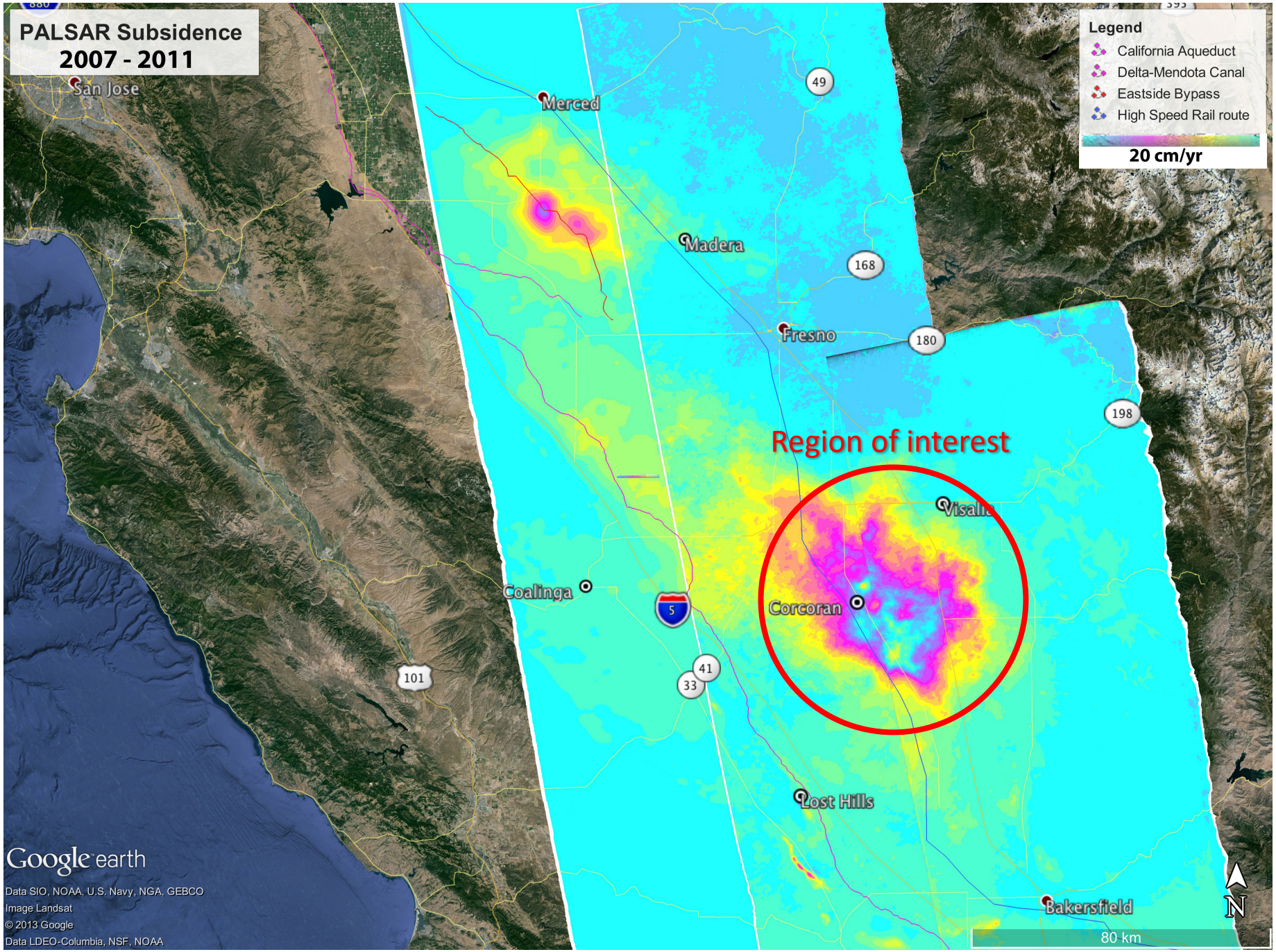
Example 4:
Quick continuous station processing

