In the tar files *SPPIM_ data_ YYYY.tar* and *other.tar* you should find:

- Data in subdirectories *YYYYMMDD/DATA/Q00, DATA/Q01,...*, one for each event that day
- Scripts to facilitate picking onsets
- A few Fortran programs to process the picks

In the DATA/Qnn directories you find:

- Mermaid seismograms with file names ending in lower case *.sac, instrument corrected to Pa
- Island station data downloaded from IRIS ending in upper case *.SAC, instrument corrected to velocity
- *smap.pdf* showing the island station data on a map, with event as star (Fig 1),
- *pmap.pdf* showing the Mermaid data on a zoomed-in map (Fig2),
- *pplt1.pdf, pplt2.pdf,...* Seismogramplots to aid onset comparison (Fig 3).

Install data, scripts and software

- Untar SPPIM_data_2018.tar in a dedicated data directory of your choice
- Untar file *other.tar*
- Change compiler *gfortran*, location of *bin* directory, or *SAC library* if necessary in *Compile_ all* (see comments in that script).
- Run *Compile_ all*

Prepare for picking

- Go into subdirectory, e.g. `cd 20181025/DATA/Q00`
- Look at *smap.pdf* and *pmap.pdf* to get an idea of the data distribution and quality
- Look at *pplt1.pdf* to check if there is a weak foreshock only visible at close distance
- Look at all *pplt*.pdf* files and decide on the character of the onset
- If there is a weak foreshock, note the time delay `tbias` of it (needed later in *rdapf2*)

