Status and Future Plans at the JPL IGS Analysis Center

2016 IGS Workshop
Sydney,
Australia

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Abstract

We present an overview of the current activities and future plans of the IGS Analysis Center located at the Jet Propulsion Laboratory. Current activities include not only our contributions to the IGS (orbit positions and clock biases of the GPS constellation of satellites, Earth Orientation Parameters, troposphere observations, yaw rates of the GPS satellites, and daily SINEX files with station positions) but upgrading and releasing the GIPSY software used to create these products as well as improving the underlying models in several areas including satellite yaw or using better externally-generated models such as time variable gravity. Furthermore, we have also been developing GIPSYx, the C++ replacement to Fortran GIPSY and plan to transition our operations to using this software within the next year. Also, once the new IGS realization of ITRF2014 is released, we will undertake a new reprocessing campaign creating GPS orbit and clock products using this new frame.

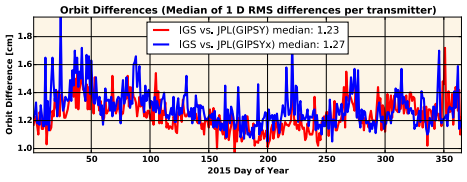
GIPSY Status

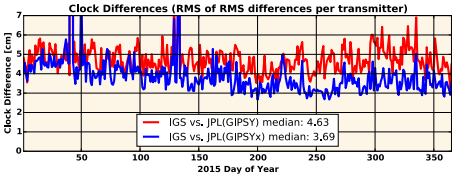
- **Latest version is GIPSY 6.4, released on Dec 3, 2015, has following features:**
  - Software upgrades to editor and PPP tool, several new utilities, bug fixes
  - Improved geophysical models:
    - Second-order ionosphere correction: improvements to use of IGRF, IRI, IONEX models
    - Time-varying gravity (including ICGEM format to GIPSY format converter)
      - For more details see poster : "The Impact of Time Variable Gravity Field on GPS Precise Orbit Determination", Amiri et al.
    - GPT2 model: finer 1° resolution and GPT2w a-priori wet delay calculation
      - For more details on recent troposphere work see talk : "Optimization of tropospheric delay estimation parameters by comparison of GPS-based precipitable water vapor estimates with microwave radiometer measurements", Selle and Desai.
  - Improved attitude modeling of GPS block IIF at noon and midnight turns
    - For more details see poster : "Observed features of GPS Bllock IIF satellites yaw attitude and corresponding modeling" , Kuang et al.
  - Improved reference frame handling with support for large ITRF2014 covariance files
    - For more details see poster: "Benefits and bottlenecks of ITRF2014 at the JPL Analysis Center", Ries and Heflin.
- **GIPSY 6.4 has been to create JPL's IGS products since 2015-11-29 (>= GPS week 1873)**

GIPSYx Status

- GIPSYx/RTGx is the C++/Python replacement for both GIPSY and Real-Time GIPSY (RTG)
- Driven by need to support both post-processing and real-time processing of multiple GNSS constellations
  - Can already process data from GPS, GLONASS, and Beidou. Galileo under development
    - However, more work is needed to be able to create non-GPS constellation orbit and clock products operationally
      - For more details on Beidou processing see talk : "Beidou Orbit Determination Processes and Products at JPL ", Sibthorpe et al.
- Readily extended to support DORIS and SLR data processing
- Multi-processor and multi-threaded capability
- Multi-GNSS PPP tool under development
- Similar but not identical file formats to current GIPSY

Transition of JPL Operations to GIPSYx





Daily orbit and clock differences for 2015 between IGS final combination and in **red** orbits and clocks produced by current operational software (which uses GIPSY) and in **blue** orbits and clocks produced by new operational software (which uses GIPSYx)

- Developing python software to generate both the GPS rapid and final products that we deliver to the IGS orbit using GIPSYx instead of GIPSY
- Testing new software by comparing both rapid and final products generated by both GIPSYx and GIPSY
- Expecting to start to use GIPSYx for operations later this year
- For more details see poster : "Transitioning the JPL IGS Analysis Center Operations from GIPSY-OASIS to GIPSYx", Sibois et al.

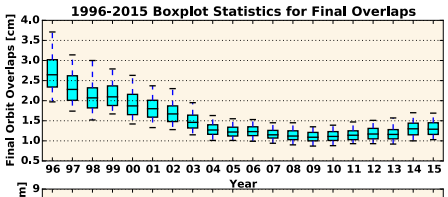
Data Processing Summary

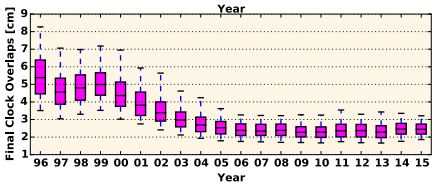
- JPL data products in IGS format available for 1992-08-16 onwards:
  ftp://sideshow.jpl.nasa.gov/pub/jpligsac

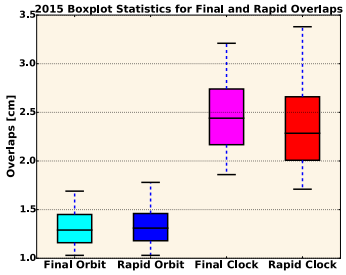
Software	GIPSY 6.3 (for 1992-08-16 – 2015-11-28) GIPSY 6.4 (for >=2015-11-29)
Orbit Arc	30 hours
Number of Stations	80 (40-80 before 1995-04-17)
Elevation Angle Cutoff	7 degrees
Station Information	IGb08 SINEX and Discontinuity
Receiver/Transmitter Antenna Calibrations	igs08.atx
Troposphere Mapping Function	GPT2w
A Priori Dry and Wet Troposphere Model	GPT2w
Solid Earth Tide (Geometric and Gravity)	IERS2010
Pole Tide (Geometric and Gravity)	IERS2010 (IERS2010 Mean Pole, including ocean load pole tide)
Ocean Tide Loading Model	GOT4.8ac with harddisp.f
Earth Orientation	IERS 2010 Tidal Model, EOPC04 (ITRF08)
Nutation	IAU2006A
Static Gravity Field	EGM2008 (12x12, C20, C30, C40, C21, S21 per IERS 2010)
Ocean Tide Gravity Field	GOT4.8ac (convolution)
Solar Radiation Pressure	GSPM13 (JPL)
Albedo Model	Knocke (1989)
Antenna Thrust	IGS Recommendation
Transmitter Clocks	5-minute and 30-second Products
Second Order Ionosphere Model	Modeled with ionosphere model IONEX (>= 1999), IRI2012 (<= 1998)
Yaw Rates	Estimated
Data Weighting	$\sin(\text{elevation})/\sigma^2$

- For more details on our data processing strategy see:
  https://igscb.jpl.nasa.gov/igscb/center/analysis/jpl.acn

Orbit and Clock Overlap Statistics







- Determine daily orbit and clock overlaps in central 5-hour region of each arc-to-arc 6-hour overlap region of noon-centered 30-hour arcs
- Orbit overlap = median of RMS of 1D orbit differences per transmitter in central 5-hour overlap region
- Clock overlap = RMS of RMS clock differences per transmitter transmitter in central 5-hour overlap region
- 1996-2015: very significant decrease in overlaps over 20 years but a slight degradation in orbit overlaps recent years possibly due to degradation of ITRF2008 frame realization due to post-seismic station loss. Use of IRF2016 might rectify this.
- 2015: final orbit and clock overlaps have few outliers compared to rapid orbit and clock outliers
- Only possible to determine overlaps and hence overlap statistics when >24-hour arcs are used

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