IVS Newsletter

Issue 22, December 2008

The Next ICRF Takes Shape

– Chopo Ma, NASA Goddard Space Flight Center

The ICRF (International Celestial Reference Frame), a catalogue of extragalactic radio sources and their positions, is a unique and fundamental product of the IVS. Since its adoption by the IAU effective 1 January 1998 these objects and positions have defined the axes in the sky to which all other celestial positions are now referred. The ICRF also provides the connection to the kinematically fixed inertial frame in which the variations of the Earth's orientation are measured. Only VLBI can monitor nutation/precession and UT1 because of its unique capability to connect terrestrial and celestial points.

Members of the IERS/IVS Working Group on the Next Realization of the ICRF at a group meeting in Dresden.

The data and analysis leading to the ICRF were carried through the middle of 1995, at which time a set of extragalactic positions was needed to provide an underlying frame for the Hipparcos stellar optical catalogue. Ten years later it was clear that both data and analysis had made great advances that could be used to significantly improve the ICRF. (Two extensions of the ICRF incorporated data through 2002 but retained the same defining sources, analysis configuration, and limits of error.) At the IAU General Assembly in Prague in 2006 a working group was established to oversee the second realization of the ICRF using VLBI. One particular requirement is that the second realization should provide consistency between the ICRF, ITRF (International Terrestrial Reference Frame), and EOP (Earth orientation parameters). The actual work of generating an improved catalogue, selecting defining sources, and transforming positions from the old to the new realization was given to an IERS/IVS working group that includes all the IVS analysis groups with interest and experience in this field. The IERS/IVS working group has had meetings in Vienna (April 2007), Paris (September 2007), St. Petersburg (March 2008), and Dresden (September 2008). The next meetings are set for Washington in December 2008 and Bordeaux in March 2009.

There are several inescapable limiting factors that must be faced in generating the ICRF from VLBI. One is the heterogeneity of the data in time and space. Most sources have few observing epochs and observations over the three decades of VLBI because only a small number (~150) have been used regularly in the geodetic observations to monitor EOP and the ITRF. Although the number of sources is roughly equal in the northern and southern hemispheres, the number of observations and epochs is much smaller for most southern sources largely because only ~10% of the VLBI stations are in the south. Another difficulty which is clear from the time series of source positions is that only a few sources have very stable positions within the measurement error. Most sources have too few epochs to allow detailed statistical analysis, and the behavior of the often observed sources varies considerably.

The IERS/IVS working group is moving ahead in preparing for the next ICRF by generating and analyzing position time series and catalogues. Conventional combination catalogues are also to be considered. The TRF and EOP results have been submitted for external validation. Another aspect under investigation is the application of source structure and source evolution to the selection of defining sources, which should have positions that are stable at a known level.

To meet the goal of having the IAU working group present the next ICRF at the IAU General Assembly in Rio de Janeiro in August 2009, the catalogue must take final form by the summer of 2009. It will be essential to prepare well for the IERS/IVS working group meeting in Bordeaux where decisions about the analysis configuration, defining sources, and position transformation will be made.

Call for 2008 Annual Report

The IVS Coordinating Center invites each IVS Component and the Coordinators to submit reports on activities during the calendar year 2008. Reports are due January 16, 2009. http://ivscc.gsfc.nasa.gov/publications/ar2008-call.html

Permanent Component

Geographical Survey Institute, Tsukuba, Japan

The Geographical Survey Institute (GSI) operates a 32-m VLBI antenna and a K5/VSSP VLBI correlator at its site in Tsukuba, which is about 50 km northeast of Japan's capital Tokyo. These two IVS components are a prime example of operational K5 technology, with Tsukuba being a cornerstone station of the IVS Intensives and a vital contributor to several IVS observation series. Newsletter Editor Hayo Hase e-interviewed the VLBI group lead Shinobu Kurihara in order to learn more about the activities at Tsukuba and their future plans.

(above) Shinobu Kurihara; (below) Tsukuba 32-m antenna.

Kurihara-san, GSI is the mapping authority of Japan. What are its tasks?

The Geographical Survey Institute is the national organization that conducts basic survey and mapping tasks and instructs related organizations to clarify the conditions of land in Japan and that provides the results of surveys to help improve this land. It dates back to 1869, when the cadastral Registration Map Section was established within the Geography Department of the Ministry of Civil Service. Later, in 1888, it was reorganized as the Japanese Imperial Land Survey in the General Staff Office of the Imperial Army, and finally, in 1945, it became the Geographical Survey Institute. Currently, GSI has widespread tasks regarding geospatial information: continuous GPS observations, gravity surveys, geomagnetic surveys, maintenance of control points, collecting and maintaining basic geographic information, disaster prevention measures, to name just a few.

