

Mermaid Data Processing Tutorial Part II

4. Picking advice

- When the plots come up, after typing *pnext*, do the following:
- Study the polarity plot to see where P waves go UP and where they go DOWN. If a moment tensor is available, the plots are coloured with the predicted polarity. In that case check if they conform to the observed polarity (sometimes the moment tensors can be wrong for the very first arrival)
- Identify distance/azimuth ranges and their polarity
- If a source time function is available, see if there is a danger of a weak foreshock with a few seconds of the main shock
- Sometimes you may wish to get an idea of the tectonic situation. Is this a very deep quake? Do the rays travel in subducted slabs?

- Stations in the oceanic domain are usually much noisier than land stations
- Mermaids record pressure, which includes pressure variations due to the water waves (near 0.2 Hz)
- GSN (island) stations record ground velocity, which includes microseismic noise from the surf, with peaks also near 0.2 Hz
- Pressure and ground velocity have the same polarity
- The onset of the P wave may be much smaller in amplitude than the noise amplitude!
- Deep quakes have P wave peaks near 1 Hz, but shallow quakes may overlap with the noise frequencies

- Whenever picking is ambiguous, *bring up a second window - copy/paste from*

```
Running PPK on 2021/20210714/DATA/Q00  
2021 195
```

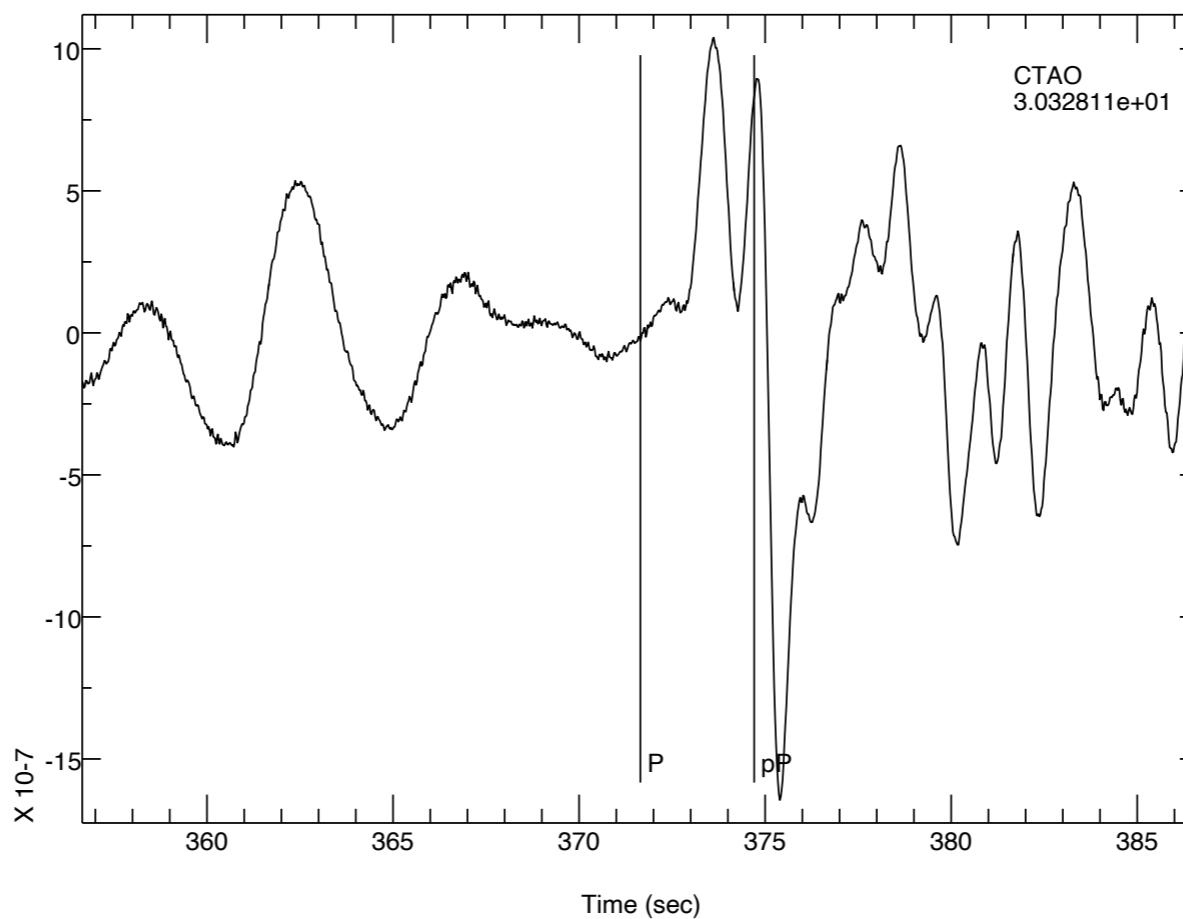
and in the second window type

```
[auguste@augustes-macbook-air SPIM % cd 2021/20210714/DATA/Q00
```

- where you can do any of the following:
- Check (again) the predicted polarity from **sisaz.pdf**. If the station is near white its P wave may go either way.
- Check the **pplt*.pdf** plots for waveform shape in nearby stations
- If necessary call SAC and bring nearby stations up in the plot. You can set a preferred time window around t0 (the predicted arrival time, e.g.: SAC> **xlim t0 -20 t0 +10**
- Experiment with different filters, e.g. SAC> **hp co 0.3**
- Line them up around t0: SAC> **p1 relative**

The pP danger

- Shallow quakes have pP following P after a few seconds
- If P is in a node of the radiation pattern, you may not see P and misidentify the pP arrival as P
- This happens sometimes with the automatic AIC pick (F in the plot) for the Mermaids
- The polarity of pP can be the same, or the inverse, of that of P so the polarity plot is of no help. But you can check nearby stations that show both P and pP to help understand what you see



The time between pP and P depends on epicentral distance and source depth
(rule of thumb: $pP-P = h/3$)

pP-P in seconds

	h=10 (*)	20	30 km
Δ=10°	2.4	4.6	6.6
20	2.9	5.5	8.0
30	3.0	6.0	8.7
50	3.1	6.1	9.0
70	3.3	6.4	9.3
90	3.4	6.6	10.0

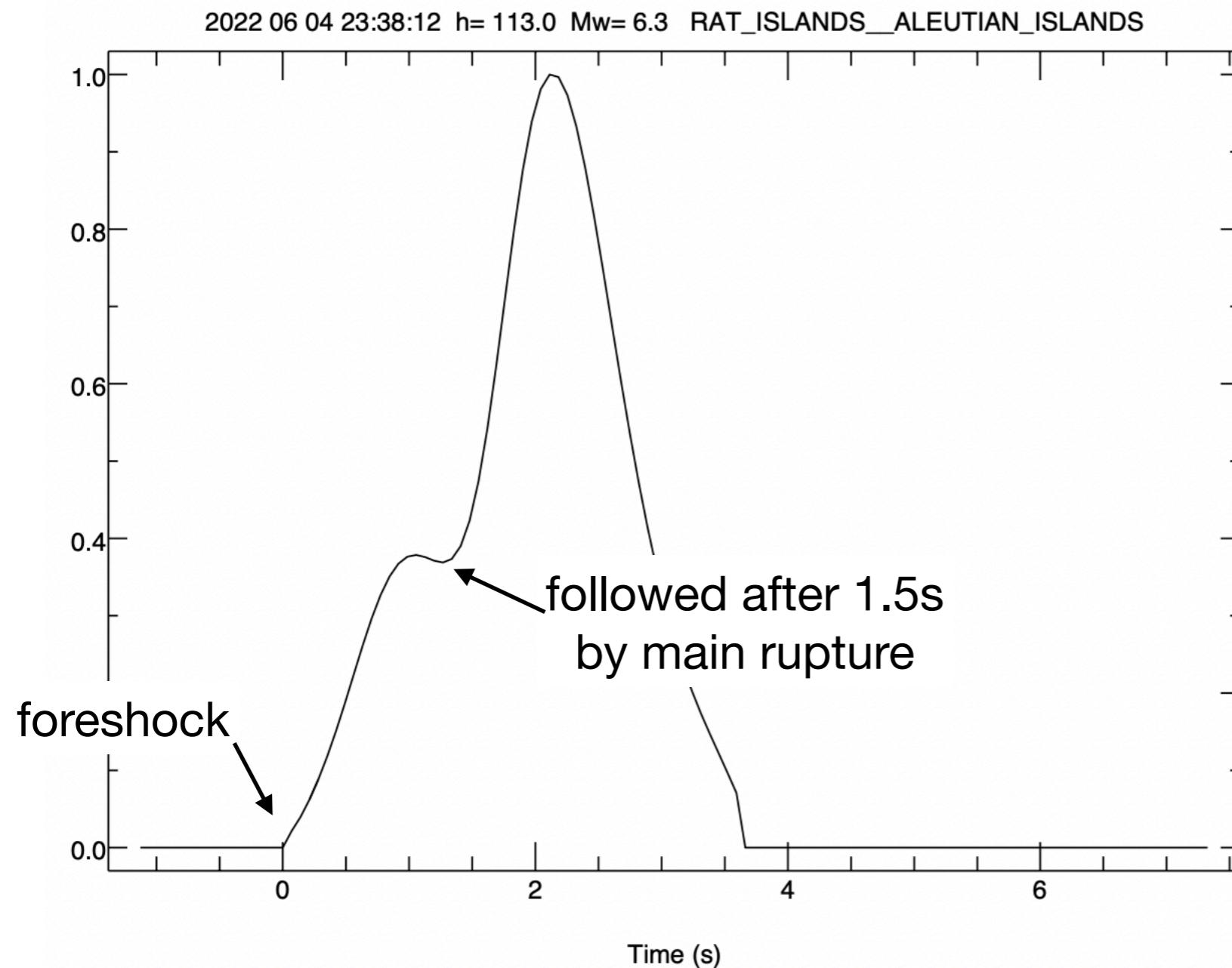
(*) If h is listed as 10 km in the catalogue it is uncertain and may be even less.

Why pick island stations?



