stress perturbations are then used to predict the visco-elastic and poro-elastic response of the Earth's crust within a few hundred kilometers from the earthquake rupture. Calculations are performed for both the homogeneous and layered half-space models. The predicted surface deformation is compared to the Interferometric SAR and GPS data. The stacked InSAR data spanning the time period between 1992 and 1999 reveal a transient post-seismic deformation with a characteristic decay time of several years. The observed deformation pattern cannot be readily explained by any single mechanism. In particular, the data exhibit high strains across the Landers rupture, inconsistent with visco-elasic models of relaxation in the lower crust or upper mantle. The poro-elastic model quite well predicts the InSAR signal, assuming that the pore fluid flow extends to the middle crust (down to about 15 km), but it underpredicts the far-field GPS data. We demonstrate that a combination of poro-elastic relaxation above the brittle-ductile transition, and afterslip on the Landers rupture is required to satisfactory explain both the InSAR and GPS data.

URL: http://igpp.ucsd.edu/~fialko/res_land.html

G21B-0273 0830h POSTER

Measuring inter-seismic deformation by INSAR in Eastern Turkey

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We seek to measure interseismic deformation across the fault systems intersecting at the Karlova Triple Junction using radar interferometry at C-band (5 cm) wavelengths. We have obtained ERS interferograms with enough correlated pixels to interpret for pairs spanning up to 3 years, provided that the images are both acquired in the summer months (June-September) and the altitude of ambiguity is very favorable (over 500 m in absolute value). This result extends the work of Wright et al. [GRL, 2001]. We have developed an approach that analyzes changes in range in profiles perpendicular to the strike of the fault. After unwrapping, these profiles show gradients which combine the interseismic deformation signal with the unmodeled orbital effects. Previous studies have neglected the orbital errors. To separate the former from the latter, we apply an approach called temporal adjustment that estimates both interseismic deformation parameters and orbital corrections. We compare the INSAR results to available GPS estimates.

G21B-0274 0830h POSTER

Connecting Aseismic Slip and Microseismicity on the Central San Andreas Fault

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High precision micro-earthquake relocations have revealed seismicity structures that may be an indicator of the fault's slip characteristics. Characteristically repeating micro-earthquakes and aligned streaks of micro-seismicity suggest that these structures are associated with areas of active aseismic fault slip. A general inverse correspondence between zones of abundant micro-seismicity and the coseismic slip area of large earthquakes also implies a relationship between creep and micro-earthquakes. We test this relationship using geodetic measurements of near-fault deformation. Modeling of such measurements allow for determination of locked and creeping sections of the fault. We focus on the central San Andreas fault near San Juan Bautista; a segment which experiences both aseismic and seismic fault slip and where there is a long history of geodetic measurements. Aseismic slip on the central San Andreas is time dependent and has varied in response to regional earthquakes and in the form of slow earthquakes. Dislocations in an elastic half space are used to evaluate a range of scenario fault slip models whose geometry is guided by the locations of micro-seismic streaks. The inversions for distributed sub-surface slip are constrained by range-change data from InSAR and GPS site velocities. The InSAR data (ERS1&2 track 299 frame 2861) spans from 1996-2000 and were processed using ROI_Pac with the SNAPHU unwrapper and combined in a patchwork stack to reduce atmospheric errors. Campaign and continuous GPS data were processed using GAMIT/GLOBK and form part of the regional BĀVŪ dataset. To minimize the effect on our analysis of transient slip induced by the 1989 Loma Prieta earthquake, we limit our dataset to GPS observations from 1994 to 2003. Preliminary results confirm that the presence of seismicity streaks and characteristically repeating micro-earthquakes are indicative of aseismic slip. However, the absence of such seismicity patterns does not necessarily rule out active fault creep.

