Working with SPOTL

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Load Computation: the SPOTL Package

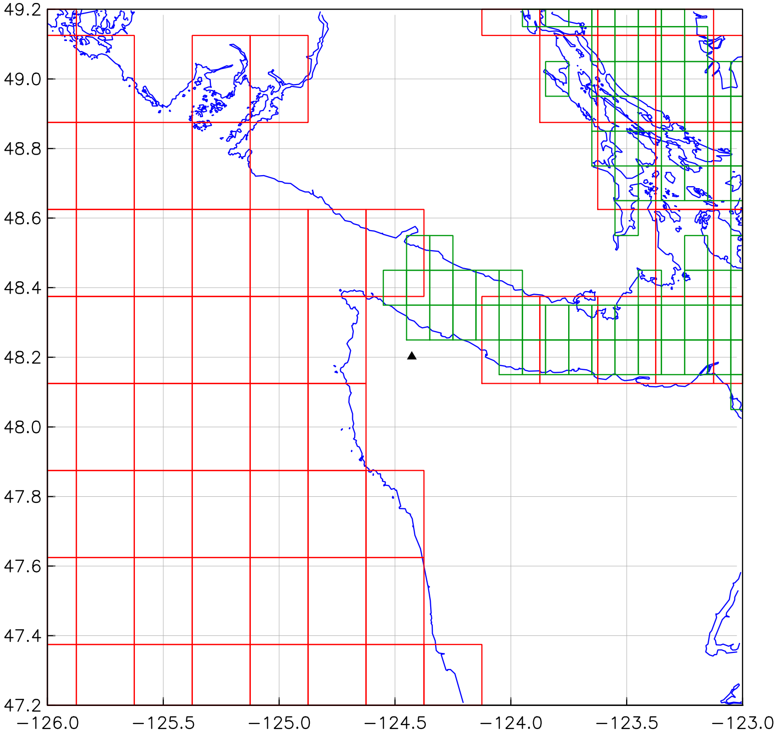
The SPOTL package includes the programs:

- 1. `nloadf` for finding the load, at one location, for a particular constituent.
- 2. `loadcomb` for combining loads from different models, adding the body tide, and adjusting for different azimuths.
- 3. `harprep` and `hartid` for using the results for many constituents to produce a time series
- 4. `ertid` for computing the body tide directly.

and the data sets:

- A. Ocean-tide models giving H for
  - A variety of global models (low-resolution)
  - High-resolution models for selected areas, with boundaries in polygon files.
- B. A land-sea model, to describe more precisely where the ocean ends.
- C. Green functions for different Earth models.