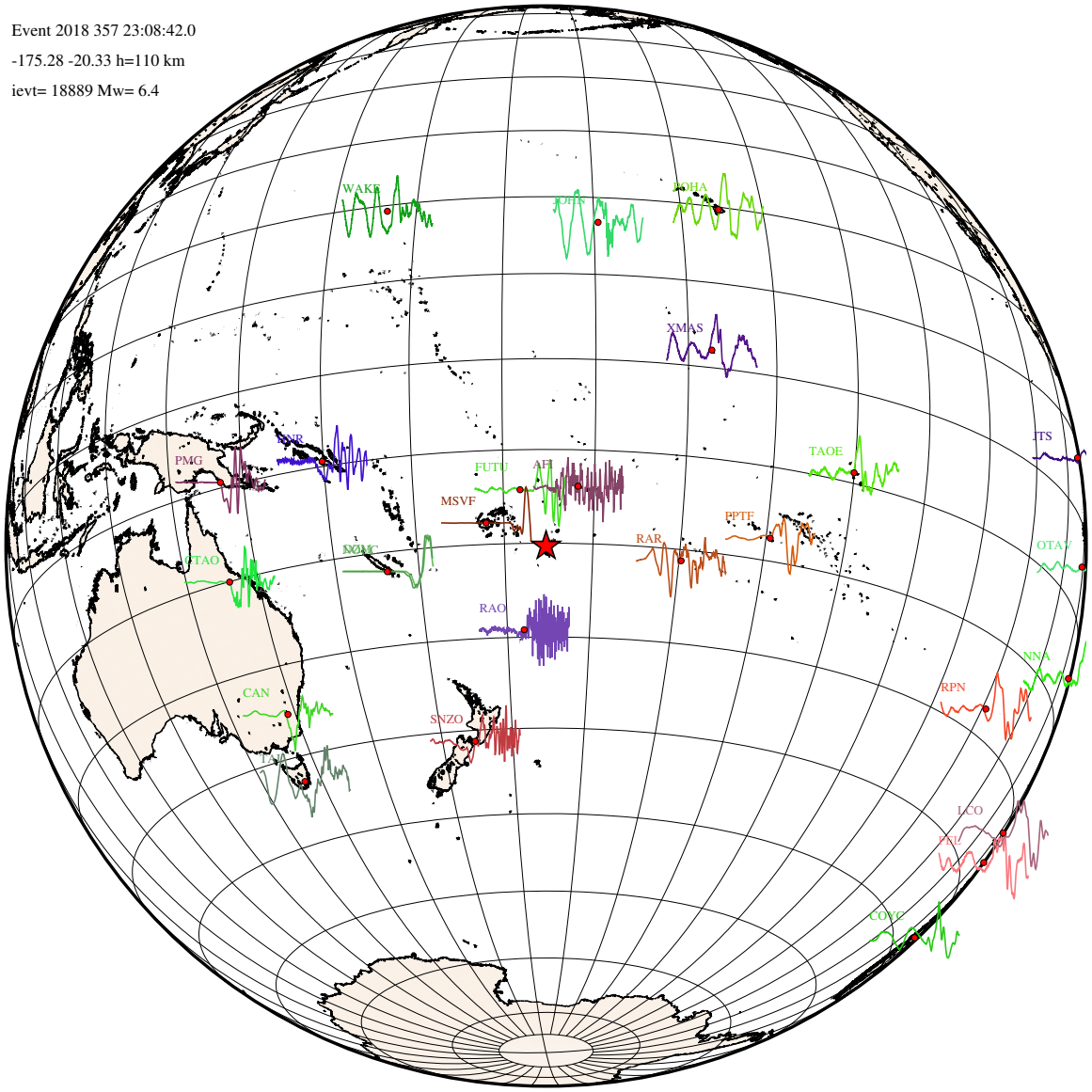

Figure 1: Plot smap.pdf of island stations around the epicentre (red star). The grid lines are every 10° of latitude/longitude.

Picking a the onset of P or PKP

- Type `mkdoppk` to create a local SAC macro doppk
- Start SAC and type `m doppk`

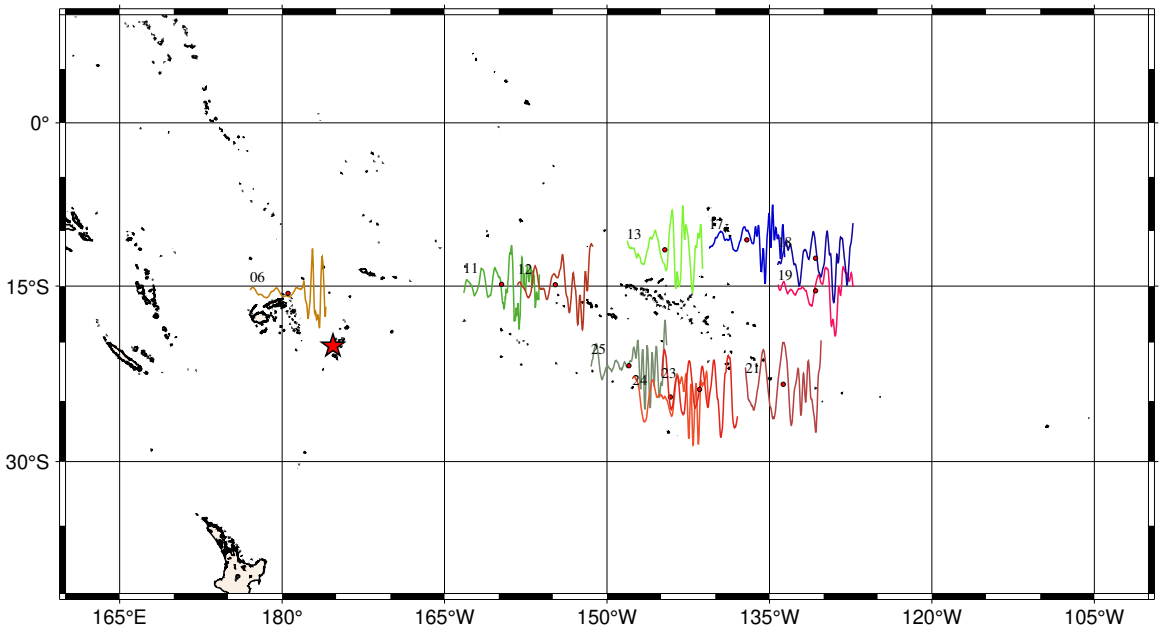

Figure 2: Plot pmap.pdf with zoom-in of the SPPIM records.

- Place the cross at the onset of the first plot, type A, then L (lower case OK) if onset is OK[1]
- Type N to go on to the next plot

To enable source corrections, please pick also the island station records that are coming up. I did some removal of noisy records but some have survived that. When in doubt, simply type N to go to the next record.

While you pick, please get a general idea of the uncertainty in the pick. This is needed for *rdapf2*. Unfortunately, SAC's ppk command does not allow to specify uncertainty in each pick and write it to APF[2]

[1]Typing A puts the pick into the header, L writes it to the APF file.
[2]The command `help ppk` seems to offer that possibility, but in SAC version 102.0 it does not work.