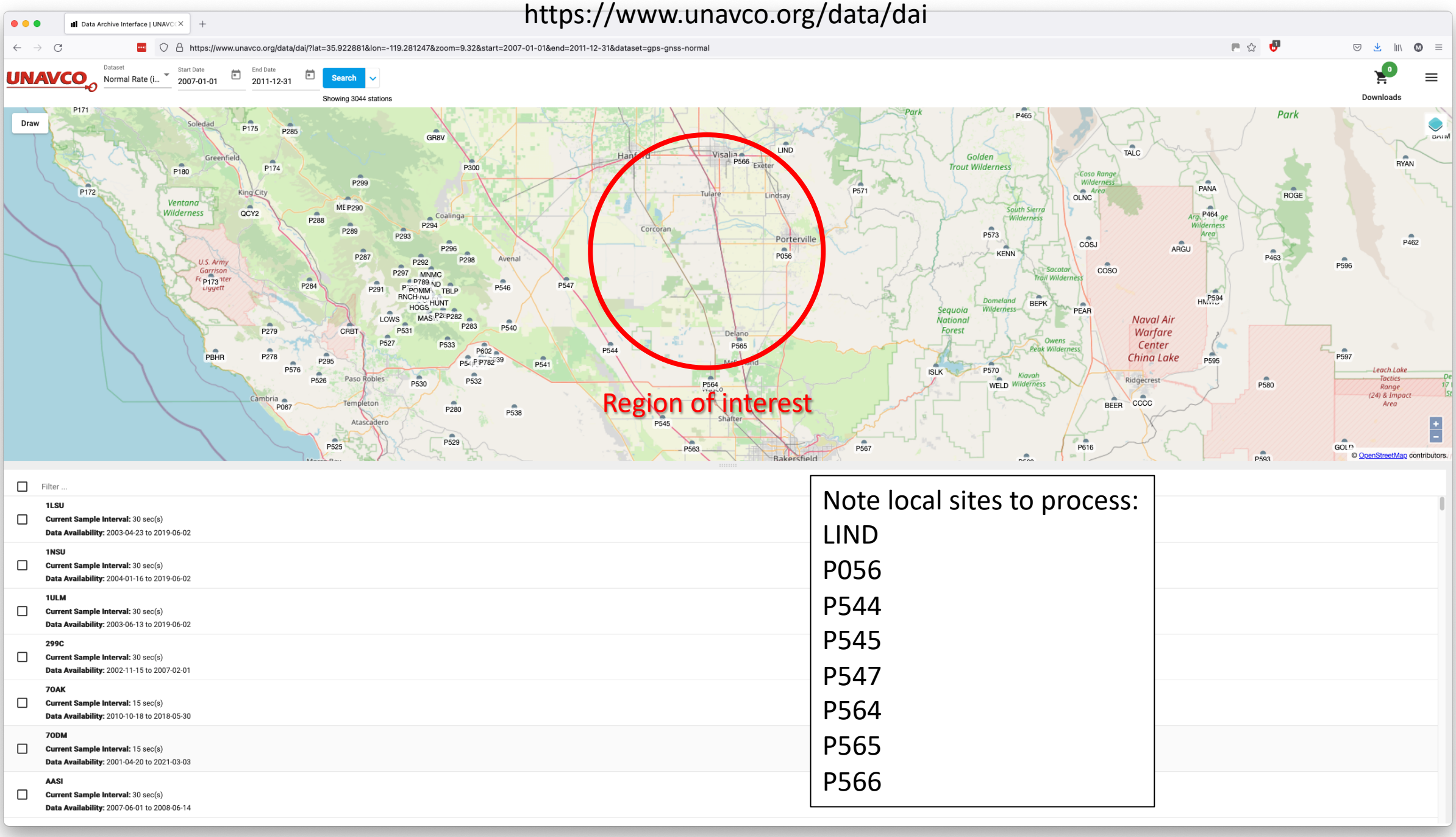
- This is an example of processing continuous stations by decimation to use only a single day per year to find an approximate rate of subsidence for an aquifer in the Central Valley of California
- We will be considering the area south of Visalia, California, as described at https://www.nasa.gov/jpl/news/california-drought-20140225/
- We will use specifically GPS observations only