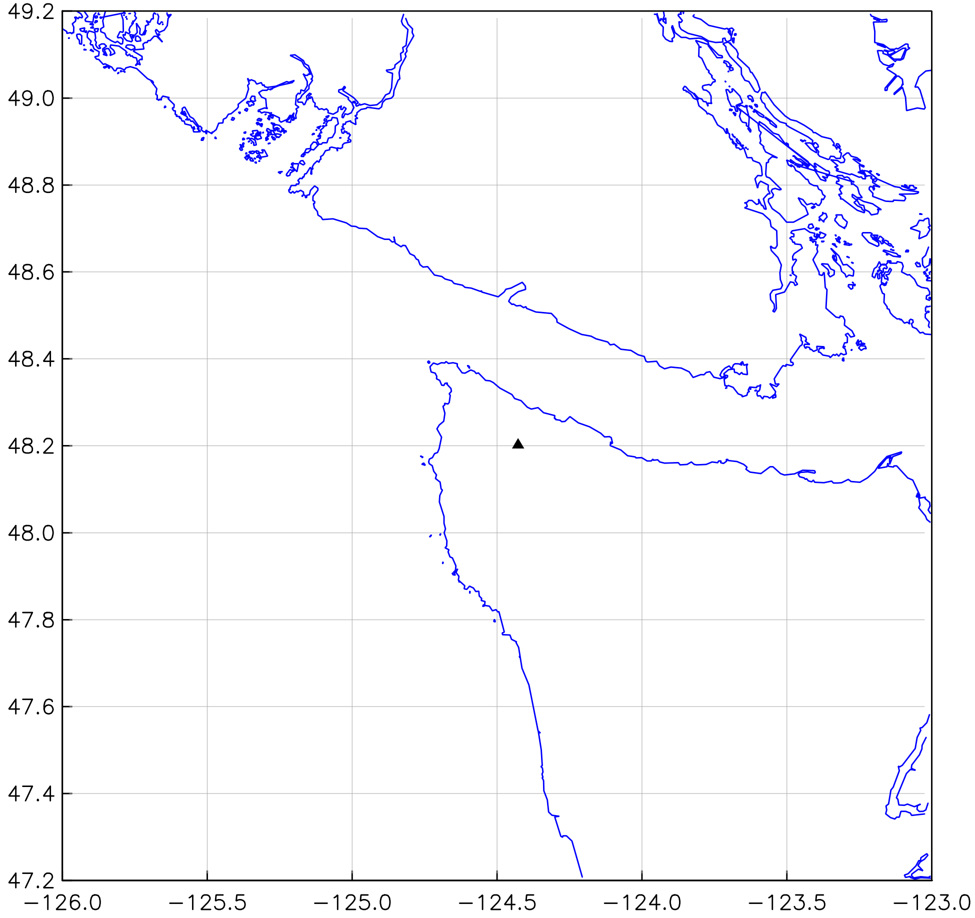
Two Ocean Models for the Pacific NW



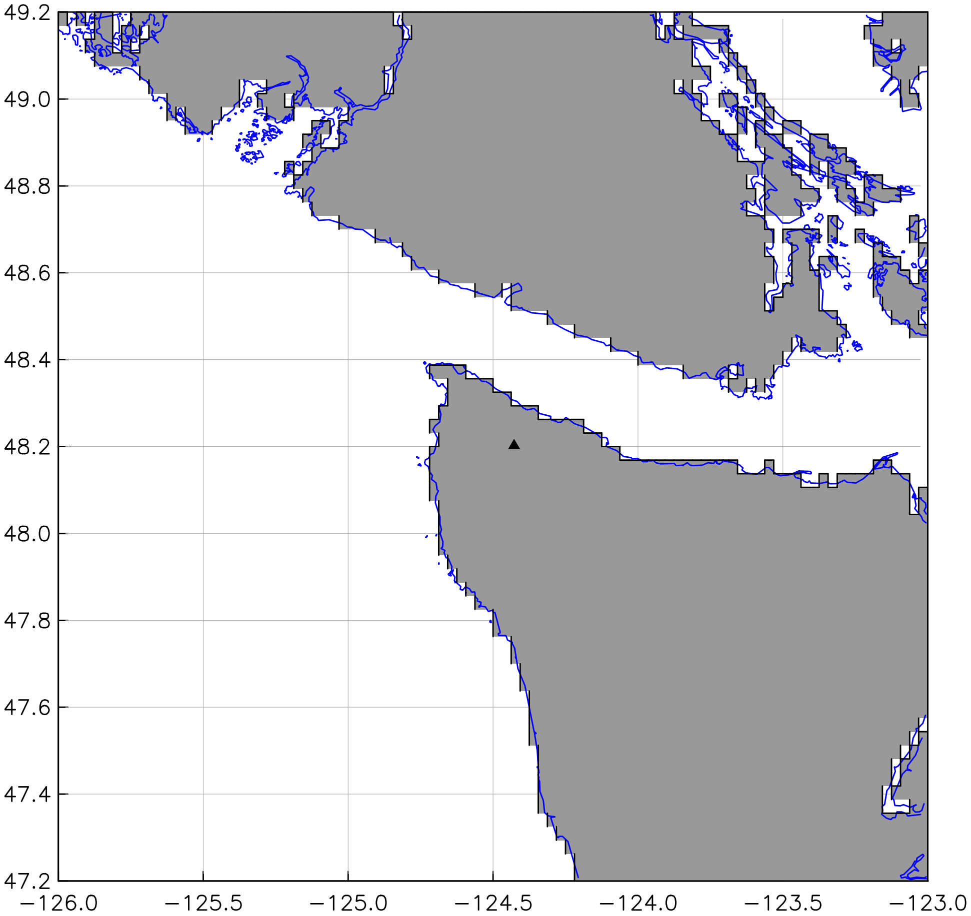
The red grid is for the global TPXO tidal model; the green is for a local model for the Straits of Georgia and Juan de Fuca.

