7th IVS General Meeting

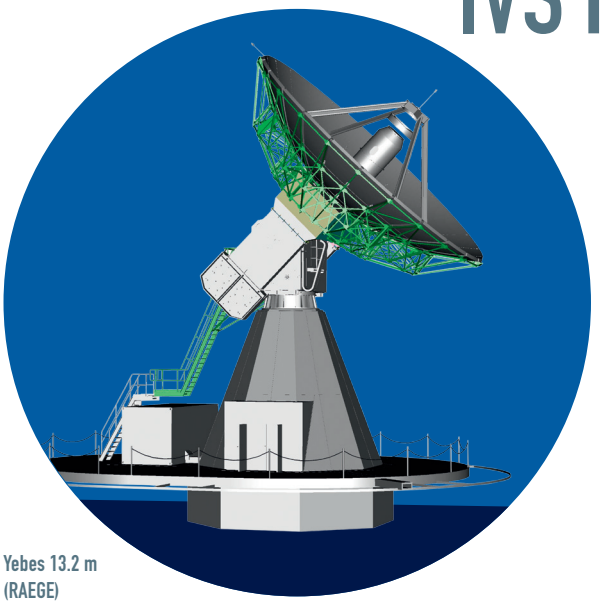
www.oan.es/gm2012/

March 4–9, 2012. Madrid. Spain

Wettzell 13.2 m
(Twin Telescope)

Hobart 12 m
(AuScope)

Launching the Next-Generation IVS Network



Yebes 13.2 m
(RAEGE)

Yebes 40 m

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Hosted by the International VLBI Service for Geodesy and Astrometry (IVS) and the National Geographic Institute of Spain (IGN)

GOBIERNO DE ESPAÑA
MINISTERIO DE FOMENTO

7th IVS General Meeting:
Launching the Next-Generation IVS Network

Madrid (Spain), March 4-9 2012

Abstract's Book

Programme

Monday, March 5th

09:00 - 09:10 Local announcements
09:10 - 09:25 H. Schuh Welcome address and Chair's Report

Session 1. The Next-Generation IVS Network and VLBI2010 Technology Developments
Chairs: B. Petrachenko (09:25-13:00), H. Hase (11:15-13:00), B. Petrachenko (14:30-16:15)

Session 2. Correlators, Stations and Operations Centers
Chair: D. Hall (16:45-18:35), R. Haas (09:00-10:45), D. Hall (11:15-12:15)

Tuesday, March 6th

Session 3. Advances in Software Development, Analysis Strategies and Data Structure
Chair: S. Lambert (12:15-13:05, 14:30-16:30, 09:00-09:30)

Wednesday, March 7th

Session 4. Results in Geodesy, Astrometry and Geophysics and Their Interpretation
Chairs: Z. Malkin (09:30-10:45), T. Artz (11:15-13:00), J. Böhm (09:00-11:25)

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10:00 - 10:15	M. Blossfeld	The role of VLBI in the weekly inter-technique combination (C) 57
10:15 - 10:30	S. Shabala	Network and quasar structure effects on the VLBI reference frame (C) 58
10:30 - 10:45	G. Bourda	Towards an accurate alignment of the VLBI frame and the future Gaia optical frame: global VLBI imaging observations of a sample of candidate sources for this alignment (C) 59
10:45 - 11:15	*Coffee break*	
11:15 - 11:30	C.S. Jacobs	The Celestial Reference Frame at X/Ka-band (8.4/32 GHz) (C) 60
11:30 - 11:45	I.Sotuela	Dual Frequency VLBI Monitoring of a Large Sample of Compact Extragalactic Sources at 8 and 32 GHz (C) 61
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12:15 - 12:30	X. Minghui	Direct estimation of the Solar acceleration using geodetic/astrometric VLBI observations (C) 64
12:30 - 12:45	L. Combrinck	A comparison of General Relativity Theory evaluations using VLBI and SLR; will GGOS improve these results ? (C) . 65
12:45 - 13:00	Z. Malkin	Celestial pole offset: from initial analysis to end user (C) 66
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10:10 - 10:25	G. Elgered	Assessing the quality of WVR data from Onsala during the CONT11 geodetic VLBI campaign (C) 71
10:25 - 10:40	H. Kierulf	Past and present-day ice mass variation on Svalbard revealed by superconducting gravimeter, GPS and VLBI measurements (C) 72
10:40 - 11:10	*Coffee break*	
11:10 - 11:25	R. Haas	VLBI and GNSS frequency link stabilities during CONT campaigns (C) 73

Session 5. VLBI Analysis and Results from the Recent Megaquakes in Japan and Chile
Chair: R. Ichikawa (11:40-13:00)

13:10 - 14:30 *Lunch break*
14:30 - 18:30 13th Analysis Workshop

Friday, March 9th

09:00 - 18:00 Meeting of the IVS Board, at the Royal Observatory of Madrid

Notes:
(I) = Invited talk (25 min)
(C) = Contributed talk (15 min)

Oral contributions

Establishment of the GGOS and the Importance of the Next-Generation VLBI System for It

Hansjoerg Kutterer, Federal Agency for Cartography and Geodesy, Germany

The International Association of Geodesy (IAG) has established the Global Geodetic Observing System (GGOS). The vision of GGOS is "Advancing our understanding of the dynamic Earth system by quantifying our planet's changes in space and time". For this purpose GGOS integrates the geometric part of Geodesy represented by the well-known observation techniques such as Global Navigation Satellite Systems (GNSS), Satellite Laser Ranging (SLR) and very Long Baseline Interferometry (VLBI) and the gravimetric part which is globally represented by satellite missions such as GRACE and GOCE. The mission of GGOS comprises two topics which are relevant in this context: (1) to provide the observations needed to monitor, map and understand changes in the Earth's shape, rotation and mass distribution, (2) to provide the global frame of reference that is the fundamental backbone for measuring and consistently interpreting key global change processes and for many other scientific and societal applications. Hence, GGOS does not represent a theoretical idea only but it strongly relies on advanced observation infrastructure and processing workflows. In this contribution the present state of GGOS will be illustrated. The importance of current and future developments in VLBI will be addressed in particular.

RAEGE: the Spanish-Portuguese contribution to GGOS

Jesus Gomez-Gonzalez, National Geographic Institute (IGN), Spain.; Marlene C.S. Assis, DSCIG, Portugal.

RAEGE (acronym for Atlantic Network of Geodynamical and Space Stations) is the Spanish-Portuguese project to install and operate 4 geodetic VLBI stations to be placed in Yebes and Canary Islands (Spain) and in the Azores Islands (Portugal). Each of these stations will be provided with a 13.2m dish radiotelescope of the VLBI2010 type, a GNSS station, and other geodetic and geophysical instruments. The starting of the RAEGE operations (that of the first radiotelescope in Yebes foreseen in 2013) will play an important role in the launching of the Next Generation IVS Network, and it will also represent an important contribution to the GGOS initiative. In this presentation we highlight the technical, scientific and political reasons which move the National Geographic Institute of Spain (IGN) and the Regional Government of Azores (GRA) to support the RAEGE project.

The Future VLBI2010 Network

Hayo Hase, Bundesamt für Kartographie und Geodäsie; Dirk Behrend, NVI, Inc. / NASA GSFC; Chopo Ma, NASA Goddard Space Flight Center; Bill Petrachenko, Natural Resources Canada (NRCan); Harald Schuh, Institute of Geodesy and Geophysics, TU Wien; Alan Whitney, MIT Haystack Observatory

The achievements of the VLBI2010 Project Executive Group (V2PEG) will be documented and an outlook of the future VLBI2010 network evolution will be given.

First broadband results with a VLBI2010 system

Arthur Niell, MIT Haystack Observatory

A 12m antenna has been installed at the Goddard Geophysical and Astronomical Observatory, Maryland, USA, and equipped with a VLBI2010 broadband signal chain, including a QRFH feed, UpDown Converters for frequency flexibility, RDBE digital backends, and Mark5C recorders. A similar system has been installed on the Westford 18m antenna, except that a Lindgren quadridge feed is used. The baseline length is approximately 600 km.

The sensitivity of the 12m antenna exceeds the nominal value that was used in the VLBI2010 simulations, achieving an SEFD at zenith that is comparable to that of the 18m antenna in its usual S/X configuration.

Initial observations are being made to evaluate 1) the performance of the broadband systems, 2) the use of the DiFX software correlator, and 3) the upgrades of the post-correlation software that have been necessary to exploit the new broadband dual-linear-polarization phase-delay observable. Results of these initial tests will be reported.

THE RAEGE VLBI2010 RADIOTELESCOPE

Jose Antonio Lopez Fernandez, IGN Spain; Jesus Gomez Gonzalez, IGN Spain; Carlos Albo Castano, IGN Spain

The RAEGE radiotelescope is described. The design, which fulfils the VLBI2010 specifications, has been finished and currently three radiotelescopes are being manufactured. The first one is scheduled in summer 2012 at Yebes Observatory.

The RAEGE radiotelescope concept is based on the elevation azimuth turning head over azimuth bearing principle. The equilibrium of the elevation is ensured by means of two counterweigths. The optical design is based on a ring focus reflector type system with a 13.2 meters main reflector diameter.

The entire mobile structure is supported by a base connected to the concrete tower that is built on the foundation of the radio telescope. On the base, a bearing is installed, which enables the azimuth movement of the structure comprising the azimuth cabin and the reflector.. A concrete pillar is installed at the center of the concrete tower, allowing the measurement of the Invariant point located at the intersection of the azimuth and elevation and being visible from the outside through openings.

The reflector is connected to the azimuth cabin by means of two elevation bearings. The drive systems are 4 in Azimuth and 4 in Elevation. The physical range of elevation is 0 Ű 100 deg and 540 deg in azimuth. The maximum azimuth velocity is 12 deg per second. The maximum elevation velocity is 6 deg per secondand the maximum AZ EL acceleration is 3 deg per square second. The servomechanism switchboards are located in a separate container placed at the ground level reducing the RFI at the receiver level.

By design, the overall pointing precision, without astronomical calibration, shall be lower than 16 arcsec. The path length error shall be lower than 0.26 mm measured from the aperture through main reflector, subreflector and feed to point of intersection of the azimuth and elevation axes. The main reflector surface is made of three stretched aluminium panels rings. The accuracy of each panel is lower than 70 microns and the RMS surface accuracy of the whole reflector will be lower than 186 microns.

New Project for constructing VLBI2010 Antenna in Japan

Yoshihiro FUKUZAKI, Geospatial Information Authority of Japan (GSI); Misao ISHIHARA, Geospatial Information Authority of Japan (GSI); Jiro KURODA, Geospatial Information Authority of Japan (GSI); Shinobu KURIHARA, Geospatial Information Authority of Japan (GSI); Kensuke KOKADO, Geospatial Information Authority of Japan (GSI); Ryoji KAWABATA, Geospatial Information Authority of Japan (GSI);

Geospatial Information Authority of Japan (GSI) has started a new project for constructing VLBI2010 antenna (radio telescope) in Japan. The basic design of the specification of the antenna is now being investigated. The candidate of the station for the new antenna is in Tsukuba (GSI's precincts) or near Tsukuba. The antenna will be installed in the site by the end of next fiscal year (March, 2013). The result of the investigation for the design of the specification will be briefly reported.

Outreach activities in the endeavor for financing an upgrade of the Geodetic Observatory in Ny-Ålesund

Per Erik Opseth

Five years back in time, NMA realized for the first time that the Geodetic Observatory in Ny-Ålesund was not compliant with the VLBI2010 requirements. According to national procedures this led us to submit a proposal to our Ministry that contained a complete upgrade with two new VLBI antennas, SLR equipment, a new control room, and other necessary infrastructure. In total this summarized to an amount of M$36.

The first submitted proposal was rejected by the Ministry, and after that time a lot of efforts have been taken to convince the decision makers about the need for an upgrade. Within the IVS community we have heard about similar situations other places in the world, so we are definitely not the only one that is struggling to get funds for such a necessary upgrade. I think we can say that the chances for NMA to succeed in near future are fairly good, but the questions are: Would we have succeeded earlier if IVS had put more attention on outreach work on global level? How can IVS contribute to this outreach work to help each respective country convincing their decision makers?

New observing strategies with twin telescopes for geodetic VLBI

Jing Sun,Vienna University of Technology ; Tobias Nilsson, Vienna University of Technology; Johannes Boehm, Vienna University of Technology; Harald Schuh, Vienna University of Technology

The concept of twin radio telescopes enables a lot of new observation strategies. These are investigated by developing the mathematical basis in terms of observation equations (single, double or even triple differences), creating new observation schedules, doing careful simulations, and finally by analyzing results. Advantages are obtained by assuming the same troposphere above the twin telescopes and connecting them to the same H-maser clock. Three different observing strategies are investigated. The first is that both twin telescopes point simultaneously to the same radio source ('array mode') to increase the sensitivity and counteract the troposphere effect. The second is that both radio telescopes record signals of different sources at the same time, then different subnets are tied via the same site. In the third strategy, one telescope is slewing while the other radio telescope is still tracking a source, thus 'continuous' observations can be realized because one of the twin radio telescopes is always on source. Hence the high slewing rates of the twin telescopes will be fully exploited for the various new observing strategies. The scheduling package of the Vienna VLBI Software (VieVS) will be used to develop different schedules allowing all the options and combinations mentioned above.

Prospects of IVS-Intensive Sessions with Twin-Telescopes

Judith Leek, University of Bonn; Thomas Artz, University of Bonn; Axel Nothnagel, University of Bonn

The Wettzell-Twin-Telescope (TTW) is currently being assembled and is expected to become operational in late 2012. The TTW promises various observation scenarios that might strengthen the parameters estimated from the observation. This is especially true for the one hour Intensive Sessions IVS-INT3 where observations are performed on three baselines with the radio telescopes NYALES20, TSUKUB32 and WETTZELL. For this session type, the number of observations will be significantly increased and the local hemisphere above either telescope will be covered in a better way. We investigate optimization scenarios for TTW within the INT3 sessions.

We will present various scheduling and simulation approaches for the IVS-INT3 sessions. The schedules are done with an automatic scheduling procedure that is based on the analysis of the variance-covariance matrix of the estimated parameters. Furthermore, the handling of local TTW-specific parameters, i.e., clocks and troposphere, will be investigated. The results will be validated by thorough analyses of the UT1 estimates.

VLBI2010: Progress and Challenges

Bill Petrachenko, Natural Resources Canada (NRCan)

It is now six years since the publication of the final report of IVS Working Group 3 entitled "VLBI2010: Current and Future Requirements for Geodetic VLBI systems" in which a bold vision for a next generation geodetic VLBI system was put forward. In the intervening years work towards the realization of that vision have been carried out under the technical leadership of the IVS VLBI2010 Committee. This talk presents an overview of progress towards achieving the VLBI2010 goals and challenges yet to be overcome.

VLBI2010 and the Westford station - the path forward

Christopher Beaudoin, MIT Haystack Observatory; Arthur Niell, MIT Haystack Observatory; Brian Corey, MIT Haystack Observatory; Michael Poirier, MIT Haystack Observatory; Bruce Whittier, MIT Haystack Observatory

For the past 3 years, the role of the Westford antenna in geodetic VLBI has been two-fold. Over this time, its primary purpose has been to participate in standard S/X-band geodetic VLBI observations. In its secondary role, the Westford antenna is converted into a research instrument, facilitating the development of the broadband geodetic VLBI observing technique. As a research instrument the Westford antenna incorporates a commercially-available ETS-Lindgren 3164 quadridge antenna as a radio telescope feed and uses the VLBI2010 data acquisition system incorporating digital backends (DBEs) which implements a polyphase filter bank processor. The process of converting the station from its mode of operations to a research instrument often introduces subtle anomalies that often must be diagnosed prior to broadband observing. Furthermore, this bifurcation of the station's role is not in line with the goals of the VLBI2010 specifications. Until recently, it has not been possible for the Westford station to serve as both an operational and research instrument without station conversion for two reasons: 1. poor sensitivity and 2. incompatibility of backend baseband filter bandwidths The poor sensitivity of the Westford antenna as a broadband radio telescope is in large part due to the commercial broadband feed which was readily available when the proof-of-concept VLBI2010 observations were initiated. However, with the materialization of the quadridge feed horn (QRFH) by the California Institute of Technology and with the improvements in the DiFX software correlator, the necessary components are now available to upgrade the Westford station to full-broadband capability while also adhering to the mandate to maintain backwards compatibility with the legacy S/X systems. In this presentation we will present the path forward for upgrading the Westford site to full-broadband capability while maintaining S/X compatibility.

