Readme for GOES 6-15 Ephemeris Data

Janet Machol and Stefan Codrescu

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1 Summary

The 'goes-l2-orb1m' product consists of netCDF files with GOES satellite locations (ephemerides) at a 1-min cadence. Location information is provided in geographic (GEO) and Geocentric Solar Ecliptic (GSE) coordinates.

The source of the ephemeris information is ASCII files obtained from the NASA Satellite Situation Center Web (SSCWeb) at `http://sscweb.gsfc.nasa.gov/` Depending on the satellite, the NASA data is provided at either 1-min or a 3-min cadence for the GOES satellites. For NASA data with a 3-min cadence, we have linearly interpolated the data to a 1-min-cadence. Ephemerides are calculated from NORAD Two Line Elements (TLEs) for the GOES spacecraft.

Table 1 shows the 'goes-l2-orb1m' data which is available from the GOES 8-15 tab at `https://www.ngdc.noaa.gov/stp/satellite/goes-r.html`. Annual files and files aggregated for the full mission through 2020 are available.

Table 1: Satellite ephemeris data.

Satellite	Years	cadence [mins] NASA	cadence [mins] NOAA
GOES-6	1993 - 1995	3	1
GOES-7	1987 - 1998	3	1
GOES-8	1994 - 2003	1	1
GOES-9	1995 - 1998	1	1
GOES-10	1997 - 2009	1	1
GOES-11	2000 - 2011	3	1
GOES-12	2001 - 2010	1	1
GOES-13	2006 - 2018	3	1
GOES-14	2009 - 2020	3	1
GOES-15	2010 - 2020	3	1

Variables are listed in Table 2. Further metadata is provided in the netCDF attributes in the files.

Table 2: Variables in satellite location files.

Variable	Description	Units
time	Spacecraft time	secs since 2000-01-01 12:00:00 UTC[1,2]
geo_llr	Spacecraft GEO position (lat., long., radius)	[deg, deg, km]
gse_xyz	Spacecraft GSE position (x, y, z)	[km, km, km]
local_time	Spacecraft local time	hours
gse_local_time	Spacecraft GSE local time	hours

[1] For satellites before GOES-11, time units are "secs since 1970-01-01 00:00:00 UTC".

[2] Time elapsed does not include leap seconds. See text.

The time variable, $time[secs] = Time[UTC] - base\_time[UTC]$, is an elapsed time in units of "secs since $base\_time$" where $base\_time[UTC]$ and was calculated without including leap seconds that occurred since

base_time. Time stamps can be calculated by the user in Coordinated Universal Time (UTC) as

$$Time[UTC] = base\_time[UTC] + time[secs] + n[secs] \qquad (1)$$

where $n = 0$ for a time conversion function which ignores leap seconds (e.g., Python cftime.num2date or netCDF4.num2date) and $n = number\ of\ leap\ seconds\ since\ base\_time$ if the function includes leap seconds. It should be noted that the reference epoch for GOES 11-15 ephemerides of "2000-01-01 12:00:00 UTC" is not the same as the J2000 epoch, because the latter is given in terrestrial time (TT) units which differ by more than a minute from UTC. For a table of leap seconds, see `https://www.nist.gov/pml/time-and-frequency-division/time-realization/leap-seconds`.