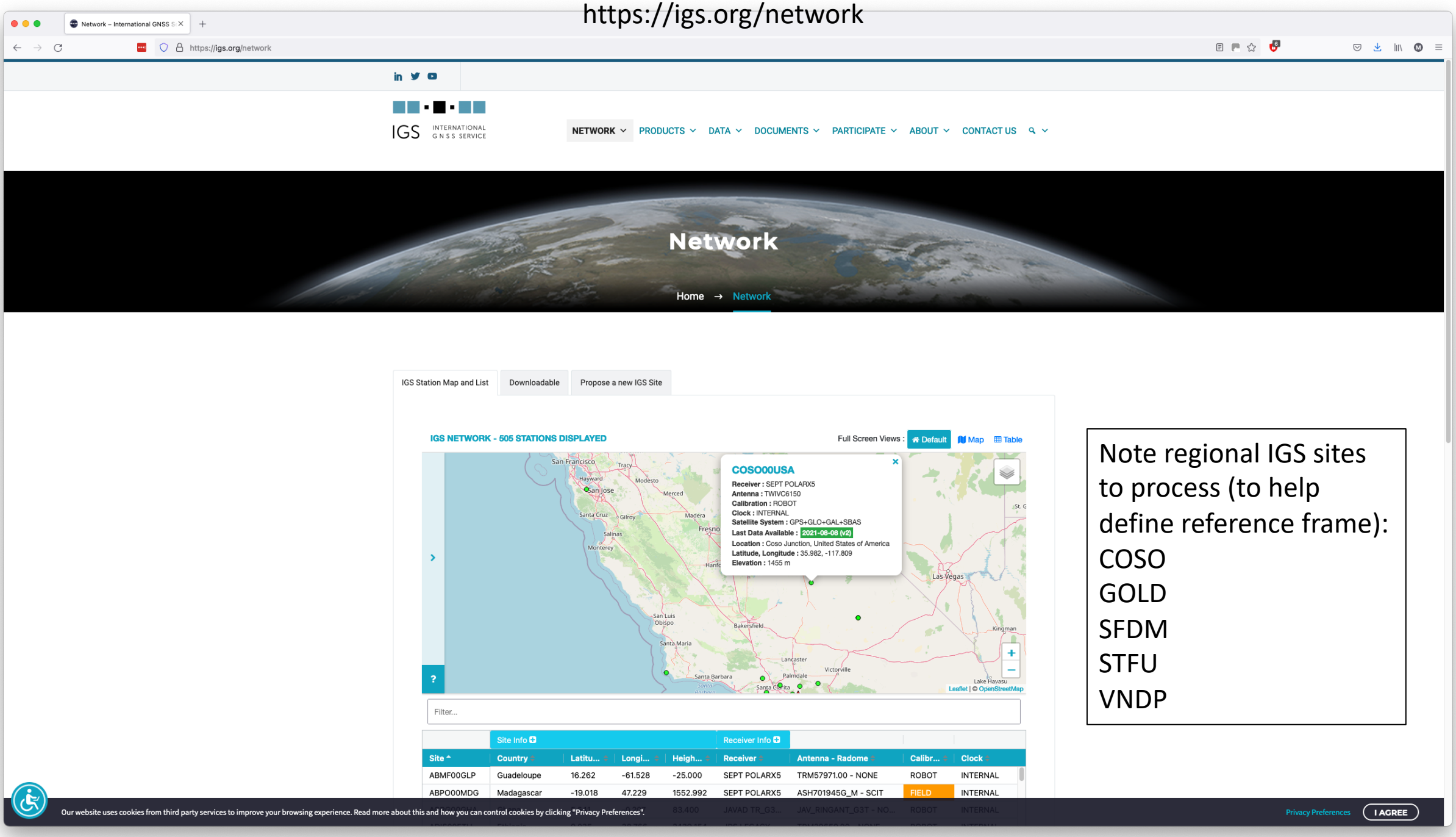
https://www.nasa.gov/jpl/news/california-drought-20140225/

We will find and process local continuous GNSS sites, one day per year over the five-year period 2007 to 2011, as noted in the web article