G21B-0275 0830h POSTER

High Resolution Continuous Tilt and Strain Measurement on Trizonia Island, Corinth Rift, Greece. Evidence for a Slow Transient Associated With a Seismic Swarm

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The Trizonia Island is located near the northern coast of the Gulf of Corinth, 5 to 10 km above the principal active normal faults, dipping north. The rate of deformation is 1.5 x10-6/yr, according to GPS measurements. Within the CORSEIS project (European Community), strain and tilt continuous measurements began in October 2002 on this island, in order to detect transient strain related to the opening and to the seismicity of the rift. In particular, they aim at detecting possible aseismic deformations related to the frequent seismic swarms of the zone, in a radius of 20 km. Hydrostatic tiltmeters, two NS and two EW, 15 m long, one filled with mercury, the other with water, were built at IPGP and were installed in parallel, 3 m under ground. Their resolution is presently 10-9 rad at short period, with continuous recording at 30 s sampling rate. The Sacks-Evertson dilatometer is installed 1 km away at 150 meters depth, and has a resolution of 10-10, with a continuous record at 5 Hz, and 50 Hz in trigger mode. The 3rd of december 2003, the strainmeter recorded a strong signal, with 10-8 amplitude, lasting one hour.It reaches a peak at about 23:04:30 UT, and then decreases and vanishes back in the tidal signal. At the maximum of the strain anomaly, the record shows the high frequency strain waves of a local earthquake located 14 km west to the site (23:04:39.5 UT,38 deg 20.42N 21 deg 53.79E),at 8 km in depth. It has reported magnitudes 3.7, and is the largest event of a swarm, which lasted about 2 weeks. The precise time coincidence of both events lead us to propose physical correlation between them, in which case the M=3.7 event seems to be triggered by the slow transient which has an equivalent moment magnitude of a 4.5 silent earthquake.

G21B-0276 0830h POSTER

Geodetic and Hydrological Aspects of the Merano Earthquake of July 17, 2001

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Even a relatively small earthquake can become a study case if the seismological data are augmented with non conventional information, such as geodetic and hydrological data. This could be the case of the M=4.8 earthquake of 17 July 2001 with epicentre near Merano, in Northern Italy, where a two year long time series of the permanent GPS station MERA, a few km from the epicentre, and water table data from four wells within 8 km of the estimated epicenter are available. A step-like signal in the time series of the geodetic coordinates of MERA is found to be simultaneous with the epoch of the earthquake. If such jump is interpreted as a co-seismic displacement, the fault plane solution of this strike slip earthquake is constrained in a manner which is consistent with the general tectonic setting of the area. Geodetic and seismological data are used to constrain the depth of the hypocenter. We show that the fault dislocation data and the geodetic displacement of the GPS station clearly support the hypothesis of a shallow earthquake ($<$ 5 km depth), in contrast with other, purely seimological indications of a deeper (12-15 km) hypocenter. We speculate that a visco-elastic relaxation model can explain the postseismic non linearities in the GPS time series, if the upper crust is mechanically decoupled from the lower crust by a ductile channel. However the relaxation times are long compared to the time series and the fit of the model to the data does not constrain the model parameters reliably. Water level data from four wells in the epicentral area show small, random changes which become coincident at the epoch of the earthquake. Assuming that the wells can be treated as hydraulic heads, we numerically compute the strain field generated on the surface of an elastic half space subject to a localized stress drop on the fault. Using the published fault plane solution as a model of the excitation source we show that the form of the changes of the water level are consistent with the one we predict numerically. Because all the wells show a rise in the water level, they must be in a compressional sector and this helps in narrowing the number of candidate epicenters. We conclude that the addition of geodetic and hydrologic data to the seismological data enables, in this study case, both the hypocenter and the fault plane solution to be constrained more uniquely than with seismological data alone.

G21C MCC: Level 1 Tuesday 0830h

Postglacial Rebound and Sea Level Posters *(joint with OS, C)*

Presiding: **E Schrama,** Delft Institute for Eartjh-Oriented Space Research, Delft University of Technology**; J A Henton,** Natural Resources Canada

G21C-0277 0830h POSTER

An inter-comparison of ocean tide loading estimates for Antarctica from models and GPS

