GIPSY-OASIS II Newsletter

Volume 1 Spring 1993 Number 1

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Editor's note

This is the first GIPSY-OASIS II newsletter. If it is found to be useful, I will publish future issues on an irregular basis. Comments, suggestions, and items for inclusion can be sent to: Ken Hurst, MS 238-600, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91190, hurst@garlock.jpl.nasa.gov Voice: (818) 354-6637 FAX: (818) 393-4965

Many thanks to the several people who contributed to this issue.

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Obtaining GIPSY-OASIS II

In order to install GIPSY-OASIS II at a institution, we ask that at least one person from the institution take a 1 week course in the use of GIPSY-OASIS II, and that an appropriate person at that institution sign a Memorandum of Understanding (MOU) with JPL. The MOU basicly states that GIPSY-OASIS II comes without warranty, that it may not be transferred further, that it is a research tool, and that JPL has a right to any changes or enhancements to the software. Either source code, or executables, or both are available free of charge via ftp after the requirements have been met.

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GIPSY-OASIS II class schedule

In order to meet the growing demand for GIPSY-OASIS II training, we have been conducting 1 week classes in various parts of the world. To date we have run classes at JPL and at Haystack Observatory in Massachusetts. The schedule for classes is given below. To inquire about setting up a class in a certain geographic area, contact Ken Hurst (hurst@garlock.jpl.nasa.gov [818] 354-6637) or Geoff Blewitt (geoff@cobra.jpl.nasa.gov [818] 354-7514).

date	location	space
3/29 - 4/2, 93	TU Delft	FULL
4/5 - 4/9, 93	Chalmers U.	FULL
7/8 - 7/14†	U. Colorado†	yes
fall/winter 93	W. Pacific	yes
winter/spring 94	Eastern USA	yes

†Tentative date and place.

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Second release of GIPSY-OASIS II: May, 1993

The second release of GIPSY-OASIS II is planned for mid May, 1993. The new release will contain new programs such as ambigon2, clockprep, genoif, exnav, qm_arc, qm_sum, gps2utc, utc2gps, and others, as well as improved versions of most programs. The most significant additions are the ambiguity resolution in ambigon2, and the ability to use FLINN orbits for regional analysis. The ability to use FLINN orbits significantly reduces the CPU time and disk space required to analyze regional GPS data.

E-mail will be sent out advising when the software is available on BODHI.

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FLINN analysis at JPL using GIPSY-OASIS II

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In support of NASA's Dynamics of the Solid Earth (DOSE) Program, and as part of our contribution to the the International GPS Geodynamics Service (IGS), analysts at JPL have, on a daily basis since 1992 June 21, reduced GPS data from a global network of Rogue and TurboRogue GPS receivers. Shown in the Table is the distribution by continent of the current total of thirty-seven Rogue (or TurboRogue) receivers. Within the next one to two years, an additional six or so sites will likely be in operation.

Continent	Number of Continuously Operating Rogue receivers
North America	16
South America	2
Europe	10
Asia	4
Australia	2
Africa	2
Antarctica	1
Total	37

The current analysis operation at JPL can be summarized as follows:

(1) query the GNOG (JPL's GPS Network Operations Group) data archive to see whether sufficient data exist for analysis of a particular day

(2) launch a Unix C-shell script which performs an end-to-end GOA-II analysis of that day's data

(3) collate a week's worth of such analyses

(4) use orbit repeatability, polar motion, and length-of-day estimates as quality control checks

(5) re-process any days for which there are problems

(6) submit a week's worth of products

Comparison of our results with other centers using different software indicates agreement in GPS ephemerides at the sub-meter level. Based on our own orbit repeatability (the degree to which position estimates from adjacent days agree near midnight), we believe our orbit product is accurate to about 30 cm.

In addition to precise GPS ephemerides, current FLINN products for external distribution include daily estimates of pole position length-of-day, with estimated accuracies of 0.6 milliarc seconds and 0.1 msec, respectively.

Other products which will be available in the near future will include station and satellite clock estimates, stochastic troposphere estimates, and stochastic solar radiation pressure estimates.

Near- and medium-term work at JPL will concentrate on methodology for using precise ephemerides in analysis of data from regional GPS networks.

JPL FLINN products can be accessed via the GNOG's BODHI computer. Contact starr@logos.jpl.nasa.gov for account information.

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Using Trimble and Ashtech receivers with the GIPSY-OASIS II software

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There are a number of misconceptions about Trimble and Ashtech receivers (such as, "Trimble receivers can't give the same precision as Rogue receivers"), and many times I have been asked "Can you use GIPSY with Trimble data?". There are only a few differences in the analysis strategy with these receivers; the changes involved are simple but important. The differences are mostly in the preprocessing stage - only one small change is required when running filter.