How did VLBI become part of GSI's duties? Since when does GSI observe VLBI experiments?

GSI started its VLBI development in 1981 in order to correct the geodetic network and to observe crustal motion. A 5-m diameter mobile parabolic antenna developed at GSI was moved from place to place in Japan, conducting VLBI experiments together with the Kashima 26-m antenna. The results from the experiments for the Chichijima site in 1987 and 1989 indicated that Chichijima had moved 7.4±0.8 cm in the direction of N67°W over the two years. This was the first successful direct measurement of the motion of the Philippine Sea plate by any method. After that the Kashima 26-m antenna was transferred from CRL (now NICT) to GSI. We participated in international experiments such as DOSE (Dynamics of the Solid Earth) and CORE.

In 1995, GSI and the National Geography Institute of Korea (now National Geographic Information Institute, NGII) conducted a Japan–Korea geodetic VLBI project. This experiment was performed by moving around a 3.8-m diameter antenna and mobile backend system developed by GSI within Korea. The results of the experiment were used to set the coordinates of the origin of the Korean Geodetic Datum.

GSI constructed Tsukuba's 32-m antenna in 1998. This led us to becoming one of the world's top level VLBI sites. A decade later, Tsukuba 32-m regularly carries out about 50 VLBI sessions per year. In addition to Tsukuba, there are three other GSI VLBI stations in Japan. These antennas also participate in international sessions such as the IVS-T2 and APSG (in 2008).

Who is who in GSI's VLBI group?

Shinobu Kurihara has the responsibility for the total coordination of the VLBI work at GSI. Kensuke Kokado is responsible for VLBI operation and analysis. The routine operation and maintenance of the entire equipment at the Tsukuba 32-m site are entrusted to Daisuke Tanimoto from Advanced Engineering Service Co., Ltd (AES). Hiromi Shigematsu takes charge of correlator processing together with Kentaro Nozawa from AES.

Kazuhiro Takashima is a senior researcher in the research center and a member of the IVS Directing Board. Yoshihiro Fukuzaki belongs to the technical staff of our group. Kozin Wada is a member of the Observing Program Committee (OPC). And Shigeru Matsuzaka, who is the director of the space geodesy division, is our supervisor.

What is GSI's contribution to the IVS?

GSI contributes to the IVS as network station and correlator. As an IVS network station we currently perform over 50 geodetic 24-hour sessions and 140 one-hour Intensive sessions per year. This year, Tsukuba participated in the continuous VLBI campaign CONT08. We also routinely process the INT2 data of the Tsukuba–Wettzell baseline on our correlator. In addition, GSI has had continuously elected Directing Board members since the start of the IVS in 1999.

GSI is one of the leading sites for e-VLBI experiments on a regular basis. Which e-VLBI experiments are you executing and processing at Tsukuba? How does e-VLBI work at Tsukuba?

All VLBI experiments carried out at Tsukuba are e-VLBI. Ever since we discarded the Mark 4 open-reel-type recorder three years ago, VLBI data at Tsukuba has been recorded on HDD by K5/VSSP developed at NICT and transferred to the target correlator (such as Bonn) via broadband network. We cannot conduct VLBI operations without e-VLBI.

Since 2007, GSI has been conducting ultra-rapid dUT1 experiments with colleagues at Kashima, Onsala, and Metsähovi. In February 2008, we achieved dUT1 results within 3.5 minutes after the end of a one-hour long dUT1 session between Tsukuba–Onsala.

It is well known that Japan has always been very active in the technological development of VLBI hardware and software. Which VLBI projects are currently planned and what is GSI's involvement?

Currently technological development is conducted on a compact VLBI system with a 1.65-m diameter antenna called MARBLE in collaboration with NICT. This VLBI system is using a pair of very small antennas in conjunction with a large antenna such as Tsukuba 32-m. While the time delay between small antennas is undetectable directly due to their low sensitivity, time delays between each small antenna and the large one can be detected. From these time delays the time delay between the two small antennas can then be obtained indirectly. GSI plans to use the MARBLE system for the validation of a reference baseline for calibrating survey instruments such as GPS receivers and EDMs.

What plans regarding the VLBI2010 vision are under discussion/development at GSI?