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We present ocean tide loading (OTL) estimates for Antarctica based on several numerical tide models and direct estimates from GPS observations. Accurate estimates of the ocean tides in the Antarctic region are difficult to obtain from numerical ocean tide models due to the lack of bathymetric information and direct tidal observations in the sub ice shelf regions in particular. Consequently, independent measurements, such as from GPS, with an extensive spatial distribution are extremely important to ensure geodetic and altimetric (e.g, IceSat) measurements are not biased by mismodelled OTL. We show that there are large variations in diurnal and semi-diurnal OTL estimates from nine numerical tide models in the regions of the very large Ross and Filchner-Ronne ice shelves. The standard deviations of the M_2, S_2, O_1, K_1 model estimates in these regions have a maximum of approximately 10, 5, 5 and 5 mm respectively for the real components and approximately 10, 5, 3 and 3 mm respectively for the imaginary components. These represent variations of up to 50% of the modelled load. Recent numerical tide models are in better agreement, although substantial variation still exists. In the non ice shelf regions the models are typically in agreement at the 1-2 mm level. We report on the impact of this mismodelling on ice sheet thinning rate estimates from GLAS measurements with the degraded IceSat orbit. In order to provide an external validation of the model estimates we estimated the eight major diurnal and semi-diurnal harmonic loading terms directly in our GPS analysis of data from $\sim$ 20 sites distributed mainly around the perimeter of the continent. By combining estimates from up to several thousand days at each site constituent amplitudes were determined with uncertainties generally less than 1 mm. Phase uncertainties are dependent on the constituent amplitude but are generally 5-20°. We compare these

estimates with the modelled values and recommend optimal numerical tide models to be used in OTL computations for geodetic measurements in Antarctica.

G21C-0278 0830h POSTER

Characterization of Instabilities in the Tidal Deformation of a Planetary Body

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In 1911, A.E.H. Love published a linear elastic model for the tidal amplitude of a uniform, compressible, self-gravitating body. Recent numerical evaluations of the solution to his governing equations reveal portions of parameter space for which infinitesimal tide raisers can raise tides of arbitrary height. In addition, using a solution technique somewhat different from Love's, investigations have been made into the effect of allowing non-uniform, radially varying material parameters in Love's formulation. The solution depends only on the effective gravitational rigidity, $\rho g R/\mu$, and the ratio of rigidity to Lamé constant, μ/λ. It has been found that the tidal instabilities persist when the body has a radially dependent density profile. However, as the magnitude of the density variation is increased, the singularity can be stabilized for certain fixed nonzero values of the rigidity and compressibility. In the two dimensional projection of the phase space (defined by the two ratios mentioned previously), it can be seen that increasing the magnitude of the density variation tends to move the location of the singularities out of the region of "physically significant" material parameters.

G21C-0279 0830h POSTER

Analyzing European Inter-Annual Sea Level Variability Using Tide Gauges and Altimetry.

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Along the European coasts, tide gauges have been used to monitor sea level for decades. For the last decade sea level have also been monitored by the T/P satellite altimeter at high spatial low temporal coverage . A comparative analysis of sea level from tide gauge and Topex/Poseidon (T/P) altimeter is an integral part of the European Sea Level Service - Research Infrastructure (ESEAS-RI) project. The seas around Europe are divided into sub basins, realizing that each basin has different characteristics, with regard to the dominant frequencies of the sea level heights, not least due to the physical configuration where narrow straits separates the basins (i.e. the Mediterranean, Baltic, Black Sea). Our analysis shows good agreement in the frequency response between tide gauges and T/P measurements, especially on timescales of 1-5 years. This holds for both closed basins and the open Northeast Atlantic Ocean. Despite their location on the basin margins, tide gauges capture the inter-annual variability on a wider spatial scale quite well. When analyzing long (50+ yrs) time series from tide gauges, it is evident, that the dominant frequencies within a basin changes over time. However, the frequency change patterns seems to be similar from basin to basin.

URL: http://research.kms.dk/~eseas

G21C-0280 0830h POSTER

Combination of altimeter data, tide gauge data and ocean climatology to reconstruct sea level change.

