GIPSY-OASIS II Newsletter

Fall 1995

CONTENTS

Editors Note

This edition of the GIPSY-OASIS II newsletter has been far too long in the making. Many thanks and my apologies to those who submitted material months ago.

Ken

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Obtaining GIPSY-OASIS II

GIPSY-OASIS II is available for research purposes to investigators at universities and research institutions. In order to install GIPSY-OASIS II at a institution, at least one person from the institution must take a 1 week course in the use of GIPSY-OASIS II, and an appropriate person at that institution must sign a license agreement with Caltech. Executables to run on Sun (Solaris 2.x) or HP 9000/700 series workstations area available via ftp after the requirements have been met.

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GIPSY-OASIS II class schedule

The schedule for 1996 is not set yet. If you are interested in taking or hosting a class in 1996 contact Ken Hurst (hurst@cobra.jpl.nasa.gov).

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Fourth release of GIPSY-OASIS II: August, 1995

The fourth release of GIPSY-OASIS II occurred August 16, 1995. The largest difference for most people will be the ability to use precise point positioning. Also, there are improvements to the GPS attitude model for those estimating orbits.

Precise point positioning is a new capability which enables analysis of data from a single GPS station entirely by itself using fixed precise orbits and GPS clocks from JPL. Identical, sub-cm ambiguity-free results are obtained as if the analysis were carried out in a conventional multi-station analysis using fixed precise orbits and GPS clocks. It is applicable anywhere in the world. Accuracies are slightly less in the southern Pacific, but are still as good as can be done in a multi-station mode. Analysis of a typical 24 hour day of data requires less than 2 minutes of CPU on an HP735 workstation. Precise point positioning can lead to greatly reduced analysis times for large numbers of stations.

The licenses for GIPSY were renewed this July. This time, the licenses are valid for 2 years instead of one. New licenses will expire 31-July-1997. The passwords for obtaining GIPSY-OASIS II were changed recently. Anyone having a valid license and needing access to the ftp area should contact Ken Hurst (hurst@cobra.jpl.nasa.gov).

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Precise orbital products available from JPL

Ken Hurst

JPL is now providing two sets of precise GPS orbits via ftp from sideshow.jpl.nasa.gov.

The regular Flinn analysis is available as soon as it is submitted to the IGS. It is available in SP3 format and in files to be read directly into GIPSY. These files are typically available 7-10 days after the end of the week. The accuracy of these orbits is 7-15 cm 3d RMS. These orbits have undergone several consistency checks and are the best we can do.

The second set of orbits is a rapid service product. It is typically available within 12-18 hours of the end of data collection each day. The daily orbit overlaps are in the range of 25-45 cm

3d RMS. These orbits are automatically generated and have not been through the careful consistency checks of the IGS submission. Never the less, eight months of experience has shown them to be of consistently high quality.

GPS orbits and clocks available via FTP from sideshow.jpl.nasa.gov	
directory	format/content
pub/jpligsac/wwww†	SP3 IGS sub
pub/gipsy_products/yyyy‡	gipsy IGS sub
pub/gipsy_products/RapidService	gipsy

†wwww == GPS week number (eg 0836)
‡yyyy == Year (eg 1995)

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Fiducial vs Non-Fiducial precise orbits - Why, how, and when to use them

JPL has recently started making available via FTP, non-fiducial precise GPS orbits and clocks. These are orbits, clocks, and polar motion estimates in which no station positions have been fixed or tightly constrained in order to fix the orbits in a particular reference frame. The main advantage of using these orbits is that it avoids the problems associated with merging solutions from multiple years which have been analyzed in multiple reference frames.

Why

In general, the transformations between realizations of the the various reference frames (eg ITRF92 to ITRF93) are not perfectly described by 7 parameters. Hence, in combining station positions expressed in multiple coordinate systems to obtain a velocity field, the presence of multiple coordinate systems can be a significant source of noise. If in addition, a station is constrained to an incorrect location when the orbits are generated (due to say an incorrect antenna height), the resulting orbits will be defective, particularly in the vicinity of the offending station. Subsequent use of the defective orbits to determine locations of other stations will result in unrecoverable errors in these locations.

