G51B-0032 0830h POSTER

Compensating atmospheric distortions in SAR interferograms using continuous GPS time series of Zenith Wet Delay estimates

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Spatial heterogeneity of the wet component of atmospheric refractivity causes distortions in radar interferograms. Integrated refractivity along the radar line-of-sight is proportional to total excess path length of of the radar signal propagating through the random 3D refractivity field, and this extra delay can contribute significantly towards the observed phase in radar interferograms. This additional component of interferometric phase can cause erroneous interpretation of useful signal information in interferograms, particularly with respect to crustal deformation studies where the ground displacement signal is on the order of the noise component. In this report, we analyze the residuals of a topography-corrected, deformation-free radar interferogram in terms of atmosphere-induced excess path delays. Furthermore, we leverage Zenith Wet Delay (ZWD) estimates from continuous Global Position System (GPS) stations operating in the same area to model the atmosphere phase screen in the radar interferogram. This modeling is performed via ordinary kriging, which takes advantage of the spatial covariance characteristics of the ZWD field known from Kolmogorov turbulence theory. The theory predicts the spatial covariance of the isotropic three-dimensional refractivity random field. For our modeling purposes, we derive the corresponding form of spatial covariance for the projection of this field onto the two-dimensional plane of the radar interferogram. The performance of our modeling efforts is gauged by computing the Power Spectral Densities (PSD) before and after subtraction of the observed phase screen with our model. Our results indicate that such minimum estimation variance modeling produces smooth estimators that track well large spatial wavelength trends. Thus, these models reduce power in only low-frequency bands, from 0.1 cycles/km to 1 cycle/km, of the PSD by almost one order of magnitude. The resulting model, however, reduces overall rms of atmosphere phase noise by about 50%. To improve the performance of the atmosphere phase screen modeling, we consider incorporating more data from each continuous GPS station in the form of time series of ZWD estimates centered around the interferogram observation times. Furthermore, we appeal to the Kolmogorov-Taylor model of a “frozen-in” atmosphere which provides a relationship between theoretical temporal covariance to correlations in the spatial domain, due to movement of the atmosphere column by wind with an average velocity, to relate temporal wet delay observations to predictions of atmosphere phase delay at unsampled spatial locations.

G51B-0033 0830h POSTER

Simulations of Troposphere Scintillation Impacts on Water Vapour Retrieval Using the Satellite-to-Satellite Measurements

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The radio occultation technique is using signals from the Global Positioning System (GPS) to measure phase and amplitude changes caused by the atmosphere. The observations are done from low Earth orbiting (LEO) satellites. The retrieved vertical profiles of the refractive index are used to extract the information of temperature, pressure, and humidity as a function of height in the troposphere and stratosphere. In order to improve the separation of the contributions of water vapour and temperature in the lower troposphere, without using external data, the ESA Earth Explorer satellite mission ACE+ will actively sound the atmosphere using LEO-to-LEO signal transmission at three frequencies around the 22 GHz water vapour absorption line (10, 17, and 23 GHz). The new and novel observations will focus on measuring amplitude and phase at the different frequencies in order to resolve the main terms for intensity changes in the received signals. The combination of the three frequencies removes the effect of liquid water droplets in clouds from the process of estimating the profile of tropospheric water vapour. The transmission of coded signals between LEOs (with similar signal structure as GPS) is the key observable for monitoring the global distribution of atmospheric water vapour. In the lower troposphere, where water vapour is abundant, the less strongly absorbed 10 and 17 GHz signals are employed. Transmitted power and receiver antennae gains are sized to achieve a worst-case moisture concentration of 20 g/kg at the bottom of the troposphere in the tropics. In the upper troposphere, where the moisture concentration can be lower by 4 orders of magnitude, the overriding consideration is detecting the relatively weak effect with sufficient precision in order to achieve accurate moisture measurements. We will present end-to-end simulations of the measurements, consisting of a forward propagation of the signals and a retrieval theory for the estimated complex refractivity profiles, to assess the importance of phase and amplitude fluctuations in relation to troposphere scintillations for the accuracy of the method. The new simulation tool consists of forward full wave signal propagation in two dimensions through a large set of phase screens placed in the fluctuating medium between the transmitter and the receiver. The received LEO-LEO phases and amplitudes are used to estimate the complex refractivity profile by applying the Full Spectrum Inversion theory and a fitting transform solution based on the complex fields of all three probing frequencies.