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This contribution deals with the combination of satellite altimetry data from the TOPEX and JASON-1 altimeter, in-situ tide gauge data and climatologic data to reconstruct long periodic variations and systematic trends in the sea level. The approach we take is to calibrate in a relative sense both altimeter systems which have operated in tandem mode during the first half year of the JASON-1 mission. As a result we find a relative altimeter bias of about 10 cm. This value is determined from the JASON-1 interim geophysical data records (IGDRs) that come with a sea state bias algorithm. Then we evaluate the absolute altimeter bias with a global network of tide gauges. This enables us to determine the sea level trend of which we provide a number of estimates including a land motion term of the involved gauges. Next we recognized that the global sea level trend is affected by the presence of annual and semi-annual cycles and the 1997-1998 ENSO. The annual cycle turns out to be related to steric variations in the oceans as can be shown by comparing the signal to a steric annual cycle reconstructed from a ocean climatologic atlas. In a similar way this atlas allows us to estimate the global thermosteric trend signal in the oceans for which we now find 1.5 mm/yr in the form of a global eustatic sea level rise.

G21C-0281 0830h POSTER

Glacial Isostatic Adjustment in North America Observed by Continuous and Episodic GPS

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We use continuous and episodic Global Positioning System (GPS) data to measure the movement caused by glacial isostatic adjustment (GIA) due to glacial unloading in eastern North America. At present it is challenging to quantify GIA motion in North American because of the limited distribution of continuous GPS sites in and around Hudson Bay, the area of maximum glacial loading. In the last two years new continuous GPS sites have been established in Canada, but they are presently of limited use due to their short time series. Episodic GPS sites provide a low cost and higher density alternative, but often have large errors, especially in the vertical. However, the large vertical signal due to GIA (>10mm/yr) in the area of maximum uplift permits this motion to be resolved, even with episodic GPS data. We present data from over 100 continuous GPS sites throughout North America and more than 40 GPS sites of the Canadian Base Network (CBN). The CBN sites located across central and southern Canada have been episodically occupied between 1994 and 2002. We have detected a coherent pattern of vertical motions around the area of maximum glacial loading, Hudson Bay. The observed velocities are initially large and upward, and decrease southward from Hudson Bay to zero, delineating the hinge line near the Great Lakes. The position of the hinge line is in agreement with some numerical GIA predictions. A three-dimensional site velocity distribution may permit assessment of the role of GIA in the seismicity of eastern North America.

G21C-0282 0830h POSTER

Absolute Gravity and Global Positioning System Measurements of Uplift in Quebec and Eastern Ontario, Canada

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The Nouveau Quebec-Labrador region was the site of one of the major ice domes of the Laurentide Ice Sheet and is currently experiencing postglacial rebound. Geodetic data provide a useful and accurate method of measuring the pattern and rates of contemporary uplift in this region. In order to monitor the temporal variations in gravitational potential resulting from regional glacial isostatic adjustment, a number of absolute gravity sites have been established in northern Quebec. These absolute-gravity field stations are co-located with sites of the Canadian Base Network (CBN). Initiated in 1994, the CBN is a network of pillar monuments with forced-centering plates for Global Positioning System (GPS) receiver antennae. Accurately positioned three-dimensionally with GPS, the CBN can serve as a monitoring network for deformation studies of the Canadian landmass. Issues such as mass redistribution or changes in density contrasts within the Earth may be better addressed by monitoring positional changes (*i.e.*, primarily height changes) and integrating these observations with gravitational variations. The comparison of the temporal rate of change of gravity with the GPS height rate is thus highly desirable. Recent velocity estimates based on both the multiple-epoch GPS network surveys as well as the preliminary results from absolute-gravity trends indicate regional uplift. These preliminary results also exhibit general agreement among the uplift rates for GPS radial velocities, gravity trends, and predictions of vertical crustal motion from post-glacial rebound models. Monitoring the temporal rate of change of gravity at key GPS sites is also an important step towards the maintenance of an integrated reference system. Co-located with the Canadian Geodetic Long Baseline Interferometry site at the Algonquin Radio Observatory (A.R.O.), the Canadian Active Control System's continuous GPS station at Algonquin Park, Ontario (ALGO) serves as an important reference site for many regional surveys, including this study. A.R.O. has thus been singled out as a key field station where a comparison of the temporal rate of change of gravity with the GPS radial position rate of change is highly desirable. Unfortunately to date, the uplift rate determined from the gravity trend at Algonquin Park appears much larger than the GPS-observed and model-predicted rates. With the gravity measurements taken at the stable base of the Algonquin Radio Observatory's 46m VLBI telescope, the cause of this apparently high uplift rate is unknown. Although the data will be further analyzed for possible instrumental offsets or biases, it is likely that the gravity trend is biased by variations in the local mass budget due to environmental or hydrological effects. To quantify these effects, we have begun more frequent (∼monthly) absolute gravity measurements. Additionally, pending further testing and evaluation, data from an autonomous, continuously-recording (but yet to be installed) gravimeter will be coupled with the absolute measurements to develop and test models of seasonal variations in the gravity field at A.R.O. due to groundwater effects.