In the non-fiducial approach, the orbits will not be perturbed by imperfect knowledge of any station coordinates because station positions are constrained only very weakly (13 stations to 10m, others to 100m). The relative geometry - the shape of the network and satellites orbits - is very well determined by the GPS data alone. The network orientation is only weakly determined. After the non-fiducial GPS solution is obtained, the network is rotated, translated, and scaled to align it with the selected reference frame and minimal internal constraints are applied to remove the effect of uncertainty of these 7 parameters from the uncertainties of the station locations.

The resulting solution has the advantages that 1) it is possible to express the solution in any reference frame with a simple 7 parameter transformation, and 2) the effect of imperfect knowledge of any one station location can be minimized. Thus, when plotting a multi-year time series of station positions, all the positions can be expressed in the best and most up-to-date coordinate system, and there will be no steps in the series due to changing coordinate systems. Station velocities will also not be contaminated by such steps.

How

There are two major steps to using the non-fiducial approach. The first step is to form the non-fiducial GPS solutions, and the second is to transform them into the desired reference frame.

To form the non-fiducial GPS solution using JPL precise orbits, ftp the non-fiducial orbits, clocks, and polar motion files from **sideshow.jpl.nasa.gov**. In the near future, either the Rapid Service orbits or the Flinn orbits which are submitted to the IGS may be used. (See the article entitled "Precise Orbital Products Available from JPL" for more info on these two products.) Be sure to use a consistent set from which ever source you chose. Do not for example use an eci file from the Rapid Service, and a clock (tdpc) file from the Flinn area. In the Rapid Service area for example you would
cd /pub/gipsy_products/RapidService/orbits and get:

1995-11-20.TPNML_nf.Z
1995-11-20.eci_nf.Z
1995-11-20.gps_clocks_nf.Z
1995-11-20.shadow_events.Z
1995-11-20.yaw_rates.Z

If you wish to use the IGS submission you would *cd /pub/gipsy_products/1995/orbits/* and get

1995-11-08_nf.eci.Z
1995-11-08.shad.Z
1995-11-08tpeo_nf.nml.Z
1995-11-08_nf.tdpc.Z

If your application requires the use of predicted orbits from the Rapid Service, clock files (*gps_clocks_nf.Z) will not be available. In this case you will need to solve for ALL the satellite AND station clocks (no reference clock).

You should then be able to use one of the strategies outlined in the article on precise point positioning, or a more conventional analysis with all stations together. The key item is that the reference clock should be set ALLGPS, and all satellite orbital parameters and satellite clocks should be fixed (ie not estimated).

The second step, putting the solution into the reference frame of your choice, involves applying a 7 parameter transformation to your solution.

At present, the only way to do this is to include several stations whose position is known in the desired frame in your solution. The theoretical minimum is 7 coordinates from 3 stations, but the more the better, up to about 15 stations. Most applications will be satisfied with 4-7 stations. These stations should have a global distribution. Common visibility with any other stations in the analysis is not required (and imposing such a requirement would probably make your station selection less global). The program *transform* will caculate a 7 parameter transformation to move one stacov file into the frame of an other, and then apply the transformation.

Soon, a second avenue will open. Then it will no longer be necessary to include known stations in your analysis, and the transformation will be more robust since it will be based on about 20 stations worldwide rather than 4-15 that were included in your analysis. Stay tuned. We will keep you posted as this second route becomes available.

When

We recommend using the non-fiducial approach for any analysis which will be used to create a multi-year time series or which may be required to be expressed in another reference frame in the future.

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DID YOU KNOW THAT... you will probably working with SINEX files in the near future?

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You might be interested to hear that soon you might be working with "SINEX" files. You are probably asking, "What is a SINEX file?" Curious? Then read on.