- Island stations (and those in Australia/New Zealand) can assist you in identifying the waveform of P and, most importantly, its *onset*
- At the time of tomographic inversion, the island stations will assist us in making small corrections to the event location and origin time
- Ideally, we have three or more island station picks for corrections
- BUT: island stations do not move like Mermaids, their information is thus quite redundant when the same raypaths occur, e.g. for aftershocks.
- Therefore *do not spend much time on a island station pick* if the arrival is ambiguous, simply do not pick but type <N> to go to next plot

Weak foreshocks

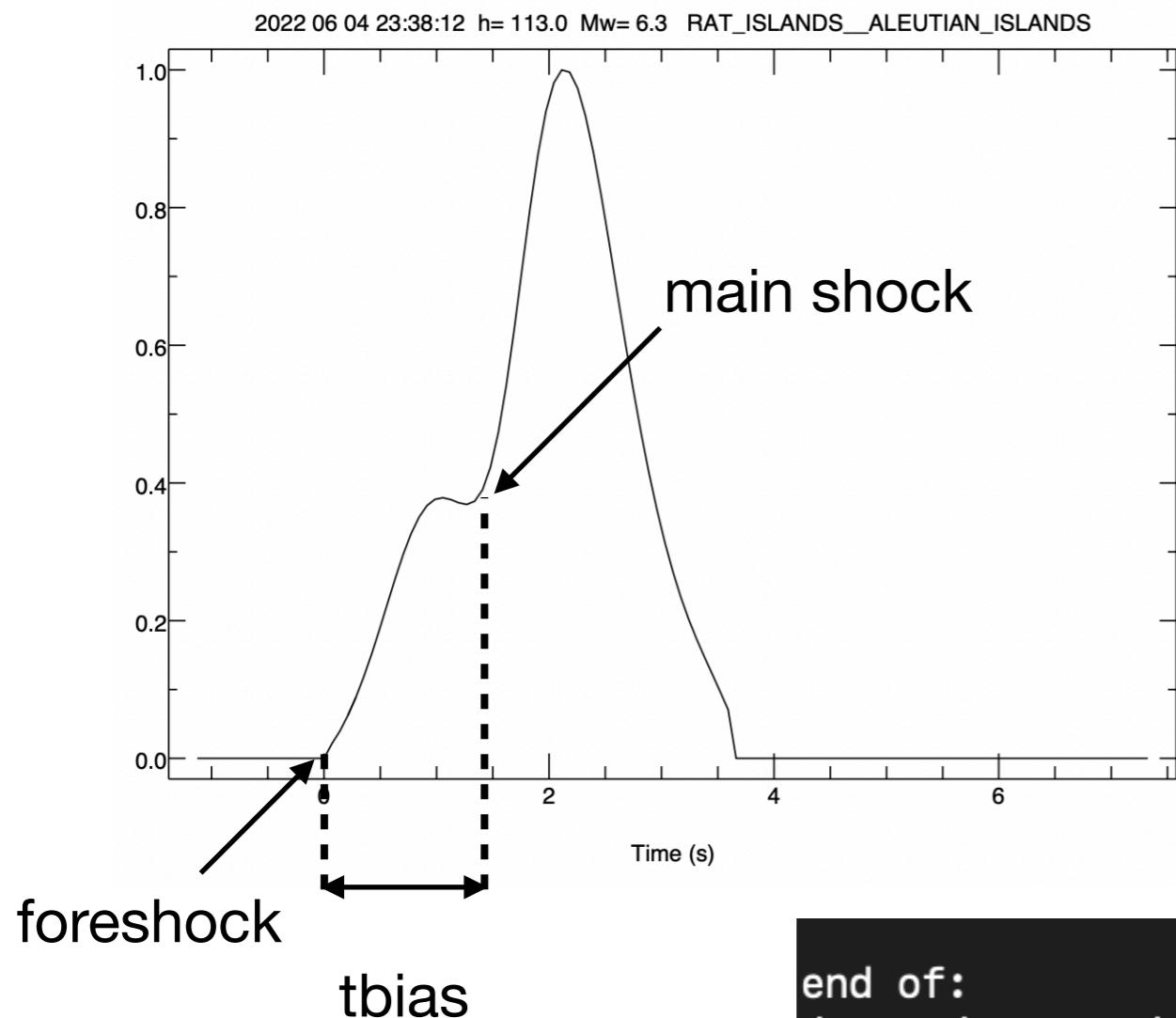


Check if the foreshock
is visible in the Mermaids

If not, check if the main
shock can be clearly
identified

Decide to pick the foreshock,
or the main shock, or (if
ambiguous) reject the event

The use of tbias when you decide to ignore a foreshock



tbias corrects the origin time of the event to reflect picking the later rupture

You can add your estimate of tbias after picking by answering [t] after picking.

No great accuracy needed (about 0.5s is fine)

```
end of:  
/Users/auguste/txt/talks/2024/SPPIMcouse/2022/20220604/DATA/Q03  
-----  
[n]ext event, give nonzero [t]bias, or [r]epeat? t  
Give tbias for rdapf2: 1.5
```

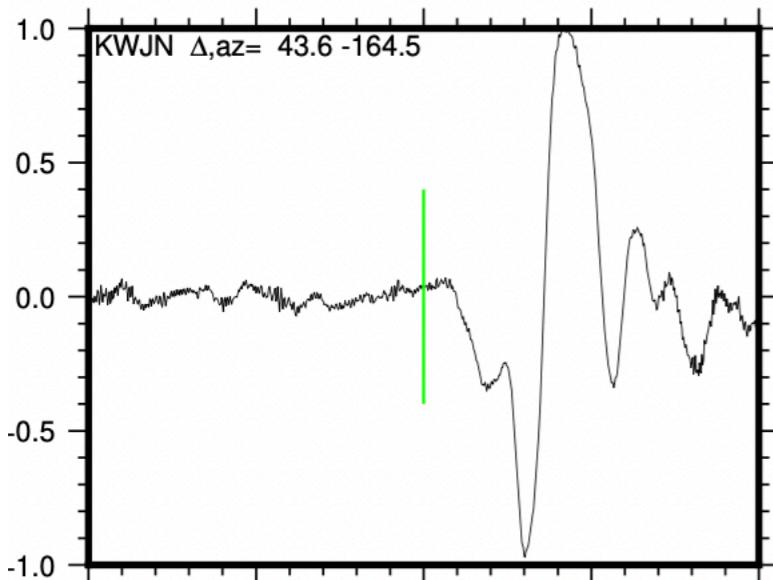
1.5 seconds

answer t

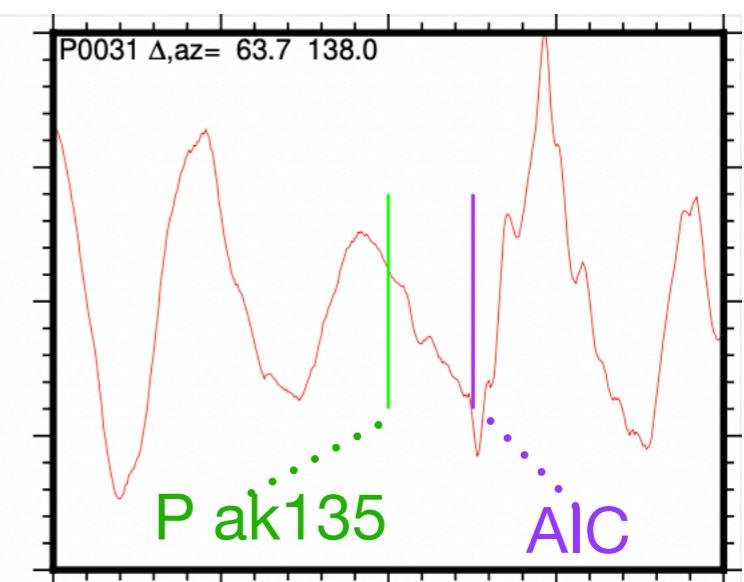
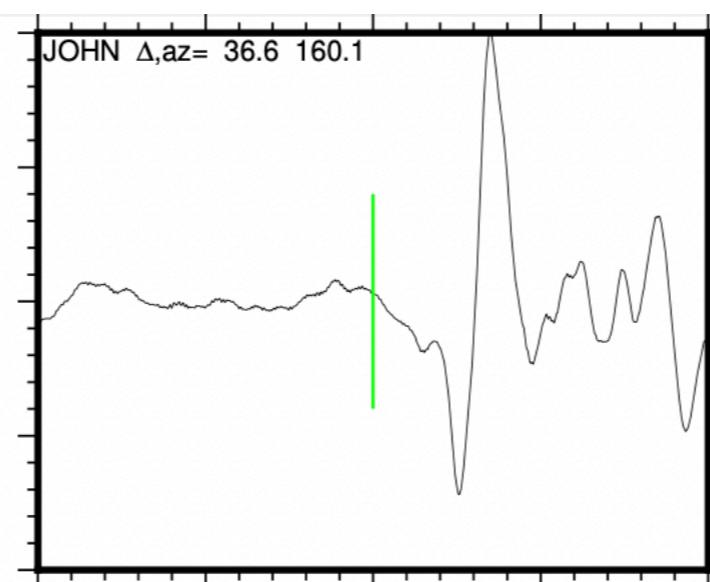
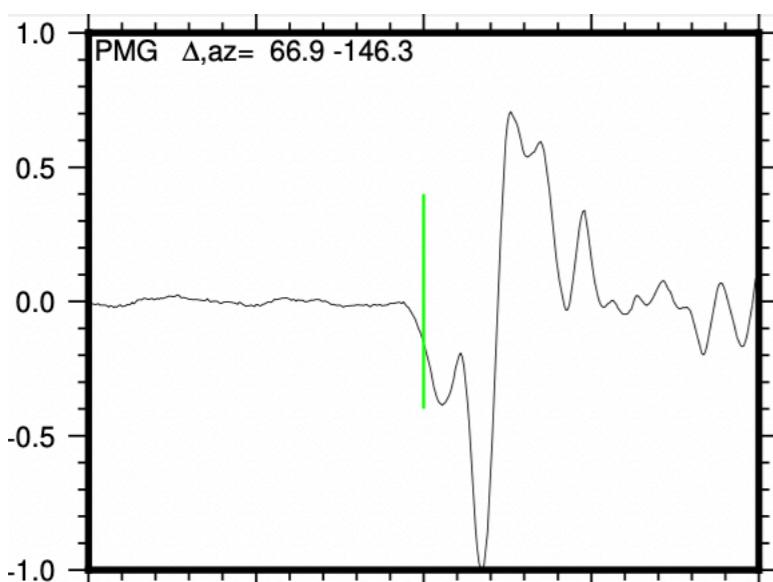
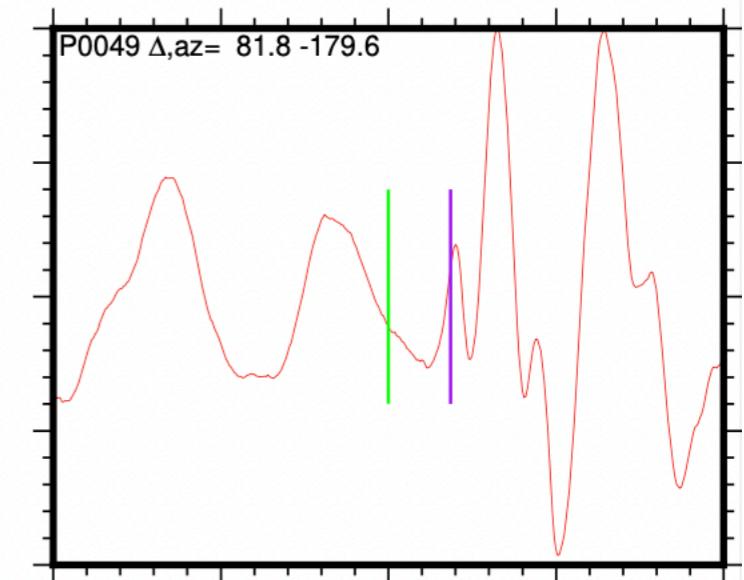
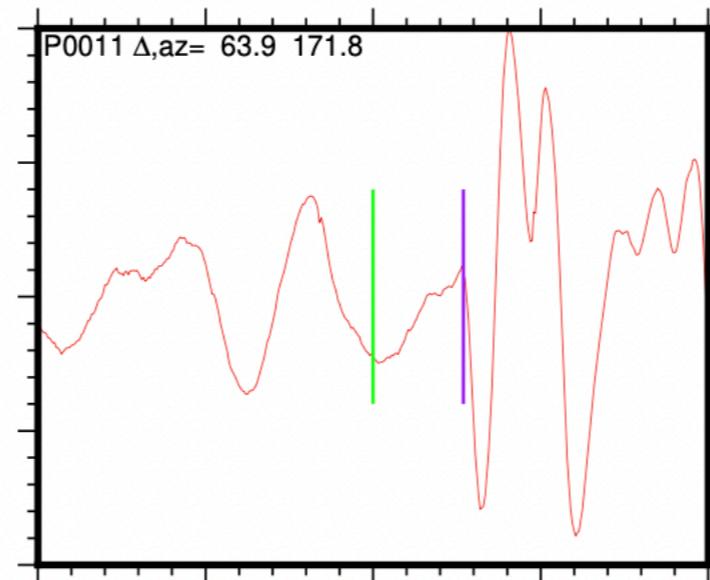
tbias

