Geodesy

G11A MC: 125 Monday 0830h

Operational Altimetry: Data Sources, Systems, and Applications I *(joint with OS)*

Presiding: **G Jacobs,** NRL**; J Lillibridge,** NOAA

G11A-01 0830h INVITED

Ocean Analysis System in the Japan Meteorological Agency

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An ocean data assimilation system (COMPASS-K) has been operated since January 2001 in the Japan Meteorological Agency (JMA). The adopted nudging procedure requires temperature and salinity fields as constraint. Those fields are objectively analyzed from altimeter and ship data using a new analysis method. The analysis area is 30S-60N, 110E-70W of the Pacific, from surface to 2000 m depth. The objective analysis method is as follows. Sea surface height anomaly (SSHA) fields are obtained by a space-time optimum interpolation applied to the TOPEX/POSEIDON altimeter data. Subsurface temperature and salinity anomalies are projected from SSHA using statistical regression relations between temperature/salinity and surface geopotential anomaly. The new point is that the projection is applied in the dual resolutions, i.e., eddy- and large-scale phenomena decomposed by spatial scale, with each own statistical regression relation. The projected temperature and salinity has slightly more consistency with values of ship observation in the comparison with the no-decomposed projection. Surface geopotential anomaly calculated using projected temperature and salinity coincides well with the altimetric SSHA. In order to obtain much more consistency with temperatures from ship observation, those are merged to the projected temperature fields using an optimum interpolation. The merged temperature fields are much improved from the JMA's former objective analysis. The merged temperature fields and the projected salinity fields are adopted as the constraint of the assimilation in the JMA operation.

G11A-02 0845h INVITED

A survey of near real-time oceanographic products for the Gulf of Mexico

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Since 1996, tandem observations of the earth's oceans by altimeters aboard the TOPEX/POSEIDON and ERS-2 satellites have been processed and posted in near real-time on the World Wide Web at the Colorado Center for Astrodynamics Research. Recently, we have added Geosat Follow-On altimetry and are prepared to include altimeter data from the Envisat and Jason-1 missions, as soon as those satellites are operational. Standard daily data products are routinely posted within 18 hours of over flight and have generated significant interest in the online user community. Feedback from these users has given insight into the variety of oceanographic products of interest to operational users. In this presentation, I will present examples of custom online products developed for near real-time monitoring the Gulf of Mexico to introduce several novel altimetry applications and altimeter-derived data products that may be applicable to other oceanographic regions.

G11A-03 0900h

The Navy operational requirements for the Geosat Follow-On satellite altimeter system

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The Geosat Follow-On (GFO) satellite was launched by the Navy to fulfill oceanographic requirements demonstrated by the previously successful Geosat-Exact Repeat Mission. The satellite system is composed of an electronic radar altimeter, microwave radiometer for wet troposphere correction, doppler beacon which provides data for rapid orbit solutions, and laser reflector cubes which provide data from which precise orbits are generated. GFO was accepted as operational in November 2000, and since that time has been returning data within expected accuracies in real time to the ocean community . The significant wave height, wind speed, and sea level observations provided within 48 hours of observation are used within both Navy and NOAA operational centers. All mission data is unclassified and publicly available. The GFO mission is an excellent example of successful interagency collaboration between the Navy, NOAA, and NASA each of which contributes a unique and critical component to this system. This presentation will examine the Navy METOC organization, the tactical use of the GFO altimetry data, a description of the system and the data processing, and the distribution of the raw and processed data to the Navy and to other services. In addition, we will discuss the current and future status of the system.

URL: http://gfo.bmpcoe.org/Gfo/

G11A-04 0915h

Satellite Altimetry: Real Time Data Processing and Analysis

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TOPEX, ERS-2 and GFO satellite altimetry data are processed on a real time basis at the Naval Oceanographic Office. The expected JASON and ENVISAT data streams will be added to these after launch. The processed altimeter data flow to the operational ocean monitoring and prediction systems in the Navy as well as at other research institutes. The data are publicly available and provide input to the Global Ocean Data Assimilation Experiment (GODAE). The techniques used in the real time processing are presented. Extensive analysis is performed on the data, both during and post processing on a daily basis. This allows problems in the data stream or processing to be identified in a real time manner. These analyses demonstrate how much data is flagged as suspect in the processing, at what point it is flagged, and for what reason. Orbit solutions are the greatest source of error in real time altimeter products, and an orbit correction algorithm provides continuous analysis of orbit accuracy. Analysis of the final data is made through examination of crossover rms values, both for each altimeter and between altimeters. The data from all altimeter satellites are processed to provide anomaly deviation from a consistent mean sea level. The results of this processing are presented graphically on a daily basis on "The Real Time Ocean Environment" web site (www7300.nrlssc.navy.mil/altimetry).

