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A Comparison of NGS Repro2 Solutions and IGS Repro2 Products

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Summary

Since the beginning of the International GNSS Service (IGS), the National Geodetic Survey (NGS) of the United States has actively participated in IGS activities. NGS contributes GNSS data from several sites, as well as antenna calibrations, ultra-rapid, rapid and final orbits and Earth rotation parameters (ERP).

The first IGS processing campaign (repro1) began in 2008, during which participating analysis centers reprocessed GNSS data collected from 1994 to 2008 in as consistent of a manor as possible. NGS contributed to repro1 by providing its reprocessed site coordinates, velocities, orbits and ERP. The IGS started its second reprocessing campaign (repro2) in 2013 for data collected from 1994 up to day 2014-298 and published those results in January of 2017 (referred to as ig2). Even though NGS was not able to contribute to the IGS repro2 processing campaign in time for the release of the new products, NGS has now completed its own repro2-like processing for internal use (referred to as ng2 products). NGS repro2 processed data collected from 1994 up to day 2017-021.

Day boundary discontinuities (DBD) of ERP and orbits were computed using ig2 and ng2 solutions and their power spectra were compared. Even though ig2 and ng2 solutions are independent, their power spectra show similar patterns. Global coordinates for sites in the IGS network were computed, along with the daily Helmert transformation parameters between the ng2 and ig2 coordinates for these sites. Power spectra of the averaged differences in North, East, and Up coordinates between ng2 and ig2 were computed for 21 selected sites with long timeseries lacking major gaps. The spectra of the daily coordinate differences show peaks that align with harmonics of the GPS draconitic year.

Earth Rotation Parameters (ERP) Day Boundary Discontinuities (DBD)

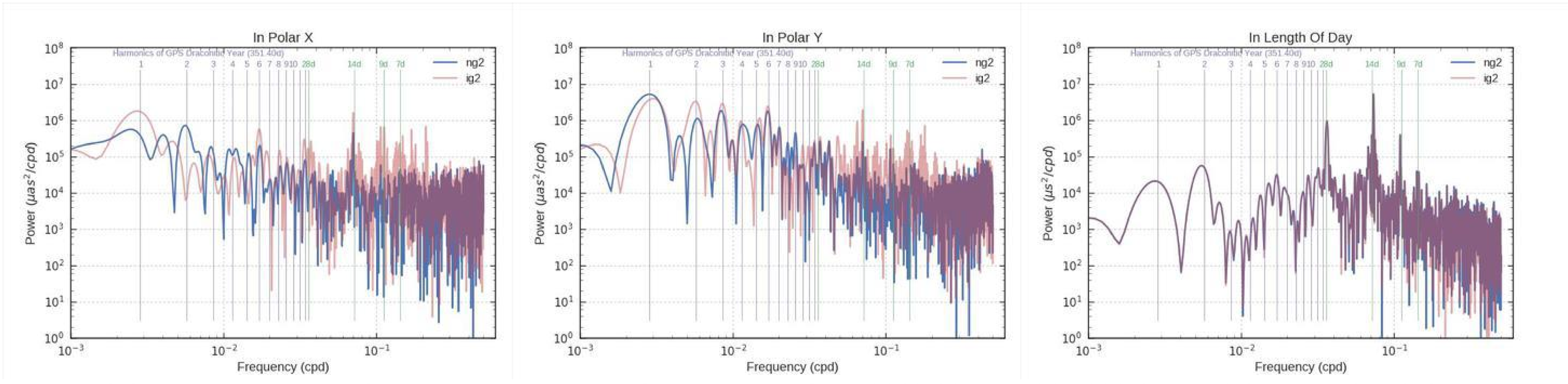


Figure 1-1 Power spectrum of ERP DBD using data for the period from 2012-204 to 2014-298 (about 2.25 years long). In this time period, **ig2 products do not have the NGS contribution**.

