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Cox and Chao [2002] reported the detection of a large anomaly in the form of a positive "jump" in the time series of Earth's lowest-degree gravity harmonic J2, or the dynamic oblateness, during 1998. In this paper we identify strong evidences that point to a likely major cause for this J2 anomaly–a seesaw of the sea-surface height (SSH) in the extratropic north + south Pacific basins. Referred to here as the ExtraTropic Pacific Seesaw (ETPS), it is the leading (nonseasonal) EOF/PC mode in SSH, that we solved from the 10-year TOPEX/Poseidon altimetry data in the extratropic Pacific region. The mode underwent a step-like jump with magnitude and time evolution that match remarkably well with the observed J2 anomaly, assuming that most of the SSH jump was mass-induced and that the steric effect only played a secondary role in this particular seesaw event. In addition, for the steric effect we analyze the leading EOF/PC mode of the sea-surface temperature (SST) in the same region; the result corroborates the above assertion. The behavior of ETPS appears to be part of the Pacific Decadal Oscillation, which shows some level of long-term correlation with the observed J2 series. This study exemplifies an interdisciplinary endeavor where a geophysical observation made by space geodesy leads to insights about certain climatic phenomenon; further studies are needed to help piece together a more complete story.

G11A-09 1050h

An Investigation of Recent Observed Changes in the Earths Oblateness

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Large changes in the Earths oblateness beginning in 1998 have recently been detected using Satellite Laser Ranging (SLR). These changes are consistent with mass moving from the higher latitudes into the equatorial region, and are the largest such changes observed since SLR started tracking the phenomena in the late 1970s. We have conducted a comprehensive investigation into the source of these changes. We have compared SLR results from several different research groups, and concluded there is no problem with the data analysis. We have considered a variety of possible geophysical sources including tide modeling errors, atmospheric mass redistribution, and ocean mass redistribution. Of these, the ocean appears to be the most likely source of the observed oblateness changes. Specifically, the changes appear to be concentrated in the Pacific Ocean. The observed oblateness variations are highly correlated with the Pacific Decadal Oscillation (PDO). We investigated the mass variations in the oceans using two different sources: 1) the ECCO ocean model, and 2) TOPEX/Poseidon sea level measurements corrected for steric sea level change using sub-surface temperature observations. These results explain a significant fraction of the observed oblateness changes, but are somewhat smaller in magnitude. Detailed results from these calculations will be presented.

G11A-10 1105h

Variations in the Earth's Gravitational Potential Caused by Pressure Changes at the Core-Mantle Boundary

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The elliptical part of Earth's gravitational potential field (J_2) varies with time. The main cause of the variations is the redistribution of mass in the ocean-atmosphere-cryosphere system, which produces a seasonal signal. Once this signal is subtracted from the data, there remains a slow linear drift, which can be accounted for by postglacial rebound. However, recent observations suggest that a considerable departure from this linear trend has occurred since 1998. The change in the trend is difficult to reconcile with the slow process of postglacial rebound and therefore suggests the presence of at least one additional physical mechanism that participates in the temporal changes of J_2.

One plausible agent for the variations in J_2 is the flow in the Earth's core. A geomagnetic jerk has been observed at the time of the trend shift, which indicates a possible correlation between the flow in the core and changes in J_2. Furthermore, a recent study showed that geomagnetic jerks are well explained by simple flow models in the core which consists of rigid azimuthal oscillations of co-axial cylindrical shells. Such a flow produces equatorially symmetric variations in the pressure field at the core-mantle boundary (CMB), which create small radial deformations of the fluid-solid interface and lead to changes in J_2. In this work we investigate the amplitude and the variations in J_2 that are produced in this manner. We show that the same flow that explains the magnetic jerks can also explain some of the changes in J_2.

G11A-11 1120h

Local Sea Level Fingerprinting of Glacier Mass Balance

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Recent research has demonstrated that melting of individual ice reservoirs produces a distinct signature, or 'fingerprint', in the accompanying global sea level record [Mitrovica et al., 2001; Plag and Juttner, 2001]. These fingerprints, in combination with suitably robust and geographically distributed observational constraints, provide a method for estimating the individual sources of present-day global sea-level rise. In our previous work, we examined the mass balance of the Antarctic and Greenland ice sheets using secular sea-level rates obtained from a subset of the available tide gauge data base. In this talk we focus on the regionally localized patterns of sea-level change associated with melting of mountain glacier complexes. In this case, significant melting (or growth) of the glacier produces a region of rather dramatic sea level fall (or rise) surrounding the glacier, and thus sea-level records close to the complex will be a highly sensitive indicator of ice mass flux and dynamics. As an illustration, we show predictions of the impact on tide gauge and sea-surface levels of a rapid melting event recently inferred for the Alaskan/British Columbian glacier system [Arendt et al., 2002].