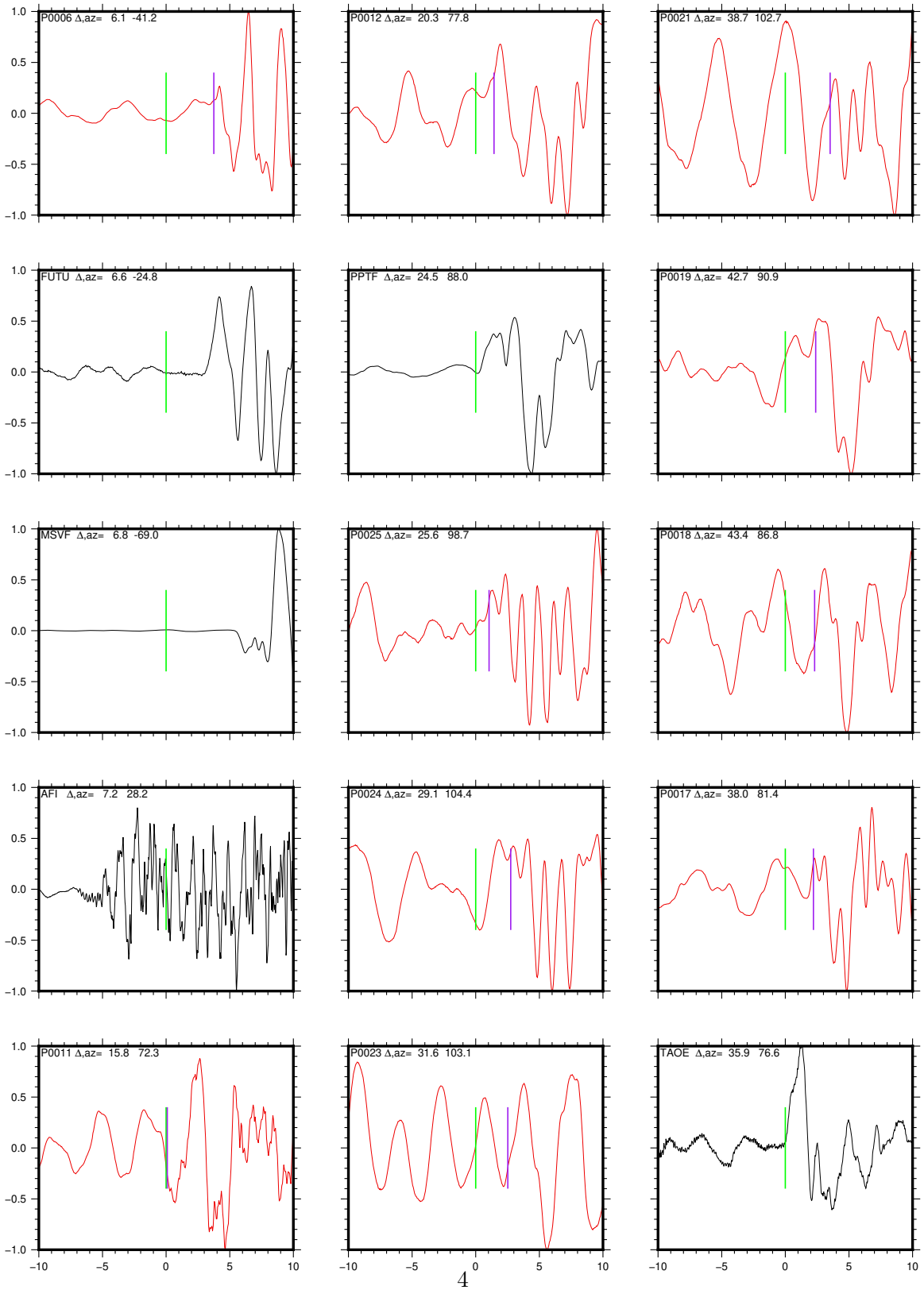

Figure 3: Plot pplt1.pdf of onsets. Seismograms are ranked such that nearby island stations are placed above and below the SPPIM records (red traces). The AK135 prediction is indicated by a green line at t=0, the AIC pick for the SPPIM records by a purple line.