https://www.unavco.org/data/dai

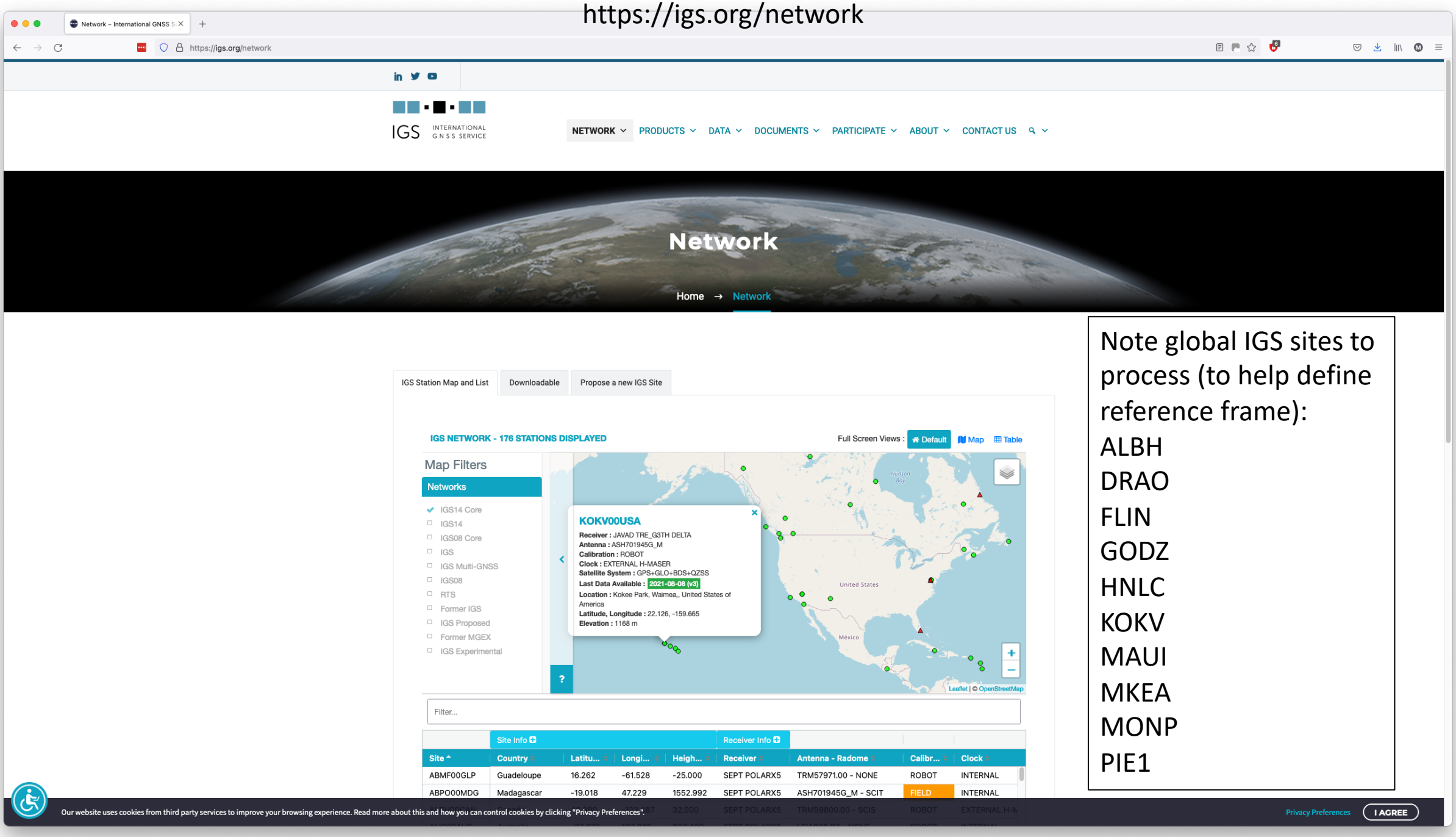


https://igs.org/network



Note regional IGS sites to process (to help define reference frame):
COSO
GOLD
SFDM
STFU
VNDP

https://igs.org/network



Note global IGS sites to process (to help define reference frame):

ALBH
DRAO
FLIN
GODZ
HNLC
KOKV
MAUI
MKEA
MONP
PIE1

Prepare the main processing directory

- Choose where to process and make a top-level directory, e.g.

```
mkdir ~/Desktop/subsidence/
```

- We are going to be processing multiple years, each of which requires a separate sub-directory for GAMIT to process, e.g.

```
mkdir ~/Desktop/subsidence/{2007,2008,2009,2010,2011}
```

- Also make a top-level tables directory where tables that are common across all years can be created and kept, e.g.

```
mkdir ~/Desktop/subsidence/tables/
```

Prepare the metadata files (sites.defaults)

- Start by defining the sites, chosen to process in the previous step, in sites.defaults using the default file as a template, e.g.

```
cd ~/Desktop/subsidence/tables/
cp -p ~/gg/tables/sites.defaults .
```

- Now edit the file accordingly for the sites to include, using any four-character experiment name (I choose “subs” for *subs*idence)
  - All sites are available from public archives, so we will set the “ftprnx” flag to instruct `sh_gamit` to download them automatically
- sites.defaults will look like the right-hand side:
  - Note the first character of instruction lines must be a whitespace character otherwise the line is considered a comment

```
 all_sites subs xstinfo
# Local sites
 lind subs ftprnx
 p056 subs ftprnx
 p544 subs ftprnx
 p545 subs ftprnx
 p547 subs ftprnx
 p564 subs ftprnx
 p565 subs ftprnx
 p566 subs ftprnx
# Regional IGS sites
 coso subs ftprnx
 gold subs ftprnx
 sfdm subs ftprnx
 stfu subs ftprnx
 vndp subs ftprnx
# IGS14 sites
 albh subs ftprnx
 drao subs ftprnx
 flin subs ftprnx
 godz subs ftprnx
 hnlc subs ftprnx
 kokv subs ftprnx
 maui subs ftprnx
 mkea subs ftprnx
 monp subs ftprnx
 pie1 subs ftprnx
```

Prepare the metadata (station.info)

- All sites are available from public archives, so there's a good chance GAMIT/GLOBK already distributes the necessary station information

```
cd ~/Desktop/subsidence/tables/
sh_upd_stnfo -ref ~/gg/tables/station.info -l sd
```

- Now verify that all sites are present, e.g. visually or using `grep`
- If everything is present, move the ".new" file to the standard name

```
mv station.info.new station.info
```

Prepare the metadata (“.apr”-file)