Figure 1 shows the GEO latitude, longitude and radius for GOES-15. Major position changes can be seen on the longitude plots. Plot of GEO coordinates for other GOES satellites are shown in Section 2. Figure 2 shows GEO latitude in the original 3-min cadence data from NASA and the interpolated data. The linear interpolation produces small errors where the data is not linear with time. Figure 3 shows the variation of GSE coordinates over one day.
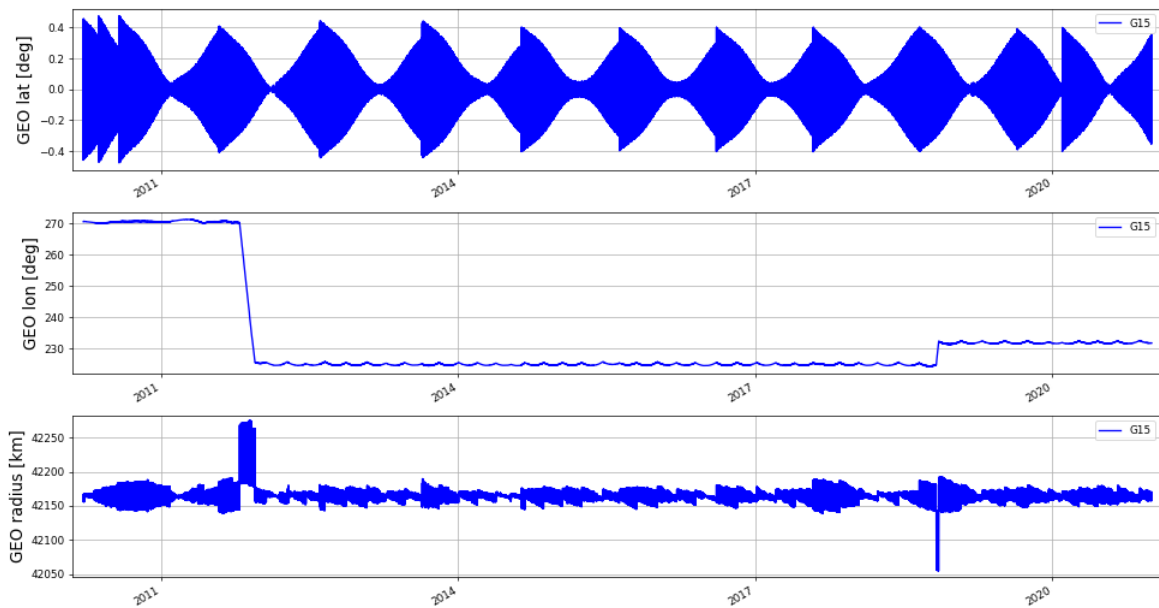