It is no longer accurate to refer to all Trimble or Ashtech receivers as "codeless receivers". Both companies now make dual- frequency P-code instruments which retain dual-frequency P-code when AS is turned on. Up until early 1992, both Trimble and Ashtech produced only receivers without P-code capability. These receivers would track L1 by correlation of the C/A code, and L2 by squaring the L2 signal (the receivers also used information about the changes in the L1 signal to help in tracking L2). This type of tracking produces reliable L1 phases, but cycle slips in L2 are common. Also, the L2 ambiguity is half-integer (and L2 cycle slips can be half-integer). The current receivers track full-wavelength L2 and dual-frequency P-code.

Data Editing

With codeless receivers, the TurboEdit algorithm cannot be used since there is no dual frequency P-code. Over the last three years, I have been developing the PhasEdit program. PhasEdit is an automatic editing program for codeless data. It is completely automatic like TurboEdit, and is nearly as successful. It will identify virtually all cycle slips, and will either fix them or flag them as unrepairable. Due to the limited data types available, it will only fix L2 slips when L1 has no slip. Since L2 slips are far more common than L1 slips, this restriction is not too severe. Based on a large sample of data, I estimate that its failure rate is roughly 5

times that of TurboEdit. A failure here is defined as a station-day of data which requires manual correction to the editing (or the use of edtpnt).

I have found that TurboEdit is sometimes ineffective in automatically editing data from the P-code Ashtech receivers. I have not tried it on P-code Trimble SSE receivers. The problem appears to be that these receivers can have small cycle slips which are below TurboEdit's detection threshold. The data I tried came from June and July 1992, and updates to the receiver firmware may have improved this situation. I found that PhasEdit was more reliable for editing this data because it has a much tighter detection threshold than TurboEdit.

If a file has been edited with PhasEdit (which reads a RINEX file and writes out a cleaned RINEX file), ninja should be run with the -noedit option. Otherwise, ninja will ignore the loss of lock flags and attempt to run TurboEdit. No other changes are required when running ninja.

Clock Offsets

The most important difference between Trimbles/Ashtech and Rogue receivers is in the method used to keep the oscillator synchronized with GPS time. Both Trimble and Ashtech use low-cost oscillators in their receivers. The drift rate of these oscillators is typically in the range of 3-4 milliseconds per hour. While tracking, the receiver continuously updates its estimate of the oscillator's offset from GPS time. When the oscillator error reaches 1 millisecond, a software counter is incremented or decremented so that the system (millisecond counter + oscillator) remains within 1 millisecond of GPS time. This makes for 1 millisecond discontinuities in the clock errors, and 1 light millisecond discontinuities in the observables.

So the receiver clock error is a sawtooth-shaped function of time, with a few discontinuities each hour. Unfortunately, the observables produced by the receiver are not in complete agreement with the clock error. The raw code measurements contain the complete clock error (counter + oscillator), and contain discontinuities of 1 light millisecond. The phase measurements are taken at the same time as the code measurements but do not contain the discontinuities. They can be made to agree with the code measurements by adding ((1 light millisecond) * (accumulated milliseconds)) to the phases. The accumulated milliseconds can be determined easily from the code measurements. Once this change is made, data from these receivers can be analyzed with GIPSY II in the normal manner.

Unfortunately, the RINEX converters (the programs which convert the raw data to RINEX) do not make this change - but instead make another change to the raw data. The RINEX converters remove the discontinuities from the code measurements and change the time tag of the data by 1 millisecond at each clock discontinuity. This change is made because it is more convenient for the Bernese software (the Bern group wrote the converter programs), and within the Bernese software the time tags are restored to their proper values. Bernese, and other double-differencing softwares, always make a clock correction to the phases no matter what receiver the data comes from, so their action makes more sense when taken in that context (although I disagree with it). The RINEX converters also have the option to convert the files without making any changes; however, these files are still not usable with GIPSY II unless the proper correction to the phase is made.

If RINEX files are used in GIPSY II without modification, the probable result will be an incorrect answer because the time tags on the RINEX file are not the times at which the data was taken, and this induces an error in the partial derivatives which will grow with the number of accumulated milliseconds. Residuals may be anomalous, but may be close enough to "normal" that they will not stand out. The problem can be detected by comparing the time tags of the data - unmodified RINEX files will seem to have the time tags moving farther and farther from the integer GPS second as time goes on. When I first learned about this, it was causing a 2 cm bias in the east component on a 25 meter baseline. I don't know if the problem would grow with baseline length, but it is safe to assume that there will be an error of at least a few centimeters caused by this problem.