In Japan, the RFI in S-band due to cellular phones has become a problem in recent years. As VLBI2010 points out, we are considering the availability of new alternative frequency bands higher than X-band, such as Ka-band, and broadband receivers/samplers. We are also considering an enhancement of the broadband network for e-VLBI.

VLBI made in Japan is not only done by GSI. Which other Japanese institutions are performing VLBI experiments?

In Japan, NICT is a pioneer in the development of VLBI. They have been developing a VLBI system called K-series since the 1970s. In the astronomy field, the National Astronomical Observatory of Japan (NAOJ) conducts research regarding VLBI. NAOJ has four 20-m diameter VLBI antennas called VERA in Japan. So, GSI conducts geodetic VLBI, NAOJ conducts astronomical VLBI, and NICT advances the technological development. Japanese VLBI is done by appropriate role-sharing and collaboration of three organizations. In addition, the Japan Aerospace Exploration Agency (JAXA) runs a space VLBI project and the National Institute of Polar Research (NIPR) conducts VLBI at Syowa Base in Antarctica. Some universities also carry out VLBI research and experiments.

How important is the IVS for your VLBI duties?

Our involvement in the IVS accounts for a large part of our VLBI duties—the IVS is necessary for our VLBI activities. As you well know, Japan is a small island nation. To observe global dynamic crustal movements like plate motion, international cooperation is indispensable.

Do you have any wish for the future?

GSI has been working as IVS network station and correlator since 1999. We want to make efforts in our analysis work. For the future we want to become an IVS analysis center.

(Top) Running a VLBI experiment in the observation room; (Right) K4-type backend rack in the observation room.

(left) GSI VLBI group (left to right): Yoshihiro Fukuzaki, Shinobu Kurihara, Daisuke Tanimoto, Kozin Wada, Yasuko Mukai, Toshio Nakajima, Kazuhiro Takashima, Kensuke Kokado, Kentaro Nozawa, Hiromi Shigematsu.

NEWS...

IAA RAS Awards Gold Medal of Merit to Wolfgang Schlüter

– Wolfgang Schlüter, BKG Germany

The Scientific Board of the Institute of Applied Astronomy of the Russian Academy of Sciences (IAA RAS) awarded Dr. Wolfgang Schlüter (Federal Office for Cartography and Geodesy, Geodetic Observatory Wettzell), first chair of the IVS in the period from 1999 to 2007, with a Gold Medal of Merit for 2007 for "fundamental achievements in the field of observational astrometry, geodynamics and space geodesy and the deployment of the IVS network".

The Gold Medals of Merit have been awarded every year, now for the fifteenth time, to two scientists for their outstanding contributions in astronomy. Previous awardees include Dr. Tom Clark (NASA GSFC) for his "outstanding achievements in development of VLBI technology" in 2005 and Professor Shuhua Ye (Shanghai Astronomical Observatory) for her "outstanding contributions to the development of space geodesy and the Russian-Chinese cooperation in this field" in 2006.

Dr. Schlüter and his wife Brigitta traveled to St. Petersburg to receive the IAA RAS Gold Medal on November 5, 2008. Professor Alexander Ipatov, Vice Director of IAA, on behalf of Professor Andrey Finkelstein, Director of IAA, handed over the gold medal during the award ceremony. Members of the Scientific Board, IAA Scientists, and the General Consul of the German Consulate in St. Petersburg attended the ceremony. After receiving the gold medal Dr. Schlüter expressed his thanks and emphasized that the outstanding achievements are based on the contributions of the entire VLBI community and on the fruitful collaboration among the IVS Directing Board members. Russia has been strongly supporting the IVS with three observing stations and now with three analysis centers.

After the ceremony Dr. Schlüter presented a lecture entitled "Geodetic VLBI and its significant contribution to GGOS". The Global Geodetic Observing System (GGOS), as the leading program of the International Association of Geodesy (IAG), aims at the realization of a precise, consistent, and long-term stable geodetic reference frame, which is required for future research and dedicated applications in the field of the geo-disciplines. It necessitates strong contributions from the VLBI technique. The IVS provides unique VLBI products, which—following the WG2 report—still needs further improvement. Following the WG3 vision for establishing a new generation VLBI system, the IVS will become a strong and important supporter of GGOS. Numerous IVS institutions are active in the renewal process following the VLBI2010 vision.

Wolfgang Schlüter and Alexander Ipatov present the award certificate and the Gold Medal of Merit.

