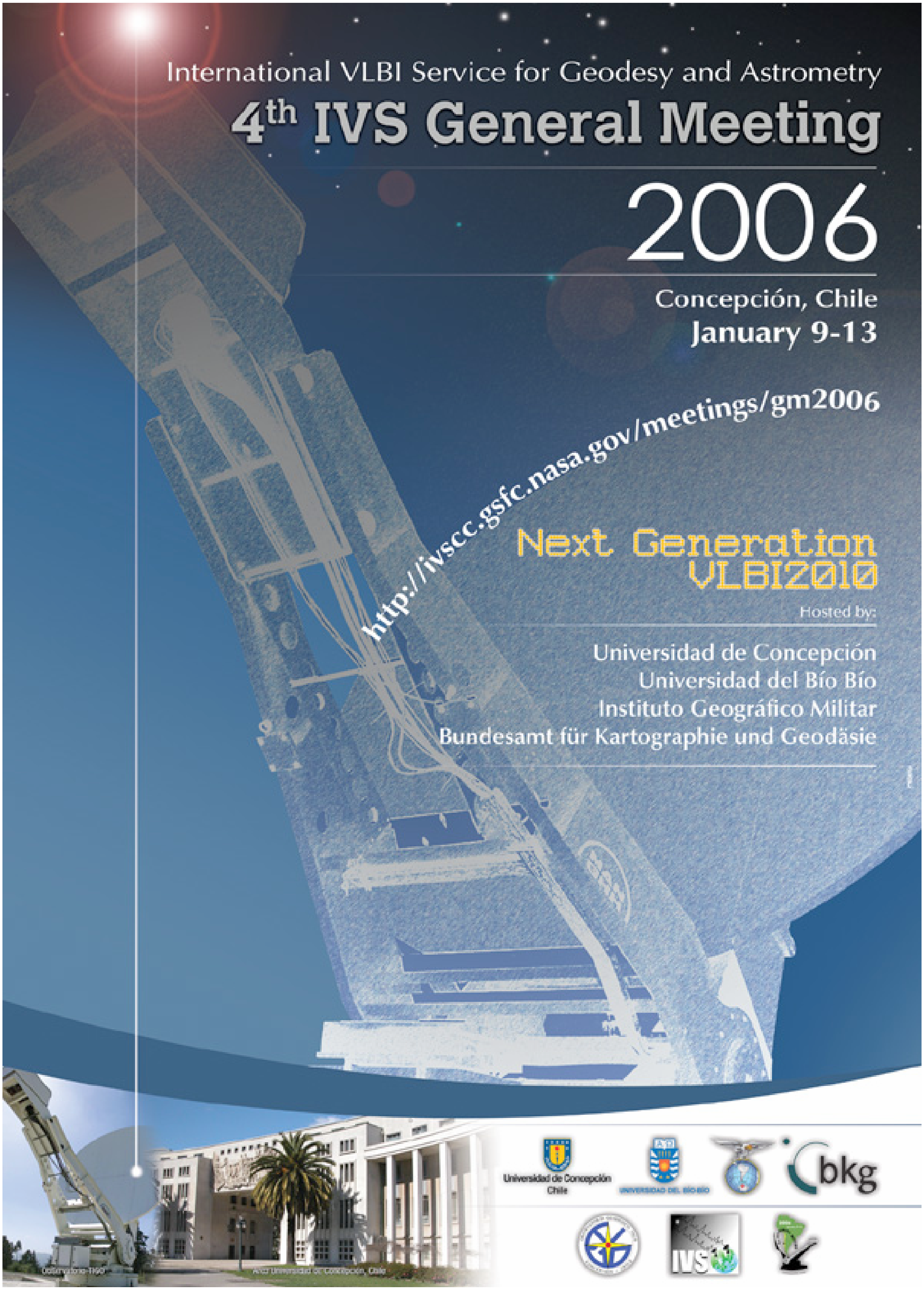
International VLBI Service for Geodesy and Astrometry
4th IVS General Meeting
2006
Concepción, Chile
January 9-13
http://ivscc.gsfc.nasa.gov/meetings/gm2006
Next Generation
VLBI2010
Hosted by:
Universidad de Concepción
Universidad del Bío Bío
Instituto Geográfico Militar
Bundesamt für Kartographie und Geodäsie
Universidad de Concepción
Chile
bkg
IVS

Fourth IVS General Meeting
Concepción, Chile

EXTENDED SCHEDULE OF EVENTS

All events take place at Facultad de Ingeniería, Universidad de Concepción.
Exceptions are indicated in angular brackets.

Sunday, January 8, 2006

13:30–20:00	Registration [Hotel Diego de Almagro, Sala Llanquihue]
20:00–22:00	Icebreaker Reception [Hotel Diego de Almagro, Sala Llanquihue]

Monday, January 9, 2006

08:30	Bus to UdeC
09:00–10:00	Opening Ceremony [Casa del Arte, Universidad de Concepción]
10:00–10:05	Official Conference Photo [Casa del Arte, Universidad de Concepción]
10:05–10:35	Coffee break
10:35–13:05	Session 1: VLBI in Science and Application
13:05–14:45	Lunch break
14:45–16:15	Session 1: VLBI in Science and Application (cont.)
16:15–16:45	Session 2: Next Generation VLBI
16:45–17:15	Coffee break
17:15–18:55	Session 2: Next Generation VLBI (cont.)
19:00	Bus to hotel
19:30–21:30	VLBI2010 Committee Meeting [Hotel Diego de Almagro, Sala Neltume]

Tuesday, January 10, 2006

08:30	Bus to UdeC
09:00–10:45	Session 3: Network Stations, Operation Centers, Correlators
10:50–11:20	Coffee break
11:20–12:20	Session 3: Network Stations, Operation Centers, Correlators (cont.)
12:20–13:05	Session 4: New Technology Developments in VLBI
13:05–15:00	Lunch break
15:00–16:30	Session 4: New Technology Developments in VLBI (cont.)
16:40	Bus to TIGO
17:00–19:00	TIGO Visit and Cocktail
19:00	Bus to hotel
20:00–22:00	OPC Meeting [Hotel Diego de Almagro, Sala Neltume]

Wednesday, January 11, 2006

08:30	Bus to UdeC
09:00–10:40	Session 5: Software and Analysis Strategies
10:40–11:10	Coffee break
11:10–12:10	Session 5: Software and Analysis Strategies (cont.)
12:10–13:00	Session 6: Results and Geodetic/Geophysical/Astrometric Interpretation
13:00–15:00	Lunch break
15:00–16:30	Session 6: Results and Geodetic/Geophysical/Astrometric Interpretation (cont.)
16:30–18:45	Poster Sessions and Closing
18:45	Bus to hotel
19:30	Bus to "La Posada"
20:00–23:30	Conference Dinner [Golf Club House "La Posada"]
23:30	Bus to hotel

Thursday, January 12, 2006

08:30	Bus to UdeC
09:00–10:45	IVS Analysis Workshop, Session I
10:45–11:15	Coffee break
11:15–13:00	IVS Analysis Workshop, Session II
13:00–14:15	Lunch break
14:15–15:45	IVS Analysis Workshop, Session III
15:45–16:05	Coffee break
16:05–17:30	IVS Analysis Workshop, Session IV
17:40	Bus to hotel
19:30–21:30	OCCAM User Group Meeting [Hotel Diego de Almagro, Sala Neltume]

Friday, January 13, 2006

08:30	Bus to UdeC
09:00–10:45	IVS Directing Board Meeting [Salón Azul, Biblioteca Central, UdeC]
10:45–11:15	Coffee break
11:15–13:00	IVS Directing Board Meeting (cont.) [Salón Azul]
13:00–15:00	Lunch break
15:00–16:45	IVS Directing Board Meeting (cont.) [Salón Azul]
16:45–17:15	Coffee break
17:15–19:00	IVS Directing Board Meeting (cont.) [Salón Azul]
19:00	Bus to hotel

Fourth IVS General Meeting
Concepción, Chile

PROGRAM

Sunday, January 8, 2006

13:30 Registration
Hotel Diego de Almagro, Sala Llanquihue

20:00 Icebreaker Reception
Hotel Diego de Almagro, Sala Llanquihue

Monday, January 9, 2006

Opening Ceremony *(Casa del Arte)*

08:30 Bus from Hotel Diego de Almagro to Casa del Arte, UdeC

09:00 Welcome Addresses and Folkloristic Show
(1) Sergio Lavanchy, Rector Universidad de Concepción; (2) Wolfgang Schlüter, IVS Chair; (3) Ballet of UdeC

10:00 Official Conference Photo

Session 1: VLBI in Science and Application *(Facultad de Ingeniería)*
Chair: Harald Schuh

10:05 Break

10:35 1-01 Chair's Report
Wolfgang Schlüter, Bundesamt für Kartographie und Geodäsie (BKG)

10:45 1-02 Coordinating Center Report
Dirk Behrend, NVI, Inc./GSFC

10:55 1-03 GGOS *(invited)*
Markus Rothacher, GeoForschungsZentrum Potsdam (GFZ)

11:20 1-04 GAIA and a New Optical Reference Frame *(invited)*
Alexandre H. Andrei, Observatorio Nacional/MCT & Observatorio do Valongo/UFRJ

11:45 1-05 Role of VLBI for Investigating Earth Rotation *(invited)*
Aleksander Brzezinski, Space Research Center, Polish Academy of Sciences

12:10 1-06 The ALMA Project *(invited)*
Massimo Tarenghi, ALMA Consortium

12:35 1-07 IVS' Contribution to the IERS Combination Pilot Project and to the ITRF2004: Status and Results
Markus Vennebusch, Geodetic Institute of the University of Bonn

12:50 1-08 Corrections to the IERS Combination Pilot Project and to the ITRF2004: Status and Results
Jinling Li, Shanghai Astronomical Observatory, Chinese Academy of Sciences

13:05 Lunch

Session 1: VLBI in Science and Application (cont.)
Chair: Jinling Li

14:45 1-09 GPS Meteorology over Northeast Brazil: Perspectives
A. Costa (1,2), A. M. Pereira de Lucena (3), P. Kaufmann (4), F. Sales Ávila Cavalcante (2), F. Geraldo de Melo Pinheiro (2), F. de Assis Travares Ferreira da Silva (3), J. Bosco Verçosa Leal Jr. (2), V. de Paula Silva Filho (1,3); (1) FUNCEME, (2) UECE, (3) INPE, (4) Mackenzie University

15:00 1-10 Global VLBI Solution IGG05R01
Robert Heinkelmann (1), Johannes Böhm (1), Harald Schuh (1), Volker Tesmer (2), (1) Institute of Geodesy and Geophysics, Vienna University of Technology, (2) Deutsches Geodätisches Forschungsinstitut

15:15 1-11 International VLBI Tracking of SELENE
Nobuyuki Kawano, National Astronomical Observatory of Japan

15:30 1-12 Spacecraft Tracking with the Chinese VLBI Network
Xiuzhong Zhang and the Chinese VLBI Network Team, Shanghai Astronomical Observatory, Chinese Academy of Sciences

15:45 1-13 The First Year of VERA Geodetic Experiments
Takaaki Jike, Yoshiaki Tamura, Seiji Manabe, NAOJ VERA Group; VERA Observatory, National Astronomical Observatory of Japan

16:00 1-14 VERA System and Recent Results
H. Kobayashi (1), S. Manabe (1), N. Kawaguchi (1), K-M. Shibata (1), Y. Tamura (1), O. Kameya (1), M. Honma (1),T. Hirota (1), H. Imai (2), T. Omodaka (2); (1) VERA Observatory, National Astronomical Observatory of Japan; (2) Department of Science, Kagoshima University

Session 2: Next Generation VLBI
Chair: Arthur Niell

16:15 2-01 Achieving a Quantum Leap in Observation Density
Bill Petrachenko, Natural Resources Canada (NRCan)

16:30 2-02 A Wide-Band VLBI Digital Backend System
Alan Whitney, Shep Doeleman, Brian Fanous, Hans Hinteregger, MIT Haystack Observatory

16:45 Break

17:15 2-03 A New Lower Cost 12m Full Motion Antenna *(invited)*
Peter Shield, Mark Godwin, InterTronic Solutions, Patriot Antenna Systems Inc.