G11A-12 1135h

Seasonal Re-distribution of Atmospheric Mass on Mars Detected From Radio Tracking of Mars Global Surveyor

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Space geodetic techniques pioneered for application to Earth dynamics are now achieving a level of accuracy that enable analog studies of the terrestrial planets. Using X-band radio tracking of the Mars Global Surveyor spacecraft, we have measured temporal changes the long-wavelength gravity field of Mars that correlate, to first order, with the pattern expected due to the seasonal re-distribution of carbon dioxide between the atmosphere and surface. Detecting these gravity field changes requires isolating perturbations in the velocity of the MGS spacecraft of $\sim 5\ \mu s^{-1}$. A comparison of very low degree gravity coefficients determined every 5 days shows an annual variation in the relative position of Mars' center-of-mass ($C_{1,0}$ spherical harmonic gravity coefficient) is 4% smaller in amplitude and 21° different in phase compared to the signal predicted by a simulation of CO_2 exchange over a typical Mars year by the Ames General Circulation Model (GCM). The temporal change in the planetary flattening ($C_{2,0}$ spherical harmonic coefficient) displays both annual and semi-annual components that are more complex than predicted by the GCM. These temporal gravity measurements can be used as a proxy for the global re-distribution of CO_2 and can be related to the mean global atmospheric pressure. Results for the MGS mapping mission are generally consistent with but more complex than predicted by the GCM and may provide a measure of the stochastic variability of the seasonal process of volatile exchange.

G12A MCC: Hall C Monday 1330h

Geodesy at the Solid-Fluid Interface II Posters *(joint with A, H, OS)*

Presiding: **R S Gross,** Jet Propulsion Laboratory**;** **C R Wilson,** University of Texas at Austin

G12A-1043 1330h INVITED POSTER

The Global Geophysical Fluids Center of IERS (and its Special Bureau for Mantle)

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The Global Geophysical Fluids Center (GGFC) was established by the International Earth Rotation Service (IERS) on IERS's 10th anniversary day January 1, 1998, in an effort to expand IERS's services to the scientific community. Under the GGFC, eight Special Bureaus (SB) have been selected, each to be responsible for research and data service activities pertaining to mass transports and related geophysical processes in specific components of the Earth system, or "global geophysical fluids," including the atmosphere, oceans, solid Earth, core, and geophysical processes of gravity, loading, tides and hydrological cycles. GGFC and the SBs have the responsibility of supporting, facilitating, and providing services to the worldwide research community, in areas related to the variations in Earth rotation, gravity field and geocenter that are caused by mass transport in the global geophysical fluids. These minute variations have been observed by various space geodetic techniques, as effective remote sensing tools, with ever increasing precision/accuracy and temporal/spatial resolution. The GGFC and SBs have organized dedicated workshops and special sessions at international conferences, published articles, and held regular business meetings. The SBs maintain individual website for data services and information exchanges. See URL bowie.gsfc.nasa.gov/ggfc/. In particular, the SB for Mantle focuses on large-scale mass redistributions that occur in the mantle in association with various dynamic processes, including seismic activities, the post-glacial rebound, and mantle convections.