What does SINEX stand for? SINEX stands for "Software-INdependendent EXchange format". The name SINEX is intended to rhyme with RINEX ("Receiver-INdependent EXchange format"), and evoke a similar image.

What is the purpose of SINEX? The purpose of SINEX is to allow space geodesists to exchange their geodetic solutions, no matter what software they used to derive the solution. The philosophy is similar to RINEX, which allows us to exchange GPS data in the same format no matter which receivers were used.

What will a SINEX file contain? The SINEX file will contain not only a geodetic solution (parameter estimates and full covariance information), but also some information on how the solution was derived (data, software, analysts, dates, eccentricities, satellites, constraints, etc.).

Why is SINEX useful? It should become very straightforward to compare and perform datum transformation between solutions generated by different groups, different software, and even different techniques. With sufficient care (concerning data weights), solutions could even be combined.

For example, you should be able to read in somebody else's global network solution and use it to impose fiducial constraints on your regional solution.

As another example, the IERS Terrestrial Reference Frame (ITRF) could be distributed in SINEX format for this purpose. All that is required is that major software packages (such as GIPSY/OASIS II) be modified to read and write SINEX files.

What does SINEX look like? Like RINEX, SINEX is an ASCII file which is reasonably user-friendly. The user should at first sight be capable of interpreting most of the information without a format description. (Of course, format descriptions will be available). For GIPSY/OASIS users, you can think of SINEX as a STACOV file with additional information.

Why and how was SINEX conceived? SINEX has arisen out of necessity. The International GPS Service for Geodynamics (IGS) has recently been discussing ways to densify the terrestrial reference frame, and it quickly became clear that a common exchange format for GPS solutions would be essential to this task (Blewitt, Bock, and Gendt, 1993; Blewitt, Bock and Kouba, 1994; Blewitt, Bock and Gendt, 1995).

At a workshop hosted by the IGS Central Bureau at JPL in December 1994, it was recommended that a working group be tasked to produce SINEX. The IGS Governing Board accepted this recommendation, and a working group was appointed (G. Blewitt (chair), Y. Bock, C. Boucher, W. Gurtner, and J. Kouba).

Is SINEX just for GPS? Although originally conceived for GPS (specifically, IGS), the current intention is for SINEX to be applicable to GPS, VLBI, and SLR. We hope that SINEX will be generally accepted outside IGS and by techniques other than GPS. At a minimum, we expect SINEX to be in general use by analysts using any major high-precision GPS software in the near future.

What is the status of SINEX? Sinex version 1.0 is available and most major GPS analysis packages (including GIPSY-OASIS II) are capable of reading and writing it.

Keep an eye out for more news on SINEX. Now at least you will know something about it when you do!

References

Blewitt, G., Y. Bock, and G. Gendt, Regional Clusters and Distributed Processing, in Proc. of the IGS Analysis Center Workshop, Edited by J. Kouba,p. 62-91, Ottawa, Canada, igscb@jpl.nasa.gov (1993)

Blewitt, G., Y. Bock, and J. Kouba, Constructing the IGS Polyhedron by Distributed Processing, in Proc. of the IGS Densification Workshop, Edited by J. Zumberge, JPL, Pasadena, igscb@jpl.nasa.gov (in press, 1994)

Blewitt, G., Y. Bock, and G. Gendt, Global GPS Network Densification: A Distributed Processing Approach, submitted to Man. Geod. (1995).

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Precise Point Positioning

Ken Hurst

Precise point positioning is a newly developed technique for analysis of GPS data for precision geodetic purposes. It is capable of providing daily precisions of a few millimeters anywhere in the world. With precise point positioning, the amount of CPU time increases linearly with the number of stations, rather than geometrically as in conventional multi-station type analyses. Hence, it is well suited for precision analysis of large numbers of stations, or to rapid analysis of a few stations. On an HP735 workstation (38 Mflops) the analysis of a full day of GPS data from one station can be accomplished in 1-2 minutes of CPU time.