URL: http://www7300.nrlssc.navy.mil/altimetry

G11A-05 0930h

Operational near real-time processing of ERS-2 orbits and altimeter data

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NOAA's Laboratory for Satellite Altimetry and the Delft Institute for Earth-Oriented Space Research have been producing near real-time altimetry products for ERS-1 and ERS-2 since 1995, enhancing ESA's fast-delivery data sets with geophysical corrections and near real-time orbits.

Being the largest contribution to altimetric height errors, the precise computation of the satellite orbital altitude is a key element in the generation of the data sets. The process is currently fully automated: at 9:00 UTC the ESA altimeter data are processed into a preliminary product adding fital geophysical corrections and a predicted orbit. The result is immediately converted into altimetric heights and crossovers and injected, together with laser tracking data, into the orbit determination. The final orbit is reinserted into the altimeter product providing a fast-delivery product for the entire previous day at about 9:20 UTC.

Several collaborative efforts in NOAA are using ERS-2 data in operational forecast models. At larger scales, the NCEP Climate Modeling Branch is assimilating altimetry into a coupled model for El Niño prediction. At finer resolution, the NCEP Ocean Modeling Branch is assimilating T/P and ERS-2 altimetry into the Coastal Ocean Forecast System, which produces now cast and 24-hour forecast fields for the Western North Atlantic region. The higher spatial resolution provided by ERS-2's sampling is expected to further improve the model's skill at determining mesoscale features. In collaboration with NOAA's National Hurricane Center a new product has become operational, containing surface height anomalies and, inferred from that, upper ocean heat content and upper layer thickness, which augment sea surface temperature and in-situ subsurface measurements. Again, the higher spatial resolution of ERS-2 will benefit the determination of these oceanic parameters, thereby improving the prediction of tropical cyclone intensity and hurricane forecasting.

G11A-06 0945h

MERCATOR, Near-Real-Time and Routine Ocean Analysis and Forecasting : first results of a one year continuous experience

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MERCATOR develops and operates a suite of analysis and forecasting systems for global ocean, based on routine assimilation of near-real-time observations into three-dimensional ocean models. This french project for operational oceanography is supported by the six public agencies involved in ocean and climate, ie the Space(CNES), Research (CNRS, IFREMER and IRD), Met Office (Meteo-France) and Navy (SHOM) agencies, and developed in collaboration with CERFACS and CLS groups in Toulouse. In the framework of the Global Ocean Data Assimilation Experiment demonstration phase (2003-2005), MERCATOR will run a middle resolution (1/4 of a degree) global ocean model with a high resolution focus (1/15 of a degree) in North Atlantic and Mediterranean regions, and assimilate routinely Jason-1 and Envisat near-real-time altimeter data and in situ ARGO profilers. MERCATOR began its routine operation phase in the early days of year 2001, with a first prototype based on a North and Tropical Atlantic model with a resolution of 1/3 of a degree. Two week ocean forecasts are routinely provided. Near-real-time Topex/Poseidon and ERS-2 altimeter data are processed and assimilated into the Atlantic ocean model based on the primitive equations OPA ocean code (Madec, 1994). The first Mercator Assimilation System is used, based on optimal interpolation SOFA scheme (De Mey, 1994) and the PALM coupler (Piacentini, 1998). Weekly forecasting bulletins are provided each Wednesday since 17 january 2001 with more than 800 new maps each week. With support of sea experiments, comparison with existing forecasting systems, internal and systematic diagnostics, the MERCATOR project team has been conducting continuous validation of this first prototype performances. First results of a one year experience of routine ocean forecasting will be shown.

URL: http://www.mercator.com.fr

G11A-07 1020h INVITED

Near-Real Time Altimeter-Derived Estimates of Hurricane Heat Potential

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The intensification of hurricanes involves a combination of different favorable atmospheric and ocean conditions. After a series of events where the sudden intensification of hurricanes occurred when their path passed over oceanic warm features, it is now speculated that the ocean may have a more important role on storm intensification than previously thought. While the investigation of the importance of warm rings and eddies on hurricane sudden intensification is a topic of research at a very early stage, preliminary results have shown their importance on the intensification of hurricane Opal (1995) and Bret (1999) in the Gulf of Mexico. Since then, the monitoring of the upper ocean thermal structure has become a key element in the study of of hurricane-ocean interaction with respect to the prediction of sudden hurricane intensification.