Is rarely needed but here is a good example.

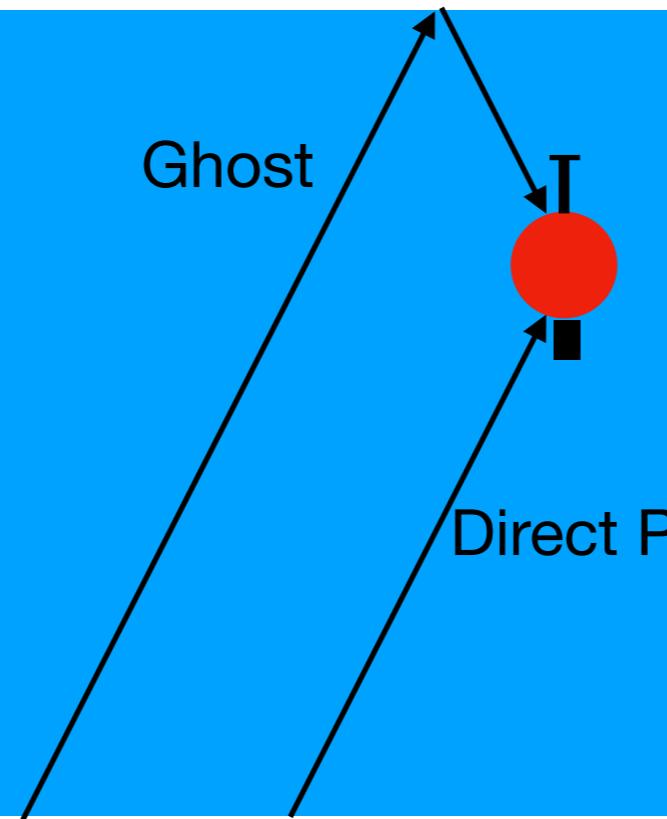
Foreshock visible
in island stations
(black plots)



Foreshock not always visible
in Mermaids (red plots)



A ghost with opposite polarity arrives after about 2s



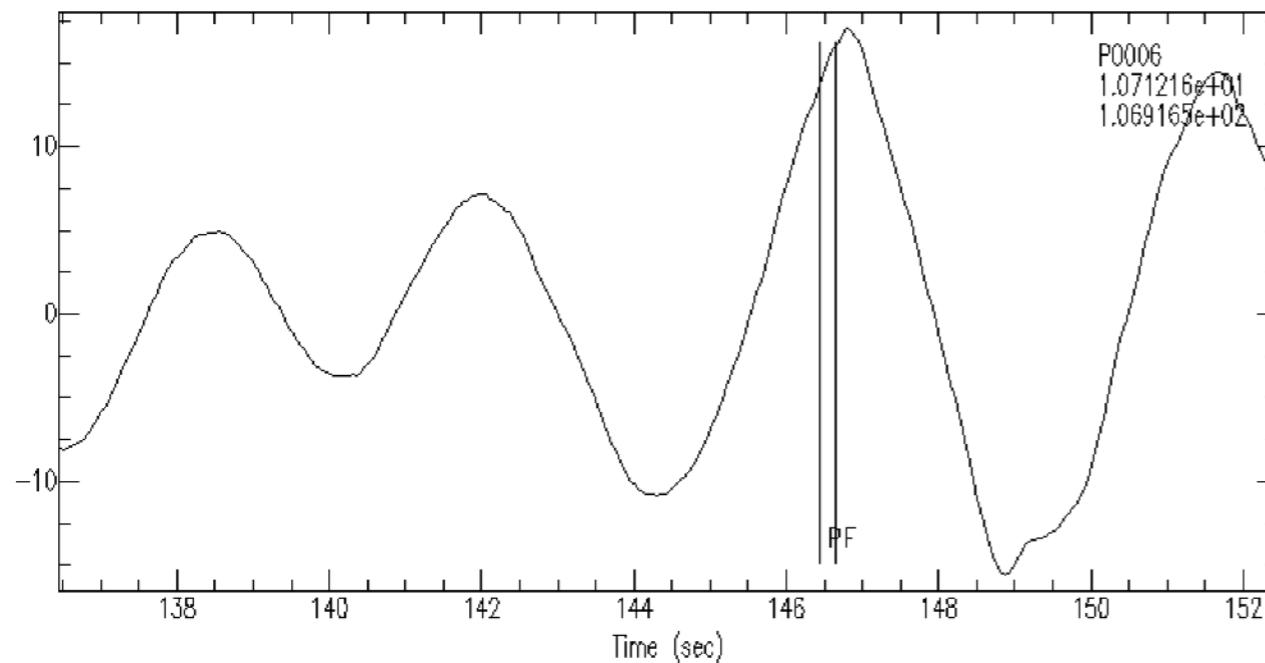
Conditions for visible ghost:

- (1) very sharp P wave (-> deep quake, low Mw)
- (2) good S/N ratio, after filtering or unfiltered

Note 1: in some cases the Mermaid is not at 1500m depth. If you think you recognize a ghost, but it arrives earlier or later (not more than 2.7s) check the float depth by going in the Qnn directory and typing *mmdepth*

Note 2: if there is interference with noise, the maxima of P and ghost may show a delay that differs from the typical 2s.

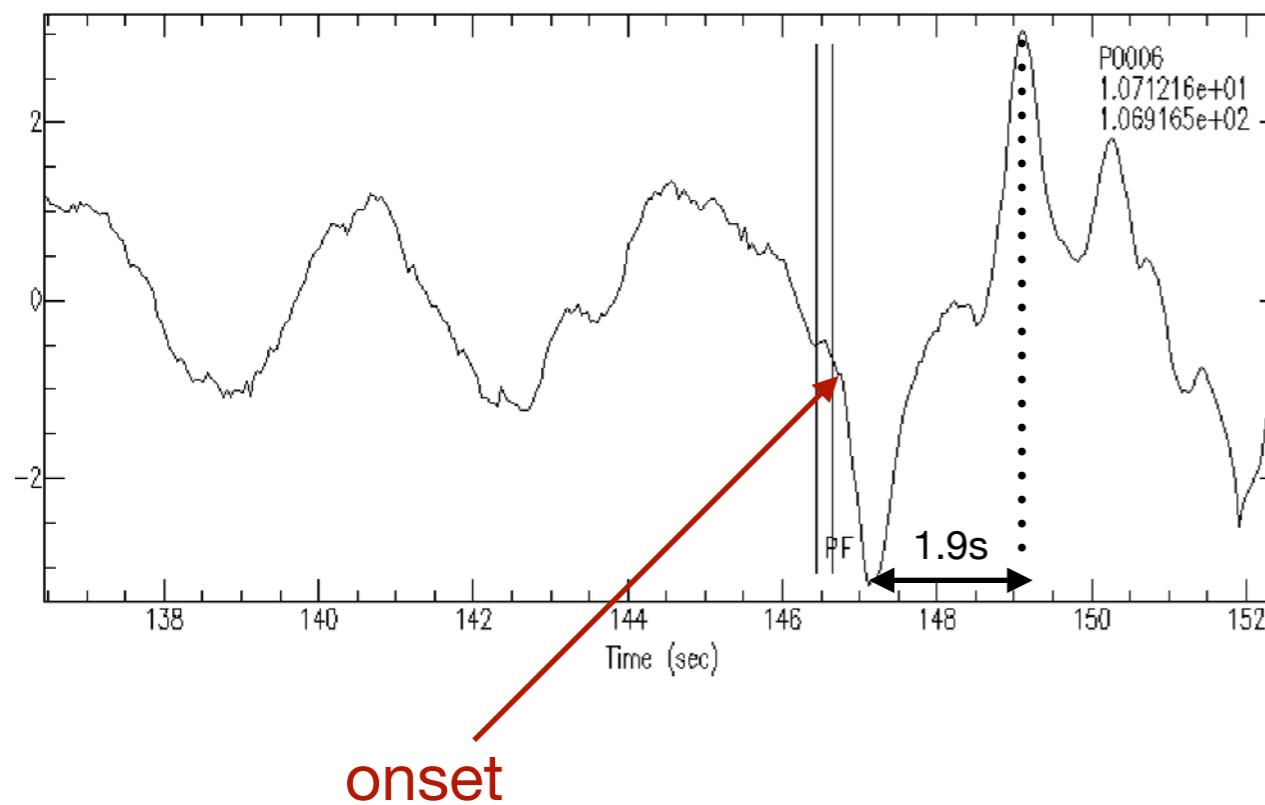
Example of a ghost



Unfiltered seismogram: no clearly visible onset.

