G22A MCC: Level 1 Tuesday 1330h

Core Dynamics: From Geomagnetism to Geodesy Posters *(joint with GP)*

Presiding: **W Kuang,** Goddard Space Flight Center**; O de Viron,** Royal Observatory of Belgium

G22A-0299 1330h POSTER

Effect of an Overlying Stable Layer on Planetary Dynamos

Gerald Schubert[1] (310-825-4577; schubert@ucla.edu)

K. H. Chan[2] (khchan@ust.hk)

X. Liao[3] (xhliao@center.shao.ac.cn)

Keke Zhang[4] (44-1392-26-3992; KZhang@maths.ex.ac.uk)

[1]Department of Earth and Space Sciences, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, 595 Charles E. Young Drive East, Los Angeles, CA 90095-1567, United States

[2]Department of Mathematics, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong 0000, China

[3]Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai Astronomical Observatory, Shanghai 200030, China

[4]School of Mathematical Sciences, University of Exeter, North Park Road, Exeter EX4 4QE, United Kingdom

A fully three-dimensional, nonlinear, time-dependent, multi-layered spherical kinematic dynamo model is used to study the effect on the observable external magnetic field of flow in a stable layer above a spherical turbulent dynamo region. For a rapidly rotating planet with sufficiently large magnetic and ordinary Reynolds numbers it is reasonable to assume that turbulence in the magnetic field generation region is associated with an α effect having a symmetry reflecting the rapid rotation. In this case, we would expect the observed planetary magnetic field to be predominantly a dipole aligned with the rotation axis. Except for Saturn, observed planetary magnetic fields are more complicated. We show that the structure of the observed field is essentially determined by the flow in the overlying stable layer. It is also shown that a strong-field planetary dynamo can be readily produced by the circulation in a stable layer above the turbulent convective region. Such stable layers might exist at the top of the Earth's core due to chemical or thermal causes, in the cores of other terrestrial planets for similar reasons, and in Saturn due to the differentiation of helium from hydrogen. An electrically conducting and differentially rotating layer could exist above the metallic hydrogen region in Jupiter especially if the observed near surface zonal winds extend to great depth. Lateral temperature gradients resulting in thermal winds drive the flow in the stable layers. It is the amplitude and structure of the flow in the stable layer that mainly determines the nature of the observable magnetic field. Saturn's axisymmetric, rotation-aligned dipole field could indicate either the presence of axisymmetric flow in an overlying stable shell (Stevenson, 1982) or the absence of such a stable layer. The structure of the Earth's magnetic field could simply reflect the structure of stable-layer thermal winds driven by lateral thermal heterogeneity in the lower mantle. Planetary dynamos might have more in common with the solar dynamo than is generally thought. It is the differential rotation in the solar tachocline below the turbulent convective dynamo region that largely determines the characteristics of the solar magnetic field. A unified model could therefore explain all solar system dynamos. Stevenson, D.J., Reducing the non-axisymmetry of a planetary dynamo and an application to Saturn, J. Geophys. Astrophys. Fluid Dyn., 21, 112–127, 1982.

G22A-0300 1330h INVITED POSTER

Information about the core from VLBI data.

Veronique Marie Dehant (3223730266; v.dehant@oma.be)

Royal Observatory of Belgium, 3 avenue Circulaire, Brussels B1180, Belgium

The Earth rotation and orientation are observed with very high precision techniques. Scientists are using the accumulation of recent data in order to get information about the Earth rotation variations: length-of-day (LOD), polar motion and nutations. The core has a large influence on the LOD at decadal timescale, and in the nutations. In particular the analysis of the Earth orientation in space from Very Long Baseline Interferometry, has provided the scientific community with information about the coupling between the inner core and the outer core and between the liquid core and the mantle at the nutation timescale. It also provides the values of the rotational normal mode periods and amplitudes. The paper will review the situation.

G22A-0301 1330h POSTER

Electromagnetic Field Decadal Variations Generated by Zonal Oscillating Flows in the Earth's Core and Their Detectability by Using Submarine Cable Geoelectric Observations

Hisayoshi Shimizu[1] (81-3-5841-5748; shimizu@eri.u-tokyo.ac.jp)

Hisashi Utada[1] (81-3-5841-5722; utada@eri.u-tokyo.ac.jp)

[1]Earthquake Research Institute, University of Tokyo, Yayoi 1-1-1, Bunkyo-ku, Tokyo 113-0032, Japan

