

3.5.6 Global Geophysical Fluids Center (GGFC)

The Global Geophysical Fluids Center (GGFC), a product center of the International Earth Rotation and Reference Systems Service, serves the worldwide research community, by providing information on the geodetic effects of fluid motions within and on the Earth. The products provided are estimates of the variations in the Earth's rotation, its shape, its gravitational field, and geocenter, (at various temporal and spatial scales) which are caused by the mass transport of geophysical fluids.

There are currently eight Special Bureaus (SB), which supply products in response to community requirements. These include: Atmospheres, Oceans, Hydrology, Tides, Mantle, Core, Loading, and Gravity/Geocenter (see attached reports). The various products generated by the SB's are based on global observations of surface fluid motion and/or state-of-the-art models, which estimate fluid motion within or on the surface of the Earth. The products are available through the individual SB web sites and can be accessed via the GGFC portal housed at the European Center for Geodynamics and Seismology (<<http://www.ecgs.lu/ggfc/>>).

In some SB's the yearly activity is high as new surface fluid models and data sets are constantly becoming available and are thus required by the geodetic research community. The annual activities of these SB's are included here in the annual report. In other SB's, the fluid models or data sets are well established and changes, if they occur, occur rarely and thus an annual report is not required. The annual report in this case, simply restates the model or data that are available from that particular SB. We find that it is still valuable to the community to have a single location where established and validated fluid models and their predicted effects on geodetic observables can be found.

In December 2006, the GGFC held a workshop in San Francisco to discuss the status of the GGFC and to evaluate if the format should be redesigned to better serve the geodetic community (see also Section 4 of this Annual Report). Numerous arguments for and against a redesign were discussed. In the end, the community and the GGFC chairs felt that we should consider a redesign in the long term. And in the short term, we should focus on validating and providing error assessments for the surface models and their geodetic effects. This is action represents the focus of the GGFC Special Bureaus for the coming years.

Tonie van Dam

Special Bureau for the Atmosphere

In conjunction with the U.S. National Oceanic and Atmospheric Administration (NOAA) the SBAtmosphere has produced data from several different operational meteorological centres. We have also produced data from atmospheric reanalyses, spanning back to 1948. SBAtmosphere organized a system to operate in two modes. In the first, it supplies the data in near-real time through the services at NOAA, including analysis and forecast terms. That mode is under the direction of Craig Long of NOAA, since November 2006. In the second mode, it updates monthly archives of the data on the FTP server at Atmospheric and Environmental Research, Inc. (AER).

The principal data prepared relate to atmospheric excitations of the Earth rotation vector, as forced by changes in the winds and surface pressure of the atmosphere, known respectively as the motion and mass terms of the atmospheric angular momentum AAM. For the axial component, related to length-of-day, the stronger term is the motion one, and for the equatorial term, related to polar motion, the mass term generally dominates. An “inverted barometer” correction is produced to the mass terms, designed to model an equilibrium condition of the oceans in which the ocean depresses in response to a higher atmospheric pressure and rises in response to a lower one.

SBAtmosphere also computes the AAM terms locally, in a number of equal-area sectors distributed around the globe, as well as globally. In addition, SBAtmosphere computes the mean atmospheric surface pressure over the globe, and various spherical harmonics, which are related to the Stokes coefficients of the Earth gravity field, of particular interest to recent space-gravity missions. SBAtmosphere archives torques from the NCEP-NCAR reanalyses that relate to the angular momentum transfer from atmosphere to solid Earth, including topographic (mountain), friction, and gravity wave drag torques. Users log in to our ftp sites to obtain the desired information.

Dr. Yonghong Zhou has been processing the atmospheric data from his position at Shanghai Astronomical Observatory to help update the SBA archives. He processes both the NCEP-NCAR reanalyses using the revised codes that were developed while he was a visitor at Atmospheric and Environmental Research. The new procedure and related scientific results are detailed in Zhou et al. (2006). The revised procedure has improved on the treatment of the lower boundary and also updated a number of geophysical constants needed to calculate the atmospheric excitations.

During 2006 we continued investigations of using atmospheric models for more rapid subdiurnal scales. Fields from one of the NASA models can be extracted hourly, in between the six-hour analyses that are routinely used. We have been investigating the feasibility of calculations of the atmospheric excitation terms for

the Earth orientation parameters. A test period was October 2002, during the special CONT'02 campaign in which measurements from Very Long Baseline Interferometry developed high temporal resolution data. Various issues involved the discontinuities at the 6-hour marks when analyses were made, and we established techniques to lessen these discontinuities. Also, we are now awaiting results from a new analysis in which a smoother signal, not subject to such discontinuities, is expected.