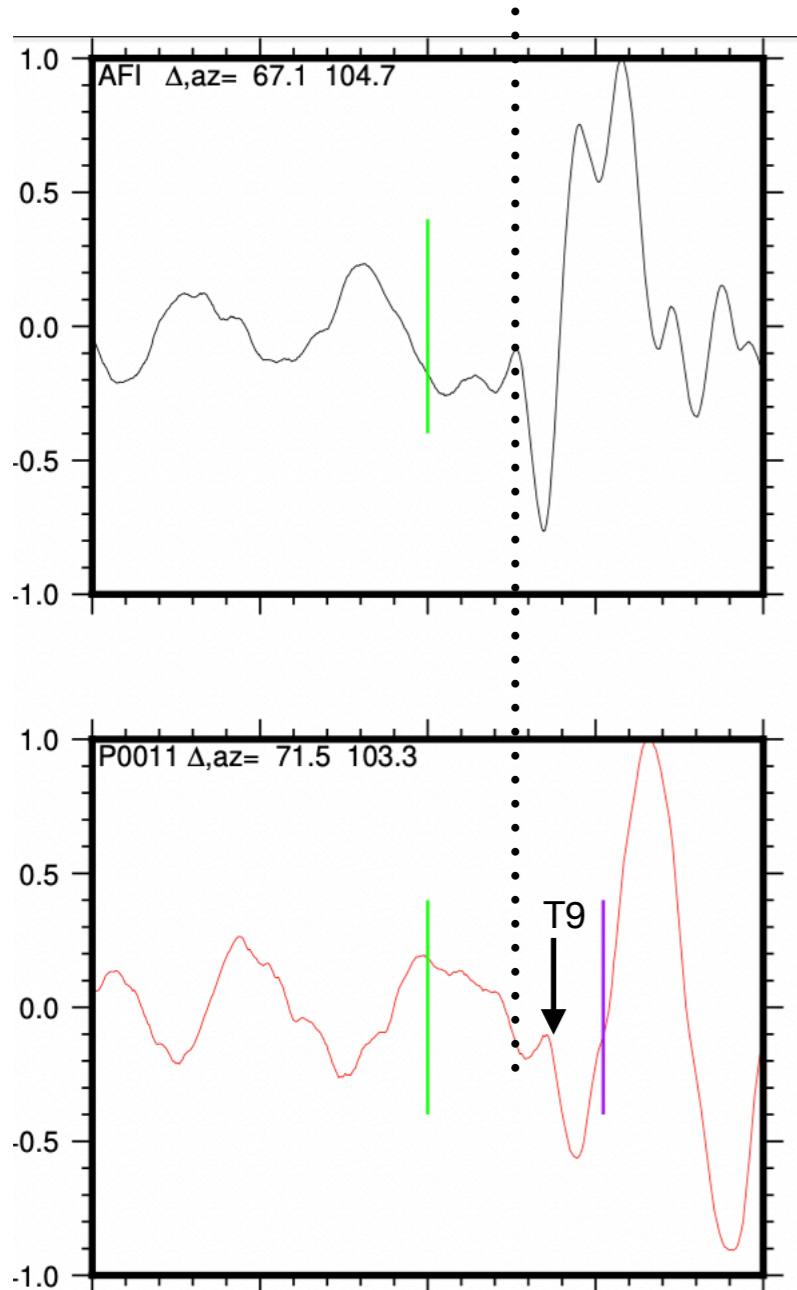
Dominant period of microseisms is 4-5s, therefore try the high pass version.

(standard ppk plot hipass is 0.5 Hz)

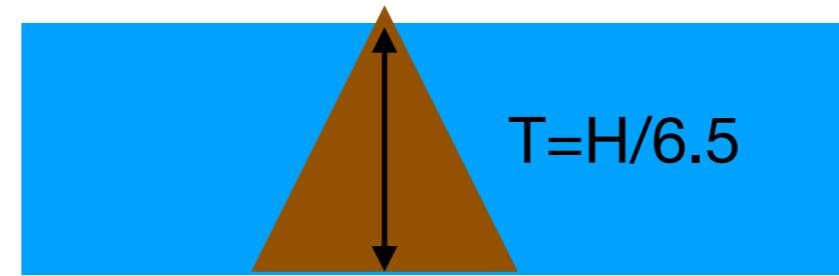
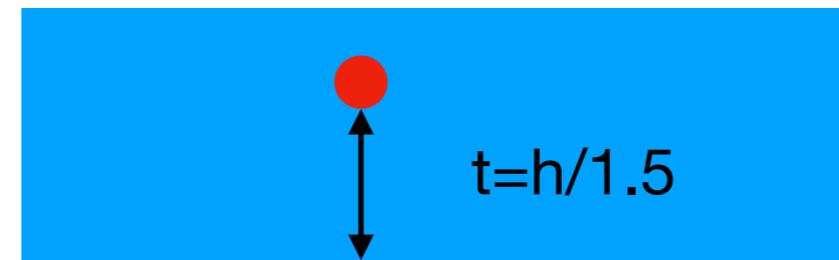


The filtered seismogram shows a ghost with the peaks 1.9s apart

The “Mermaid delay”



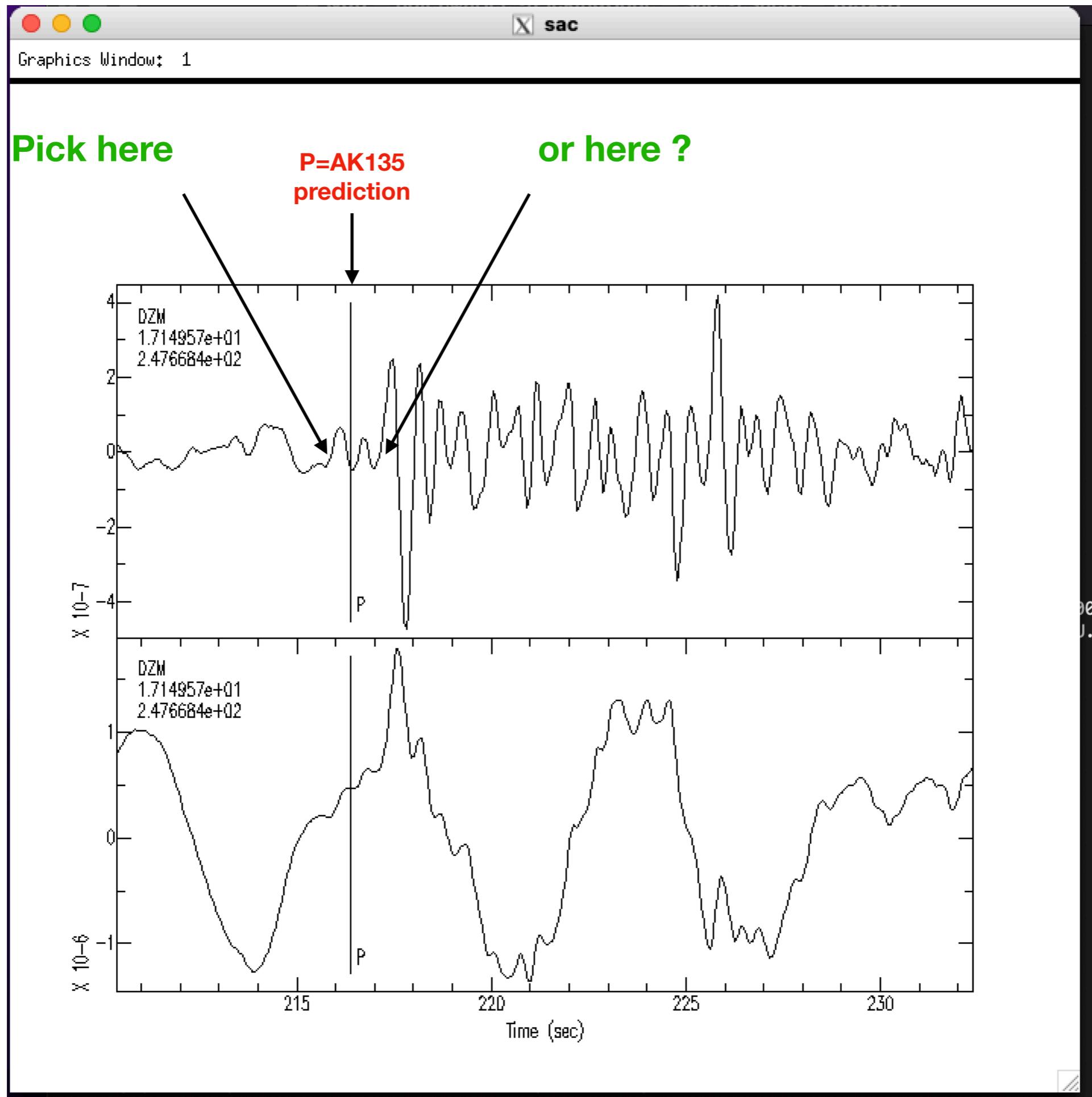
Onset in Mermaids is generally later
than in nearby island stations