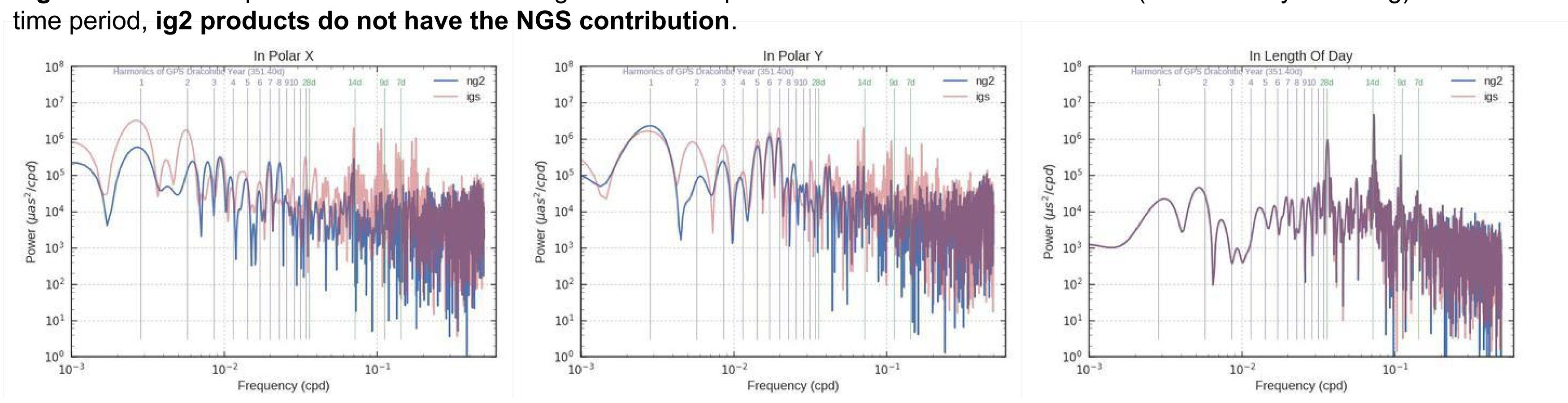


Figure 1-2 Power spectrum of ERP DBD using data for the period from 2014-299 to 2017-021 (about 2.25 years long). In this time period, **igs products (operational IGS final products) have the NGS contribution**.

- IGS ERP files contain polar x (Xp), polar y (Yp) and their rates at 12:00 of each day as well as length of day (LOD). DBD values are computed by propagating Xp, Yp values to 24:00 using their rates. DBD of LOD is computed by differencing two consecutive values.
- In the power spectrum of Xp and Yp, ng2 products show less prominent peaks at 7, 9, 14 and 24 day cycles than ig2 products. Power spectrum of ig2 also shows peaks at sub-weekly cycles unlike ng2 products.
- Power spectrum of LOD DBD show prominent and distinct peaks at 7, 9, 14 and 24 day cycles.
- There is no noticeable difference between upper plots and lower plots meaning that NGS contribution to IGS products does not change the characteristics of power spectrum in IGS ERP products.

Orbit Day Boundary Discontinuities

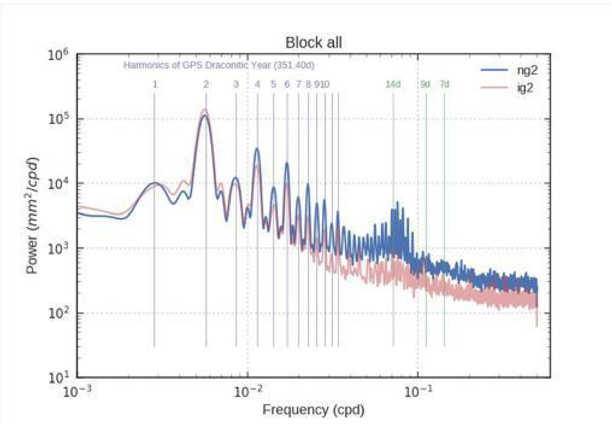


Figure 2-1 Power spectrum of orbit DBD using data for the period from 2004-004 to 2014-298 (about 11 years long). There were 39 satellites in this time period.

- Orbit DBD is computed by propagating orbit ephemeris in SP3 files forward and backward to 23:52:30 and computing RSS of differences in XYZ directions.
- Peaks appear at the harmonic frequencies of GPS draconitic year (351.40 day).
- Peaks near 14 day cycle is broader than those that appear in ERP DBD plots. One proposed explanation for these peaks is that they are caused by error in the subdaily ERP tidal model. [J. Griffiths, et al., GPS Solut, 2013]
- There are visible peaks at 9 day and sub-weekly cycles with ig2 products, but there are no such peaks visible in ng2 products probably shadowed by higher noise.