Dr. Katherine Quinn has been assisting in some analyses and the preparation of some new data sets, including Earth rotation/polar motion excitations from the ECMWF 40-year reanalysis (ERA-10) and a new set of NCEP reanalyses (called the NCEP-2 reanalyses).

Also during the year, Dr. Jolanta Nastula of the Space Research Center of the Polish Academy of Sciences, Warsaw, visited AER for the purpose of calculations of regional fields of the Earth orientation parameter excitation fields to help understand better the atmospheric excitations of polar motion.

Results of the SBA were presented at the European Geosciences Union meeting, the American Geophysical Union meeting, and a special workshop of the IERS Global Geophysical Fluids Center.

Analyses and forecasts are being provided to the campaign for prediction of Earth orientation parameters.

Reference Zhou Y. H., D. A. Salstein, J. L. Chen (2006), Revised atmospheric excitation function series related to Earth's variable rotation under consideration of surface topography, *J. Geophys. Res.*, 111, D12108, doi:10.1029/2005JD006608.

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David Salstein

Special Bureau for the Oceans

Introduction

The oceans have a major impact on global geophysical processes of the Earth. Nontidal changes in oceanic currents and ocean-bottom pressure have been shown to be 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

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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 IERS SBO web site at <<http://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.

Data Products

Five different oceanic angular momentum series are currently available from the IERS Special Bureau for the Oceans:

- (1) *ponte98.oam*, a series computed by Ponte *et al.* (1998) and Ponte and Stammer (1999, 2000) from the products of a simulation run of the MIT ocean general circulation model which spans January 1985 to April 1996 at 5-day intervals;
- (2) *johnson01.oam*, a series computed by Johnson *et al.* (1999) from the products of version 4B of the Parallel Ocean Climate Model (POCM) which spans January 1988 to December 1997 at 3-day intervals;
- (3) *c20010701.oam* & *c20010701.chi*, a series computed by Gross *et al.* (2003, 2004) from the products of a simulation of the oceans' general circulation run by the Estimating the Circulation and Climate of the Ocean (ECCO) group at JPL which spans January 1980 to March 2002 at daily intervals and which is available either as a series of angular momentum values (*c20010701.oam*) or as a series of effective excitation functions (*c20010701.chi*);
- (4) *ECCO_50yr.oam* & *ECCO_50yr.chi*, a series computed by Gross *et al.* (2005) from the products of a simulation of the oceans' general circulation run by the ECCO group at JPL which spans January 1949 to December 2002 at 10-day intervals and which is available either as a series of angular momentum values (*ECCO_50yr.oam*) or as a series of effective excitation functions (*ECCO_50yr.chi*); and
- (5) *ECCO_kf049f.oam*, *ECCO_kf049f_6hr.oam*, & *ECCO_kf049f_6hr.chi*, a series computed by Gross *et al.* (2005) from the products of a data assimilating model of the oceans' general circulation run by the ECCO group at JPL which spans January 1993 through March 2006 at both 6-hour and daily intervals and which is available either as a series of angular momentum values (*ECCO_kf049f.oam* & *ECCO_kf049f_6hr.oam*) or as a series of effective excitation functions (*ECCO_kf049f_6hr.chi*).

Five different oceanic center-of-mass series are also currently available from the IERS Special Bureau for the Oceans:

- (1) `dong97_mom.cm`, a series computed by Dong *et al.* (1997) from the results of a version of the Modular Ocean Model (MOM) run at JPL which spans February 1992 to December 1994 at 3-day intervals;
- (2) `dong97_micom.cm`, a series also computed by Dong *et al.* (1997) from the results of running the Miami Isopycnic Coordinate Ocean Model (MICOM) at JPL which also spans February 1992 to December 1994 at 3-day intervals;
- (3) `c20010701.cm`, a series computed by Gross (personal communication, 2003) from the results of a simulation run of the ECCO ocean model done at JPL which spans January 1980 to March 2002 at daily intervals;
- (4) `ECCO_50yr.cm`, a series computed by Gross (personal communication, 2004) from the products of a simulation of the oceans' general circulation run by the ECCO group at JPL which spans January 1949 to December 2002 at 10-day intervals; and
- (5) `ECCO_kf049f.cm`, a series computed by Gross (personal communication, 2004) from the products of a data assimilating model of the oceans' general circulation run by the ECCO group at JPL which spans January 1993 through March 2006 at daily intervals.