- Again, all sites are available from public archives, so there’s a good chance GAMIT/GLOBK already distributes the necessary station information
- So verify that all sites are present in the default a priori coordinate file (~/gg/tables/igb14_comb.apr)
- A few NOTA stations (P056, P544, P547, P564, P565 and P566) are missing, so we could either:
  - Leave their a priori coordinates to be calculated by `sh_gamit`
  - Download GAGE’s products, in which they are present, from https://www.unavco.org/data/gps-gnss/derived-products/derived-products.html (under “Direct File Access”, “File Server”, “GPS Site Coordinates”), then write coordinates for these sites to a file (e.g. subs.apr) and edit tables/process.defaults to define our own “.apr”-file (e.g. with “set aprf = subs.apr”) so that `sh_gamit` merges it with tables/lfile. before processing

Process using `sh_gamit`

- For one day each year, say day 100, process the data

```
cd ~/Desktop/subsidence/2007/
sh_setup -yr 2007
cp -p ../tables/sites.defaults tables/
cp -p ../tables/station.info tables/
cp -p ../tables/subs.apr tables/
cp -p ../tables/process.defaults tables/
sh_gamit -d 2007 100 -expt subs -orbit igsf
```

- Then do the same for 2008, 2009, 2010 and 2011 in their respective sub-directories of the main processing directory
  - This can be done simultaneously to shorten the time taken to process everything
- You will see a lot of output to the screen showing what GAMIT is doing, which can be saved to a file using redirection, e.g. "`>& sh_gamit.log`", at the end of the `sh_gamit` command

Any warnings or errors so far?

- You will notice many “RCLOCK” messages when `model` is calculating synthetic observations for site LIND, which is listed as excluded in the sh_gamit summary files:

```
List of sites without Prefit coordinate solutions:
LIND NoPrefit

List of sites without Postfit coordinate solutions:
LIND NoPostfit
```

- This is usually a sign of poor a priori coordinates, which manifest as clock errors (because time is distance with ranging measurements)
- Double-checking back over the “.apr”-file, we see that the a priori coordinates from LIND come from the NGS17P03 solution but appear to be for a site nearer Ellensburg, Washington, not Visalia, California

Iterate with corrected a priori coordinates

- We need to be careful to remove the bad LIND coordinates from the lfile. because this is a site ID clash, e.g. remove or comment LIND from 2007/tables/lfile., 2008/tables/lfile., etc.
- We also need to be careful that the other LIND does not appear in any file defining discontinuities and which version of site coordinates to use for given periods, that relate to the other LIND
  - It does, so we need to make a local copy of the accompanying ".eq"-file and link it to the generic file name used by GAMIT (tables/eq_rename)

```
cp -p ~/gg/tables/igb14_comb.eq tables/
ln -s -f tables/igb14_comb.eq tables/eq_rename
```

then edit tables/igb14_comb.eq to remove or comment out any records for LIND, e.g. "#rename LIND LIND_2PS 1998 07 27 00 00 2100 01 01 00 00"

- We already have RINEX files and broadcast navigation files downloaded from the first attempt, so calculate a priori coordinates using those and a nearby site with accurate known coordinates for reference, e.g.

```
cd ~/Desktop/subsidence/2007/
sh_crx2rnx -f rinex/lind1000.07o.gz rinex/gold1000.07o.gz
sh_rx2apr -site rinex/lind1000.07o -nav brdc/brdc1000.07n -ref rinex/gold1000.07o -apr ~/gg/tables/igb14_comb.apr
cat lind.apr >> ../tables/subs.apr
```

- Then repeat partially the steps in slide 10 for 2007, 2008 and 2009 (LIND is not available in 2010 and 2011), after moving or removing the first run's output directory, e.g.

```
cd ~/Desktop/subsidence/2007/
cp -p ../tables/subs.apr tables/
mv 100 100.old
sh_gamit -d 2007 100 -expt subs -orbit igsf
```

Prepare h-files for GLOBK

- We need to convert plain text (ASCII) h-files output from GAMIT to binary h-files for input to GLOBK
- The h-files are written by GAMIT to each day sub-directory in the year directories, so we could be explicit for the one day we processed, e.g.

```
htoglb 2007/glbf /dev/null -a 2007/100/hsubsa.07100
```

- or we could use a more generic command if many days were processed, e.g.

```
htoglb 2007/glbf /dev/null -a 2007/???/hsubsa.07???
```

- Repeat one of these commands for each year

Prepare GLOBK command files

- Create local copies of the `globk` and `glorg` command files in a solution directory

```
mkdir ~/Desktop/subsidence/gsoln/
cd ~/Desktop/subsidence/gsoln/
cp -p ~/gg/tables/globk.cmd ~/gg/tables/glorg.cmd .
```

- Add our local All_CWU_igs14.apr file *after* the default ~/gg/tables/igb14_comb.apr, in both the newly copied gsoln/globk.cmd and gsoln/glorg.cmd files, so the correct LIND coordinates in the former do not get overwritten by the wrong ones in the latter, e.g.

```
# Optionally add additional apr files for other sites
 apr_file ../tables/subs.apr
```