Precise point positioning uses precise GPS orbital and GPS satellite clock estimates from a global analysis. The GPS orbits and clocks are fixed (not estimated), and the stations are analyzed one at a time. The stacov files are then merged at the end to obtain the stacov file with all the stations, and/or the smcov files are merged prior to ambiguity resolution.

When both the GPS satellite orbits and GPS satellite clocks are fixed and not estimated, (and tropospheres are not correlated in the estimation strategy) all correlations between stations are zero. This enables us to break the solution up into N smaller estimation runs (N == number of stations) and obtain the identical estimates and covariances for the (bias free) station positions.

Ambiguity resolution for this case is still under development.

The Mechanics

The necessary files are generated by JPL and are available via anonymous FTP from sideshow.jpl.nasa.gov

There are three cases to consider: the "old" way, the "current" way, and the "Rapid Service" way.

We have provided a script *fetch_orbits* which takes care of most of the details presented below of retrieving the right files, uncompressing and if necessary manipulating and renaming them. *Fetch_orbits* will by default get non-fiducial orbits for a given day. It will get fiducial orbits or predicted orbits if given the appropriate switches. It is available in update_4.

The "Old" way:

These files were generated as part of the JPL IGS analysis effort. Examples of these files are:

clocks/1995-01-01CLOCK.Z
clocks/1995-01-01badCLOCK.Z
orbits/1995-01-01.eci.Z
orbits/1995-01-01tpeo.nml.Z

The program *pqm* ("prune_qm") should be run after *merge_qm* to delete data from the

QMfile for which the GPS satellite clock solution is not good (as given in the badCLOCK file).

If you are using xt-gipsy, you should

```
zcat 1995-01-01CLOCK.Z > CLOCK
zcat 1995-01-01badCLOCK.Z > badCLOCK
zcat 1995-01-01.eci.Z > peci
zcat 1995-01-01tpeo.nml.Z > tpeo.nml
```

Then use the fixed_precise_orbit+clock strategy of xt-gipsy

The "Current" way

These files are being generated as part of the JPL IGS analysis task. The orbit overlaps are 10-20 cm. They are available 1.5-2.5 weeks after data collection.

```
clocks/1995-11-12.tdpc.Z
clocks/1995-11-12_nf.tdpc.Z
orbits/1995-11-12.eci.Z
orbits/1995-11-12.shad.Z
orbits/1995-11-12_nf.eci.Z
orbits/1995-11-12tpeo.nml.Z
orbits/1995-11-12tpeo_nf.nml.Z
```

If you are using xt-gipsy, you should:

```
zcat 1995-07-28_nf.tdpc.Z > TDPfile
zcat 1995-07-28_nf.eci.Z        > peci
zcat 1995-07-28.shad.Z  > Shadow
zcat 1995-07-28tpeo_nf.nml.Z > tpeo.nml
```

Then use the fixed_precise_orbit+clock-TDP+Shadow strategy of xt-gipsy

The "Rapid Service" way

These files are generated by a separate process from the JPL IGS analysis They are typically available within less than 20 hours after data collection. The eci and TPNML files are predicted forward by 3 days. The orbit overlaps for these orbits are 30-45 cm for 0 days, 50-80 cm for 1 day, 150-200 cm for 2 days and about 300 cm for 3 day predictions.

```
1995-12-05.TPNML.Z
1995-12-05.TPNML.predict.Z
1995-12-05.TPNML_nf.Z
1995-12-05.eci.Z
1995-12-05.eci.predict.Z
1995-12-05.eci_nf.Z
1995-12-05.gps_clocks.Z
1995-12-05.gps_clocks_nf.Z
1995-12-05.shadow_events.Z
1995-12-05.yaw_rates.Z
```

If you are using xt-gipsy, you should:

```
zcat 1995-08-13.TPNML.Z > tpeo.nml
zcat 1995-08-13.eci.Z > peci
zcat 1995-08-13.gps_clocks.Z > TDPclock
zcat 1995-08-13.shadow_events.Z > Shadow
zcat 1995-08-13.yaw_rates.Z > YAWfile

yaw_rates2tdp YAWfile | tv2c - > TDPyaw
cat TDPclock TDPyaw | sort -n >> TDPfile
rm YAWfile TDPclock TDPyaw
```

Then use the fixed_precise_orbit+clock-TDP+Shadow strategy of xt-gipsy.