Although AVHRR-derived sea surface temperature observations can be obtained several times a day, they only provide information of the temperature of the skin surface layer which could very well not be realted to the ocean thermal conditons in the upper tens of meters. Alternatively, sea height anomaly data, as derived from altimetry, may provide information of the upper ocean thermal structure and its dynamics when combined with historical hydrographic data.

The hurricane heat potential is a parameter proportional to the integrated vertical temperature between the sea surface and the 26^{o}C isotherm, which is the approximate sea surface temperature needed for a storm to mantain hurricane strength. Specific research objectives are now focussed to determine the hurricane heat potential in the Caribbean Sea, Gulf of Mexico and tropical Atlantic, and with special emphasis on warm core rings, the Loop and Florida currents and the Gulf Stream. The close relationship that exists between the dynamic height and the ocean mass field allows these two parameters to be used within a two-layer reduced gravity ocean scheme to monitor the upper layer thickness, which is defined to go from the surface to the depth of the 20^{o}C isotherm. Although there are many factors controlling the sea height anomaly, it is assumed here that most of its variability is due to changes in the thickness of the upper layer and to steric and barotropic effects. The thermal profiles are then constructed using near-real time altimeter-derived upper layer thickness from three altimeters by NOAA/NESDIS along with the sea surface temperature fields. Estimates of this parameter are posted daily during hurricane season to help forecasters and scientists on identifying regions of high hurricane heat potential and possible hurricane intensification.

URL: http://aoml.noaa.gov/phod/cyclone/data

G11A-08 1040h

Establishing an Operational Data System for Surface Currents Derived from Satellite Altimeters and Scatterometers; Pilot Study for the Tropical Pacific

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We are initiating a pilot processing system and data center to provide operational ocean surface velocity fields from satellite altimeter and vector wind data. The team includes the above authors plus M. Bourassa (FSU), V.Kousky (NOAA/NCEP), J.Polovina (NOAA/NMFS/Hawaii CoastWatch), R.Legeckis (NOAA/NESDIS), G. Jacobs (NRL), F. Bonjean (ESR), E.Johnson (ESR) and J.Gunn (ESR). Methods to derive surface currents are the outcome of several years of NASA sponsored research and the pilot project will transition that capability to operational oceanographic applications. The regional focus will be the tropical Pacific. Data applications include large scale climate diagnostics and prediction, fisheries management and recruitment, monitoring debris drift, larvae drift, oil spills, fronts and eddies. Additional uses for search and rescue, naval and maritime operations will be investigated.

The pilot study will produce velocity maps to be updated on a weekly basis initially, with a goal for eventual 2-day maximum delay from time of satellite measurement. Grid resolution will be 100 km for the basin scale, and finer resolution in the vicinity of the Pacific Islands. Various illustrations of the velocity maps and their applications will be presented. The project's goal is to leave in place an automated system running at NOAA/NESDIS, with an established user clientele and open Internet data access.

URL: http://www.esr.org/sfcurrents/sfc.html

G11A-09 1055h

Sea Level Variability During the 1993-1999 Estimated by Assimilating TOPEX/POSEIDON Data Into a General Circulation Model

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Sea surface height variability is analyzed from ocean model simulations and altimer data. The estimate of the ocean state is obtained by constraining the LSG model of the Max Plank Institute of Meteorology, Hamburg. Seven years (1993-1999) TOPEX/POSEIDON (T/P) sea surface heights relative to the EGM96 geoid model are assimilated into the model. 4D-VAR is used to optimize a set of control variables. The impact of the geoid data is presented by comparing the variability of the simulated sea level, ocean transport of heat and freshwater from two seven-year experiments in which we assimilate either T/P sea level height relative to EGM96 geoid or the sea level temporal anomaly only, provided by T/P.