G12A-1044 1330h INVITED POSTER

Activities of the Special Bureau for the Atmosphere of the IERS

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As a component of the Global Geophysical Fluids Center of the International Earth Rotation Service, we collect, archive, make available, and advise on atmospheric information related to global geodetic studies. Due to exchanges of angular momentum between solid Earth and atmosphere, records of atmospheric angular momentum possess most of the variance in that of the solid Earth on timescales between several days and years. Thus the axial and equatorial components of Earth momentum related to length of day and polar motion, respectively, are strongly tied to the signature of winds and atmospheric mass. We have records up to several times per day from several of the worlds large weather centers in which we have studied the angular momentum covering over 99 percent of atmospheric mass. When angular momentum from such a domain is considered, it captures many of the climate related signatures associated with intraseasonal and interannual variability, such as Madden-Julian oscillations, the El Nino/Southern Oscillation, and the North Atlantic Oscillation. Such angular momentum associations also exist at very high (daily and subdaily) and very low (decadal and longer) frequencies. Models of the atmosphere also reproduce the signatures necessary to determine the angular momentum, though less perfectly. The torques that dynamically relate the atmosphere to the Earth through its lower interface, including transfer through the ocean, are of interest as well in this regard; normal forces of atmospheric pressure against sloping topography and tangential forces of winds against the surface are involved here. Other geodetic signals that may originate in or be related to the atmosphere are those of global gravity and the geocenter, and the atmospheric mass field is used to study such signals. Some recent atmospheric analyses are produced to high resolutions, some with spherical harmonics greater than degree 200, and so can be useful in the interpretation of gravity information derived from new and planned satellite missions, like GRACE. Atmospheric signals are also related to the loading of the Earth, and the Special Bureau for the Atmosphere works with the IERS Special Bureau for Loading to interpret related signatures of atmospheric surface pressures.

URL: http://www.aer.com/groups/diag/sb.html

G12A-1045 1330h INVITED POSTER

The IERS Special Bureau for the Oceans

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The oceans have a major impact on global geophysical processes of the Earth. Nontidal changes in oceanic currents and bottom pressure have been shown to be a major source of polar motion excitation and also measurably change the length of the day. Changes in the mass distribution of the oceans cause the Earth's gravitational field to change, an effect which is being accurately measured by the CHAMP and GRACE satellite missions. As the mass distribution of the oceans change, the center-of-mass of the oceans will 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. Recognizing the important role that nontidal oceanic processes play in Earth rotation dynamics and terrestrial reference frame definition, the International Earth Rotation Service (IERS) has created a Special Bureau for the Oceans as a component of its Global Geophysical Fluids Center in order to facilitate research into these and other solid Earth geophysical processes affected by the oceans. An overview of the IERS Special Bureau for the Oceans will be presented and its current status and activities described.

G12A-1046 1330h INVITED POSTER

The IERS Special Bureau for Tides

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The Global Geophysical Fluids Center of the International Earth Rotation Service (IERS) comprises 8 special bureaus, one of which is the Special Bureau for Tides. Its purpose is to facilitate studies related to tidal effects in earth rotation. To that end it collects various relevant datasets and distributes them, primarily through its website at bowie.gsfc.nasa.gov/ggfc/tides. Example datasets include tabulations of tidal variations in angular momentum and in earth rotation as estimated from numerical ocean tide models and from meteorological reanalysis products. The web site also features an interactive tidal prediction 'machine' which generates tidal predictions (e.g., of UT1) from lists of harmonic constants. The Special Bureau relies on the tidal and earth-rotation communities to build and enlarge its datasets; further contributions from this community are most welcome.

G12A-1047 1330h INVITED POSTER

Monitoring the Hydrologic Cycle for Geodesy at the IERS GGFC Hydrology Bureau

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The Hydrology Bureau of the International Earth Rotation Service Global Geophysical Fluid Center works to collect global estimates of changes in water storage over land. The data are useful not only in understanding earth rotation and gravity field changes, but also potentially in estimating geodetic site displacement due to surface loading. This paper reports on the status of data resources, which now include land-surface estimates that are ancillary products of the National Center for Environmental Prediction (NCEP) and European Center (ECMWF) global models. These resources provide relatively primitive estimates of the variable water load, as they are derived from models that lack water conservation. However, wide-spread scientific interest in global land surface models are expected to soon lead to new data resources in the form of data-assimilating land surface models.

G12A-1048 1330h INVITED POSTER

The GGFC Special Bureau for Loading: Scientific issues to solve and current status

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The International Earth Rotation Service (IERS) has established a Special Bureau for Loading (SBL) as part of its Global Geophysical Fluids Center (GGFC). The main purpose of the SBL is to provide reliable, consistent model predictions of loading signals, that have been thoroughly tested and validated. The products will describe at least the surface deformation, gravity signal and geo-center variations due to the various surface loading processes in reference frames relevant for direct comparison with existing geodetic observing techniques. To achieve these goals, major scientific advances are required with respect to the Earth model, the theory and algorithms used to model deformations of the Earth as well as improvements in the observational data related to surface loading. In this presentation, we will report on the current status of the SBL.