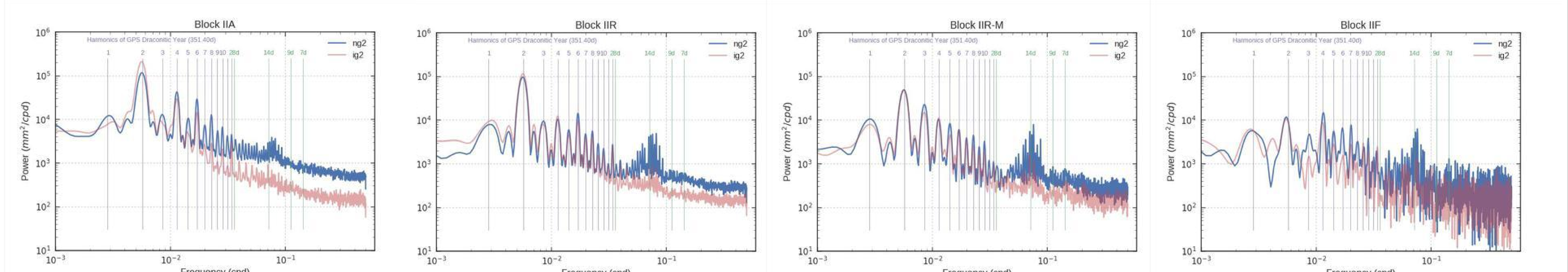


Figure 2-2 Power spectrum of orbit DBD using data for the period from 2012-204 to 2014-298 (about 2.25 years long). In this time period, **ig2 product does not have NGS contribution**. During this time period, there were 18 Block IIA satellites, 12 Block IIR satellites, 7 Block IIR-M satellites and 2 Block IIF satellites. The power spectrum for Block IIF is noisier since there were not many satellites for averaging.

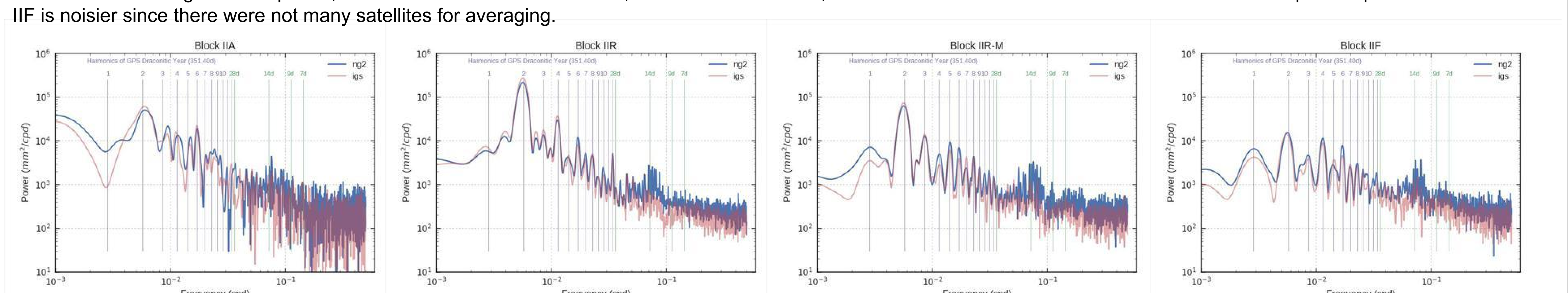


Figure 2-3 Power spectrum of orbit DBD using data for the period from 2014-299 to 2017-021 (about 2.25 years long). In this time period, **igs product (operational IGS final product) has NGS contribution**. During this time period, there were 2 Block IIA satellites, 12 Block IIR satellites, 7 Block IIR-M satellites and 8 Block IIF satellites. The power spectrum for Block IIA is noisier since there were not many satellites for averaging.

- Power spectra with all blocks show broad peaks near 14 day cycle. The peak with Block IIA looks less prominent but that seems to be a side effect of overall higher noise with Block IIA.
- The peak at half draconitic year cycle with Block IIF is noticeably lower than those with other blocks. One possible explanation is that Block IIF is less affected by solar radiation pressure modeling error.
- Noise level of ng2 products is generally higher than ig2 products, especially with Block IIA. This can be explained considering that combination processing to generate ig2 products cancels noise in individual products from analysis centers.
- There is no noticeable difference between upper plots and lower plots meaning that NGS contribution to IGS products does not change the characteristics of power spectrum in IGS SP3 products.