- We also need to be sure that the other LIND does not appear in any file defining discontinuities ("eq_file" option in globk.cmd)
  - It does, so we need to edit globk.cmd to use the local copy instead and increase tolerance for preliminary coordinates

```
eq_file ../tables/igb14_comb.eq
```

- We are processing some NOTA stations and GAMIT/GLOBK also distributes GAGE control files in tables/, so let's add some appropriate files defining known discontinuities, e.g.

```
# Optionally add a second eq_file for analysis-specific renames
 eq_file ~/gg/tables/All_PBO_ants.eq
 eq_file ~/gg/tables/All_PBO_unkn.eq
 eq_file ~/gg/tables/All_PBO_eqs.eq
```

Create time series from GAMIT results

- We will generate time series for the whole period of processing with one `glred` command, which runs globk once per session to create individual data points at each time
- We do this in the top-level multi-year solution directory by listing the files we wish to include in a ".gdl"-file (global directory listing) and running `glred` with that list, e.g.

```
cd ~/Desktop/subsidence/goln/
ls ../20??/glbf/h*_subs.glx > subs.glx.gdl
glred 6 glred_20210810.prt glred_20210810.log subs.glx.gdl globk.cmd
```

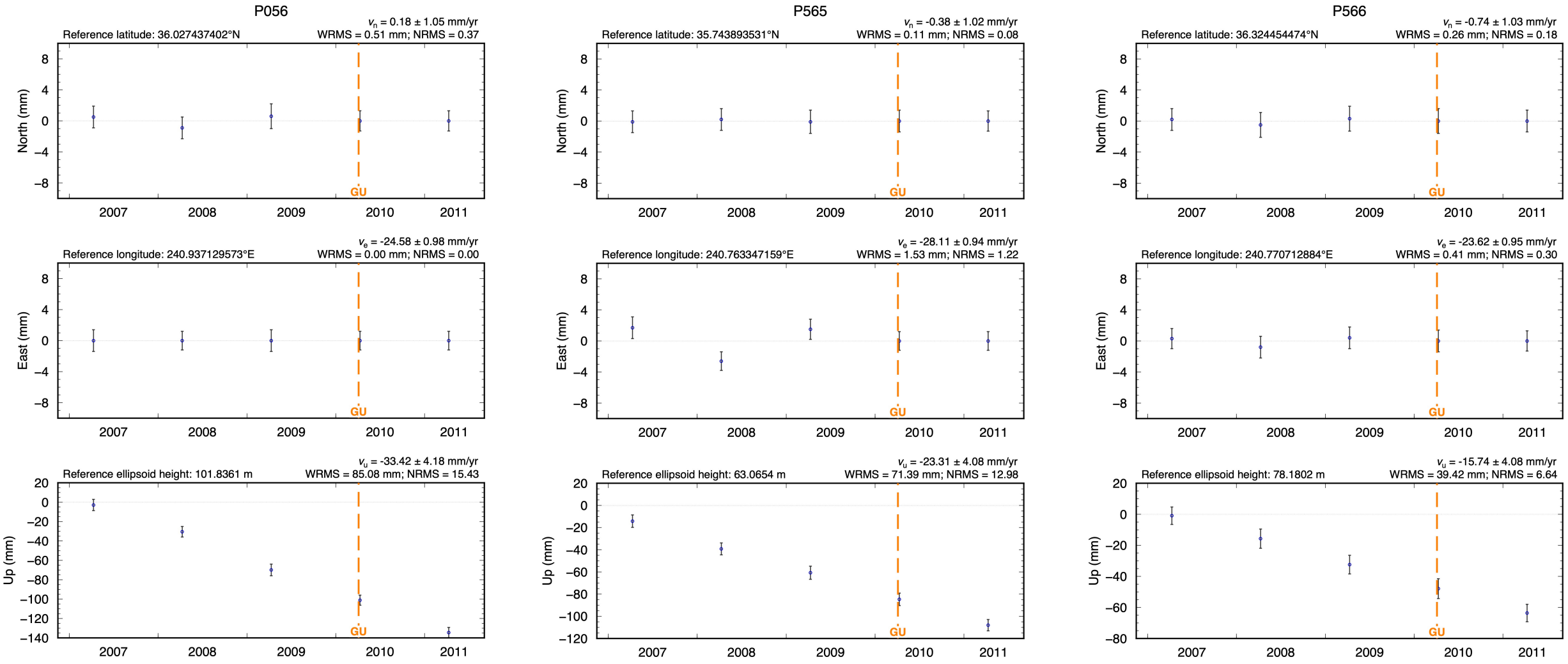
- The output file names (glred_20210810.prt, which will become glred_20210810.org after `glorg` is run by `glred` to define the reference frame, and glred_20210810.log) are arbitrary but we recommend some type ("glred" or "rep" for repeatability, i.e. time series) and date identifier

Create some plots for viewing (GMT)