G12A-1049 1330h POSTER

Multidisciplinary Study of the Core and Computation of Core Angular Momentum

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In 1998, the IERS established the Global Geophysical Fluids Center (GGFC), which consists of eight Special Bureaus for the different geophysical fluids. The Special Bureau for the Core (SBC) focuses on theoretical modelling and observations related to core flow, and on inner core - outer core - mantle interactions. The fluid outer core is in constant motion, and related changes in core angular momentum are known to cause length-of-day variations of a few milliseconds at decadal time scales. This poster will give an overview of the activities of the SBC. Since its creation in 1998, the SBC has created a web site (www.astro.oma.be/SBC/main.html) as the central mechanism for providing services to the geodynamic community. The web site contains documented model data on core flow and core angular momentum and an extensive bibliography. In addition, a description is given of the relevant theories and of the dynamical assumptions used for constructing the flow.

Reference

Core Dynamics, structure, and rotation. eds. V. Dehant, K. Creager, S. Karato, S. Zatman, AGU monograph, 2002, in press, and articles therein such as Ponsar, S., Dehant, V., Holme, R., Jault, D., Pais, A., Van Hoolst, T., The Core and fluctuations in the Earth's rotation

G12A-1050 1330h POSTER

Torsional oscillations in the Earth core: analysis of the core angular momentum by multi-channel Singular Spectrum Analysis

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Torsional oscillations in the axial angular momentum of the Earths liquid core are investigated by dividing the core into twenty idealized equi-volume annuli coaxial with the axis of rotation of the Earth. The temporal variations in the axial angular momentum component of each annulus are determined from the core-mantle boundary (CMB) velocity field under the assumption of rigid rotation of each annulus. With the available velocity fields at the CMB as derived from geomagnetic variation observations (as calculated by A. Jackson), the general characteristics of axial core angular momentum (CAM) are explored over 15 decades (1840 1990). Five modes (with a mode being defined as a global oscillation with common variability among the 20 annuli) are isolated and are studied separately by using the Multi-channel Singular Spectrum Analysis. By perturbing the data using a set of technique, we have tested the robustness of the obtained mode. The three first modes have been shown quite robust, while the two last have only succeeded to part of the test implying that their existence needs to be verified by further study.

G12A-1051 1330h POSTER

Consistent Atmospheric and Oceanic Excitation of a Free Gyroscopic Earth Model

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Mass redistributions on or within the Earth as a consequence of geophysical processes and gravitational interactions with celestial bodies influence the Earth's rotation on sub-daily to secular time scales. Rotational variations manifest in polar motion and changes in length-of-day. The effects of excitations are superposed by free oscillations of the Earth, i.e. the Chandler wobble and the free core nutation. To get insight into the rotational dynamics of the Earth a non-linear gyroscopic model has been developed. In contrast to most of the former approaches the numerical model dispenses with any explicit information concerning amplitude, phase, and period of free oscillations. Thus, the characteristics of the Earth's free nutation has to be reproduced the model solely from rheological and geometrical parameters. By regarding the rotational deformation of the Earth's body in the model, the period of the free nutation is lengthened from the Euler period (304 days), which would be the period of the free oscillation if the Earth was rigid, to the Chandler period of approximately 434 days. As the rotational deformation is a backcoupling mechanism of polar motion on the Earth's rotational dynamics it is assumed that both period and amplitude of the Chandler wobble are time-dependent when considering additional excitation, e.g., from atmospheric or oceanic mass redistributions. To study this effect, the gyro is forced by consistent atmospheric and oceanic excitations. These are derived from the global atmospheric ECHAM3-T21 general circulation model which is based on sea-surface temperature registrations and from the ocean model for circulation and tides OMCT. Mass redistributions in the Earth's body due to gravitational and loading deformations are calculated and additionally introduced into the model. Besides, external torques are considered which are exerted by Moon and Sun. For validation, the numerical results of the gyro are contrasted to the geodetically observed time series of polar motion and length-of-day variations which are published by the IERS.

G12A-1052 1330h POSTER

Subdaily Variations of Polar Motion from GPS and Related Atmospheric Signals

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Sub-daily spectra of polar motion variations are derived from the GPS (CODE) analysis. These polar motion data series were computed with a resolution of two hours and they cover a period of about 5 years (from 1996 till 2001). Besides the well-known tidal contribution at diurnal and semidiurnal frequencies oscillations with periods from 12 hours down to 6 hours and with

amplitudes of the order of 0.02 - 0.05 mas were detected from this GPS data. A study of a dense set of equatorial components of Effective Atmospheric Angular Momentum shows similar oscillations with peaks at both 8 and 12 hours. This meteorological data set is based on global surface pressure of the NASA GEOS Data Assimilation System with a resolution of three hours for the years 1990 - 1995. Although covering different epochs, the GPS and atmospheric signals have a similarity that suggests a relationship between the high frequency polar motion oscillations and the atmospheric forcing, at least for distinct periods. Pros and cons of this assumption will be presented in detail.