17:40 2-04 Uses of the ICRF and Implications for Future VLBI
Chopo Ma, Goddard Space Flight Center

Session 2: Next Generation VLBI (cont.)
Chair: Bill Petrachenko

17:55 2-05 Softc + Beowulf – JPL's Newest Correlator
Stephen Lowe, Jet Propulsion Laboratory

18:10 2-06 Real Time Correlator in FPGA
Zhijun Xu, Xiuzhong Zhang, Shanghai Astronomical Observatory, Chinese Academy of Sciences

18:25 2-07 Simulations for VLBI 2010
Jörg Wresnik, Johannes Böhm, Harald Schuh, Institute of Geodesy and Geophysics, Vienna University of Technology

18:40 2-08 Singular Value Decomposition – A Tool for VLBI Simulations
Markus Vennebusch, Geodetic Institute of the University of Bonn

19:00 Bus to hotel

Tuesday, January 10, 2006

Session 3: Network Stations, Operation Centers, Correlators
Chair: Ed Himwich

08:30 Bus from Hotel Diego de Almagro to Facultad de Ingeniería, UdeC

09:00 3-01 A New 40-m Radio Telescope in Yebes (Spain) for Geodetic VLBI Studies by IGN *(invited)*
Jesús Gómez-González, Francisco Colomer, Alberto Barcia, José Antonio López-Fernández, Instituto Geográfico Nacional (IGN) of Spain

09:25 3-02 K5/VSSP Data Processing System of Small Cluster Computing at Tsukuba VLBI Correlator *(invited)*
Morito Machida, Masayoshi Ishimoto, Kazuhiro Takashima, Tetsuro Kondo, Yasuhiro Koyama, Geographical Survey Institute, National Institute of Information and Communications Technology (NICT)

09:50 3-03 Remote Control of VLBI Operations
Gonzalo Remedi, Sergio Sobarzo, Cristobal Jara, Roberto Aedo, Carlos Verdugo, Hayo Hase, UBB, UdeC, BKG

10:05 3-04 National Geodetic VLBI Plan in Korea
Tuhwan Kim (1), Tetsuo Sasao (1,2), Younghee Kwak (1), Kidok An (3), Wonkuk Lee (3), Jongwan Kim (3); (1) Ajou University, (2) Korea Astronomy & Space Science Institute, (3) National Geographic Information Institute

10:20 3-05 Radio Astronomy and VLBI Developments in Brazil
Pierre Kaufmann, Mackenzie Presbyterian University

10:35 3-06 Footprint Observations at the Fundamental Station Wettzell
Wolfgang Schlüter, Thomas Klügel, Christian Schade, Bundesamt für Kartographie und Geodäsie (BKG)

10:50 Break

Session 3: Network Stations, Operation Centers, Correlators (cont.)
Chair: Yasuhiro Koyama

11:20 3-07 Bonn Correlator Report for Astronomy and Geodesy
Arno Müskens, Walter Alef, Dave Graham, Geodetic Institute of the University of Bonn, Max-Planck-Institute for Radioastronomy

11:35 3-08 Washington Correlator Report
Kerry Kingham, U.S. Naval Observatory

11:50 3-09 Network Coordinator Report
Ed Himwich, NVI Inc./GSFC

12:05 3-10 First Fringes to New Zealand
Sergei Gulyaev, Auckland University of Technology

Session 4: New Technology Developments in VLBI
Chair: Alan Whitney

12:20 4-01 DBBC – A Flexible Platform for VLBI Data Processing
Gino Tuccari (1), Salvatore Buttaccio (1), Gaetano Nicotra (1), Ying Xiang (2), Michael Wunderlich (3); (1) IRA/INAF, (2) SHAO/CAS, (3) MPI-Bonn

12:35 4-02 FPGA Implementation in DBBC
Ying Xiang (1), Gino Tuccari (2), Wenren Wei (1); (1) Shanghai Astronomical Observatory (CAS), (2) National Astrophysical Institute (IRA)

12:50 4-03 e-VLBI Developments with the K5 VLBI System
Yasuhiro Koyama, Tetsuro Kondo, Moritaka Kimura, Hiroshi Takeuchi, Masaki Hirabaru, National Institute of Information and Communications Technology (NICT)

13:05 Lunch

15:00 4-04 The Development of the Streamlined Correlation Software Using Bitset Class Library
Fujinobu Takahashi (1), Kazuki Yanashima (1), Yuji Yoshida (1), Tetsuro Kondo (2); (1) Yokohama National University (YNU), (2) National Institute of Information and Communications Technology

15:15 4-05 Development of a New VLBI Sampler Unit (K5/VSSP32) Equipped with a USB 2.0 Interface
Tetsuro Kondo, Yasuhiro Koyama, Hiroshi Takeuchi, Moritaka Kimura; Kashima Space Research Center/NICT

Session 4: New Technology Developments in VLBI (cont.)
Chair: Gino Tuccari

15:30 4-06 VSI Interfaces for Legacy Systems
Dan Smythe, MIT Haystack Observatory

15:45 4-07 Integration of the Mk5B Playback System into the Mk4 Correlator
Roger Cappallo, MIT Haystack Observatory

16:00 4-08 The Mark 5B VLBI Data System
Alan Whitney, MIT Haystack Observatory

16:15 4-09 e-VLBI Development Program at Haystack Observatory
Alan Whitney, Chet Rusczcyk, MIT Haystack Observatory

16:40 Bus to TIGO

17:00 TIGO Visit and Cocktail

19:00 Bus to hotel

Wednesday, January 11, 2006

Session 5: Software and Analysis Strategies
Chair: Oleg Titov

08:30 Bus from Hotel Diego de Almagro to Facultad de Ingeniería, UdeC

09:00 5-01 Impact of Different Tropospheric Mapping Functions on the TRF, CRF, and Position Time Series Estimated from VLBI *(invited)*
Volker Tesmer (1), Johannes Böhm (2), Robert Heinkelmann (2), Harald Schuh (2); (1) Deutsches Geodätisches Forschungsinstitut (DGFI), (2) Institute of Geodesy and Geophysics, Vienna University of Technology

09:25 5-02 Interaction of Atmosphere Modeling and Analysis Strategy
Arthur Niell, MIT Haystack Observatory

09:40 5-03 Comparison of Wet Path Delays Observed with WVR, Sun Spectrometer, Radiosondes, GPS and VLBI at Wettzell
Wolfgang Schlüter (1); Walter Schwarz (1); Beat Bürki (2); Alexander Somieski (2); Petra Häfele (3); (1) Fundamentalstation Wettzell, (2) Eidgenössische Technische Hochschule Zürich/CH, (3) Universität der Bundeswehr, München

09:55 5-04 Linear Horizontal Gradients of Refractivity vs. 3D Raytracing
Johannes Böhm, Harald Schuh, Institute of Geodesy and Geophysics, Vienna University of Technology

10:10 5-05 A Comparison of R1 and R4 IVS Networks
Sebastien Lambert (1), Anne-Marie Gontier (2); (1) Royal Observatory of Belgium, (2) Paris Observatory

10:25 5-06 First Results from CONT05
Dan MacMillan, David Gordon, Dirk Behrend, Chopo Ma, Goddard Space Flight Center

10:40 Break

Session 5: Software and Analysis Strategies (cont.)
Chair: Johannes Böhm

11:10 5-07 Radiosource Instability in the Analysis of VLBI Data *(invited)*
Daniel MacMillan, NVI, Inc./GSFC

11:25 5-08 The Effect of Reference Radiosource Instabilities on the TRF Solution
Oleg Titov, Geoscience Australia

11:40 5-09 First Steps to Investigate Long-term Stability of Radio Sources in VLBI Analysis
Gerald Engelhardt, Volkmar Thorandt, Bundesamt für Kartographie und Geodäsie

11:55 5-10 Correlation in VLBI Observations
John M. Gipson, NVI, Inc./GSFC

Session 6: Results and Geodetic/Geophysical/Astrometric Interpretation
Chair: Seiji Manabe

12:10 6-01 VLBA Phase Referencing for Astrometric Use *(invited)*
Edward Fomalont, National Radio Astronomy Observatory

12:35 6-02 High-frequency Earth Orientation Variations and Geodetic VLBI *(invited)*
Rüdiger Haas, Chalmers University of Technology, Onsala Space Observatory

13:00 Lunch

15:00 6-03 Extending the ICRF to Higher Radio Frequencies: Global Astrometric Results at 24 GHz
C.S. Jacobs, G.E. Lanyi, C.J. Naudet, O.J. Sovers, L.D. Zhang (1); P. Charlot (2); E.B. Fomalont (3) D. Gordon, C. Ma (4); and the KQ VLBI Collaboration; (1) NASA/Caltech's JPL, (2) Bordeaux Observatory, (3) NRAO, (4) NASA/GSFC

15:15 6-04 Astrometric Suitability of ICRF Sources Based on Intrinsic VLBI Structure
Patrick Charlot (1); Alan Fey (2); Roopesh Ojha (3); David Boboltz (2); (1) Bordeaux Observatory, (2) U. S. Naval Observatory, (3) Australia Telescope National Facility

15:30 6-05 How Compact Are Faint Radio Sources?
Richard Porcas, MPIfR Bonn

Session 6: Results and Geodetic/Geophysical/Astrometric Interpretation (cont.)
Chair: Dan MacMillan

15:45 6-06 E3 Network Results
Anthony Searle, Mario Bérubé, Bill Petrachenko, Natural Resources Canada (NRCan)

16:00 6-07 A Generalized Scheme to Retrieve Wet Path Delays from WVR Measurements Applied to the European Geodetic VLBI Network
J. Cho (1,2), A. Nothnagel (2), A. L. Roy (3), R. Haas (4); (1) Korea Astronomy & Space Science Institute, (2) Geodetic Institute, University of Bonn, (3) Max-Plank Institute for Radio Astronomy, (4) Onsala Space Observatory, Chalmers University of Technology

16:15 6-08 Combination of Long Time Series of Tropospheric Parameters
Robert Heinkelmann, Johannes Böhm, Harald Schuh; Institute of Geodesy and Geophysics, Vienna University of Technology

Poster Sessions and Closing

16:30 Closing Remarks
Wolfgang Schlüter, Bundesamt für Kartographie und Geodäsie (BKG)

16:45 Poster Sessions and Refreshments

18:45 Bus to hotel

19:30 Bus from Hotel Diego de Almagro to Golf Club House "La Posada"

20:00 Conference Dinner

23:30 Bus to hotel

Posters

Session 1P: VLBI in Science and Application

1-01P VLBI Delay Model for Radio Sources at Finite Distance
Mamoru Sekido (1), Toshio Fukushima (2); (1) National Institute of Information and Communications Technology, (2) National Astronomical Observatory Japan

Session 2P: Next Generation VLBI

2-01P Carbon Fibre Antennas for Geodetic VLBI
Peter Dewdney (1), Gordon Lacey (1), Bill Petrachenko (2); (1) National Research Council of Canada (NRC), (2) Natural Resources Canada (NRCan)

2-02P Network Size Simulations
Anthony Searle, Mario Berube, Bill Petrachenko; Geodetic Survey Division, Natural Resources Canada

Session 3P: Network Stations, Operation Centers, Correlators

3-01P Antenna Cross-Polarization Characteristics at Geodetic VLBI Stations
Brian Corey, Michael Titus; MIT Haystack Observatory

3-02P An Investigation on a GPS-based Approach to Local Tie Computation
Claudio Abbondanza (1), Monia Negusini (2), Pierguido Sarti (2), Luca Vittuari (1); (1) DISTART - Università di Bologna, Italy (2) Istituto di Radioastronomia - INAF - Bologna, Italy

3-03P GPS Measurements on the VLBI Telescopes at Onsala and Ny-Ålesund
Daniel Hernandez, Rüdiger Haas; Chalmers University of Technology, Onsala Space Observatory

3-04P Photogrammetry, Laser Scanning, Holography and Terrestrial Surveying of the Noto VLBI Dish
Pietro Bolli (1), Simonetta Montaguti (1), Monia Negusini (1), Pierguido Sarti (1), Luca Vittuari (2), Gianluigi Deiana (3); (1) Istituto di Radioastronomia - INAF - Bologna, Italy (2) DISTART - Università di Bologna, Italy (3) Osservatorio Astronomico di Cagliari - INAF, Italy

3-05P Observation Activities at the Tsukuba Station
Junichi Fujisaku, Kensuke Kokado, Masayoshi Ishimoto, Kazuhiro Takashima and Yoshihiro Fukuzaki; Geographical Survey Institute

3-06P Status and Results of JARE Syowa Station, Antarctica
Yoshihiro Fukuzaki (1), Kazuo Shibuya (2), Koichiro Doi (2); (1) Geographical Survey Institute, (2) National Institute of Polar Research

3-07P Onsala Space Observatory - Station Report
Rüdiger Haas, Chalmers University of Technology, Onsala Space Observatory

3-08P Noto Station Status Report
Gaetano Nicotra, Gino Tuccari, Salvatore Buttaccio, Pietro Cassaro, Corrado Contavalle, Leonardo Nicotra, Carlo Nocita, Luigi Papaleo, Mario Paternò, Francesco Schillirò; Istituto di Radioastronomia - INAF (Italy)

Session 4P: New Technology Developments in VLBI

4-01P e-VLBI Demonstrates Real-time Correlation Using Both K5 and Mark 5 End Systems
Chester Ruszczyk (1), Yasuhiro Koyama (2), Alan Whitney (1); (1) MIT Haystack Observatory, (2) Kashima Space Research Center/NICT

4-02P e-NRTV - Radar VLBI Network
Gino Tuccari (1), Igor Molotov (2), Alexander Volvach (3); (1) Istituto di Radioastronomia INAF (Italy), (2) Central Pulkovo Astronomical Observatory (Russia), (3) Institute of Radio Astronomy (Ukraine)