Any of these methods can be used for fiducial analysis using fixed orbits and clocks (see article on non-fiducial solutions). The files will have the same names except that there will be no _nf in the file name.

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GPS based research at IEEC

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Recently a non-profit consortium has been created between the Spanish Research Council (CSIC) and the three Universities of Barcelona (Universitat Politecnica de Catalunya, Universitat i de Barcelona and Universitat Autonoma de Barcelona). Its goal is to stimulate the development of the research in Space Sciences and Technologies. Two areas connected with GPS are geodynamical studies and ionospheric modeling.

Geodynamics

Our main activity has been in the frame of the Atlantic Eurogauge Project. This project is funded by the Science program of the European Union and coordinated by the Nottingham University (UK) with participation of Instituto Portugues de Cartografia e Cadastro (Portugal), the Institute Geographique National (France), the Instituto Geografico Nacional (Spain), the Ordnance Survey of Great Britain (UK), the Proudham Oceanographic Laboratory (UK), the University of Newcastle-upon-Tyne (UK) and the CSIC (Spain).

Two independent GPS measurement campaigns have been performed during the periods 15-19 November 1993 and 14-18 March 1994. The data was collected at 16 Atlantic and Mediterranean tide gauges. We have analyzed this data in concert with the data obtained simultaneously with the International GPS Service for Geodynamics (IGS) using GIPSY with strategies based on the non-fiducial approach. Preliminary results shows repeatabilities and inter-campaign agreements below 1 cm for the radial component. See for details of the processing strategy Rius et al 1995.

Ionosphere

Another line of research is the application of the GPS observables to the production of global ionospheric models for electromagnetic propagation. The use of Turboedit and PhasEdit, for the detection of cycle slips, has allowed the extension of our previous work on global ionosphere modeling (see Sardon et al (1994a),Sardon et al (1994b)) by including a greater number of stations and allowing to process data in A/S conditions. An example of a global TEC model is shown in figure 1.

Figure 1:

Global Ionospheric Radial TEC (10**17 e/m**2) as a function of the Right Ascension (from 0 to 360 degrees) and the Declination (from 25 to 80 degrees) during the day 15th November 1993. The Sun, which is outside this plot, has right-ascension and declination of (230, -18) degrees respectively. (*The figure is in a seperate mail message, and is also available via anonymous ftp from sideshow.jpl.nasa.gov*).

References

Sardon E., A. Rius, N. Zarraoa (1994a): "Ionospheric calibration of single frequency VLBI and GPS observations using dual GPS data", Bulletin Geodesique, 68, 230-235.

Sardon E., A. Rius, N. Zarraoa (1994b): "Estimation of the transmitter and receiver differential biases and the ionospheric total electron content from Global Positioning System observations", Radio Science, Vol 29, Number 3, Pages 577-586,

A. Rius,J.M.Juan, M.Hernandez,A.M.Madrigal (1995) Measuring geocentric radial coordinates with a non-fiducial network", Manuscripta Geodetica (accepted). A preprint postscript compressed version can be anonymous ftp'd from mach.laeff.esa.es at the directory /pub/users/rius as files radial.*.

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Accurate Height Determination in The Netherlands

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In 1990, the Survey Department of the Directorate-General for Public Works and Water Management organized the NEREF/MAREO (NEtherlands REference Frame, MAREO indicates the maritime application) GPS campaign to establish a network for monitoring the vertical movements of tide gauges along the Dutch North Sea coast. In 1991, another GPS campaign (called NEREF) was organized to establish a 3-D reference frame in the Netherlands, and to find transformations between coordinates referring to different datums, also internationally, to a geocentric datum. Additionally, the NEREF 1991 campaign was organized to generate a second coordinates solution in a series, which is required before any conclusions about height changes can be drawn.