G12A-1053 1330h POSTER

Time-Frequency Analysis of Earth Rotation, Geocenter Coordinates and Some of the Geophysical Fluids Time Series.

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The nature of some oscillations in Earth rotation parameters and motion of the geocenter is irregular due to their irregular geophysical excitation thus, the wavelet and Fourier transform band pass filter spectro-temporal analysis methods were applied. These methods enable computation of the time-frequency spectra of x, y pole coordinates data, length of day and the coordinates of the geocenter as well as some of the geophysical fluids time series like atmospheric and oceanic angular momentum. The time-frequency coherence and cross-covariance functions between these time series show time-frequency relationship between Earth rotation and its excitation. Such analysis helps to understand better the interaction of some of the geophysical fluids with the solid Earth. The prediction accuracy of the Earth rotation parameters and geocenter coordinates data is discussed too.

G12A-1054 1330h POSTER

Oceanic Effects on Earth Rotational Change: A Case Study with Satellite Altimetry and Data Assimilating OGCM

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We compute oceanic contributions to polar motion and length-of-day (LOD) variation using non-steric sea level change derived from TOPEX/Poseidon satellite radar altimeter observations over a 9 years' period (1993 - 2001) and outputs from a data assimilating ocean general circulation model (OGCM). Both the altimeter derived oceanic mass variations and the data assimilating OGCM estimates indicates that the oceans play an important role in driving the Earth rotational change, especially in polar motion and at intraseasonal time scales. The results from this study show considerable improvement in the agreement between observed polar motion and LOD excitations (after atmospheric effects are removed) and contributions from the ocean when compared with previous studies.

G12A-1055 1330h POSTER

Three Dimensional Ocean Angular Momentum Fluctuations 1980-2001 Estimated From a Simple Ocean Data Assimilation Analysis

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Abstract. Three dimensional ocean angular momentum (OAM) changes 1980-2001 are obtained to determine oceanic contribution on the Earth Rotation variation, calculated from the monthly output of a simple ocean data assimilation (SODA) analysis. SODA uses an ocean model based on Geophysical Fluid Dynamics Laboratory MOM2 physics. Assimilated data includes temperature and salinity profiles from the World Ocean Atlas-94 (MBT, XBT, CTD, and station data), as well as additional hydrography, sea surface temperature, and altimeter sea level. The data region includes 0°-360°longitude and 60°S-60°N, and the data resolutions are 1.0°longitude and different latitude intervals with the average 1.0°. OAM consists of a mass term caused by ocean bottom pressure changes, and a current term due to ocean current velocity fluctuation. The mass term can be further divided into two components, individually affected by sea surface height (SSH) change and ocean water density (DEN) fluctuation.

For equatorial components, the mass terms due to SSH change and DEN fluctuation are nearly out of phase both for χ_1 and χ_2. This suggests that our results are not such significant excitations on the annual polar wobble as some previous results estimated from purely ocean models. However, for axial component, the mass term due to SSH change seems nothing to do with that from DEN fluctuation as the equatorial components show, but in negative phase with one result caused by an uniform sea level change since the ocean volume is not strictly conserved in reality (Ponte, JGR, C1, 1999). And the total axial ocean contribution to annul length of day change is small as before.

Our experiment shows that the combination of the atmospheric (JMA or NCEP) and SODA oceanic angular momentums in annual variation could not account well for the geodetic observing the earths rotation changes so far. This suggests that there are still some uncertainties in the estimation of OAM, and at the meaning time, the hydrologic contribution should be comprehensively considered.

G12A-1056 1330h POSTER

Low-degree, non-seasonal time-variable gravity and oceanic contributions

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We investigate the non-seasonal, low-degree time-variable gravity field induced by the oceanic mass circulation variations. We compute the ocean bottom pressure field (OBP) using the classical outputs (i.e. temperature and salinity at several depths and the sea surface height deviations) from two ocean general circulation models – CLIO (Coupled Large-scale Ice Ocean model, 1997-2001 which does not assimilate observational data) and ECCO (Estimating the Circulation and Climate of the Ocean, 1993-2000, which assimilates sea surface height and temperature and monthly Levitus climatology) and validate them with comparison to several pressure recorders.