S/X/Ka coaxial feed for the tri-band receiver for RAEGE antennas

Félix Tercero, Instituto Geografico Nacional (IGN); JA.López-Fdez, Instituto Geografico Nacional (IGN); JA.López-Pérez, Instituto Geografico Nacional (IGN);

The tri-band cryogenic receiver for the first light observations of the first RAEGE project antenna in Yebes observatory is being developed, in the framework of the VLBI2010 project.

The 13m new ring focus antennas are suitable to be feed by a broad-band feed like the Eleven Feed. However other feed configurations are possible to cover narrower bands, like the S, X and Ka bands. With this frequency arrangement, the feed makes possible the backward compatibility with classical VLBI and it will be especially useful for the Ka commission in of the antenna. X/Ka simultaneous observation will be also possible to link this antenna with another VLBI networks.

The feed, designed to illuminate the ring focus antenna, is made of a coaxial waveguide, for the S and X bands, and a circular waveguide for the Ka band. Four outputs from their corresponding field probes at S and X bands must be combined with 180ž and 90ž hybrid circuits to get dual-circular polarization. In the Ka band case, the dual-circular polarization is obtained with a septum polarizer. The feed, hybrids and polarizer will operate at cryogenic temperature.

A tri-band cryogenic receiver for the RAEGE project antennas

J.A. López-Pérez, Instituto Geografico Nacional (IGN); F. Tercero, Instituto Geografico Nacional (IGN); J. M. Serna, Instituto Geografico Nacional (IGN); J.A. López-Fernández, Instituto Geografico Nacional (IGN)

The Spanish Centro de Desarrollos Tecnológicos (CDT) is developing a tri-band cryogenic receiver for the first light observations of the first RAEGE project antenna in Yebes observatory, in the framework of the VLBI2010 project.

The RAEGE project plans to install three new ring focus 13m antennas in compliance with the VLBI2010 specifications. These antennas are unde construction.

The receiver envisaged for these antennas will operate in the S (2.2 - 2.7 GHz), X (7.5 - 9 GHz) and Ka (28 - 33 GHz) bands simultaneously in order to be backwards compatible with non-VLBI2010 stations and forward compatible with new VLBI2010 stations.

The estimated equivalent noise temperature for this receiver is lower than 15K for all the frequency bands.

The output signals from the cryostat will be sent to their corresponding room temperature downconverters for later amplification, filtering and mixing. The final IF signal will range from 500 to 1000 MHz, as in a classical geodetic VLBI receiver.

An advantage of having the Ka band receiver is that it will allow the radiometric characterization of these antennas during commissioning. In addition, simultaneous X/Ka operation would be possible too.

The first receiver of this type is planned to be finished by September, 2012. Currently the procurement of components is in progress and the feed is under construction.

Study of RF direct sampling technique for geodetic VLBI

Takefuji K., NICT ; Kondo T., NICT; Sekido M., NICT; Ichikawa R., NICT; Kurihara S., GSI ; Kokado K., GSI; Kawabata R., GSI

In a conventional VLBI system, RF signals of S and X-band are converted to baseband signals with an analog baseband converter, then converted to digital signals (Heterodyne system). Recently it becomes available to sample RF signals directly (Homodyne system) because of the progress of sampling device performance. This RF direct sampling will make the front-end system simple and will increase the reliability of the system.

We carried out a test VLBI experiment by using an RF direct sampling technique between Kashima 11m antenna and Tsukuba 32m antenna in May 2011, and could detect the fringes at the first time in the world as an RF direct sampling adopted to X band signals.

As a successful result, we have carried out a 24-hour geodetic VLBI experiment in Oct 2011 also on Kashima-Tsukuba baseline. In the experiment we adopted a brand new technique of which S and X band signals were combined in RF signals. Then combined signals were sampled by the only one sampling device, i.e., sampled data are a single digital data stream. We could detect good fringes for both S and X band signals from this single data stream, and succeeded in a baseline analysis, The obtained baseline vector is consistent with those obtained by conventional VLBI experiments.

DBBC3 - A full digital implementation of the VLBI2010 backend

G. Tuccari, INAF - Istituto di Radioastronomia, Noto - Italy;

The project of the third version for DBBC backend system implementation is presented. This system is able to fully implement in digital the functionalities required by a complete VLBI2010 backend, including the sky frequency conversion in the entire range 2-14 GHz, so avoiding any need of an analogue down-conversion to be used as preprocessor of a polyphase digital filter bank. The architecture and adopted methods are described.

VLBI 2010 using the RDBE and Mark5C

Chet Ruszczyk, MIT Haystack Observatory; Russ McWriter, MIT Haystack Observatory; Arthur Niell, MIT Haystack Observatory; Alan Whitney, MIT Haystack Observatory; Geoff Crew, MIT Haystack Observatory; Shep Doleman, MIT Haystack Observatory; Chris Beaudoin MIT Haystack Observatory; Jon Romney, NRAO; Walter Brisken, NRAO; Hichem Ben Frei, NRAO; Paula Metzner, NRAO; Matt Luce, NRAO;

Two key components of the VLBI 2010 system are the digital backend and the recording system. In this presentation we present an overview of both the RDBE and the Mark5C capabilities and follow up with the status of the hardware, firmware, and software. We will then follow up with the future directions of the FPGA capabilities expected for the RDBE as used in a 2010 systems and RDBE's in general.

Mark 6 Next-Generation VLBI Data System

Alan Whitney, MIT Haystack Observatory; Roger Cappallo, MIT Haystack Observatory; David Lapsley, MIT Haystack Observatory

The Mark 6 VLBI data system is being developed by MIT Haystack Observatory as a next-generation disk-based VLBI data system capable of supporting the goals of VLBI2010, with a maximum sustained recording rate of 16 Gbps writing to an array of 32 magnetic disks. The Mark 6 is based on COTS hardware and open-source code and is being designed to transition easily from the widely used Mark 5 system. A successful 16Gbps per station VLBI experiment was conducted with Mark 6 in October 2011 as a proof-of-concept. Haystack Observatory is collaborating with the NASA/GSFC High-End Network Computing Group in the selection of high-performance COTS hardware platforms and with Conduant Corporation in development of a high-performance disk module for Mark 6. Existing Mark 5 systems will be upgradeable to Mark 6, and existing Mark 5 SATA modules will be upgradeable for compatibility with Mark 6. The Mark 6 system is projected to be available to the VLBI community in mid/late 2012.

Correlation and Post-processing for VLBI2010

Roger Cappallo, MIT Haystack Observatory

The characteristics of the VLBI2010 system are sufficiently different from the venerable geodetic S/X system that new techniques must be adopted in correlation and post-processing. High data-rates and mismatch of bandwidths between VLBI2010 and legacy stations are handled by software correlation. The wide frequency range necessitates removal of the ionosphere in the fringe-fitting process. The use of linear polarizations brings new challenges, especially when they are being combined with existing circularly- polarized data from other stations. These issues will be discussed, as will plans for how best to treat them in correlation and post-processing.

Recent Activities of Tsukuba Correlator/Analysis Center

Kensuke Kokado, Shinobu Kurihara, Ryoji Kawabata, Kentarou Nozawa;

The Geospatial Information Authority of Japan (GSI) became an IVS operational analysis center on April 7th, 2010. Since then, we have been in charge of correlation and rapid analysis for IVS-INT2 sessions. The results of the INT2 sessions can be submitted to IVS data center within a few minutes after the observing session. GSI has also implemented some ultra-rapid dUT1 experiments in cooperation with ONSALA, HOBART stations in 2011. The data processing system for the sessions and experiments was developed to correlate and analyze the data in real-time. The detail of the data processing system of Tsukuba Correlator/Analysis Center and the results of the ultra-rapid dUT1 experiments are shown on the presentation.

Bonn Correlator Status Report.

Alessandra Bertarini, University of Bonn and Max-Plank Institute for Radioastronomy.; Walter Alef, Max-Plank Instutute for Radioastronomy.; Arno Mueskens, University of Bonn.; Helge Rottmann, Max-Plank Institute for Radioastronomy.

At Bonn, in 2011 the DiFX correlator completely replaced the old MarkIV correlator. In this presentation we review the experience gained in using the DiFX for both geodesy and astronomy and describe the enhancement to the DiFX done in Bonn.

e-transfer at the Bonn correlator

Simone Bernhart, IGG Bonn University; Arno Mueskens, IGG Bonn University

During the last years, the number of stations that transfer their observational data via high-speed network connections to the correlators, has increased significantly. In order to help coordinating e-transfers among correlators and stations, the Geodesy VLBI Group has set up a website that shows ongoing transfers. I am going to present the usage of this website as well as the overall status of e-transfers at the Bonn correlator.

Improving VLBI Station Performance

Ulrich Schreiber, Bundesamt fuer Kartographie und Geodaesie

Higher Bandwidth and a vastly increased number of observed radio sources are basic elements of the roadmap into the future of VLBI. The new TWIN telescope system in Wettzell is in agreement with these basic goals. Systematic intratechnique biases are of eaqually high importance. Modern instrumentation of quantum optics and recent progress in high resolution event timing provide new tools for studying system behavior and the improvement of system stability. Compensated optical fibers may qualify as suitable tools for one-way system delay reduction. This talk will introduce current activities for system stabilization, inter- and intra- technique bias reductions in Wettzell.

e-RemoteCtrl: Concepts for VLBI station control as part of NEXPReS

M. Ettl, FESG, TU München / MPIfR; A. Neidhardt, FESG, TU München; M. Mählbauer; W. Alef, MPIfR; E. Himwich, NVI Inc, NASA/GSFC; C. Beaudoin, MIT Haystack Observatory; C. Plötz; J. Lovell

In the "Novel EXploration Pushing Robust e-VLBI Services"-project (NEXPReS) the Technische Universitaet Muenchen (TUM) realizes concepts for continuous quality monitoring and station remote control in cooperation with the Max Planck Institute for Radio Astronomy, Bonn. NEXPReS is a three-year project, funded within the European Seventh Framework program. It is aimed to develop e-VLBI services for the European VLBI Network (EVN), which can also support the IVS observations (VLBI2010). Within this project, the TUM focuses on developments of an operational remote control system (e-RemoteCtrl) with authentication and authorization. It includes an appropriate role management with different remote access states for future observation strategies. To allow a flexible control of different systems in parallel, sophisticated graphical user interfaces are designed and realized. The software is currently under test in the new AuScope network, Australia / New Zealand. Additional system parameters and information are collected with a new system monitoring (SysMon) for a higher degree of automation, which is currently under preparation for standardization within the IVS Monitoring and Control Interface (MCI) Collaboration Group. The whole system for monitoring and control is fully compatible to the NASA Field System and extends it.

Warkworth geodetic station as a potential GGOS core site in New Zealand

Hiroshi Takiguchi, Institute for Radio Astronomy and Space Research/AUT; Tim Natusch, Institute for Radio Astronomy and Space Research/AUT; Sergei Gulyaev, Institute for Radio Astronomy and Space Research/AUT;

The GGOS goal is the origin definition at 1mm accuracy or better and a temporal stability of the order of 0.1mm/yr, with similar numbers for the scale and orientation components. Warkworth is the only geodetic station in New Zealand that has the capability to become the national GGOS core site. As the GGOS core site has to provide stable and high quality outputs, here we reconsider the geodetic analysis procedure at Warkworth, including the ocean tide loading at the site. The displacements due to ocean tide loading calculated for Warkworth are up to $\pm$10mm for the horizontal components, and $\pm$40mm for the vertical component. A high-resolution land-sea data grid which represents the coastline is one of the important components for calculation of an accurate site-dependent ocean tidal coefficient. We compare the ocean tide loading displacements calculated using different grid data. One of the site-dependent coefficients was calculated by the Ocean Tide Loading Provider maintained by the Onsala Space Observatory. Another was calculated using GOTIC2 software with the Shuttle Radar Topography Mission data set, which provides 3 arc-second grid data all over the world. Differences between the ocean tide loading displacements in the two models were less than 1mm for the East-West component, $\pm$1mm for the North-South component, and $\pm$2mm for the vertical component. These differences are significant for the goal of 1mm target accuracy, demonstrating the importance of the right choice of coastline grid data.

Korea Geodetic VLBI station

SangOh Yi, National Geographic Information Institute (NGII); Younghyun Moon, National Geographic Information Institute (NGII); Seunghun Kim, National Geographic Information Institute (NGII); Jungil Lee, National Geographic Information Institute (NGII); Hyunghee Ju, National Geographic Information Institute (NGII); Hongjong Oh, National Geographic Information Institute (NGII); Tetsuro Kondo, National Institute of Information and Communications Technology (NICT); Tuwhan Kim, Ajou University

We summarize briefly the status of Korea Geodetic VLBI construction and system performance test results. Also becoming an IVS member and future plans are included.

Estimation of the invariant reference point: first steps at Yebes

Alvaro Santamaría-Gómez, Instituto Geográfico Nacional.; Susana García-Espada, Instituto Geográfico Nacional.; Rdiger Haas, Chalmers University of Technology.; Javier López-Ramasco, Instituto Geográfico Nacional.

The relative position of the reference points of the different space geodetic instruments at the Yebes observatory is a key issue in order to realize the International Terrestrial Reference Frame. We present the simulations carried out to estimate the invariant reference point (IRP) coordinates of the 40m radio-telescope at the Yebes observatory. In addition, in order to assess the robustness of the used algorithm, we compared the estimated IRP coordinates of the 20m radio-telescope at the Onsala Space Observatory using real survey observations.

From these simulations we show how the precision of the estimated IRP coordinates depends on the number, quality and geometry of the simulated survey observations. Based on these results, a new observation strategy will be set up at the Yebes observatory in order to determine the IRP of the 40m radio-telescope.

VLBI Data Acquisition Terminal modernization at the Deep Space Network

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The Deep Space Network is replacing the aging MarkIV Data Acquisition Terminal (DAT) with a digital backend: the Deep Space Communications Complex VLBI Processor (DVP). It is based on the Wideband VLBI Science Receiver (WVSR), a custom made open-loop digital receiver developed in JPL that is successfully supporting differential-VLBI for spacecraft navigation (DDOR) and other radio astronomy applications: Earth orientation parameters determination, astrometry, spectroscopy observations, etc.

The new acquisition terminal has inherited from the WVSR the IF digitizer module, the firmware architecture and monitor and control software. Among the new features it improves considerably the recording rate providing at least 1 Gbps with the goal of achieving 4 Gbps, it uses a CASPER ROACH board for real-time Digital Signal Processing and channelization and streams the data into a Mark5C recorder. This contribution describes in detail the DVP in the context of similar digital developments (RDBE, DBBC, etc.).

As the new backend will not use the standard Field System environment to perform the VLBI observations, efforts are under way to make it compatible with the correlators, providing monitor and calibration data in the appropriate format. Lately an important effort has been made in the DSN towards automation of the VLBI data acquisition using the Automation Language for Managing DSN Operations (ALMO). The automation process will be adapted for the new DAT.

The AuScope VLBI Array

Jim Lovell, University of Tasmania; Jamie McCallum, University of Tasmania; Stas Shabala, University of Tasmania; John Dickey, University of Tasmania; Christopher Watson, University of Tasmania; Oleg Titov, Geoscience Australia

The AuScope VLBI array, consisting of three new 12m radio telescopes in Australia dedicated to geodesy, has now commenced operations. The telescopes at Hobart (Tasmania), Katherine (Northern Territory) and Yarragadee (Western Australia) are co-located with other space geodetic techniques including GNSS, gravity and SLR. This new facility is making significant contributions to improving the densification of the International Celestial Reference Frame in the southern hemisphere, improving the International Terrestrial Reference Frame in the region and in measurement of intraplate deformation of the Australian tectonic plate.

We will present an overview of the current status of the VLBI facility, it's current performance, and plans for an upgrade to a VLBI2010 broadband system. We will also highlight some of the geodetic research projects currently underway at the University of Tasmania that are taking advantage of this new facility.

Geodetic VLBI observations for the CMONOC project

Fengchun Shu, SHAO/CAS; Weimin Zheng, SHAO/CAS; Xiuzhong Zhang, SHAO/CAS; Bo Xia, SHAO/CAS; Min Wang, YAO/CAS; Yusup Aili, XAO/CAS

The first regular domestic geodetic VLBI observing program in China, dedicated to the project Crustal Movement Observation Network of China (CMONOC), has been carried out from the year 2011 onward, with participation of Shanghai, Kunming and Urumqi stations. In order to support the data correlation of the geodetic observations, the Shanghai correlator system, which was originally designed for the tracking of the Chinese lunar satellites, has been upgraded to be compatible with geodetic sub-array mode and Mark 5B data format. The whole system is now an operational, fully functional and internationally compatible system. In order to connect with the global terrestrial reference frame more accurate, Kunming has also begun to join in a few IVS sessions on annual basis. It is anticipated that the wider bandwidth observations (16ch$imes$32MHz/ch) by taking advantage of CDAS and wider frequency coverage at X band (8.2-9.0GHz) will be operational in the near future to reduce the measurement error.