4-03P An Evaluation of Atmospheric Path Delay Correction in Differential VLBI Experiments for Spacecraft Tracking
Ryuichi Ichikawa, Mamoru Sekido, Yasuhiro Koyama, Tetsuro Kondo; Kashima Space Research Center, NICT

4-04P A 2 Gbps DAS for Spacecraft VLBI
Hiroshi Takeuchi, Moritaka Kimura, Junichi Nakajima; NICT

4-05P The Post-Correlation Processing of VLBI Satellite Observations at SHAO
Guangli Wang, Shanghai Astronomical Observatory, Chinese Academy of Sciences

Session 5P: Software and Analysis Strategies

5-01P Calc 10 Implementation
David Gordon (1), Dan MacMillan (2), Karen Baver (1); (1) Raytheon/NASA GSFC; (2) NVI Inc./NASA GSFC

5-02P Baseline and Site Repeatability in the IVS Rapid Network
Sebastien Lambert; Royal Observatory of Belgium (formerly at NVI, Inc./U.S. Naval Observatory)

5-03P Thermal Deformation of Radio Telescopes Onsala and Wettzell
Jörg Wresnik (1), Rüdiger Haas (2), Johannes Böhm (1), Harald Schuh (1); (1) Institute of Geodesy and Geophysics, Vienna University of Technology, (2) Chalmers University of Technology, Onsala Space Observatory

Session 6P: Results and Geodetic/Geophysical/Astrometric Interpretation

6-01P Improving Astrometric VLBI by Using Water Vapor Radiometer Calibrations
C.S. Jacobs, S.J. Keihm, G.E. Lanyi, C.J. Naudet, L. Riley, A.B. Tanner; Jet Propulsion Laboratory NASA/Caltech

6-02P Tropospheric Parameters Long Time Series Analysis
Sergey Kurdubov, Elena Skurikhina, Julia Sokolova; Institute of Applied Astronomy RAS

6-03P VLBI as a Tool to Probe the Ionosphere
T. Hobiger (1), T. Kondo (2), H. Schuh (1); (1) IGG, Vienna University of Technology; (2) NICT

6-04P Detection of Short Period Ionospheric Variations from VLBI Fringe Phases
T. Hobiger (1), T. Kondo (2), K. Takashima (3), H. Schuh (1); (1) IGG, Vienna University of Technology; (2) NICT; (3) Geographical Survey Institute

6-05P The First Dual Frequency VLBI Observation Using VERA
Bong Won Sohn (1), Hideyuki Kobayashi (2) Tetsuo Sasao (1), Tomoya Hirota (2), Osamu Kameya (2), Yoon Kyung Choi (2); (1) KASI, Korea Astronomy & Space Science Institute; (2) NAOJ, National Astronomical Observatory of Japan

6-06P Crustal Deformation in South America from GPS and VLBI
Annika Edh, Rüdiger Haas; Chalmers University of Technology, Onsala Space Observatory

6-07P Preliminary Study on Plate Motion Measurements in Korean Peninsula by New Korean VLBI
Younghee Kwak (1), Tetsuo Sasao (1,2), Tuhwan Kim (1); (1) Ajou University, (2) Korea Astronomy & Space Science Institute

6-08P Modeling of the Earth Free Core Nutation
V.S. Gubanov, S.L. Kurdubov; Institute of Applied Astronomy of RAS, St. Petersburg, Russia

6-09P Local Tie Survey at VERA Ogasawara Station at Site Chichijima
Yoshimitsu Masaki (1), Shigeru Matsuzaka (1), Yoshiaki Tamura (2); (1) Geographical Survey Institute, (2) National Astronomical Observatory of Japan

Fourth IVS General Meeting
Concepción, Chile

ABSTRACTS

Session 1: VLBI in Science and Application

1-01 Chair's Report
Wolfgang Schlüter, Bundesamt für Kartographie und Geodäsie (BKG)

1-02 Coordinating Center Report
Dirk Behrend, NVI, Inc./GSFC
The status of Coordinating Center projects and activities will be reviewed and discussed.

1-03 GGOS *(invited)*
Markus Rothacher, GeoForschungsZentrum Potsdam (GFZ)

1-04 GAIA and a New Optical Reference Frame *(invited)*
Alexandre H. Andrei, Observatorio Nacional/MCT & Observatorio doValongo/UFRJ
The ESA mission GAIA (Global Astrometry for Astrophysics), currently scheduled for launch in mid-2010 for a 5 years mission, will repeatedly measure the position nearly one billion stars to perform a statistically complete galactic census, carrying on astrometric and multi-band photometric observations. The target position accuracy is 10uas at V=15 and 50uas at V=18. To translate such accuracies into astrometric precision, it will be used a primary frame as small as 10,000 quasars, recognized through the analysis of the satellite observation capabilities outputs themselves. Although by principle self-consistent, the quasars primary frame will also tie the GAIA positions to the existing frames. Here the GAIA astrometry is reviewed, as well as the strategies for defining the quasars primary frame. For the later, the direct realization of an inertial frame in the visible wavelength in the framework the ICRS concepts, and the relationship to the ICRF are addressed.

1-05 Role of VLBI for Investigating Earth Rotation *(invited)*
Aleksander Brzezinski, Space Research Center, Polish Academy of Sciences
Very long baseline interferometry (VLBI) is the only space-geodetic technique capable of independently determining all of the Earth orientation parameters (EOP): precession-nutation (celestial pole offset), spin (UT1 / length of day) and polar motion. Currently, this is the unique technique for monitoring the celestial pole offset and the long-term variability of UT1. Regular determinations, since more than 20 years, of the EOP by the VLBI enabled in turn constraining different geophysical parameters related to the internal constitution and rheology of the Earth

as well as to the global dynamics of the outer fluid layers - the atmosphere and the oceans. An important achievement in the interpretation of the VLBI measurements of Earth rotation was development of the high- precision precession-nutation model, the recently adopted IAU 2000 model. This paper gives an overview of the advances in Earth rotation studies done on the basis of the VLBI observations. We also report on our own investigations related to this subject.

1-06 The ALMA Project *(invited)*

Massimo Tarenghi, ALMA Consortium

1-07 IVS' Contribution to the IERS Combination Pilot Project and to the ITRF2004: Status and Results

Markus Vennebusch, Geodetic Institute of the University of Bonn

The VLBI group of the Geodetic Institute of the University of Bonn (GIUB), Germany combined the individual solutions of almost 3600 VLBI sessions on the level of datum free normal equation matrices. These combined sessions form an important basis for the new ITRF2004 and for the new combination strategy within the IERS Combination Pilot Project for the combination of all geodetic space techniques (VLBI, GPS, SLR and DORIS). In this talk the status and some results of this so-called VLBI intra-technique combination will be presented to show the quality of VLBI SINEX data. The results contain comparisons of EOP series derived from IVS SINEX data as well as Helmert parameters of the combined solutions with respect to ITRF2000.

1-08 Corrections to the IERS Combination Pilot Project and to the ITRF2004: Status and Results

Jinling Li, Shanghai Astronomical Observatory, Chinese Academy of Sciences

During Chang'E-1, the Chinese lunar mission, the range and Doppler as well as VLBI observations will be used together in the satellite positioning and orbit determination. In this presentation the correction of ionosphere delay in VLBI observations of satellite is discussed. The Total Electron Content (TEC) along the ray path measured by VLBI dual-band technique and predicted by GPS observations for Seshan25–Urumqi baseline and baselines of CONT02, a two-week campaign of continuous VLBI sessions in 2002, were compared, which shows that the TEC from GPS observations could be applied to correct the VLBI observations of satellite, but there sometimes exists significant systematic difference of TEC between the two techniques. This difference could be vary between two VLBI trackings and so for each tracking of satellite the observations of extragalactic radio sources (ERS) are required in order to determine the quasi-clock corrections including this difference regardless whether the S/X dual-band observations of satellite are available or not. When the observation elevation is low this difference is much scattered, the observations of ERS nearby the tracking pass is therefore desirable, and the increase in GPS sampling rate and those observations from GPS local network are beneficial to the improvement in the prediction precision of TEC by GPS observations, especially at low elevation.

1-09 GPS Meteorology over Northeast Brazil: Perspectives

A. Costa (1,2), A. M. Pereira de Lucena (3), P. Kaufmann (4), F. Sales Ávila Cavalcante (2), F. Geraldo de Melo Pinheiro (2), F. de Assis Travares Ferreira da Silva (3), J. Bosco Verçosa Leal Jr. (2), V. de Paula Silva Filho (1,3); (1) FUNCEME, (2) UECE, (3) INPE, (4) Mackenzie University

FUNCEME, the Ceara State Foundation for Meteorology and Water Resources, UECE, the State University of Ceara, INPE, the Brazilian National Institute for Space Research and Mackenzie University are establishing a cooperative program in which the meteorological use of GPS information over Northeast Brazil is one of its components. It is well known that knowing accurately the GPS position, one may calculate the delay in the signal from the satellite to the receiver in order to estimate the integrated water vapor in the atmosphere. In fact, that information is already a by-product, available at the IGS site. In order to incorporate this information in the operational activities at FUNCEME, we proposed that calibration and validation of the GPS-based data, using surface and upper-air observations, as well as satellite retrievals.

1-10 Global VLBI Solution IGG05R01

Robert Heinkelmann (1), Johannes Böhm (1), Harald Schuh (1), Volker Tesmer (2), (1) Institute of Geodesy and Geophysics, Vienna University of Technology, (2) Deutsches Geodätisches Forschungsinstitut

At the Institute of Geodesy and Geophysics (IGG), Vienna, a global VLBI solution has been obtained using the OCCAM v. 6.1 least-squares method and the DOGS-CS software package developed at DGFI, Munich. With this effort the IVS Special Analysis Center IGG aims to contribute to future realizations of VLBI and IERS combined terrestrial and celestial reference frame products and to EOP time series. The basic properties of the global solution IGG05R01 are introduced and the products VieTRF, VieCRF, and VieEOP are compared to the established references: ITRF2000/VTRF2003, ICRF-Ext.1, and IERSC04-series. A special research task will be to investigate the influence between long term characteristics of VLBI parameters, such as station velocities and trends of the tropospheric parameters.

1-11 International VLBI Tracking of SELENE

Nobuyuki Kawano, National Astronomical Observatory of Japan

Japanese lunar explorer SELNE will be launched in 2007. The two sub-satellites, a relay satellite and a VLBI satellite, transmit S and X band carrier signals for measuring precise lunar gravity field. It is expected that Wettzell, Shanghai, Urumqi, Hobart and VERA stations take part in intensive international VLBI observations. The observation period will be 8 hours of 3 days a week in separate two months.

1-12 Spacecraft Tracking with the Chinese VLBI Network

Xiuzhong Zhang and the Chinese VLBI Network Team, Shanghai Astronomical Observatory, Chinese Academy of Sciences

VLBI system with highest resolution technique is used for astronomers to detail study the most distant objects. e-VLBI has got rapid progress in the past 4-5 years. With these characteristics, the VLBI systems are more and more used for orbiting application. The orbiting experiments and results with Chinese VLBI network will be introduced in this paper.

1-13 The First Year of VERA Geodetic Experiments

Takaaki Jike, Yoshiaki Tamura, Seiji Manabe, NAOJ VERA Group; VERA Observatory, National Astronomical Observatory of Japan

One year ago, the VERA (VLBI Exploration of Radio Astrometry) group of the National Astronomical Observatory of Japan started the semi-regular geodetic VLBI experiments. These experiments are to monitor the motion and stability of VERA network for astrometry. From more than 20 geodetic VLBI observations in one year, we produced the time series of site positions by using the software called CALC3/MSOLV and obtained long-term average positions and rates of the VERA sites. Positions of the VERA antenna are also monitored with GPS and the two results are compared.

1-14 VERA System and Recent Results

H. Kobayashi (1), S. Manabe (1), N. Kawaguchi (1), K-M. Shibata (1), Y. Tamura (1), O. Kameya (1), M. Honma (1), T. Hirota (1), H. Imai (2), T. Omodaka (2); (1) VERA Observatory, National Astronomical Observatory of Japan; (2) Department of Science, Kagoshima University

VERA is the first VLBI array, which is designed to be free from the atmosphere phase fluctuations. It has four VLBI station with 2,300 km maximum baseline length within Japan archipelago. And observing frequencies are 2, 8, 22, and 43 GHz. 22 and 43 GHz frequencies are mainly used for H2O and SiO maser objects observations, respectively. And 2 and 8 GHz bands are mainly used for geodetic observations. And VERA uses a 1Gbps recording system with cassette magnetic tapes. They are correlated by the VSOP correlator at Mitaka. VERA aims astrometry observations with 10 micro-arc-second accuracy to detect annual parallaxes for all around the galaxy. In order to achieve such high accuracy, only VLBI technique must be used with phase referencing techniques. To compensate phase fluctuations of interferometer visibilities, which are mainly caused by the atmospheric turbulences and phase drifts of local oscillators, VERA antenna has two-receiver system which makes simultaneous observations of two objects. By the comparison the visibility phase between these two objects, simultaneous phase referencing VLBI will be achieved. Usually a galactic maser object is selected as a target and a extra galactic object is selected as a reference source. At my talk, I will present the status of VERA and some results from it.