How do we find loads from each one, and combine them?

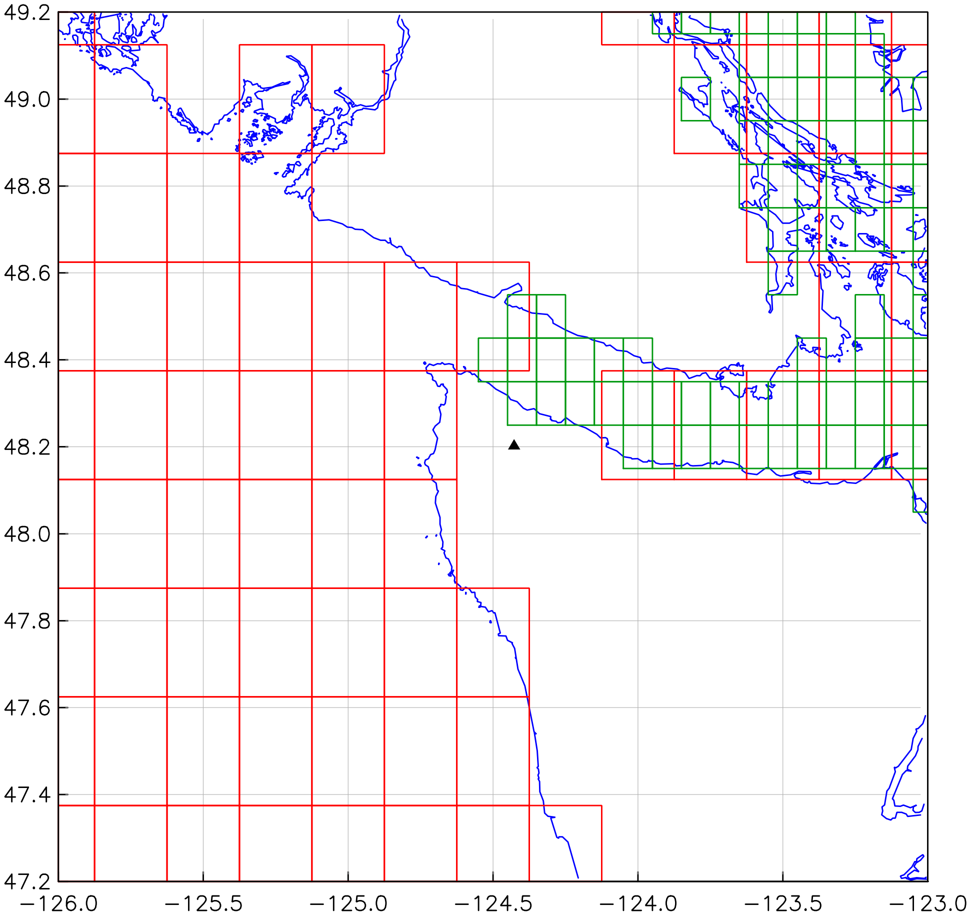
What there is: Ocean (with tides) and Land