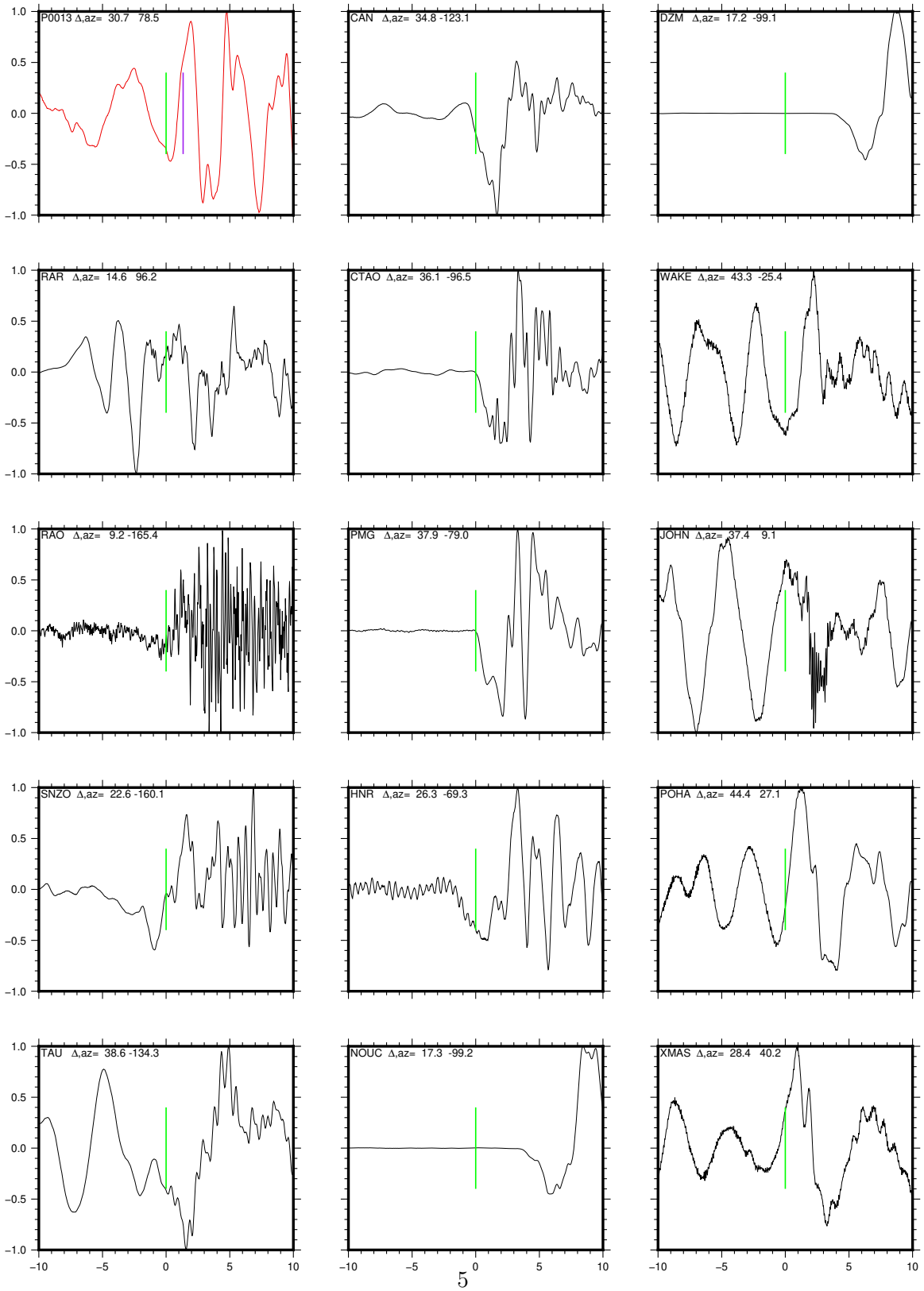

Figure 4: Figure 3 continued: plot pplt2.pdf of onsets.

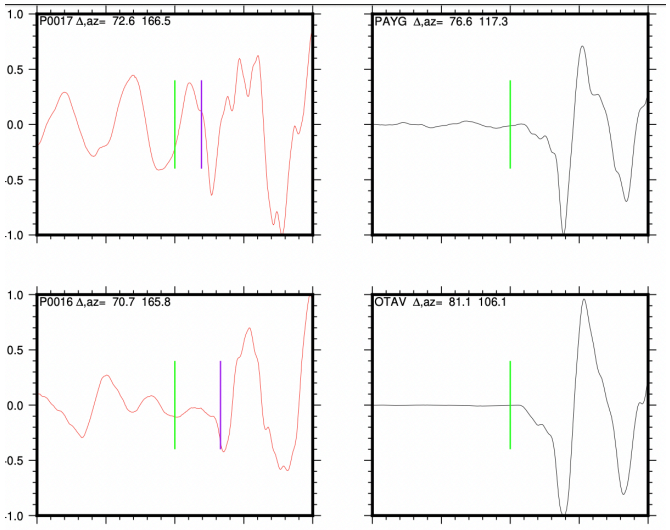

Figure 5: Records showing a pre-shock in the event of Nov 30, 2018 (To 17:29:28 , 61.36°N, 149.99°W, depth 57 km, Mw 7.0