G51B-0034 0830h POSTER

Observation of the Antarctic Sudden Stratospheric Warming of September 2002 using GPS Radio Occultation Technique

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The vertical resolution and global coverage of GPS radio occultation (GPSRO) measurements of temperatures in the stratosphere makes it an ideal tool to study the appearance and evolution of sudden stratospheric warmings (stratwarms). Additionally, the nearly polar orbits of the CHAMP and SAC-C satellites that carry GPSRO sensors give excellent coverage in the polar regions where sudden stratwarms occur. In this poster, we analyze the Antarctic sudden stratwarm event of September 2002 using the combined data from both satellites.

G51B-0035 0830h POSTER

Diurnal signatures of atmospheric water vapor observed by GPS receivers on Taiwan

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In light of the tremendous potential of GPS in atmospheric and geodetic research and education, National Science Council (NSC) of Taiwan initiated a project to set up a 200 GPS sites network in year 2000. Major funding to support the network comes from Central Weather Bureau (CWB), Department of Interior, Academic Sinica, and NSC. Up to date, there are in total more than 100 GPS sites are completed. In this paper, we present the diurnal signatures of atmospheric water vapor observed by the GPS receivers. Atmospheric water vapor is a key variable in the atmospheric radiation budget and global hydrological cycles. Traditionally, its diurnal variation is primarily examined using the observations from radiosonde soundings, which are typically launched twice daily and, hence, insufficient to capture the representative characteristics of the diurnal water vapor variation. Recently, the GPS observations that provide continuous measurements of atmospheric water vapor were used to study its diurnal variations in USA. In this contribution, we investigate the diurnal variation of water vapor based on GPS observations in Taiwan whose climatology dramatically differs from that in the Northern America. The differences are primarily due to the fact that Taiwan is located in the boundary of the sub-tropical and tropical regions with much more abundant of water vapor in the atmosphere in addition to its fast changing topography surrounding by the oceans. The GPS data that are used for the current study are mainly obtained from the dense network supported by the Central Weather Bureau. The diurnal variations of the water vapor are described and quantified by sinusoidal functions. The characteristics of diurnal water vapor variation and semi-diurnal variations are then discussed.

G51B-0036 0830h POSTER

Monitoring the Water Vapour Content of the Atomsphere using the Austrian GNSS Reference Station Network

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GPS has become an important tool both in navigation and in precise point positioning. One of the nuicance parameters limiting the accuracy of point determination is the water vapor content of the troposphere. On the other hand meteorologists are interested in the wet component of the troposphere as a valuable tool for Numerical Weather Prediction and Climate Studies. Therefore GPS offers a low cost monitoring of water vapor with high temporal resolution. We make use of continuous measurements of the GPS/GLONASS reference station network in Austria, which currently consists of about 27 sites with a mean distance of 50 km. The total zenith path (TZPD) delays for 2 weeks in 2002 (May and August 2002) with an anticipated huge difference in the water vapour content were calculated. Subsequently the results are compared to contributions of different processing centers of the COST-716 project (Exploitation of Ground Based GPS for Climate and NWP) and with zenith path delay estimates provided by the IGS. Based on the observed atmospheric pressure field the Zenit Wet Delay has been separated from the TZPD estimates. As meteorologists need the water vapor within less than two hours, special attention is paid to the availability, reliability and especially on the quality of the satellite orbits used for the network calculations. For this reason we try to use rapid ephemeris instead of the IGS final orbits, whereby we make a quality control of the rapid orbits. If one or more satellites show poor quality or if one satellite is missing at all we include the broadcast ephemeris information instead.

G51C MCC: 2010 Friday 1020h

Advancing the Cutting Edge of Geodesy II: Dynamics of the Earth

Presiding: **O de Viron,** Royal Observatory of Belgium**; G Blewitt,** Nevada Bureau of Mines and Geology and Seismological Laboratory