Figure 1: GEO latitude (top), longitude (middle) and radius (bottom) for GOES-15 satellite position.
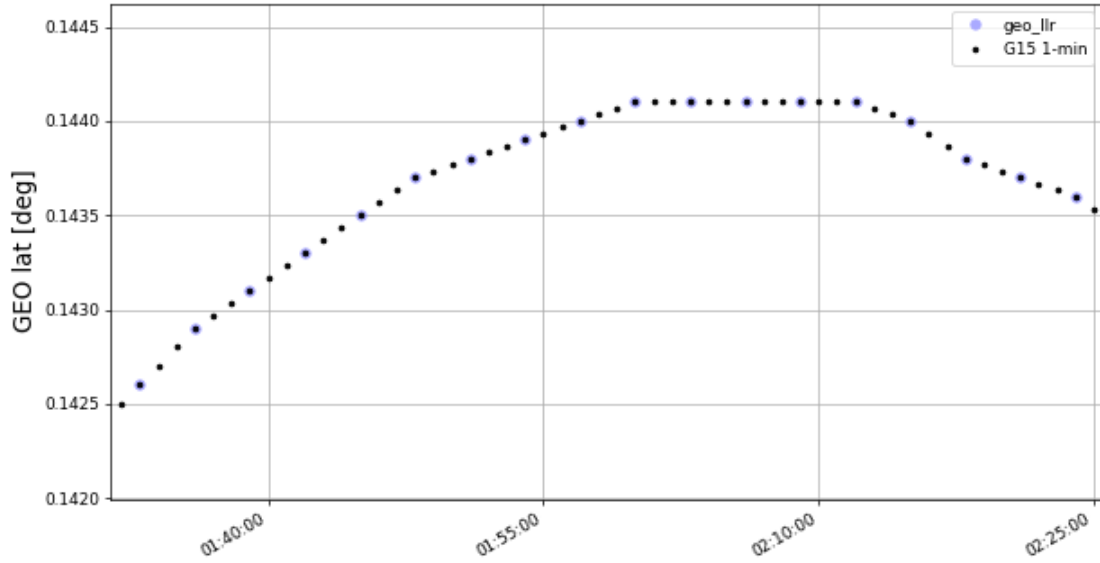
Figure 2: GEO latitude with 3-min cadence (large green dots) and 1-min cadence (black dots) data on GOES-15 on 2016-01-01. Errors due to the interpolation are most significant where the data has the most curvature.
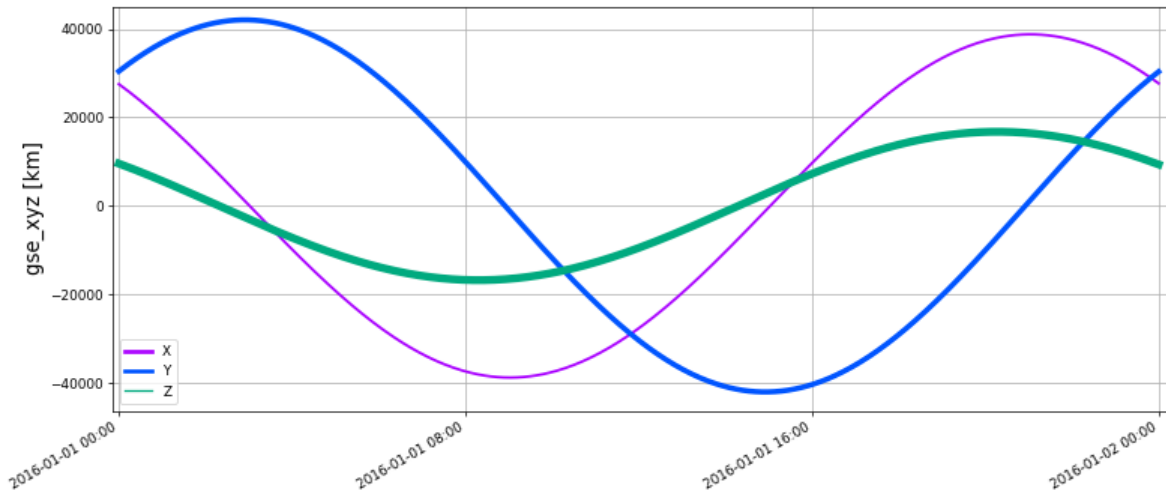

Figure 3: GSE X (purple), Y (green) and Z (blue) for GOES-15 satellite position for 2016-01-01.