Electric field observations by using 1,000 km scale submarine cables have been performed since early 1990's. One of the main purposes of the observations is to obtain observational constraints on the dynamics of Earth's core such as the strength and the distribution of the toroidal magnetic field and its variation at the core mantle boundary. Several constraints have been obtained until present, but the electromagnetic plausibility of them has not been examined. In this presentation, electromagnetic field variations generated by a simple spherical mean-field kinematic dynamo within an electrically conducting mantle are discussed. The field variations are assumed to be generated by perturbing a steady α^2-dynamo with nearly cylindrically symmetric zonal oscillating flows (i.e. torsional oscillation type flows) having period of 30 years. It is confirmed that the kinematic dynamo can generate the observed amplitude of electric voltage variation ($\sim$100mV) naturally. The amplitude of voltage variation is controlled mainly by the energy state of the dynamo, i.e., the magnetic Reynolds numbers, and the strength of the toroidal field variation at the CMB is determined by the magnetic Reynolds numbers and the conductance of the D'' layer. Potential obstacles for the detection of the 100mV signal in 1,000km scale submarine cable voltage variations are the electric voltages induced by external magnetic field variations (magnetotelluric induction) and those induced by ocean flow (motional induction). Although the magnetotelluric current with decadal time scales seems negligibly small, the motional induced electric field variation can be as much as 100mV for 1,000km scale. It is necessary to know the time variation of ocean flux in order to discuss the electric voltages generated in the deep interior of Earth correctly.

G22A-0302 1330h POSTER

Torsional Oscillations and Mechanisms of Core-Mantle Angular Momentum Exchange

Jon Mound[1] (jmound@physics.utoronto.ca)

Bruce Buffett[2] (buffett@geosci.uchicago.edu)

[1]Department of Physics, Univesity of Toronto, 60 Saint George Street, Toronto, ON M5S 1A7, Canada

[2]Department of Geophysical Sciences, University of Chicago, 5734 S. Ellis Avenue, Chicago, IL 60637, United States

Motions in the fluid core, observable through variations in the magnetic field, are known to correlate with length-of-day changes on decadal timescales. However the physical mechanism that enables the angular momentum exchange remains uncertain. Proposed mechanisms include electromagnetic, topographic and gravitational couplings. We use a finite volume model of the core-mantle system to investigate each mechanism with respect to observed properties of the fluid motion. General observational constraints include fluid velocities on the order of 10 km/yr, wave-like oscillations with decadal periods and an associated length-of-day signal of several milliseconds. Angular momentum exchange between the core and mantle has also been proposed to explain length-of-day oscillations at interannual periods. We find that for reasonable values of core and mantle properties, electromagnetic coupling is too weak and too dissipative for the observed fluid velocities to produce the required torques on the mantle. Similarly, core-mantle boundary topography is likely too small to produce the required angular momentum exchange. Gravitational coupling between the mantle and inner core is the candidate mechanism that best reproduces the observed behaviour, provided that inner core viscosity is sufficiently large.

G22A-0303 1330h POSTER

Sub-grid scale modeling for simulations of magnetoconvection in the Earth's core

Hiroaki Matsui[1] (matsui@geosci.uchicago.edu)

Bruce A. Buffett[1] (773-702-8107; buffett@geosci.uchicago.edu)

[1]Department of the Geophysical Sciences, the University of Chicago, 5734 S Ellis Ave., Chicago, IL 60637, United States

The fluid motion and the magnetic field in the Earth's outer core have small scale components which cannot be resolved in numerical simulations because of the small Ekman number and large Rayleigh number. Many geodynamo simulations have been performed with much larger viscosity or hyper diffusivity, but more realistic sub-grid scale (SGS) modeling is required. The influence of sub-grid scale motion and magnetic field are modeled in magneto-convection simulations using the nonlinear gradient model by Leonard (1994). We implement this method using a gaussian filter in a dynamo simulation code using the finite-element method. As a preliminary test, we investigated the contribution of SGS terms in each equation using the results of a magneto-convection simulation in a cubic domain. We consider a cubic domain with equal dimensions in three coordinate directions. The directions of gravity and rotation vectors are parallel to the z-axis, and a constant magnetic field is imposed in the y-direction. We investigate magnitudes of the sub-grid heat flux, momentum flux, Maxwell stress, and induction terms using the results of the direct simulation. We compared the ratio of running mean square of the SGS nonlinear terms to corresponding original terms. The results show that the ratio of the SGS momentum flux and that of the SGS heat flux are similar. However, the ratios of the SGS Maxwell stress term and induction term are approximately 10^{-5} times of the ratio of the SGS heat advection and inertia terms. The results suggest that the SGS modeling for the momentum and heat flux is more important than that of the Maxwell stress and the induction terms. We will investigate how these ratios change under the large Rayleigh number and small Ekman number cases.