G11A-10 1110h INVITED

Altimeter Assimilation in the NRL Global Coupled Ocean/Atmosphere Analysis/Prediction System

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The objective of our work is to develop, test and validate a global coupled data assimilation system comprised of atmosphere and ocean components. Each component will contain programs to perform data quality control, data analysis, initialization and numerical forecasts. Our approach is to build the coupled system using a combination of existing and newly developed components and a generalized flux coupler to allow for the exchange of relevant parameters across the air-ocean interface. The atmosphere forecast component of the system is the Navy Global Atmospheric Prediction System (NOGAPS), and atmospheric data assimilation is performed using a three dimensional variational (3DVAR) analysis. For the ocean, the Parallel Ocean Program (POP) model is the forecast component of the system and ocean data assimilation is performed using a three dimensional multivariate optimum interpolation (3DMVOI) analysis. The ocean analysis variables are temperature, salinity, geopotential and the u,v velocity components. In the 3DMVOI method, adjustments to the mass field are correlated with adjustments to the flow field, and a short-term POP model forecast provides the analysis background field. We are investigating two approaches to the assimilation of satellite altimeter sea-surface-height-anomalies (SSHA) in the coupled system. In the first approach, the SSHA are converted to temperature profiles in the upper 1500 M of the water column using stored regressions of dynamic height and temperature at depth computed from historical profile data. This method is the so-called synthetic BT approach. Salinity is computed from the temperature profiles using historical TS relationships and geopotential observations are computed relative to a prescribed level of no motion. In the second approach, geopotential increments are computed directly from the sea level anomalies using a modified form of the Cooper and Haines (1996) method. Increments of T and S are then computed from the geopotential increments based on conservation of the local TS relationship. In this talk I will give a brief description of the global coupled system and a status report on the strengths and weaknesses of the two altimeter assimilation schemes.

G11A-11 1130h

Real-time Assimilation of Altimeter Derived Synthetic Profiles Into a Global version of the Naval Research Laboratory's Coastal Ocean Model (NCOM)

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A global implementation of the Navy Coastal Ocean Model (NCOM), developed by the Naval Research Laboratory (NRL) at Stennis Space Center is currently running in real-time and is planned for transition to the Naval Oceanographic Office (NAVOCEANO) in 2002. The model encompasses the open ocean to 5 m depth on a curvilinear global model grid with 1/8 degree grid spacing at 45N, extending from 80 S to a complete arctic cap with grid singularities mapped into Canada and Russia. Vertically, the model employs 41 sigma-z levels with sigma in the upper-ocean and coastal regions and z in the deeper ocean. The Navy Operational Global Atmospheric Prediction System (NOGAPS) provides 6-hourly wind stresses and heat fluxes for forcing, while the operational Modular Ocean Data Assimilation System (MODAS) provides the background climatology and tools for data pre-processing.

Operationally available sea surface temperature (SST) and altimetry (SSH) data are assimilated into the NAVOCEANO global 1/8 degree MODAS 2-D analysis and the 1/16 degree Navy Layered Ocean Model (NLOM) to provide analyses and forecasts of SSH and SST. The 2-D SSH and SST nowcast fields are used as input to the MODAS synthetic climatology database to yield three-dimensional fields of synthetic temperature and salinity for assimilation into global NCOM. The synthetic profiles are weighted higher at depth in the assimilation process to allow the numerical model to properly develop the mixed-layer structure driven by the real-time atmospheric forcing.

Global NCOM nowcasts and forecasts provide a valuable resource for rapid response to the varied and often unpredictable operational requests for 3-dimensional fields of ocean temperature, salinity, and currents. In some cases, the resolution of the global product is sufficient for guidance. In cases requiring higher resolution, the global product offers a quick overview of local circulation and provides initial and boundary conditions for higher resolution coastal models that may be more specialized for a particular task or domain. Nowcast and forecast results are presented globally and in selected areas of interest and model results are compared with historical and concurrent observations and analyses.

URL: http://www7300.nrlssc.navy.mil

G11A-12 1145h

Assimilation of Satellite Altimeter Data and MCSSTs into An Experimental Real-Time North Pacific Ocean Nowcast/Forecast Model

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Satellite altimeter data and MCSST are assimilated into an experimental real-time ocean nowcast/forecast model covers North Pacific on a daily basis. Real-time satellite altimeter data and MCSSTs are used to generate 3D ocean temperature and salinity analyses. The analyses are then assimilated into the 3D primitive equations model to produce a nowcast.

The ocean model covers North Pacific Ocean from 16S to 60N with 1/4 degree horizontal resolution. The model is restarted daily from previous nowcast fields. Once the model is restarted, it continuously assimilates the temperature/salinity fields constructed from altimeter sea surface height anomaly data and MCSSTs, and is forced by the Navy Operational Global Atmospheric Prediction System (NOGAPS) surface forcing to generate a nowcast. Forecasts up to 72 hours are made with available NOGAPS forecasts.