Time series of the ocean-bottom pressure are currently available from the IERS SBO through a link to the JPL ECCO web site at <http://ecco.jpl.nasa.gov/external> from which two dimensional ocean-bottom pressure fields can be obtained that have been produced from purely surface flux-forced ocean models as well as ocean models that additionally assimilate satellite and in situ data. A link is also provided to the GLObal Undersea Pressure (GLOUP) data bank of ocean-bottom pressure measurements at <http://www.pol.ac.uk/psmslh/gloup/gloup.html>.

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 IERS SBO web site along with a bibliography of related articles.

Acknowledgments

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Richard Gross

Special Bureau for Tides

There were only a few minor activities to report regarding the Special Bureau for Tides. Some additional tables of tidal Earth rotation parameters were added based on some newly developed tidal models. Our Tide Prediction Machine was unfortunately disabled because of security risks; there were two users who reported being impacted by this – in both cases they were oceanographers using the machine for standard sea level tide predictions.

Richard Ray

Special Bureau for Hydrology

The Special Bureau for Hydrology provides internet access to data sets of water storage load variations for major land areas of the world. The web site contains results 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 LaDWorld land dynamics model. Global terrestrial water storage changes estimated from GRACE (Gravity Recovery and Climate Experiment) time variable gravity observations during the period April 2002 and November 2005 are also provided in our online data archive (at <http://www.csr.utexas.edu/research/ggfc/>). The NASA GLDAS and CPC LDAS data products are updated on a regular basis.

As a new addition to our online data archive, LaDWorld is global land dynamics model developed by scientists at the NOAA Geophysical Fluid Dynamics Laboratory. Simulated variables include snow water equivalent, soil water, shallow ground water, soil temperature, evapotranspiration, runoff and streamflow, radiation, and sensible and latent heat fluxes. This particular simulation (named Fraser and released in March 2007), differs from previous runs in the temporal extent of the simulation, which runs through November 2006. Additionally, the initial condition is one that is better equilibrated with climatic forcing. The improved initial condition removed a minor spin-up issue that had affected earlier LaDWorlds. Details of the LaDWorld models are available online at <<http://www.gfdl.noaa.gov/~pcm/project/ladworld.htm>>.

GLDAS is an advanced land surface modeling system jointly developed by scientists at the NASA Goddard Space Flight Center (GSFC) and the NOAA NCEP. GLDAS parameterizes, forces, and constrains sophisticated land surface models with ground and satellite products with the goal of estimating land surface states (e.g., soil moisture and temperature) and fluxes (e.g., evapotranspiration). In this particular simulation, GLDAS drove the Noah land surface model version 2.7.1, with observed precipitation and solar radiation included as inputs. GLDAS estimates are the sum of soil moisture (2 m column depth) and snow water equivalent. Greenland and Antarctica are excluded because the Noah model does not include ice sheet physics. The GLDAS data are provided on $1^\circ \times 1^\circ$ grids and at 3-hourly intervals. Daily average terrestrial water storage is computed from the 3-hourly model estimates. Antarctica is not included in the model and estimates over Greenland are not recommended to use, because of the lack of ice dynamics in the model.

The NCEP reanalysis model is a fixed data-assimilating global numerical model, designed mainly for atmospheric studies. It has been run for a period starting in 1948, up to the present. NCEP results are valuable for their global coverage and long duration. The hydrologic part of this model is mainly employed as a lower boundary condition in the model, and reflects a combination of an imposed (non data-assimilating) hydrologic cycle, and interaction with the atmosphere. The NCEP reanalysis variations are probably representative of the real Earth, but not accurate in detail. They lack the level of inter-annual variability expected in the real hydrologic cycle, and observed in some more sophisticated data-assimilating land surface model results. In addition, there are evident flaws over Antarctica and Greenland, which probably result from locating highly variable sea ice at land grid points. Therefore Antarctica and Greenland are excluded from geodetic calculations. The web site includes daily NCEP water storage in Gaussian grid (T62) form for Jan. 1979 – Dec. 2004, and polar motion and length of day excitation time series for Jan. 1948 – Dec. 2004, as well.

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The ECMWF data-assimilating reanalysis model, similar to NCEP, also with a surface hydrologic cycle. We find that it appears more realistic than NCEP, showing greater interannual variability. In addition, its seasonal cycle resembles long-term average results based on local budget (Precipitation-Evaporation-Runoff) calculations. The web site includes 2.5-degree gridded values at daily intervals for the period 1979–1993.