1-01P VLBI Delay Model for Radio Sources at Finite Distance

Mamoru Sekido (1), Toshio Fukushima (2); (1) National Institute of Information and Communications Technology, (2) National Astronomical Observatory Japan

A relativistic VLBI delay model for radio sources at finite distance was derived as an expansion of standard VLBI delay model (consensus model). The effect of curved wave front was taken into account up to the second order by solving the delay equation with Halley's method. The precision of the new delay model is 1 ps for all the Earth-based VLBI observations from Earth satellites to galactic objects. The VLBI observation delay in Terrestrial Time is expressed with terrestrial coordinates of observation stations and with radio source coordinates in TDB-frame. In case the radio source is farther than 10 pc away, an approximated expression of the delay model provides correction terms to adapt the consensus model for finite-distance radio sources quite easily.

Session 2: Next Generation VLBI

2-01 Achieving a Quantum Leap in Observation Density

Bill Petrachenko, Natural Resources Canada (NRCan)

It is a general rule of thumb in geodetic VLBI that performance improves as the observation density (number of scans per day) increases. An acquisition system and observing strategy will be described to increase the number of scans per day by roughly an order of magnitude. This will be achieved at a sensitivity that will allow nearly all CRF sources to be observed each day. Resulting benefits will be discussed.

2-02 A Wide-Band VLBI Digital Backend System

Alan Whitney, Shep Doeleman, Brian Fanous, Hans Hinteregger, MIT Haystack Observatory

Virtually all next-generation radio astronomy applications, including VLBI, can be enhanced by inexpensive new Digital Back-End (DBE) processors. For VLBI, one implementation of the DBE consists of:

1. High-speed analog-to-digital converter (A/D) which samples wideband analog input signals;
2. Polyphase Filter Bank processing for the desired spectral resolution and isolation of output channels.

Haystack Observatory is collaborating with the UC Berkeley Space Sciences Laboratory to develop a powerful and low-cost replacement for the current analog BBCs for both geodesy and astronomy VLBI applications. Based on a general-purpose FPGA-based signal-processing board developed at Berkeley, each board will accept up to two analog 500MHz BW IF signals, and process each into sixteen 32MHz BW channels at 2 bits/sample, for a total aggregate output rate of 4 Gbps to two VSI output connectors. We will report on the status and performance of this DBE system and possibilities for utilizing it for both geodetic and astronomy applications.

2-03 A New Lower Cost 12m Full Motion Antenna *(invited)*

Peter Shield, Mark Godwin, InterTronic Solutions, Patriot Antenna Systems Inc.

A new lower cost 12m Ka band antenna and pedestal together with a novel high accuracy control system has been designed and delivered to NASA JPL for the DSN array. This new antenna was designed and manufactured by Patriot Antenna

Systems to suit their higher volume manufacturing techniques and has taken advantage of the latest mechanical structures and control loop components available to achieve cost targets for larger Ka band antennas never seen before. The surface accuracy of this new design is 0.012 inches RMS including temperature and wind effects and its control system is capable of 0.005 degree RMS absolute pointing accuracy (Spatial coordinates) using fast response position and speed control loops. The control system uses only economical, standard commercial modules and provides a wide speed range - repositioning to anywhere on sky within 2 minutes and with tracking at speeds down to much less than 1 millidegree/sec. Corrections for axes misalignments are built into the controller and a choice of interfaces allows antennas in an array to be nodes on a LAN such that a controlling computer can broadcast common instructions to all antennas. Each antenna can store track data to execute at scheduled times and has facilities for initial pointing calibration and calibration monitoring. This antenna is suitable for deep space communications, radio astronomy, conventional GEO and even LEO satellite communications. Several options are available for the drive system mechanics including conventional gear drives in both axes as well as more economical precision jack screw elevation drives.

2-04 Uses of the ICRF and Implications for Future VLBI

Chopo Ma, Goddard Space Flight Center

Since its inception on 1 Jan 1998, the fundamental ICRF has been set by the VLBI positions of 212 “defining” extragalactic radio sources. In all there are ~3000 sources with usefully accurate (< few mas) positions consistent with the ICRF. The uses of the ICRF include fundamental astrometry, monitoring of Earth orientation, and spacecraft navigation. For fundamental astrometry, stability and accuracy are most important, and realizations at different frequencies must be in proper registration. However, there is no preferred frequency, and the GAIA mission has the potential for an optical ICRF with 500,000 objects at the 50 microarcsec level some time after the planned 2011 launch. The radio ICRF should be properly prepared for a transition to assure long-term stability and consistency. Earth orientation monitoring requires objects attached to the solid Earth, and VLBI will continue to be the fundamental technique. For this purpose it is essential that the new VLBI stations contemplated in the VLBI2010 report be capable of observing a sufficiently large and well-distributed set of stable sources, and identifying these sources is an on-going effort. Spacecraft navigation by differential VLBI is planned using the Ka-band telemetry signal, and work has begun towards an ICRF realization suitable for this purpose. The balancing of different needs related to the VLBI ICRF will be discussed.

2-05 Softc + Beowulf – JPL’s Newest Correlator

Stephen Lowe, Jet Propulsion Laboratory

Softc, JPL's software correlator which has been operational for over 4 years, has now been ported to a Beowulf cluster. System performance and speed-limitations will be discussed, and future applications will be presented.

2-06 Real Time Correlator in FPGA

Zhijun Xu, Xiuzhong Zhang, Shanghai Astronomical Observatory, Chinese Academy of Sciences

A real time correlator using FPGA technology has been developed in China for the purpose of the e-VLBI development in Chinese VLBI Network (CVN). The system diagram will be described and some test results will be given in the report.

2-07 Simulations for VLBI 2010

Jörg Wresnik, Johannes Böhm, Harald Schuh, Institute of Geodesy and Geophysics, Vienna University of Technology

There has been a lot of discussion in recent years how VLBI could exploit its present resources more efficiently and how future VLBI networks should look like. In October 2003 the International VLBI Service for Geodesy and Astrometry (IVS) installed Working Group 3 (WG3) "VLBI 2010" to examine current and future requirements for geodetic VLBI systems. There is a clear demand by the "sub-group on observing strategies" of WG3 that thorough and systematic simulation studies should be carried out. At the IGG, Vienna different simulations will be done to propose new observing strategies and schedules, to improve troposphere and clock modeling, to find the best antenna configuration and to optimize the network geometry. The simulation studies will be realized by a sequence of three software programs. After scheduling the observations with SKED, the artificial observations are transformed to NGS format. These files are the input for the VLBI analysis software package OCCAM, which will be adapted for the simulations. The covariance and correlation matrices from OCCAM will be available in SINEX format and will be the input for a Matlab program called VV-SIM (Vienna VLBI-Simulation), which allows the interpretation of the results with distinct numbers and figures to deliver objective criteria for comparison.

2-08 Singular Value Decomposition – A Tool for VLBI Simulations

Markus Vennebusch, Geodetic Institute of the University of Bonn

Usually VLBI observations are adjusted by least-squares approaches like the Gauss-Markoff model with the use of normal equations. It is well known that parameter estimation methods based on this strategy show some numerical disadvantages. A new approach makes use of a more stable least squares algorithm, called singular value decomposition (SVD) and provides interesting insight into the composition of the estimated parameters and shows the impact of particular observations on the parameters. For a few VLBI sessions the results of the new method will be presented and the suitability of the SVD approach for simulations and for the improvement of VLBI schedules will be shown.

2-01P Carbon Fibre Antennas for Geodetic VLBI

Peter Dewdney (1), Gordon Lacey (1), Bill Petrachenko (2); (1) National Research Council of Canada (NRC), (2) Natural Resources Canada (NRCan)

Carbon fibre is an ideal material for geodetic VLBI antennas. It has a coefficient of thermal expansion approximately an order of magnitude lower than that of steel and is extremely stiff per unit weight. For moderate size antenna structures (for example the 12m antennas proposed in the VLBI2010 report), annual thermal signatures will be very small and tilts due to differential solar irratiation negligible. In addition, a light stiff reflector will enable the design of antennas with insignificant gravitational deflection, and allow positioners to be envisioned that can cross the sky in a matter of seconds. Initial estimates indicate that moderate size carbon fibre antenna structures can be fabricated at costs that are competitive given the performance advantages.

2-02P Network Size Simulations

Anthony Searle, Mario Berube, Bill Petrachenko; Geodetic Survey Division, Natural Resources Canada

A series of SKED/SOLVE simulations investigates the potential size and configuration of a fictitious network of identical stations characteristic of the recomendations of the VLBI2010 report. Standard observing strategies and bandwidths are applied.

Session 3: Network Stations, Operation Centers, Correlators

3-01 A New 40-m Radio Telescope in Yebes (Spain) for Geodetic VLBI Studies by IGN *(invited)*

Jesús Gómez-González, Francisco Colomer, Alberto Barcia, José Antonio López-Fernández, Instituto Geográfico Nacional (IGN) of Spain

The construction of a new 40-m parabolic radiotelescope in Yebes, near Madrid (Spain) is being finalized. The instrument, built by the Spanish Instituto Geográfico Nacional (Ministerio de Fomento) will soon operate at frequencies between 2 and 115 GHz, and will become a key partner for both the astronomical (in European and global projects) and the geodetic VLBI communities (through IVS). During the last decade, IGN has colaborated in the EUROPE and CORE campaigns with the 14-m radiotelescope. The staff is acquainted with the concepts, observing procedures and instrumentation involved. New infrastructures are being constructed in Yebes, such as a high speed fiber optic link to GEANT, and a new building to hold a gravimeter system, in order to enable the station to become a Fundamental Geodetic Station soon. Scientific projects in Geodesy and Astrometry is also being conducted by IGN scientists.

3-02 K5/VSSP Data Processing System of Small Cluster Computing at Tsukuba VLBI Correlator *(invited)*

Morito Machida, Masayoshi Ishimoto, Kazuhiro Takashima, Tetsuro Kondo, Yasuhiro Koyama, Geographical Survey Institute, National Institute of Information and Communications Technology (NICT)

A software correlation system at Tsukuba VLBI Correlator of GSI is currently in process of upgrading its architecture with using K5/VSSP which is PC-based correlation system for geodetic VLBI developed by NICT. Performing K5/VSSP correlation is firstly based on a set of NICT's kernel programs which covers calculating apriori delay(apri_calc), correlation processing(cor, sdelay) and bandwidth syntdesis(komb). As an initial step, we introduced hardware consisting of one management computer, 24 data servers and eight rack mount correlation servers with 3GHz Intel Xeon dual CPUs. The second step of upgrading K5/VSSP correlation system is building intelligent application (PARNASSUS) with graphical user interface to aid operating K5/VSSP kernel programs. K5/VSSP enables us cluster computing for distributed correlation since it provides us with data store in Unix files for every four channels per scan. PARNASSUS is able to optimize operator's input into kernel program and comprehensively handle distributed correlation. As for GSI, there has been increase of demand for domestic session and intensive session in a few years. It means Tsukuba VLBI Correlator should meet greater number of data to process. However routine run of K5/VSSP correlator which is being operated in the small cluster computing does not take extra operational time for data processing so far in spite of increased number of session. Hot debate involving new-fasioned VLBI technology has been developed in IVS and its community. To the stations and correlators, some kind of active system development has been proposed from laboratories across the world. GSI leaves for K5/VSSP.

3-03 Remote Control of VLBI Operations

Gonzalo Remedi, Sergio Sobarzo, Cristobal Jara, Roberto Aedo, Carlos Verdugo, Hayo Hase, UBB, UdeC, BKG

The Geodetic Observatory TIGO developed an easy-to-use software which enables remote control and monitoring of VLBI operations. This software is a Java-applet and can be executed from any web browser. Several tests have been successful. The remote control operation of VLBI opens new observation strategies involving more observation without additional staff by making use of different time zones.

3-04 National Geodetic VLBI Plan in Korea

Tuhwan Kim (1), Tetsuo Sasao (1,2), Younghee Kwak (1), Kidok An (3), Wonkuk Lee (3), Jongwan Kim (3); (1) Ajou University, (2) Korea Astronomy & Space Science Institute, (3) National Geographic Information Institute

A project of constructing the first geodetic VLBI system in Korea is in progress by National Geographic Information Institute (NGII). The primary purpose for this antenna will be to participate in the IVS international geodetic VLBI observations, and to maintain the Korean geodetic origin precisely defined in the world geodetic frame, ITRF. However, since there was no former research or project about geodetic VLBI in Korea, a new R&D is necessary on the fundamental design of the VLBI system. In this presentation, a preliminary study on the necessity of geodetic VLBI in Korea and basic specifications for a core station of geodetic VLBI will be presented together with the possibility of producing VLBI antenna in Korea.