G51C-01 1020h INVITED

Seasonal Crustal Deformation in Japan and its Interannual Variation

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A dense array of GPS is useful to study seasonally changing load through periodic components in crustal movements. In this paper I review observed and predicted seasonal crustal movements in the Japanese Islands, where both nationwide dense GPS array and meteorological sensor network are available. From comprehensive evaluation of various sources contributing to seasonal signals, the largest factor in Japan is found to be snow, weighing over 1000 kg per square meter in some regions. This is followed by various kinds of loads on the land area, such as atmosphere, soil moisture and dam, and non-tidal ocean loads also cause certain seasonal signatures. Seasonal crustal deformations are calculated by synthesizing all these seasonal load changes, some of which are directly measured meteorologically and others are inferred through models. They are compared with real data observed by the dense GPS array in Japan, and they agreed fairly well. The seasonal signals observed by GPS also include artifacts, such as scale changes due possibly to atmospheric refraction, and atmospheric delay gradients. We often discuss subtle crustal deformation signals, e.g. those associated with silent earthquakes, isolating them by removing secular and periodic components. Understanding seasonal signals and their interannual variability is crucial in removing these unwanted signals. Amplitudes of seasonal signals in Japan were suggested to have increased in 2000, and I discuss its causal relationship with the increase in snow depths in the 1999/2000 winter.

G51C-02 1035h INVITED

Seasonal Variation in the Spatial Distribution of Surface mass Estimated Using GPS.

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Spatial variation in the distribution of the Earth's surface mass causes significant seasonal deformation of the solid Earth. Such deformation is not only detectable with modern geodetic techniques but is a strong component of many GPS coordinate time series. Utilizing a global GPS tracking network it is possible to invert for a truncated spherical harmonic expansion of the Earth's geometric shape and hence with an elastic earth model estimate spherical harmonic coefficients of the surface mass load. Such an estimation using 4 years of IGS data from 122 sites is presented. The degree of truncation plays a strong role in the reliability of the estimated coefficients, whilst it must be low enough to provide a stable and reliable interpolation of the surface deformation field, a greater truncation degree decreases the effects of aliasing from neglected higher degrees. Stability and aliasing of the coefficients is investigated with respect to truncation degree and model design, both empirically and using models of continental and atmospheric water. The seasonal component of the surface load is analyzed by fitting annual and semi-annual periodic signals to the harmonic coefficient time series. The reduction in variance by fitting seasonal signals varies with truncation degree and associated aliasing between spectral coefficient series but is largest for the degree-1 zonal harmonic (40 to 60 %) and the degree 2 sine tesseral harmonic (30 to 50 %) series, these harmonics are closely related to geocenter and polar motion respectively. A better estimate of the spatial variation in surface mass at seasonal frequencies is given by partitioning the total load into individual spherical harmonic representations over both land and sea respectively. This is achieved by enforcing conservation of total mass and under the assumption of static equilbrium, constraining the sea surface to be an equipotential.

G51C-03 1050h INVITED

Seasonal Geodetic Signatures and Global Surface Mass Variations

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The hydrosphere, cryosphere and atmosphere are volatile layers of the Earth. Their dynamic motions involve significant horizontal surface mass transport at the seasonal time scale. The changing mass loads and deforms the solid Earth surface, perturbs the external gravity field, and excites Earth orientation variations. Recent advancement and proliferation of space geodetic techniques allow all these different signatures to be accurately measured. More importantly, we can use the geodetic information to infer the mass variations and learn about the associated global change processes. Using continuous GPS data from a globally distributed tracking network, we have conducted monthly inversions for global surface mass variations in terms of truncated spherical harmonic series. A combined hydrological, atmospheric and oceanic mass distribution model is also used to assist the truncations and error evaluation. The seasonal amplitudes and phases of the mass coefficients are converted to those of geocenter and zonal gravity coefficients, and compared with corresponding SLR results from previous authors. Good agreements are found at the lowest degrees where results appear to be reliable for both techniques. Satisfactory comparison not only validates both measurement techniques but also reinforces the overarching theory of surface mass variations. New inversion results using more data and a combination of least squares and best linear estimator techniques under the platform of singular value decomposition will also be reported.

G51C-04 1105h

Effect of Mapping Function Errors on Estimates of Surface Mass Changes

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Temporal variations in the spatial distribution of atmospheric, hydrologic, and oceanic mass causes significant deformation of the solid Earth at periods ranging from daily to annual. Such deformation is not only detectable with modern geodetic techniques but is a strong component of many GPS coordinate time series. In fact, using a global GPS tracking network it has been demonstrated that it is possible to invert for a truncated spherical harmonic expansion of the Earth's geometric shape. This deformation, combined with an elastic earth model, can be used to estimate spherical harmonic coefficients of the surface mass load. In this way, we can determine surface mass distributions that are consistent and that conserve mass in terms of the global water budget. One problem with this approach to deriving the surface mass variations is spatial correlation between the loading signal and inadequate modelling of the zenith tropospheric delay (ZTD). Correlations between these signals will affect our estimates of the amplitude of the mass load. In this paper, we compare the spatial and temporal variations of modeling errors in the ZTD with various loading phenomena and estimate the amplitude of the effect.

