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The Combined Solution C04 for Earth Orientation Parameters Consistent with International Terrestrial Reference Frame 2005

IAG Symp., 134:265-270, DOI: 10.1007/978-3-642-00860-3_41, 2009

Bizouard, Christian; Gambis, Daniel

Times Cited: 30

Abstract: The Earth Orientation Center of the IERS, located at Paris Observatory, SYRTE, has the task to provide to the scientific community the international reference time series for the Earth Orientation Parameters (EOP), referred as "IERS C04" (Combined 04), resulting from a combination of operational EOP series, each of them associated with a given geodetic technique. The procedure developed to derive the C04 solution was recently upgraded for several reasons: first we have implemented the new IAU2000 conventions; secondly it has been necessary to re-align the solution to improve its consistency with respect to the ITRF. Due to the separate determination of both celestial and terrestrial reference frames and EOP, there has been a slow degradation of the overall consistency and discrepancies at the level of 300 micro-arc-seconds were existing between the current IERS C04 and the ITRF realization. We have taken this opportunity to upgrade the numerical combination procedure; improvements concern in particular routines, tables dimensions, generalized double precisions. Using the combined polar motion solution associated with the newly release International Terrestrial Reference Frame 2005 (ITRF 2005), we produce a better solution including estimates of the errors of combined values. Individual EOP series have been reprocessed since 1984. Pole coordinates are now fully consistent with ITRF. The nutation offsets and UT1 are made consistent with the International Celestial Reference Frame (ICRF). The new C04 solution, referred as 05 C04, updated two times per week became the official C04 solution since October 2007.

Current State of Precise Point Positioning and Future Prospects and Limitations

IAG Symp., 133:615-623, DOI: 10.1007/978-3-540-85426-5_71, 2009

Bisnath, S.; Gao, Y.

Times Cited: 20

Abstract: The Precise Point Positioning Working Group within the Next Generation RTK Sub-Commission of IAG Commission 4 has been involved with Precise Point Positioning (PPP) developments for the past few years. The information presented here summarizes the Working Group's findings concerning the state of PPP technology, and discusses the probable

near-term future potential and limitations of the technique. The broad question of the place of PPP within the future spectrum of space geodetic measurement techniques is addressed by investigating specific aspects of the method.

The Actual Plate Kinematic and Crustal Deformation Model APKIM2005 as Basis for a Non-Rotating ITRF

IAG Symp., 134:95-99, DOI: 10.1007/978-3-642-00860-3_15, 2009

Drewes, Hermann

Abstract: A present-day plate kinematic and crustal deformation model is needed as a reference system for station velocities in the ITRF. The common rotation of all points of the Earth surface has to become zero in order to be consistent with Earth rotation parameters (condition of no net rotation, NNR). To realize this condition, we divide the surface into rigid plates and inter-plate deformation zones. Both, plate motions and deformations are modelled from the observed station velocities. The plate motions are represented by one rotation vector per plate, the inter-plate deformations are computed using a least squares collocation approach. In the APKIM2005, rotation vectors of 17 major plates and deformations in five plate boundary zones (Alps-Aegean, Persia-Tibet-Burma, Alaska-Yukon, Gorda-California, Andes) are estimated. The global integration is done in a 1 degrees x1 degrees grid covering the entire Earth surface. The ITRF2005 velocities result in a rotation of about 0.06 mas/year compared with the non-rotating terrestrial reference frame.

Precise Gravity Time Series and Instrumental Properties from Combination of Superconducting and Absolute Gravity Measurements

IAG Symp., 133:301-306, DOI: 10.1007/978-3-540-85426-5_35, 2009

Wziontek, H.; Falk, R.; Wilmes, H.; et al.

Abstract: Precise monitoring and a conclusive interpretation of temporal gravity variations at a given station is based upon accurate knowledge about the properties of the used instruments. Only the combination of concurrent sets of superconducting and absolute gravity measurements allow both. Whereas absolute gravimeters provide the scale and reference level, superconducting gravimeters enable to determine gravity variations with high sensitivity and temporal resolution. A method is proposed here to derive the scale factor and zero drift function of the superconducting gravimeter as well as a reliable survey of the instrumental stability of absolute meters with high precision without the need of gravity reductions. In this way it is possible to separate between geophysical signals and instrumental effects in the time series. Results for the stations Bad Homburg, Wettzell in Germany are presented, demonstrating the potential of the technique.