2 Plots of Satellite Locations in GEO Coordinates

This section has plots of GEO latitude, longitude and radius for GOES-8 through -14. (GOES-6 and -7 are not plotted.) The GEO coordinates for GOES-15 are shown in Figure 1.
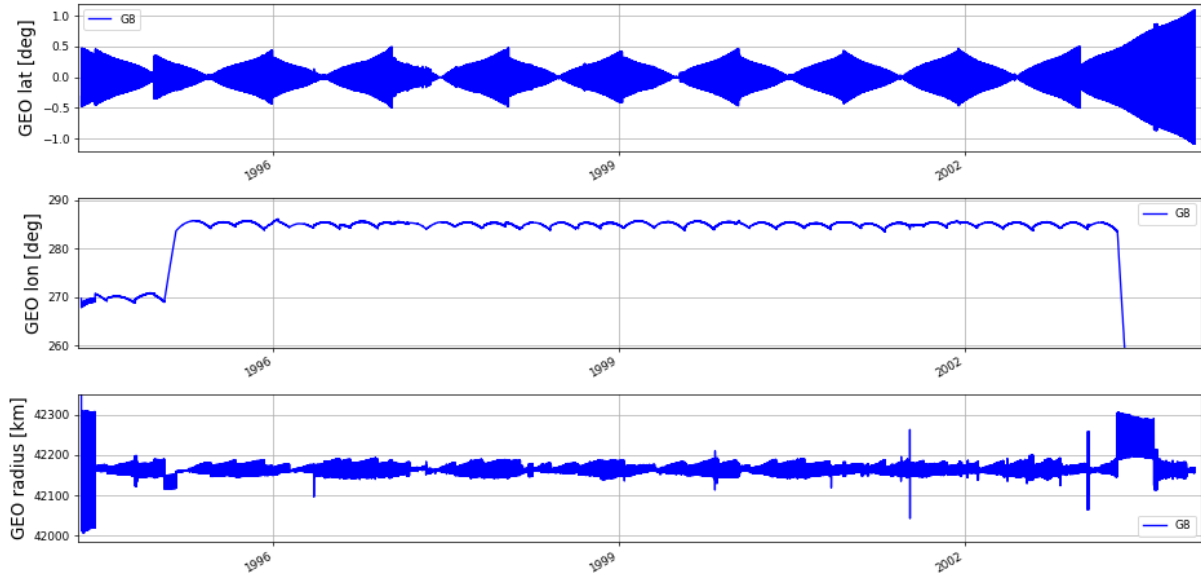
Figure 4: GOES-8 satellite position in GEO coordinates: latitude (top), longitude (middle) and radius (bottom).
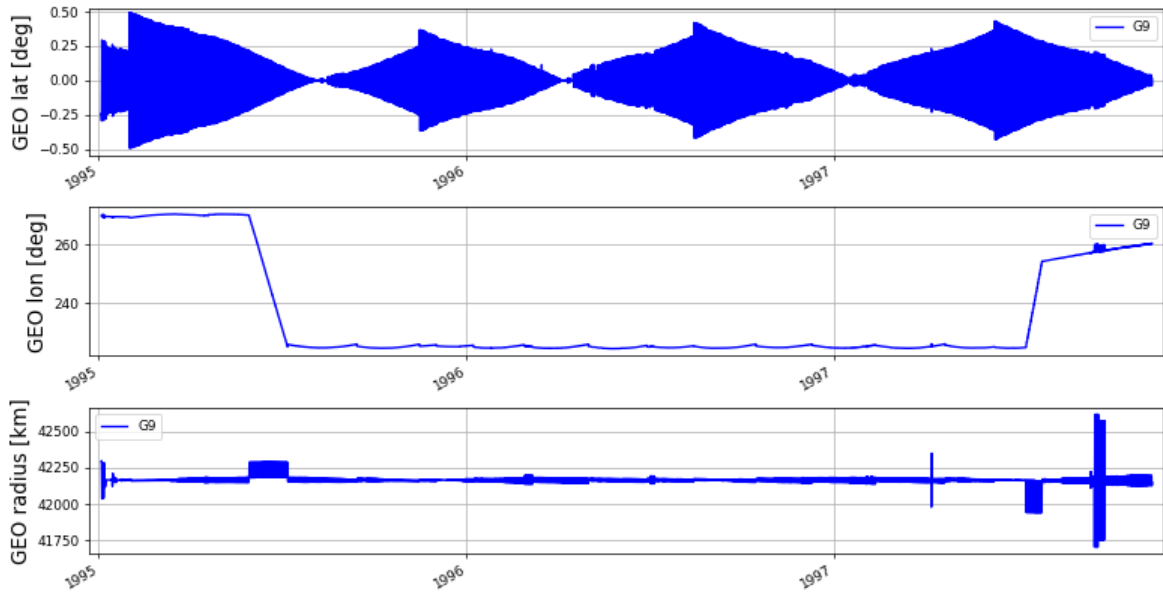
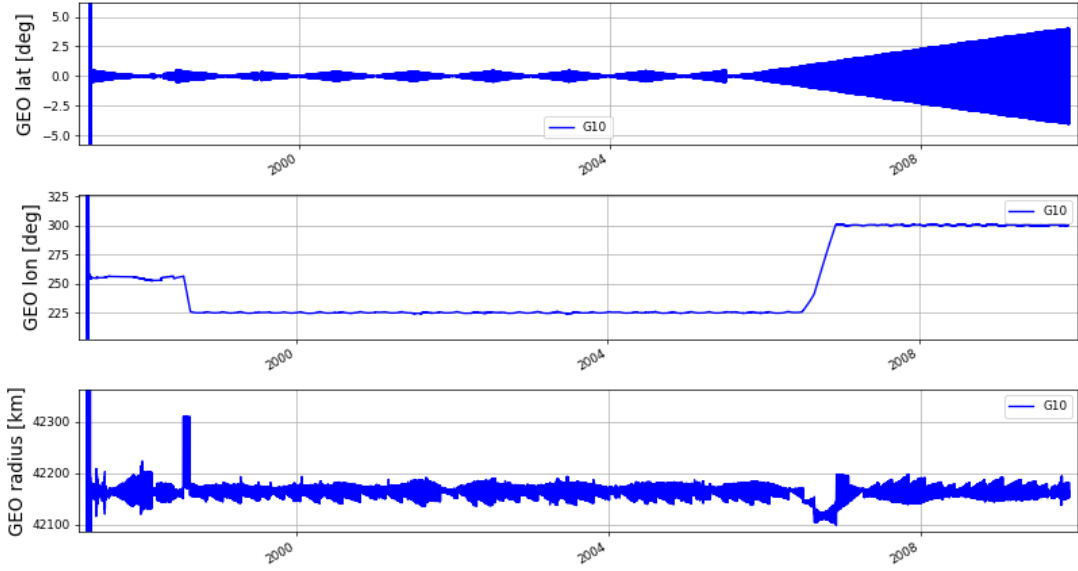Figure 5: GOES-9 satellite position in GEO coordinates.

