GIPSY-OASIS II Newsletter

Volume 1 Fall 1993 Number 2

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Editor's note

Comments, suggestions, and items for inclusion can be sent to the editor: Ken Hurst, MS 238-600, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, 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. .ce □ .B .sp .sp .ce GIPSY-OASIS II class schedule .PP The schedule for future GIPSY-OASIS II 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)

date	location	space
May 16 - 20, 94	GSFC Greenbelt Md	yes
second half of 94	Japan	yes

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GIPSY-OASIS II meeting at Fall AGU

There will be a meeting for past, current, and future users of the GIPSY-OASIS II GPS analysis software.

Thursday Dec 9,1993 7:00 - 9:00 PM
Twin Peaks Room - Ramada Hotel
1231 Market Street
San Francisco

Topics to be discussed will include

- Announcement and discussion of impending upgrade which includes
  - Low Earth Orbiter package
  - xt-gipsy: a GUI interface for GIPSY-OASIS II
- New anonymous ftp service for dissemination of data, products, and information.
- New ftp distribution of GIPSY-OASIS II software
- State of a Solaris 2 version of GIPSY-OASIS II
- Discussion of topics brought up by non-JPL users

It has been roughly one year now since the first release of GIPSY-OASIS II took place. In that time 23 institutions have started using it. I see this as an opportunity for us at JPL to get some feedback from the growing user community. Hence I expect the structured announcements/presentation to be rather short, followed by a more lengthly discussion of users perceptions, needs and desires.

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Second release of GIPSY-OASIS II: July, 1993

The second release of GIPSY-OASIS II happened in July of 1993. The new release contained new programs such as clockprep, genoif, qm_arc, qm_sum, gps2utc, utc2gps, and others as well as improved versions of most programs. The most significant additions are the ability to analyze data from Low Earth Orbiters, 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.

We are in the process of preparing an update which contains a number of new programs and scripts which will greatly ease the processing of Low Earth Orbiter data and an easy-to-use, easy-to-learn Graphical User Interface (GUI) for typical geodetic applications. This update will be released in December 1993 or perhaps early January 1994.

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Accessing JPL FLINN analysis results, JPL reports and papers, and GIPSY-OASIS II software releases

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Starting Dec 1, 1994, it will be possible to use anonymous ftp to get FLINN analysis results JPL reports and papers, and GIPSY-OASIS II software releases from sideshow.jpl.nasa.gov (128.149.70.41). Information available will be: precise orbit files (SP3 exchange format and eci format for use with GIPSY-OASIS II), station locations, clock files, tropospheric delay files, postscript-format copies of JPL reports and papers, and perhaps others. At present the precise orbits and a paper are available. The other products will be added over the next month or two.

To access a information stored on the ftp server via anonymous ftp:

1 ftp sideshow.jpl.nasa.gov *(128.149.70.41)*

2 Log in with user name anonymous.

3 Please put in your e-mail address for the password

From here several directorys to choose from.

igscb/
Lots of useful information beyond the scope of this newsletter.

pub/
jpligsac/
JPL IGS products in exchange formats.
gipsy_products/
FLINN analysis products for direct use in regional campaign analysis using GIPSY.
PS-DOCUMENTS/
JPL papers and reports which may be of interest to members of the GIPSY-OASIS II community.

The GIPSY-OASIS II software is available via named ftp from the same source. Institutions which have met the requirements for obtaining GIPSY-OASIS II should already have received directions for using this ftp service via electronic mail.

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GIPSY-OASIS II e-mail hotline

There is a new e-mail address for questions about GIPSY: *gipsy@cobra.jpl.nasa.gov* This mail drop will make sure someone reads the gipsy mail even if the primary mail-handler is not available. People may of course still send their questions to individuals if they wish, in which case if the individual is away for whatever reason the mail will be read when the individual returns.

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Orbit Fixing in GIPSY-OASIS II

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Introduction

Several events that took place in 1993 should make the GIPSY-OASIS II software more useful to those analyzing regional network GPS data. One of these was the ability for qregres to read and interpolate ephemerides in tabular form. The second was the daily production at JPL of precise ephemerides in the format required by qregres. (Note that older methods, such as genoif, are no longer recommended for precision orbit fixing.)

