ITRF by constraining 5 IGS station velocities to their ITRF 2000 values is 0.5 mm per y. To get a measure of the real velocity precision, several analysis parameters will be tested, like the total time span of REGAL measurements, simulations of semi-permanent measurements at permanent stations or non-linear motion of the sites. The degree of convergence of the velocity results with adding observation epochs for the semi-permanent stations will be evaluated. Our first results indicate that the residual velocities, relative to the stable foreland, are less than 1 mm per y, and they are consistent with the velocity field calculated for the permanent stations in the western Alps (Nocquet and Calais, 2003, GJI), with a relative extension across the western Alps. Moreover, a differential displacement is recorded between the external and the internal Alps, which suggests that the Pennine Frontal Thrust is active, as previously shown by Nocquet and Calais (2003). Most of the semi-permanent points have a residual velocity towards the NW, consistent with the geological models that consider the same propagation of Jura folds and thrusts to the NW. Moreover, the preliminary calculation shows that differential velocities (0.5 mm per y) characterizes the points bordering the Vuache fault, one of the active faults of the Jura, indicating a pure left-lateral strike-slip motion on this fault, in agreement with the seismological and geological data.

G21D-0295 0830h POSTER

Activities of the LEGOS/CLS Analysis Center Within the International DORIS Service

laurent Soudarin[1] (+33 (0)5 61 39 48 49; Laurent.Soudarin@cls.fr)

Jean-Francois Cretaux[2] (+33 (0)5 61 33 29 89; Jean-Francois.Cretaux@cnes.fr)

Jean-Jacques Valette[1] (+33 (0)5 61 39 47 62; jean-jacques.valette@cls.fr)

Anny Cazenave[2] (+33 (0)5 61 33 29 22; Anny.Cazenave@cnes.fr)

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

[2]CNES/GRGS/LEGOS CNES/GRGS/LEGOS , 18 Avenue Edouard Belin, Toulouse 31400, France

LEGOS/GRGS and CLS have been involved in DORIS data processing since the launch of Spot-2 in 1990. They are in charge of the scientific analysis of DORIS data in the field of geodesy, geophysics and space oceanography. They decided to jointly participate as Analysis Center for the International DORIS Service (IDS) which has been officially started on July 1, 2003 as an IAG Service. The goal of this paper is to present the current activities of the Center realized with the GINS/DYNAMO software, as well as the recent evolutions brought to the processing. One of the most important is the contribution of the three new instruments launched during the last two years onboard Jason-1, Spot-5, and Envisat. We will present the contribution of the new satellites to the positioning performances. Recently, the first Grace Gravity Model has been released. We will present results obtained with this new gravity model.

G21D-0296 0830h POSTER

On-Line Operating 3-D Seafloor Positioning System (1)

Takao Eguchi (+81-46-841-3810 ext. 3234; eguchi@nda.ac.jp)

Earth and Ocean Sciences, National Defense Academy, 1-10-20, Hashirimizu, Yokosuka 239-8686, Japan

We propose a new observation system of on-line 3-D positioning which will be deployed on the sea-bottom of convergent type plate boundaries where large interplate seismic events occurred historically. The system has observation sites at assigned intervals along optical fiber cables. Using the several cables, crossing each other, we can construct a real-time operating network of triangular base lines. Each observing site on the cable will be equipped with two-kind high gain instruments i.e., the laser ranging and pressure gauge sensors, as well as additional apparatuses to remove the influence of temperature and salinity etc. on the data. Attenuation rate of visible rays in seawater is relatively smaller at bands of blue-color (wave length; $\sim$ 450nm) to yellowish green-color ($\sim$ 550nm). The attenuation rate of optical signals of blue to yellow-green color in highly transparent seawater is 0.1 $\sim$ 0.5 dB/m. If we can utilize the high power optical laser output of the blue to yellow-green band for the positioning, the signals can reach the target receiver station with highly sensitive detector located at the distance of 10**2 m or larger. Using additional data of thermal and salinity fields etc. for compensating refractive index of laser signal ray path in clean seawater, we may attain the resolution of laser ranging at an order of 1 mm for each triangular base line with the total length of 1 $\sim$ 2 km. The base line consists of several secondary positioning stations with the spacing of $\sim$ 10**2 m. To improve the data resolution, we apply signal processing such as low-pass filtering etc. As is important, we cannot decompose the change of the base line distance data into 3-D individual components. We need another kind data, such as pure vertical coordinate of the positioning sites to resolve the 3-D components. To measure the vertical coordinate of the seafloor stations, we utilize data from the high gain pressure sensor. In the case of crystallized quartz-based pressure sensor which are commonly used in several on-line sea-bottom seismic observation systems in Japan, the resolution of water depth change is $\sim$ 1 mm being sufficient to detect the arrival of larger tsunamis or similar phenomena. As a result of our previous observation based on the crystallized quartz-based pressure sensor, the maximum amplitude of pressure change due to tsunamis on the flat seafloor with the depth of 2 $\sim$ 3 km is approximately ten-times smaller than that at the tide gauge station at neighboring open shore. Generally, most of flat sea-bottom at plate boundary regions are covered with less consolidated sedimentary layer with variable thickness. During large shallow seismic events at regional distances, freely settled sea-bottom stations from the sea surface may suffer some additional or differential movement(s), especially in the horizontal directions, from deeper basal rock layer. To get observation data with high reliability even for long periods including some intermittent activity of shallow large earthquakes with the epicentral distances of several hundred km or less, we must carefully monitor the position not of instruments landed freely on sea-bottom surface but of those tightly fixed with the deeper basal rock. Thus, we have to install and fix observation sites of the network on deeply rooted boreholes or on tightly coupled tool with the basal rock layer, as many as possible. To raise the ratio of the number of observation items vs. the total system expense, we should add some other geophysical instruments such as gravity, broad-band seismic, or electro-magnetic sensors at selected stations.