3-05 Radio Astronomy and VLBI Developments in Brazil

Pierre Kaufmann, Mackenzie Presbyterian University

The first radio astronomy developments in Brazil began as early as 1958. Nearly all accomplishments were obtained with direct or indirect participation of the Center for Radio Astronomy and Astrophysics-CRAAM of Mackenzie Presbyterian

University from Sao Paulo, later in association with the National Space Research Institute (INPE) since 1977. The first VLBI efforts were carried out at Itapetinga Radio Observatory, near Sao Paulo, in the seventies. The participation into geodetic-VLBI began nearly 16 years ago, with the installation of the Eusebio station near Fortaleza, Cear· State in the NE of Brazil, by CRAAM in association with several Brazilian institutes (Mackenzie, USP, Unicamp, INPE) in international cooperation (NOAA, NASA, USNO, IfAG-BKG), which progresses, problems and prospects are described.

3-06 Footprint Observations at the Fundamental Station Wettzell

Wolfgang Schlüter, Thomas Klügel, Christian Schade, Bundesamt für Kartographie und Geodäsie (BKG)

Footprint observations are performed in order to document the local, geological stability in the vicinity of a geodetic observatory. Beside local ties observations, which cover usually the observatory area of some 100 meters, some geodetic footprint markers should be established up to 10 to 50 km separate from the observatory and included in the geodetic survey to monitor local movements. 7-30 km apart from the Fundamental Station Wettzell four footprint points are established, which are permanently observed with GPS. For a period of four years observations are available from the four sites and analysed together with GPS observations taken at the observatory from those GPS-markes which are integrated in the International Networks as IGS, EUREF and GREF. With respect to the geodetic marker in Wettzell as fixed point, the observations are evaluated and day to day coordinates are generated employing the Bernese Software. The time series show a precision in the order of a few Millimeters. Moreover systematic and seasonal effects can be seen. The paper gives information about the footprint and local network, the analysis strategies and the results for a period of more than four years.

3-07 Bonn Correlator Report for Astronomy and Geodesy

Arno Müskens, Walter Alef, Dave Graham, Geodetic Institute of the University of Bonn, Max-Planck-Institute for Radioastronomy

A report of the present status, capabilities and usage of the MK IV VLBI correlator in Bonn is given. Status and plans concerning Mark 5 at correlator side are discussed as well as an overview of the processing efficiency and throughput for astronomy and geodesy.

3-08 Washington Correlator Report

Kerry Kingham, U.S. Naval Observatory

In the last two years, several important changes have occured with respect to processing at the Washington Correlator. First, the conversion to Mark 5 recordings has been completed. Second, the intensive observations from Wettzell are being transferred by eVLBI. Finally, unattended operation has been instituted at night and on weekends. The implications of these changes, plus future plans for the Correlator Facility will be presented. The month of January, 2006 marks the completion of 20 years of operations at Washington Correlator.

3-09 Network Coordinator Report

Ed Himwich, NVI Inc./GSFC

This report will include an assessment of the network performance in terms of the yield of usable data over the preceeding 12-month period. Significant improvements in the handling of correlator clock adjustments have been made in the last year. The new situation will be reviewed.

3-10 First Fringes to New Zealand

Sergei Gulyaev, Auckland University of Technology

Efforts to build a radio astronomy capability in New Zealand took a big step forward with the first successful VLBI experiment between New Zealand and Australia. The 1.6 GHz observation of PKS 1921-293 took place in late July, between a 6 m telescope in New Zealand and the Australia Telescope Compact Array (ATCA), with the data being correlated on the Swinburne University of Technology's supercomputer. This result follows 6 months of intense development and testing of the systems with the support of a number of institutions, led by the Auckland University of Technology, the Swinburne University of Technology, and the CSIRO Australia Telescope National Facility. Plans for the future development of New Zealand VLBI, as well as the reasons for New Zealand involvement in the IVS will be critically discussed.

3-01P Antenna Cross-Polarization Characteristics at Geodetic VLBI Stations

Brian Corey, Michael Titus; MIT Haystack Observatory

A major source of instrumental error in geodetic VLBI is the cross-polarization response of the nominally right-circularly-polarized (RCP) antenna feeds. Many geodetic antennas have cross-polarized responses (LCP) only 15-20 dB below RCP; the corresponding multi-band delay instrumental error, which depends on the parallactic angle difference between feeds and on the frequency dependence of the LCP responses, can be in the range 5-10 ps. In order to measure the polarization performance of a large set of geodetic VLBI antennas, an R&D session involving six VLBA stations observing both polarizations at S and X was carried out on 1996 July 22-23. The first 10 hours of the schedule was designed to allow the instrumental polarization responses of the antennas to be determined. For the remainder of the session, the six antennas tagged along with the concurrent NAPS-2 and GTRF-11 sessions. The polarization characteristics of the VLBA and non-VLBA antennas estimated from the fringe amplitudes in these three sessions will be presented.

3-02P An Investigation on a GPS-based Approach to Local Tie Computation

Claudio Abbondanza (1), Monia Negusini (2), Pierguido Sarti (2), Luca Vittuari (1); (1) DISTART - Università di Bologna, Italy (2) Istituto di Radioastronomia - INAF - Bologna, Italy

A few comprehensive methods based on terrestrial measurements have proved to be effective for computing local ties, estimating eccentricity vectors between different geodetic instruments and for generating related SINEX files. These methods have been intercompared, tested on different eccentricities and their geometrical principles have proved to be reliable on both simulated and real data sets. One of the open issues of local ties remains the alignment of the topocentric frame into ITRF. We investigate the possibility of performing purely GPS-based local ties using the Medicina 2001 and 2002 GPS measurements for estimating the eccentricity between the GPS and VLBI instruments. Results will be compared with the "classically" derived analogous eccentricities.

3-03P GPS Measurements on the VLBI Telescopes at Onsala and Ny Ålesund

Daniel Hernandez, Rüdiger Haas; Chalmers University of Technology, Onsala Space Observatory

During the last years, the VLBI radiotelescopes at Onsala and Ny Ålesund were periodically equipped with GPS antennas and corresponding receivers. The purpose of the GPS-measurements was to perform local-tie studies. The data were mainly observed when the telescopes were pointed to the local zenith directions. However, at Onsala some data were also obtained when the telescope was pointed to different directions according to a predefined schedule. We present the results of our GPS data analyses and compare them to other local tie information at these two IVS sites.

3-04P Photogrammetry, Laser Scanning, Holography and Terrestrial Surveying of the Noto VLBI Dish

Pietro Bolli (1), Simonetta Montaguti (1), Monia Negusini (1), Pierguido Sarti (1), Luca Vittuari (2), Gianluigi Deiana (3); (1) Istituto di Radioastronomia - INAF - Bologna, Italy (2) DISTART - Università di Bologna, Italy (3) Osservatorio Astronomico di Cagliari - INAF, Italy

In early Autumn 2005 both Medicina and Noto antennas were surveyed with the purpose of measuring the eccentricity vector between the co-located VLBI and GPS instruments. The surveys were performed following the well-established procedure successfully applied earlier to both radio telescopes. Along with the usual terrestrial measurements performed for local tie purposes, laser scanning observations were performed on both telescopes. In particular, the internal parts of the dishes were laser scanned at seven different elevations. In earlier years, the surface of the Noto dish had also been measured using photogrammetry and through ad hoc holographic campaigns. The measurements collected applying these different approaches now form a comprehensive set of information that can be carefully handled and combined for recovering and validating relative and absolute gravitational deformations of the antenna. We describe in detail the terrestrial and laser scanning surveys performed in 2005 and describe the different data sets collected in Noto and currently available for combination.

3-05P Observation Activities at the Tsukuba Station

Junichi Fujisaku, Kensuke Kokado, Masayoshi Ishimoto, Kazuhiro Takashima and Yoshihiro Fukuzaki; Geographical Survey Institute

This presentation gives an overview of the observation activities at the Tsukuba 32-m VLBI station by the Geographical Survey Institute (GSI) VLBI group. In

2005, the station had 34 international, 12 domestic, 90 intensive UT1 and the CONT05 sessions. All of the sessions since June 2005 except RDV sessions were carried out using K5 sampling/recording system with Internet data transfer in association with MIT Haystack Observatory.

3-06P Status and Results of JARE Syowa Station, Antarctica

Yoshihiro Fukuzaki (1), Kazuo Shibuya (2), Koichiro Doi (2); (1) Geographical Survey Institute, (2) National Institute of Polar Research

The Japanese Antarctic Research Expedition (JARE) started regular VLBI experiments at Syowa Station (69.0 deg S and 39.6 deg E) on East Ongul Island, Antarctica in 1998. This experiment was called 'Syowa VLBI experiment' or 'SYW session.' Three stations in the southern hemisphere, Syowa, Hobart (Australia) and HartRAO (South Africa), have participated in this session. Meanwhile, Syowa Station has participated in 'OHIG session' since 1999. This was the first VLBI observation with the intra-Antarctic plate baseline. SYW session ended in December 2004 and Syowa Station started to participate in CRF deep-south (CRDS) session in addition to OHIG since 2005. K5 recording system was introduced in 2004 and fully replaced K4 with in 2005 at Syowa Station. Until the end of 2005, Syowa Station has performed 65 sessions, and 40 sessions from May 1999 to December 2004 have been reduced and analyzed using CALC/SOLVE. The results show that the length of the Syowa-Hobart baseline is increasing linearly with a rate of 54.8 +- 0.9 mm/yr. The Syowa-HartRAO baseline is also increasing, but at the lower rate of 11.1 +- 0.8 mm/yr. These results approximately agree with those of GPS and NNR-Nuvel1A plate motion model. On the other hand, we cannot find obvious change with the Syowa-O'Higgins baseline. Current status of Syowa Station and the results of the analysis are briefly reported.

3-07P Onsala Space Observatory - Station Report

Rüdiger Haas, Chalmers University of Technology, Onsala Space Observatory

The poster will give a short report on the current status of the IVS station Onsala Space Observatory. The geodetic VLBI activities at Onsala will be presented, including the eVLBI efforts. Upgrade work at the 20 m telescope and the microwave radiometers will be summarized.

3-08P Noto Station Status Report

Gaetano Nicotra, Gino Tuccari, Salvatore Buttaccio, Pietro Cassaro, Corrado Contavalle, Leonardo Nicotra, Carlo Nocita, Luigi Papaleo, Mario Paternò, Francesco Schillirò; Istituto di Radioastronomia - INAF (Italy)

Noto station presented several important problems in 2005, obliging the antenna to remain not operative for more than six months. A report is given about the hardware faults that have been met and a description of the plan for taking the station back to optimal operative behaviours.

Session 4: New Technology Developments in VLBI

4-01 DBBC – A Flexible Platform for VLBI Data Processing

Gino Tuccari (1), Salvatore Buttaccio (1), Gaetano Nicotra (1), Ying Xiang (2), Michael Wunderlich (3); (1) IRA/INAF, (2) SHAO/CAS, (3) MPI-Bonn

The development of the first version of DBBC is complete and an extended testing phase is expected in 2006. The instrument is a flexible environment where today a complete analog VLBI pre-recording terminal is realized in digital technology, but having the chance to process data in a different fashion for multiple or very wide band channels without changing any hardware part. A description of this instrument is shown, reporting on the performance with the present implementation, and pointing out the potentiality for a different implementation within the same hardware. Moreover a description of the second version is given with some details on new hardware parts for additional functionalities, such as RFI mitigation, AD sampling in the receiver site.

4-02 FPGA Implementation in DBBC

Ying Xiang (1), Gino Tuccari (2), Wenren Wei (1); (1) Shanghai Astronomical Observatory (CAS), (2) National Astrophysical Institute (IRA)

As one of the main equipments for VLBI station, VLBI data acquisition rack takes on the tasks of frequency selection, data collection, data encoding, data recording and etc. As the main part of this equipment, Analog Base-Band Converter (Analog BBC) has very complex analog circuits who is poor reliability and very expensive. This paper mainly describes to use the digital integrated circuits (FPGAs) to realize corresponding algorithm called Digital Base-band Converter (DBBC) to take place of the analog BBC.

4-03 e-VLBI Developments with the K5 VLBI System

Yasuhiro Koyama, Tetsuro Kondo, Moritaka Kimura, Hiroshi Takeuchi, Masaki Hirabaru, National Institute of Information and Communications Technology (NICT)

The K5 VLBI system has been developed at Kashima Space Research Center of National Institute of Information and Communications Technology. The concept of the K5 VLBI system is to realize real-time VLBI observations and correlation processing under the various observing modes by combining multiple components in a flexible manner. The system is also intended to be VSI-H compliant by using the VSI-H PCI interface card and VSI-E compliant by developing a set of software programs work with the vtp (VLBI Transfer Protocol) libraries developed at Haystack Observatory. The current status of the K5 VLBI system's developments and the recent achievements for e-VLBI by using the K5 VLBI system will be reported.