We examine the non-seasonal OBP variations in terms of the empirical orthogonal function (EOF) decomposition in various ocean basins. We especially put in evidence in the two models a quick OBP change occurring in 1998 in the southern Pacific Ocean of about 10 millibars.

The results show that the ocean mass redistribution explains most of the non-seasonal low-degree (i.e. large-scale) gravity field variations after removal of atmospheric and post-glacial rebound (PGR) contributions, in particular with respect to the observed J2 anomaly that happened during 1998 as reported by Cox and Chao (2002).

G12A-1057 1330h POSTER

Self-Organized Mappings for the Visualization of Satellite Altimetry Data: A Comparison of Supervised and Unsupervised Networks as Data Reduction Methods

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Satellite altimetry is an important data source providing mesoscale resolution of the oceans' bathymetry. The data offer researchers significantly greater swaths (radial diameter of 165 km from an initial pulse of 13 GHz) of information than the more traditional shipborne sonar mapping methods of the oceans' surfaces. Altimeters onboard the Navy's GEOSAT and GFO satellites, offer 2.5 km spatial resolution of the Southern Ocean from 44°S 30°E through 50°S 38°E and provide gravity anomaly readings (mgals) over a swath of ocean displaying exceptional elevation contrasts.

Data reduction methods involving neural networks maximize the efficiency of computation time to achieve the most consistent visual representation of the data. A K-means clustering of randomized prototype vectors of the GEOSAT data provided the design requirements for an unsupervised neural network tasked with self-organizing a mapping of the gravity readings into the minimum number of clusters. The results from this self-organized mapping (SOM) network generated a map in a minimum of nine clusters. This clustering allowed for the reduction of the data matrix from 180x240 to a matrix of 70x240.

Histograms of the upper matrix for these nine clusters were examined to determine the comparative placement of regions exhibiting the greatest topographic relief and regions of greatest topographic depression. Clusters of gravity readings >250 mgals are found to exert too great an influence on the assignment of neurons to their respective neighborhoods, thereby suggesting that the SOM must be a restructured in a supervised design.

Prototype vectors are assigned in a least squares minimization procedure rather than through random probabilty density functions. Histograms of the new clusters are compared to determine if a supervised network better distributes data points while maintaining the topographic variability.

G12A-1058 1330h POSTER

Testing Ocean Tide Models Using Superconducting Gravimeter Observations

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Observations from the global network of superconducting gravimeters in the Global Geodynamics Project (GGP) are used to test 10 recent ocean tide models. In addition, observations are used from selected sites with LaCoste and Romberg gravimeters with electrostatic feedback, where special attention has been given to achieving a calibration accuracy of 0.1%. At some superconducting gravimeter sites there are anomalies in the in-phase components of the main tidal harmonics, which are due to calibration errors of up to 0.3%. It is shown that the recent ocean tide models are in better agreement with the tidal gravity observations than were the earlier models of Schwiderski and FES94.1. However, no single ocean tide model gives completely satisfactory results in all areas of the world. For example, for M2 the TPXO.5 and NAO99b models give anomalous results in Europe, whereas the FES95.2, FES98 and FES99 models give anomalous results in China and Japan. It is shown that the observations from this improved set of tidal gravity stations will provide an important test of the new ocean tide models that will be developed in the next few years.

G12A-1059 1330h POSTER

A new Time-Domain Method of Implementing the Sea-Level Equation in Glacial-Isostatic Adjustment

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The sea-level equation (SLE) describing the redistribution of melt water in the oceans is complicated to implement in conjunction with the Laplace-transform method conventionally used to model glacial-isostatic adjustment (GIA). The recently developed spectral-finite element method (Martinec, 2000) solves the field equations governing GIA in the time domain and, thus, eliminates the need of applying the Laplace-transform method. Moreover, the spectral finite-element approach allows us to solve the SLE when modelling GIA in a 3-D viscosity model. The present test is restricted to a radially symmetric, self-gravitating, incompressible earth model consisting of a fluid core, a Maxwell-viscoelastic lower and upper mantle, and an elastic lithosphere. The Pleistocene deglaciation is simulated using the global ice model ICE-3G. To study the sensitivity of the GIA predictions, we consider three ocean models, i.e. approximations to the complete solution of the SLE. This test confirms the importance of allowing for geoid undulations and for moving coastlines when calculating the redistribution of melt water in

GIA. Finally, we compare our predictions with different types of observational constraint from Canada and Fennoscandia.