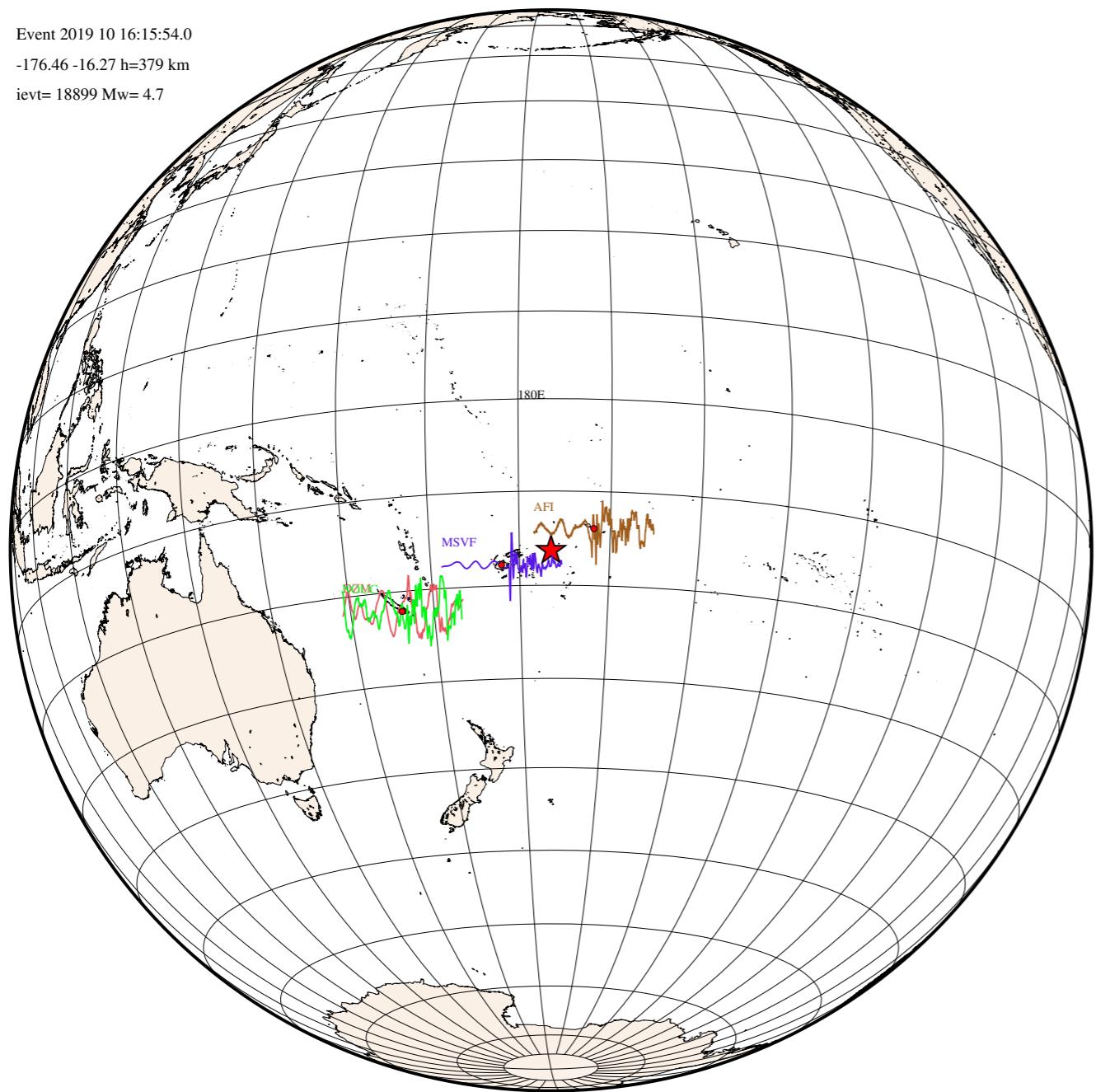
Example

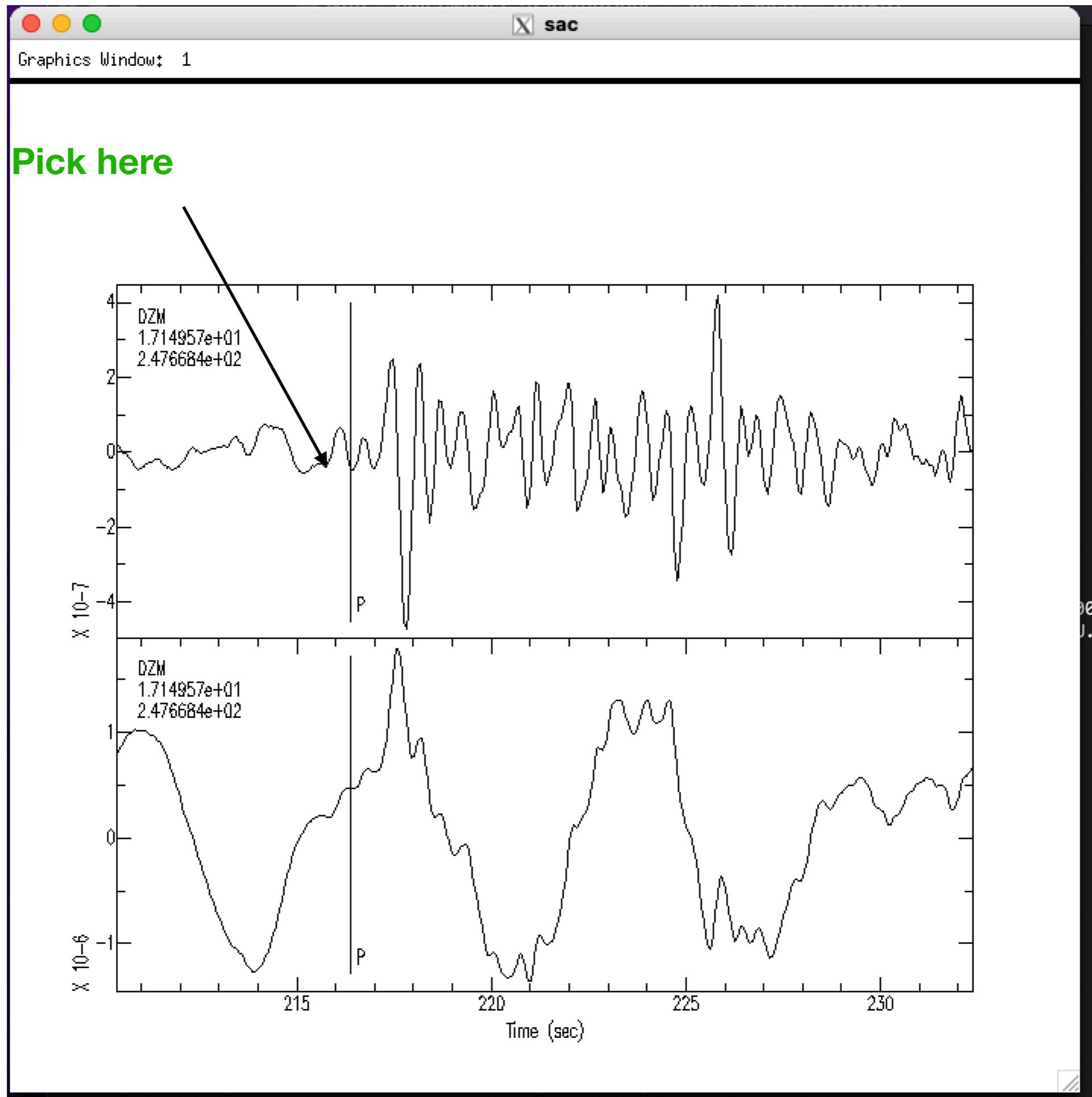
If $h=3.5\text{km}$, $H=5\text{km}$ then
 $T=0.8\text{s}$, $t=2.3\text{s}$: the difference is 1.5s

5. Examples

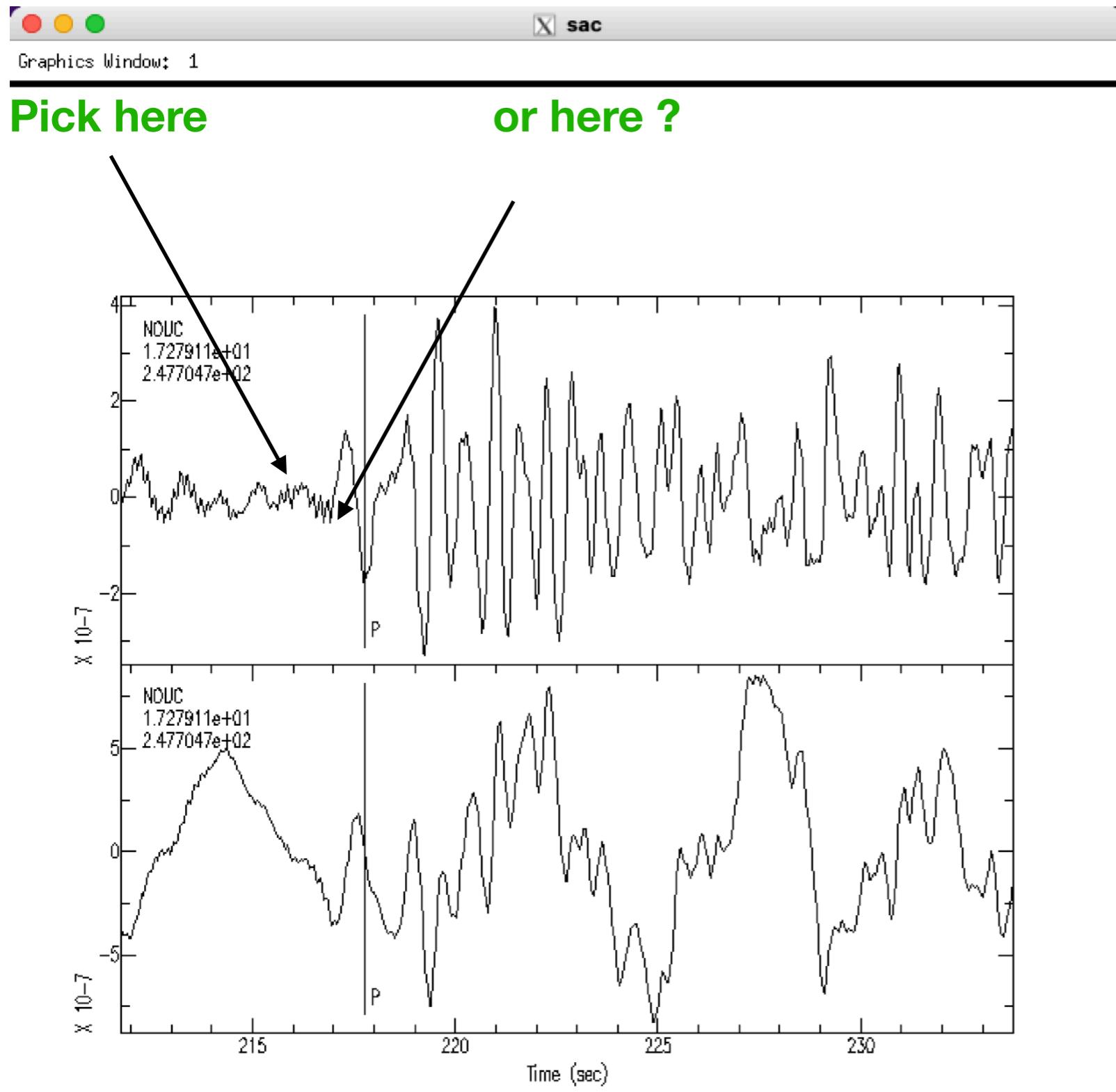


Station DZM is in New Caledonia on subduction zone, quake is at 279 km depth -> guided wave in slab precedes large onset