EOP Determination using the Russian Domestic VLBI Network "Quasar"

E.Skurikhina, A.Finkelstein, A.Ipatov, S.Smolentsev, I.Surkis, A. Melnikov, V. Zimovsky, A.Salnikov, I.Gayazov, L. Fedotov, I.Rahimov, A.Dyakov, R.Sergeev, S.Kurdubov, D.Ivanov, V. Mardishkin, Institute of Applied Astronomy RAS, Russia

We present the state-of-the-art of the of Russian Domestic VLBI network "Quasar". The observations are carried out within the scope of two programs: Ru-U for the operational determination of Universal Time in near real-time and Ru-E for the determination of EOP from 24-hour sessions. Correlation of the data is performed at the IAA correlator ARC. The IAA analysis center performs data processing with the QUASAR and OCCAM/GROSS software packages. We show the progress in the EOP determination accuracy following the upgrade of the registration system to the R1002M DAS developed at IAA. We complete the presentation with future plans for the development of the "QUASAR" network.

A New VLBI Intensive Series Using the Mauna Kea and Pie Town Stations of the VLBA

David Boboltz, USNO; Walter Brisken, NRAO; Kerry Kingham, USNO; Kenneth Johnston, USNO; David Hall, USNO; Nicole Geiger, USNO; Alan Fey, USNO

The U.S. Naval Observatory (USNO) and the National Radio Astronomy Observatory (NRAO) have begun a series of geodetic intensive experiments using the Mauna Kea, HI and Pie Town, NM stations of the Very Long Baseline Array (VLBA). This single-baseline series will supplement existing IVS intensives for the purpose of providing daily UT1 measurements at reduced latency. We describe the end-to-end VLBI data path including: new data collection systems at the VLBA stations, new high-speed network connections for rapid e-transfers, and the USNO implementation of the DiFX software correlator for processing the data. We present preliminary results from the series and discuss prospects for the release of the data to the IVS community.

MARBLE (Multiple Antenna Radio-interferometry for Baseline Length Evaluation): Development of a compact VLBI system for calibrating GNSS and electronic distance measurement devices

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We are developing a compact VLBI system with a 1.6 m diameter aperture dish in order to provide reference baseline lengths for calibration. The reference baselines are used to validate surveying instruments such as GPS and EDM and is maintained by the Geospatial Information Authority of Japan (GSI). The compact VLBI system will be installed at both ends of the reference baseline. Since the system is not sensitive enough to detect fringes between the two small dishes, we have designed a new observation concept including one large dish station. We can detect two group delays between each compact VLBI system and the large dish station based on conventional VLBI measurement. A group delay between the two compact dishes can be indirectly calculated using a simple equation. We named the idea "Multiple Antenna Radio-interferometry for Baseline Length Evaluation (MARBLE)' system. The compact VLBI system is easy transportable and consists of the compact dish, a new wide-band front-end system, azimuth and elevation drive units, an IF down-converter unit, an antenna control unit (ACU), a counterweight and a monument pillar. Each drive unit is equipped with a zero-backlash harmonic drive gearing component. A monument pillar is designed to mount typical geodetic GNSS antennas easily and an offset between the GNSS antenna reference point and the location of the azimuth-elevation crossing point of the VLBI system is precisely determined with an uncertainty of less than 0.2 mm. We have carried out seven VLBI experiments on the Kashima-Tsukuba baseline (about 54 km) using the two prototypes of the compact VLBI system between December 2009 and December 2010. The average baseline length and repeatability of the experiments is $54184874.0pm2.4mm$. The results are well consistent with those obtained by GPS measurements. In addition, we are now planning to use the compact VLBI system for precise time and frequency comparison between separated locations.

Co-location of VLBI with other techniques in space: a simulation study

Benjamin Männel, ETH Zurich; Markus Rothacher, ETH Zurich

The quality of the links between the different space geodetic techniques (VLBI, SLR, GNSS and DORIS) is still one of the major limiting factors for the realization of a unique global terrestrial reference frame that is accurate enough to allow the monitoring of the Earth's system. Typically the local ties between the techniques are estimated during terrestrial surveyings, unfortunately for many fundamental sites the offset values are inaccurate, incomplete or even missing. A good alternative arises by additional co-locations in space, where the different space geodetic techniques are combined on board a satellite using eccentricities measured before launch.

While quite a few scientific satellites provide GPS and SLR data in good quality for such co-locations in space (e.g. JASON1, CHAMP, GRACE, GOCE, TerraSar-X, TanDEM-X), the NanoGEM and GRASP missions, specifically dedicated to co-location, will also integrate a VLBI transmitter (and a DORIS receiver). The optimal use of VLBI signals transmitted by a satellite requires some special mission characteristics especially concerning the orbital parameters. Based on orbit simulations with various values for the orbital elements, in particular for the satellite altitude, the observability of the co-location satellite, depending on the VLBI baseline configurations and the elevation cutoff angle, will be discussed. In addition, a realistic scenario has to take into account the slew rates of the telescope and the available observation time. First results of a variance-covariance study concerning the estimates of the orbit, the station coordinates and tropospheric delays will be presented.

Plans for geo-VLBI in parallel to astro-VLBI observations at the VIRAC, Latvia

Ivars Schmelds, Ventspils University College; Normuds Jekabsons, Ventspils University College; Valdis Avotins, Ventspils University College; Janis Kaminskis, Riga Technical University

We have valuable historical heritage of radio telescopes (RT). Ventspils International Radio Astronomy centre; VIRAC http://virac.venta.lv/en has been founded in 1994 on base of former military site, contained two parabolic antennas with diameter 32 (latitude 57.553ř N, longitude 21.855řE) and 16 meters. At this moment we have practice and some experience in astronomical VLBI observations and some international projects. In future we have plans to participate in geodetic VLBI observations and contribute to Global Geodetic Observation System (GGOS) network in cooperation with Nordic countries. At the Irbene/RT station we have permanent GNSS station, running now more than for 10 years and absolute gravity station. Our place of RT station location is placed in region of active movement of Fenno-Scandinavia land uplift, like till 2 mm/year.

Simulation Analysis of Positioning for probes in Chinese CE-3 mission

Li Liu, Shanghai Astronomical Observatory; Jinling Li, Shanghai Astronomical Observatory

The Chinese lunar exploration spacecraft Chang'E-3 satellite will be launched during 2012 2013. In this mission, the two kinds of probes lander and rover will arrive at the surface of the moon. It will bring new challenge to technology and theories comparing with the traditional VLBI in current CE missions. As the ΔDOR and SBI methods are adopted, the old models should be updated synchronously. Besides, after the lander lands it will stand still on the moon as time variation, the observations will be accumulated along with time, adjusted algorithm will be used to speed up the solution, and of course the precision of angular position should be greatly improved. Moreover, the rover will move and stop in different sessions. So the D-VLBI models will also be different in the two situations, and the Kalman filter method will be introduced to solve the parameters. This paper reported the simulation analysis results in all the above cases in CE-3 mission, including the verification of positioning models, discussions aiming at the possible problems arise in practice, and precision evaluation, etc.

Report of IVS Working 4: Proposed VLBI Data Format

John Gipson, NVI, Inc/NASA GSFC

I present an overview of the "openDB format" for storing, archiving, and processing VLBI data. In this scheme, most VLBI data is stored in NetCDF files. NetCDF has the advantage that there are interfaces to most common computer languages including Fortran, Fortran-90, C, C++, Perl, etc, and the most common operating systems including linux, Windows and Mac. The data files for a particular session are organized by special ASCII "wrapper" files which contain pointers to the data files. This allows great flexibility in the processing and analysis of VLBI data. For example it allows you to easily change subsets of the data used in the analysis such as troposphere modeling, ionospheric calibration, and editing and ambiguity resolution. It also allows for extending the types of data used, e.g., source maps. I present a roadmap to transition to this new format. The new format is already in use by several analysis packages. This new format can now be used by various analysis packages.

Combination of Astro-Geodetic Techniques at the Normal Equation Level.

Daniel Gambis, Paris Observatory,SYRTE, GRGS; Jean Yves Richard, Paris Observatory,SYRTE, GRGS

The various astro-geodetic techniques contribute, at various levels, to the determination of geodetic parameters: earth orientation parameters (EOP), terrestrial reference frame, zenith troposphere delays and quasars coordinates. Therefore, their combination at the observation level seems advantageous to detect systematic biases and improve the accuracy, the time resolution and the overall consistency of the combined geodetic products. A major task of the IERS Working Group "COL" on Combination at the Observation Level created in 2009 is to study methods and advantages of combining astro-geodetic techniques (VLBI, LLR, GNSS, SLR and DORIS), searching for an optimal strategy to solve for geodetic parameters. The first action of the Working Group was to organize an inter-comparison benchmark campaign over CONT08 to serve as a test. We present the first analyses performed at Paris Observatory for Earth Orientation parameters and troposphere delays.

IVS combination center at BKG: Recent Activities

Sabine Bachmann, BKG, Germany; Michale Lösler, BKG, Germany

In addition to the routine rapid combination, the IVS combination center at BKG is working on various other projects basing on VLBI combination. The generation of a quarterly solution (long term combination of VLBI sessions) is one of the main projects. This solution includes the computation of a VTRF and the analysis of station coordinates and velocities. Mainly the changes in station position and station motion caused by significant earthquakes, as they happened in the recent past, are investigated. An increasing number of ACs is starting to contribute source positions, besides EOP and station coordinates. Hence, an analysis of these positions can be carried out within the combination process. Recently four institutions, with mostly proprietary developed analysis software, are on the way to be integrated in the combination process and to become new ACs. The upcoming diversity of software packages supports the heterogeneity of the input data and promises a more balanced combination. All combined products will benefit from this aspect. Another focus at BKG has been set to the investigation of outlier tests and weighting strategies within the combination procedure. A model of a robust outlier test using the Least Median Square (LMS) has been introduced. Results of all projects are published on the combination centers web sites, including features to perform web-based data analysis.

Remote Control and Monitoring of VLBI Experiments by Smartphones

Cristian Herrera, TIGO - Universidad de Concepcion.; Hayo Hase, TIGO - Bundesamt für Kartographie und Geodäsie; Octavio Zapata, TIGO - Universidad de Concepcion; Felipe Pedreros, TIGO - Universidad de Concepcion

For the remote control and monitoring of VLBI operation we developed a software optimized for smartphones. This is a new tool based on a client-server architecture with a web interface optimized for smartphone screens and cellphone networks. The server uses variables of the FieldSystem and its station specific parameters stored in the shared memory. The client running on the smartphone by a web interface analyzes and visualizes the current status of the radiotelescope, receiver, schedule, and recorder. In addition it allows to send commands remotely to the FieldSystem computer and displays the log entries. The user has full access to the entire operation process, which is important in emergency cases. The software also integrates a webcam interface.

Ideas for a cooperative software development for future GGOS stations

Alexander Neidhardt, FESG, TU München; Martin Ettl FESG, TU München

The development of software is a creative process, which offers a huge degree of freedom. Especially in scientific fields a lot of researchers develop their own software for specific needs. Everyone has its own preferences and backgrounds regarding the used programming languages, styles and platforms. This complexity causes software, which is not always directly usable by others in the communities. In addition the software is often error-prone, as hidden bugs are not always revealed. Therefore first ideas came up, to solve these problems at the observatory Wettzell. The results were coding layouts and policies, documentation strategies, the usage of version control and a consistent process of continuous integration. Within this, the discussed quality factors can define quality metrics, which help to quantize code quality. The resulting software is a repository of tested modules, which can be used in different programs for the geodetic space techniques. This is one possible contribution to future GGOS stations.

The First Release of nuSolve.

Sergei Bolotin, NVI, Inc./NASA GSFC; Karen Baver, NVI, Inc./NASA GSFC; John Gipson, NVI, Inc./NASA GSFC; David Gordon, NVI, Inc./NASA GSFC; Daniel MacMillan, NVI, Inc./NASA GSFC

In this talk we present a first release of nuSolve, a replacement for the interactive part of the current Solve VLBI analysis software. We discuss our design philosophy, current status and plans for future development. Currently nuSolve has all of the capabilities required to produce a fully resolved and edited version 4 database including: ambiguity resolution; outlier elimination; automatic detection of clock breaks; ionospheric calibration; etc. In the near future we plan on working on automating routine database analysis.

Improving VLBI Processing by using Homogeneous Data for Pressure and Temperature

Karine Le Bail, NVI Inc - GSFC/NASA; Johanna Juhl, Chalmers University of Technology; John M. Gipson, NVI Inc - GSFC/NASA; Dan S. MacMillan, NVI Inc - GSFC/NASA

Meteorological data, pressure and temperature, affects the VLBI processing via the atmospheric delay and the thermal deformation of the antenna. Errors in met data can cause errors in the estimation of station coordinates, (predominantly local Up) of up to several mm, and degrade baseline length repeatability. This presentation will show examples of problems found in the database used at GSFC including missing data, outliers and jumps, and their impact on the results obtained. To improve the homogeneity of the meteorological data, Solve has been enhanced to give users the ability to use external meteorological data. Initially we used pre-derived pressure and temperature series from ECMWF obtained from the Institute of Geodesy and Geophysics at the Vienna University of Technology. However these series contain jumps due to model changes, which will affect the VLBI calculations. Therefore we have derived time series for all the VLBI sites from the ECMWF data, using the same model for the entire period. Using this homogenous pressure series derived from ECMWF improves the WRMS repeatability for 60% of the baselines, while using the temperature series derived from ECMWF improves the WRMS repeatability for 61% of the baselines considered.

Universal Time from VLBI Intensives with ray-traced delays

Matthias Madzak, Vienna University of Technology; Vahab Nafisi, The University of Tehran, Iran; Johannes Böhm, Vienna University of Technology; Harald Schuh, Vienna University of Technology

VLBI Intensive sessions are used for the estimation of UT1-UTC (DUT1) which is needed in near real-time for the accurate prediction of Universal Time (UT1) as well as for navigation purposes. These 1-hour IVS sessions (INT1 and INT2) are carried out every day to provide this quantity on a regular basis. Due to the small number of observables per session most parameters, which are usually estimated in VLBI analyses, are fixed to their a priori values. This means that all a priori values should be known as accurately as possible to derive accurate DUT1 estimates. One possibility of deriving a priori tropospheric delays is ray-tracing through numerical weather models. These tropospheric delays also account for azimuthal asymmetries, what might as well increase the accuracy of DUT1 estimates. We analyze Intensive sessions from July 2010 to October 2011 using the Vienna VLBI Software (VieVS) and compare the obtained DUT1 values based on ray-traced delays to those from standard approaches. Furthermore we calculate Length-of-Day (LoD) from DUT1 and compare these values to LoD from GPS.

Effects of Tropospheric Spatio-Temporal Correlated Noise on the Analysis of Space Geodetic Data.

Andrew Romero-Wolf and Christopher Jacobs, Jet Propulsion Laboratory

The standard VLBI analysis models the distribution of measurement noise as Gaussian. Because the price of recording bits is steadily decreasing, thermal errors will soon no longer dominate. As a result, it is expected that troposphere and instrumentation/clock errors will increasingly become more dominant. Given that both of these errors have correlated spectra, properly modeling the error distributions will become more relevant for optimal analysis. This paper will discuss the advantages of modeling the correlations between tropospheric delays using a Kolmogorov spectrum and the frozen flow assumption pioneered by Treuhaft and Lanyi. We will show examples of applying these correlated noise spectra to the weighting of VLBI data analysis.

This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration. Government sponsorship acknowledged.