Station Coordinate Differences

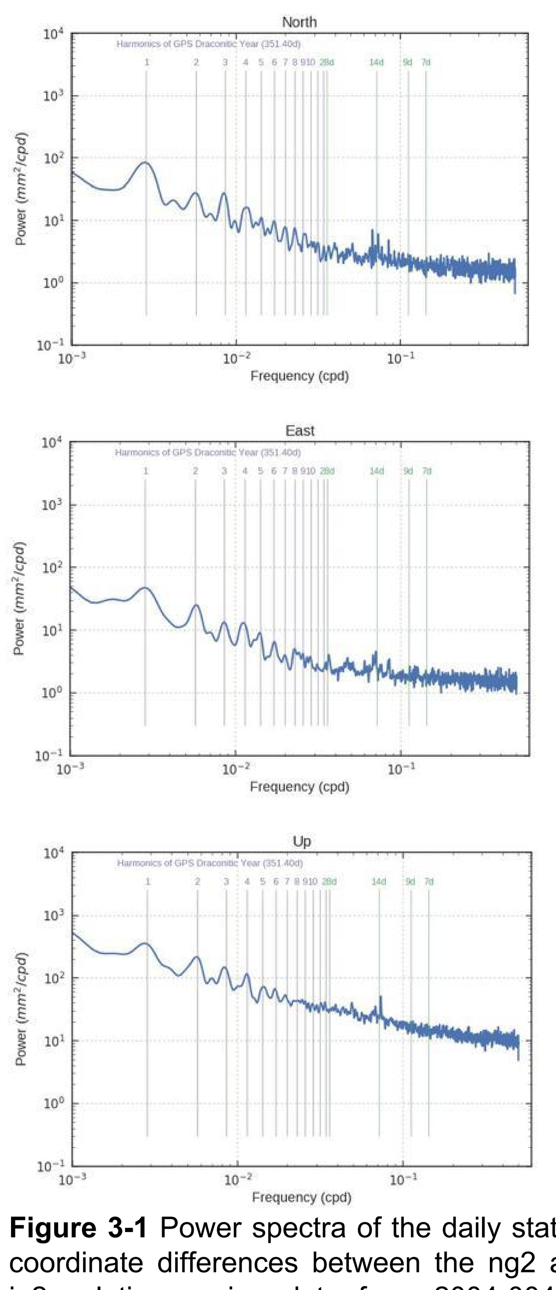
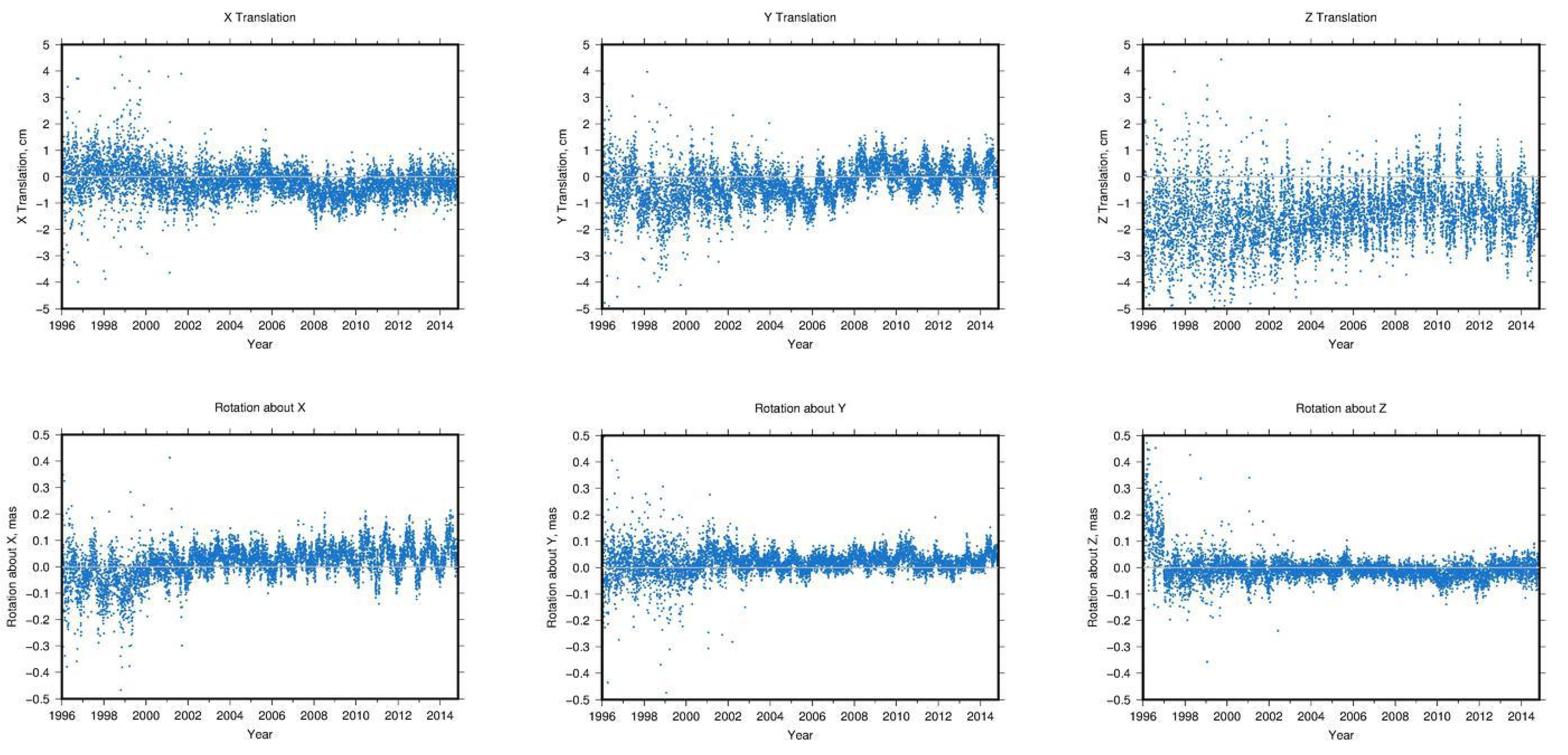