AIUB-GRACE02S: Status of GRACE Gravity Field Recovery Using the Celestial Mechanics Approach

IAG Symp., 136:161-169, DOI: 10.1007/978-3-642-20338-1_20, 2012

Jaeggi, A.; Beutler, G.; Meyer, U.; et al.

Abstract: The gravity field model AIUB-GRACE02S is the second release of a model generated with the Celestial Mechanics Approach using GRACE data. Inter-satellite K-band range-rate measurements and GPS-derived kinematic positions serve as observations to solve for the Earth's static gravity field in a generalized orbit determination problem. Apart from the normalized spherical harmonic coefficients up to degree 150, arc-specific parameters like initial conditions and pseudo-stochastic parameters are solved for in a rigorous least-squares adjustment based on both types of observations. The quality of AIUB-GRACE02S has significantly improved with respect to the earlier release 01 due to a refined orbit parametrization and the implementation of all relevant background models. AIUB-GRACE02S is based on 2 years of data and was derived in one iteration step from EGM96, which served as a priori gravity field model. Comparisons with levelling data and models from other groups are used to assess the suitability of the Celestial Mechanics Approach for GRACE gravity field determination.

The Development of the European Gravimetric Geoid Model EGG07

IAG Symp., 133:177-185, 2009, DOI: 10.1007/978-3-540-85426-5_21, 2009

Denker, H.; Barriot, J. -P; Barzaghi, R.; et al.

Abstract: The European Gravity and Geoid Project (EGGP) is a project within IAG Commission 2, reporting to Sub-commission 2.4. The main goal of the project is to compute an improved European geoid and quasigeoid model based on new and improved data sets which have become available since the last computation in 1997 (EGG97). The improvements include better global geopotential models from the CHAMP and GRACE missions, better digital elevation models (DEMs) in some regions (e.g., new national DEMs, SRTM3, GTOPO30), updated gravity data sets for selected areas, updated ship and altimetric gravity data, improved procedures for the merging of ship and altimetric data, the use of GPS/levelling data, as well as refined computation techniques. This contribution describes the progress made during the 4-year term from 2003 to 2007, including the development of a new geoid and quasigeoid model EGG07 for entire Europe. First, the status of the gravity and terrain data sets as well as the development of the EGG07 model by the spectral combination approach is described. Then, the EGG07 and other models are evaluated by independent GPS and levelling data, showing that the use of GRACE geopotential models as well as upgraded gravity and terrain data leads to significant improvements compared to EGG97 (in total by 25 - 65%). The results indicate an accuracy potential of the EGG07 model in the order of 0.03 - 0.05 m at continental scales and 0.01 - 0.02 m over shorter distances up to a few 100 km, provided that high quality and resolution input data are available.

Results of the European Comparison of Absolute Gravimeters in Walferdange (Luxembourg) of November 2007

IAG Symp., 135:31-35, DOI: 10.1007/978-3-642-10634-7_5, 2010

Francis, O.; van Dam, T.; Germak, A.; et al.

Times Cited: 9

Abstract: The second international comparison of absolute gravimeters was held in Walferdange, Grand Duchy of Luxembourg, in November 2007, in which twenty absolute gravimeters took part. A short description of the data processing and adjustments will be presented here and will be followed by the presentation of the results. Two different methods were applied to estimate the relative offsets between the gravimeters. We show that the results are equivalent as the uncertainties of both adjustments overlap. The absolute gravity meters agree with one another with a standard deviation of 2 mu gal (1 gal = 1 cm/s(2)).

Results of the Seventh International Comparison of Absolute Gravimeters ICAG-2005 at the Bureau International des Poids et Mesures, Sevres

IAG Symp., 135:47-53, DOI: 10.1007/978-3-642-10634-7_7, 2010

Vitushkin, L.; Jiang, Z.; Robertsson, L.; et al.

Times Cited: 9

Abstract: The International Comparison of Absolute Gravimeters ICAG-2005 was held at the Bureau International des Poids et Mesures (BIPM), Sevres, France in September 2005. The organization of ICAG-2005, measurement strategy, calculation and presentation of the results were described in a technical protocol pre-developed to the comparison. Nineteen absolute gravimeters carried out 96 series of measurements of free-fall acceleration g at the sites of the BIPM gravity network. The vertical gravity gradients were measured by relative gravimeters. For the first time the budgets of uncertainties were presented.