Baseline analysis of 24-hour GPS-VLBI Hybrid observation

Younghee Kwak, Korea Astronomy and Space Science Institute; Tetsuro Kondo, National Institute of Information and Communications Technology; Tadahiro Gotoh, National Institute of Information and Communications Technology; Jun Amagai, National Institute of Information and Communications Technology; Hiroshi Takiguchi, Institute for Radio Astronomy and Space Research AUT; Mamoru Sekido, National Institute of Information and Communications Technology; Lucia Plank, Vienna University of Technology; Ryuichi Ichikawa, National Institute of Information and Communications Technology; Jungho Cho, Korea Astronomy and Space Science Institute; Tuhwan Kim, AJou University; Tetsuo Sasao, Yaeyama Star Club

GPS-VLBI(GV) Hybrid System is developed to combine VLBI and GPS techniques in observation level . In the system, VLBI antennas and GPS antennas located at the same site receive signals from quasars and GPS satellites, respectively. Both signals are recorded and correlated in normal VLBI way. We carried out a 24-hour validation experiment of the system between Kashima and Koganei baseline in 2009. In the experiment, we stably acquired huge volume of GPS data through VLBI system and obtained correlation fringes with high signal to noise ratio simultaneously from all GPS satellites on the sky. We could eventually ascertain the feasibility of the GV Hybrid System. In this paper, we present the baseline analysis results of GV Hybrid Observation data and discuss the next observation plan.

Processing SELENE Differential VLBI Data

Lucia Plank, Vienna University of Technology; Johannes Boehm, Vienna University of Technology; Matthias Madzak, Vienna University of Technology; Claudia Tierno Ros, Vienna University of Technology; Harald Schuh, Vienna University of Technology

The Japanese lunar mission SELENE was observed in differential VLBI (D-VLBI) mode with terrestrial VLBI antennas in Japan and overseas. We present our strategy of processing D-VLBI data with the Vienna VLBI Software (VieVS), which was validated by comparison of the residuals obtained with alternative software. When processing D-VLBI data, many parameters (e.g. station coordinates or a priori spacecraft positions) have less influence on the computed time delay than in "normal" geodetic VLBI. For the SELENE data, this level of cancellation is determined empirically and presented for various parameters. Special attention is given to the atmosphere, the biggest remaining error source. While the ionospheric delay is modeled with GPS-determined Total Electron Content (TEC-) maps, the wet slant delays are approximated by using numerical weather model data. Furthermore, we simulate the remaining influence of atmospheric turbulence and give estimations on the expected errors for the short Japanese and the longer intercontinental baselines. In VieVS, relative spacecraft positions can be estimated. This is tested with SELENE data, with the goal of improvement for future applications of navigation and the connection of dynamic reference frames with the kinematically defined ICRF.

Multi-frequency Same Beam VLBI Method Based on General TT& C Signal

Lue Chen, Beijing Aerospace Control Center ; Geshi Tang, Beijing Aerospace Control Center; Ming Chen, Beijing Aerospace Control Center; Huicui Liu, Beijing Aerospace Control Center; Hongtao Han, Beijing Aerospace Control Center; Mei Wang, Beijing Aerospace Control Center; Li Li, Beijing Aerospace Control Center;

The relative measurement of two spacecrafts is very important for multi-spacecrafts cooperative flight mission and improving spacecraft's orbit determination accuracy for space science exploration research. The method of multi-frequency same beam VLBI utilizing general Tracking, Telemetry and Control (TT&C) signal is proposed to implement two spacecrafts relative positioning in this paper. Based on the mathematical calculation of the difference phase delay, the validity of this method in deep space mission is verified by simulation. A model modification method of differential delay measurement error is proposed, and the observing condition of same beam VLBI utilizing ground measurement stations is analyzed. Utilizing the multi-frequencies information of the general TT&C signal of the two spacecrafts, the simulation results shows that picoseconds level differential delay measurement value is obtained via delay error model modification. This could provide reliable measurement technology for relative navigation and position between two spacecrafts in deep space mission.

Challenges and perspectives for celestial and terrestrial reference frame determination

Johannes Böhm, Vienna University of Technology; Zinovy Malkin, Pulkovo Observatory; Sebastien Lambert, Observatoire de Paris ; Chopo Ma, Goddard Space Flight Center

This presentation addresses tasks, challenges, and possibilities that need to be considered for a consistent and improved determination of celestial and terrestrial reference frames (CRF/TRF). Besides the benefit from improved geophysical and astronomical modeling on CRF and TRF as well as on the Earth orientation parameters connecting those frames, there is an interesting list of upcoming possibilities to improve the VLBI-derived frames and their consistency. For example, the estimation can be done together with the other space geodetic techniques, e.g., by stacking the normal equations using local ties on ground. Furthermore, troposphere ties or even space ties can be applied as they are proposed for missions like the Geodetic Reference Antenna in Space (GRASP) or by observing GNSS satellites with VLBI radio telescopes. The situation will be further improved with VLBI2010 and observations with twin telescopes which can observe sources and satellites in parallel. The GAIA mission scheduled for launch in 2013 is expected to achieve an optical realization of the CRF with precision similar to or better than the ICRF2 and with at least an order of magnitude more objects. However, since the CRF has to be accessible from ground extragalactic objects suitable for both optical and radio observation have to be identified and the connections need to be investigated. We present an overview of IAG Sub-Commission 1.4 (Interaction of Celestial and Terrestrial Reference Frames) and the plan of activities consisting of theoretical considerations, simulations, and analysis of real observations to improve the frames.

Consistent computation of ITRF and ICRF from homogeneously processed observation data

Manuela Seitz, DGFI; Peter Steigenberger, TU München; Thomas Artz, Universität Bonn

The International Earth Rotation and Reference Systems Service (IERS) is in charge of the computation of the International Terrestrial Reference Frame (ITRF) and the International Celestial Reference Frame (ICRF). The ITRF is computed by combining the data of the four geodetic techniques VLBI, SLR, GNSS and DORIS in order to exploit the individual potentials provided by these four techniques w.r.t. the determination of the geophysical parameters (origin, scale, network geometry and EOP). The realization of the ICRS is based on VLBI. It is the only one of the techniques observing extragalactic radio sources. Thus, the unique characteristic of VLBI is, that it can provide the link between the ITRF and the ICRF. But both reference frames are computed separately today. Therefore, ICRF, and ITRF and the respective EOP series are not fully consistent.

This paper deals with the common adjustment of ITRS and ICRS realizations. It presents a computational approach, which allows for minimizing the network deformation by applying only minimum conditions. It presents the results of a consistent TRF-CRF realization, which is based on homogeneously processed VLBI, GNSS and SLR input data. The paper demonstrates the advantages of such an approach in terms of consistency and stability of the frames and the EOP.

The role of VLBI in the weekly inter-technique combination

Mathis Blossfeld, DGFI; Manuela Seitz, DGFI

The geodetic space-techniques VLBI, GPS and SLR show a different grade of sensitivity on geodetic parameters like station coordinates and Earth orientation parameters (EOP). While the satellite techniques GPS and SLR are able to determine the Earth's center of mass, VLBI is, as an unique technique, able to determine the full set of EOP including - besides the coordinates of the terrestrial pole - also the coordinates of the celestial pole and the rotation angle of the Earth. The accuracy of all obtained parameters depends strongly on the geometry of the technique-specific station networks. In order to benefit from the strength of each geodetic space-technique and to get a most stable solution of station coordinates and the full set of EOP within one adjustment, the techniques could be combined in an inter-technique combination. A very important step in the combination process is the calculation of variance factors for the relative weighting the different techniques. In this paper, we point out the special role of VLBI in the inter-technique combination. We describe how the combined solutions are calculated and we emphasize to what extend the VLBI solution (station coordinates and EOP) could benefit from the combination with GPS and SLR. We present weekly inter-technical solutions and compare an empirically derived constant weight of the techniques against weights derived from a weekly performed variance component estimation. We also compare epoch solutions with a multi-year solution and discuss the impact of the different parametrizations of station position variations on the consistently estimated EOP.

Network and quasar structure effects on the VLBI reference frame

Stanislav Shabala, University of Tasmania; Jim Lovell, University of Tasmania; Oleg Titov, GeoScience Australia; Jamie McCallum, University of Tasmania; Christopher Watson, University of Tasmania; John Dickey, University of Tasmania

Network geometry and structure of quasars making up the quasi-inertial celestial reference frame provide two key limitations of the geodetic VLBI technique as it is currently implemented. Both these effects are especially pronounced in the Southern Hemisphere. Recent construction of the AuScope array helps address these issues. Inclusion of new Australian antennae improves network geometry and hence the reference frame realization. It will also allow the effects of southern quasar structure on the reference frame to be studied in more detail.

Towards an accurate alignment of the VLBI frame and the future Gaia optical frame: global VLBI imaging observations of a sample of candidate sources for this alignment

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The space astrometry mission Gaia will construct a dense optical QSO-based celestial reference frame. For consistency between optical and radio positions, it will be important to align the Gaia and VLBI frames with the highest accuracy. However, the number of quasars that are bright in optical wavelength (for the best position accuracy with Gaia), that have a compact core (to be detectable on VLBI scales), and that do not exhibit complex structures (to ensure a good astrometric quality), was found to be limited (Bourda et al. 2008). It was hence realized that the densification of the list of such objects was necessary. Accordingly, we initiated a multi-step VLBI observational project, dedicated to finding additional suitable radio sources for aligning the two frames. The sample consists of sim450 optically-bright weak extragalactic radio sources, which have been selected by cross-correlating optical and radio catalogs. The initial observations, aimed at checking whether these sources are detectable with VLBI, and conducted with the European VLBI Network (EVN) in 2007, showed an excellent sim90% detection rate (Bourda et al. 2010). The second step, dedicated to identify the most point-like sources of the sample, by imaging their VLBI structures, was initiated in 2008. About 25% of the detected targets were observed with the Global VLBI array (EVN+VLBA; Very Long Baseline Array) during a pilot imaging experiment, revealing that about 50% of them are point-like sources on VLBI scales (Bourda et al. 2011). The rest of the sources were observed during three additional imaging experiments in March 2010, November 2010 and March 2011. In this paper, we present the results of these imaging campaigns and draw plans for the final stage of the project, which will be dedicated to measuring accurately the VLBI position of the most point-like of such sources.

The Celestial Reference Frame at X/Ka-band (8.4/32 GHz)

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We have constructed an X/Ka-band (8.4/32 GHz) celestial reference frame using fifty-seven $\sim$24-hour sessions with the Deep Space Network. We detected 467 sources covering the full 24 hours of right ascension and declinations down to -45 deg. Comparison of 447 X/Ka sources in common with the S/X-band (2.3/8.4 GHz) ICRF2 shows wRMS agreement of 200 microarcsec (μas) in RA cos(dec) and 270 μas in Dec. There is evidence for systematic errors at the 100 μas level. Known errors include limited SNR, lack of phase calibration, troposphere mismodelling, and limited southern geometry. Compared to X-band, Ka-band allows access to more compact source morphology and reduced core shift. Existing X/Ka data and simulated Gaia data predict a frame tie precision of 10-15 μas (1-sigma, per 3-D rotation component) with anticipated improvements reducing that to 5-10 μas per component.

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Dual Frequency VLBI Monitoring of a Large Sample of Compact Extragalactic Sources at 8 and 32 GHz

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We are carrying out regular monitoring of 400+ compact extragalactic sources using large DSN (Deep Space Network) antennas over intercontinental baselines at 8, and 32 GHz simultaneously. This program provides precision astrometric measurements of AGN compact cores, used to maintain the JPL extragalactic reference frame. In addition to astrometric observables, this program has the potential to provide regular flux density measurements at each of these observing frequencies with precision at the level of 10-20%.

Such monitoring of compact radio emission serves as a direct measure of AGN core activity, probing intrinsic jet parameters and providing the opportunity for discriminating between different models of the high-energy emission in these objects by cross-correlating the radio and $gamma$-ray flux densities. Simultaneous multi-frequency observations will provide high precision spectral information of AGN compact emission regions at the parsec-scale unaffected by the errors often introduced when combining multi-frequency data obtained at different epochs. The spectral index can be used to compare the relativistic electron energy distribution with the photon spectral index seen in $gamma$-rays. For instance, if Compton up-scattering by the radio synchrotron electron population is the basic process producing the $gamma$-rays, the spectra in both spectral regions should be directly related.

By providing measurements on both East-West and North-South baselines with large antennas and Gbit/s recording capability, our program can probe sources at the 30 mJy flux limit (10-sigma), potentially increasing the sample to a fainter population of sources. In these regards, our program complements well existing northern and southern hemisphere VLBI monitoring programs, by providing flux measurements at 32 GHz, covering a fainter population sample, and by filling the gap for sources in the [-20:-40] degree declination range. Further, our program also provides additional flexibility for target of opportunity observations.

32 GHz Celestial Reference Frame Survey for Dec < -45 deg.

Shinji Horiuchi, Canberra Deep Space Communications Complex/NASA; Chris Jacobs, NASA JPL/Caltech; Chris Philips, Australian Telescope National Facility/CSIRO; Ioana Sotuela, Madrid Deep Space Communications Complex/NASA; Cristina Garcia-Miro/Madrid Deep Space Communications Complex/NASA

We have been developing a celestial reference frame catalogue at 32 GHz (Ka-band) using 34m Beam Wave Guide (BWG) antennas of NASA Deep Space Network (DSN) to complement the current IAU standard S/X-band ICRF2. However, the DSN VLBI network alone can only cover limited part of the full sky, missing in the declination range from -45 to -90 degree. To extend the 32 GHz catalogue, we recently initiated a project to survey candidate catalogue sources in the southern sky using Canberra DSS-34 BWG antenna in conjunction with two elements of the Long Baseline Array (LBA) that can observe at 32 GHz, the Mopra telescope and the Australian Telescope Compact Array (ATCA). We formed a list of 144 new Ka-band candidate catalogue sources at -90 $<$ Dec. $<$ -45 deg. as target sources of this pilot survey. We selected those sources as expected to be reasonably strong and compact for our purpose, considering estimated flux densities at 32 GHz based on the results of the ATCA 20 GHz (AT20G) survey with 8.6 GHz flux density measurements, as well as characteristics of the X-band unresolved components based on the RFC2011c version catalogue sources. The candidate list of 144 sources includes 46 ICRF2 sources with 29 "Defining" objects. This would allow cross-checking with the S/X results of ICRF2. The ultimate goal of our project is to establish a reference source catalogue at 32 GHz for the south polar cap region, which has never been covered in existing catalogues at that frequency. The catalogue can be used for future space navigation as well as astronomical and geodetic observations with southern radio telescope arrays such as ATCA and LBA.

Radio Astrometry of Red Supergiant VY CMa

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We report astrometric results of phase-referencing VLBI observations of 43 GHz SiO maser emission toward the red hypergiant VY Canis Majoris (VY CMa) using the Very Long Baseline Array (VLBA). We measured a trigonometric parallax of 0.83 $\pm$ 0.08 mas, corresponding to a distance of $1.20^{+0.13}_{-0.10}$ kpc. Compared to previous studies, the spatial distribution of SiO masers has changed dramatically, while its total extent remains similar. The internal motions of the maser spots are up to 1.4 mas y^{-1}, corresponding to 8 km s^{-1}, and show a tendency for expansion. After modeling the expansion of maser spots, we derived an absolute proper motion for the central star of $\mu_x = -2.8 \pm 0.2$ and $\mu_y = 2.6 \pm 0.2$ mas y^{-1} eastward and northward, respectively. Based on the maser distribution from the VLBA observations, and the relative position between the radio photosphere and the SiO maser emission at 43 GHz from the complementary Very Large Array (VLA) observations, we estimate the absolute position of VY CMa at mean epoch 2006.53. The position and proper motion of VY CMa from the VLBA observations differ significantly with values measured by the Hipparcos satellite. These discrepancies are most likely associated with inhomogeneities and dust scattering the optical light in the circumstellar envelope. The absolute proper motion measured with VLBA suggests that VY CMa may be drifting out of the giant molecular cloud to the east of it.

Direct estimation of the Solar acceleration using geodetic/astrometric VLBI observations

XU Minghui, Shanghai Astronomical Observatory; WANG Guangli, Shanghai Astronomical Observatory; ZHAO Ming, Shanghai Astronomical Observatory

The secular aberration variation due to the acceleration of the Solar system barycenter will result in the apparent proper motion of extragalactic radio sources. Then VLBI delay observables can be expressed as a function of acceleration parameters, which allow us to determine them using the USER_PARTIAL function provided by Calc/Solve. We analyzed geodetic VLBI sessions with duration more than 18 hours and the longest baseline length of relative networks larger than 3000 km from 1980 April to 2011 September, and obtained the estimation of the acceleration parameters with high accuracy at the level of approximately two orders of the magnitude of the acceleration vector. In this talk we will discuss it in detail.

A comparison of General Relativity Theory evaluations using VLBI and SLR; will GGOS improve these results ?