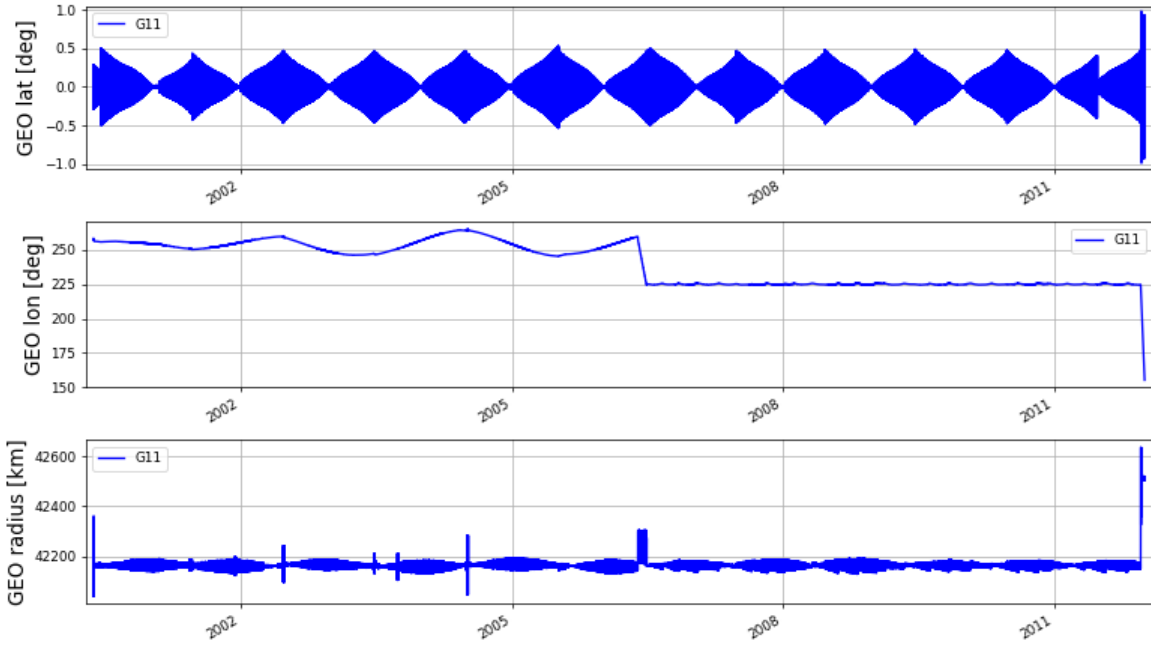Figure 6: GOES-10 satellite position in GEO coordinates.