The solution is to undo what the RINEX converter did, and make the proper adjustment to the phase (that should have been done in the first place). It is very easy to detect the offsets in the time tags, so the correction can be made automatically. The program to do this is called ClockPrep. ClockPrep automatically determines

what correction needs to be made, and makes an output file which has the corrections. When it is not sure what to do it prints a warning and outputs an unchanged file. ClockPrep will not harm a file if it is run when it is not necessary. Once ClockPrep is run, the data can be used in GIPSY II without further changes.

Constraints on Phase Ambiguities

The idea of applying constraints on the phase ambiguities instead of analyzing pseudorange data is not new. It was proposed in 1988 by Geoff Blewitt and Ulf Lindqwister (JPL IOM 335.4-88-149). The P-code or C/A-code pseudorange data can be used to estimate approximate values for the phase ambiguities which are accurate to within a few cycles. Both TurboEdit and PhasEdit automatically make this adjustment. Applying a 1 light millisecond a priori sigma (instead of the typical sigma of 1 light second) to the ambiguities without using pseudorange data gives an answer which is almost as precise as if the pseudorange data are used. There is a small but measurable improvement in precision when pseudorange data are used.

Codeless receivers do not have dual frequency pseudorange measurements. However, the ambiguity constraint approach can still be used, and produces results which are almost as good as if the receivers had pseudorange data available. When only phase data are used without ambiguity constraints, it is difficult to estimate the ambiguities because they are very highly correlated with the clock error. The improvement in precision as a result of ambiguity constraints can be as much as a factor of 3-5, principally in the baseline east component.

At present, constraining the ambiguities requires hand editing of the Batch input file for filter. I have made a small modification to my version of preprefilter which allows me to set the a priori sigma and stochastic sigma for the phase ambiguity parameters in the $PREP namelist. The change is very small, and could easily be made in the official version as well.

Conclusions

By applying the techniques described above, I have routinely analyzed data from codeless receivers, and from P-code Trimbles and Ashtechs. In a global scale network, there is no observed difference in precision between Rogues and Trimbles/Ashtechs. P- code receivers produce slightly better results than codeless receivers, much better when ambiguities can be resolved for the P- code receivers. Ambiguity resolution in codeless receivers remains problematic except for short baselines.

PhasEdit is available from the author. Send email to jeff@pangea.stanford.edu to request a copy.

ClockPrep is available from the author or from JPL. JPL may not always have the most recent version, although I attempt to keep them updated (most source files in the current version were last modified on October 9, 1992). If there is any question, please send me email.

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FLINN GPS data analysis using GIPSY-OASIS II at CGS, Canada

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Three persons are actively working on improvements on our utilization of GIPSY-OASIS II on an HP700 series machine. The three people are Jan Kouba, Geological Survey of Canada; Remi Ferland and myself both at the Geodetic Survey of Canada. In addition, one person is helping with the day to day IGS operations.

We are still using the pre-release May 92 test version we got from JPL. We fixed the obvious bugs in this pre-release version such as hard coded leap seconds, satellite arrays too small as well as the required changes needed to accommodate the switch from prn32 to prn1. I did retrieve a more recent release from BODHI back in December but did not have time to integrate it into our automation scripts.

Significant enhancements

We have developed a suite of scripts and fortran code to automate the daily processing as much as possible. We have recently incorporated automatic selection of the previous day's GIPSY solution or broadcast ephemerides for OAPV (*genoi for most users*) on a satellite basis. Satellite apriori weights are adjusted accordingly (1m previous solution / 1km broadcast). We have also added greater flexibility for weighting (i.e., we can now assign data weights per station and satellites).

We are now working on a different clock strategy - i.e., using previous solutions in order to apply tighter constraints.

We are resurrecting STAPOS for the ACCUME format and adding some more statistical flexiblity.

Weighting of Rogue phase and pseudorange data.

A careful look at GIPSY residuals has confirmed phase deterioration in a similar fashion at low elevation angles as code. We are using the following expression to compute sigmas of a code or phase observation:

$$\sigma(z) = \sigma_0 + \sigma_1 e^{(-z/z_0)} \qquad (1)$$

Where z is the elevation angle. For most stations we use these values:

	phase	code
σ_0	3 mm	120 mm
σ_1	10 mm	600 mm
z_0	20 deg	20 deg

The namelists and corresponding routines have been modified to accommodate this.

Estimation strategies

Almost from the beginning we have stayed away from using broadcast orbits as aprioris. We are using the previous day's solution mapped for the beginning of the next day and using 1, 0 and 1 as apriori for GX,GY and GZ. This avoids the problems of large and unreasonable values resulting from a tragedy fitting, possibly causing serious problems at filter and other stages.