NEREF/MAREO was carried out in the period 17-27 July 1990. During this two-week period, two types dual-frequency Trimble receivers (SLD and 4000 SST), 8 in total, were deployed at the most important tide gauges along the Dutch North Sea coast, and at the well-known EUREF-sites: Westerbork, Kootwijk, Delft, Huisduinen, Oostende (Belgium), and Pilsum (Germany).

The complete network consists of 16 points, and was divided into 4 smaller, overlapping sub-networks. The EUREF-stations Kootwijk (co-located with SLR) and Westerbork (collocated with VLBI) were part of each subnetwork. Five of the Trimble receivers were kindly submitted by the Faculty of Geodetic Engineering (DUT), the Triangulation Department, and the Landesvermessung Hannover. Both types of receivers recorded carrier phase measurements on both L1 and L2, and C/A-code pseudorange measurements on L1. Those measurements were recorded at 15 s intervals for about 6.5 hours per day at each site.

At the time of the campaign, the GPS constellation consisted of 6 operational Block I satellites (SV 3, 6, 8, 9, 10, 11), and 7 Block II satellites (SV 13, 14, 16, 17, 18, 19, 20), all of which were observed. It should be noted, however, that the Trimble SLD and 4000 SST receivers could only track 5, respectively, 8 satellites simultaneously.

The Section Space Research & Technology analyzed the measurements from the NEREF/MAREO 1990 GPS campaign, and investigated the use of GPS for accurate height determinations in the Netherlands. The acquired results show that the accuracy of the most computed heights, based on comparisons with results from the Faculty of Geodetic Engineering (DUT) [Mulder93], is at a level of about 14 mm. Thus, sufficiently accurate to serve as a first result in a series of future-determined height components.

The analyses also show that the accuracy of the computed heights is affected by the active Selective Availability in combination with the data sampling interval of the used Trimble receivers (ie, data sampled on integer multiples of 256 milliseconds of the GPS week). Successful ambiguity resolution could not be performed, because the daily networks did not consist of a sufficient mix of baseline lengths, P-code pseudorange data were not available, and the nominal GPS orbits (derived from orbits computed by the National Geodetic Survey (NGS)) were not improved.

A detailed description of the analyses can be found in [Overgaauw93 and Overgaauw95].

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Monitoring the Oosterschelde Stormsurge Barrier with GPS

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After the flood disaster of February 1953, the Dutch Delta works were initiated to provide reliable protection to the lowland delta area in the Southwest of the Netherlands. The stormsurge barrier in the estuary of the Oosterschelde not only completed these Delta works, but is also by far the largest and most spectacular structure of the Delta works.

In the initial plans, the estuary of the Oosterschelde was to be closed by a massive dam. In 1976, after considerations on environmental aspects, the Dutch government decided not to construct a massive dam but a hydraulic structure. It took a little over ten years to realize this, in many aspects, unique structure: the barrier does not interrupt the tidal movements, except in the event of severe storm floods when it closes.

The behavior of large engineering structures such as the Oosterschelde stormsurge barrier has been traditionally monitored geodetically by triangulation and trilateration techniques which provide direct, precise measurements of position displacement as a function of time. However, these techniques are quite expensive and are therefore only repeated periodically and generally in cases where there is suspicion of impending structural distress.

Improvements in the technology of the GPS receivers (eg, more channels and a better signal-to-noise ratio), the completion of the GPS satellite constellation, and the availability of precise IGS orbits, have resulted that GPS techniques probably also yield sufficiently accurate results to monitor the possible deformations of the stormsurge barrier. Therefore, the Section Space Research & Technology (DUT) and the Kootwijk Observatory for Satellite Geodesy (DUT) organized three GPS campaigns (19-23 July 1993, 19-28 November 1993, and 31 May - 8 June 1994) to investigate the possibility to monitor the possible movements, induced by ebb and flow, of the Oosterschelde stormsurge barrier.