G21C-0283 0830h POSTER

Repeated High-Precision Gravity and GPS Measurement Techniques

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Repeated high-precision gravity and GPS measurements are becoming a common tool for tracking changes in subsurface reservoirs. Despite this, there is little literature which discusses measurement techniques and the expected errors. Our research has focused on improving measurement techniques to be applied to ground water and geothermal steam reservoirs, including quantifying the minimum error levels with modern equipment. We applied these methods in two studies: ground water monitoring of the southern Salt Lake valley, Utah, USA, and steam monitoring of The Geysers geothermal field, California, USA. Gravity measurements using modern relative high-precision meters, such as Scintrex CG-3Ms or L&R E series, can now be routinely made to an accuracy of 5 μGal. Such accuracy requires the use of time series analysis at each station, and non-linear instrument drift functions. Modern computerized meters are capable of internally storing a time series of measurements for each station; older meters can often be fitted to log such data to a field computer. This time series, typically of 10-15 minute duration in our work, can then be analyzed in several ways to produce stable estimates of the gravity reading. In particular, our research has emphasized using a weighted arithmetic average (for long occupations), or a Thiele extrapolation scheme (for shorter station occupations). Instrument drift is removed through a superposition of a linear long-term drift function, and an empirical staircase function formed from differences between repeated station occupations. To achieve high-accuracy GPS measurements while maximizing the number of field stations in a survey, rapid-static measurements are necessary. We have tested the effect of occupation time and processing schemes on the absolute accuracy of the resulting GPS position. Using a post-processing differential method with a fixed (but not necessarily continuous) base station within 15 km, positioning error of <4 cm vertical is achievable with 30 minute occupations and broadcast orbital parameters. There is a definite correlation between baseline length and positioning accuracy. Using precision orbital parameters removes this correlation. Occupations of 60

minutes or more also improve accuracy; combining 1 hour occupations with precise orbital data yields a vertical error of <3 cm for all stations within 20-30 km of the fixed reference. In both case studies, gravity measurements tracked known mass changes in the reservoir. In the southern Salt Lake valley study, mass changes measured along the line of gravity stations qualitatively tracked water well level changes, but very complicated local hydrology precluded more detailed quantitative comparisons. At the Geysers, the station grid shows coherent spatial signals, with gravity changes that are within measurement error of theoretical predictions.

URL: http://thermal.gg.utah.edu/~gettings

G21C-0284 0830h POSTER

Sea Level, Tectonics, Environmental Monitoring and Altimeter Calibration in Eastern Mediterranean