But NOUC is not so clear - skip by typing 'N' without picking

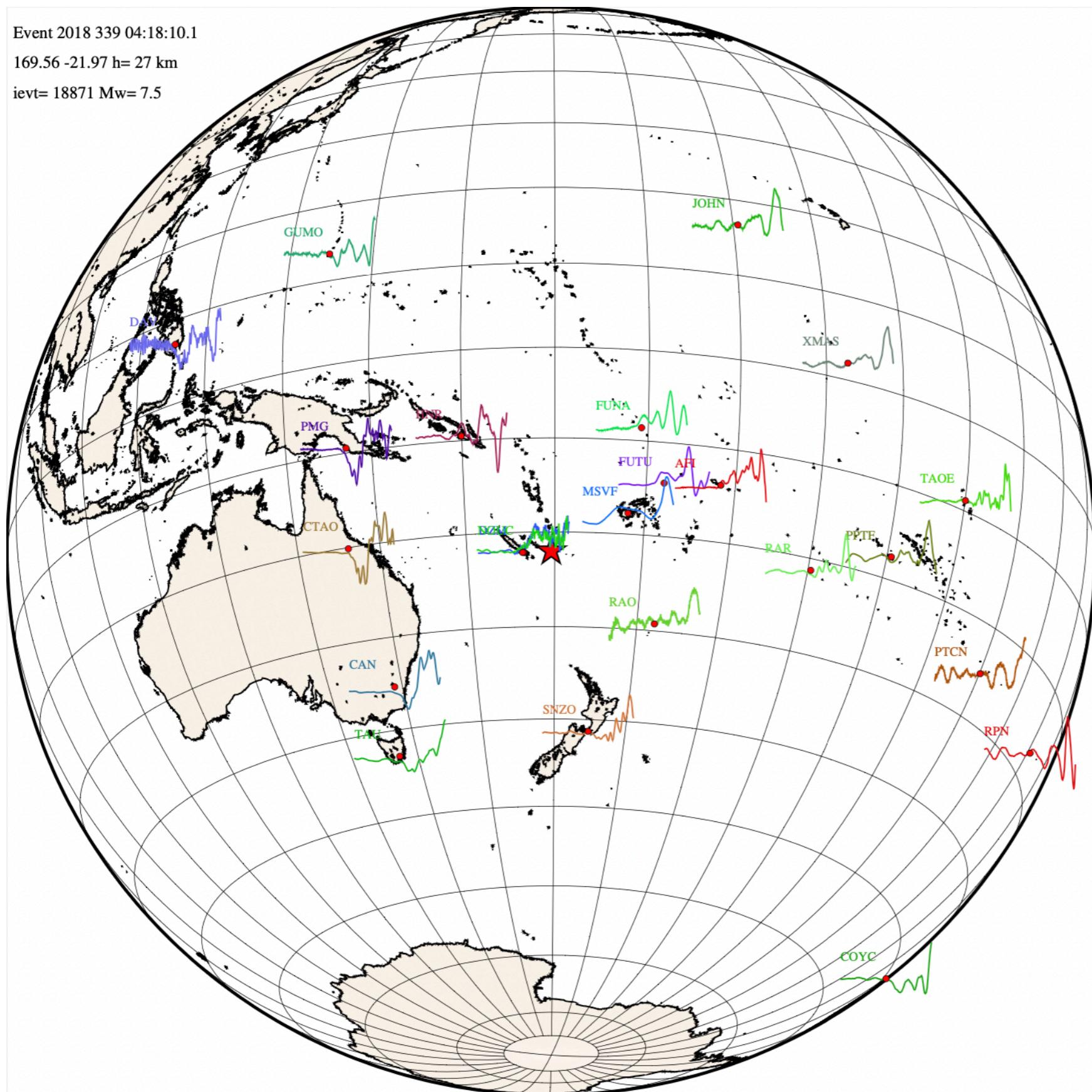


Mw 7.5, h=27 km

Event 2018 339 04:18:10.1

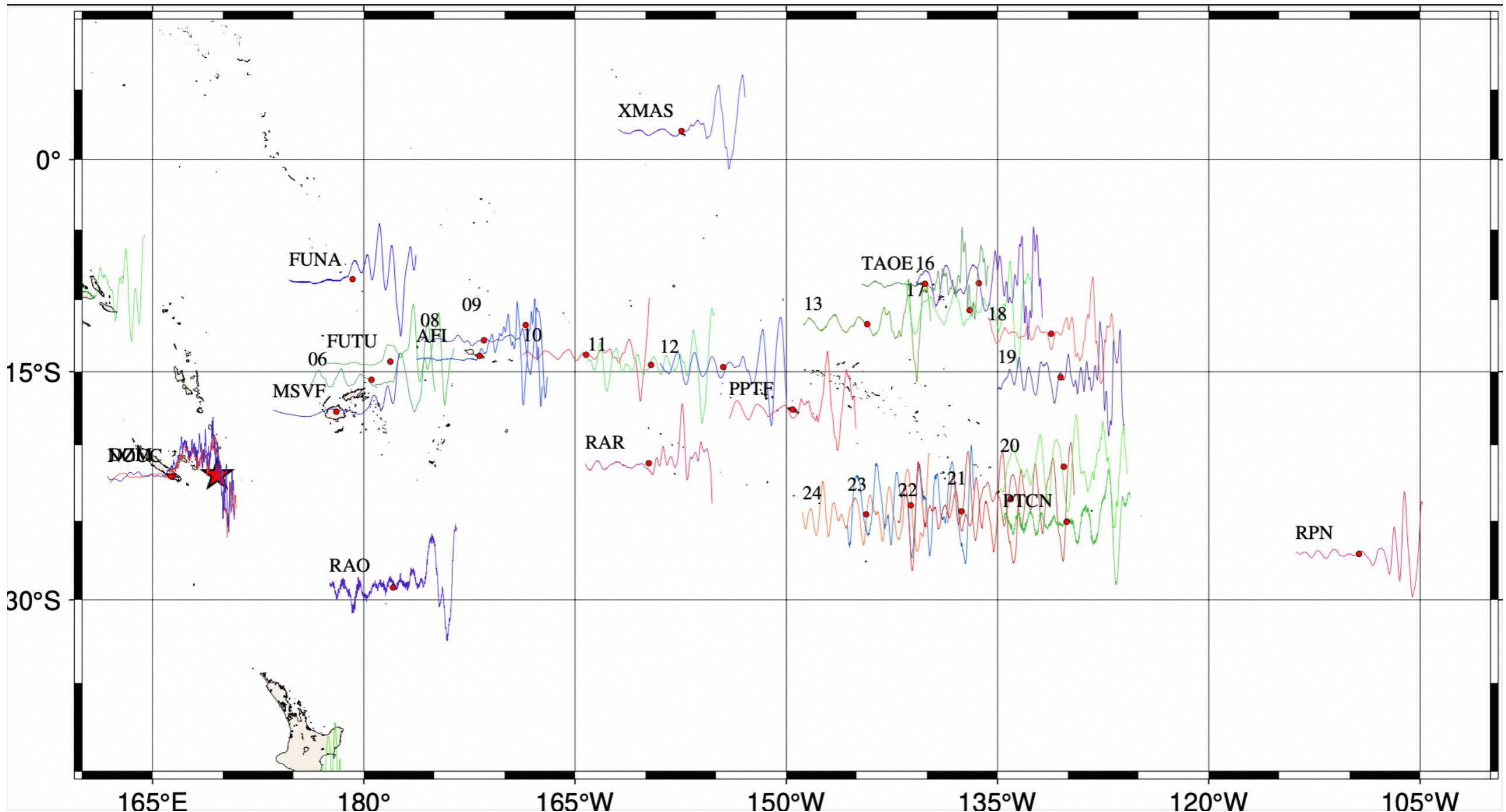
169.56 -21.97 h = 27 km

ievt= 18871 Mw= 7.5



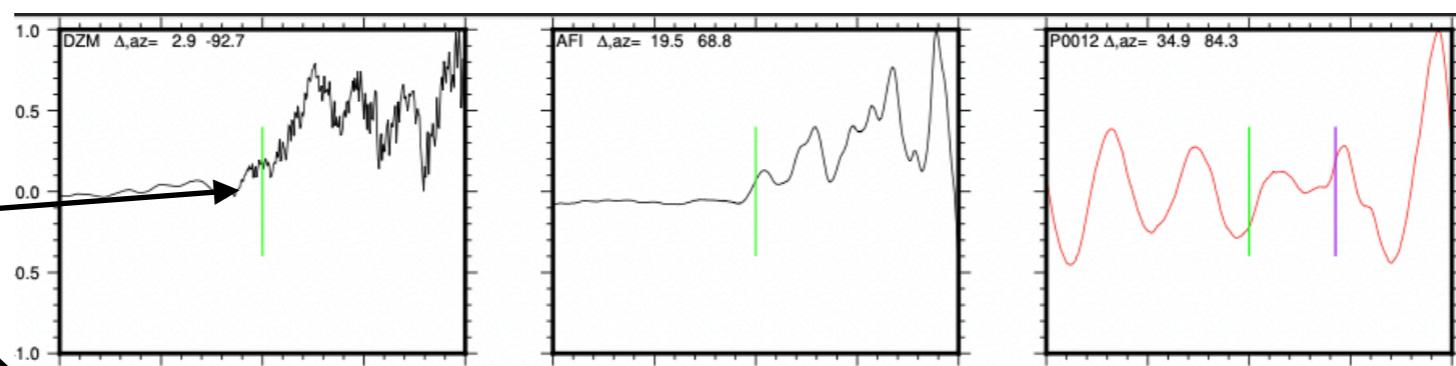
Danger of pP
misidentification as P

Lots of Mermaid records