During the three campaigns (called DEMOO: DEtermination of possible MOvements of the Oosterschelde stormsurge barrier), 3 TurboRogue SNR-8000 receivers (TR) were deployed at sites on and near the Oosterschelde stormsurge barrier, and 1 TR was deployed at the EUREF-marker in Delft. During the first DEMOO campaign, another TR was also deployed at the EUREF-marker in Huisduinen, in order to compute new coordinates of that monument. The network has been extended with the permanent IGS sites Kootwijk, Brussels, and Wettzell to obtain a regional network (longest baseline 700 km).

Besides the two TurboRogues from DUT, two TurboRogues from the Royal Observatory of Belgium (Brussels) were used. During the first campaign, another TR was borrowed from the National Aerospace Laboratory (Amsterdam). The Kootwijk Observatory for Satellite Geodesy provided the ancillary equipment, set up the antennas and controlled the network.

Measurements were recorded at 30 sec intervals for 24 hours per day, at each site, with a minimum elevation angle of 15 degrees. Selective Availability was off during DEMOO-01, and Anti-Spoofing was on during DEMOO-03. At the time of DEMOO-01, the GPS constellation consisted of 3 Block I and 20 Block II satellites, during DEMOO-02 it consisted of 3 Block I and 22 Block II satellites, and during DEMOO-03 the constellation was almost completed (1 Block I and 24 Block II satellites).

Spectral analysis techniques on 2-hourly arc solutions, and comparisons of the estimated heights with sea-level heights from tide gauge measurements, seem to indicate diurnal and semidiurnal movements of the stormsurge barrier with amplitudes of about 2 mm. These apparent motions can be due to ebb and flow, but can also be due to the unresolved errors in the GPS orbits, variations in the meteorological conditions, and multipath. It must be noted that leveling measurements performed by the Survey Department of the Directorate-General for Public Works and Water Management did not indicate any significant movements.

In conclusion, although a few conventional techniques may yield higher accuracy, permanent GPS arrays and/or frequent reoccupations of short-range networks with GPS receivers have been shown to be viable tools for rapid and dense millimeter-level measurements of heights, which will ultimately yield values for the vertical motions of construction works or reference stations. More details are presented by [Overgaauw94,Overgaauw95].

References

[Mulder93] Mulder, J. E. V. and H. van der Marel, Analysis of the first measurement of the NEREF/MAREO GPS Network 1990, Delft University of Technology, Faculty of Geodetic Engineering, The Netherlands, 1993.

[Overgaauw93] Overgaauw, B., Accurate Height Determination in the Netherlands using the Global Positioning System, Contract no. MD499, Delft University of Technology, Faculty of Aerospace Engineering, The Netherlands, November, 1993.

[Overgaauw94] Overgaauw, B., Monitoring the Oosterschelde Stormsurge Barrier with GPS, in: Land subsidence monitoring with SAR Interferometry (in press), Delft University of Technology, Faculty of Aerospace Engineering, The Netherlands, 1994.

[Overgaauw95] Overgaauw, B., Towards Millimeter-Level Accuracy in GPS Positioning Applications, PhD thesis, Delft University of Technology, Faculty of Aerospace Engineering, The Netherlands, 1995 (in press).

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PhaseEdit

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An updated version of PhaseEdit is available by anonymous ftp to any of the following machines: cotopaxi.stanford.edu, arena.stanford.edu, kilauea.stanford.edu, hilina.stanford.edu, or sinbad.stanford.edu. On all of these machines, the file is called phasedit.tar and is located in the pub/outgoing directory.

(Ed. Note: It is also available as phasedit2 in update_4. It has seen limited use at JPL as yet, so we should all trust and thank Jeff.)