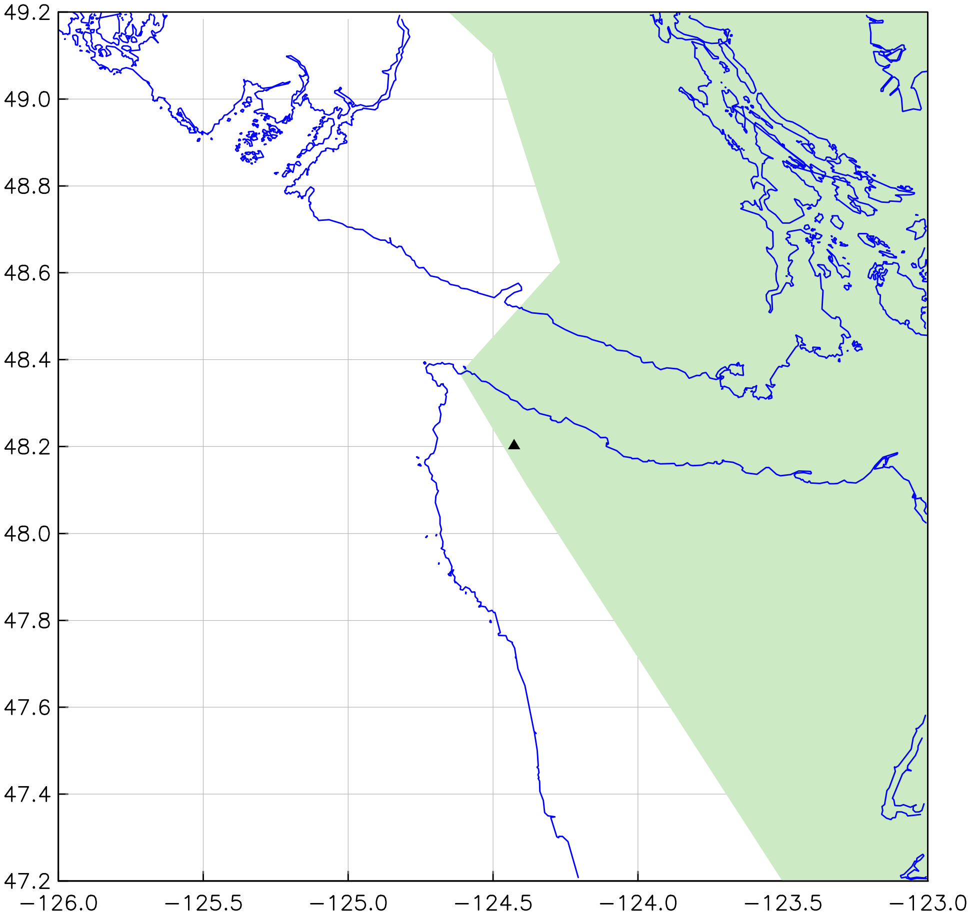
Global Land-sea Database



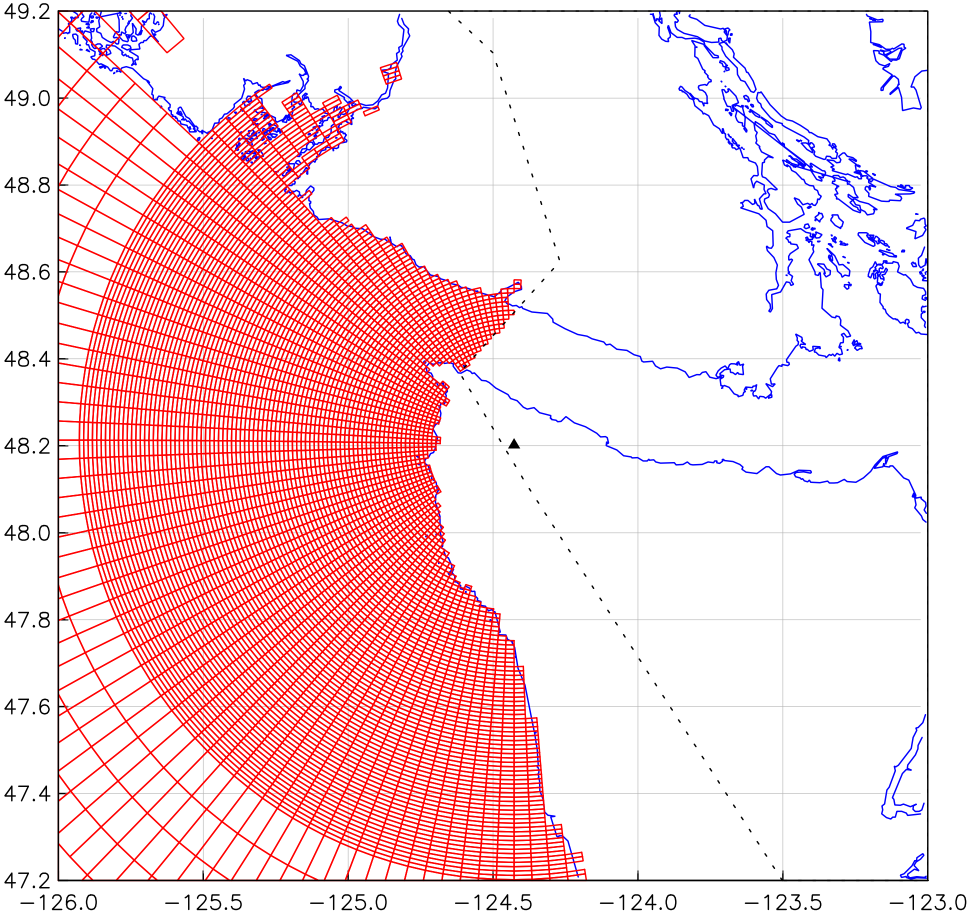
Ocean Tide Models



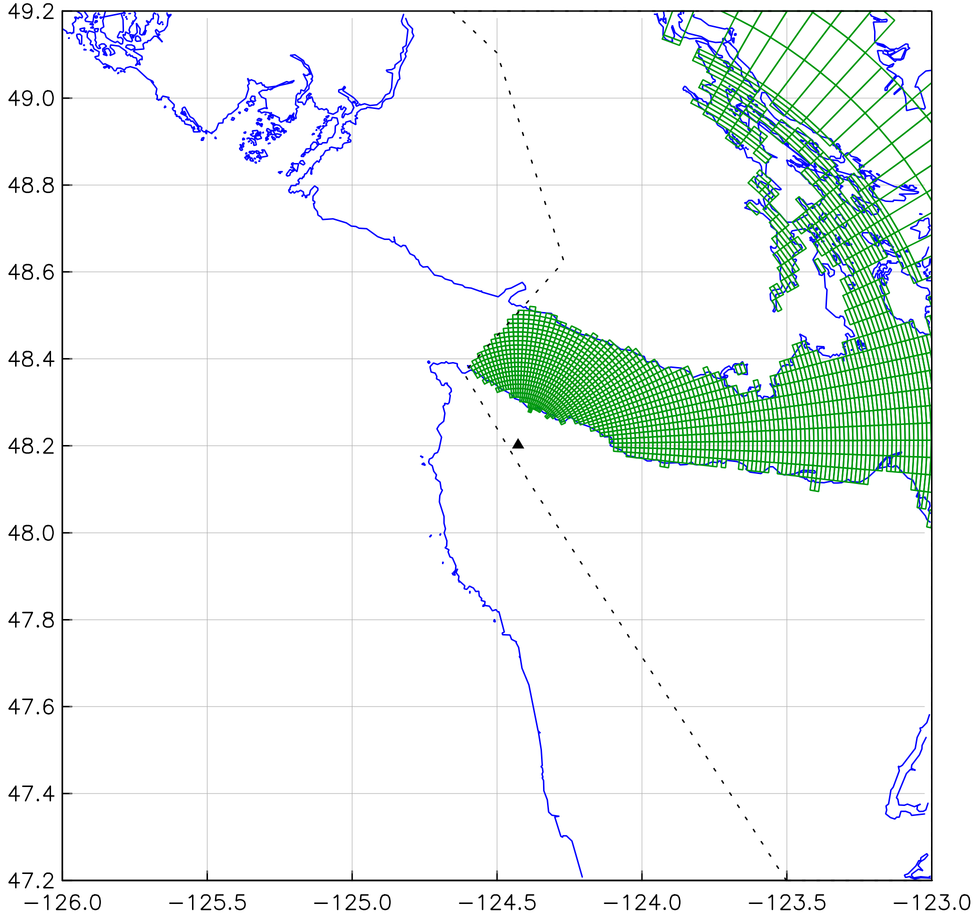
Polygon for Separating Different Models



Load Grid for Global Model



Load Grid for Local Model



Computing a Load

```
nloadf HOKO 48.202 -124.427 100. m2.gefu green.gbavap.std l poly.gefu + > tmp.m2.l
```

The command line includes (the order is required):

- Station information (name and position)
- Name of ocean model file
- Name of Green function file file
- The phase convention (don't ask)
- Information on use of a polygon file (optional)

and the result is sent to standard output (here, to a file).

Computing and Combining Loads

```
nloadf HOKO 48.202 -124.427 100. m2.gefu   green.gbavap.std l poly.gefu + > tmp.m2.l

nloadf HOKO 48.202 -124.427 100. m2.tpxo70 green.gbavap.std l poly.gefu - > tmp.m2.g

