Introduction to JPL's GNSS Time Series

Edited Time Series, Velocity Field, and Web Site
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Point Positions
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Orbits and Clocks
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GNSS Time Series - Four Basic Steps

**Step 1 – Orbits and Clocks**
Get data from roughly eighty global GNSS receivers
Compute precise GNSS orbits and clocks in NNR GNSS reference frame
Compute transformation parameters from NNR GNSS frame to IGS14

**Step 2 - Point Positions**
Compute point positions for thousands of global GNSS receivers in NNR GNSS reference frame
Resolve phase ambiguities
Apply transformation parameters to obtain positions in IGS14

**Step 3 – Time Series**
Search for breaks
Remove outliers
Estimate positions, velocities, breaks, and seasonal parameters

**Step 4 – Web Site**
Create tables and plots which are posted on the web site
Create edited time series and residuals which can be downloaded
Step 1 – Orbits and Clocks

Input Data
Daily rinex files from roughly eighty global GNSS receivers

Fit Parameters
Satellite initial conditions, non-gravitational forces, and clocks.
Receiver positions and clocks except for one reference clock
Receiver tropospheric zenith delays and gradients
Polar motion, polar motion rate, and UT rate
Transformation parameters from NNR GNSS frame to IGS14
Resolved phase ambiguities

Models
Gravity from Earth, Sun, Moon, and other planets
DE421 planetary ephemeris
GSPM10 satellite solar pressure model
GYM95 satellite yaw model
IAU06 model for precession and nutation
IERS2010 tides
FES2004 ocean loading
IGS satellite and receiver antenna phase center models
GPT2w tropospheric mapping functions and nominals
2\textsuperscript{nd} order ionospheric corrections applied
7 degree elevation angle cutoff
Step 2 - Point Positions

**Input Data**
Daily rinex files for thousands of global GNSS receivers
Satellite orbits from step 1
Satellite clocks from step 1
Phase ambiguities from step 1
Transformation parameters from step 1

**Fit Parameters**
Receiver tropospheric zenith delay and gradients
Receiver position
Receiver clocks
Resolved phase ambiguities

**Reference Frame**
NNR orbits and clocks are used for point positioning
Transformation parameters from step 1 are applied to obtain position estimates in IGS14
Step 3 - Time Series

**Input data**
Daily GNSS point positions

**Fit Parameters**
Receiver positions
Receiver velocities
Receiver breaks
Receiver seasonals

**Breaks**
CHI^2 is computed with and without each break candidate and those with F > 150 are accepted

\[
F = \left\{ \frac{\text{Chi}^2(\text{without}) - \text{Chi}^2(\text{with})}{\text{Chi}^2(\text{with})} \right\} \times \left\{ \frac{\text{ndata} - \text{pwith}}{\text{pwith} - \text{pwithout}} \right\}
\]

ndata is the number of position observations being fit
pwith is the number of parameters with the break included
pwithout is the number of parameters without the break included

**Outliers**
Points with formal errors > 5 mm in any component

**Error Scaling**
Parameter errors multiplied by 20 to make them consistent with one sigma data decimation results
Step 4 - Web Site

Web Launch date
November 29, 1994

Implementation
HTML
KML
Javascript

Interface
Google map
List of sites

Tables
Positions
Velocities
Breaks
Seasonals
Methods

Download
Time series
Residuals

GNSS Time Series

The Global Positioning System (GPS) is a constellation of 30 satellites which is used for navigation and precise geodetic position measurements. Data from over 2000 receivers have been analyzed at the Jet Propulsion Laboratory, California Institute of Technology under contract with the National Aeronautics and Space Administration. JPL's GipsyX software is used to produce these time series and other useful data products. Horizontal velocities, mostly due to motion of the Earth's tectonic plates, are represented on the map by lines extending from each site. Click on a dot or name to see detailed time series for a particular site. Additional information may be obtained from Michael.Heflin@jpl.nasa.gov.

Geodetic Positions and Velocities II Cartesian Positions and Velocities
Break Estimates II Seasonal Estimates
Time Series II Residuals
Methods
Time Series and Residual Format
Column 1: Decimal_YR
Columns 2-4: East(m) North(m) Vert(m)
Columns 5-7: E_sig(m) N_sig(m) V_sig(m)
Columns 8-10: E_N_cor E_V_cor N_V_cor
Column 11: Time in Seconds past J2000
Columns 12-17: Time in YEAR MM DD HR MN SS

Observations
Black points with error bars

Fit
Red points

Breaks
Green bars
Download Instructions

**Download edited time series for a single site**
Click “Time Series” on web site
Right click site of interest
Choose “Download Linked File”

**Download residual time series for a single site**
Click “Residuals” on web site
Right click site of interest
Choose “Download Linked File”

**Download all edited time series**
wget -r -nd -np -R "index.html**" -A "*.series"

**Download all residual time series**
wget -r -nd -np -R "index.html**" -A "*.resid"