CPC LDAS is forced by observed precipitation, derived from CPC daily and hourly precipitation analyses, downward solar and long-wave radiation, surface pressure, humidity, 2-m temperature and horizontal wind speed from NCEP reanalysis. The output consists of soil temperature and soil moisture in four layers below the ground. At the surface, it includes all components affecting energy and water mass balance, including snow cover, depth, and albedo. Monthly averaged soil water storage changes are provided on a 1 x 1 degree grid. These data are averaged from the original 0.5 x 0.5 degree grid and converted into NetCDF and standard ASCII format. The data cover the period Jan. 1980 through Dec. 2005. No estimate is provided over Antarctica. A README file and a few Matlab scripts used for doing the conversion are provided as a reference to the data format.

The README file with the NCEP and ECMWF data also includes details on the way in which actual loads are calculated from the soil moisture model field. Data are available in both ascii and NetCDF (.nc) formats. In addition, there are helpful sample Matlab commands lists and m-files for reading the data in NetCDF format with Matlab, and for interpolating from the original model grid to a uniform (for example 1 x 1 degree) grid.

We provide estimates of equivalent surface water storage using GRACE time variable gravity observations provided by the GRACE team at the Center for Space Research (CSR), University of Texas at Austin. 22 monthly, unconstrained GRACE solutions (RL01) covering the period April 2002 and July 2004 are used to estimate global surface mass change on a 1 x 1 degree grid. Results with 3 different spatial Gaussian smoothing scales, 600 km, 800 km, and 1000 km are provided. The GRACE spherical harmonics are truncated at degree and order 60, and the C20 term is not included. A newly added similar product is the equivalent surface water storage change derived from 3.5 years of GRACE RL01 constrained solutions provided by CSR. This new product is from 40 GRACE monthly solutions covering the period April 2002 and November 2005.

Table 1 summarizes the current datasets in our online data archive (<<http://www.csr.utexas.edu/research/ggfc/>>).

Jianli Chen

Table 1: GGFC SBH Online Data Archive

Parameters	Sources	Information
Water Storage Change From GRACE	GRACE (Gravity Recovery And Climate Experiment)	Time Span: Apr/May 2002 - Nov 2005 Sampling Rate: Monthly, 40 Solutions CSR RL01 Constrained (k20) Grid: 1 x 1 Degree Grid Gaussian Smoothing: 500, 800, 1000 km Truncation at degree 60, No C20
Water Storage Change From GRACE	GRACE (Gravity Recovery And Climate Experiment)	Time Span: Apr/May 2002 - Jul 2004 Sampling Rate: Monthly, 22 Solutions CSR RL01 Unconstrained Grid: 1 x 1 Degree Grid Gaussian Smoothing: 600, 800, 1000 km Truncation at degree 60, No C20
NOAA LaDWorld Monthly Water Storage (New!)	NOAA LaDWorld (Fraser)	Time Span: Jan., 1980 - Nov., 2006 Sampling Rate: Monthly Grid: 1 x 1 Degree Units: mm of water height
GLDAS Daily Water Storage	NASA Global Land Data Assimilation System	Time Span: Jan. 1, 2002 - April 30, 2006 Sampling Rate: Daily Grid: 1 x 1 Degree Units: mm of water height
CPC Monthly Water Storage	CPC Land Data Assimilation System	Time Span: Jan. 1980 - Dec. 2006 Sampling Rate: Monthly Grid: 1 x 1 Degree
NCEP Daily Water Storage	NCEP/NCAR Reanalysis-I Soil Moisture and Snow	Time Span: Jan. 1979 - Dec. 2004 Sampling Rate: Daily Grid: Gaussian (T62), ~1.904 x 1.875 Degree
ECMWF Daily Water Storage	ECMWF Reanalysis Soil Moisture and Snow	Time Span: 1979 - 1993 Sampling Rate: Daily Grid: 2.5 x 2.5 Degree
Water Storage	NCEP/NCAR Climate Data Assimilation System I (CDAS-1) soil moisture and snow	Time Span: 1993 - 1998 Sampling Rate: Monthly Grid: 1 x 1 degree
Water Flux	NCEP/NCAR Climate Data Assimilation System I (CDAS-1) soil moisture and snow	Time Span: 1993 - 1998 Sampling Rate: Monthly Grid: 1 x 1 degree

Special Bureau for Mantle No report submitted.