G21D-0297 0830h POSTER

Examination on Repeatability of GPS/Acoustic Seafloor Positioning for the Reference Points deployed around Japan

Masayuki Fujita[1] (81-3-3541-4232; masayuki-fujita@kaiho.mlit.go.jp)

Mariko Sato[1] (81-3-3541-4232; mariko-satou@kaiho.mlit.go.jp)

Tetsuichiro Yabuki[1] (81-3-3541-4387; tetsuichirou-yabuki@kaiho.mlit.go.jp)

Masashi Mochizuki[2] (81-3-5452-6188; moma@iis.u-tokyo.ac.jp)

Akira Asada[2] (81-3-5452-6187; asada@iis.u-tokyo.ac.jp)

[1]Hydrographic and Oceanographic Department, Japan Coast Guard, 5-3-1, Tsukiji, Chuo-ku, Tokyo 104-0045, Japan

[2]Institute of Industrial Science, Univ. of Tokyo, 4-6-1, Komaba, Meguro-ku, Tokyo 153-8505, Japan

We have been developing a system for precise seafloor geodetic measurement with the GPS/Acoustic combination technique and deploying about fifteen seafloor reference points on the land-ward slope of the major trenches around Japan, such as Japan Trench and Nankai Trough. Each reference point has four sets of seafloor acoustic transponders placed in a square. The primary purpose of our observation is to detect and monitor the crustal deformation caused by the subduction of the oceanic plate near the plate boundary. At each point, we carry out a campaign observation with several days using a survey vessel of Japan Coast Guard and revisit it once or twice a year, though the weather condition often hinders sufficient data acquisition. The procedure of data analysis consists of following three different stages as a whole: (1) kinematic GPS analysis, (2) acoustic wave analysis to obtain round travel time between the transducer on board and seafloor transponder, (3) a combination of results from (1) and (2) to get the precise seafloor position. The analysis for (3) is performed by a linear inversion method based on the least squares estimation. Acoustic velocities are given from the CTD measurement as initial values and corrected in the process by using residuals of the travel time data. Using data from our reference points with comparatively many observation days, we examine repeatability of obtained seafloor positions. For this purpose, we divided data from one campaign epoch into independent subsets, each with one or two days, and compared the obtained coordinates. The best result shows a repeatability of several centimeters in the horizontal components for the averaged coordinates of four sets of stations.

G21D-0298 0830h POSTER

Repeated Observation of Sea-floor Crustal Deformation at Suruga and Nankai Trough in 2002 and 2003

Shingo Sugimoto[1] (sugimoto@eps.nagoya-u.ac.jp); Masataka Ando[1] (ando@seis.nagoya-u.ac.jp); Keiichi Tadokoro[1] (tad@seis.nagoya-u.ac.jp); Takashi Okuda[1] (okuda@seis.nagoya-u.ac.jp); Kazunori Takatani[1] (kazunori@eps.nagoya-u.ac.jp); Kazuyuki Yada[1] (yada@eps.nagoya-u.ac.jp)