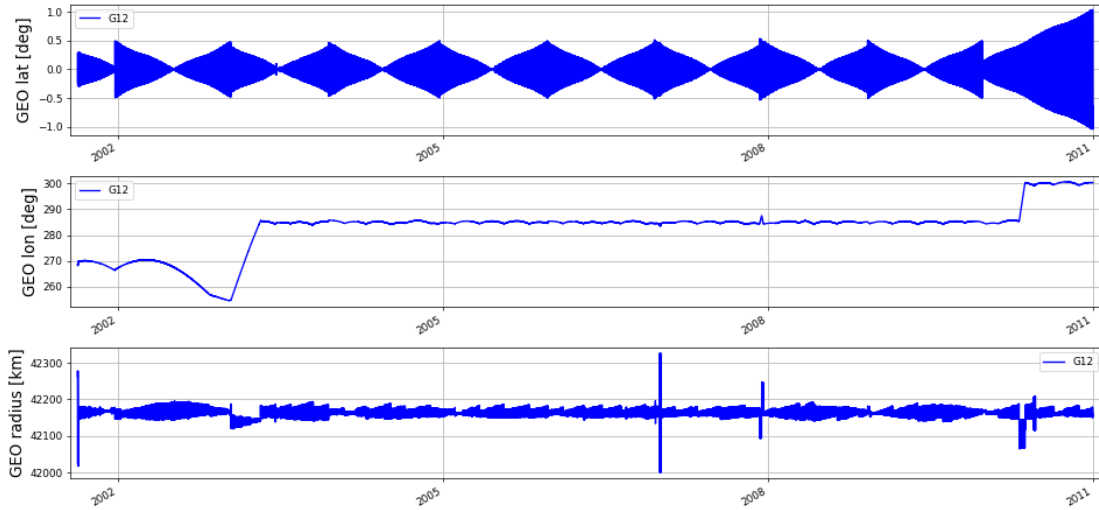Figure 7: GOES-11 satellite position in GEO coordinates.