The data assimilation scheme is incremental adjustment with a vertical weighing function based on the oceanic variability scales.

The data assimilating North Pacific Ocean nowcast/forecast model has been experimentally in real time at NRL since July 1, 1999. The assimilation of satellite data shows a strong improvement in retaining the ocean energetics, particularly in the Kuroshio extension region. The comparison with TAO array temperature profiles shows model with data assimilation are better then persistence and the analysis.

URL: http://www7320.nrlssc.navy.mil/npacnfs_www/

G21A MC: 131 Tuesday 0830h

Crustal Deformation: New Results I

(joint with S, T, V, DI)

Presiding: **J T Freymueller,** University of Alaska, Fairbanks**; A Tikku,** Lamont-Doherty Earth Observatory of Columbia University

G21A-01 0830h INVITED

Monitoring the Earth's Gravity Field Using the GGP Network

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Continuous high precision gravity measurements are the basis of the Global Geodynamics Project (See Crossley et al., 1999, Network of superconducting gravimeters benefits a number of disciplines, Trans. Am. Geophys. U., 80, 121-126). We now have 4 years of recording, since July 1, 1997 and the project will end in 2003. So far about 17 stations have contributed to the database that is maintained at the International Center for Earth Tides in Brussels. The data is used for a number of projects, some local, some global. For example, at each station, tidal analysis yields information on ocean tidal loading and the correlation between atmospheric pressure, local hydrology and gravity. When combined with data from absolute gravimeter measurements, regularly taken at many of the stations, some long term tectonic signatures are beginning to emerge.

Data from various parts of the GGP network are also combined for other projects. Most of the Japanese stations contribute data to the Ocean Hemisphere Project that combines seismic and tectonic measurements in the Western Pacific region. In Europe a project is underway to use the GGP stations to provide ground truth for satellite gravity missions, such as GRACE, that are searching for large scale hydrology and other signals. Finally all of the GGP stations contribute data to the detemination of Earth rotation parameters such as the polar motion and Free Core Nutation. The latest results from these and other projects will be presented.

G21A-02 0845h

Constraints on the Mid-Continent Deformation Gravity Gradient Determined from Co-located GPS and Absolute Gravity Observations

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The deformation gravity gradient (DGG) is the ratio of the time rate of change of surface gravity to vertical crustal velocity. Different processes generate different theoretical predictions of the DGG. Consequently, observational constraints on the DGG are necessary to link crustal uplift observations to satellite-derived observations of the time rate of change of the Earth's gravitational field, which will be generated by upcoming satellite missions such as GRACE. Larson and van Dam (2000) have compared secular gravity trends from 4 sites in interior North America to crustal uplift rates obtained from global point-positioning analyses of GPS observations, and found they agree, assuming a nominal DGG value appropriate to postglacial rebound of -0.15 μGal/mm (Wahr et al., 1995). Here we revisit and extend their analysis in order to determine the observational constraints on the DGG in mid-continent North America. We use recently published gravity rates derived from significantly more absolute gravity observations and a different GPS analysis scheme. Lambert et al. (2001) have published secular gravity rates for 7 sites in mid-continent North America, using all available absolute gravity observations and allowing for instrumental offsets. The sites, chosen to sample postglacial rebound, lie on a transect from Churchill, Manitoba, located on Hudson Bay, to North Liberty, Iowa. Four of these sites (Churchill, Flin Flon, Lac du Bonnet, and North Liberty) also feature a nearby GPS station. The GPS observations were analyzed using double differencing with Bernese 4.2, yielding 5 year time series for vertical position. The daily repeatabilities of 5 to 9 mm compare well to the weekly repeatabilities of 7-8 mm reported by Larson and van Dam (2000). A comparison of the vertical rates derived from these time series to the secular solid-surface gravity trends finds a DGG of -0.14 $\pm$ 0.06 μGal/mm. This value is in good agreement with model predictions for postglacial rebound, which range from -0.135 to -0.17 μGal/mm using the ICE-3G postglacial rebound model and a nominal viscosity structure. More sites with co-located absolute gravity and GPS are needed to reduce the relatively large uncertainty of the derived DGG.