G22A-0304 1330h POSTER

Density anomalies in the mantle and gravitational core-mantle interaction

Weijia Kuang[1] (301-614-6108; Weijia.Kuang-1@nasa.gov)

Lanbo Liu[2] (lanbo.liu@uconn.edu)

[1]Space Geodesy Branch, NASA Goddard Space Flight Center, Greenbelt Rd, Greenbelt, MD 20771, United States

[2]Department of Geology and Geophysics, University of Connecticut, 354 Mansfield Rd., Unit 2045, Storrs, CT 06269, United States

Seismic studies suggest that the bulk of the mantle is heterogeneous, with the density varies in depth as well as in horizontal directions (latitude and longitude). This density variation produces a three-dimensional gravity field throughout the Earth. On the other hand, the core density also varies in both time and space, due to convective core flow. Consequently, the fluid outer core and the solid mantle interact gravitationally due to the mass anomalies in both regions. This gravitational core-mantle interaction could play a significant role in exchange of angular momentum between the core and the mantle, and thus the change in Earth's rotation on time scales of decades and longer. Aiming at estimating the significance of the gravitational core-mantle interaction on Earth's rotation variation, we introduce in our MoSST core dynamics model a heterogeneous mantle, with a density distribution derived from seismic results. In this model, the core convection is driven by the buoyancy forces. And the density variation is determined dynamically with the convection. Numerical simulation is carried out with different parameter values, intending to extrapolate numerical results for geophysical implications.

G22A-0305 1330h POSTER

How important is the lateral variation of mantle density to earth rotation in tidal frequencies

Lanbo Liu[1] (1-860-486-1388; lanbo.liu@uconn.edu)

Weijia Kuang[2] (Kuang@santafe.gsfc.nasa.gov)

Benjamin Fong Chao[2] (chao@santafe.gsfc.nasa.gov)

[1]Department of Geology and Geophysics, University of Connecticut, 354 Mansfield Road, U-2045, Storrs, CT 06269-2045, United States

G

[2]Goddard Space Flight Center, NASA, Space Geodesy Branch, Code 926, Greenbelt, MD 20731, United States

Advances in space geodesy in the last couple of decades have made two types of precise geophysical data available: (i) tidal signals in the Earth's rotational speed variations and polar motion; and (2) the contribution of ocean tides to the above signals as predicted by satellite altimetry derived tide models. The difference of the two, at all tidal periods (long-periods, diurnals, and semidiurnals), contains contributions of the lateral density heterogeneity of the mantle. We developed an algorithm and conduct the computation using 3-demensional mantle heterogeneity models derived by seismological and gravity means (e.g., the SPRD6 model, Isshii and Tromp, 1999). We discuss the importance of the mantle heterogeneity by comparing with the earth rotation observations conducted by NASA using VLBI networks, and the ocean tides model derived from Topex/Poseidon. In general, the effect from ocean tides accounts for more than 90% of the observed polar motion signals in the tidal frequencies, while the effect from the solid mantle only accounts for less than 10%. Accounting for the effect from the density heterogeneity in the mantle reduced the said discrepancy in the observed tidal signals. Conversely, the latter signals therefore provide global constraints to 3D mantle density models for a better understanding of the internal dynamics of the solid Earth.

G22B MCC: Level 1 Tuesday 1330h

Reference Frame Definition and Modeling and Influence of Geophysical Fluids II Posters *(joint with A, H, OS)*

Presiding: **B F Chao,** NASA Goddard Space Flight Center**; R Noomen,** Delft University of Technology

G22B-0306 1330h POSTER

Analysis of Geocenter Time Series Derived From SLR, GPS and DORIS

Xavier Chavet[1]

Jean-Jacques Valette[1] (Jean-Jacques.Valette@cls.fr)

Martine Feissel-Vernier[2] (feissel@ensg.ign.fr)

[1]CLS - Collecte Localisation Satellites, 8-10 rue Hermes Parc Technologique du Canal, Ramonville 31526, France

[2]Observatoire de Paris/SYRTE and Institut Géographique National/LAREG, 8 Avenue Blaise Pascal Champs sur Marne, Marne la Vallee 77455, France

Using various time series of sets of station coordinates derived from satellite geodetic observations, we describe the motion of the Earth's geocenter by the time series of the origin of the individual data sets in a common reference frame. The goal of the analysis of these time series is to extract and compare various components such as trend, seasonal and irregular components. In addition to the comparative analysis of the individual signals, a noise analysis of the series is performed. The geodetic techniques involved are DORIS, SLR and GPS, and the respective time intervals are monthly, weekly and daily.