cat tmp.m2.l tmp.m2.g | loadcomb c > tmp.m2.load

cat tmp.m2.load | loadcomb b > tmp.m2.body

cat tmp.m2.load | loadcomb t > tmp.m2.th
```

These five commands

- Put loading results from two models (with the polygon used for the boundary) into two files
- Combine these two files to give the total load (vector addition of the loads).
- Find the body tide (not needed, strictly speaking).
- Combine that load with the body tide to produce the theoretical tide.

Sample SPOTL Output: `tmp.m2.l`

```
S  HOKO                                        48.2020 -124.4270      100.
O M2        2 0 0 0 0 0     Straits of Georgia and Juan de Fuca
G                 GUTENBERG BULLEN GREENS FUNCTIONS  JOBO2Q 10/19/71
G    Rings from   0.03 to   1.00 with spacing 0.01 - detailed grid used
G    Rings from   1.05 to   9.95 with spacing 0.10 - detailed grid used
G    Rings from  10.25 to  89.75 with spacing 0.50 - ocean model grid used
G    Rings from  90.50 to 179.50 with spacing 1.00 - ocean model grid used
P Polygon to include the Straits of Georgia and Juan de Fuca
P   all polygon areas included
C   Version 3.2 of load program, run at Wed Aug 25 19:39:56 2010
C   closest nonzero load was   0.09 degrees away, at   48.28 -124.39
C       23 zero loads found where ocean present, range   0.78-   3.05 deg
L l         Phases are local, lags negative
X
g              0.2297  107.9319
p              1.2406  -95.4251
d              0.2350  -87.3167    0.1802  -97.2629    0.8072   96.1769
t             22.2885  -30.4658   30.6713  -12.8066
s              1.6887 -112.2628    4.2123   13.6132    5.7803  -17.1302
```

Last lines are amp and local phase of gravity (g), potential (p), displacement (d: ENU), tilt (EN) and strain (ε_{EE}, ε_{NN}, ε_{EN})