Specifically, you can now specify as the -sc argument in qregres, the name of an eci file. (See /goa/file_formats/eci for a description of an eci file.) Such a file specifies, at regular time intervals, the inertial Cartesian coordinates of one or more satellites. The location at an arbitrary time is determined by polynomial interpolation, and is accurate to the precision of the eci file (1 cm).

Because GPS receivers generally make measurements in an earth-fixed frame (Topex/Poseidon, of course, is a notable exception!), one must specify earth orientation parameters when fixing orbits in inertial space. This is done by including information in the $tpnml and $earth_orientation namelist groups in the qregres namelist file.

There are generally two sources of precise orbits for GIPSY-OASIS II users. The first is JPL's daily precise orbit file, determined from the global network of Rogue receivers. The second is the International GPS Service for Geodynamics (to which JPL also contributes).

Flinn Orbit Products

These are available via anonymous ftp from sideshow.jpl.nasa.gov (128.149.70.41) You can pick up daily solutions by the following means (for specificity this example uses 1993 Oct 07):

1 ftp sideshow.jpl.nasa.gov (or ftp 128.149.70.41)

2 Log in as anonymous. Please use your email address as your password.

3 cd pub/gipsy_products/1993/orbits

4 mget 1993-10-07*

5 quit

6 Uncompress the two files that you picked up: 93oct07.eci.Z and 93oct07tpeo.nml.Z (If you are using xt-gipsy, name them peci and tpeo.nml or provide soft links to them with these names)

7 Make your qregres namelist file as you normally do (for example, with hvor).

8 Remove any exiting $earth_orientation namelist group for the qregres namelist file.

9 Append 93oct07tpeo.nml to your qregres namelist.

10 Assuming you've already made your QMfile, run qregres, and use 93oct07.eci as the -sc argument (done automatically by xt-gipsy).

Note that xt-gipsy will automatically handle steps 7-10.

Beware that the Flinn-produced orbits have been "cleansed" of poorly-modeled satellites (using cleanjpl; try man cleanjpl), and you may have to run del_qm on your QMfile to purge it of such satellites before running qregres. A new script called weed_qm to be included in the update will take a QMfile and a peci file and delete the necessary satellites from the QMfile. This also is done automatically by xt-gipsy.

IGS Products

If the starting point for fixed orbits is a file in the sp1 or sp3 format, you need to do the following:

1 Make a tp namelist in a file, say TPNML. Use tp_nml if you like.

2 Run spx2eci on your .sp1 or .sp3 file.

3 Concatenate the resulting gps??.eci files (cat gps??.eci > all.eci)

4 Append TPNML to your qregres namelist.

5 Assuming you've already made your QMfile, run qregres, and use all.eci as the -sc argument.

In this case, what you use to make TPNML is largely inconsequential, but you must be consistent! That is, the $tpnml group in step 1, used in transforming the earth-fixed coordinates to inertial space, must be the same as the $tpnml group in your qregres namelist, which qregres uses to transform between inertial and earth-fixed reference frames.

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Station Coordinate Analysis Tools

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The five programs stacov, stamrg, statistics, project, and transform are powerful station coordinate analysis tools. Help for each program can be obtained by simply typing its name. The ascii format written by stacov is easy to read, write, and transport. Solutions can be easily combined or constrained using stamrg. Baselines, coordinates, and their corresponding repeatabilities can be computed in a variety of coordinate systems with statistics. Minimal constraints can be applied using project. Coordinates can be easily transformed from one reference frame to another using transform.

Absolute coordinates in any reference frame can be obtained without fixing any site positions using the no-fiducial approach which proceeds in three general steps. First, daily solutions derived with weak constraints are combined using stamrg. Second, the program project applies 7 minimal constraints to remove uncertainties due to the loosely defined reference frame. Third, the program transform is used to estimate and apply a 7-parameter transformation from one reference frame to another.

The fiducial approach is also fully supported. Fiducial constraints can be applied before or after the filter is run. The program stamrg allows application of fiducial constraints after the filter has been run, hence the choice of fiducial strategy can be delayed until after the filter has completed. Both position and velocity constraints can be applied using stamrg.

The following example computes Cartesian coordinates and baseline components in ITRF92 for a global experiment using the no-fiducial approach.