G22B-0307 1330h POSTER

Excitation of the Chandler wobble by varibale annual oscillation of polar motion

Wieslaw Kosek (48 (22) 6403766 ext.306; kosek@cbk.waw.pl)

Space Research Centre, Polish Academy of Sciences, Bartycka 18A, Warsaw 00-716, Poland

Analysis of the IERS pole coordinates data in polar coordinate system shows energetic oscillation with a period of 6-7 years in polar motion radius and velocity. This 6-7 years oscillation is a beat period of the Chandler and annul oscillations and it is variable mostly due to variable phase of the annual oscillation of polar motion. It has been found that the increase of the annual oscillation phase is associated with the increase of the envelope of the Chandler oscillation. This may suggest that the Chandler wobble may be excited by the variable annual oscillation of polar motion which is excited by the atmospheric and oceanic angular momentum. Some correlations of this beat period and the annual oscillation phase/amplitude with Nino indices were also detected.

G22B-0308 1330h POSTER

Millimeter QC of the ITRF using SLR

Van S Husson[1] (1-301-805-3981; van.husson@honeywell-tsi.com)

John C Ries[2] (1-512-471-7486; RIES@CSR.UTEXAS.EDU)

Richard J Eanes[2] (1-512-471-7560; EANES@CSR.UTEXAS.EDU)

Julie E Horvath[1] (1-301-805-3951; julie.horvath@honeywell-tsi.com)

[1]HTSI, 7515 Mission Drive, Lanham, MD 20706, United States

[2]CSR, 3925 W. Braker Lane, Suite 200, Austin, TX 78759-5321, United States

Using Satellite Laser Ranging (SLR) data, the 3-dimensional quality of the International Laser Ranging Service (ILRS) network coordinates can be objectively evaluated to the few millimeters (mm) level. SLR was used to define the ITRF200 origin and scale and its rate. Certain SLR sites in ITRF2000, which had performance problems or short occupational histories, do have questionable coordinates and velocities (e.g. Riyadh, Beijing). The standard error associated with a coordinate set is one-way to quickly access its quality, but in reality the TRUE' coordinate error could be an order of magnitude larger than the standard error. Another way of performing a site coordinate reality check it by treating any site with a height rate larger than a few mm per year as potentially suspect. For example, Beijing and Riyadh height rates of +23 and -17 mm per year; respectively, immediately raises concern. For a given site, the geometry of the ground tracks from LAGEOS and Jason ranging coupled with pass-by-pass range and time bias estimates from global short arcs (i.e. 1-3 days) can be examined to determine the accuracy of the horizontal components of the coordinates. To determine the accuracy of the vertical component involves simultaneously estimating station positions and range biases every 28-days for a period of at least a few months. Currently, Riyadh ITRF2000 coordinates at epoch 2003 are in error by 10 centimeters (cm) in both North and Up and 5 cm in East. Two SLR analysts groups (ASI and CSR) have computed new Riyadh positions using LAGEOS and a combination of LAGEOS and Jason data, respectively. Their coordinates agree to a 3 cm, 1cm, and 2cm in North, East, and Up, respectively. We will use the global SLR LAGEOS and Jason normal point data sets in 2002 and 2003 to resolve which Riyadh coordinate set is more accurate.

G22B-0309 1330h POSTER

TRF Datum Definition and Geocenter Motion Estimate

Zuheir Altamimi[1] (33 1 64 15 32 55; altamimi@ensg.ign.fr)

Claude Boucher[2] (cbpro@club-internet.fr)

Jim Ray[3] (jimr@ngs.noaa.gov)

Gerard Petit[4] (33 1 45 07 70 67; gpetit@bipm.org)

[1]Institut Geographique National, ENSG/LAREG, 6-8 Avenue Blaise Pascal, Champs-sur-Marne 77455, France

[2]Institut Geographique National, Direction Technique, 2 Avenue Pasteur, Saint-Mande 94160, France

[3]National Geodetic Survey, 1315 East-West Highway, Silver Spring, MD 3282, United States

