

3.5.6 Global Geophysical Fluids Centre

The Global Geophysical Fluid Center (GGFC, <http://loading.u-strasbg.fr/GGFC>) of the International Earth Rotation and Reference Systems Service (IERS) provides the community with models of geodetic effects (Earth rotation, gravity and deformation) due to the temporal redistribution of the Earth geophysical fluids. These include fluid motions within the solid Earth (core and mantle) as well as motions at the Earth's surface (ocean, atmosphere and continental hydrology). The GGFC is composed of four operational entities: the Special Bureau for the Atmosphere (SBA, chair: D. Salstein), the Special Bureau for the Oceans (SBO, chair: R. Gross), the Special Bureau for Hydrology (SBH, chair: J.-L. Chen) and the Special Bureau for the Combination Products (SBCP, chair: T. van Dam). The Atmosphere, Hydrology and Ocean SBs have been firmly established since the creation of the GGFC in 1998. The operational Combination Products SB was established in 2009 to host new datasets that model the mass movement of combined environmental fluids such as atmosphere + ocean. There is finally a non-operational component of the GGFC, the GGFC Science and Support Products, serving as a repository for models and data used regularly in data processing, but that do not change often. The GGFC is still actively searching for a chair for this component. Since 2016, J.-P. Boy acts as the chair of GGFC, with T. van Dam as a co-chair.

Special Bureau for the Atmosphere

The Special Bureau for the Atmosphere (SBA) is concerned with the atmospheric information that is needed for a number of geodetic issues. The SBA was an outgrowth of the earlier Sub-bureau for Atmospheric Angular Momentum prior to the creation of the GGFC, and can be accessed at <http://www.aer.com/science-research/earth/earth-mass-and-rotation/special-bureau-atmosphere>.

Calculations of atmospheric angular momentum (AAM) are made from a number of global meteorological operational analyses and re-analyses, and are archived at the SBA. Long-term archives are at Atmospheric and Environmental Research in the file <http://files.aer.com/aerweb/AAM/>. It should be noted that these have different file names from previous versions, because the host institution changed from an ftp to a different server.

AAM from analyses and forecasts are updated daily at NOAA on <http://ftp.cpc.ncep.noaa.gov/long/aam/>. On-line readme files on these two sites are useful in documenting the data sets.

Operational atmospheric analyses are fields determined from observations during the epoch they are valid from the resident atmospheric analysis system in use at that time. Thus the systems, the main components of which are atmospheric forecast models and data assimilation

systems, have changed over the years. In contrast, atmospheric reanalysis systems use a constant analysis system to reprocess the historical atmospheric observational data. Thus the earlier periods are analyzed with a more advanced system than existed during their era, and the whole record of reanalysis is more suitable for long-term studies. The reanalyses were developed for consistent climate studies, and we use them here for long-term geodetic studies.

The AAM and related data are from the following large meteorological centers: US National Centers for Environmental Prediction, NCEP (formerly known as the National Meteorological Center); the Japan Meteorological Agency, JMA; the United Kingdom Meteorological Office, UKMO; and the European Center for Medium-Range Weather Forecasts (ECMWF). The ECMWF AAM is not updated daily in the on-line service but rather by links by our contributors, as noted below.

The SBA has on-line links from a number of contributors listed on the website; these include a number of atmospheric data related to surface loading, path delays, and gravity. The specialized ECMWF fields are accessed this way. Cooperating institutions are: the GeoForschungsZentrum, Potsdam, Germany; Vienna University of Technology, Austria; University of Luxembourg, Goddard Space Flight Center, University of Strasbourg, France, and the University of New Brunswick, Canada.

During 2018, the SBA fields of AAM were updated by Dr. Y. Zhou of the Shanghai Astronomical Observatory, China. These were for the full years of 2017 and 2018, as well as the early part of 2019.

Special Bureau for the Ocean

The oceans have a major impact on global geophysical processes of the Earth. Nontidal changes in oceanic currents and ocean-bottom pressure are a major source of polar motion excitation and also measurably change the length of the day. The changing mass distribution of the oceans causes the Earth's gravitational field to change and causes the center-of-mass of the oceans to change which in turn causes the center-of-mass of the solid Earth to change. The changing mass distribution of the oceans also changes the load on the oceanic crust, thereby affecting both the vertical and horizontal position of observing stations located near the oceans. As part of the IERS Global Geophysical Fluids Center, the Special Bureau for the Oceans (SBO) is responsible for collecting, calculating, analyzing, archiving, and distributing data relating to nontidal changes in oceanic processes affecting the Earth's rotation, deformation, gravitational field, and geocenter. The oceanic products available through the SBO website at <https://euler.jpl.nasa.gov/sbo> are produced primarily by general circulation models of the oceans that are operated by participating modeling groups and include oceanic angular momentum, center-of-mass, and bottom pressure. Through the SBO website, oceanic data can be downloaded and a bibliography of

publications pertaining to the effect of the oceans on the solid Earth can be obtained. Additional information about the SBO can be found in an unpublished manuscript available through the SBO Publications website at https://euler.jpl.nasa.gov/sbo/sbo_publications.html and in the SBO chapter of IERS Technical Note 30, Proceedings of the IERS Workshop on Combination Research and Global Geophysical Fluids.

During 2018, NASA mandated that all NASA Centers, including JPL, disallow the use of ftp to access web sites and download files. So during 2018, the SBO web site was re-written to remove access by ftp, replacing it with https. The SBO web site can now be accessed and files downloaded using either https (web interface) or curl and wget (command line interface).