IVS Turns Ten

March 1, 1999 marks the date of the official start of the IVS. Reason enough to look back at the first ten successful years of the service and to get a glimpse of what the future might bring.

Marking this occasion the IVS Directing Board invites you to attend a special anniversary event in the afternoon of March 25, 2009 in Bordeaux, France. The 10th anniversary celebration will be imbedded into the series of VLBI meetings taking place in the week March 23-28 in Bordeaux. We would like to thank Patrick Charlot and his team for making this possible

Science is organized knowledge.
Wisdom is organized life.

- Immanuel Kant

News...

Station Staff Coming to TOW in April 2009

– Ed Himwich, NVI Inc./GSFC

As part of the continuing series of bi-annual workshops, the 5th IVS Technical Operations Workshop (TOW) will be held at MIT Haystack Observatory April 27-30, 2009. An icebreaker reception will be held on the Sunday evening before the workshop. This meeting is intended for the technical staff responsible for collecting VLBI data at the observatories.

As in previous TOW meetings all aspects of VLBI operations will be covered in lectures, hands-on workshops, and seminars. The final list of topics to be covered will be decided upon by the Program Committee after obtaining feedback from the potential participants. At this point we anticipate the continuation of core topics plus a few new topics. The possible list of topics includes:

Operations workshops
* Experiment pre-checks and experiment operations
* Mark 5 recorder operations and testing
* Antenna pointing models and gain calibration

Maintenance workshops
* Rack, recorder (disk based), and receiver maintenance
* RFI identification and remedies
* Spectrum Analyzer use for diagnostics
* System tests
* Hydrogen maser monitoring and maintenance

Seminars and lectures
* Science overview
* IVS
* Correlator theory and operations
* Phase-cal basics
* Gain Calibration theory
* Real-time and near-real-time e-VLBI
* Timing Systems
* Basic Linux and Linux system administration
* FS programming

New topics
* VLBI2010 system overview
* DBE2 and Mark 5C overview
* DBBC overview
* FS remote operation interface development

Participants are encouraged to provide feedback about what topics they would like to see covered. The Program Committee will be established soon and a call for program feedback will be sent out in early 2009. In the meantime, please send any ideas or requests for topics you may have to the Network Coordinator Ed Himwich, Ed.Himwich@nasa.gov.

We hope that all VLBI stations will be able to send technical representatives. This meeting represents a rare opportunity for both training and communication with personnel from stations, the coordinating center, and the correlators.

http://ivscc.gsfc.nasa.gov/meetings/tow2009

Upcoming Meetings...

AGU Fall Meeting
San Francisco, USA
December 15-19, 2008

VLBI2010 Workshop
Wettzell, Germany
March 18-21 2009

19th EVGA Meeting
Bordeaux, France
March 24-25, 2009

IVS 10th Anniversary
Bordeaux, France
March 25, 2009

IVS Analysis Workshop
Bordeaux, France
March 25-26, 2009

EGU General Assembly
Vienna, Austria
April 19-24, 2009

5th IVS TOW
Haystack Observatory
Westford, MA, USA
April 27-30, 2009

6th Orlov Conference
Kiev, Ukraine
June 22-24, 2009

IAU General Assembly
Rio de Janeiro, Brazil
August 3-14, 2009

IAG Scientific Assembly
Buenos Aires, Argentina
Aug. 31 - Sep. 4, 2009

http://ivscc.gsfc.nasa.gov/meetings

The IVS Newsletter is published three times annually, in April, August, and December. Contributed articles, pictures, cartoons, and feedback are welcome at any time.

Please send contributions to
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The editors reserve the right to edit contributions. The deadline for contributions is one month before the publication date.

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The newsletter is published in color with live links on the IVS web site at http://ivscc.gsfc.nasa.gov/.

NEWS...

DRAO Hosts 20th Directing Board Meeting

– Dirk Behrend, NVI Inc./GSFC

The Dominion Radio Astrophysical Observatory (DRAO) near Penticton, BC, Canada was the venue of the 20th Directing Board meeting on September 13, 2008. The location in the Okanagan Valley, in a beautiful setting among lakes and mountains in British Columbia's interior, along with the excellent organization by Bill Petrachenko, Natural Resources Canada, paved the way for a very successful meeting. We only missed a sighting of the Ogopogo, the local answer to the Loch Ness monster.

The Directing Board in front of DRAO's 26-m antenna. This antenna was involved in the first VLBI experiment on a long baseline (with Algonquin) successfully yielding fringes in 1967.