[4]BIPM Time section, Pavillon de Breteuil, Sevres 92312, France

Are satellite geodesy techniques currently able to accurately measure the geocenter motion? We try to discuss this question using the geometric method based on the three translation components of the 7 Helmert transformation parameters under minimum constraints condition. Geocenter motion estimates as results from independent combinations of time series of station postions available in weekly sinex files from SLR, GPS and DORIS techniques will be compared. Expecting a few millimeter variations, care should be paid to the analysis strategy used for geocenter motion estimates, being intimately dependent on the datum definition of the underlying Terrestrial Reference Frame (TRF). The most challenging task is then to be able to de-correlate geocenter motion signal from other computational artefact, being often inherent to the TRF implementation. We concentrate mostly on seasonal variations, more easily detectable by satellite geodesy than the secular part believed to be slow over a time period larger than the available data span. Some conclusions will be drawn and implications for IERS, in particular the next ITRF solution and the Global Geophysical Fluids Product Center, will be addressed.

G22B-0310 1330h POSTER

Realisation of the TRF Origin by Different Satellite Techniques

Barbara Meisel[1] (0049-89-23031-216; meisel@dgfi.badw.de)

Detlef Angermann[1] (angermann@dgfi.badw.de)

Hermann Drewes[1] (drewes@dgfi.badw.de)

Michael Gerstl[1] (gerstl@dgfi.badw.de)

Horst Mueller[1] (mueller@dgfi.badw.de)

[1]Deutsches Geodaetisches Forschungsinstitut, Marstallplatz 8, Muenchen 80539, Germany

The origin of the International Terrestrial Reference System (ITRS) is defined as the center of mass of the Earth, including solid earth, hydrosphere and atmosphere. In order to realize the origin for a TRF it is essential to analyse the contribution of the different space techniques (SLR, DORIS, GPS). This is important to detect systematic differences caused by deficiencies in the modelling of parameters that are correlated with the origin (e.g. orbit errors). Incorrect realisations of the origin cause common errors in the station coordinates of the entire network. Reversely common variations of the station coordinates may be transformed into changes of the origin. The goal of this paper is to analyse those effects. We use weekly network solutions of the different techniques. We processed a SLR solution at DGFI over eleven years using LAGEOS 1 and 2 data and applyied the latest models. GPS solutions were obtained from IGS and weekly DORIS solutions from the joint IGN/JPL analyis center. We investigate common signals in the coordinate time series that can be interpreted either as station position variations or origin variations. We compare these time series of the different techniques regarding offsets, periodic or nonlinear effects. We analyse the strengths and weaknesses of the techniques to realise the origin parameters and the effect of the network distribution. Finally we discuss the impact of these results for a TRF combination from weekly network solutions.

G22B-0311 1330h POSTER

Determination of Forced Diurnal Polar Motion Using Large Ring Lasers Gyroscopes

Markus Rothacher[1] (rothacher@bv.tum.de)

Ulrich Schreiber[1] (schreiber@wettzell.ifag.de)

Thomas Kluegel[2] (kluegel@wettzell.ifag.de)

Geoffrey E. Stedman[3] (g.stedman@phys.canterbury.ac.nz)

Bob Hurst[3] (bob.hurst@canterbury.ac.nz)

[1]Forschungseinrichtung Satellitengeodaesie, TU Munich, Arcisstrasse 21, Munich D-80290, Germany

[2]Bundesamt fuer Kartographie und Geodaesie, Fundamental Station Wettzell, Koetzting D-93444, Germany

[3]Department of Physics and Astronomy, University of Canterbury, Private Bag 4800, Christchurch 8020, New Zealand

In October 2001, a very large ring laser gyroscope with an area of 16 m^2 was inaugurated at the Fundamental Station in Wettzell, Bavaria. Large gyroscopes with areas of 1 m^2, 16 m^2, and 367 m^2 are also operational at the University of Canterbury in Christchurch, New Zealand. These ring lasers, measuring the frequency difference between two counter-rotating laser beams, are now approaching a precision of 10 ppb for geophysical signals with periods of less than 2 days and therefore allow the monitoring of variations in Earth rotation (polar motion and length of day) in the high-frequency spectrum. For the first time, forced diurnal polar motion (also called "Oppolzer terms", caused by the gravitational attraction of Sun and Moon) with variations up to 20 mas (60 cm on the Earth's surface) can directly be measured. This is a novelty, because with the space geodetic techniques like VLBI, GPS, SLR/LLR, and DORIS, nutation and forced diurnal polar motion cannot be separated. With a few months of data stemming from the two most accurate ring lasers, the amplitudes of the largest terms of forced diurnal polar motion have been determined with a precision of about 1 mas. The results are discussed and compared to theoretical models.

URL: http://www.wettzell.ifag.de