Ludwig Combrinck, Hartebeesthoek Radio Astronomy Observatory, South Africa

Constant instrumental and data analysis upgrades throughout the development of the VLBI technique have delivered a continuous improvement in the accuracy of the evaluations of Parameterised Post Newtonian parameter gamma. Lunar Laser Ranging can be used to estimate Beta, as well as test possible temporal variation of the gravitational constant. Satellite Laser Ranging can be used to evaluate frame dragging. New applications using SLR data recently have attempted to estimate Gamma and Beta directly. These different space geodesy techniques of evaluating GRT are discussed in terms of current status, and the possible impact of GGOS on their evaluations are considered. It was found that if improvements in VLBI estimates are extrapolated to 2020, results will equal that of gamma estimates obtained by radiometric tracking data of the Cassini spacecraft on its approach to Saturn (the best estimate to date). This implies that GGOS will have to provide numerous improvements in instrumentation, network geometry and modelling utilised in data analysis.

Celestial pole offset: from initial analysis to end user

Zinovy Malkin (1,2); (1) Pulkovo Observatory, St. Petersburg, Russia; (2) St. Petersburg State University, St. Petersburg, Russia

Celestial pole offset (CPO) are small corrections to the official IAU precession-nutation model needed, in particular, to the users required highly accurate transformation between terrestrial and celestial reference frames. The CPO time series are initially computed at the IVS Analysis Centers as routine products. Each analysis center computes its own final CPO time series containing results obtained for each processed 24-hour VLBI session, and/or datum free normal equations for each session. These results are archived in the IVS Data Centers. The latter data are also used in the IVS Coordinator Office to derive the IVS combined CPO series, also given for each VLBI session. IVS combined series is also placed in the IVS Data Centers. In turn, IERS Combination Centers use original ACs' and/or IVS combined CPO series to derive the IERS combined product, given in this case at the midnight epochs, available through the IERS Product Centers. All these transformations between the original series derived by the IVS Analysis Centers and final IERS products recommended and usually used by users, may introduce random and systematic differences between CPO series available to users, which evidently requires clear recommendations on using this kind of VLBI product. This study is devoted to investigation of differences between various CPO series to make the first steps towards such recommendations.

High frequency Earth rotation parameters estimated from the CONT campaigns

Tobias Nilsson, Vienna University of Technology; Johannes Böhm, Vienna University of Technology; Michael Schindelegger, Vienna University of Technology; Harald Schuh, Vienna University of Technology

We estimate Earth rotation parameters (ERP) with hourly resolution from the continuous VLBI campaigns CONT11, CONT08, CONT05, and CONT02. These are then used to study the diurnal and semi-diurnal variations in the rotation of the Earth. The VLBI ERP time series are compared to those obtained from other techniques, such as GNSS and ring laser gyroscopes, as well as with atmospheric excitations calculated from ECMWF data. Furthermore, we study the impacts of various VLBI analysis options on the estimated ERP. For example, we investigate the systematic effects caused by errors in the celestial reference frame.

Influence of source constellations on UT1 derived from IVS INT1 sessions

Minttu Uunila, Aalto University Metsähovi Radio Observatory; Axel Nothnagel, Institute of Geodesy and Geoinformation, University of Bonn; Judith Leek, Institute of Geodesy and Geoinformation, University of Bonn

We examine the influence of the spatial distribution of the observations on the quality of UT1 results derived from IVS INT1 sessions. The Kokee - Wettzell baseline midpoint is chosen as a reference point for the analysis. A Matlab code is written for classification of the topocentric source positions in different sections of the sky, as seen from the reference point. A combination of these key numbers is then used to classify the sessions with quality codes and compare them with their respective formal errors. Furthermore, we checked how many observations could not be used in the UT1 estimates although they were included in the schedules.

Solid Earth tide parameters from VLBI measurements and FCN analysis

Hana Spicakova, TU Vienna; Johannes Boehm, TU Vienna; Sigrid Boehm, TU Vienna; Harald Schuh, TU Vienna

With the Vienna VLBI Software (VieVS) we have done a complete reanalysis of the 24-hour IVS sessions from 1984.0 till 2011.0 following the current IERS Conventions 2010. In a common global adjustment we have estimated simultaneously terrestrial reference frame (station positions and velocities), celestial reference frame (radio source positions) and Earth orientation parameters. In this paper we focus on the estimation of complex Love and Shida numbers and their frequency dependence in the diurnal band caused by the resonance with the Free Core Nutation (FCN). As the FCN period is contained in the model of the solid Earth tidal displacements and also in the celestial pole offsets we can estimate it in the global solution. We develop a model with two frequencies for the remaining signals in celestial pole offsets w.r.t. the IAU 2006/2000A precession-nutation model by estimating the amplitudes as global parameters.

Recent advances in applications of geodetic VLBI to geophysics

Veronique Dehant, Sebastien Lambert, Laurence Koot, Antony Trinh, and Marta Folgueira

This paper will present recent advances in Earth Orientation Parameters determination and in their modeling. These advances are related to the increase of the precision of the observation and the implementation of dedicated strategy to better obtain them. The advances are also related to the determination of Earth geophysical parameters from VLBI observations and to better modeling of the phenomena within the Earth. Further improvement in the observation precision will in turn enhance our understanding of the interior of the Earth. In particular, we will examine the coupling mechanisms at the core-mantle boundary: the electromagnetic coupling, the topographic coupling, and the viscous coupling. We also present future developments necessary for a better understanding of the Earth interior and its orientation parameters.

Assessing the quality of WVR data from Onsala during the CONT11 geodetic VLBI campaign

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Two microwave radiometers, called Astrid and Konrad, were operated during the CONT11 campaign at the Onsala Space Observatory. Astrid was running during the whole experiment but suffered from a data loss on Sunday, September 25, when the azimuth drive failed. During the remaining part of the experiment this WVR was carrying out elevation scans between the East and the West in a continuous mode. The Konrad WVR has been maintained, and improved, for several years. There were software difficulties in the beginning but from September 20 Konrad acquired data in a sky-mapping mode until the end of the campaign.

A well known feature of WVRs is that their algorithm brakes down when there are large drops of water in the observation beam of the WVR. Without any independent information one has to rely on the WVR data themselves to detect rain and remove the corresponding low quality results. In order to assess this technique we operated three different types of rain sensors during CONT11: a zenith looking Doppler rain radar, plus three optical, and three capacitive sensors. Fortunately there were also several rainy periods during CONT11. The first 8.25 days had many precipitation events whereas the last 7.75 days where significantly drier.

We assess different editing criteria of the WVR data, using the different types of rain detectors. The inferred time series of the equivalent Zenith Wet Delay (ZWD) and linear horizontal gradients are compared to the corresponding results from the VLBI data and the GPS data from the IGS station ONSA.

Past and present-day ice mass variation on Svalbard revealed by superconducting gravimeter, GPS and VLBI measurements

Halfdan Kierulf, Norwegian Mapping Authority; Ove Omang, Norwegian Mapping Authority

The measured uplift in Ny-Ålesund has varied based on geodetic technique, analyse strategy and time period used. This has caused problems both for reference frame issues as well as geophysical interpretations of the results. In Arctic areas deglaciation after the last glacial maximum, Holocene ice-mass variation as well as present day ice melt, contribute to the land uplift. In addition, tectonic contribution can not be excluded. We will use both geometric and gravity data from the observatory in Ny-Ålesund as well as in-situ mass balance measurements of the local glaciers, to separate the different processes contributing to the land uplift in Ny-Ålesund and Svalbard.

Measurements from the geodetic observatory in Ny-Alesund indicate a land uplift in Ny-Ålesund much larger than expected from traditional models of glacial isostatic adjustment. In addition the land uplift shows large variations from year to year. A combination of the measured variations in the land uplift with local ice-mass variations give a good constraint on the land uplift caused by the present day ice melt. However, we are still not able to explain all the measured uplift.

The changes in measured gravity is consistent with the geometric measurements, but also much larger than expected from glacial isostatic adjustment and present day ice melt. The ratio between unexplained gravity change and unexplained geometric uplift indicate a viscoelastic process. Most likely is the unexplained uplift caused by late Holocene ice-mass variations.

Omang, O. C. D. and H. P. Kierulf (2011), Past and present-day ice mass variation on Svalbard revealed by superconducting gravimeter and GPS measurements, Geophys. Res. Lett., 38, L22304, doi:10.1029/2011GL049266.

VLBI and GNSS frequency link stabilities during CONT campaigns

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Both geodetic space techniques, VLBI and GNSS, can be used for frequency and time-transfer. A requirement for a meaningful comparison of the performance of the two techniques is that VLBI and GNSS instrumentation is co-located and connected to the same frequency standard, i.e. the same H-maser. The continuous VLBI campaigns provide perfect test beds to compare and evaluate the performance of the two techniques. These campaigns last several days and involve several internationally well distributed co-location stations with the potential to use the same frequency standard for the techniques. During CONT08 seven out of the 11 participating stations used the same frequency standard for VLBI and GPS. Frequency link stabilities of 1.2e-15 and 6.2e-16 at averaging times of one day were reported from the analysis of CONT08 VLBI and GPS data, respectively. During CONT11 eight out of the 13 participating stations used the same frequency standard for VLBI and GPS. In this presentation we compare the frequency link stabilities achieved from CONT08 and CONT11 data.

Real-time e-VLBI in the EVN and software correlation developments at JIVE

Bob Campbell, JIVE; Arpad Szomoru, JIVE

I will review the capabilities and operation of the European VLBI Network (EVN) correlators at JIVE. Real-time e-VLBI has grown to become an integral part of the EVN, accounting for 769 network hours in 103 observations over the past three years. The turning point came with the ability to provide sustained reliable Gbps real-time data transfer and correlation. Compared with disk-based VLBI, e-EVN better enables astronomers to pursue rapid-response science, and also presents more frequent observing opportunities outside the traditional thrice-annual EVN sessions. The transition from the EVN MkIV correlator to the EVN software correlator at JIVE (SFXC) is also well underway. SFXC was used to correlate more than half of the experiments from the May/June 2011 EVN session. Besides overcoming the physical limits of the MkIV in terms of spectral capacity and sampling rate, SFXC also offers pulsar gating/binning, multiple phase-centers, and correlation of near-field targets. There have been EVN observations in 2011 that have taken advantage of each of these new features.

The Rotational and Gravitational Signature of Recent Great Earthquakes

Richard Gross, Jet Propulsion Laboratory, California Institute of Technology

Besides generating seismic waves, which eventually dissipate, an earthquake also generates a static displacement field everywhere within the Earth. This global displacement field rearranges the Earth's mass thereby causing the Earth's rotation and gravitational field to change. The size of this change depends upon the magnitude, focal mechanism, and location of the earthquake. Using a spherical, layered Earth model, the coseismic effect of the recent great 2004 Sumatran, 2010 Chilean, and 2011 Japanese earthquakes upon the Earth's length-of-day, polar motion, and low-degree harmonic coefficients of the gravitational field are computed. While the effects of these earthquakes have been observed in GRACE gravity measurements, the challenge of observing them in Earth rotation and low-degree SLR gravity measurements lies in being able to accurately model and remove the much larger atmospheric, oceanic, and hydrologic signals.

The impact of the 2011 off the Pacific coast of Tohoku Earthquake on Tsukuba 32-m VLBI station

Shinobu Kurihara, Geospatial Information Authority of Japan; Kensuke Kokado, Geospatial Information Authority of Japan; Jiro Kuroda, Geospatial Information Authority of Japan; Misao Ishihara, Geospatial Information Authority of Japan; Ryoji Kawabata, Geospatial Information Authority of Japan;

A 9.0-magnitude earthquake named "the 2011 off the Pacific coast of Tohoku Earthquake" hit eastern areas of Japan on March 11. The earthquake measured a lower 6 on the seven-point JMA seismic intensity scale around Tsukuba. The gear wheel for elevation drive of Tsukuba 32-m VLBI antenna was swayed by the earthquake, but there was no critical damage in the antenna and other equipment. Meanwhile, in Tsukuba correlator, several servers and hard-disks fell down from rack and some of them were broken. But the damage was not as serious as our correlator operation couldn't be continued. Many aftershocks measured an intensity of 4 or greater on JMA scale followed over a few weeks after the main shock. We put off restarting VLBI operation due to fear of aftershocks until early April. Tsukuba 32-m returned to the IVS VLBI session from April 4. Following VLBI sessions produced some VLBI positions of Tsukuba, and co-seismic and post-seismic displacement was detected by VLBI. By the way, GSI has installed and maintained over 1,200 of GNSS-based control stations, a large number of triangulation points and benchmarks throughout Japan. Since the crustal displacement was widespread and the magnitude of it was very large, we needed to revise the coordinates of control points. This revision covered the eastern half of Honshu Island; 438 GNSS-based control stations, approx. 43 thousand of triangulation points and approx. 1.9 thousand of benchmarks. All these new coordinates were calculated based on the amount of displacement detected by VLBI observation on May 10. This was because we needed an absolute coordinate based on the international geodetic observation after the earthquake.

Effects of the 2011 Tohoku Earthquake on VLBI geodetic measurements

Daniel MacMillan, NVI Inc./NASA Goddard Space Flight Center; Shinobu Kurihara, Geospatial Information Authority of Japan; Dirk Behrend, NVI Inc./NASA Goddard Space Flight Center

The VLBI antenna TSUKUB32 at Tsukuba, Japan regularly observes in 24-hour observing sessions once per week with the R1 operational network and on additional days with other networks on a more irregular basis. Further, the antenna is an endpoint of the single-baseline, 1-hr Intensive sessions observed on the weekends for determination of UT1. TSUKUB32 returned to normal operational observing 25 days after the earthquake. The antenna is 160 km west and 240 km south of the epicenter (about the same distance west of the plate subduction boundary). We looked at the transient behavior of the TSUKUB32 position time series following the earthquake and found that significant deformation is continuing. The eastward rate as of July 2011, 4 months after the earthquake, is 20 cm/yr greater than the long-term rate prior to the earthquake. The VLBI series agrees with the corresponding JPL GPS series measured by the co-located GPS antenna TSUK. The coseismic UEN displacement at Tsukuba was approximately (-90 mm, 550 mm, 50 mm). We examined the effect of the variation of TSUKUB32 position on EOP estimates and specifically how best to correct its position for estimation of UT1 in the intensive experiments. For this purpose and to provide operational UT1, the IVS scheduled a series of weekend Intensive sessions observing on the Kokee-Wettzell baseline immediately before each of the two Tsukuba-Wettzell Intensive sessions. Comparisons between UT1 estimates from these pairs of sessions were used in validating a model for the post-seismic displacement of TSUKUB32.

Determination of Tsukuba VLBI station post-Tohoku earthquake coordinates using VieVS

Niko Kareinen, Aalto University Metsähovi Radio Observatory; Minttu Uunila, Aalto University Metsähovi Radio Observatory

We determine the new coordinates for Tsukuba VLBI station, which was affected by the Tohoku earthquake on March 11, 2011. A total of 38 VLBI XA/XE sessions dating from 2011-01-03 to 2011-09-15 were pre-processed with Vienna VLBI Software (VieVS v. 1d), removing low quality data (e.g. TIGO station), clock breaks and outliers. A priori coordinates from NGS file headers were used for TSUKUB32 in order to exclude the station from NNT/NNR conditions. After the initial VieVS analysis, a visualization tool was written in Matlab to analyze the possible change in the coordinates and to detect possible low quality measurements missed by initial processing. The visualization tool has a functionality to transform the ECEF coordinates and errors acquired with VieVS to the local tangent plane of Tsukuba for better comparison possibilities. The visualization tool was written in a way that it could be added in the next version of VieVS as a general time series tool.

The time series demonstrated a clear shift in the coordinates before and after the quake. A mean shift of (X,Y,Z) = (-38.4, -57.0, -4.3) cm pm (0.4, 0.3, 0.6) cm was detected in ECEF and (E, N, U) = (68.3, 0.7, -8.3) cm pm (0.5, 0.5, 0.3) cm in ENU. Also post-seismic movement was clearly seen in the time series.

Posters

Session 1

The Next-Generation IVS Network and VLBI2010 Technology Developments

1.1
RF compatibility of VLBI with DORIS and SLR at GGOS stations: An experimental methodology to validate the models

Christopher Beaudoin, MIT Haystack Observatory; Brian Corey, MIT Haystack Observatory; Bill Petrachenko, Natural Resources Canada; Lawrence Hilliard, NASA-GSFC

A continuing thrust in the space geodetic community is to deploy instruments using different techniques at common sites. While the close proximity (of order 100 meters) of the instruments to each other affords improved inter-comparison tests, it also increases the potential for interference between instruments. Of present concern to VLBI are DORIS beacons and the aircraft surveillance radars used in conjunction with satellite laser ranging (SLR). Initial numerical studies were conducted to obtain rough estimates of the degree to which the VLBI SNR is degraded for various levels of DORIS and SLR radar interference. Numerical studies are only as good as the models upon which they are based, however, and there is sufficient uncertainty regarding their accuracy that field and laboratory validation is warranted. In this contribution, we present a measurement methodology designed to resolve the major uncertainties in the models. We also summarize the experimental results to date.