Figure 8: GOES-12 satellite position in GEO coordinates.
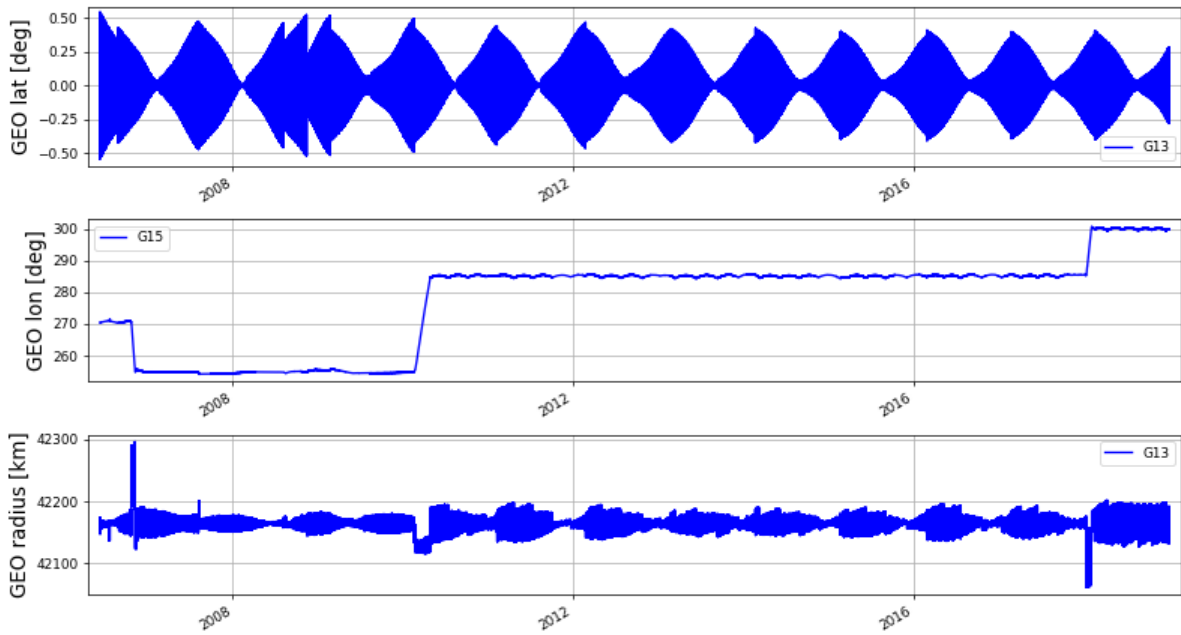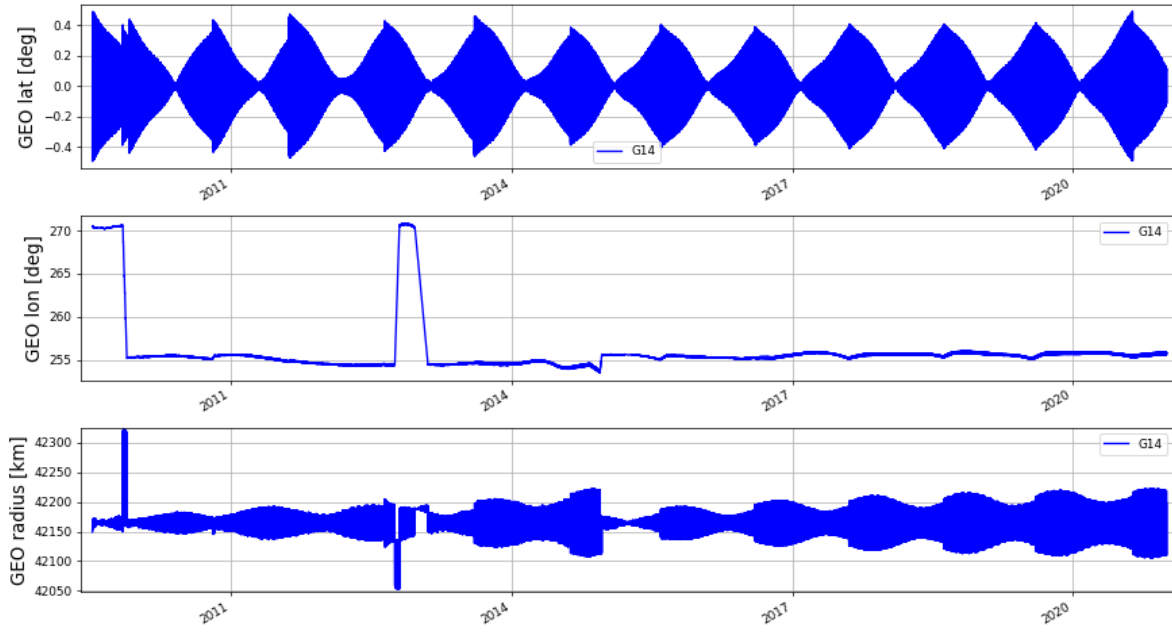

Figure 9: GOES-13 satellite position in GEO coordinates.

Figure 10: GOES-14 satellite position in GEO coordinates.