G51C-05 1120h INVITED

Mass Loads, Surface Deformation, and the Earth's Rotation

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A fluid, mobile atmosphere and oceans surrounds the solid Earth and upon its land surface lies a continually changing global distribution of ice, snow, and ground water. The changing distribution of mass associated with the motion of these surficial fluids changes the load on the solid Earth, thereby causing its shape to change. It has recently been demonstrated that large-scale changes in the shape of the Earth's surface can be measured using the global network of GPS receivers. Any dynamic Earth process that rearranges the Earth's mass will, in general, change the Earth's inertia tensor, and hence change the Earth's rotation. Thus, many (if not all) of the dynamic Earth processes causing the Earth's shape to change will also cause variations in the Earth's rotation. Observations of changes of both the Earth's shape and rotation arising from the same underlying dynamic process should, of course, be consistent with each other. Here, observations of changes in the Earth's shape are used to infer changes in the mass load that are causing the Earth's shape to change. The second-degree harmonics of this inferred mass load are then used to compute the change in the Earth's inertia tensor and hence the change in the Earth's rotation. This predicted change in the Earth's rotation is then compared to observations of the Earth's rotation. Prior to this comparison, motion effects due to winds and currents on the Earth's rotation are first removed from the observations using the NCEP/NCAR reanalysis atmospheric model and a data-assimilating version of the ECCO ocean model, respectively. It is shown that there is a good agreement between the observed changes in the Earth's rotation and those predicted by the inferred mass load, particularly at seasonal frequencies.

G51C-06 1135h INVITED

Surface Time-Variable Gravity Signals And Possible Sources Including Core Mass Flow

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Over two decades of geodetic satellite-laser-ranging (SLR) data show that the variation of the Earth's oblateness parameter J2 has a clear seasonal signal of amplitude of about 3e-10 and a secular decrease of about -2.8e-11/year, superimposed on some interesting interannual fluctuations. Physically, any change in mass distribution on/inside the Earth will be reflected in the time-variable gravity signal obtained outside the Earth, according to Newton's gravitational law. Therefore, such signal contains contributions from all geophysical sources that redistribute mass, on all temporal and spatial scales, including those from the core. Besides Earth rotation and geomagnetic field variations, the time-variable gravity also contains information linking Earth surface observations with internal core dynamical processes. The time scales of the gravity signal are critical in helping differentiate different contributions. The atmosphere and hydrosphere are responsible for the seasonal and much of the interannual and intraseasoanl fluctuations, while the secular trend is due mainly to the post-glacial rebound but possibly core mass flow. To estimate the latter effect, we use our MoSST (Modular, Scalable, Self-consistent, Three-dimensional) core dynamics model to forward simulate the core flow, and density variation due to the core convection. Our results suggest that, when upward continued to the surface, the J2 component of the core mass redistribution can reach an overall amplitude of e-11/year, approaching the SLR detectability and significant in geophysical terms. We also find a general westward drift of the mass flow, with a speed comparable to that of the geomagnetic westward drift.

G51C-07 1150h INVITED

Hydromagnetic Oscillations of the Earth's Core: Constraints on the Structure and Dynamics of the Core from Geodetic and Geomagnetic Observations

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Numerical models of the geodynamo have been remarkably successful in reproducing features of the Earth's magnetic field at the surface. However, the internal workings of different models can be surprisingly different. Efforts to distinguish between these possibilities are hampered by a lack of relevant observations. The most useful sources of information include estimates of fluid flow at the surface of the core, variations in the length of day, and changes in the gravity field. Interpreting this information relies on models to relate the observations to physical processes in the core. We address the need for better models by developing a new theoretical framework based on methods commonly employed in normal-mode seismology. The underlying mathematical models describe hydromagnetic waves in the core (torsional oscillations) and the accompanying motion of the mantle and inner core. The coupled motion of the core and mantle can be decomposed into an infinite set of normal modes. The frequency and spatial form of the normal modes depend on the physical properties of the core (include the structure of the internal magnetic field), whereas the modal amplitudes are related to the excitation source. The orthogonality of the normal modes is used to define a Green's function for the response of the system to an excitation which is localized in space and time. The predicted response for a spatially distributed, time-dependent source is obtained by convolving the source with the Green's function. We give several representative examples and show how this approach can be used to jointly invert observations of fluid flow at the core surface, variations in the length of day, and changes in the gravity field for the structure of the internal magnetic field and for the convective processes in the core that excite the oscillations