1.2
VLBI2010 imaging and structure correction impact

Arnaud Collioud, Laboratoire d'Astrophysique de Bordeaux; Patrick Charlot, Laboratoire d'Astrophysique de Bordeaux

Simulations show that the next generation VLBI system is generally well suited for imaging extragalactic radio sources. In addition to revealing the morphology of the sources, simulated VLBI2010 images may also be used to generate structure correction maps which characterize the impact of source structure on the VLBI measurements. This may be studied by comparing the structure corrections for a set of simulated images based on Monte-Carlo generated visibilities with theoretical structure corrections derived from the model, for both the whole u-v plane and the actually observed u-v points.

1.3
Using linearly polarized antenna feeds in VLBI2010

Brian Corey, MIT Haystack Observatory

In standard S/X geodetic VLBI, the righthand circularly polarized signals received from a radio source at multiple stations are cross-correlated, and the VLBI observables such as phase and delay are constructed from the resulting visibilities. Most VLBI2010 antenna feeds are intrinsically linearly polarized. This difference in polarization type has non-trivial consequences. Either the station hardware or the correlator software will have to be modified to accommodate observations with linear feeds. Some of the modification options will be presented, and their relative advantages will be discussed.

1.4
Real-time VLBI network with 10GbE connection, OCTAVE

Yusuke Kono, NAOJ; Tomoaki Oyama, NAOJ ; Noriyuki Kawaguchi, NAOJ ; Shunsaku Suzuki, NAOJ ; Kenta Fujisawa, Yamaguchi university; Hiroshi Takaba, Gifu university; Kazuhiro Sorai, Hokkaido university; Mamoru Sekido, NICT; Shinobu Kurihara, GSI ; Yasuhiro Murata, JAXA; Hisao Uose, NTT

Japanese real-time VLBI network OCTAVE (Optically Connected Array for VLBI Exploration) has been developed to increase sensitivity by expanding bandwidth with optical fiber links. Six stations are connected to correlators with dedicated 10GbE modules via an academic network, a test bed network and local access networks. The real-time correlation is useful to increase operation efficiency without media transportation. Disk storage modules has also been developed to connect stations without optical fiber link to special non real-time observations. A next generation AD convertor of 16Gbps bandwidth is under development for high sensitivity observation. The dedicated modules which are called OCTAVE-families are described in this paper.

1.5
VLBI2010 in NASA's Space Geodesy Project

Chopo Ma, NASA Goddard Space Flight Center

In the summer of 2011 NASA approved the proposal for the Space Geodesy Project (SGP). A major element is developing at the Goddard Geophysical and Astronomical Observatory a prototype of the next generation of integrated stations with co-located VLBI, SLR, GNSS and DORIS instruments as well as a system for monitoring the vector ties. VLBI2010 is a key component of the integrated station. The objectives of SGP, the role of VLBI2010 in the context of SGP, near term plans and possible future scenarios will be discussed.

1.6
Two weeks of continuous remote attendance during CONT11

Neidhardt, A.; Ettl, M.; MÃijhlbauer, M.; Plötz, C.; Hase, H.; Sobarzo, S.; Herrera, C.; Onate, E; Zaror, P.; Pedreros, F.; Zapato, O.

Between September 15th, 2011 and September 29th, 2011 a continuous VLBI session was operated by the network of the International VLBI Service for Geodesy and Astrometry (IVS). This CONT11 campaign is a continuation of the series of very successful continuous VLBI campaigns that were observed at irregular intervals since 1994. Within these two weeks, fourteen telescopes contributed to this experiment. Therefore, this was a perfect opportunity to demonstrate the stability of e-RemoteCtrl over long time. Furthermore, it was very useful to gather experience in remote attendance over a longer time period. The software, developed by the Observatory Wettzell, was used to attend the sessions at TIGO Concepción, Chile during the night shifts without any problems. This remote control experiment showed the usability of the new observation strategies for future experiments and developments. In parallel, a second testing connection was established to the Australian telescope Kathrine for a monitoring and integration test. Overall, the CONT11 experiment was very productive for demonstrating, testing and collecting experience with station remote control capabilities with e-RemoteCtrl over long distances and over a longer time period.

1.7
New observing System to support VDIF specifications with 10 GbE for VERA, JVN and KJJVC

Tomoaki Oyama, Yusuke Kono, Noriyuki Kawaguchi from NAOJ; Moritaka Kimura, Mamoru Sekido from NICT

Japanese real-time VLBI network OCTAVE (Optically Connected Array for VLBI Exploration) has been developed VLBI observation Systems (OCTAVE-Families) to support the VDIF specifications. The Octave systems consist of a high speed 8-Gsps 3-bit ADC (OCTAD) enable us to acquire not only wide intermediate frequency but also radio frequency up to 50 GHz, a converter (OCTAVIA) between one 10 GbE port and four 2 Gbps input and output ports conformable to VSI-H and new recorders (OCTADISK and OCTADISK2) at a rate of 4.5 Gbps and above 8 Gbps with 10 GbE and high speed software correlator system (OCTACOR) using GICO3 was developed by NICT. These OCTAVE systems are connected with VDIF (Vlbi Data Interchange Format) specifications via 10 GbE network. These components are used for VERA, JVN(Japanese VLBI network) and KJJVC (Korea-Japan Joint VLBI Correlator). We will report the detailed performances and results of test VLBI observations.

1.8 VLBI technology development at JAXA

Hiroshi Takeuchi

JAXA has been developing overall VLBI system which contains digital backend, observation supporting system, raw data format translators, and software correlator. Although the system is developed for deep spacecraft navigation at JAXA, it is also used for geodetic and astrometric VLBI observations and some of components can be applicable to VLBI2010.

1.9
Development of Wide Band Feeds

UJIHARA Hideki,National Institute of Information and Communications Technology; ICHIKAWA Ryuichi,National Institute of Information and Communications Technology

Wide Band feeds has been developing in NICT, NAOJ and universities in japan. for VLBI2010, SKA projects and MARBLE. MARBLE is small portable stations for VLBI developed in NICT and GSI in Japan, which seems to be suitable for test bench of our development. We are now studying Arrayed Travel Wave Antennas (Arrayed TWA) with dual linear polarization. The status and experimental results will be presented in this workshop.

1.10
e-VLBI applications of Chinese VLBI Network

Zheng Weimin, Shanghai Astronomical Observatory, Chinese Academy of Sciences; Shu Fengchun, Shanghai Astronomical Observatory, Chinese Academy of Sciences; Wang Guangli, Shanghai Astronomical Observatory, Chinese Academy of Sciences

Recently the stations and the data processing center of the Chinese VLBI Network (CVN) were updated to achieve new e-VLBI capabilities. The new terminals like digital BBC and MK5B+ were mounted at four station of CVN, the correlator was upgraded for e-VLBI applications. One is for the deep-space spacecraft tracking, while another is for geodesy observations. Until now, we have done several e-VLBI demonstration experiments for rapid UT1 measurement and extragalactic radio source mapping. To meet the requirement of rapid spacecraft e-VLBI tracking, the total data latency will decrease to less than one minute. Now the network speed of Shanghai Sheshan station for EVN realtime session is up to 512Mbps. For faster e-VLBI, the network condition will change for the better.

Session 2

Correlators, Stations and Operations Centers

2.11
Organizaton, Correlation, and First Results of CONT11

Dirk Behrend, NVI, Inc./NASA GSFC; Cynthia Thomas, NVI, Inc./NASA GSFC; Ed Himwich, NVI, Inc./NASA GSFC; Brian Corey, MIT Haystack Observatory; Kerry Kingham, USNO; David Hall, USNO; Ruediger Haas, Onsala Space Observatory; Kensuke Kokado, GSI; Thomas Hobiber, NICT; David Gordon, NVI, Inc./NASA GSFC; Dan MacMillan, NVI, Inc./NASA GSFC

In the second half of September 2011 the continuous VLBI campaign CONT11 was observed. Thirteen globally distributed VLBI stations collected data for fifteen consecutive days without interruption. In addition an ultra-rapid dUT1 determination demonstration was performed on the baseline Onsala-Tsukuba yielding dUT1 estimates with very low latency during the ongoing CONT11 campaign. In this presentation we describe the planning and organization of the campaign, give an overview of the correlation effort, and conclude with first results from the campaign.

2.12
Coordinating Center Report

Dirk Behrend, NVI, Inc./NASA GSFC

The presentation will summarize the activities and projects of the IVS Coordinating Center during the report period. It will cover, among other things, IVS meetings and publications, creation and maintenance of the yearly observing plan, special observing campaigns, and liaison with other organizations. It will conclude with an outlook on upcoming activities and future plans.

2.13
Geodetic VLBI activities at the National Geographic Institute of Spain

Francisco Colomer, Pablo de Vicente, Susana Garcia-Espada, Jesus Gomez-Gonzalez, Jose Antonio Lopez-Fernandez

Geodetic VLBI observations have been performed with the radio telescopes at Yebes since 1995. An overall description will be presented, from the early work with the 13.7-m antenna, to the current 40-m dish, towards the new Spanish-Portuguese RAEGE project.

2.14
Tying VLBI and GPS terrestrial frames: case study at Yebes Observatory

S. Garcia-Espada, Instituto Geografico Nacional (IGN), Spain; A. Santamaría-Gómez, Instituto Geografico Nacional (IGN), Spain

Through a re-analysis of geodetic VLBI and GPS data, we have estimated the relative position between the GPS station and the 40m VLBI radiotelescope at Yebes observatory. The local-tie vector between both space geodetic instruments is a key issue for the realization of the International Terrestrial Reference Frame. As a preliminary assessment of the local-tie survey, the estimation of the position and velocity in the ITRF2008 is used to derive the relative vector between these two instruments at Yebes observatory. In the absence of systematic errors in the VLBI, the GPS and the terrestrial survey observations, local-tie surveys and ITRF-derived relative vectors should agree. From the estimated coordinates of their reference points in the ITRF2008, we discuss the main issues of tying both VLBI and GPS terrestrial frames: how precisely the relative position of both instruments is determined? How does the data analysis and the observation setup impact the ITRF-derived vector?

2.15
The Swedish Fundamental Geodetic Station at the Onsala Space Observatory: Status in Early 2012

Gunnar Elgered, Earth and Space Sciences, Chalmers University of Technology, Onsala Space Observatory, SE 439 92 Onsala, Sweden; Rüdiger Haas, Earth and Space Sciences, Chalmers University of Technology, Onsala Space Observatory, SE 439 92 Onsala, Sweden; Hans-Georg Scherneck, Earth and Space Sciences, Chalmers University of Technology, Onsala Space Observatory, SE 439 92 Onsala, Sweden

The Onsala Space Observatory hosts the Swedish Fundamental Geodetic Station. We summarize the main instruments of importance for geodesy and geophysics:

- Geodetic VLBI: we operate a 20 m radio telescope with geodetic S/X capability that is part of the IVS. Currently, about 40 observing sessions are performed per year, and the observing history of the 20 m telescope goes back to 1980.
- e-VLBI: the observatory is connected by a 10 Gbps connection to the international optical fibre backbone network.
- GNSS: the Swedish mapping, cadastral and land registration authority operates a GNSS-receiving station that is part of the IGS network. There are several redundant GNSS-receivers, and the observing history goes back to the very start of IGS.
- Time and frequency laboratory: together with SP Technical Research Institute of Sweden, we operate two hydrogen masers and a Cesium standard.
- Superconducting gravimetry: since May 2009 we operate a superconducting gravimeter, located in a thermally controlled building. The temperature in the bedrock and the ground water level in its surroundings are monitored.
- Absolute gravity: there are measurement pillars for absolute gravimeter observations.
- Seismometer: Since 2010 the Swedish National Seismic Network (SNSN) operates a broadband seismometer at the observatory.
- Tide gauge: since 2010 we operate a GNSS-based tide gauge to measure sea-level variations.
- Microwave radiometry: we operate two ground-based radiometers to monitor the amount of atmospheric water vapour.
- Weather station: we monitor several meteorological parameters: pressure, temperature, humidity, precipitation, wind speed, and wind direction.

2.16
Beam pattern characterization of the 6 m TIGO telescope

Felipe Pedreros, Universidad de Concepción; Hugo Pacheco, Universidad de Concepción; Hayo Hase, Bundesamt für Kartographie und Geodäsie

An investigation to characterize the beam pattern of the 6 m telescope of the TIGO observatory was carried out during the days without operation. The aims of this work were to experimentally verify the shape of the beam and to detect the existance of sidelobes. The experiment required the use of a signal generator as the RF source, since celestial sources are not enough bright to detect sidelobes. The measurements were performed at the near field and at the far field in X-band (8.4 GHz), by locating the RF source at 115 m and 2.84 km from the telescope, respectively. Through an automatic raster scan in the azimuth axis and by taking the data from a base band converter, it was possible to characterize the beam pattern and localize the existance of a sidelobe at a level of 15 dB below the maximum. For comparison of the telescope beam pattern, only a computed beam model based on measured feed beam pattern is present in the documentation of the manufacturer. Therefore an experimental verification of the actual beam pattern of the radio telescope was performed.

2.17
Network Coordinator Report

Ed Himwich, NASA/GSFC/NVI

This presentation will be a review of network performance for 2011. In addition, prospects for future operations and new stations will be presented.

2.18
The Potential for a Ka-band (32 GHz) Worldwide VLBI Network

Christopher S. Jacobs, Jet Propulsion Laboratory, California Institute of Technology/NASA,; Uwe Bach, Max-Planck-Institut fuer Radioastronomie,; Francisco Colomer, Instituto Geografico Nacional,; Cristina Garcia-Miro, Madrid Deep Space Communications Complex, INSA/NASA,; Jesus Gomez-Gonzalez, Instituto Geografico Nacional,; Sergei Gulyaev, Institute for Radio Astronomy and Space Research, Auckland University of Technology,; Shinji Horiuchi, Canberra Deep Space Communications Complex, CSIRO/NASA,; Ryuichi Ichikawa, Kashima Space Research Center, NICT,; Alex Kraus, Max-Planck-Institut fuer Radioastronomie,; Gerhard Kronschnabl, Bundesamt fuer Kartographie und Geodaesie,; Jose Antonio Lopez-Fernandez, Instituto Geografico Nacional,; James Lovell, University of Tasmania,; Walid Majid, Jet Propulsion Laboratory, California Institute of Technology/NASA,; Tim Natusch, Institute for Radio Astronomy and Space Research, Auckland University of Technology,; Alexander Neidhardt, Technische Universitaet Muenchen,; Chris Phillips, CSIRO Astronomy and Space Science,; Richard Porcas, Max-Planck-Institut fuer Radioastronomie,; Andres Romero-Wolf, Jet Propulsion Laboratory, California Institute of Technology/NASA,; Ladislao Saldana, ITT Mission Systems,; Ulrich Schreiber, Bundesamt fuer Kartographie und Geodaesie,; Ioana Sotuela, Madrid Deep Space Communications Complex, INSA/NASA,; Hiroshi Takeuchi, ISAS/JAXA,; Joseph Trinh, Jet Propulsion Laboratory, California Institute of Technology/NASA, ; Anastasios Tzioumis, CSIRO Astronomy and Space Science,; Pablo de Vicente, Instituto Geografico Nacional,; Vladimir Zharov, Sternberg State Astronomical Institute

Ka-band VLBI capability now exists, is under development, or is being considered at 20 sites around the world. Thus, there is now an opportunity to create a worldwide Ka-band VLBI network. This paper will examine the potential for a cooperative network capable of high resolution imaging and astrometry. Initial fringe tests on a few individual baselines have been successful and more tests are planned. With baselines approaching a Giga-lambda, a Ka-band network would be able to probe source structure at the nano-radian (200 muas) level and thus gain insight into the astrophysics of the most compact regions of emission in active galactic nuclei.