0. Use GIPSY to create the input smcov files.
1. *stacov -i day1.smcov -o day1.stacov* Run stacov once for each day.
2. *stamrg -i day*.stacov -o combined.stacov* Combine all days and put the output in combined.stacov.
3. *project -i combined.stacov -o project.stacov -s 4.5* Apply minimal constraints and one-sigma errors by 4.5.
4. *transform -i project.stacov -f itrf92.stacov -o final.stacov -r -t -s -nc* Transform the projected solution into ITRF92.
5. *statistics -r final.stacov -nev* Calculate the North, East, and Vertical components for all baselines.

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The first low earth orbiter with precise GPS positioning: TOPEX/POSEIDON

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Ed. Note: *A paper by Willy Bertiger et al. was submitted to the newsletter. It is too long to include in the newsletter itself, so a compressed postscript version of the paper has been put on the anonymous ftp area on sideshow described in an earlier article, and the abstract has been included below. The paper also appears in the proceedings of the September 1993 ION GPS meeting. To retrieve a copy of the paper from anonymous ftp follow the directions in the earlier article.*

Abstract

The Topex/Poseidon oceanographic satellite was launched in August 1992 carrying a high performace GPS receiver. The purpose of the receiver is to evaluate GPS for precise orbit determiniation of low orbiting Earth satellites. Using GPS, we have obtained an estimated radial orbit accuracy of 3 cm RMS for Topex/Poseidon, and estimated cross track and along track accuracies of better than 10 cm.

To obtain this accuracy, we have used specialized filtering strategies that take advantage of the global 3-dimensional coverage provided by the GPS constellation. The particular family of filtering strategies used has come to be known as reduced dynamic tracking. In this technique a small adjustment to an arbitrary 3-dimensional acceleration is made at each measurement time to correct for mismodeled dynamics using the strength of the GPS measurement system. Since each adjustment is essentially local, the information needed to compute the adjustment must come primarily from the instantaneous measurement geometry rather than satellite dynamics.

Orbit accuracy has been evaluated through such techniques as postfit measurement residuals, orbit differences between overlapping data arcs, orbit differences with traditional dynamic orbit solutions derived from different measurement systems (laser ranging and DORIS doppler) and different analysis software, and altimeter crossover statistics.

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GIPSY-OASIS II and GPS related research at DUT/SSR&T

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Installation on IBM RS/6000 running AIX

The Section Space Research and Technology, the Delft University of Technology (DUT/SSR&T) has been using GIPSY since 1988. Until March 1993 GIPSY was running on a VAX 3100 workstation. In early 1993 we got the first release of the GIPSY-OASIS II software which was installed on an IBM RS6000 workstation running AIX. In July the second release of the GIPSY II software became available and was ported again to the IBM RS6000. However the installation was not without problems. Due to a new release of the IBM FORTRAN compiler the handling of namelists was changed which meant that all programs writing namelists had to be changed significantly. The most troubling problem was opening of the same file more than once. The IBM does not support that feature and therefore a small C program was written which checks if the file which is to be opened is already open and, if so, it creates a new link to this file and opens this 'linked file'. Further more a large number of small errors occurred due to using nonstandard FORTRAN statements. Nevertheless the installation took little more than one week.

Changes and additions to the program

The second release does not yet contain the ambigon2 program for ambiguity resolution. Since we got a prerelease version of ambigon2 we have installed it and are using it with success for baselines up to 1000 km.

Since we have a lot of Trimble data to process, or more generally non P-code data, we wanted to be able to use the technique of constraining the phase ambiguities as discussed by Jeff Freymueller in the previous newsletter. Therefore a small change was made to the preprefilter program. The flag TRIMBLE was added to the preprefilter namelist. By default it is set to FALSE which means that the YADDSG parameter in the prefilter namelist will be 3.0D5 (the default 1sec). If the option is set to TRUE the value of YADDSG will be 3.0D-1 (1 microsecond).

Furthermore a number of postprocessing utilities have been developed which include amongst others helmert transformations, baseline repeatability plots, coordinate scatter plots and orbit comparisons. Three scripts were developed which are very similar to the postplot script. These scripts can plot the estimated wet zenith tropospheric delay and the estimated satellite and station clocks. The scripts extract the necessary information from the the smsol.nio file using a slightly changed version of rdsmsol and after some grepping, awking and other Unix tools they will plot the extracted information using gnuplot. If anyone is interested in any of these tools they are available from the author.