Analysis of Mass Variations in Northern Glacial Rebound Areas from GRACE Data

IAG Symp., 133:501-509, DOI: 10.1007/978-3-540-85426-5_60, 2009

Steffen, Holger; Mueller, Juergen; Denker, Heiner

Times Cited: 7

Abstract: Since 2002 the Gravity Recovery and Climate Experiment (GRACE) satellite mission is mapping the Earth's gravity field, showing variations due to the integral effect of mass variations in the atmosphere, hydrosphere and geosphere. After reduction of oceanic and atmospheric contributions as well as tidal effects during the GRACE standard processing, monthly solutions of the gravity field are provided by several institutions. The solutions of the analysis centres differ slightly, which is due the application of different reduction models and centre-specific processing schemes. In addition, residual signals from insufficient pre-

processing of the transmitted satellite data may be present. We present our investigation of mass variations in the areas of glacial isostatic adjustment (GIA) in North America and Northern Europe from GRACE data, especially from the latest release of the GFZ Potsdam. One key issue is the separation of GIA parts and the reduction of the observed quantities by applying dedicated filters and models of hydrological variations. In a further step, we analyse the results of both regions regarding their reliability, and finally a comparison to results from geodynamical modelling is presented. Our results clearly show that the quality of the GRACE-derived gravity change signal benefits from improved reduction models and dedicated analysis techniques. Nevertheless, the comparison to results of geodynamic models still reveals differences, and thus further studies are in progress.

Gravity Recovery from Formation Flight Missions

IAG Symp., 132:29-34, DOI: 10.1007/978-3-540-74584-6_5, 2008

Sneeuw, N.; Sharifi, M. A.; Keller, W.

Times Cited: 9

Abstract: We present a proof-of-concept of gravity field recovery from satellite-to-satellite tracking (SST) in formation flight (FF). Three orbit types will be investigated: GRACE-type SST, co-orbital FF on a 2:1 relative ellipse. and out-of-plane FF on a circular relative orbit. All formations have comparable orbit characteristics: near polar, near eccentric, and short baselines of typically 10 km length. First. we demonstrate that these orbits are sufficiently stable at low altitudes in a realistic gravity field. Next. we perform a closed-loop simulation, in which an input gravity field is used for orbit integration and generation of observations in the forward mode. Subsequently, in the inverse mode, the gravity field is recovered. Comparison between input and output fields demonstrate that gravity recovery based on SST observables from formations containing radial and/or out-of-plane information outperform GRACE-type along-track SST. The gravity fields recovered from the former formation types possess a lower error spectrum and an isotropic error structure.

Greenland Ice Sheet Mass Loss from GRACE Monthly Models

IAG Symp., 135:527-532, DOI: 10.1007/978-3-642-10634-7_70, 2010

Sorensen, L. Sandberg; Forsberg, R.

Times Cited: 8

Abstract: The Greenland ice sheet is currently experiencing a net mass loss. There are however large discrepancies between the published qualitative mass loss estimates, based on different data sets and methods. There are even large differences between the results based on the same data sources, as is the case with those estimated from GRACE data. In this chapter we have used a generalized inversion method to estimate the Greenland ice sheet mass change from the monthly global gravity solutions, provided by three different GRACE processing centers; CSR, JPL and GFZ. In order to derive mass change from these monthly global gravity models, we first calculate the gravity trend from these. When isolating the gravity trend signal, which is caused by the ice mass change, we first subtract the signal produced by the postglacial rebound (PGR) in Greenland. This is done by a simple method based on the

ice history model ICE-5G and on ground measurements made in Scandinavia. We find that the PGR signal corresponds to a mass change signal of approximately -4 Gt per year. We conclude that there are large differences between these estimated mass change models. We find a total mass loss of 189, 146 and 67 Gt/year based on the CSR, GFZ and JPL solution respectively.

Regional Astrogeodetic Validation of GPS/Levelling Data and Quasigeoid Models

IAG Symp., 133:413-420, DOI: 10.1007/978-3-540-85426-5_49, 2009

Voigt, Christian; Denker, Heiner; Hirt, Christian

Abstract: In the context of a GOCE regional validation and combination experiment in Germany, a work package within the framework of the GOCE-GRAND II project, gravity observations, vertical deflections and GPS/levelling data are collected as independent data sets. The observation of absolute gravity values is carried out by the Bundesamt fur Kartographie und Geodasie (BKG), while the vertical deflections are observed by the Institut fur Erdmessung (IfE) using the Hannover digital transportable zenith camera system TZK2-D. The vertical deflections have an accuracy of approx. 0.1 arc seconds and are arranged along a North-South and East-West profile. The two profiles have a length of about 500km each with a spacing of 2.5-5km between adjacent stations. Furthermore, a national GPS and levelling data set of about 900 stations with an accuracy of approx. I cm is available for Germany.

