODA (our system administrators have disabled ftp). The data format is described below.

[1] (see also: Chepurin and Carton, 1999). (NOTE: These papers are based on our older version of lower resolution run which is global with 2.0x2.5 lat-lon horizontal resolution in midlatitude reducing to 0.5x2.5 resolution in the tropics for a total 96x146 horizontal grid points. The vertical resolution is the same 20 levels.)

Data Format:
Each file contains one year's = 12 monthly analyses (after unzipping & untarring). The first file begins with January, 1950 which duplicates with February, 1950; both are corresponding to February, 1950. Within each month the files include 4 (resolution: 360x128x20) arrays containing global temperature (degC), salinity (ppt), and horizontal velocity components (cm/s). In addition, the files contain 6 two dimensional arrays (360x128): wind stress components (Dyn./cm^2), diagnosed sea level (cm), depth of the 20C contour (determined by linear interpolation, m), and heat content 0-125m and 0-500m (degCm). The files are written in netcdf format and is broken down into yearly files for easy handling. The data format was chosen so that the files can be read using Grads software (see: http://www.grads.iges.org) or Ferret. Users on our system will be able to access this data from /data/ocean9/cao/SODA_beta23/. Other users may obtain this data through DODS or the LAS.

BETA23 methodology:

Data: The analysis relies on subsurface temperature and salinity from NODC WDB-01, additional CTD, ARGO, and XBT data from the GTSPP and other sources, thermistor temperature from the TAO and PIRATA arrays, in situ and satellite SSTs. Data are limited to the upper 1099.66m. Finally, satellite altimeter sea level from GEOSAT, ERS/1, ERS/2 and TOPEX/POSEIDON are obtained from the T/P Pathfinder website. Many references for these data sets are given in Carton et al. (2000a,b).

Since the data used in this analysis comes from data archives listed above, they are first subject to the archive quality control. We conduct additional quality control including checks for duplicate reports, errors in the recorded position and time of observations, static stability, deviation from climatology, and checks on the relationship between temperature and salinity. This eliminates 5% of the observations.

Model: The forecast model uses MOM2.b numerics with 1degx0.45degx20-level resolution in the tropics telescoping to a uniform 1degx1deg resolution in midlatitudes for a total 362x130 horizontal grid points. The domain extends from 70S-62N. 4. Surface fresh water flux and river discharges are added. Vertical resolution is 10m nearsurface. The analysis forecast model uses conventional choices for mixing, etc.

Surface forcing: Winds are provided by the NCEP/NCAR reanalysis (Kalnay et al., 1996) which have had their time-mean and RMS biases corrected by comparison with the daSilva version of COADS winds. A linear trend computed at each horizontal location has been removed to account for spurious trends in the NCEP/NCAR reanalysis winds. Rainfall is provided by the Xie-Arkin climatology, while evaporation is provided by

Error covariances: subsurface error covariances are multivariate, exploiting empirical estimates of temperature/salinity error covariances, flow-dependence, depth-dependence, and a suite of simple balances (hydrostatic, geostrophic, level-of-no-motion) that allow us to relate sea level errors to errors in temperature and salinity at depth. The zonal and

meridional correlation scales at the surface in the tropics, for example, are 450km and 250km, smoothly approaching a uniform 375km in midlatitudes. The scales decrease somewhat with depth. Errors within the mixed layer (whose depth is determined by a density-based criterion), in contrast, are assumed to be highly correlated vertically, with broad 850kmx650km horizontal scales (decreasing somewhat with latitude), but temperature and salinity errors are assumed to be uncorrelated.

Assimilation algorithm: The analysis uses a multivariate version of optimal interpolation in which the temperature, salinity and sea level fields are analyzed using statistical objective analysis. Analyses are produced every 10 days using a digital filter time-stepping routine (IUA) that reduces spurious gravity waves as well as the effects of forecast bias.

Questions:

If you have any questions, please e-mail Xianhe Cao at cao@atmos.umd.edu