The Coordinating Center Director Dirk Behrend reported on the successful observation of the Continuous VLBI Campaign 2008 (CONT08). Eleven IVS stations observed 15 consecutive days at a rate of 512 Mbps in the time August 12−26, 2008. The observing was done on the basis of UT days with each CONT08 day running from 0 UT to 24 UT. The staggered station check times of two-hour length worked very well avoiding complete observational gaps as was the case for CONT05. The campaign is currently being correlated at the Washington Correlator. We would like to thank all stations for their exceptional work and strong commitment.

The special astrometric observing session in support of the International Year of Astronomy (IYA2009) is tentatively scheduled for November 18, 2009. Almost thirty stations are foreseen to participate in this session. A Task Force was established consisting of Patrick Charlot (chair), Dirk Behrend (co-chair), Axel Nothnagel, Hayo Hase, and Oleg Titov. The Task Force will coordinate the efforts with the International Astronomical Union (IAU) and investigate the scientific merit of the, most likely, largest CRF session ever.

The VLBI2010 Committee (V2C) continued its work, in particular focusing on Monte Carlo simulations, subsystem recommendations, and proof-of-concept efforts. A progress report is planned to be finalized by the end of the year. A workshop on future radio frequencies and feeds is planned for March 18−20, directly followed by a V2C meeting on digital back ends and software correlators for VLBI2010 on March 21, 2009. Both events will take place in Wettzell, Germany. A conceptual design review with external reviewers is tentatively scheduled for fall 2009. Finally, the establishment of a project office was contemplated and will be further evaluated.

The call for proposals for combination centers and additional analysis centers was very successful. Four proposals have been received, two for each component type. The Board unanimously approved all four proposals and we are glad to be able to welcome the following new components in the IVS family: Bundesamt für Kartographie und Geodäsie/Deutsches Geodätisches Forschungsinstitut (BKG/DGFI) Combination Center, Korea Astronomy and Space Science Institute (KASI) Combination Center, Sternberg Astronomical Institute (SAI) Analysis Center, and DGFI Operational Analysis Center. We would like to thank all institutions for their willingness to cooperate, and we appreciate their commitment and look forward to their import contributions.

Board members Xiuzhong Zhang, Axel Nothnagel, and Oleg Titov (left to right) inspect the S2 correlator (here: the playback units) during a short tour of the observatory.

Editorial Note: Software Correlators

Correlation of raw VLBI data can be carried out on a dedicated hardware correlator, as is currently the case for the Mark IV (Mark 5) correlator. This technology is well established operationally. The advent of more powerful computers and network connectivity brought along the possibility to perform the correlation on a distributed network of off-the-shelf computers in a purely software-based mode—a so-called software correlator. In between, there are hybrid correlators as a mixture of hardware and software correlators.

The general trend is to go towards software correlators. The Japanese groups of NICT and GSI have pioneered this technology for K5 with the INT2 Intensive sessions, which are being correlated with the K5/VSSP software correlator on an operational basis for a few years now. In the meantime other groups are following. It is only a question of time when larger networks can be correlated using software correlators. In this line, the news from the U.S. Naval Observatory is very encouraging.

USNO Successfully Tests Prototype Software Correlator

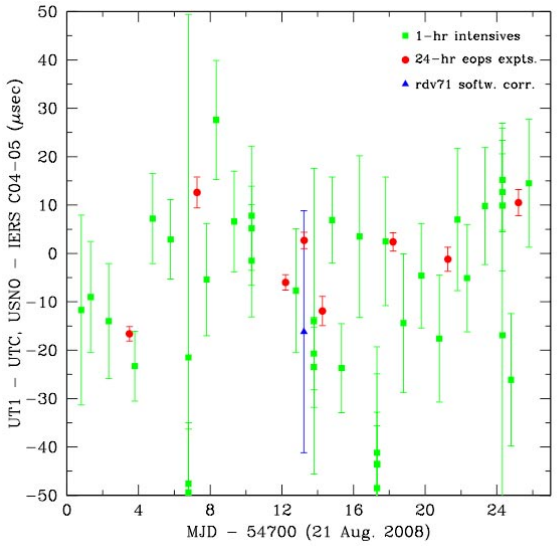
–Roopesh Ojha, Dave Boboltz and Alan Fey, U.S. Naval Observatory

The U.S. Naval Observatory (USNO) has successfully processed "software correlated" VLBI data to estimate the UT1 component of Earth Orientation Parameters (EOP). Personnel in the USNO Astrometry department worked closely with the National Radio Astronomy Observatory (NRAO) and Swinburne University in Australia to establish a USNO implementation of the Swinburne/NRAO "DiFX" software correlator. The advantage of a software correlator is that it can be implemented with minimal initial investment in hardware and can easily be expanded as the processing requirements are increased. The USNO prototype version of the DiFX software correlator is currently installed on two dual-processor x86 machines and two single-processor x86 machines, each running an identical version of the Linux operating system.