TOPEX orbit determination from GPS measurements

The main reason for quickly installing the second release was that the first release version did not have the capability to process TOPEX/POSEIDON GPS data, or more generally GPS data from satellite borne receivers. Since SSR&T has a long history in precise orbit determination the use of GPS in this area is a logical extension of our work.

We have selected one cycle, cycle 14, to study different orbit determination techniques. Investigations concentrated on the differences between using the GEM-T1 or JGM-2 gravity fields, using IGS orbits without and with orbit improvement and using a dynamic or a reduced dynamic approach. The best results were obtained using the JGM-2 gravity field, estimating the TOPEX orbit using a reduced dynamic technique, and orbit improvement for the IGS GPS orbits. The 6 hour overlap of two consecutive 30 hour Topex orbits gives a mean radial RMS of about 15mm for the nine overlaps in this 10 day cycle. The difference between the reduced dynamic orbit and the dynamic orbit are in the order of 30mm, 35mm and 75mm in radial, cross and along track for a 30 hour arc. Also interesting is the change of the GPS orbits which gives an indication of the accuracy of the IGS orbits. The combined IGS orbit which was used in these analysis is a weighted average of the orbits from all IGS analysis centers and has a believed accuracy of about 30cm for the time span of this cycle (currently the accuracy seems to be around 15-20cm). It was found that the difference between the TOPEX improved orbit and the a priori is around 25cm in all three components.

Accurate Height determination using GPS

As part of the PhD-thesis of Bart Overgaauw we are investigating how to obtain the most accurate height determination from GPS data. For this purpose a small network was designed in the area of the well known Stromsurge Barrier in the Oosterschelde, the Netherlands. We use our own 2 TurboRogues which were bought in mid 1993 and borrow 4 TurboRogues: 2 from the National Dutch Aerospace Laboratory (NLR) and 2 from the Royal Observatory of Brussels. The network will be measured three times (in the period July 1993 - February 1994) in order to be able to study the repeatability over a longer time span and in different seasons. The first measurement were taken on July 19-23, 1993. The second campaign will be one week in November and the third campaign is scheduled in February.

The results of the first campaign show a height repeatability of 6-8mm after fixing the phase ambiguities using ambigon. For this analysis we used the combined IGS orbit without any orbit improvement. For this project leveling measurements were taken from the Stromsurge and the results will be compared with the GPS results in the near future.

As an other part of this project a number of SAR reflectors will be deployed in the same area. GPS will be used to determine the positions of these reflectors. In the future this should yield the possibility to compare heights derived from GPS measurements with height differences found from differential SAR images.

The WEGENER/GPS-92 campaign

The first data set processed with the second GIPSY release at SSR&T was GPS data from all the WEGENER/MEDLAS sites under the leadership of IfAG (Institute for applied Geodesy, Germany) in cooperation with DUT. This campaign was carried out during the time span of the EPOCH-92 campaign, two weeks centered around August 1, 1992. The 17 sites were all occupied with Trimble SST receivers but for the processing with GIPSY we had to include another station since none of the Trimbles used a stable clock. Therefore 4 Rogues of the IGS network were added to the dataset. The six days, of which three were under AS (which affected the Rogues severely), were processed using the combined IGS orbit but with orbit improvement for the AS days since the orbit proved not accurate enough.

The baseline length repeatability for this network is in the order of 4-5mm with no significant length dependency. Daily coordinate comparisons using a seven parameter Helmert transformation show a rms agreement in the range of 3-8mm. Most interesting is of course the comparison of the GPS coordinates with the coordinates from SLR analysis (also from SSR&T). This comparison shows 15mm agreement between the two coordinate sets.

Miscellaneous

Other GPS related issues under investigation at SSR&T include studies of the antenna phase center variations, improvement of the solar radiation models for the GPS satellites and monitoring our IGS station at Kootwijk (KOSG) using combined IGS orbits and a number of other European IGS stations.

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IGS analysis at the Geodetic Survey of Canada

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New Clock Estimation Strategy

Our new clock estimation is now almost ready for inclusion in the EMR International GPS Service for Geodynamics (IGS) processing. The new strategy consists of estimating all stations and satellites clocks using appropriate apriori values and constraints. The idea being to remove the time reference dependency on a single clock. This should also eliminate the gaps with no time reference which are typical for single clock reference estimation.