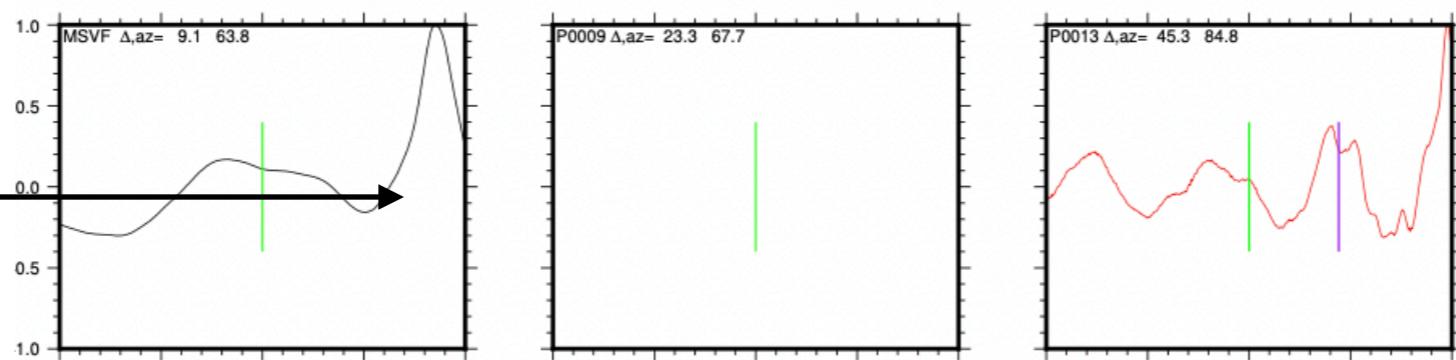
pplt plots

DZM and NOUC
are ~1s early

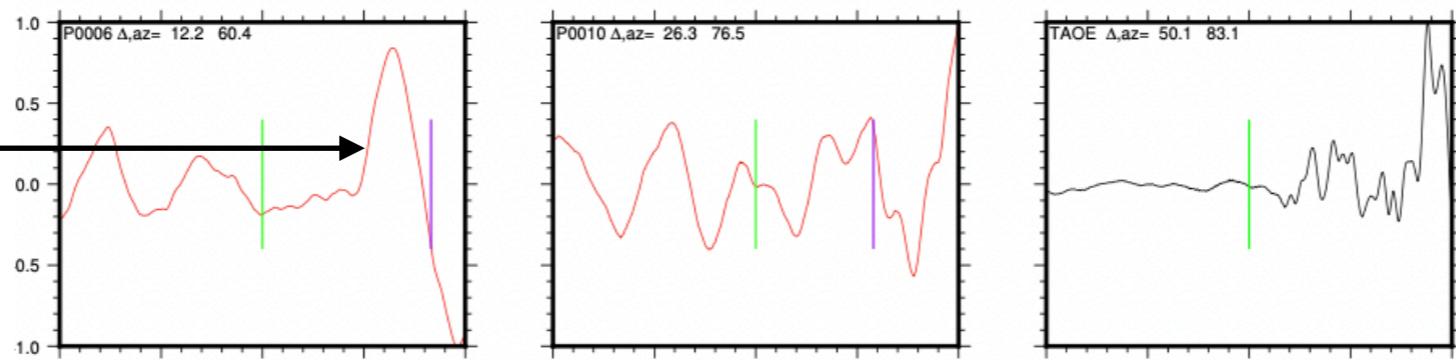


Same for 08!

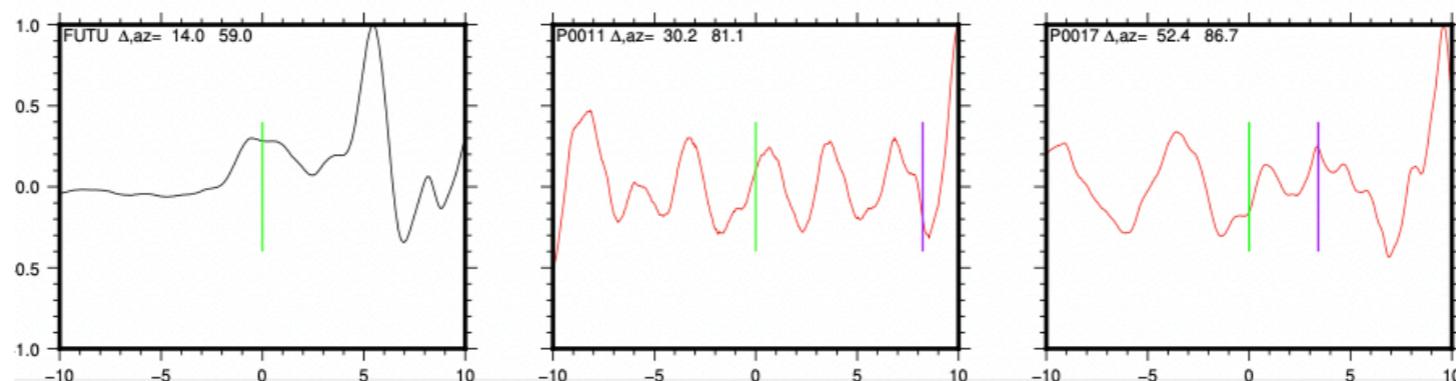
But MSVF seems
~6s late. Is it pP?



Same for 06!

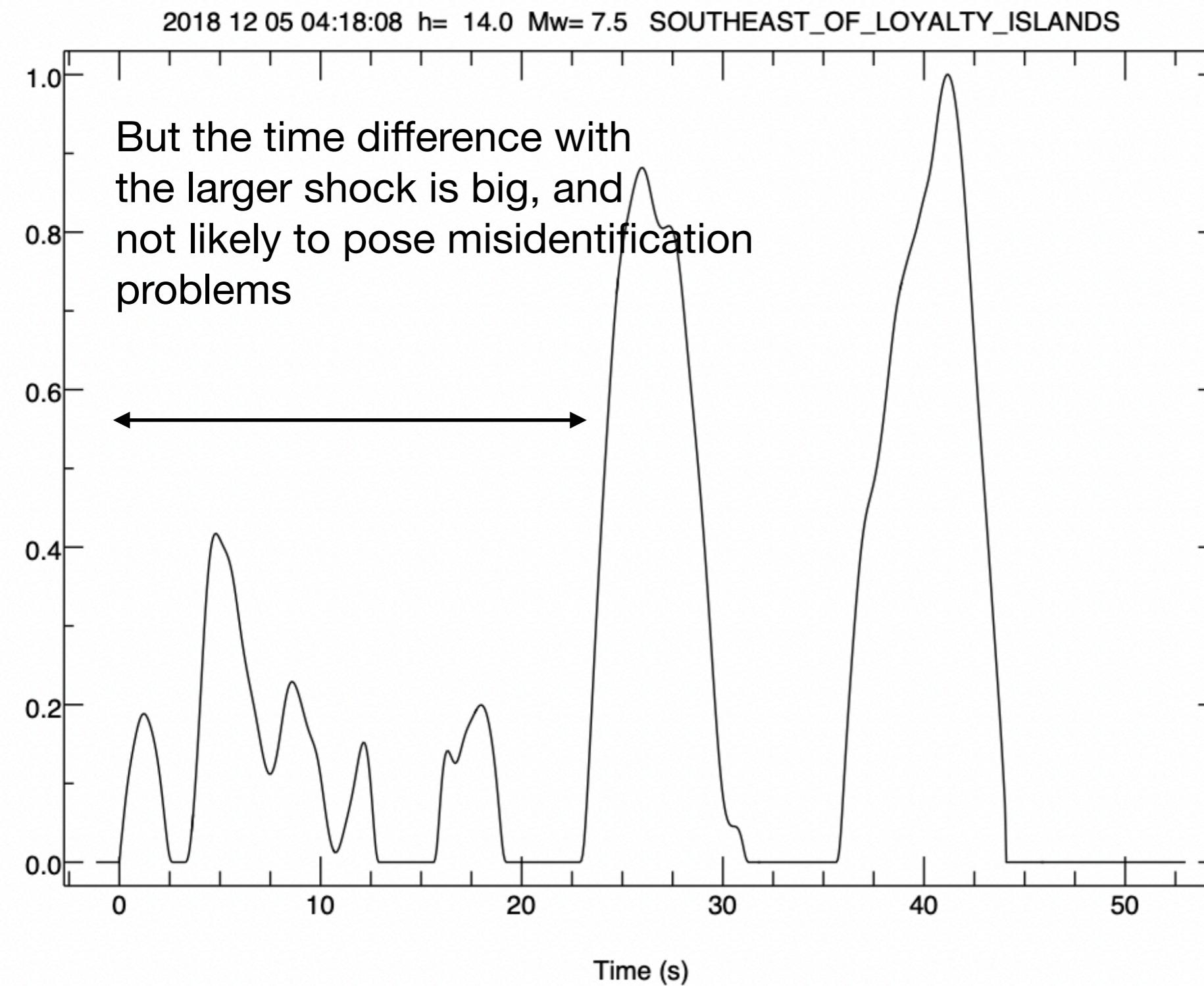


FUTU shows both
P (early) and what
may be pP.