Accuracy Assessment of the ITRF Datum Definition

IAG Symp., 132:101-110, DOI: 10.1007/978-3-540-74584-6_16

Altamimi, Z.; Collilieux, X.; Boucher, C.

Abstract: One of the main objectives of the International Terrestrial Reference Frame (ITRF) is to provide a standard global reference frame having the most attainable accuracy of its datum definition in terms of its origin. scale and the time evolution of its orientation. This latter should satisfy, by convention. the no net rotation condition. The accuracy of the ITRF datum specifications are obviously dependent on the quality and the internal consistency of the solutions contributing, to its elaboration and definition. In this paper. we examine and review the quality of the current ITRF datum definition with an accuracy assessment based on the ITRF2005 results and by consistency evaluation with respect to ITRF2000. The availability of time series of station positions and Earth Orientation Parameters, used now as input for the current ITRF construction, will facilitate the accuracy assessment. When rigorously stacking the time series of a given technique to estimate a long-term frame solution, the 7 transformation parameters of each individual temporal set of station positions are also estimated. B applying dynamically internal constraints (equivalent to minimum constraints approach) over the time series of the 7 parameters. we then preserve some physical "natural" parameters as tor instance the scale and the origin from VLBI and SLR, respectively. Our

conservative evaluation of the estimated accuracy of the ITRF datum definition is that the origin and its rate are accurate at the level of 5 mm and 2 mm/yr, the scale and its rate are at the level of 1 part per billion (ppb) and 0.1 ppb/yr and the No-Net-Rotation condition implementation is at the level of 2 mm/yr.

The Permanent Tide in Height Systems

IAG Symp., 133:81-87, DOI: 10.1007/978-3-540-85426-5_10, 2009

Makinen, Jaako; Ihde, Johannes

Abstract: We describe the treatment of the permanent tide in various geodetic quantities with an emphasis on systems of gravity-related heights. We review the historical development leading to the present situation, and discuss possible scenarios for the future, especially in view of the adoption of a World Height System.

Bootstrapping with Multi-frequency Mixed Code Carrier Linear Combinations and Partial Integer Decorrelation in the Presence of Biases

IAG Symp., 136:925-933, DOI: 10.1007/978-3-642-20338-1_116, 2012

Henkel, P.

Abstract: Carrier phase measurements are extremely accurate but ambiguous. The reliability of integer ambiguity resolution is improving with Galileo which uses a Binary Offset Carrier (BOC) modulation, large signal bandwidths of up to 50 MHz and additional carrier frequencies. In this paper, a group of multi-frequency mixed code carrier linear combinations is derived which preserves geometry, eliminates the ionospheric delay and maximizes the ratio between wavelength and noise standard deviation of the combination. Moreover, a partial integer decorrelation is suggested to improve the robustness of ambiguity resolution over biases due to orbital errors, satellite clock offsets, and multipath. The proposed group of multi-frequency mixed code carrier linear combinations is characterized by a wavelength of more than 3 m, which makes this group of combinations an interesting candidate for both Wide Area Real Time Kinematics (RTK) and Precise Point Positioning.

Measurement of Inland Surface Water from Multi-mission Satellite Radar Altimetry: Sustained Global Monitoring for Climate Change

IAG Symp., 135:221-229, DOI: 10.1007/978-3-642-10634-7_29, 2010

Berry, P. A. M.; Benveniste, J.

Abstract: Multi-mission satellite radar altimetry makes a unique contribution to the monitoring of global inland surface water; existing datasets already allow derivation of decadal time-series over hundreds of targets worldwide. These data are utilised both for climate change research, to inform water resource management, and, in synergy with GRACE data, to examine time-varying gravity signatures from land surfaces and (potentially) measure sub-surface hydrological flow. As the number of gauged catchments continues to fall, the importance of a global remote sensing measurement capability becomes ever more critical. The key to unlocking this potential is to retrack the complex waveforms returned from inland water targets, to identify and discard echo components returned from targets not directly beneath the satellite, and to discriminate successfully between wet land and inundated surface. This paper presents a global assessment of current capabilities, showcases decadal time-series from past and current altimeters, and demonstrates the Near Real Time measurement capability now running for the ENVISAT RA-2 and soon for Jason-2 as an ESA pilot system, allowing users access to these data within 3 days of measurement. The enhancement of this unique capability anticipated from the series of proposed future missions (such as CryoSat-2 and Sentinel-3) is discussed, and the key contribution to global climate change monitoring is demonstrated.