Special Bureau for the Core
Introduction

Flow in the fluid outer core and motion of the inner core with respect to the outer core can result in various geodetic phenomena observable from the Earth's surface or space. These phenomena include variations in the Earth's rotation and orientation, surface gravity changes, geocenter variations, and surface deformations. Although small, these variations can or could be observed by very precise space geodetic techniques. Observation of these effects yields unique insight into the core, which cannot be observed directly, and the resulting better understanding of the core will lead to improved models and predictions for the geodetic quantities.

Activities The Special Bureau for the Core is responsible for collecting, archiving, and distributing data related to the core and plays a role in promoting and coordinating research on this topic. In particular, the SBC focuses on theoretical modelling and observations related to core structure and dynamics (including the geodynamo), and on inner core – outer core – mantle interactions. The SBC has about twenty members from the fields of geomagnetism, Earth rotation, geodynamo modelling (numerical and experimental), and gravimetry. The SBC has set up a web site (www.astro.oma.be/SBC/main.html) as the central mechanism for providing services to the geophysical community. Since one of the goals of the SBC is to distribute general information on the core, to make the geophysical community aware of the various geodetic effects that could be linked with the core, and to stimulate, support and facilitate core research, we present on our website concise explanations on topics as core convection, core flow, geomagnetism, core-mantle boundary torques, inner core differential rotation, Earth's rotation changes due to the core, and core composition. Additionally, we have built and continuously update a bibliography of articles relevant to the core that at present contains more than a thousand references.

Data products The web site presently contains model data on core flow and core angular momentum. Most data are based on the observed surface geomagnetism field, and various hypotheses and physical assumptions are used to determine the flow and the angular momentum of the core. Moreover, a high-resolution time series is given that is determined by subtracting computed atmospheric angular momentum series from a time series for length-of-day variations. In addition to the data, a description is given of the relevant theories and of the dynamical assumptions used for constructing the flows.

Tim Van Hoolst

Special Bureau for Gravity/Geocenter

In 2006, the Special Bureau for Gravity and Geocenter continued nominal operations, functioning primarily as a portal for obtaining GRACE and SLR gravity solutions which are generally produced by groups external to the SB. We received a record number of web hits in 2006, due primarily to the increasing interest in GRACE data. SBGG personnel also participated in the development of a separate website that provides high-level data products from GRACE, and we have discussed the possibility of merging these or other related sites at some point in the future. This will continue to be studied in the upcoming year as we monitor the user requests.

In addition, SBGG personnel continued to participate very significantly in the development of dealiasing products for GRACE. These products primarily include daily atmospheric and ocean mass dis-

tribution models, and often have significant overlap with the interests and motives of the other SB's. We therefore maintain at least annual communication with these SB's about the status and capability of these products for comparison and validation as needed. We expect this may become a larger job as more users migrate to the project data centers for the access of the routine gravity solutions.

Michael M. Watkins

Special Bureau for Loading

Introduction

The solid Earth is constantly impacted by loads due to mass relocations in the atmosphere, oceans, cryosphere and terrestrial water storage. These loads deform the Earth, change the gravity field and introduce perturbations in Earth's rotation. Mass redistributions occur on a wide range of time scales including those of tsunamis (minutes to hours), tides (semi-diurnal, diurnal, fortnightly, monthly, and seasonal), meteorological (several days) and climatological changes (seasonal to multi-decadal), and changes in the ice cover (years to millenniums). These deformation, if not account for correctly, affect the geodetic terrestrial reference frame and can lead to a significant degradation in accuracy. Loading signals in the vertical component significantly exceed the 10 mm level at diurnal and seasonal time scales, while secular signals associated with postglacial rebound are on the level of 10 mm/yr. Surface displacements induced by seasonal exchanges between ocean and terrestrial hydrosphere are of the order of 10 mm. Thus, achieving a reference frame with sub-millimeter accuracy requires accurate modeling of the loading signals both for station motion models and the alignment of geodetic solutions to the *International Terrestrial Reference Frame (ITRF)*. It is the task of the *Special Bureau for Loading (SBL)* to provide predictions of the loading signals for research as well as operational space-geodetic analyses.