G51C-08 1205h INVITED

Inner Core Tilt and Polar Motion: Probing the Dynamics Deep Inside the Earth

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A tilted inner core permits exchange of angular momentum between the core and the mantle through gravitational and pressure torques and, as a result, changes in the direction of Earth's axis of rotation with respect to the mantle. Some of the observed variations in the direction of Earth's rotation could then be caused by equatorial torques on the inner core which tilt the latter out of its alignment with the mantle. In this work, we investigate whether such a scenario could explain the decade polar motion known as the Markowitz wobble. We show that a decade polar motion of the same amplitude as the observed Markowitz wobble requires a torque of 10^{20} N m which tilts the inner core by 0.07 degrees. This result critically depends on the viscosity of the inner core; for a viscosity less than 5×10^{17} Pa s, larger torques are required. A torque of 10^{20} N m with decadal periodicity can perhaps be produced by electromagnetic coupling between the inner core and a component of the flow in the outer core known as torsional oscillations, provided that the radial magnetic field at the inner core boundary is on the order of 3 to 4 mT and satisfies certain geometrical constraints. The resulting polar motion thus produced is eccentric and polarized, in agreement with the observations. Our model suggests that equatorial torques at the inner core boundary might also excite the Chandler wobble, provided shorter wavelength torsional oscillations with higher natural frequencies have enough power or provided there exists another physical mechanism that can generate a large torque at a 14 month period.

G52A MCC: Level 1 Friday 1330h

High-Rate GPS: Infrastructure and Applications Posters *(joint with S)*

Presiding: **M Caissy,** NRCAN**; G Weber,** BKG

G52A-0037 1330h POSTER

High-Rate GPS Data From the National CORS Network

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The U. S. National Continuously Operating Reference Station (CORS) network contains 100+ stations that collect GPS data at a 1-hertz rate. Organizations that operate these high-rate CORS include the Federal Aviation Administration (FAA) and the States of Florida, Michigan, North Carolina, Ohio, Pennsylvania, and Vermont, as well as other organizations. The FAA-operated CORS comprise the Wide Area Augmentation System that serves primarily to enable safe and efficient air navigation. The remaining high-rate CORS serve primarily to enable highly accurate static and kinematic positioning, especially for postmission surveying and mapping applications. NOAA's National Geodetic Survey currently distributes GPS data from these high-rate CORS with a 1-hour latency. A significantly shorter latency is technically possible for many of these CORS.

URL: http://www.ngs.noaa.gov/CORS/

G52A-0038 1330h POSTER

A multipurpose high-rate GPS observatory for northwestern Mexico

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We describe a proposed joint atmospheric and geophysical high-rate GPS observatory in northwestern Mexico complementing and extending analogous networks in the United Stated. The observatory would measure atmospheric water vapor during the North American Monsoon Experiment (NAME) as well as crustal velocities within and across the Gulf of California and the Mexican Basin and Range region for geodetic applications. The NOAA-sponsored NAME scheduled for several summers beginning in 2004 addresses the challenging issue of determining and improving the predictability of warm season precipitation in the mountainous region of the Northwestern Mexico and Southwestern US. Much of the rainfall in the region comes during the North American Monsoon each summer. Rainfall in the region is particularly difficult to model and predict because the orography and the complex land-sea geometry of the region with moisture sources in the Gulf of Mexico, Gulf of California and the eastern subtropical Pacific Ocean. The GPS provides accurate, near-continuous observations of water vapor in clear and cloudy air needed to sample the large diurnal variations in the dynamic and thermodynamic properties of the atmosphere. GPS in combination with wind and other measurements scattered in and around the region will provide much needed constraints to determine quantitatively the sources supplying moisture for precipitation within the NAME area. Tectonic applications of this continuous GPS network in Mexico include high-precision determinations of plate boundary deformation in and around the Gulf of California and possible diffuse deformation within the Mexican Basin and Range province. Because of the high sampling rate (1 Hz), the network will also provide data for seismological applications, including surface wave studies (e.g., Larson et al., SCIENCE, 2003) and potential near-field displacement records. Furthermore the network would complement the US-based Plate Boundary Observatory (PBO) facility by extending continuous GPS coverage into northern Mexico and other relatively smaller-scale continuous GPS networks in southern Mexico as well as provide important data for surveying and mapping applications. Several years of observations are required to capture the substantial year-to-year variations in the monsoon and yield accurate estimates of tectonic motion. Both objectives can be accomplished relatively inexpensively with the simple and robust GPS observations made in collaboration with investigators in Mexico.