4-04 The Development of the Streamlined Correlation Software Using Bitset Class Library

Fujinobu Takahashi (1), Kazuki Yanashima (1), Yuji Yoshida (1), Tetsuro Kondo (2); (1) Yokohama National University (YNU), (2) National Institute of Information and Communications Technology

Yokohama National University (YNU) starts the development of the software using bitset class library. VLBI or space geodetic raw data are typical example bit-streams from space. The library for dynamic bitsets is developed with C++ language. Originally it has been developed for the research of mathematical theory of sets. The boost C++ class library is usually installed with GCC in the recent Linux distributions by default. Using the library, we can construct and destruct any length of bit-stream objects dynamically in the possible heap memory space. We can use various bitfield member functions or operations such as bit shift, correlation or bit counting necessary for VLBI data processing. We can flexibly connect, append and cut any bitset and also insert or extract any bit at any bit allocation point. Bitset class library now gives us the possibility to realize more streamline VLBI or space geodetic software using low cost super PCs. We will report the preliminary result of XF type correlation software using dynamic bitsets.

4-05 Development of a New VLBI Sampler Unit (K5/VSSP32) Equipped with a USB 2.0 Interface

Tetsuro Kondo, Yasuhiro Koyama, Hiroshi Takeuchi, Moritaka Kimura; Kashima Space Research Center/NICT

National Institute of Information and Communications Technology (NICT) has been developing a new VLBI sampler unit named K5/VSSP32 dedicated to e-VLBI which is a successor to the K5/VSSP. The maximum sampling frequency per channel of the K5/VSSP32 is 32 MHz, which is twice that of K5/VSSP. When the number of quantization bit is limited to one, the sampling frequency of 64MHz is possible. In addition to the maximum sampling frequency, there is a difference in the interface to a host PC. A USB 2.0 (Universal Serial Bus specification revision 2.0) interface is used to connect the sampler with a host PC in the K5/VSSP32, while a PCI-bus interface is in the K5/VSSP. It is hence possible to use even a notebook PC for VLBI observations with the K5/VSSP32. We will report the results of some test observations using K5/VSSP32 at the meeting.

4-06 VSI Interfaces for Legacy Systems

Dan Smythe, MIT Haystack Observatory

The upgrade of a Mark 5A Data Transport System (DTS) to Mark 5B requires more than simply upgrading the Mark 5A system to Mark 5B. Since the Mark 5A system was designed as a plug-in replacement for a Mark IV or VLBA tape recorder, the station or correlator interfaces to the tape recorder DTS must be converted to the VSI, the VLBI Standard Interface. To that end, a set of interface boards has been designed to interface Mark IV or VLBA samplers to the VSI input of a Mark 5B Data Input Module, and to interface the Mark 5B Data Output Module to a Mark IV correlator. This paper will describe the details of these interface devices.

4-07 Integration of the Mark 5B Playback System into the Mark IV Correlator

Roger Cappallo, MIT Haystack Observatory

The Mark 5B I/O boards, along with a few supporting modules, will bring a number of new capabilities to the Mark IV correlator. With this upgrade we will also be able to eliminate many of the problems associated with the Mark IV station unit. We will discuss the Mark 5B features, update the status of implementation of both correlator hardware and software, and present a brief look into our future plans for maximizing the effective usage of the Mark 5B.

4-08 The Mark 5B VLBI Data System

Alan Whitney, MIT Haystack Observatory

Development of the Mark 5B VLBI data system has now been completed at MIT Haystack Observatory. Mark 5B is based on the same physical platform, uses the same disk-modules as the Mark 5A, and supports the same maximum data rate of 1024 Mbps. However, the Mark 5B incorporates a VSI standard interface and command set. Full phase-calibration processing and state counting are included on both record and playback. Existing Mark IV and VLBA systems can be modified to provide a VSI interface to the Mark 5B system. For existing Mark IV systems, the Mark 5B will allow connection of all 14 BBC's to two Mark 5B's for a total aggregate data rate of 1792 Mbps. In addition, the Mark 5B is being designed to support all critical functionality of the Mark IV Station Unit, so that the Mark 5B may connect to the Mark IV correlator through a simple interface. Mark 5B systems are expected to be available from Conduant Corp in early 2006.

4-09 e-VLBI Development Program at Haystack Observatory

Alan Whitney, Chet Rusczcyk, MIT Haystack Observatory

e-VLBI development at Haystack Observatory continues on several fronts.

1. Mark 5 development: Testing continues with modern motherboards to achieve a full 1024 Mbps with e-VLBI. Up to ~1200 Mbps has been achieved in back-to-back Mark 5 transfers, but this rate has not yet been realized over real networks.
2. Experiment-Guided Adaptive Endpoint: EGAE software is now operational for near-real-time transfers from Japan to Haystack; development is continuing.
3. Optical path switching: In collaboration with the DRAGON project led by the Univ of Maryland, Haystack Observatory is participating in the development of on-demand optically switched network connections. As part of this work, we hope to soon upgrade Haystackís network connection from 2.4Gbps to 10Gbps.
4. Routine e-VLBI experiments: Operational near-real-time e-VLBI data transfers from Tsukuba and Wettzell to Haystack are now taking place on a regular basis. Tsukuba data are recorded on K5, transferred to Haystack, then converted to Mark 5A format. VSI-E is undergoing testing
5. e-VLBI test experiments: Real-time experiments with no disk buffering have been conducted at 512 Mbps both nationally and globally.

4-01P e-VLBI Demonstrates Real-time Correlation Using Both K5 and Mark 5 End Systems

Chester Ruszczyk (1), Yasuhiro Koyama (2), Alan Whitney (1); (1) MIT Haystack Observatory, (2) Kashima Space Research Center/NICT

In e-VLBI the VSI-E specification defines a common communication format and protocol, at the transport layer, between data systems to support the real-time transfer of data. It is transport layer independent, meaning that TCP or UDP or variants there of, can be used to meet the needs of an end-to-end system with varying network characteristics. These characteristics can be based on intermediate nodes supporting jumbo frames (up to 9000 byte packets), error rates, dedicated paths set up between end systems and varying round trip times. In this presentation the viability of having a common communication mechanism will be presented along with the results of the SuperComputing 2005 demonstration. The demonstration connected K5 and Mark5 end systems streaming real-time data to Haystack where it was correlated in real-time. The stations that participated were Kashima (Kb), Onsala (On), GGAO (Gg), Westford (Wf), Westerbork, and Jodrell Bank. VSI-E, using UDP, was used to interconnect the K5 end system to Haystack's Mark5. TCP, with jumbo frame support, was utilized as the transport protocol between Mark5's. This presentation will also concentrate on the end-to-end considerations in designing the demo. These considerations include data format, network configuration and network characteristics.

4-02P e-NRTV - Radar VLBI Network

Gino Tuccari (1), Igor Molotov (2), Alexander Volvach (3); (1) Istituto di Radioastronomia INAF (Italy), (2) Central Pulkovo Astronomical Observatory (Russia), (3) Institute of Radio Astronomy (Ukraine)

The Near Real Time Radar VLBI Network LFVN is progressively increasing its performance and processing structures. Dedicated acquisition and recording NRTV terminals are placed in Bear Lakes (Russia), Noto (Italy), Simeiz (Ukraine), Evpatoria (Ukraine), Urumqi (China). A new entirely digital terminal has been developed for such network, and two units will be placed during 2006 in two radiotelescopes. A collaboration program is in development with the European Space Operations Center and the Ballistic Center of the Keldysh Institute of Applied Mathematics, and two VLBI sessions were carried out in 2005. First experiment was in September for VLBI radar research of the small space debris fragments, second experiment was in October for differential VLBI measurements of the Mars-Express interplanetary spacecraft position. A new dedicated software correlator is under development for a distributed correlation process. The more recent scientific results are reported. The VLBI fringes were received and fringe rates were measured for radar echo-signals of Moon, Venus and space debris objects on baselines Noto-Bear Lakes-Simeiz-Urumqi.

4-03P An Evaluation of Atmospheric Path Delay Correction in Differential VLBI Experiments for Spacecraft Tracking

Ryuichi Ichikawa, Mamoru Sekido, Yasuhiro Koyama, Tetsuro Kondo; Kashima Space Research Center, NICT

Two HAYABUSA differential VLBI experiments were carried out in October 2004 in order to evaluate reducing propagation delays. The HAYABUSA spacecraft and an angularly nearby quasar "2126-158" were observed

sequentially, not simultaneously, during each period with various time intervals of data acquisition. The maximum angular separations of the spacecraft from the quasar are less than 3 degrees. We estimated the zenith path delay due to the water vapor (ZWD: Zenith Wet Delay) using the data sets of the GPS stations that are adjacent to each VLBI antenna. A principle observable feature of VLBI is the difference in arrival times of radio signals between two stations. Then, we calculated difference between the slant path delays which are values as a ZWDs at each station multiplied by a mapping function. We defined this "differential wet delay" and investigated the magnitude of the delays. If the angular separation is sufficiently small, the differential wet delays for both radio sources are almost equal. Then, these are canceled out by the difference procedure. On the other hand, if these are different, the differences between them are added directly to the observables as an error source. According to our analysis, a large difference value of up to 10 cm of the differential wet delay for the Kashima-Uchinoura baseline was estimated in spite of a small separation angle between the HAYABUSA spacecraft and quasar. Such large value was mainly caused by the humid condition around Uchinoura due to the typhoon approaching. Moreover, the east-west direction of the baseline vector and the large difference in elevation angle of radio source between both stations helped to enlarge the difference value.

4-04P A 2 Gbps DAS for Spacecraft VLBI

Hiroshi Takeuchi, Moritaka Kimura, Junichi Nakajima; NICT

A VSI-compliant data acquisition system (DAS) whose sampling rate is 2048 Mbps has developed. It has two VSI-H output ports and each operates at a clock frequency of 32 MHz or 64 MHz. Thus maximum output rate reaches 4096 Mbps. In the DAS, digitalized data with a 2 Gbps, 8-bit A/D converter are sent to an FPGA device (Xilinx XC2VP40) to be decimated. The output rate is selectable from 2Gbps/2bit, 1Gbps/4bit, 512Mbps/8bit, 256Mbps/8bit and 128Mbps/8bit. The FPGA code is easily rewritable with a compact flash card so that it can be used for multiple applications such as digital baseband converter for multi-channel geodetic VLBI, software demodulator for spacecraft downlink signal in spacecraft VLBI, or spectrometer for broadband astronomical observations. The specifications of the DAS and first experimental results are described in detail.

4-05P The Post-Correlation Processing of VLBI Satellite Observations at SHAO

Guangli Wang, Shanghai Astronomical Observatory, Chinese Academy of Sciences

Session 5: Software and Analysis Strategies

5-01 Impact of Different Tropospheric Mapping Functions on the TRF, CRF, and Position Time Series Estimated from VLBI *(invited)*

Volker Tesmer (1), Johannes Böhm (2), Robert Heinkelmann (2), Harald Schuh (2); (1) Deutsches Geodätisches Forschungsinstitut (DGFI), (2) Institute of Geodesy and Geophysics, Vienna University of Technology

It is a well-known fact that the impact of the troposphere on microwave measurements such as VLBI and GPS is difficult to predict and to estimate sufficiently detailed. It has been shown many times that different mapping functions significantly influence almost the whole set of parameters estimated in geodetic solutions, mostly even systematically. This is also the case for the tilting of the troposphere and azimuthal dependency described by gradients. As the geodetic community aims to overcome systematic differences between various solutions, this presentation compares estimated TRF, CRF and position time series w.r.t. systematic differences, scale, annual signals as well as repeatability. All solutions are computed at DGFI using the OCCAM6.1 and DOGS-CS software and VLBI data from 1984 till 2005. They solely differ in the mapping functions: NMF (Niell) and the recently developed GMF (Global) consist of easy to handle stand-alone formulae whereas the IMF (Isobaric) and VMF (Vienna) are determined from numerical weather models.

5-02 Interaction of Atmosphere Modeling and Analysis Strategy

Arthur Niell, MIT Haystack Observatory

Estimates of the height component of station position are sensitive to the minimum elevation of observations included in the analysis, which is usually a global parameter that applies to all antennas. Although for GPS both the mean value and the scatter are affected by the choice, for VLBI it is primarily the scatter. Two effects are strongly elevation dependent and compete in determining what minimum elevation should be adopted: the formal uncertainty of the height estimate, and uncertainties from the atmosphere delay model. The sky coverage of a VLBI antenna depends on the type of mount (az/el, ha/dec, or XY, and on the limits in each axis, but in general the lower the elevation that can be observed, the smaller the uncertainty in the UP component. On the other hand, the error due to the inadequacy of the atmosphere mapping function increases as the minimum elevation goes lower. In general, the smaller the geometric uncertainty of the UP component, the higher the minimum elevation can be before it is dominated by the atmosphere uncertainty. Comparisons will be presented of the magnitudes and characteristics of these effects, including recent advances in atmosphere mapping functions, that might help to address the following questions: (1) Which mapping function should be used?