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The Eastern Mediterranean area is one of great interest for its intense tectonic activity as well as for its regional oceanography. Recent observations convincingly demonstrated the importance of the area for regional meteorological and climatologic changes. Monitoring tide-gauge locations with continuous GPS on the other hand removes the uncertainties introduced by local tectonics that contaminate the observed sea level variations. Such a global tide-gauge network with long historical records is already used to calibrate satellite altimeters (e.g. on TOPEX/POSEIDON, GFO, JASON-1, ENVISAT, etc.), at present, a common IOC-GLOSS-IGS effort –TIGA. Crete hosts two of the oldest tide-gauges in the regional network, at Souda Bay and Heraklion. We recently completed the instrumentation of a third, state-of-the-art mean sea level (MSL) monitoring facility in southwestern Crete, on the isle of Gavdos, the southernmost European parcel of land. Our project (GAVDOS) further expands the regional tide gauge network to the south, and contributes to TIGA and MedGLOSS. The presentation will focus on the altimeter calibration aspect of the facility, in particular, its application to the JASON-1 mission. Another component of the "GAVDOS" project is the repeated occupation of the older tide-gauges at Souda Bay and Heraklion, and their tie to the new facility. We will present results from positioning of these sites and some of the available tidal records. The Gavdos facility is situated under a ground-track crossing point of the original T/P and present JASON-1 orbits, allowing two calibration observations per cycle. It is an ideal site if the tectonic motions are monitored precisely and continuously. The facility hosts in addition to two tide gauges, multiple GPS receivers, a DORIS beacon for positioning and orbit control, a transponder for direct calibration, and is visited periodically by water vapor radiometers and solar spectrometers, GPS-laden buoys, and airborne surveys with gravimeters and laser profiling lidars. The French transportable laser ranging system (FTLRS) completed recently a co-location campaign at Chania, Crete, for improved orbit control over the site, and to ensure the best possible and most reliable results.

URL: http://www.gavdos.tuc.gr

G21C-0285 0830h POSTER

Results of TOPEX/Poseidon-Jason Calibration and Recent Changes in Global Mean Sea Level

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The Jason-1 radar altimetry mission was designed to resolve changes in global mean sea level variation to provide for studies of interannual sea level change. We have completed a calibration of the Jason-1 measurements as part of an effort to continue the 10-year time series of sea level change measurements compiled by the TOPEX/ POSEIDON (T/P) mission. We have completed detailed comparisons of the T/P and Jason-1 sea level measurements, including each of the measurement corrections using the latest instrument and geophysical corrections, including precise orbits and seastate bias models. We present the results of cross-satellite and independent tide gauge calibrations. In late 2002 global mean sea level (GMSL) as measured by Jason-1 and TOPEX/POSEIDON satellite altimetry surged by 15 mm over a period of a few weeks. This anomaly is on the order of the longer surge seen during the strong El Niño event of 1998. Interannual and low-frequency signals in sea level variability can have significant effects on the recovery of secular trends in short records. *Nerem et al.* [1999] estimated that one would need at least 10 years of continuous altimeter coverage to resolve a 2 mm yr^{-1} secular trend with an accuracy of 0.5 mm yr^{-1} in the presence of ENSO variability. Similarly, *Chambers et al.* [2002] have observed that long-term GMSL from tide gauges is significantly affected by El Niño/Southern Oscillation (ENSO) climate cycles, although the size of the Southern Oscillation Index (SOI) does not predict the magnitude of change in GMSL. Sea level anomalies associated with El Niño events are mostly attributable to steric changes in the ocean. However, thermal affects mask eustatic changes due to the addition of water to the ocean, such as surges in glacier melt [*Dyurgerov*, 2002]. We use results from satellite altimetry, Expendable Bathythermograph, and the Estimating the Circulation and Climate of the Ocean (ECCO) model to investigate the spatial extent and depth distribution of the contributions to GMSL.

G21D MCC: Level 1 Tuesday 0830h

Deformation Processes Posters

Presiding: **J T Freymueller,** University of Alaska, Fairbanks**; M Battaglia,** University of California, Berkeley

G21D-0286 0830h POSTER

Continental Dynamics Between India and Antarctica by Global Network Solution Using Maitri, Indian GPS Station at Antarctica

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The GPS-Geodesy program initiated in 1995 by establishing a Permanent IGS GPS Tracking station at NGRI has resulted in the estimation of Indian plate motion to be 37 $\pm$2.0 mmy^{-1} towards NNE direction. To understand the tectonic activity and crustal deformation in the south of Indian peninsula, the driving mechanisms and the response of the Indian Ocean Lithosphere and holistically compound the Indian Plate kinematics, NGRI has extended the GPS-Geodesy programme by establishing a permanent GPS station at Maitri, at Antarctica in 1997 in Schirmacher oasis between SANAE and SYOWA. The data from the IGS stations in the islands surrounding Indian plate is included in the global network solution. Very long baselines from Kerguelen, as it is relatively a stable site, to Maitri and other IGS Stations in different plates Casey, Davis, Seychelles, Coco, Hartebeesthoek, Yaragadee, and Tidbinbilla have been estimated. The GPS derived velocity vectors of these sites throw a significant insight into the plausible causes of northward movement of Indian plate. These results also elucidate the strain accumulation processes in the Indian Ocean and the effects of these forces on the Indian Plate.