G21A-03 0900h INVITED

Absolute Gravity Changes In Alaska

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Visco-elastic deformation models such as that of Soldati et al. [1999] predict time varying gravity signals associated with post-seismic deformation following the 1964 Prince William Sound earthquake (Mw=9.2). The rates of change are a function of the upper mantle viscosity. Aseismic creep is also a candidate mechanism for the deformation. The models differ in the spatial distribution of gravity changes; visco-elastic signals span a much larger region.

Previous absolute gravity measurements have been made in Fairbanks, Alaska and Palmer, Alaska, during 1990-1991. Estimated uncertainties are in the 3-5 uGal range Visco-elastic gravity changes for Palmer are predicted to range from zero to tens of uGal, depending on the model viscosity and thickness parameters. New absolute gravity measurements at these sites are scheduled for September 2001, with 2 uGal estimated uncertainty. We hope to present initial results of the new measurements, with discussion of their implications for model testing. Different time series and instruments will be merged, and necessary corrections will be discussed

G21A-04 0915h INVITED

Temporal Gravity Observations in Volcanic Areas : Contribution and Limitation of Field Relative Gravimetry

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Relative gravimetry has been successfully used in the last decades to evidence temporal gravity changes related with ground deformation or mass flux in volcanic areas. Recent instrumental developments in relative gravity data acquisition combined with performances of GPS surveying have significantly improved the sensitivity and the efficiency of the measurement of the gravity field on land. Classical analogical land gravity meters are now advantageously replaced by new generations of microprocessor based instruments allowing automatic measurements digitally recorded along with other useful information. Such improvements offer new potentialities for the study of internal processes through precise surveying or differential continuous recordings. In the meantime, due to intrinsic properties of relative instruments, rigorous and constraining protocols for data acquisition and processing are required to minimize the effects of instrumental drift and possible calibration changes that should be carefully controlled. The combination of relative and absolute gravity measurements then appears as a promising way to study the mass flux associated with the volcanic activity especially in strong topography or island areas. Current potentialities and limitations of relative instruments are discussed here from results of laboratory experiments and field surveys in volcanic areas performed by IRD and IPGP.

G21A-05 0935h

The Interpretation of Gravity Changes and Crustal Deformation in Active Volcanic Areas

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Combined geodesy and gravity measurements allow us to infer the density of intrusive bodies, and better constrain deformation sources. Estimates of the parameters (volume, mass, density) of the intrusion in volcanic areas are usually computed matching gravity and uplift data to an isotropic point source in a homogeneous half-space. We investigate three factors that can help in obtaining a more realistic picture of the intrusive body:

(1) A layered Earth model, with one or more elastic layers.

(2) Coupling between elastic and gravitational effects. Deformation changes the gravitational field in two ways: dilatational strains change the local density, and displacements perturb any density contrasts, especially at the free surface.

(3) Non-spherical source geometries.

Our results show that:

(1) For an elastic model appropriate to Long Valley caldera, we find no major differences between modeling the intrusion using a point source in a homogeneous or layered medium. For the layered medium we find (a) a slightly deeper source (9.4 vs 8.8 km) and larger mass (0.500 vs 0.447 M.U.) for the numerical model; (b) the same volume (0.155 km^3) for both models; (c) the density of the intrusive body increases of about 10% for the numerical model (from 2900 to 3200 kg/m^3).

(2) Coupling between elastic and gravitational effects (or self-gravitation) are second order over the distance scales normally associated with volcano deformation. We find no significant differences in any of the source parameters.

(3) Choosing the right source model to invert geodetic and gravity data is the critical step in the geological interpretation of the data. If the source does not possess a spherical symmetry, the standard approach of using a point source to invert uplift and gravity data will lead to biased estimates of the source parameters. In the case of Long Valley caldera, the inflation source (a vertical prolate ellipsoid) is located 5.9 km beneath the resurgent dome with an aspect ratio equal to 0.475, a volume change from 1982 to 1999 of 0.136 km^3 and a density of around 1700 kg/m^3. A spherical source overestimates the source depth by 2.9 km (33% increase), the volume change by 0.019 km^3 (14% increase) and the density by about 1200 kg/m^3 (40% increase).

G21A-06 1010h

Assessing the Time-Predictable Earthquake Recurrence Model at Parkfield, CA Using Geodetic Data

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The elapsed time since the 1966 M6 earthquake at Parkfield, CA has significantly exceeded the expected interevent time according to the time-predictable recurrence model. This model, used in many seismic hazard predictions, states that the time until the next earthquake is the stress drop of the most recent event divided