SBL goals and contributions

The SBL, which was established in 2002 in response to an expressed need for standardized loading predictions, is part of the IERS Global Geophysical Fluid Center. It has the goal to provide predictions of surface-load induced changes in the Earth's geometry, gravity field and rotation. The initial goal of the SBL was the provision of predictions of changes in Earth's geometry induced by atmospheric loading, preferably in near-real time. In 2003, time series of predicted station displacements due to atmospheric loading were made available for the stations in the main global and regional geodetic networks. These predictions (denoted as Research Products) are available for different atmospheric pressure data sets, Earth models, and computational approaches (see Van Dam et al., 2003, for more details) and they are intended mainly for research. In 2004, the semi-operational near-real time provision of station dis-

placement as well as global grids was started. These products (denoted as Operational Products) are made available for air pressure provided by the *European Center for Medium Range Weather Forecast* (ECMWF), only (see <http://www.sbl.statkart.no/products> for more information on these products).

Atmospheric loading

In 2006, the main focus was on the error budget of the atmospheric loading computation. The goal of the SBL is to achieve predictions with an accuracy of the daily displacements of better than 1 mm in all three coordinate components. Main contributions to the error budget come from differences in the meteorological data sets themselves, miss-modeling of the topographic effect, and miss-modeling of the ocean response to atmospheric pressure and wind forcing. The reference pressure field used to compute the pressure anomaly also needs considerable attention in order to avoid a significant deformation of the ITRF reference polyhedron.

During 2006, progress was made in accurately modeling the effect of Earth's topography on the air pressure anomaly. The long-period variations in air pressure were studied in order to inform a decision on what reference pressure field to use in an ITRF context.

For the prediction of the atmospheric loading signal, the air pressure anomaly is required at a model of the Earth's surface topography with sufficient spatial resolution. The question what spatial resolution would be sufficient is not trivial. In the meteorological models, the Earth's surface is represented by a model orography, typically given with a resolution of one or more degrees. The pressure field at this model orography does not have sufficient spatial resolution to achieve the target accuracy. After some iterations with meteorological institutions (see Plag, 2007, for a summary), an appropriate process of computing pressure at topographic height was found to be based on geopotential heights of isobars. The geopotential heights of isobars are model parameters, which are provided by the meteorological centers for a number of pressure levels on a routine basis. With spatial interpolation (both horizontally and vertically), pressure at topographic height can be computed in a straightforward procedure (see Plag et al., 2007, for details).

In order to quantify the long-term variations in air pressure, decadal averages of the surface pressure fields at topographic height were computed. The topographic heights were taken from the ETOPO5 model (<http://www.ngdc.noaa.gov/mgg/global/etopo5.HTML>) and all computations were done with 5 minutes spatial resolution. The geopotential heights were taken from the ECMWF reanalysis data set (ERA 40, http://data.ecmwf.int/data/d/era40_daily/), and these data allowed for the computation of four decadal averages. These decadal averages are available through the SBL web page. Variations from decade to decade are of the order of up to ± 3 hPa, which

translates into a maximum of ± 1.5 mm in deformations. The largest interdecadal trends over the full 40 years are of the order of ± 6 hPa with the maximum found mainly over the ocean off Antarctica. As a result of these studies, it is concluded that for a given meteorological data set, a reference pressure field can be computed as a decadal average. However, recent comparisons show that differences in mean pressure at topographic height for different meteorological data sets exceed the acceptable limit by far. Therefore, reference pressure fields have to be determined specifically for each data set. An issue still to be studied is how frequent changes in the meteorological models affect the mean pressure field.

Perspective

The computation of the surface pressure anomaly for loading predictions has to use pressure at topographic height, where a spatial resolution of 5 minutes appears to be sufficient. An appropriate procedure for the computation of pressure at topographic height can be based on geopotential heights of isobars. The reference pressure field has to be computed specifically for each meteorological data set in order to keep biases in the loading predictions below the 1 mm level. Based on these criteria, the SBL will recompute all operational products.

Open questions are the impact of temporal inhomogeneities in the meteorological models on the loading predictions, the error associated with the current approach to modeling the ocean response to atmospheric loading, and the spatial resolution required for the computation of loading signal from the (high-resolution) air pressure anomaly. These questions have been addressed in 2007 and will be further resolved in 2008.

Acknowledgment

The SBL web page is hosted by the Norwegian Mapping and Catastre Authority (NMCA), Hoenefoss, Norway, which also provides the resources for the provision of the operational products. The operational products are under the responsibility of Halfdan P. Kierulf at the NMCA. The author would like to thank NMCA and Halfdan Kierulf for their continuous support of the SBL activities. The SBL research at the Nevada Bureau of Mines and Geology, University of Reno, Nevada, was supported by several NASA projects in the ROSES-Earth Surface and Interior program.

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Available at <<http://www.bipm.org/en/events/iers/papers.html>>.

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Hans-Peter Plag