Also during 2018, SBO products from the ECCO/JPL ocean model were updated. The kf080h data assimilating run of the ECCO/JPL ocean model was discontinued and replaced by a new run, kf080i, that assimilates the latest version of the altimetry data. Daily values of oceanic angular momentum, oceanic excitation functions, and oceanic center-of-mass from the kf079 (simulation) and kf080i (data assimilating) runs of the ECCO/JPL ocean model are now available from 02 January 1993 through 19 February 2019. These values can be extended back to 06 January 1949 using the corresponding values from a 50-year-long simulation run of the ECCO/JPL ocean model whose results are also available through the SBO website.

In addition, a link is provided to the ECCO/JPL website at <https://ecco.jpl.nasa.gov> from which grids of modeled ocean-bottom pressure can be obtained, a link is provided to the GGFC website at <http://geophy.uni.lu/ggfc-oceans/ECMWF-loading.html> from which grids of ocean loading determined from the ECCO/JPL modeled ocean-bottom pressure can be obtained, and a link is provided to the GLObal Undersea Pressure (GLOUP) data bank of ocean-bottom pressure observations at <http://www.ntsif.org/files/acclaimdata/gloup/gloup.html>. Finally, a link is provided to the GFZ Helmholtz Centre Potsdam's Effective Angular Momentum Functions (EAM) website at <https://isdc.gfz-potsdam.de/esmdata/eam> from which consistent estimates of atmospheric, oceanic, and hydrologic angular momentum can be obtained.

In addition to these data sets, a subroutine to compute oceanic angular momentum, center-of-mass, and bottom pressure from the output of general circulation models can be downloaded from the SBO website along with a bibliography of related articles.

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Special Bureau for Hydrology

The Special Bureau for Hydrology (<http://www.csr.utexas.edu/research/ggfc/>) provides access to data sets of terrestrial water storage (TWS) variations from major climate and land surface models and GRACE (Gravity Recovery and Climate Experiment) satellite gravity measurements. The web site contains TWS estimates from five numerical models, the NCEP (National Center for Environmental Prediction) reanalysis, the ECMWF (European Center for Medium Range Weather Forecasting) reanalysis, the CPC (Climate Prediction Center) Land Data Assimilation System (LDAS), the NASA's Global Land Data Assimilation System (GLDAS), and the NOAA LandWorld land dynamics model. Global gridded TWS changes estimated from GRACE time-variable gravity observations are also provided in our online data archive (at <http://www2.csr.utexas.edu/research/ggfc/dataresources.html>). The NASA GLDAS and GRACE data products are updated on a regular basis.

SBH also provides fully normalized gravity spherical harmonic coefficients (in the same definition as the GRACE products) up to degree and order 100, computed from the GLDAS-estimated TWS changes. This product offers the convenience for hydrologists who want to compare GRACE estimates and model predictions in a more consistent way by applying similar truncation and spatial filterings to both GRACE and model estimates. This data set is highly welcomed by the hydrological community.

In addition, TWS change estimates from historical GRACE release-01 and release-04 products are also provided in our online data archive (at <http://www2.csr.utexas.edu/research/ggfc/dataresources.html>). Some other data sets available in the SBH online data archive include daily hydrological excitations of polar motion and length-of-day computed from the NCEP/NCAR Reanalysis and the list of global major artificial reservoirs and their capacities. We have updated the monthly GLDAS TWS estimates to extend the coverage from January 2002 to September 2018. The new GRACE release-06 monthly TWS estimates with decorrelation and 300 km and 500 km Gaussian smoothing applied have been provided for the period April 2002 to August 2016 (the last 7 GRACE R06 solutions will be released by the GRACE team in early 2019).

Combinational Products

A complete list of the available combination products is provided below:

- UNB Vienna Mapping Function Service (<http://unb-vmf1.gge.unb.ca/Products.html>), M. Santos, University of New Brunswick, Canada.

- AAM analysis (and forecast) series from various atmospheric models (<http://files.aer.com/aerweb/AAM/>), D. Salstein, Atmospheric and Environmental Research, USA.
- Vienna Mapping Function Service, AAM analysis, Atmospheric loading and time-variable gravity (<http://ggosatm.hg.tuwien.ac.at/index.html>), J. Boehm & M. Schindelegger, Technical University of Vienna, Austria.
- Time-variable gravity field and AM from various hydrology models and from GRACE (<http://www.csr.utexas.edu/research/ggfc/>), J.-L. Chen, University of Texas at Austin, USA.
- Atmospheric (<http://vlbi.gsfc.nasa.gov/services/aplo/>), non-tidal oceanic (http://vlbi.gsfc.nasa.gov/services/ocean_load/) and hydrological (http://vlbi.gsfc.nasa.gov/services/hydro_load/) loading, D. MacMillan, NASA Goddard Space Flight Center, USA.
- Atmospheric, oceanic and hydrological loading, AM and time-variable gravity (<http://isdc.gfz-potsdam.de/esmdata/>), H. Dobslaw & R. Dill, GFZ, Potsdam, Germany.
- Atmospheric, oceanic and hydrological loading (<http://geophy.uni.lu/>), T. van Dam, University of Luxembourg, Luxembourg.
- Atmospheric, oceanic and hydrological loading and time-variable loading (<http://loading.u-strasbg.fr>), J.-P. Boy, EOST/IPGS, University of Strasbourg, France.

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