G21D-0287 0830h POSTER

Observation of Sea-floor Deformation in Tokai-Nankai Region, Japan

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We have developed an observation system for observing sea-floor crustal deformation. The observation system is composed of 1) acoustic measurement between a ship transducer and sea-floor transponders, and 2) kinematic GPS positioning of the observation vessel. A sea-floor positioning test has revealed that our system can obtain the horizontal location of a sea-floor station within 5-6 cm (95-% confidence interval) [Tadokoro et al., 2001].
We installed transponder networks at Tokai region (Suguga trough), and Nankai trough, Japan, with water depths of 1000-2200 m. The transponders are set in a 13-inchs glass sphere, and equipped batteries for five-years-measurement. Large subduction earthquakes are expected to occur in these regions during early this century. It is necessary to monitor spatial distribution of coupling regions and their temporal changes for predicting these earthquakes and disaster prevention. The sea-floor transponder network is expected to be a useful tool to accomplish them. Each network is composed of two to four transponder arrays. We plan to monitor sea-floor deformation in the regions five years.
The GPS positioning causes the major error in our whole system. An experiment on kinematic GPS positioning with several base lines and a moving antenna shows that larger base lines, especially for those about 50 km or longer, causes larger GPS positioning error [Sato et al., 2001].
Temporal and spatial variations of sound speed structure in seawater is also a possibility of error source. We repeatedly measured sound speeds in regions of about 4 square-miles by using CTD profilers. The results are as follows:) The long-term (seasonal and annual) change in sound speed is up to 15 m/s (1 %) in a portion shallower than about 600 m.) The short-term (within several hours to one day) change is 3-5 m/s at several layers.
We also performed CTD profiler measurements with two vessels so that we could detect correct lateral variations of sound speed. The distances between the two vessels are 2, 1, 0.6, 0.3, and 0.15 miles. The two vessels were located on lines parallel and perpendicular to the orientation of ship drift.
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The Adriatic region: an independent microplate within the Africa-Eurasia collision zone

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We use Global Positioning System measurements at 30 sites to study crustal motion in the Adriatic region (central Mediterranean), alternately viewed as a promontory of North Africa or as a microplate within the Africa-Eurasia plate boundary.

We employ publicly available GPS observations made stations of the European Reference Permanent Network (EUREF) and the Italian Space Agency (ASI) continuous GPS networks to estimate deformation in the Adriatic region. We analyze the data using the GAMIT/GLOBK software. To improve the realization of a stable reference frame for the velocity solution, additional sites from the International GPS Service (IGS) and EUREF networks are included through the publicly available global regional loosely constrained solutions performed by the Scripps Orbit and Permanent Array Center (SOPAC). All together, our solution includes data spanning 4 years from 106 stations, including 44 in the Mediterranean area. We incorporate 23 additional sites from McCluski et al. [2000] to resolve the deformation in the Eastern Mediterranean and Caucasus.

Preliminary motions (1999-2002), relative to stable Eurasia, show a north-westward motion (N 24±5 W) at 5±1 mm/yr for stations located on the northern edge of the African plate. Sites in Corsica and northwestern Italy show no significant deformation, while the stations close to the Adriatic sea are characterized by a north-eastward motion (N 24±5 E) at 5±1 mm/yr. Stations located on the eastern edge of the Adriatic Sea move in the same direction (N 21±8 E) at a somewhat slower rate (3±1 mm/yr). The northward displacement (N 3±8 E at 3±1 mm/yr) of sites in the southern Italian peninsula may reflect a transition zone between the African plate and the Adriatic region.

To test the competing tectonic models proposed, we develop a block model of regional deformation that accounts for plate angular velocities and strain accumulation on plate boundary faults. The results suggest that an independent microplate model provides a better explanation for most of the deformation observed the Mediterranean area. In particular, this model correctly