Sample SPOTL Output: `tmp.m2.g`

```
S  HOKO                                         48.2020 -124.4270      100.
O M2        2 0 0 0 0 0     OSU TPXO 7.0
G                  GUTENBERG BULLEN GREENS FUNCTIONS  JOBO2Q 10/19/71
G    Rings from   0.03 to   1.00 with spacing 0.01 - detailed grid used
G    Rings from   1.05 to   9.95 with spacing 0.10 - detailed grid used
G    Rings from  10.25 to  89.75 with spacing 0.50 - ocean model grid used
G    Rings from  90.50 to 179.50 with spacing 1.00 - ocean model grid used
P Polygon to include the Straits of Georgia and Juan de Fuca
P   all polygon areas excluded
C   Version 3.2 of load program, run at Wed Aug 25 19:39:58 2010
C   closest nonzero load was   0.17 degrees away, at   48.21 -124.69
C       39 zero loads found where ocean present, range   0.83-   9.85 deg
L l          Phases are local, lags negative
X
g             5.5521 -178.6621
p            34.7121   -1.0729
d             7.3550  178.3120    2.0137 -103.0084   19.4539  178.7385
t           146.5715 -169.9169   30.0543 -144.0923
s            16.0916    6.5470    6.7084  168.4417    3.2678   47.7671
```

When we combine two files, the results part (the last 5 lines) are added; the other lines are concatenated to give a complete record of what was done.

Sample SPOTL Output: `tmp.m2.load`

```
S  HOKO                                            48.2020 -124.4270      100.
O M2        2 0 0 0 0 0     Straits of Georgia and Juan de Fuca
G                GUTENBERG BULLEN GREENS FUNCTIONS  JOBO2Q 10/19/71
G    Rings from   0.03 to   1.00 with spacing 0.01 - detailed grid used
G    Rings from   1.05 to   9.95 with spacing 0.10 - detailed grid used
G    Rings from  10.25 to  89.75 with spacing 0.50 - ocean model grid used
G    Rings from  90.50 to 179.50 with spacing 1.00 - ocean model grid used
P Polygon to include the Straits of Georgia and Juan de Fuca
P   all polygon areas included
C   Version 3.2 of load program, run at Wed Aug 25 21:42:17 2010
C   closest nonzero load was   0.09 degrees away, at   48.28 -124.39
C       23 zero loads found where ocean present, range   0.78-   3.05 deg
L l          Phases are local, lags negative
O M2        2 0 0 0 0 0     OSU TPXO 7.0
G                GUTENBERG BULLEN GREENS FUNCTIONS  JOBO2Q 10/19/71
G    Rings from   0.03 to   1.00 with spacing 0.01 - detailed grid used
G    Rings from   1.05 to   9.95 with spacing 0.10 - detailed grid used
G    Rings from  10.25 to  89.75 with spacing 0.50 - ocean model grid used
G    Rings from  90.50 to 179.50 with spacing 1.00 - ocean model grid used
P Polygon to include the Straits of Georgia and Juan de Fuca
P   all polygon areas excluded
C   Version 3.2 of load program, run at Wed Aug 25 21:42:18 2010
C   closest nonzero load was   0.17 degrees away, at   48.21 -124.69
C       39 zero loads found where ocean present, range   0.83-   9.85 deg
L l          Phases are local, lags negative
X
g             5.6220  179.0940
p            34.6401   -3.1194
d             7.3408 -179.8589    2.1931 -102.5371   19.5748  176.3950
t           130.4428 -163.5393   25.0510  -77.1638
s            15.3493    1.0151    3.4055  136.6995    7.7535    5.3059
```

This is what is produced by `loadcomb c`, combining files.

Sample SPOTL Output: `tmp.m2.body`

```
S  HOKO                                             48.2020 -124.4270      100.
O M2          2 0 0 0 0 0     Body Tide computed for spherical Earth
L l            Phases are local, lags negative
X
g              38.7089    0.0000
p              75.3014    0.0000
d              20.1002  180.0001   27.0429   90.0000   66.4731    0.0000
t              35.3610   90.0000   26.2828  180.0001
s               1.2501    0.0000   11.1075    0.0000    4.7195  -90.0000
```

This is what is produced by `loadcomb b`, which gets the tidal amplitude (implicitly) and the location from the input file.