2.19
Continuous monitoring surveys of the Hobart AuScope VLBI Antenna

Jim Lovell, School of Maths and Physics, University of Tasmania; Christopher Watson, School of Geography and Environmental Studies, University of Tasmania; Alistair Cole, School of Geography and Environmental Studies, University of Tasmania; Stas Shabala, School of Maths and Physics, University of Tasmania; Jamie McCulum, School of Maths and Physics, University of Tasmania; John Dickey, School of Maths and Physics, University of Tasmania

The Australian AuScope VLBI array incorporates three new 12 m radio telescopes at Hobart (Tasmania), Yaragadee (Western Australia) and Katherine (Northern Territory). Following the end of the commissioning phase, the Hobart telescope undertook its first IVS observations in October 2010. An important focus of recent activity has been the design and implementation of a monitoring system to assess the deformation of the telescope invariant point (IVP) at each site in the AuScope array. The primary aim of this study is to utilize continuous observations from a Leica TDRA6000 total station to characterize the deformation of the IVP as a function of time, temperature and orientation.

In this contribution, we present our approach and provide initial results for surveys undertaken at the Hobart Mt Pleasant observatory. Our system includes the observation of temperature throughout the telescope structure (including its foundation), whilst a Finite Element Analysis (FEA) enables the thermal response of the structure to be modeled against the observed thermal profile. Our terrestrial survey design has an emphasis on the calibration of incidence angle effects on our chosen targets which are Leica 0.5" Tooling Ball Reflectors (TBRs). We adapt code provided by Schmeing et al to achieve a continuous monitoring capability to a series of targets mounted on custom mounts over the telescope, in addition to its foundation, and other local geodetic reference marks. We conclude with the presentation of the expected (modeled) thermal response of the telescopes at Yaragadee and Katherine, both areas that exhibit significant diurnal and seasonal temperature variation.

2.20
Remote operation and performance of the Auscope Array

Dr. Jamie McCallum[1]; Dr Jim Lovell[1]; Dr Stas Shabala[1]; Prof John Dickey[1]; Dr Christopher Watson[2]; Dr Oleg Titov[3]; ; [1] School of Maths and Physics, University of Tasmania, Hobart, Australia; [2] School of Geography and Environmental Studies, University of Tasmania, Hobart, Australia; [3] Geoscience Australia

The Auscope Array consists of three new 12m radio telescopes in Australia dedicated to geodesy. One telescope (Hobart) is located near to our centre of operations at the University of Tasmania, while the other two (Katherine & Yarragadee) are located in isolated remote sites. We present a description of our observing system and methods for operating a geodetic array which spans a continent, and provide details of the performance of the telescopes. Their potential use in improving the astrometry of Southern ICRF sources is also discussed, and some future experiments outlined.

2.21
Local-tie survey at the Korea Geodetic VLBI Station

Hyunhee Joo, National Geographic Information Institute (NGII); Hongjong Oh, National Geographic Information Institute (NGII); Younghyun Moon, National Geographic Information Institute (NGII); Seunghun Kim, National Geographic Information Institute (NGII); Jungil Lee, National Geographic Information Institute (NGII); Sangoh Yi, National Geographic Information Institute (NGII); Taejun Jung, Sungkyunkwan University

We describe the local-tie at the Korea Geodetic VLBI Station. And the processes and results are will be posted briefly.

2.22
Network Determination and Timeliness of the Rapid Sessions

Cynthia C. Thomas, NVI, Inc./NASA GSFC; Dirk Behrend, NVI, Inc./NASA GSFC; Daniel MacMillan, NVI, Inc./NASA GSFC

The end of 2011 marks the completion of the first decade of the IVS rapid sessions. Starting in January 2002, the "Rapids" were run every week on Monday (IVS-R1) and Thursday (IVS-R4) with about 100 sessions per year resulting in about 1000 sessions for the full decade. A primary goal of the "Rapids" is to produce the final correlated data within 15 days from the end of the observing period. In this presentation we will describe how the networks for the R1s and R4s are determined and coordinated each year. We will analyze the data shipment times from the stations to the correlators and look into the release times of the correlated sessions. The main goals of this investigation thus are: (1) to show how many sessions made the criteria of 15 days since 3 January 2002 to 30 December 2011; (2) to show what caused the delays if the goal was not met; and (3) to show how we can reduce the delays. With this information in hand, we will look into options to further decrease the turnaround time for the "Rapids".

Session 3

Advances in Software Development, Analysis Strategies and Data Structure

3.23
UT1 Intensive Observing Sessions Revisited

Thomas Artz, University of Bonn; Judith Leek, University of Bonn; Axel Nothnagel, University of Bonn; Maike Schumacher, University of Bonn

Intensive Sessions are currently performed on a daily basis lasting for about 60 minutes with the main purpose to provide daily UT1 estimates. However, the results show large formal errors which lead to almost negligible weights within any combination. In the end of 2011, three IVS-INT3 Intensives have been scheduled with a duration of 120 minutes each. Furthermore, in 2009 four IVS R&D sessions (RD0907-RD0910) took place with the aim to improve IVS-INT1 scheduling.

In this paper, we will present a detailed analysis of the sessions mentioned above. We compare the UT1 results derived from different time spans of 60 minutes and evaluate the correlation with other parameters. Since we have only a few real observations yet, they are supplemented with comparable simulation scenarios. Furthermore, we apply the method of least squares collocation in addition to the least squares adjustment within the same software package. In this way, we assess the impact of a more realistic representation of the troposphere and clock parameters.

3.24
IVS combination center at BKG - Robust outlier detection and weighting strategies

Sabine Bachmann, BKG, Germany; Michael Lösler, BKG, Germany

Outlier detection plays an important role within the IVS combination. Even if the original data are the same for all contributing ACs, the analyzed data show differences due to analysis software characteristics. The treatment of outliers is thus a fine line between keeping data heterogeneity and elimination of real outliers. Robust outlier detection using the Least Median Square (LMS) is used within the IVS combination. This method allows a reliable outlier detection even with a small number of input parameters. A similar problematic arises for the weighting of the individual solutions within the combination process. The variance component estimation (VCE) is used to control the weighting factor for each AC. The Operator-Software-Impact (OSI) method takes into account that the analyzed data are strongly influenced by the software and the responsible operator. Thus it allows to make the VCE more sensible to the divers input data. This method has already been set up within GNSS data analysis as well as the analysis of troposphere data. The benefit of an OSI realization within the VLBI combination and its potential in weighting factor determination has not been investigated before.

3.25
Assessment of the First Use of the Uniform Sky Strategy in Scheduling the Operational IVS-INT01 Sessions

Karen Baver, NVI, Inc./NASA Goddard Space Flight Center ; John Gipson, NVI, Inc./NASA Goddard Space Flight Center; Kerry Kingham, United States Naval Observatory; Merri Sue Carter, United States Naval Observatory Flagstaff Station;

The primary purpose of the IVS-INT01 sessions is the estimation of UT1. Improving the accuracy and the precision of the UT1 estimates is an important goal in the scheduling of these sessions. In 2009 and 2010, the GSFC VLBI Analysis Center requested and received the use of nine IVS R&D sessions for the evaluation of a new strategy for scheduling the IVS-INT01 sessions. This strategy maximizes sky coverage and the number of scheduled sources, and it has now been named the Uniform Sky Strategy. The initial results were sufficiently promising that in July 2010, the USNO NEOS Operation Center began to alternate the use of the original and new strategies in scheduling the operational IVS-INT01 sessions in order to develop a basis for assessing the operational effectiveness of the new strategy. After a three month hiatus during which one of the IVS-INT01 stations was unavailable due to repairs, the alternating series resumed in early December 2010, and it has now generated over a year of continuous data. In this poster, we assess the operational effectiveness of the Uniform Sky Strategy.

3.26
RDV Processing Using Fourfit

David Gordon, NVI/NASA GSFC; Roger Cappallo, MIT Haystack Observatory; Mike Titus, MIT Haystack Observatory

Beginning in early 2011, it has been possible to fringe the VLBA difx correlated RDV sessions using the Haystack HOPS/Fourfit program. Previous VLBA correlated sessions were fringed using the NRAO AIPS program. The AIPS data was considered excellent and has had a very favourable impact on the TRF, CRF, and EOP from VLBI. Nonetheless, Fourfit processing presents several important advantages, such as the ability to fringe all channels within a band coherently, and the ability to use the many HOPS diagnostic tools that were designed specifically for geodetic processing. To develop this new ability, RDV's 85-89 were Fourfit fringed at Haystack Observatory. This involved considerable data and software debugging and various fixes to the difx2mark4 and Fourfit pograms. These 5 sessions were also AIPS processed at GSFC. In comparison, the Fourfit processing shows an approximately two-fold improvement in sensitivity, better detection of weak sources, fewer subambiguity problems, and the ability to use the difx-extracted phase cals. We will describe the new data processing path and will present a comparison of the AIPS vs. Fourfit processing of RDV's 85-89.

3.27
GSFC VLBI Analysis Center Activities

David Gordon, NVI/NASA GSFC; Karen Baver, NVI/NASA GSFC; Dirk Behrend, NVI/NASA GSFC; Sergei Bolotin, NVI/NASA GSFC; David Eriksson, Chalmers Univ./NVI/GSFC; John Gipson, NVI/NASA GSFC; Ed Himwich, NVI/NASA GSFC; Johanna Juhl, Chalmers Univ./NVI/GSFC; Karine Le Bail, NVI/NASA GSFC; Chopo Ma, NASA GSFC; Dan MacMillan, NVI/NASA GSFC

We will present a summary of the current activities and future plans of the GSFC VLBI Analysis Center. The GSFC Analysis Center analyzes all IVS sessions, makes regular IVS submissions of data and analysis products, and performs research and software development. Current major efforts include development of a new VLBI analysis program (nuSolve), transitioning the RDV processing from AIPS to Fourfit fringing, preparations for VLBI2010, and numerous other research activities aimed at improving the VLBI technique.

3.28
Fully-automated multi-baseline ambiguity resolution and analysis

Thomas Hobiger, NICT; Toshimichi Otusbo, Hitotsubashi Univ.; Mamoru Sekido, NICT; Ruediger Haas, Onsala Space Observ. / Chalmers Univ.

Automated processing of UT1 single baseline session has been demonstrated by Hobiger et al. (2010) and is currently applied to regular INT2 experiments as well as ultra-rapid test sessions. We have extended the concept of fully unattended session analysis to multi-baseline sessions and applied it successfully to three station EOP experiments. Thereby the ambiguity resolution is the crucial part which needs to be handled by a robust and straightforward algorithm before the estimation of the geodetic target parameters can start. Based on our software c5++, we will present a simple multi-baseline ambiguity resolution approach and demonstrate its effectiveness. Moreover we discuss results from real-time EOP estimation experiments and give an outlook how this would affect VLBI2010 operation.

3.29
Continuous integration and quality control during software development

Ettl, M.; Neidhardt, A.; Brisken, W.; Dassing, R.

Modern software has to be stable, portable, fast and reliable. This requires a sophisticated infrastructure supporting and providing the developers with additional information about the state and the quality of the project. That is why we have created a centralized software repository, where the whole code-base is managed and version controlled on a centralized server. Based on this, a hierarchical build system has been developed where each project and their sub-projects can be compiled by simply calling the top level makefile. On the top of this, a nightly build system has been created where the top level makefiles of each project is called every night. The results of the build, along with the compiler warnings reported to the developers using generated html pages. In addition, all the source code is automatically checked using a static code analysis tool, called cppcheck. This tools produces warnings, similar to those of a compiler, but more pedantic. The reports of this analysis are translated to html and similar to the nightly-build, reported to the developers. Armed with this information, the developers can reveal issues in their projects at an early development stage. This overall reduces the number of possible issues in our software to ensure quality of our projects at every development stage. These checks are also offered to the community developments and currently successfully used within the DiFX software correlator project.

3.30
Data assimilation of ground-based GPS precipitable water vapor to mesoscale numerical weather prediction model and its impact on ray-traced atmospheric total slant delays for GNSS positioning

ICHIKAWA Ryuichi, National Institute of Information and Communications Technology; HOBIGER Thomas, National Institute of Information and Communications Technology; SHOJI Yoshinori, Meteorological Research Institute, Japan Meteorological Agency; MIYAUCHI Yuka, National Institute of Information and Communications Technology

The "KAshima RAytracing Tools (KARAT)" is capable of calculating total slant delays and ray-bending angles considering real atmospheric phenomena. One advantage of KARAT is that the reduction of atmospheric path delay will become more accurate each time the numerical weather model is improved. On October 27, 2009 the JMA started data assimilation of zenith wet delays obtained by the GPS Earth Observation Network System (GEONET) operated by Geospatial Information Authority of Japan (GSI) for meso-scale NWP model. The improved NWP model data assimilating the GPS PWV data has the potential to correct the atmospheric path delay more precisely. Meteorological Research Institute (MRI) of Japan has evaluated the impact of ground-based GPS precipitable water vapor (GPS PWV) derived from the GEONET on meso-scale NWP model under the localized heavy rainfall event in Tokyo, Japan on 5 August 2008. A terrific thunderstorm occurred across the Kanto area of Japan, and it caused flooding in downtown Tokyo. During the event, the rainfall intensity increased to over 100 mm per hour within thirty minutes. We have assessed the impacts of GPS PWV assimilation into the NWP model on the KARAT correction by comparisons of the precise point positioning (PPP) solutions. In the nationwide scale of Japan, the short time repeatability of the PPP results for both horizontal and height positions applying KARAT correction through the MRI NWP model with GPS PWV assimilation are about several percent better than that through the conventional MRI NPW model w/o GPS PWV assimilation. On the other hand, the best result is based on the atmospheric delay correction using VMF1 with gradient model. In spite of the present model imperfectness and coarse time resolution, we have concluded that the GPS PWV data assimilation is effective to improve the NWP model for applying the GNSS positioning.

3.31
Data analysis at BKG in the frame of IVS

Volkmar Thorandt, BKG; Gerald Engelhardt, BKG; Dieter Ullrich, BKG; Reiner Wojdziak, BKG

BKG VLBI group in Leipzig is responsible for the computation of time series of Earth Orientation Parameters (EOP) and tropospheric parameters, the generation of SINEX files for 24 hours VLBI sessions and Intensive sessions, and quarterly updated global solutions for Terrestrial Reference Frame (TRF) and Celestial Reference Frame(CRF) realizations. Additionally at BKG one of the three primary IVS Data Centers is managed.

3.32
European sessions and datum definitions

Vincenza Tornatore, Politecnico di Milano (DIIAR); Hana Spicakova, TU Vienna, Institute of Geodesy and Geophysics

The European geodetic VLBI network (also designated as the EUROPE network) has been operating in an area of geophysical interesting regions since 1990. The network configuration started with a core of six radio telescopes observing on a regular basis, with an average of six sessions per year. Today a number of fourteen radio telescopes participates to the European sessions. In this work we present results of adjustments of all European sessions since 1990 till the end of 2010. The adjustments have been performed under same conditions but with different datum definitions. Statistical analysis of estimated parameters was then performed to evaluate how datum choice can influence the estimate goodness of parameters of interest.

3.33
Automated analysis of dUT1 from IVS Intensive sessions with VieVS

Minttu Uunila, Aalto University, Metsähovi Radio Observatory; Rüdiger Haas, Chalmers University of Technology, Onsala Space Observatory; Niko Kareinen, Aalto University, Metsähovi Radio Observatory; Timo Lindfors, Aalto University, Metsähovi Radio Observatory

The Vienna VLBI Software (VieVS) version 1d is used in its batch mode to analyze IVS intensive sessions automatically to derive the Earth rotation parameter dUT1. The automation process uses a shell script that is run daily by a cron process. The goal is to achieve dUT1 results as soon as the NGS file is fetched from the VieVS server. Three types of analysis strategies are used in the process in order to compare different parameterizations and to improve the latency of deriving dUT1. The first analysis strategy uses as a priori Earth orientation parameters the values provided by the EOP-file "finals2000A", uses as mapping function the Global Mapping Function (GMF), and does not apply atmospheric loading. The second analysis strategy differs from the first analysis strategy by using the Vienna Mapping function (VM1) instead of the GMF and by applying atmospheric loading. The third and final analysis strategy differs from the second approach by using the IERS C04 values as a priori Earth orientation parameters. All other parameters are treated the same for the three analysis strategies.

The latency of the results for the first analysis strategy is 2-3 days from the end of a session and is dominated by the time that is necessary to correlate the observational data and to preprocess the data, i.e. to provide a NGS file where group delay ambiguities are resolved and the ionospheric effects are corrected. The latency of the results for the second strategy is slightly worse, about 3-4 days, mainly due to the time that it takes until VMF1 and atmospheric loading based on ECMWF analysis data are available. The latency of the results for the third strategy is even worse, about 8-9 days, and is dominated by the time that it takes until the IERS C04 data are available. The RMS values of the formal errors of the three strategies in the case of INT1 sessions are 22, 19 and 18 microseconds for strategy 1, 2 and 3, respectively. As the latency becomes worse, the formal errors improve. To enhance the latency of the first analysis strategy, we currently work on to include the necessary pre-processing steps, i.e. group delay ambiguity resolution and ionospheric correction, directly into VieVS.