[1]Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8602, Japan

In order to monitor seafloor crustal deformation is one of the most important roles of global strain measurement because about 70 % of the Earth's surface is covered with seawater. Additionally, most part of the plate boundaries and seismogenic zones of interplate earthquakes are located under the sea. To achieve the monitoring of seafloor crustal deformation, we have developed a system with kinematic GPS positioning and acoustic ranging. We have repeatedly tested for the accuracy of our system in both Suruga Bay and Kumano Basin, central Japan in 2002 and 2003. The Suruga Bay is an appropriate site to test the seafloor observation system because it can be well-surrounded by coastal GPS reference stations with short baselines $<$ 15km. In addition, a subduction plate boundary between the Philippine Sea and Eurasian plates lies in the Suruga bay, where a large earthquake has been anticipated to occur in a seismic gap. The Suruga Trough is thus worthy of monitoring the sea-floor crustal deformation. In the Suruga Trough, we installed two sets of three ocean-bottom units at depths about 800 m on both sides of the trough on October 29-30 and November 19-21, 2002, respectively. In the Kumano Basin, eastern Nankai Trough, we installed two arrays at about 2200 m depth on June 12 and July 14, 2003. We measured the slant ranges between the acoustic transducer on the observation vessel and those of the ocean-bottom units. Combining ship positions measured by GPS, vessel's attitudes, and acoustic travel-time data, we determine the precise locations of ocean-bottom units. Our system will make it possible to estimate very accurate seafloor position with acoustic ranging data. During the survey we also measured two CTD profiles at the same time over distances 0.1nm to 2 nm, to estimate lateral heterogeneity of the sea-water sound velocity. On the basis of such data, the observations enable us to estimate the strain accumulation at those plate boundaries. We report the evaluation about the locations of ocean-bottom units and these systematic errors in our whole observations. The present observation system will attain a centimeter-level resolution of sea-bottom position.

G

G21E MCC: 2010 Tuesday 1020h

Effect of Atmosphere and Ocean on Geodesy and Geodynamics: Observation and Modeling I *(joint with A, OS)*

Presiding: **D A Salstein,** Atmospheric and Environmental Research, Inc.**; T Johnson,** U.S. Naval Observatory

G21E-01 1025h

Global atmospheric datasets for excitations of Earth rotation and gravity

David Salstein (781-761-2229; salstein@aer.com)

Atmospheric and Environmental Research, Inc., 131 Hartwell Ave., Lexington, MA 02421

Atmospheric reanalyses are routinely used in geodetic applications because of their general reliability and consistency. Those from the US National Centers for Environmental Prediction-National Center for Atmospheric Research span over 55 years, including the whole era during which satellite-based data were available for ingestion into data assimilation systems. From this reanalysis system, fields of winds and surface pressures are used to compute excitations for Earth rotation and polar motion and related values of the torques that transfer angular momentum between the atmosphere, ocean, and solid Earth. Additionally, the surface pressure field closely reflects the atmospheric mass distribution, important for studies of terrestrial gravity. The reanalyses of the European Centre for Medium Range Weather Forecasts, first over 15 years, and scheduled soon for 40+ years, provides an alternate, and higher resolution, set of such data. These supplement the operational series that provide the state-of-the-art results at any particular time. To investi-

gate periods outside those spanned by reanalyses, or to study how the atmosphere dynamically interacts with the solid Earth, we turn to atmospheric models driven by appropriate boundary conditions. For example, monthly mean results from 19 different general circulation models from the second phase of the Atmospheric Model Intercomparison Project, for the period 1979-95, are used to study the relationship of the atmosphere to length of day and polar motions. We note the seasonal and interannual variability of such excitation terms, including the spread among models, which may be considerable. We seek to determine the most effective set of physical modeling techniques that yield the observed (three-dimensional) fields of angular momentum and the related Earth rotational parameters of interest. When such models are run for extended periods of time, they may used to estimate the angular momentum over century-long periods; an example of such a model is that of the U.K. Hadley Centre. Lastly, coupled atmosphere-ocean models are necessary to understand the fluids' angular momentum and mass balance and geodetic implications. Future global warming scenarios have been simulated with these models and organized in the Coupled Model Intercomparison Project.

G21E-02 1040h INVITED

The Dynamics of Equatorial Atmospheric Angular Momentum

Steven B Feldstein (814-865-7042; sbf@essc.psu.edu)

EMS Environment Institute The Pennsylvania State University, 2217 Earth-Engineering Science Building, University Park, PA 16802, United States