5-03 Comparison of Wet Path Delays Observed with WVR, Sun Spectrometer, Radiosondes, GPS and VLBI at Wettzell

Wolfgang Schlüter (1); Walter Schwarz (1); Beat Bürki (2); Alexander Somieski (2); Petra Häfele (3); (1) Fundamentalstation Wettzell, (2) Eidgenössische Technische Hochschule Zürich/CH, (3) Universität der Bundeswehr, München

The water vapour in the atmosphere contributes significantly to the tropospheric refraction. Geodetic observations, in particular observations in the microwave domain as GPS and VLBI are suffering from the inhomogenous distribution. Even if the analysis models care for the influence it seems still to be of interest to observe independently the water vapour and its influence to the observations with Water Vapour Radiometers. In April 2005, five water Vapour Radiometers and one sun spectrometer were collocated at the Fundamental Station Wettzell in order to investigate the resolution of the wet path delay results observed with radiometers in terms of precision and systematic effects. Sun spectrometers allow the determination of the wet path delays only during daytime, in particular during sunshine. Such observations provide independently precise results which can be used for calibration of radiometers. In addition during a 7 days period, balloons radio sondes were launched, at noon and midnight each day, measuring temperature, pressure and humidity profiles up to 25 km in height. This allows estimating the zenith path delay for the launch times. As the zenith path delays were also derived from GPS and VLBI observations a set of interesting observations is available for comparisons. This paper describes the collocation experiment and compares the results of the various techniques.

5-04 Linear Horizontal Gradients of Refractivity vs. 3D Raytracing

Johannes Böhm, Harald Schuh, Institute of Geodesy and Geophysics, Vienna University of Technology

Davis et al. (1993) developed a gradient model for the 'wet' radio refractivity of air which is based on the assumption of linear horizontal gradients of refractivity above the sites. Thus, taking the wet refractivity gradients for the vertical profile above the VLBI or GPS station from a numerical weather model, the corresponding north and east gradients can be determined without using information about the atmosphere at the line-of-sight. This approach can also be applied to hydrostatic gradients. On the other hand, Böhm and Schuh (2005) introduced the Vienna Mapping Functions 2 (VMF2), which are azimuth-dependent mapping functions based on 3D raytracing. Both concepts agree very well for CONT02 using data from the ECMWF, but the approach of linear horizontal gradients can much easier be implemented on a regular basis for all VLBI and GPS stations. Both concepts are compared for the continuous VLBI campaigns in 2002 and 2005, and the effect on coordinate time series and baseline lengths is investigated.

5-05 A Comparison of R1 and R4 IVS Networks

Sebastien Lambert (1), Anne-Marie Gontier (2); (1) Royal Observatory of Belgium, (2) Paris Observatory

This study compares the two parallel 24-hour R1 and R4 networks run by the IVS since 2002. We investigate the possible influence of the network geometry as well as the consistencies between Earth orientation parameters solutions and terrestrial reference frame realized separately through R1 or R4 experiments. We point out finally that the effects of using two different networks with different geometries and observational strategies show up in the operational series and such consequences should be carefully examined in the future.

5-06 First Results from CONT05

Dan MacMillan, David Gordon, Dirk Behrend, Chopo Ma, Goddard Space Flight Center

CONT05 was a two-week campaign of continuous VLBI sessions in September 2005. The CONT05 network consisted of eleven stations. The plan for CONT05 was to obtain the highest accuracy that VLBI is capable, with practical limitations, over the continuous 2-week period. Goals of CONT05 were to address several scientific questions including the origin of discrepancies between high frequency (subdaily) EOP tidal models and observed subdaily EOP, to study technique improvement, to study reference frame accuracy day to day, and to compare measurements made by co-located geodetic systems. Daily EOP values determined by CONT05 has a precision matched only by the larger RDV sessions. Formal errors are in the range of ~35-40 micro-arc-seconds for X and Y pole, ~1.4-1.5 microseconds for UT1, and ~75 and ~30 micro-arc-seconds for nutation longitude and obliquity. We will discuss the scheduling and geometrical design for CONT05 and will present preliminary analysis results from the campaign.

5-07 Radiosource Instability in the Analysis of VLBI Data *(invited)*

Daniel MacMillan, NVI, Inc./GSFC

The source position time series for many of our frequently observed sources show systematic variation of as much as 0.5-1.0 mas due mainly to source structure changes. In our standard geodetic solutions, we only estimate global source position from data from all observing sessions. If these effects are not modeled, they produce corresponding systematic variations in estimated EOP parameters at the level of 0.02-0.04 mas in nutation and 0.01-0.02 mas in polar motion. We discuss two strategies for handling source instabilities: 1) estimate the positions of all unstable sources for each session they are observed and 2) Estimate spline parameters chosen to fit the specific variation seen in the position time series.

5-08 The Effect of Reference Radiosource Instabilities on the TRF Solution

Oleg Titov, Geoscience Australia

Routinely, VLBI data analysts fix positions of several hundreds radiosources to provide the reference frame for other estimated parameters. The original ICRF catalogue of 'defining' radiosources or any alternative list of objects can be used for the purpose. The positions of selected reference radiosources are expected to be stable through the 25-year period and adjusted as global parameters. However, if their positions are not properly stable the estimates of other parameters will be corrupted. Three global solutions with different lists of reference radiosources are studied in this paper. It is shown that the southern hemisphere VLBI site positions are sensitive to selected list of reference radiosources. Temporal instabilities of the fixed radiosource positions contribute up to 10 mm bias to the resulted VLBI site position estimates (Hobart). The problem is enforced by the small number of observations due to low slew rate of the southern hemisphere sites (~1 degree/second for Hobart). To improve the geodetic results in southern hemisphere it is necessary to improve the celestial reference frame as well as technical parameters of the radiotelescopes.

5-09 First Steps to Investigate Long-term Stability of Radio Sources in VLBI Analysis

Gerald Engelhardt, Volkmar Thorandt, Bundesamt für Kartographie und Geodäsie

Presently, the observation period of several radio sources observed by geodetic VLBI covers more than 20 years. So, the estimation of global source parameters with the modelling of only one source position for the complete length of VLBI data should only be applied to stable compact radio sources. One important tool to handle this aspect consists in analyzing time series for radio source coordinates. The main features referred to the estimation of time series of radio source positions in global VLBI solutions are explained. On the basis of these time series a weighted mean was estimated for each radio source component. The residuals to the weighted mean were tested for normal distribution for the purpose of uncovering systematic errors. First results are discussed.

5-10 Correlation in VLBI Observations

John M. Gipson, NVI, Inc./GSFC

A crucial assumption that goes into processing VLBI data is that all of the data is independent. Hence on a scan involving N stations, there are assumed to be N*(N-1)/2 independent baselines. However, there are many sources of error that lead to noise which is correlated on all baselines involving a common station. Examples of such sources include atmosphere mis-modeling, cable effects, and p-cal. We show that the size of this correlated noise is on the order of 10 ps. This leads to correlation between the observables. We study how to handle this correlation, and show that it leads to a reduction in the effective number of observations. This has consequences for both the formal errors, which are increased, and the parameter estimates, which are modified.

5-01P Calc 10 Implementation

David Gordon (1), Dan MacMillan (2), Karen Baver (1); (1) Raytheon/NASA GSFC; (2) NVI Inc./NASA GSFC

A new version of Calc is being implemented. Calc version 10 makes use of the Celestial Ephemeris Origin (CEO) based method (the new paradigm) to compute the instantaneous TRF-to-CRF rotation matrix for each observation. The CEO-based, or non-rotating origin method uses the position of the Celestial Intermediate Pole (CIP) in the Geocentric Celestial Reference System (GCRS) [precession-nutation], the position of the CIP in the International Terrestrial Reference System (ITRS)[Polar motion], and the Earth Rotation Angle (which is linear with UT1). The coordinates of the CIP in the GCRS are based on the IAU2000A precession-nutation model. Calc 10 also uses high frequency EOP models for ocean tidal and nutation effects, the JPL DE405 ephemeris, an antenna axis tilt model, and has other numerous minor changes. Corresponding modifications to Solve are also necessary to use Calc 10. These changes will be mostly transparent to the users. Calc 10 will run on both HP and Linux Calc/Solve systems. We will present a detailed description of all the changes and new features in Calc 10. We will also compare the Solve analysis outputs using Calc 9 and Calc 10 in terms of the TRF, the CRF, and the EOP's.

5-02P Baseline and Site Repeatability in the IVS Rapid Network

Sebastien Lambert; Royal Observatory of Belgium (formerly at NVI, Inc./U.S. Naval Observatory)

Lengths of 51 baselines and 15 sites with large observational history within the IVS rapid 24-hour networks R1 and R4 are studied. The repeatability of the baseline lengths in function of the baselength as well as the sensitivity to tropospheric gradients are investigated. We point out several sites showing systematically higher wrms for which the sources of error could be found in network deficiencies or local difficulties that should be investigated for the future of the IVS and the full efficiency of VLBI.

5-03P Thermal Deformation of Radio Telescopes Onsala and Wettzell

Jörg Wresnik (1), Rüdiger Haas (2), Johannes Böhm (1), Harald Schuh (1); (1) Institute of Geodesy and Geophysics, Vienna University of Technology, (2) Chalmers University of Technology, Onsala Space Observatory

Geodetic VLBI is one of the major space geodetic techniques that contribute to the International Terrestrial Reference Frame (ITRF). Error contributions due to atmospheric propagation effects, loading phenomena and technical reasons have been minimized during the last years. Today the accuracy of geodetic VLBI results is on sub-cm level. For further improvements the thermal deformations of the radio telescopes have to be taken into account in the analysis of geodetic VLBI data. Thermal deformation effects typically have seasonal and daily signatures. The annual amplitudes can reach several millimeters in particular for the vertical position of the antenna reference point. The magnitude depends on the design of the antenna structure, the material, and on environmental influences. Two radio telescopes, Onsala (Sweden) and Wettzell (Germany), are equipped with measurements systems that are based on invar rods or invar wires and provide direct observations of the vertical variation of the telescope reference points. Based on these measurements we developed models that can be used to model thermal deformations as a function of environmental temperature. Direct observations of thermal deformation of the radio telescopes at Onsala and Wettzell are presented and the corresponding models for thermal deformation are discussed.

Session 6: Results and Geodetic/Geophysical/Astrometric Interpretation

6-01 VLBA Phase Referencing for Astrometric Use *(invited)*

Edward Fomalont, National Radio Astronomy Observatory

The relative positional accuracy between ~100 mJy sources that are less than about four degrees apart in the sky can be measured to an accuracy ≤20 μsec using phase referencing techniques. However, obtaining this accuracy requires the excellent calibration of the array astrometric parameters, determination of the variable tropospheric refraction, and the precise location of the true radio core between observation epochs and observing frequencies. In contrast, the ICRF frame is defined by observing relatively bright sources over the sky using VLBI group delays, and have obtained a typical source position accuracy of about 100 μsec with many years of observations. Possible schemes for extending the phase referencing approach on relatively faint sources within a relatively small area of sky to the all-sky catalogs and ICRF frame definition are discussed.

6-02 High-frequency Earth Orientation Variations and Geodetic VLBI *(invited)*

Rüdiger Haas, Chalmers University of Technology, Onsala Space Observatory

Several models exist that predict high-frequency Earth orientation variations due to mainly oceanic and atmospheric influences. Besides variations in the diurnal and semi-diurnal tidal bands, also small ter-diurnal variations in polar motion and earth rotation are predicted. VLBI data of the continuous VLBI campaigns are analyzed and used to assess the theoretical models.

6-03 Extending the ICRF to Higher Radio Frequencies: Global Astrometric Results at 24 GHz

C.S. Jacobs, G.E. Lanyi, C.J. Naudet, O.J. Sovers, L.D. Zhang (1); P. Charlot (2); E.B. Fomalont (3) D. Gordon, C. Ma (4); and the KQ VLBI Collaboration; (1) NASA/Caltech's JPL, (2) Bordeaux Observatory, (3) NRAO, (4) NASA/GSFC

Extending the ICRF to Higher Radio Frequencies: Global Astrometric Results at 24 GHz|6|Oral|Chris.Jacobs@jpl.nasa.gov|A celestial reference frame at K-band (24 GHz) has been constructed using eight 24-hour VLBA sessions which covered the full 24 hours of right ascension and declinations down to -40 deg. The resulting catalog contains 259 sources with median formal position uncertainties of 100 micro-arcsec in RA cos(dec) and 200 microarcsec in declination. In order to constrain the long arcs of the K-band catalog to those obtained with the S/X-band ICRF, four K-band high quality source positions well-separated in the sky were set to the S/X-band positions. After this registration, comparison of the K-band frame to an S/X-band ICRF-like frame shows agreement of 200 micro-arcsec in RA cos(dec) and 300 micro-arcsec in declination. The motivations for extending the ICRF to frequencies above 8 GHz are to use more compact sources less susceptible to structure changes in order to construct a more stable frame, to provide calibrators for phase referencing, and to support spacecraft navigation at higher frequencies.