GRACE Gravity Field Determination Using the Celestial Mechanics Approach - First Results

IAG Symp., 135:177-184, DOI: 10.1007/978-3-642-10634-7_24, 2010

Jaeggi, A.; Beutler, G.; Mervart, L.

Times Cited: 6

Abstract: We present the first gravity field model AIUB-GRACE01S, which has been generated using the Celestial Mechanics Approach in an extended version. Inter-satellite K-band range-rate observations and GPS-derived kinematic positions are used to solve for the Earth's gravity field parameters in a generalized orbit determination problem. Apart from the normalized spherical harmonic (SH) coefficients, arc-specific parameters like initial conditions and pseudo-stochastic pulses are set up as common parameters for all measurement types. Our first results based on 1 year of GRACE data demonstrate that the Earth's static gravity field can be recovered with a good quality, even using EGM96 as a priori model and without accelerometer data and sophisticated background models like short-term mass variations. The use of accelerometer data and sophisticated background models will be a prerequisite for the near future, however, to further improve the inferred gravity field solutions.

DGFI Combination Methodology for ITRF2005 Computation

IAG Symp., 134:11-16, DOI: 10.1007/978-3-642-00860-3_2

Angermann, Detlef; Drewes, Hermann; Gerstl, Michael; et al.

Time Cited: 6

Abstract: In its function as an ITRS Combination Centre DGFI has computed a solution of the International Terrestrial Reference Frame 2005 (ITRF2005). It is based on the combination of epoch normal equations (weekly or session data sets, respectively) of station positions and Earth Orientation Parameters (EOPs) from the geodetic space techniques-specific normal equations, the inter-technique combination using local tie measurements at co-location sites, and the computation of the ITRF2005 solution

Recent Progress in the VLBI2010 Development

IAG Symp., 133:833-840, DOI: 10.1007/978-3-540-85426-5_96, 2009

Behrend, D.; Boehm, J.; Charlot, R.; et al.

Times Cited: 6

Abstract: From October 2003 to September 2005, the International VLBI Service for Geodesy and Astrometry (IVS) examined current and future requirements for geodetic VLBI, including all components from antennas to analysis. IVS Working Group 3 "VLBI 2010", which was tasked with this effort, concluded with recommendations for a new generation of VLBI systems. These recommendations were based on the goals of achieving I mm measurement accuracy on global baselines, performing continuous measurements for time series of station positions and Earth orientation parameters, and reaching a turnaround time from measurement to initial geodetic results of less than 24 It. To realize these recommendations and goals, along with the need for low cost of construction and operation, requires a complete examination of all aspects of geodetic VLBI including equipment, processes, and observational strategies. Hence, in October 2005, the IVS VLBI2010 Committee (V2C) commenced work on defining the VLBI2010 system specifications. In this paper we give a summary of the recent progress of the VLBI2010 project.

Least Squares, Galerkin and BVPs Applied to the Determination of Global Gravity Field Models

IAG Symp., 135:511-517, DOI: 10.1007/978-3-642-10634-7_68, 2010

Sacerdote, F.; Sanso, F.

Times Cited: 5

Abstract: The determination of global gravity potential models is a central issue in Geodesy. In principle the existence of solutions, i.e. of harmonic potentials, given certain boundary conditions, depends on the solvability of certain boundary value problems (BVP) for the Laplace equation, an item that has recently received quite an impulse in terms of abstract theorems. Yet, the real problem is that of approximating such solutions. In general, least squares (l.s.) in Hilbert spaces can give an easy and converging solution to such a problem. Yet, l.s. is very demanding from the numerical point of view because of the notable variability of the boundary, be it the actual surface of the earth or the telluroid. Another, somewhat simpler, technique to approximate a BVP is the so called Galerkin method. The relation between the l.s. and Galerkin is analyzed and clarified. Finally, one has to recognize that in reality the true method used

in geodesy to construct approximations is the use of the downward continuation followed by orthogonality relations. The paper shows that this geodetic approach can be seen as an approximation of the solution of Galerkin's system and, at the same time, as an accelerator of the so called change of boundary method.

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