The physical processes that drive intraseasonal equatorial atmospheric angular momentum (EAAM) fluctuations are examined with data from an aquaplanet GCM run and with NCEP/NCAR reanalysis data. The GCM has an all-ocean lower boundary with a zonally symmetric sea surface temperature field. The EAAM budget is dominated by the equatorial bulge torque in both the GCM and in observations. For the GCM and the atmosphere, both components of the EAAM vector exhibit a strong spectral peak near a period of 10 days. An analysis with the linearized shallow water model equations on the sphere shows that this 10-day period can be interpreted as arising from the westward propagation of a free, antisymmetric, zonal wavenumber one, Rossby wave. The amplitude fluctuations of the EAAM vector are found to be related to tropical convection in both the GCM and the atmosphere. For the GCM, this convection is associated with an equatorial mixed Rossby-gravity wave. In the atmosphere, in addition to mixed Rossby-gravity waves, EAAM amplitude fluctuations are also related to both the Madden-Julian Oscillation (MJO) and to constructive and destructive interference between the propagating and stationary components of EAAM vector. The latter two processes arise because of the large, nonzero, seasonal mean values of the components of the EAAM vector. The above findings collectively suggest that the latent heat release in the tropics excites poleward Rossby wave propagation which alters the amplitude of the EAAM vector.

G21E-03 1100h INVITED

Oceanic Excitations of Earth Rotation from Model Estimates and Altimeter Observations

Jianli Chen[1] (chen@csr.utexas.edu)

Clark Wilson[1,2] (clarkw@maestro.geo.utexas.edu)

[1]Center for Space Research, University of Texas at Austin,, 3925 W. Braker Lane, #200, Austin, TX 78759, United States

[2]Department of Geological Sciences, 1 University Station C1100, Austin, TX 78712, United States

We estimate oceanic contributions to polar motion and length-of-day (LOD) variation using outputs from a data assimilating ocean general circulation model (OGCM) and sea level anomalies derived from TOPEX/Poseidon satellite radar altimeter observations over a 9 years' period (1993 - 2001, with steric effects removed using the model). Both altimeter derived oceanic mass variations and 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 results from previous studies.

G21E-04 1120h

Temporal Evolution of Atmospheric and Oceanic Excitation of Earth Orientation Variations During the Past 50 Years

Richard S Gross[1] (1-818-354-4010; Richard.Gross@jpl.nasa.gov)

Ichiro Fukumori[1] (1-818-354-6965; fukumori@jpl.nasa.gov)

Dimitris Menemenlis[1] (Dimitris.Menemenlis@jpl.nasa.gov)

[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, United States

The Earth rotates about its axis once a day, but does not do so uniformly. Instead, the rate of rotation fluctuates by up to a millisecond per day, and the Earth wobbles as it rotates. The principle of conservation of angular momentum requires that changes in the rotation vector of the solid Earth must be manifestations of (a) torques acting on the solid Earth or (b) changes in the mass distribution within the solid Earth, which alter its inertia tensor. Angular momentum is exchanged between the solid Earth and the fluid regions (the underlying liquid metallic core and the overlying hydrosphere and atmosphere) with which it is in contact; concomitant torques are due to hydrodynamic or magnetohydrodynamic stresses acting at the fluid / solid Earth interfaces. Here, the principle of conservation of angular momentum is used to study the effect on the Earth's orientation of changes in the mass distribution and motion of the atmosphere and oceans that have occurred during the past 50 years. The winds and surface pressure fields of the NCEP/NCAR reanalysis project are used to model the time varying angular momentum of the atmosphere since 1949. The NCEP/NCAR reanalysis surface fluxes are also used to force a model of the global oceans. The time varying angular momentum of the oceans since 1949 is computed from the resulting oceanic currents and bottom pressure fields. The modeled atmospheric and oceanic angular momentum series are then compared to observed changes in the Earth's orientation. The agreement between the observed and modeled Earth orientation variations is shown to improve as the accuracy of the Earth rotation observations and atmospheric and oceanic models has improved during the past 50 years.

G21E-05 1135h

Acceleration of Mass Inflow from Glaciers to the Ocean

Mark B Dyurgerov (303-492-5800; dyurg@tintin.colorado.edu)

Net melt-water inflow defined here as the additional mass (B) contributed by glaciers to the water cycle and to the ocean resulted from negative mass balance of glaciers averaged worldwide. Net melt-water inflow has been contributed of about 20-30% of total rise in the sea level, but (B) believed to be the dominant component of mass flux, because the steric component does not contribute into this. Acceleration in (B) flux from glaciers to the ocean, observed directly over the last decades, may affects the changes in gravitational field and oblateness of Earth, and may regionally affects of water salinity, temperature and circulation. I use here the results of direct measurements of (B) from about 300 individual glaciers worldwide averaged by mountain and subpolar systems to show acceleration in glacier contribution to mass input to the ocean over the last decades. I will also show on how this input shifts in time from the Northern and Southern hemispheres.