The results of the automated analysis are provided both as data files and in graphical form on the Metsähovi web pages http://www.metsahovi.fi/vlbi/vievs/results_GMF .../results-VM1 .../results_C04, respectively.

3.34
Space-time ARIMA modeling of global TEC fields

Choliy Vasyl, Kyiv Shevchenko University; Prokhorenkov Andrew, Kyiv Shevchenko University

We present the results of TEC global maps modeling based upon representation of the data as an stochastic fields.

We model the TEC fields with ARMA estimators build in every successive data points. Effective forecasts use neighbour points at the previous map too.

Accuracy of our estimater is somehow near 5-10 %.

3.35
DOR Signal Processing Using Chirp-z Transform Correlator

Li Chaozheng, Shanghai Astronomical Observatory, Chinese Academy of Sciences; Zheng Weimin, Shanghai Astronomical Observatory, Chinese Academy of Sciences

VLBI is a powerful tool of spacecraft tracking. The spacecraft onboard DOR (Differential of One-way Ranging) beacon will emit a series of tones other than the normal bandwidth signals. Chirp z-transform (CZT) is a kind of zoom spectrum analysis method and is appropriate to process the DOR beacon. CZT samples in the frequency domain along the arbitrary spire in the Z-plane. Theoretical analysis and computer simulation show that CZT can obtain higher spectral resolution and take shorter calculation time than the normal Fast Fourier Transform (FFT) method. A VLBI correlator with CZT ability is under development which is suitable for DOR analysis and spectrum VLBI.

3.36
Analysis of VLBI data with different stochastic models.

Nataliya Zubko, Finnish Geodetic Institute; Markku Poutanen, Finnish Geodetic Institute; Johannes Böhm, Vienna University of Technology; Tobias Nilsson, Vienna University of Technology

The VLBI observations are generally analyzed using least-squares method. For the accurate results the functional and stochastic models need to be well defined. In the standard stochastic model the variance- covariance matrix is dependent on only one stochastic parameter, describing by common level of variance. The analysis of observations can be improved by taking into account additional parameters in the stochastic model, such as the station and elevation angle dependent effects. Thus the model becomes reliant on several stochastic properties. A stochastic model, which includes station and elevation angle dependence of observations, has been implemented in VieVS software. We present results of a comparative analysis using traditional and advanced stochastic models. In advanced stochastic model the variance components of VLBI observations were estimated with the simplified MINQUE method.

Session 4

Results in Geodesy, Astrometry and Geophysics and Their Interpretation

4.37
The Statistic Analysis of Atmospheric Effects of Differential VLBI

WANG Guangli, Shanghai Astronomical Observatory; GUO Linjing, Shanghai Astronomical Observatory

During the Chinese Lunar Mission hundreds of VLBI observations have been carried, we re-analysis all the quasar observations which used to calibrate the satellite observables. In each observation there are two quasar scans lasting about one hour, we use these data by splitting them into different time intervals and doing self-calibration each other in phase-referencing style to investigate the relationship of differential atmospheric delay and different "time-switching". In this report we will present our primary result.

4.38
Report on the IVS Task Force on UT1 Intensives

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In 2010 an IVS Task Force on UT1 Intensives was initiated in order to improve the performance of the IVS INT series. A number of topics were identified, including a proposal for an unified analysis strategy, the possibility of providing different INT-products, automated analysis, and routine automated ultra-rapid dUT1-sessions. There was tremendous success for some of these topics. In this presentation we present the current status of the work done in this IVS Task Force, and give an outlook for the work to be completed.

4.39
Implementation of group delay ambiguity resolution and ionospheric correction in VieVs

Rüdiger Haas, Chalmers University of Technology, Department of Earth and Space Sciences, Onsala Space Observatory, SE-439 92 Onsala, Sweden; Minttu Uunila, Aalto University, Metsähovi Radio Observatory, Metsähovintie 114, FIN-02540 Kylmää, Finland;

Currently, the Vienna VLBI Software (VieVs) works on the basis of so-called NGS-cards version-4. The latter include VLBI data where the group delay ambiguities have been resolved and ionospheric effects have been corrected already with the Calc/Solve software. This means that VieVs uses pre-processed VLBI data and is not independent from Calc/Solve. To overcome this dependency it is necessary to include group delay ambiguity resolution and ionospheric correction directly in VieVs. We present first steps to achieve these goals by a new pre-processing module for VieVs.

4.40
Status Report on KASI Combination Center

Younghee Kwak, KASI; Jungho Cho, KASI

This paper reports the current status of the Korea Astronomy and Space Science Institute (KASI) as an IVS Combination Center. We combine the products of individual IVS Analysis Centers (ACs) at normal equation level using Bernese GPS Software Version 5.0. Since the software was initially developed for GPS data processing and analysis, we modified the software to deal with IVS analysis products properly. In order to validate the modified Bernese S/W, we reanalyzed solutions of BKG, GSFC and OPA that use identical analysis software, Calc/Solve, and combined them. As a preparatory combination analysis, we also combined IVS analysis products of six ACs, BKG, DGFI, GSFC, IAA, OPA and USNO and then compared our combination solutions with BKG/DGFI combination center. The next combination tasks are under discussion with the IVS analysis coordinator.

4.41
A search for the free inner core nutation in VLBI data

Sébastien Lambert, Observatoire de Paris, SYRTE, CNRS, UPMC; Séverine Rosat, Institut de Physique du Globe de Strasbourg, CNRS, Université de Strasbourg; Xiaoming Cui, Institute of Geodesy and Geophysics, Chinese Acad. of Sciences; Yves Rogister, Institut de Physique du Globe de Strasbourg, CNRS, Université de Strasbourg; Christian Bizouard, Observatoire de Paris, SYRTE, CNRS, UPMC

We investigate the time-frequency spectrum of VLBI nutation series, including operational series released by IVS analysis centers. Especially, we focus on the interannual, prograde band, wherein the signal associated with the free inner core nutation (FICN) should be searched. We point out the features showing up in the spectrum and we try to propose possible explanations and to draw conclusions or recommendations for future analyses.

4.42
Regularization of nutation time series at GSFC

Karine Le Bail, NVI Inc - NASA/GSFC; John Gipson, NVI Inc - NASA/GSFC; Sergei Bolotin, NVI Inc - NASA/GSFC

VLBI is unique in its ability to measure all five Earth orientation parameters. In this talk we focus on the two nutation parameters X and Y, which characterize the orientation of the Earth's rotation axis in space. We look at the spectral characteristics of these parameters and discuss their meaning. We also investigate different methods of regularizing the series, taking into account the spectral and stochastic properties of the signals, and discuss the pros and cons of different approaches including the Singular Spectrum Analysis, and the Kalman filter.

4.43
The status of K-band Korean VLBI Network geodesy

Jeong Ae Lee, Korea Astronomy and Space science Institute & University of Science and Technology; Bong Won Sohn, Korea Astronomy and Space science Institute; Taehyun Jung, Korea Astronomy and Space science Institute; Sang-sung Lee, Korea Astronomy and Space science Institute; Leonid Petrov, Astrogeo Center

Korean VLBI Network (KVN) consists of three 21-m antenna with a maximum baseline of about 500km, operating at 22/43/86/129GHz enabling simultaneous multi-frequency observations. In order to obtain more accurate KVN position and better astrometry data, we participated VERA K-band geodesy first at 29-30th November, 2011 and we have joined VERA K-band geodesy again (December, 2011). Also, we have carried out K-band geodesy of KVN only at December 2011. In addition, we will conduct the K-band KVN fringe search at early 2012. We will perform regular K-band KVN geodesy, continuously. Here, we report geodetic activities of KVN.

4.44
Continental hydrology loading observed by VLBI measurements

Daniel MacMillan, NVI, Inc./NASA Goddard Space Flight Center; David Eriksson, NVI, Inc./NASA Goddard Space Flight Center

Vertical deformation due to hydrological loading is large enough to be seen in VLBI geodetic parameter estimates. Typical peak-to-peak vertical variations are 3-8 mm at VLBI sites. The hydrological signal at VLBI sites generally has a seasonal character, but we also observe interannual variations. These variations are caused by temporal variations of the geographic distribution of surface mass. Here, we have calculated the mass loading derived from GRACE gravity measurement time series from 2003 to 2011. Specifically, we have evaluated the convolution of FarrellŠs loading Green's function with the global loading mass field, given by a global grid of equal-area GRACE mascons. We compare hydrology loading series derived from GRACE with those computed using the GLDAS (M. Rodell). We find significant reduction in baseline length and site position scatter when hydrology loading is applied in VLBI analysis.

4.45
Vienna SAC-SOS: Analysis of the russian VLBI sessions

Matthias Madzak, Vienna University of Technology; Florian Göbel, Vienna University of Technology; Tobias Nilsson, Vienna University of Technology; Johannes Böhm, Vienna University of Technology; Harald Schuh, Vienna University of Technology

The Institute of Geodesy and Geophysics (IGG) of the Vienna University of Technology is an IVS Special Analysis Center for Specific Observing Sessions (SAC-SOS). As such, we are analyzing the Russian VLBI sessions on a routine basis with the Vienna VLBI Software (VieVS). Since 2006 VLBI observation data from the QUASAR network, formed by the three stations Badary, Svetloe and Zelenchukskaya, is available in NGS format. Due to the large extent in east-west direction and a long enough north-south component, these observations can be used to estimate all Earth orientation parameters. In the poster presentation, we show some statistics about the sessions, baseline length repeatabilities, station velocities, precision and accuracy as well as from EOP estimates, and we also report about problems in the analysis of the Russian VLBI sessions since 2006. This summary will also be used to give feedback to the participating stations.

4.46
Joint analysis of the Polar Motion and Celestial Pole Offset time series

Natalia Miller (1), Zinovy Malkin (1,2); (1) Pulkovo Observatory, St. Petersburg, Russia; (2) St. Petersburg State University, St. Petersburg, Russia;

Earth rotation is a complicated process, and the rotation axis moves with respect to both terrestrial and celestial reference systems. These movements are described by the Earth rotation parameters, the polar motion (PM) and the celestial pole offset (CPO) respectively. It is very important that many irregularities of these movements are caused by the same physical reasons, and thus are physically connected. In this work, we use the Multi-Channel Singular Spectrum Analysis (M-SSA) to perform a joint PM and CPO time series analysis. Three groups of common principal components (PCs) were found: trends, and quasi-harmonic terms with near-annual and near-Chandlerian frequencies. After that the sum of found common PCs was subtracted from the original time series, and the residuals were investigated by the SSA method. Finally, joint analysis of the EOP and some geophysical time series was undertaken to reveal various factors responsible for excitation of the Chandler Wobble and the Free Core Nutation.

4.47
Impact of covariance information on the orientation parameters between radio source position catalogues

Julia Sokolova (1),Zinovy Malkin (1,2); (1) Pulkovo Observatory, St. Petersburg, Russia; (2) St. Petersburg State University, St. Petersburg, Russia

As was shown by Jacobs et al. (2010), accounting for correlations between the source positions derived from VLBI global solution changes significantly the orientation parameters between compared CRF realizations if a microarcsecond level of accuracy is required. In this study we performed more detailed analysis of this effect. We conducted comparisons of several commonly used rotational alignment models with 3, 4 and 6 parameters with three methods of accounting for the covariance information: using the position errors only, using only RA/DE correlations reported in radio source position catalogues in the IERS format, and using the full covariance matrices. CRF solutions from several IVS Analysis Centres providing the CRF solution in the SINEX format are used for this work. Detailed results of this analysis are reported.

4.48
Vienna SAC-SOS: ANALYSIS OF THE EUROPEAN VLBI SESSIONS

Claudia Tierno Ros, Vienna University of Technology; Peter Pavetich, Vienna University of Technology; Tobias Nilsson, Vienna University of Technology; Johannes Böhm, Vienna University of Technology; Harald Schuh, Vienna University of Technology

The Institute of Geodesy and Geophysics (IGG) of the Vienna University of Technology is an IVS Special Analysis Center for Specific Observing Sessions (SAC-SOS). As such, we are analyzing the European VLBI sessions on a routine basis with the Vienna VLBI Software (VieVS). In this poster presentation, we present some statistics about the sessions, baseline length repeatabilities, station velocities, precision and accuracy, and we will also report about problems in the analysis of the European VLBI sessions since 1990. This summary will also give feedback to the participating stations.

4.49
Comparison of UT1 and polar motion from IVS sessions derived from VieVS and Solve analysis

Minttu Uunila, Aalto University Metsähovi Radio Observatory; Karen Baver, NVI, Inc., NASA Goddard Space Flight Center; John Gipson, NVI, Inc, NASA Goddard Space Flight Center; Tobias Nilsson, Vienna University of Technology

We compare the results of using Vienna VLBI Software (VieVS) and Calc/Solve to estimate UT1 and Polar Motion using IVS sessions from 2011. The results from both 24 hour sessions and intensives are compared. We discuss the formal errors of the estimates, as well as the agreement of the two sets estimates with other EOP time series.

Session 5

VLBI Analysis and Results from the Recent Megaquakes in Japan and Chile

5.50
Movement of the 2011 off the Pacific coast of Tohoku Earthquake detected by VERA geophysical observations

Takaaki Jike, National Astronomical Observatory of Japan; Yoshiaki Tamura, National Astronomical Observatory of Japan; Seiji Manabe, National Astronomical Observatory of Japan; Makoto Shizugami, National Astronomical Observatory of Japan;

The VERA project is carrying out daily GPS observations in parallel to geodetic VLBI observations, in order to monitor motions of the positions of the VERA antenna stations. And, continuous measurement of gravity is performed as co-location or a station of GGP in Kamioka mine and Mizusawa. These geophysical observations caught co-seismic or post-seismic phenomena, crustal movement, change of the atmospheric pressure by tsunami, post-seismic creeping, free oscillation of the Earth, and time variation of gravity, accompanying the 2011 off the Pacific coast of Tohoku Earthquake.

5.51
Present status of NICT Kashima 34-m antenna: Aftermath of the 2011 Tohoku Megaquake, Japan

ICHIKAWA Ryuichi, National Institute of Information and Communications Technology; SEKIDO Mamoru, National Institute of Information and Communications Technology; KAWAI Eiji, National Institute of Information and Communications Technology; HOBIGER Thomas, National Institute of Information and Communications Technology; AMAGAI Jun, National Institute of Information and Communications Technology; TAKEFUJI Kazuhiro, National Institute of Information and Communications Technology; UJIHARA Hideki, National Institute of Information and Communications Technology; TSUTSUMI Masanori, National Institute of Information and Communications Technology; HASEGAWA Shingo, National Institute of Information and Communications Technology; MIYAUCHI Yuka, National Institute of Information and Communications Technology; TAKEE Miwa, National Institute of Information and Communications Technology; HANADO Yuko, National Institute of Information and Communications Technology; KOYAMA Yasuhiro, National Institute of Information and Communications Technology; KONDO Tetsuro, National Institute of Information and Communications Technology

At first, we would like thank global VLBI community for their concerns about the devastating tragedy due to the $M_w 9.0$ megaquake that occurred on March 11th, 2011. We suffered from strong ground motion and a 5.2-m-high Tsunami which attacked the Kashima port. In addition, we were facing serious restrictions due to the Fukushima nuclear accident. Fortunately, we have no staff casualties in KSRC/NICT. Our 34-m antenna has some minor damage due to the strong motion which exceeded 650 gal as recorded around Kashima region. The other facilities at KSRC/NICT (e.g. main building, guest room building, and outreach building) are also partly damaged. Thus, these building are currently under repair. We expect that the 34-m antenna will be recovered by the end of this fiscal year. Coseismic crustal deformations measured by our GPS station nearby the 34-m antenna showed movements of up to 749 mm in the horizontal (eastward) and -245 mm in the vertical. Postseismic deformations following the main shock reached values of over 300 mm in the horizontal and about +100 mm in the vertical component as recorded until the end of November. Moreover, postseismic deformation between Kashima 11-m and Koganei 11-m (about 109 km baseline length) has been also measured. The baseline changes reach up to 100 mm from March 11th to the end of November. We are going to inform IVS colleagues about the updated site coordinates of the 34-m and 11-m antennas.

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