We can currently model clocks either as a white noise bias or with a random walk combined with an estimated constant drift. Only the best "clocks", such as hydrogen masers, can be modeled with a random walk and constant drift. An apriori sigma of 0.2ns/sqrt(day) was found to work well for the random walk estimation of the best hydrogen masers such as the one at Algonquin. Other masers may need slightly larger apriori sigmas. We use an apriori sigma of about 175ns for the white noise estimation of block II satellites clock biases which accounts for the SA clock dithering.

All clocks are initialized by using the previous day's estimates. Consequently, our scripts for daily end-to-end Gipsy processing had to be modified to avoid over-constraining clocks for which no previous day estimates are available. We must also provide safeguards against clock resets. In order to detect resets, we rely on clock estimates computed during our data validation stage which uses single point positioning and broadcast orbits.

Finally, some work remains to be done in the selection of a clock ensemble which will provide the best set of weighted constraints to align our clock estimates to GPS time.

Processing of AS Data

We have adopted a strategy similar to JPL for processing of AS Rogue data. We currently deweight, to 100m, all pseudo-range data of AS affected satellites. The drawback of this approach is that the pseudo-range data for the AS satellites remain deweighted for the full span of the data even though some pseudo-ranges may have been tracked in P-code mode. All of our results are affected by AS, but the most remarkable deterioration is seen for clock solutions for AS satellites since effectively no pseudo-ranges are used.

Statistical Tools

Two programs have been written to assist in the analysis and processing of GPS data with GIPSY.

The first program is called "RESULTS". Its main purposes are to compare and display GIPSY solutions. The program is controlled by an option file having a namelist structure. The information used by the program is extracted from ACCUME files. Four types of processing can be done: 1) Correlation analysis on given pairs of parameters and/or within a given correlation range; 2) Solution report; 3) Solution statistical testing and report; 4) Solutions difference testing and report. The various tests and reports can be prepared for all or selected satellites and stations parameters. The testing and reporting can be done in cartesian and geographic coordinates for stations and in cartesian and Keplerian for the satellites. The statistical testing is done with the Chi-squared test. The overall variance factor can also be estimated. Based on tests a variance factor estimate of about 8 was obtained.

The second program is called "STRETCH". This program's purpose is to stochastically update the variance-covariance (SRIF) information contained in an ACCUME file. The objective is to use the updated ACCUME file to initialize the apriori estimates and sigmas for a subsequent GIPSY run. This program is also controlled by an option file having a namelist structure. Any parameter can be stochastically updated as a white noise, random walk or first order Gauss-Markov process. This program is still under development.

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First Experiences Using GIPSY-OASIS II at the Space Geodesy Center of the Italian Space Agency

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At the Space Geodesy Center of the Italian Space Agency GIPSY-OASIS II runs on a HP9000/835 workstation. It has been installed and compiled with HP-UX operating system 9.0 and FORTRAN compiler related to HP-UX 9.0.

In order to be sure that GIPSY runs in the proper way, we tested it on a subset of data from the GIG91 campaign acquired by 15 globally distributed Rogue receivers. We examined geodetic parameters and obtained results comparable with those published by JPL. We will evaluate orbits and earth orientation parameters in order to be able soon to process GPS data collected both in global and in regional campaigns.

Ed Note: Rosa and her colleagues at the Italian Space Agency needed to run GIPSY-OASIS II on their HP835 machines. JPL supplies executables for HP700 series machines, but these are not compatable with the HP800 series machines. Hence, it needed recompilation.

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Recent papers and reports of work done using GIPSY-OASIS II

Ed Note: This is a new feature of the GIPSY-OASIS II newsletter. If you know of a paper or report which might be of interest to the rest of the GIPSY-OASIS II user community, send me the reference (hurst@garlock.jpl.nasa.gov) and I will include it in future issues of the newsletter. In this issue, I have confined myself to JPL authors.

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Malla, R., S. Wu, and S. Lichten, Geocenter location and variations in Earth Orientation using Global Positioning System Measurements *Jour. Geoph. Res., 98,* 4611-4167, 1993.

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