Postprocessing the APF file

- Verify that the APF file has your picks. If you picked an onset twice (because you changed your mind or clicked accidentally) *rdapf2* will only accept the last entry, so there is no need to delete these lines. If you left SAC halfway and started over, earlier picks are stored in *APF.org* and you must manually merge it with the new APF file. Insert it before the first entry in APF, so that duplicate lines have the last entry as the correct one.
- Call `rdapf2 P pickerror`, where pickerror is a general picking error for the whole data set. Or, if you picked a later onset and $tbias > 0$, call `rdapf2 P pickerror tbias`.
- To verify your picks, you may wish to redo the ppltn.pdf files, which now include also the pick locations (blue vertical lines). Type `runpickhelp` to do that.
- Check the output file `add_to_datafile.Pnnnnn` (where nnnnn denotes the event number). The travel time and its error are on the 4th line of every entry. This is the time to edit the error if there are any records for which you judge the default estimate wrong.

When to use the tbias option

Figure 5 shows the purple AIC pick for Mermaids 16 and 17: it identifies a sharp downward turn as the onset. Station OTAV shows that a weaker onset occurs instead 2.3 seconds before the sharp downward onset. This is also visible in PAYG (and in many other records not shown here). Since the weaker onset is not, or at least not well, visible in the noisier records one should prefer to pick

the main shock, delayed by 2.3 seconds. We thus have a 'pre-shock' followed by a 'main shock' after 2.3 s.

The role of *tbias* in the inversion stage is to avoid that damping of the origin time corrections biases the correction to the weaker onset, which corresponds in all likelihood to the origin time reported by ISC or NEIC which is used by us for this event. The inversion program will instead bias to the origin time for the main event.

If one assumes the main shock onset can be picked with a uncertainty of 0.2 s, the call to rdapf2 should be: `rdapf2 P 0.2 2.3`.

How rdapf2 combines errors

The delay that is interpreted by the tomography program has different sources of error, of which the picking error is usually the smallest, except when there is a danger of misidentification. The main error is introduced by the crustal correction (we use model LITH1.0). Though the oceanic crust correction is more precise than that of continental crust, for Mermaids this is offset by the uncertainty in the bathymetry, which can easily be hundreds of meters. Program `rdapf2` assumes a standard error of 0.4 s due to the crustal correction. The location error in the Mermaids introduces an equivalent delay time error $dt = pd\Delta$ that is usually well below 0.1 s but can be substantial if the Mermaid is caught in an eddy current. This error is in `out.cfneic` (see Appendix) and used by `rdapf2`. The program adds the variances and takes the square root to arrive at the final error.

Appendix: files out.cfneic and quake

Each directory Qnn has a file out.cfneic with one row for each Mermaid, and 30 columns:

1-6 Origin time: year, Julian day, hour, minute, sec, msec

7-9 Event longitude, latitude and depth from ISC or latest NEIC[3]

10,11 Drift distanced before previous (d01) and most recent surfacing (d23)

12 Event magnitude

13 Angle between last three surfacings

14-17 Station name, longitude, latitude and distance (corrected for path curvature)[4]

18-19 Observed travel time and its error according to AIC

20 Ascent time in seconds

[3]The SAC headers have this location.

[4]The SAC headers maintain the original station location as derived from linear interpolation.

21-23 S/N ratio, ocean depth and station elevation (negative)

24 Slowness p in sec/km

25-26 Average deep drift velocity in km/s before (v1) previous surfacing and before current (v2)

27 Acceleration of the float's drift in km/s^2

28-29 Location difference with linear interpolation along path (b) and perpendicular (h) locnerr

30 Equivalent travel time error derived from location difference

Each event is characterized in the file `quake` with four rows:

1. Event year and Julian day
2. Origin time hour, minute,seconds,milliseconds
3. Latitude, longitude (latest estimates)
4. Depth (km), Magnitude, event number