Recently we have started to estimate DUT1 as well. This is accomplished by constraining the orbit apriori at 1m/.5mm/s which is approximately equivalent to stochastic (random walk) model of (1m/.5mm/s)/sqrt(1day) as the formal orbit sigmas are about an order of magnitude smaller.

For apriori DUT1R we use the current USNO Bull A corrected for DUT1S, and once a week we fix the USNO DUT1R and solve for the unconstrained orbits. (We have a program to generate apriori EOP namelists from USNO bull A)

The automated script for daily reductions have been improved considerably, we can now downweight or exclude specific stations/data; specify a different paths for namelists and/data, generating corrected orbits and EOP, etc.

AS data

We have spent considerable effort on this popular problem, and are now able to get relatively good results. The problem turned out to be considerably more difficult than expected, mainly due to receiver bugs, multipath, and higher data noise.

Since the truncation of AS data in the RamManager on the Rogue receiver was identified by JPL we have been downloading data from DataManager, and assuming that data from the three DSN sites (GOLD,MADR,TIDB) are also correct. This necessitated some changes, namely the capability to delete some satellites at specific stations . We have included this in NINJA namelist where we can now delete the undesired sv's (AS satellites at all stations except for the Canadian and DSN stations) *[Ed. Note: This same effect can be accomplished using the del_qm utility which may not have existed when EMR got the pre-release version of GIPSY-OASIS II.]*

Another hardware problem we were unaware of was the bias between C1 and P1 observable. Namely there is a constant [receiver dependent] offset (sometimes up to 10 m) between C1 and P1 pseudoranges. *[Ed. Note: This difference on Rogues is understood, and unlikely to be eliminated.]* This is of course serious when we mix P1 and C1 on AS days. We correct C1 pseudoranges for these offsets again through namelist at the NINJA stage. (By the way we've just received our TURBOROGUES and noticed a large ~ 130m difference between C1 and P1 pseudoranges, this time constant for all receiver. We were under the impression that this problem does not exist for TurboRogues!) *[Ed. Note: The difference between C1 & P1 on TurboRogue is understood, and has been corrected in firmware compiled since December 1992]*

Another modification required for AS data was also in NINJA, where it does widelaning, namely when the widelane(wl) correction exceeds 1.0 wl and/or k*sigma(wl) which is almost always the case, NINJA creates a lot of artificial widelane slips which does a lot of damage latter on for the narrow laning. In the test we have simply excluded the 1.0wl window and relying on the sigma test only which

improved NINJA performance for AS data (though likely not as reliable as for non AS due to much higher phase noise)

The last modification required for AS data was allowing different sigmas for specific (i.e. AS) satellites, again in the same fashion as for exponential weighting the namelists and corresponding routines were modified to accommodate this. The limitation here is that the SV has the same weight for all stations and this overrides any different weighting at a particular station. Currently for AS data we also use the exponential weighting corresponding to σ_0 of 12mm for phase and 1000mm for pseudoranges.

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Porting GIPSY-OASIS II to an IBM RS6000 running AIX

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Boudewijn Ambrosius at the Delft University of Technology has ported GIPSY-OASIS II to an IBM RS6000 running AIX. The port was accomplished during the month of January, 1993. For reference, GIPSY-OASIS II consists of over 400,000 lines of source code (comments included).

The upcoming GIPSY-OASIS II training class to be held at Delft March 29 - April 2, will use the IBM machines.

Boudewijn has sent us the changes he made, and we are in the process of including as many as are feasible in our version. Since we do not have an RS6000 here at JPL, we can not promise to maintain near transparent portability as we are with Sun and HP computers. We will continue to work with Boudewijn to make the port of future releases as simple as possible.

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Accessing JPL FLINN Analysis results and GIPSY-OASIS II software releases

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The JPL GPS Network Operations group provides access to data directories for raw and RINEX format data, and data products as well as software through requests. The data and released software is available through login only. Currently data is available online for the previous 180 days and is stored in a compressed format. The compressed format is compatible with most flavors of UNIX compressors. Logins are available for the asking, it may take a while to establish a login as it is done on a time available basis. To obtain a login send the following information to "starr@logos.jpl.nasa.gov": Your name, address, phone number, fax number, user name, IP address of computer(s) you will be using to access our guest computer, and complete E-mail address as some gateways to do not provide correct return address information. A brief description of the work you are doing and the type and frequency of data retrieval will be helpful. You will receive via the provided E-mail address instruction on how to access our guest computer and account information. The README files will explain how to use the service.

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