- We would like to view the results, so let's plot the time series and ask the plotting script, `sh_plot_pos`, to do some basic analysis for us, like determine the rates, using the same discontinuities files that we included in globk.cmd, e.g. (note the line wrap)

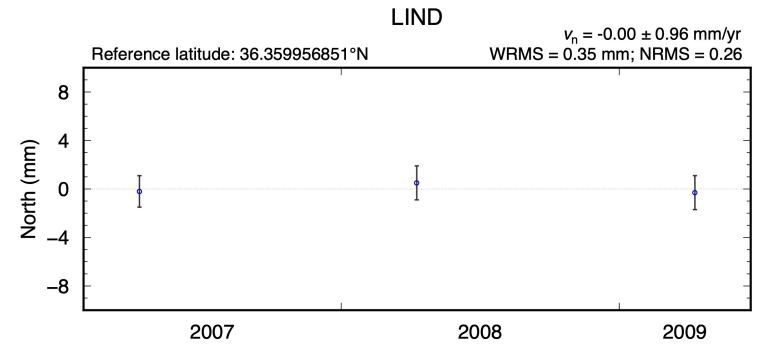
```
sh_plot_pos -f glred_20210810.org -k -t -r -u -b ~/gg/tables/igb14_comb.eq
~/gg/tables/All_PBO_ants.eq ~/gg/tables/All_PBO_unkn.eq -e
~/gg/tables/All_PBO_eqs.eq -d _20210810
```

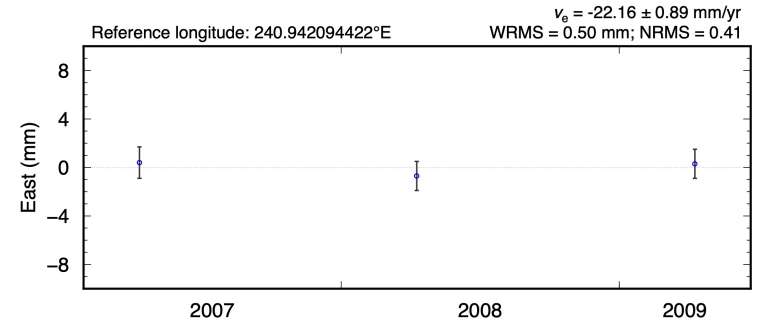
- This will generate a series of ".pos"-files from the ".org"-file output by glred in a pos_20210810/ directory and a series of plots of those ".pos"-files, with velocities estimated, in a plots_20210810/ directory
  - The plots are PostScript

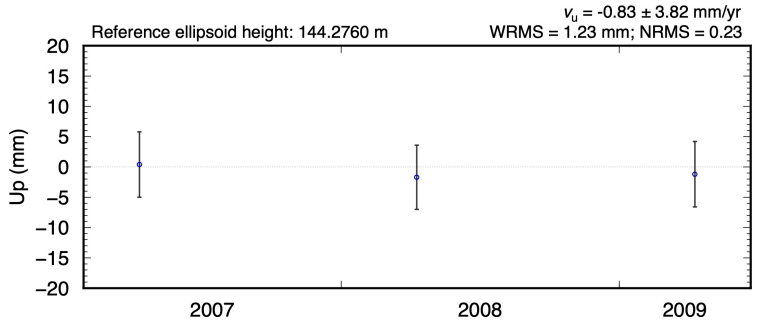


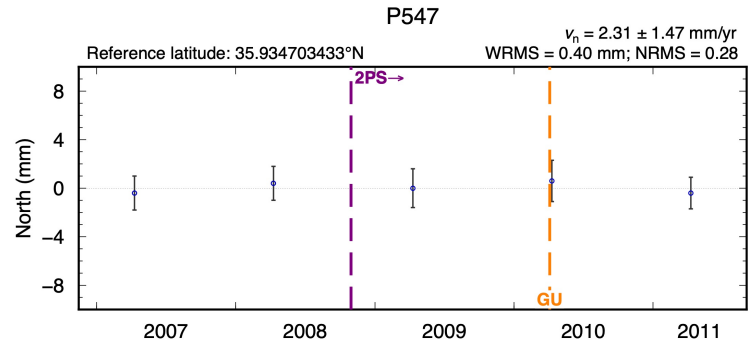
All rates are relative to ITRF2014 because we did not use any keyword at the end of the `glred` command in slide 15