Sample SPOTL Output: `tmp.m2.th`

```
S  HOKO                                         48.2020 -124.4270      100.
O M2         2 0 0 0 0 0     Body Tide computed for spherical Earth
O M2         2 0 0 0 0 0     Straits of Georgia and Juan de Fuca
G                  GUTENBERG BULLEN GREENS FUNCTIONS  JOBO2Q 10/19/71
G    Rings from   0.03 to   1.00 with spacing 0.01 - detailed grid used
G    Rings from   1.05 to   9.95 with spacing 0.10 - detailed grid used
G    Rings from  10.25 to  89.75 with spacing 0.50 - ocean model grid used
G    Rings from  90.50 to 179.50 with spacing 1.00 - ocean model grid used
P Polygon to include the Straits of Georgia and Juan de Fuca
P   all polygon areas included
C   Version 3.2 of load program, run at Wed Aug 25 21:42:17 2010
C   closest nonzero load was   0.09 degrees away, at   48.28 -124.39
C       23 zero loads found where ocean present, range   0.78-   3.05 deg
L l          Phases are local, lags negative
O M2         2 0 0 0 0 0     OSU TPXO 7.0
G                  GUTENBERG BULLEN GREENS FUNCTIONS  JOBO2Q 10/19/71
G    Rings from   0.03 to   1.00 with spacing 0.01 - detailed grid used
G    Rings from   1.05 to   9.95 with spacing 0.10 - detailed grid used
G    Rings from  10.25 to  89.75 with spacing 0.50 - ocean model grid used
G    Rings from  90.50 to 179.50 with spacing 1.00 - ocean model grid used
P Polygon to include the Straits of Georgia and Juan de Fuca
P   all polygon areas excluded
C   Version 3.2 of load program, run at Wed Aug 25 21:42:18 2010
C   closest nonzero load was   0.17 degrees away, at   48.21 -124.69
C       39 zero loads found where ocean present, range   0.83-   9.85 deg
L l          Phases are local, lags negative
X
g           33.0877    0.1539
p          109.9063   -0.9827
d           27.4409 -179.9623   24.9066   91.0952   46.9532    1.5021
t          125.1067 -179.2668   32.0279 -130.3048
s           16.5992    0.9387    8.9396   15.1450    8.6961  -27.4038
```

This is what is produced by `loadcomb t`: body and load combined.

Getting Harmonic Constants

To produce a time series of the tide, we need to create a file of harmonic constants for at least one diurnal and one semidiurnal constituent.

This is done with `harprp`, which

- Reformats the files into harmonic constants.
- When needed, computes the appropriate values for vector and tensor quantities.

```
cat tmp.o1.th tmp.k1.th tmp.m2.th tmp.s2.th | harprp l 45 > tmp.harc.nee
```

The output file has the constants for the extension (`l`) at an azimuth of 45°.

Sample Harmonic Constants File: `tmp.harc.nee`

```
l
-124.427
 1-1 0 0 0 0   6.3030   -58.08
 1 1 0 0 0 0   7.3674   -84.40
 2 0 0 0 0 0  20.5116    -7.56
 2 2-2 0 0 0   7.7320   -26.61
-1 0 0 0 0 0   0.0000     0.00
```

This file starts with phase information (and local phase needs the longitude), and then gives

- The *Doodson number*, a way of specifying the frequency of the constituent;
- The amplitude (in whatever units are being used).
- The phase, in degrees.

The last line uses an impossible Doodson number as an EOF.

Creating a Time Series

```
cat tmp.harc.nee | hartid 2010 237 0 0 0 10000 300 > timeseries
```

This sends the harmonic constants to `hartid`, which takes on the command line:

- The time of the first term (year month day hr min sec, or, as here, year day-of-year hr min sec),
- The number of terms to write out.
- The sample interval (sec) of the time series.

The output file just contains the data values, with no time information.

Important point: the program uses many constituents for its computation, independent of how many are read in; the amplitudes and phases of these others are inferred by scaling them against the potential.