6-04 Astrometric Suitability of ICRF Sources Based on Intrinsic VLBI Structure

Patrick Charlot (1); Alan Fey (2); Roopesh Ojha (3); David Boboltz (2); (1) Bordeaux Observatory, (2) U. S. Naval Observatory, (3) Australia Telescope National Facility

The intrinsic radio structure of the extragalactic sources is one of the limiting errors in the analysis of astrometric and geodetic VLBI observations. Based on VLBI images obtained with the VLBA and other VLBI telescopes around the world, we evaluate this effect for 545 ICRF sources (about 75% of the current frame) and calculate a so-called "structure index" to define the astrometric source quality. The structure index ranges from 1 for the most compact sources to 4 for the most extended sources. The most recent addition to our database is for a hundred southern-hemisphere sources. We discuss the overall distribution of structure index in the ICRF and the structure index variability with time for those individual sources that have VLBI images available at multiple epochs. We also draw prospects about using this indicator as a primary criterion to select defining sources for the next realization of the ICRF.

6-05 How Compact Are Faint Radio Sources?

Richard Porcas, MPIfR Bonn

Results from a survey of compact structure in faint (≥ 1 mJy) radio sources will be presented.

6-06 E3 Network Results

Anthony Searle, Mario Bérubé, Bill Petrachenko, Natural Resources Canada (NRCan)

For the past four years the Canadian Technology Development Center has been coordinating and analyzing the IVS-E3 network. The E3 network uses the S2 VLBI system at 6 stations worldwide and its sessions are correlated at the Dominion Radio Astronomical Observatory. Analysis of the E3 observations for EOP and TRF will be presented. Experience with the network has allowed for the use of GPS clock results in VLBI analysis and some new approaches to operations. The future of the network is discussed with an eye towards VLBI2010.

6-07 A Generalized Scheme to Retrieve Wet Path Delays from WVR Measurements Applied to the European Geodetic VLBI Network

J. Cho (1,2), A. Nothnagel (2), A. L. Roy (3), R. Haas (4); (1) Korea Astronomy & Space Science Institute, (2) Geodetic Institute, University of Bonn, (3) Max-Plank Institute for Radio Astronomy, (4) Onsala Space Observatory, Chalmers University of Technology

A fluctuation in the water vapor in the atmosphere is one of the largest sources of error of ground-based space geodetic techniques using radio frequencies such as VLBI and GPS. A number of different water vapor radiometer (WVR) instruments are currently deployed for the determination of wet path delays (WPD) to be used as corrections for space geodetic techniques. Although a WVR is an ideal instrument for monitoring the water vapor content in the atmosphere, its benefits for geodetic VLBI have not been demonstrated yet. Site-dependent and frequency-dependent WPD retrieval problems still inhibit the routine use of these corrections. In this study we focused on whether one can find a reliable WPD retrieval scheme that can be applied to the several different microwave radiometers operated at four sites of the European geodetic VLBI network. To validate the WVR measured WPD, which is necessary before introducing the WPD into VLBI data processing, we have used several different WPD inversion methods and compared the resulting WPDs for each site. Finally we discussed a generalized scheme to extract valid WPDs from WVR data for most geodetic stations as a step towards the proposal in the VLBI2010 plan.

6-08 Combination of Long Time Series of Tropospheric Parameters

Robert Heinkelmann, Johannes Böhm, Harald Schuh; Institute of Geodesy and Geophysics, Vienna University of Technology

Several Analysis Centers of the IVS submit their long time series of tropospheric parameters for comparison and combination to the Institute of Geodesy and Geophysics (IGG), Vienna. Requirements for the contribution are minimal: Zenith delays and gradients are provided at integer hours, the time resolution of the zenith delays is one hour. The inclusion of different analysis options, models, and terrestrial reference frames adds analyst noise to the combined time series. On the other hand it allows the detection of systematic errors therein and averages their effect. The combined long time series are the basis for a reliable determination of linear trends and provide independent information about the change of water vapor in the troposphere. The method of combination is discussed and prerequisites for a combination on normal equation level are addressed.

6-01P Improving Astrometric VLBI by Using Water Vapor Radiometer Calibrations

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Astrometric observations of distant active galactic nuclei (AGN) using the VLBI technique have been used to construct quasi-inertial global reference frames, most notably the International Celestial Reference Frame (ICRF) which now forms the basis for all astrometry including deep space navigation. The accuracy of VLBI global astrometry has long been limited by systematic errors—most notably stochastic fluctuations of the refractive delay caused by atmospheric water vapor. In order to calibrate the water vapor induced path delay fluctuations, a pair of advanced design water vapor radiometers (A-WVR) have been built and deployed. We will present intercontinental VLBI results calibrated with the A-WVRs showing a factor of 2.5 to 3 improvement in phase delay residuals over time scales of 10 to 1000 seconds. These results suggest that it may be possible to develop the next generation ICRF (at X/Ka-band) much more rapidly than previously estimated and that spacecraft navigation may be possible at sub-nanoradian levels of accuracy.

6-02P Tropospheric Parameters Long Time Series Analysis

Sergey Kurdubov, Elena Skurikhina, Julia Sokolova; Institute of Applied Astronomy RAS

Long time series of tropospheric parameters was calculated from all 24-h VLBI observations with OCCAM/GROSS and QUASAR packages. OCCAM/GROSS package use Kalman Filter for estimation stochastic parameters, QUASAR package use Least Square Collocation Method for estimation stochastic

parameters. Terrestrial reference frame was fixed with VTRF03, VTRF05 catalog and catalog station positions and velocity obtained from the first QUASAR global solution. In QUASAR global solution all available VLBI 24-h observations from Aug 1979 onward were used. Positions and velocities of all station and positions of all sources have been estimated as global parameters. We will pay special attention to comparison of linear trend parameters and amplitudes of seasonal parts of the series. Analysis of stochastic part of the series will be performed, too.

6-03P VLBI as a Tool to Probe the Ionosphere

T. Hobiger (1), T. Kondo (2), H. Schuh (1); (1) IGG, Vienna University of Technology; (2) NICT

A method will be presented, which was developed within the project VLBIonos at the IGG, Vienna. It is capable of estimating ionospheric parameters, in terms of vertical total electron content from VLBI data without any external information. The results obtained are cross-validated against GPS, satellite altimetry data and theoretical models of the ionosphere. As VLBI observations cover more than two complete solar cycles, longer than all other space geodetic techniques using radio signals, the relation to space weather indices on long time-scales can be shown. It can be stated that the overall agreement between VLBI and GPS is within the formal error of each technique and that both systems detect the same periods of ionospheric variations. But only VLBI is able to reveal long period signals like the solar cycle, since it covers a sufficiently long time-span.

6-04P Detection of Short Period Ionospheric Variations from VLBI Fringe Phases

T. Hobiger (1), T. Kondo (2), K. Takashima (3), H. Schuh (1); (1) IGG, Vienna University of Technology; (2) NICT; (3) Geographical Survey Institute

The usage of fringe phase information from VLBI measurements is a new and challenging field of research, which can be utilized for the detection of short period variations (scintillations) of the ionosphere. A method for the extraction of such disturbances is presented and it is discussed how dispersive influences can be separated from intra-scan delay variations. By an example it is shown that a short period variation can be detected very precisely, if the SNR is high enough. A possible physical origin of the disturbance is presented and the results are validated against GPS measurements.

6-05P The First Dual Frequency VLBI Observation Using VERA

Bong Won Sohn (1), Hideyuki Kobayashi (2) Tetsuo Sasao (1), Tomoya Hirota (2), Osamu Kameya (2), Yoon Kyung Choi (2); (1) KASI, Korea Astronomy & Space Science Institute; (2) NAOJ, National Astronomical Observatory of Japan

We report our first simultaneous dual frequency VLBI experiment using VERA. The purpose of this Korean-Japanese joint experiment is to examine the feasibility of the simultaneous multi-frequency phase referencing technique, an atmospheric phase delay correction method, which is suggested for KVN system. This method is based on the idea that the differential atmospheric phase delay is mainly caused by the differential water-vapor-induced excess path length in the troposphere. The technique takes advantage of the non-dispersive nature of the water-vapor-

induced phase delay. Our VERA experiment was conducted on 15th April 2005 between 14:15 and 21:30 (UT). At 22GHz (Beam A), NRAO512 was scheduled, and at 43GHz (Beam B), a bright quasar 3C345, which is only 0.5 degree apart from NRAO512, was observed. 128MHz broadband continuum observation mode was taken and single LL circular polarization mode was used. Different from the previous multi-frequency phase referencing technique, we recorded signals from two quasars without apparent time delay. This simultaneous observation ensures that the phase delay solution interval problem, which could be severe in the previous one, does not exist in out case. In this talk, we will present our preliminary multi-frequency phase delay correction results based on the non-dispersive phase delay model. Short discussions about the instrumental calibration effects, the possible ionospheric effect, and future plans will be given.

6-06P Crustal Deformation in South America from GPS and VLBI

Annika Edh, Rüdiger Haas; Chalmers University of Technology, Onsala Space Observatory

We present contemporary crustal deformations in South America derived from GPS and VLBI observations. GPS data since late 1999 are analyzed using the Precise Point Positioning (PPP) strategy with the Gipsy/Oasis II software. The GPS network consists of about 20 continuously operating GPS stations, most of them IGS stations. We also include GPS data from a station operated at the ALMA site in Northern Chile at about 5000 m height. We use all existing South American geodetic VLBI data. Crustal deformation in terms of stations velocities and strain-rates are derived and compared to other investigations.

6-07P Preliminary Study on Plate Motion Measurements in Korean Peninsula by New Korean VLBI

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The Korean Peninsula is generally assumed to be located in stable area in East Asia. It is also postulated to be a separate micro-plate, called Amurian plate (AM), other than Eurasian plate (EU). In near future, we will have 4 Very Long Baseline Interferometry (VLBI) stations in Korea: a geodetic VLBI station in Suwon, and 3 astronomical VLBI stations (Korean VLBI Network, KVN), which are also feasible for geodetic observations. Even though the Korean VLBI array is relatively small in size and consists of a small number of stations, it is possible to achieve good determination of plate motion parameters, as shown in my simulation with a small VLBI array consisted of stable stations in the North American plate (NA). We estimated determination accuracy of AM plate motion parameters with the Korean VLBI array, assuming typical error of station velocities measured with VLBI. The results showed that the Korean VLBI array will distinguish previous research results on the Amurian motion and verify, or exclude, the existence of AM as a separate rigid plate, if observation accuracy of 0.2 - 0.5 mm/yr for station velocities is achieved. Therefore new Korean geodetic VLBI array can contribute to crustal deformation studies in East Asia. New

Korean VLBI station will be an important reference point for determining ITRF, if it indeed turns out to be a stable mid-plate VLBI station in East Asia.

6-08P Modeling of the Earth Free Core Nutation

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The time series of the Celestial Intermediate Pole (CIP) coordinates X and Y derived by U.S. National Earth Orientation Service (NEOS) from raw VLBI data sets within period 1984-2005 were analyzed with the help of Fast Fourier Transform (FFT) and Least-Squares Collocation (LSC). In the retrograde free core nutation (RFCN) frequency domain were detected two damping elliptic oscillations. Their parameters (P is period in [solar days]; a is exponential damping parameter in [1/day], and S is standard deviation in [mas^2]) are as follows:

$P1=-490.93$, $a1=1.92\cdot10^{-4}$, $S1_X=33.4\cdot10^{-4}$, $S1_Y=25.4\cdot10^{-4}$,

$P2=-418.44$, $a2=4.28\cdot10^{-4}$, $S2_X=167.6\cdot10^{-4}$, $S2_Y=127.1\cdot10^{-4}$.

These results are not consistent with RFCN parameters of the MHB_2000 theory (P=-430.20).

6-09P Local Tie Survey at VERA Ogasawara Station at Site Chichijima

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We made the local-tie survey between the VLBI station, VERA-Ogasawara station of National Astronomical Observatory of Japan (DOMES code S005), and the GPS station, CCJM (S003), at the site Chichijima (DOMES site number 21732). The site Chichijima is one of Bonin(Ogasawara) Islands on the Philippine Sea plate. Since there is no other suitable site for geodetic observation nearby, the local-ties at Chichijima have important role for the maintenance of the terrestrial reference frame. This is the first local-tie at this site, except for the one classified as 'a dubious tie' in 'ITRF Report 4 on local ties'. Our result shows that the relative position between these two stations is determined with standard deviations of (X, Y, Z) = (2mm, 1.4mm, 1.5mm). We also checked the accuracy by comparing another result obtained independently by Tamura and VERA group. The difference in relative position between these two results is about 7mm. This is below the required accuracy for local-ties (1cm). We will also report error budgets of our analysis process used in this study.