Much of the work implementing the DiFX correlator at USNO has involved identifying and creating data pathways from pre-processing through correlation and finally to post-processing. The pre-processing stage involves geometric model calculation, starting from the observing schedule and telescope log files, using the Goddard Space Flight Center (GSFC) CALC software. The actual software correlation step comes next. The DiFX correlator is capable of reading VLBI data in several formats including directly from Mark 5A units.

The correlation process currently runs at about 2.5 times wall clock time of the observations. This factor is limited primarily by the number of processors. The DiFX software efficiently distributes computational load among the available processors but the optimum number for real-time correlation has not yet been determined. Post-processing of the correlated data involves fringe fitting and group delay estimation.

Preliminary results (see figure) suggest that the use of the DiFX software correlator for correlation of VLBI data used for EOP estimation is viable; at least for 2−3 station Intensive experiments. Further verification of the use of the DiFX software correlator for geodetic and astrometric purposes and the feasibility of using software correlation for many station VLBI experiments remain the goal of future work.



A test was done with partial data of the recent RDV71 experiment. Twenty-two group delay measurements, which is about equivalent to the number of scans observed in a regular 1-hr Intensive session, on the Kokee-Park–Wettzell baseline yielded a value of UT1−UTC that agrees with IERS C04-05 to within 16 microseconds of time with a formal error of 25 microseconds. The figure shows the differences between UT1−UTC USNO time series and IERS C04-05 series over a four-week period. Results for the 1-hr Intensive (eopi) series are shown as squares and those for the 24-hr (eops) series are shown as circles. The software correlated RDV71 Kokee-Park–Wettzell baseline result is plotted as a triangle near the center of the figure.

What's the Scoop on the Observing Program?

– Dirk Behrend, NVI Inc./GSFC

Every summer/fall the IVS Observing Program Committee (OPC) discusses the observing plan for the upcoming year. The planning of 2009 was no exception and by October 2008 the observing plan for 2009 was approved by the OPC. This was the result of the Coordinating Center working closely with the OPC and with the stations to match the OPC's goals with the station availability. The overall observing program structure follows the general guidelines that were laid out in the IVS Working Group 2 report. Calendar year 2009 will mark the eighth year of the IVS observing program. The first rapid turnaround R1 and R4 sessions—if you can remember that far back—were started in the first week of January 2002.

The scarcest resource continues to be the station observing time. So it was bad news during the planning discussions to hear that Hartebeesthoek, South Africa suffered a major failure of a polar shaft bearing and will likely be down for the entire observing year. We hope that a repair or replacement of the bearing will be possible on a faster time scale, but this seems unlikely at the time of writing. With HartRAO being one of the few southern hemisphere stations, several IVS observing series will have a weaker geometry and are strongly impacted. The biggest impact, in this context, will be on the CRF sessions with emphasis on the southern hemisphere (CRF deep-south and CRF medium-south), where no adequate replacement station is available.

The good news in terms of station time is that in the second part of 2009 a 12-m antenna will come online in Warkworth, New Zealand (north of Auckland) and possibly two of the three AuScope antennas in Australia (new Hobart, Tasmania and Yarragadee, Western Australia). These are in addition to the new 40-m antenna at Yebes, Spain, which started observing a few months ago.

For the CONT08 campaign several institutions purchased disk modules; there are 42 new 4-TB modules and 25 new 6-TB modules. These modules will enter the geodetic disk pool once the CONT08 campaign is fully correlated. The Washington Correlator expects the release of the modules by the middle of January at the latest. At the time of writing nine CONT08 days have been completely correlated and temporary databases have been created and sent to the Analysis Coordinator, Axel Nothnagel, for a quality check. We do not expect major issues and hope to be able to report on the high quality results of the CONT08 campaign in the April 2009 issue of the Newsletter.

With the availability of the CONT08 media, it is planned to increase the observing rates of the rapid turnaround sessions. The R1 sessions will be increased from 256 Mbps to 512 Mbps and the R4 sessions from 128 Mbps to 256 Mbps. The increase is expected to be implemented in the second quarter of 2009.

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