G12A-1060 1330h POSTER

Inverting the Fennoscandian Relaxation-Time Spectrum in Terms of a 2D Viscosity Structure With a Cratonic Lithosphere

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The Fennoscandian relaxation-time spectrum (RTS), recently revised by Wieczerkowski et al. (1999), is a classical data set used in studies of glacial-isostatic adjustment (GIA). We interpret these data in terms of a 2D viscosity structure with a thick cratonic lithosphere below the former Fennoscandian ice sheet and a much thinner lithosphere underlain by an asthenosphere in the peripheral regions. The forward modelling of GIA is implemented in the time domain using the spectral-finite element approach developed by Martinec (2000). The computed vertical displacement for individual spherical harmonics is fitted by a single exponential function and the relaxation time is determined. The synthetic RTS for degrees 10 to 40 is then compared with the observational RTS and the acceptability of the underlying earth model is evaluated. The free parameters for the inverse modelling are either the thickness of the cratonic lithosphere and the upper-mantle viscosity or the thickness of the peripheral lithosphere and the asthenosphere viscosity. We show that a 2D viscosity structure with a cratonic lithosphere of 200 km thickness satisfies the observational Fennoscandian RTS as good as a conventional spherically symmetric earth model with a 95 km thick lithosphere.

G12B MCC: 123 Monday 1330h

New Results From the GRACE Mission *(joint with H, OS)*

Presiding: **M M Watkins,** Jet Propulsion Laboratory**; B D Tapley,** University of Texas**; J M Wahr,** University of Colorado

G12B-01 1330h

The GRACE Mission: Status and Performance Assessment

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The Gravity Recovery and Climate Experiment (GRACE) was selected under the NASA Earth System Science Pathfinder (ESSP) program with the goal of observing the static and time-variable gravity field with an unprecedented level of accuracy over the course of the five-year mission. The GRACE mission, successfully launched on March 17, 2002, consists of two satellites, co-orbiting in a polar orbit and separated by 200 km. Each satellite carries a microwave, dual frequency one-way ranging system, which is providing measurements of the differential satellite perturbations due to variations in the gravity field. Each satellite carries a high precision accelerometer and a GPS receiver to aid in the recovery of the gravity field from the observational data. The extended mission life coupled with the precision of the measurements is expected to provide a static gravity field model which is several orders of magnitude more accurate than current models and will provide measurements of the temporal variations which will provide new insight into mass and momentum transport among the Earths atmosphere, ocean and land components. The mission, which is one of the first NASA Earth System Pathfinder Missions, is implemented through a collaborative arrangement by NASA and DLR. The presentation will summarize the mission status and will describe some of the preliminary analysis results.

URL: http://www.csr.utexas.edu/grace/

G12B-02 1345h

GRACE Gravity Field Results from JPL

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The GRACE team at the Jet Propulsion Laboratory have over the past few years adapted the MIRAGE software used for deep space tracking data analysis and determination of the gravity field of planetary bodies such as Mars, Venus, the Moon, and 433 Eros, for GRACE applications. We have used this software to produce Earth gravity fields of unprecedented quality from a combination of the first GRACE K/Ka-band intersatellite tracking, GPS, accelerometer, and star camera data. In this paper we will present the results of that gravity field analysis, including the parameterization used, the spectral content of the residuals, the calibrated covariance, and performance in external tests such as orbit fits and sea surface topography. In addition, since the software and parameterization are independent of that used at the University of Texas and GFZ Potsdam, it provides a type of verification of the fields, and we will discuss the results of the intercomparison of the available gravity solutions.