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Rogue Pseudo-Range Observations and Clock Estimation

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Undifferenced processing of phase and pseudo-range data as is used by the GIPSY software, has the advantage of producing precise estimates of receiver and transmitter clocks. These clock solutions can be utilized along with precise orbits and simple software to perform point positioning. Since the precision of the point positioning is a function of the satellite clock estimates' precision, it pays to produce good quality clock estimates. One way to improve the quality of the clocks produced by GIPSY is by processing precise pseudo-range observations along with the carrier phase observations. Unfortunately, precise P-code pseudo-range observations are no longer available to most users since Anti-Spoofing (AS) was permanently activated; C/A code pseudo-ranges must, therefore, be used. The quality of the C1 and reconstructed P2, by cross-correlation, produced by Rogue receivers in AS mode tracking is still quite good - 30 to 40cm in a low multipath environment versus the 10 to 20cm for non-AS real P1 and P2 observations. The C1 and reconstructed P2 observations are, however, biased with respect to the L1 and L2 carrier phase observations and must, therefore, be corrected if they are to be properly combined with carrier observations in GIPSY processing.

As part of our IGS daily processing at Natural Resources Canada (NRCan), formerly EMR, we have computed pseudo-range bias corrections for the subset of IGS stations equipped with Rogue receivers running MEENIX V7.8 or TurboRogue receivers. These bias corrections have been obtained using the mean post-fit residuals taking into account that SV10, a Block I satellite operating in non-AS mode only, has a zero bias. These biases are fairly stable but may be affected by receiver resets and must therefore be monitored for any variations. Table 1 lists average biases used on January 31, 1995 along with the type of receiver and firmware version. Table 1 also lists RMS of the biases about the mean due to satellite or tracking channel variations.

The pseudo range bias corrections are introduced in the GIPSY processing stream in NINJA. We have modified NINJA to accept a new namelist containing satellite specific biases as well as start and stop times for which the biases are to be active. The time window feature is especially useful when AS is turned on and off which still occasionally happens.

Table 1
Mean Bias Corrections for Ionospheric Free Combination of C1 and P2

Station	Average Bias/RMS (m)	Receiver	Firmware
ALBH	0.591/0.148	ROGUE SNR-8000	Turbo 3.0.32.2
ALGO	1.259/0.179	ROGUE SNR-8000	Turbo 3.0.32.2
AREQ	0.031/0.179	ROGUE SNR-8000	Turbo 2.8.32
DAV1	2.332/0.114	ROGUE SNR-8100	Turbo 2.8.1.1
DRAO	-1.303/0.139	ROGUE SNR-8000	SFG2 (beta v. 3.0)
FAIR	25.906/0.216	ROGUE SNR-8	Meenix 7.8
FORT	-0.635/0.171	ROGUE SNR-8000	Turbo 2.8
GOLD	21.090/0.304	ROGUE SNR-8	Meenix 7.8 (DSN)
HART	19.516/0.310	ROGUE SNR-8	Meenix 7.8
KIT3	0.798/0.916	ROGUE SNR-8000	Turbo 2.8.32
KOKB	22.026/0.215	ROGUE SNR-8	Meenix 7.8
KOSG	24.125/0.227	ROGUE SNR-8	Meenix 7.8
MADR	24.374/0.252	ROGUE SNR-8	Meenix 7.8 (DSN)
MCM4	-0.204/0.167	ROGUE SNR-8000	Turbo 3.0
RCM5	0.405/0.173	ROGUE SNR-8000	Turbo 3.0.32.2
SANT	31.197/0.181	ROGUE SNR-8	Meenix 7.8
STJO	-0.654/0.221	ROGUE SNR-8000	Turbo 2.8
TAIW	-1.014/0.146	ROGUE SNR-8000	???
TIDB	19.474/0.250	ROGUE SNR-8	Meenix 7.8 (DSN)
TSKB	-0.614/0.191	ROGUE SNR-8000	Turbo 2.8
WETT	11.423/0.272	ROGUE SNR-8	Meenix 7.8
YAR1	19.150/0.227	ROGUE SNR-8	Meenix 7.8
YELL	0.915/0.148	ROGUE SNR-8000	Turbo 2.8.32.1

□