Figure 3-1 Power spectra of the daily station coordinate differences between the ng2 and ig2 solutions using data from 2004-004 to 2014-298 (about 11 years long), averaged from 21 stations with long, continuous timeseries with no major gaps. In this time period, **ig2 product does not have the NGS contribution.**

- The power spectra of the differences in the North, East and Up components of the coordinate differences between the ng2 and ig2 solution coordinates averaged at 21 sites show the strongest peaks in the spectrum at the draconitic year period (351.40 days), with subsequent peaks at its harmonic frequencies up to about the 8th harmonic.
- Even though these are the differences between coordinates at the same site, differences in processing methods between NGS and the other analysis centers of IGS could explain these patterns.
- High frequency scatter makes everything shorter than the 14-day period difficult to discern from the graph. However, each of the 3 components shows a clear signal at the 14-day interval.
- The differences in the Up direction have higher noise as compared with the North and East components.



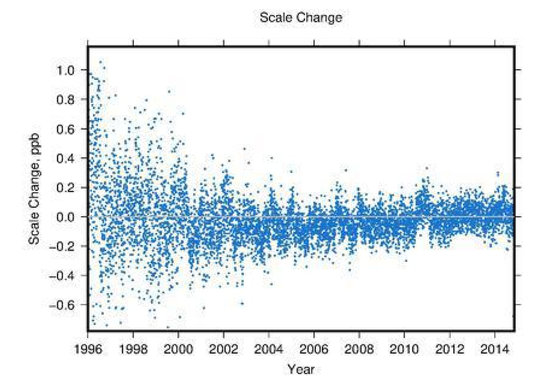


Figure 3-2 Daily Helmert transformation parameters between IGS-derived coordinates and NGS-derived coordinates from repro2 processing. Shown here are the comparisons between the ig2 results without the NGS contribution and ng2 results from 1996-001 to 2014-298. The top row shows the 3 translation parameters, in cm. The middle row shows the 3 rotation parameters, in milli-arcseconds. The plot in the lower row shows the scale change in ppb.

- The Helmert transformation parameters represent the reference frame difference between the ig2 and ng2 solutions. The translation in the Z-direction is noisier than the translations in X and Y with a generally negative offset in Z.
- These parameters were computed daily based on the global IGS stations available on that day.
- All of the parameters are much noisier earlier on in the timeseries, especially prior to about 2002.