G52A-0039 1330h POSTER

NTRIP: Networked Transport of RTCM via Internet Protocol - Internet Radio Technology for Real-Time GNSS Purposes

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The massive worldwide growing of Internet capacity enables the introduction of new services such as Internet Radio or Internet Video-on-Demand, which transfer continuous data-streams by IP-packages. These services include the data transport via mobile IP-Networks like GSM, GPRS, EDGE, and UMTS where costs are nowadays rapidly decreasing. As a consequence, the global Internet can be used for the real-time collection and exchange of GNSS data, as well as for broadcasting derived differential products. Compared to Multimedia applications, the bandwidth required for streaming GNSS data is relatively small. The introduction of a real time streaming of GNSS data via Internet as a professional service is demanding with respect to network transparency, network security, program stability, access control, remote administration, scalability and client simplicity. This paper will discuss several possible technical/protocol solutions for streaming GNSS date over the Internet: Unicast vs. IP-Multicast, TCP vs. UDP, Client/Server vs. Client/Server/Splitter architecture. Based on this discussion, a novel HTTP-based technique for streaming GNSS data to mobile clients over the Internet is introduced. It allows simultaneous access of a large number of PDAs, Laptops, or GNSS receivers to a broadcasting host via Mobile IP-Networks. The technique establishes a format called "Networked Transport of RTCM via Internet Protocol" (NTRIP). NTRIP is designed for disseminating differential correction data (e.g. in the RTCM-104 format) or other kinds of GNSS streaming data.

G52A-0040 1330h POSTER

Large Scale GPS Processing at ESOC for LEO, GNSS and Real-Time Applications

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Most POD systems that are used in GPS data analysis, for instance in routine IGS processing, are large FORTRAN programs that have evolved from early generation systems over many years of use. These systems do not exploit the advantages of modern software engineering technology, and their limited processing efficiency constrains their application to emerging large-scale GPS processes, like real-time GPS, high-rate data processing or combined solutions for LEO + MEO constellations. In support of such high-performance applications, the ESOC IGS Analysis Centre is developing a new POD system based on the latest software engineering methods. This system is optimised in its use of both CPU and memory, following fundamental rules of minimum information containment that are more commonly found in internet search engines or artificial intelligence applications. Although this new system still has an experimental status it is expected to augment the GPS data processing capacity at ESOC by at least one order of magnitude. Some innovative concepts behind the system will be presented, together with first examples of GPS processes that until now were prohibitively large or slow.

G52B MCC: Level 1 Friday 1330h

G

Signal Versus Noise in GPS Height Time Series II Posters

Presiding: **T van Dam,** European Center for Geodynamics and Seismology**; G Blewitt,** Nevada Bureau of Mines and Geology and Seismological Laboratory

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GPS observations of Ocean Tide Loading in the British Isles

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Model predictions show that ocean tide loading (OTL) in the British Isles is particularly large (up to several cms in the S. W. of Britain). The primary cause of uncertainty in OTL models is the ocean tide models on which they depend. Interaction of the tides in the open oceans and the more restricted coastal regions, along with the intricate shape of the coastline, make accurate modelling of OTL in the British Isles difficult. Therefore an approach to directly measure these effects has been devised, using data gathered from a network of continuously operating GPS receivers (COGRs), in an attempt to validate or improve existing OTL models. We observe OTL at diurnal and semi-diurnal periods by directly estimating fixed-period harmonic motions within individual daily GIPSY/OASIS II GPS analyses. This approach enables us to solve separately for the tropospheric zenith wet delay (ZWD) as a random-walk parameter. An iterative Kalman Filter approach to combine the multiple daily solutions enables us to isolate the principal near-diurnal (K_1, O_1, P_1, Q_1) and near-semi-diurnal (M_2, S_2, N_2, K_2) OTL components. A preliminary test shows that data from six UK sites produce estimates which are in good agreement with OTL predicted by the FES99 model, where values vary from 3-43 mm in amplitude (M_2) at the six sites. Our final estimates are generated using approximately 1000 days of data in the solution, resulting in amplitude standard deviations of approximately 1 mm per component (compared with an RMS difference between OTL models of 2 mm per component). However, the phase estimates of the OTL components take much longer to