G12B-03 1400h INVITED

GRACE Orbit and Gravity Field Recovery at GFZ Potsdam - First Experiences and Perspectives

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Since the launch of the two GRACE satellites on March 17, 2002, both satellites follow each other in a distance of about 220 km in an almost polar, circular and 500 km high orbit. For orbit and long-wavelength gravity field recovery the GRACE mission concept follows CHAMP's configuration, i.e., GPS satellite-to-satellite tracking and accelerometry on each of the two satellites. The essentially new element is the K-band microwave link measuring the relative distance of one satellite with respect to the other in both directions with an ultra-high precision (few m). To fully exploit this high precision, the requirements on the performance and precision of the accelerometers to measure non-gravitational orbit perturbations are one order of magnitude more stringent than on CHAMP. The goal of GRACE is a distinct progress in global gravity field recovery from space with respect to accuracy and spatial as well as temporal resolution. First experiences of the GFZ project team with the instrument and sensor performance on the GRACE satellites, the parametrization of the data in precise orbit determination and first tentative gravity field solutions are discussed and compared with CHAMP related results. GRACE data processing at GFZ Potsdam is part of the GRACE level-2 product generation and validation, which is shared with UTEX/CSR and NASA/JPL. On level-1, GFZ Potsdam is responsible for providing high frequency atmosphere and ocean mass variation models to avoid alias effects in GRACE's envisaged sequence of monthly gravity field solutions. Gravity de-aliasing products quality will be discussed.

G12B-04 1415h INVITED

GRACE Level-1 Data Processing

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The beginning of the science processing for the GRACE mission, called Level-1 processing, consists of data reformatting, data compression, editing, and precise time tag alignment based on GPS precise orbit determination for the formation of the dual one way range. This task is performed at the Jet Propulsion Laboratory, California Institute of Technology (JPL) GRACE Science Data System team working in cooperation with the Physical Oceanography Data Active Archive Center (PO-DAAC). In this talk an overview will be given of the data flow from raw telemetry (Level-0) to Level-1 data which is used to estimate gravity fields by the Level-2 processing centers at the Center for Space Research, University of Texas at Austin, Geo Forschungs Zentrum, Potsdam and JPL.

Furthermore, the quality control assessment for all data products will be discussed as well as experience gained by processing the GRACE data set. Finally an overview will be given of all science data products to be distributed to the science community and the method of distribution.

URL: http://www.csr.utexas.edu/grace

G12B-05 1430h INVITED

Validation of GRACE Time Variable Gravity Against Atmospheric Mass Variations

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GRACE will resolve temporal variations in gravity at length scales of a few hundred km and larger, and produce a complete global map once every 30 days. The data delivered by GRACE will need to be calibrated and validated in order to ensure their quality and reliability. The Calibration/Validation (Cal/Val) phase will validate the data collected during the on-orbit checkout phase and verify the quality of the data for the entire life span of the mission. In order to Cal/Val GRACE data, we must select an area of greater than 2×10^5 km^2 where the integral of all surface mass changes can be constrained with an accuracy better than 1 cm of water thickness equivalent. As it would be difficult to constrain the hydrology and precipitation signals in a typical region with sufficient accuracy, we Cal/Val GRACE in relatively water-free areas where the atmospheric pressure can be well constrained. We present the results of the Cal/Val of GRACE satellite data in the desert of southwestern Egypt. This extremely dry region has several barometers and rain gauges within or nearby. The gravity variation measured by GRACE in the selected area will be the sum of contributions from the GRACE measurement error, the error in removing the atmospheric mass variation using geopotential heights from an ECMWF global circulation model, the fluctuation of water mass in the Nile river and Lake Nasser, aquifer depletion, and sea surface variations in surrounding seas. In general, only the atmospheric mass variation will be significant at the 1 cm level of water thickness equivalent within the Cal/Val area. Simulations indicate that the other signals besides the atmosphere should contribute negligibly to the time variable gravity measured by GRACE.To approximate the error in removing atmospheric mass distribution from GRACE data, we calculate the difference between surface pressure from barometer measurements and modeled surface pressure from ECMWF, averaged over periods of GRACE monthly estimates of geoid. We will compare residual differences with the signal measured by GRACE. If the two signals are significantly different we will investigate if the fluctuation of water mass in the area can be responsible for the observed discrepancy.

G12B-06 1445h INVITED

GRACE: Mission Profile and its Relation to Science Goals

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On March 17, 2002, the twin GRACE satellites were successfully launched, with the purpose of collecting data leading to dramatic improvements in the estimates of the long-term mean and temporal variability of the Earth gravity field. The gravity information from GRACE is contained within the inter-satellite (microwave) range-change measurements, supported by measurements of the non-gravitational accelerations, the attitude and the GPS tracking data. Ensuring sufficient quality of these measurements to meet the science goals had led to unique requirements on the precision of the GRACE attitude pointing system, its dimensional stability & precision of instrument accomodation, as well as on other aspects of the flight system & mission design.

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