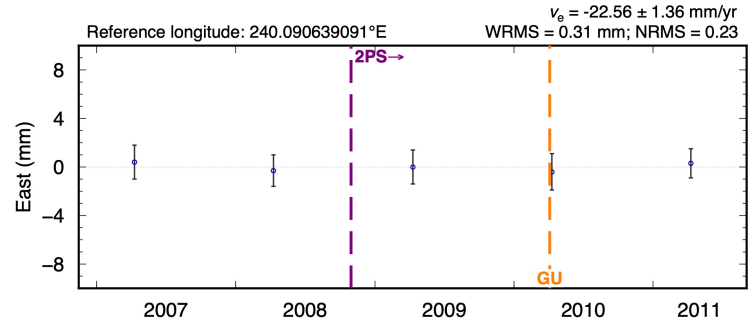
Orange lines represent earthquakes, defined in the ".eq"-files we provided in both globk.cmd and to the `sh_plot_pos` command, that may be close enough to affect the site; other discontinuities appear in purple

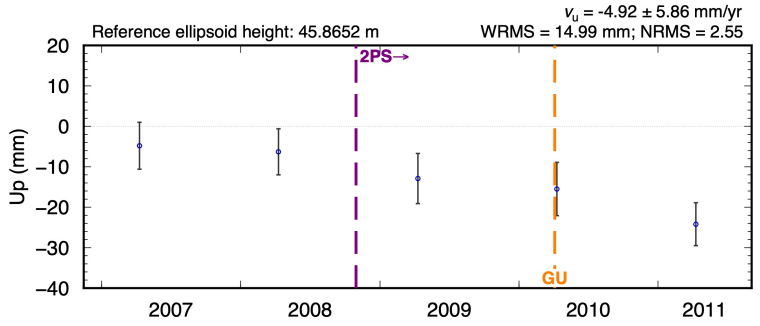


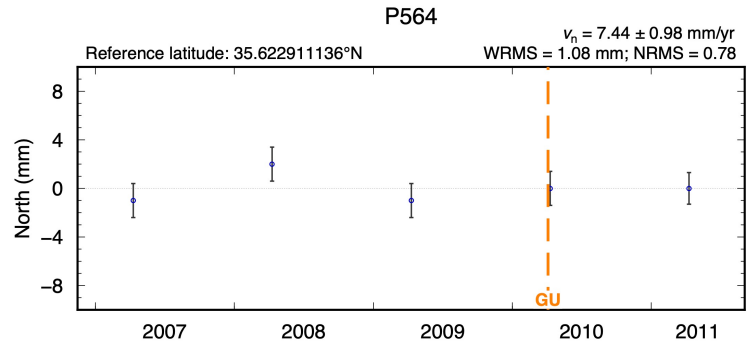


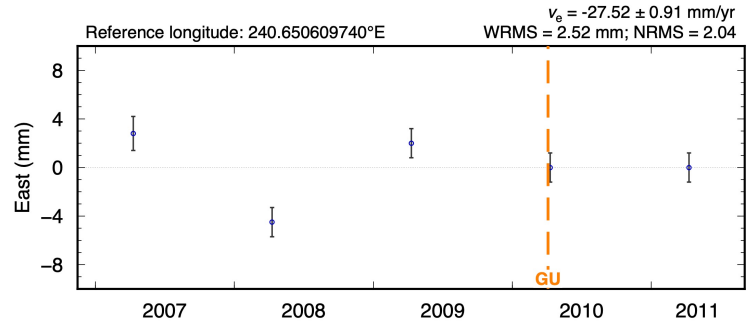


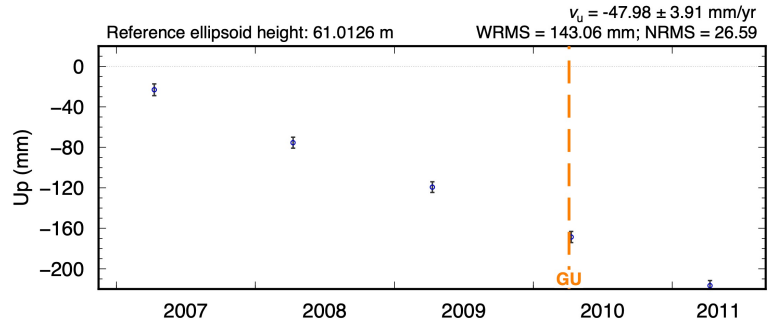












All rates are relative to ITRF2014 because we did not use any keyword at the end of the `glred` command in slide 15

Orange lines represent earthquakes, defined in the ".eq"-files we provided in both globk.cmd and to the `sh_plot_pos` command, that may be close enough to affect the site; other discontinuities would appear purple

What was done for you

- This example was straightforward because a lot of information was predefined
  - Equipment records in the default station.info file
  - Coordinates in the default ~/gg/tables/igb14_comb.apr file and a secondary ".apr"-file ~/gg/tables/subs.apr using coordinates from GAGE
  - Discontinuities affecting the sites in the default ~/gg/tables/igb14_comb.eq and GAGE's ~/gg/tables/All_PBO_*.eq files
- Normally this takes more work by the user to record, define and iterate the analysis
- We did have to deal with the site ID clash of LIND and updating its coordinates accordingly