G21E-06 1150h

Ocean-Atmosphere interaction observed from comparison of the ENSO signatures in the time series of J_2 and the Earth's spin rate

Ming Fang[1] (617-253-3077; fang@chandler.mit.edu); Xiaoyun Zang[1] (xiaoyun@ocean.mit.edu); Dawei Zheng[2]; Bradford H Hager[1]; Carl Wunsch[1]; Xiaoli Ding[3]

[1]Department of Earth Atmospheric & Planetary Sciences, MIT, 77 Mass. Ave., Cambridge, MA 02139, United States

[2]Shanghai Observatory, Chinese Academy of Sciences, Nandan Road, Shanghai 200030, China

[3]Department of Surveying & Geo-informatics, Hong Kong Polytechnic University, Hong Horn Kowtoon, Hong Kong 033333, Hong Kong

Significant interannual variations have been observed from the multi-satillite SLR solutions of the Earth's oblateness, known as the J_2 time series, by the Texas CSR group (Cheng & Tapley, submitted) with a time span from 1975 to the present, as well as by our independent analysis of the Godard series (courtesy of Ben Chao for the data) with a time span from 1979 to the present. These variations are closely related to the ENSO events as evidenced by their apparent correlation, not perfect though, with the Southern Oscillation Index. Our preliminary analysis shows that the ENSO signature in the atmospheric circulation is not adequate to account for up to 50% of the interannuals in the J_2 series. In contrast, the atmosphere contributes better than 80% of the observed time variation of the Earth's rotation rate i.e. the length of day (LOD) at the ENSO time scale, mostly from the thermally driven eastward wind fields (e.g. Zheng et al, 2003). We normalize the LOD and J_2 series by making the maxima in both data sets units, and make a comparison. A strong correlation is found between the LOD and J_2. It is apparently due to a common cause from the ENSO. At the same time, noticeable differences are observed, especially with the phases. These differences are ultimately attributed to the ocean-atmosphere interaction during the ENSO events. As a preliminary study, we calculate the oceanic contribution to the interannuals of LOD and J_2 by running a high-resolution state-of-art self-consistent and volume conserving ocean numerical model with realistic atmospheric forcing. A simple model for the ocean-atmospheric interaction will be employed to calculate the changes in the wind and pressure fields. Solid Earth deformation induced by the bottom pressure change is also considered in the modeling. Correlation analysis are conducted between the "fully model" ENSO driven LOD and J_2. Comparisons between the observed and modeled correltions will be presented.

G21E-07 1205h INVITED

New Perspectives by Considering Jointly Earth Gravity and Rotation

Harald Schuh[1] (harald.schuh@tuwien.ac.at)

Laura Fernandez[2] (lauraf@fcaglp.unlp.edu.ar)

[1]Institute of Geodesy and Geophysics, Vienna University of Technology, Gusshausstr. 27-29, Wien 1040, Austria

[2]Facultad de Ciencias Astronomicas y Geofisicas, Universidad La Plata, Paseo del Bosque, La Plata B1900FWA, Argentina

The present satellite missions CHAMP and GRACE and the future GOCE satellite will allow to determine the gravity field of the Earth with high spatial and temporal resolution. A short overview about the present state of these missions will be given. As these satellites will play an important role for the new IAG lead project IGGOS (Integrated Global Geodetic Observing System) the relation between geometry and rotation of the Earth and it's gravity field will be described with respect to the interactions of the various components of system Earth. Mass redistribution, changes of the geometry and variations of the density are common causes for variations of Earth rotation and of the gravity field. Mass redistribution in surface fluid envelopes, e.g. in the oceans and in continental water reservoirs (soil moisture, snow cover, and groundwater), in the cryosphere, and to a small amount in the atmosphere could cause such variations that occur on very different time scales. As CHAMP and GRACE shall produce monthly gravity field solutions all short-term (hourly to weekly) atmospheric, oceanic and hydrological mass variations have to be taken into account because these mass variations cause time variant forces acting on the orbiting satellites. For this process, called de-aliasing, appropriate models of the mass variations are required that could be validated by observed short period EOP variations. Vice versa, medium and long periods detected in the gravity field could be taken for comparison and validation of EOP variations in the particular frequency band. The continental water storage change was studied using a model based on assimilated soil moisture and snow accumulation data from the NCEP/NCAR reanalysis with a Gaussian scheme grid of 1.875° in longitude and about 1.905° in latitude. The soil moisture data include two layers from the surface to 200 cm in depth. The Stokes time series were calculated up to degree two. Using the trace of the Earth inertia tensor as well as C20 changes, the variations of the EOP due to this continental hydrology model are shown.