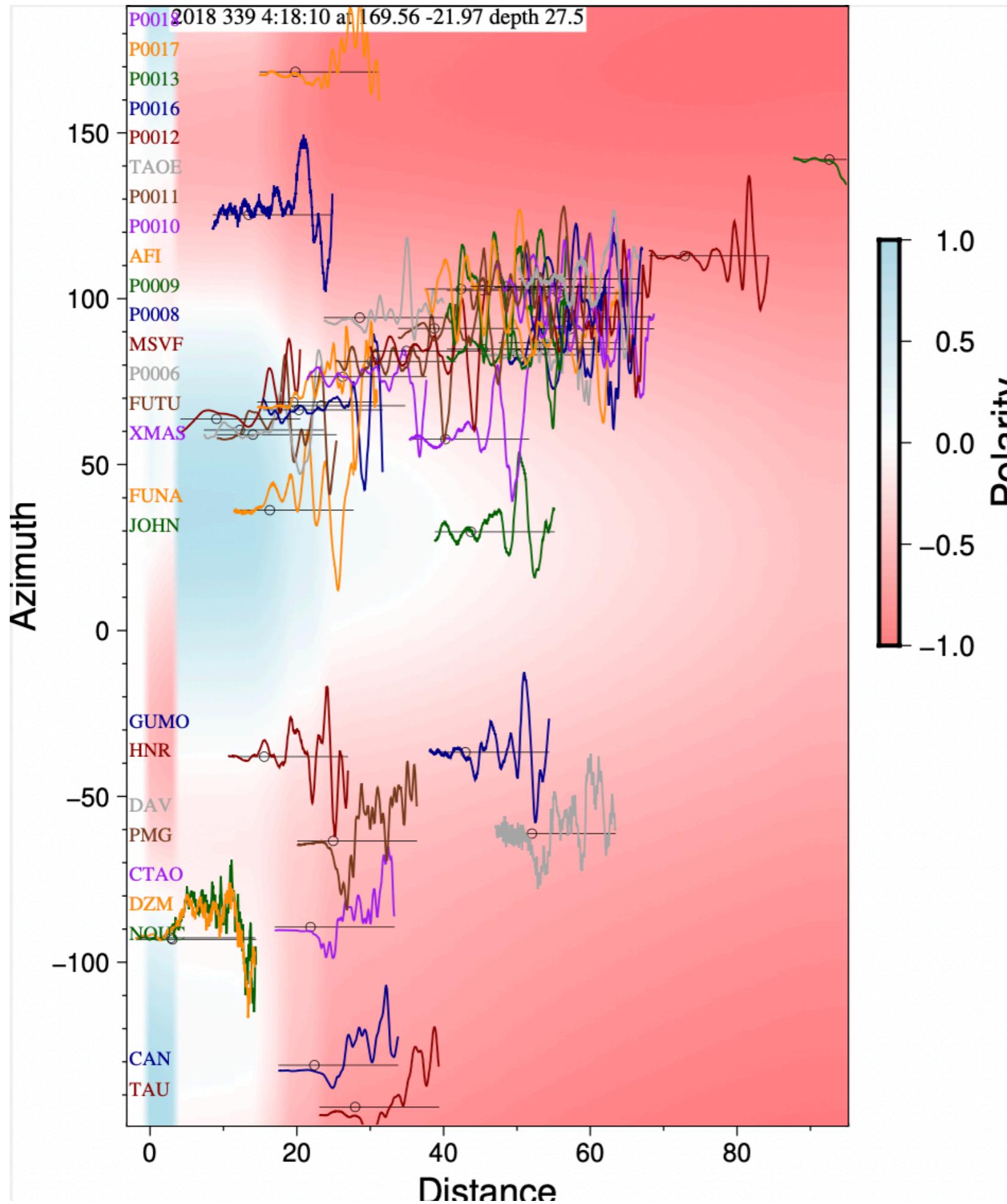


And probably all
other Mermaids

Another headache: the source time function is complicated



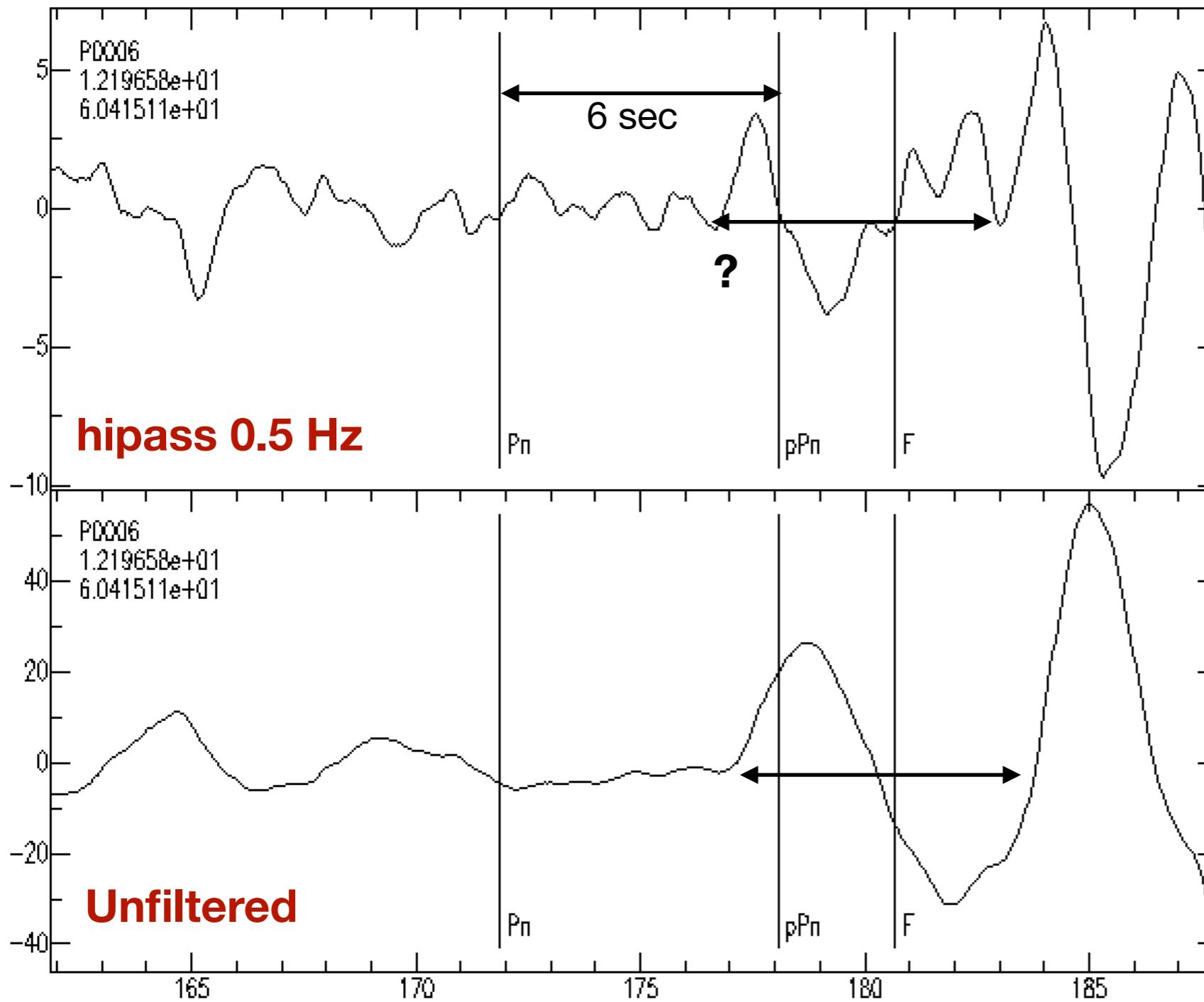
The subshocks
may interfere with
 $pP \rightarrow$ complicated
coda but not a
problem if the onset
is visible above the
noise.



To see P we must hope for the best in the hipass, and pay attention to the polarity prediction

For the Mermaids, 06 is in positive territory (blue), 08 is in blue-ish white.

For all others we should look for a negative onset



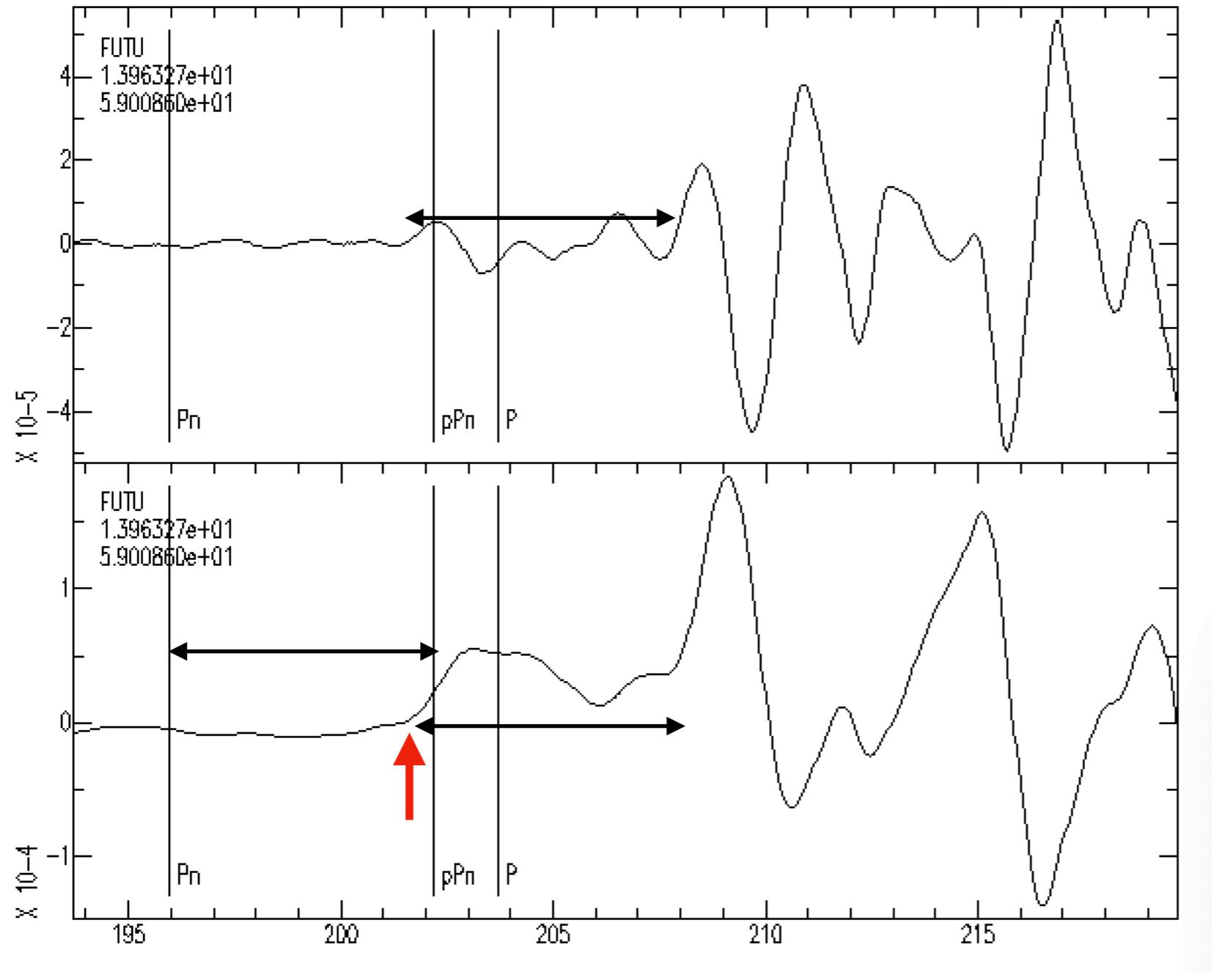
pP-P is 6s in AK135

Possible onset is *before* predicted pP

It is *positive* as predicted

And it is followed by a larger wave after 6s, as predicted for pP-P

I therefore accept ? as the onset of P.

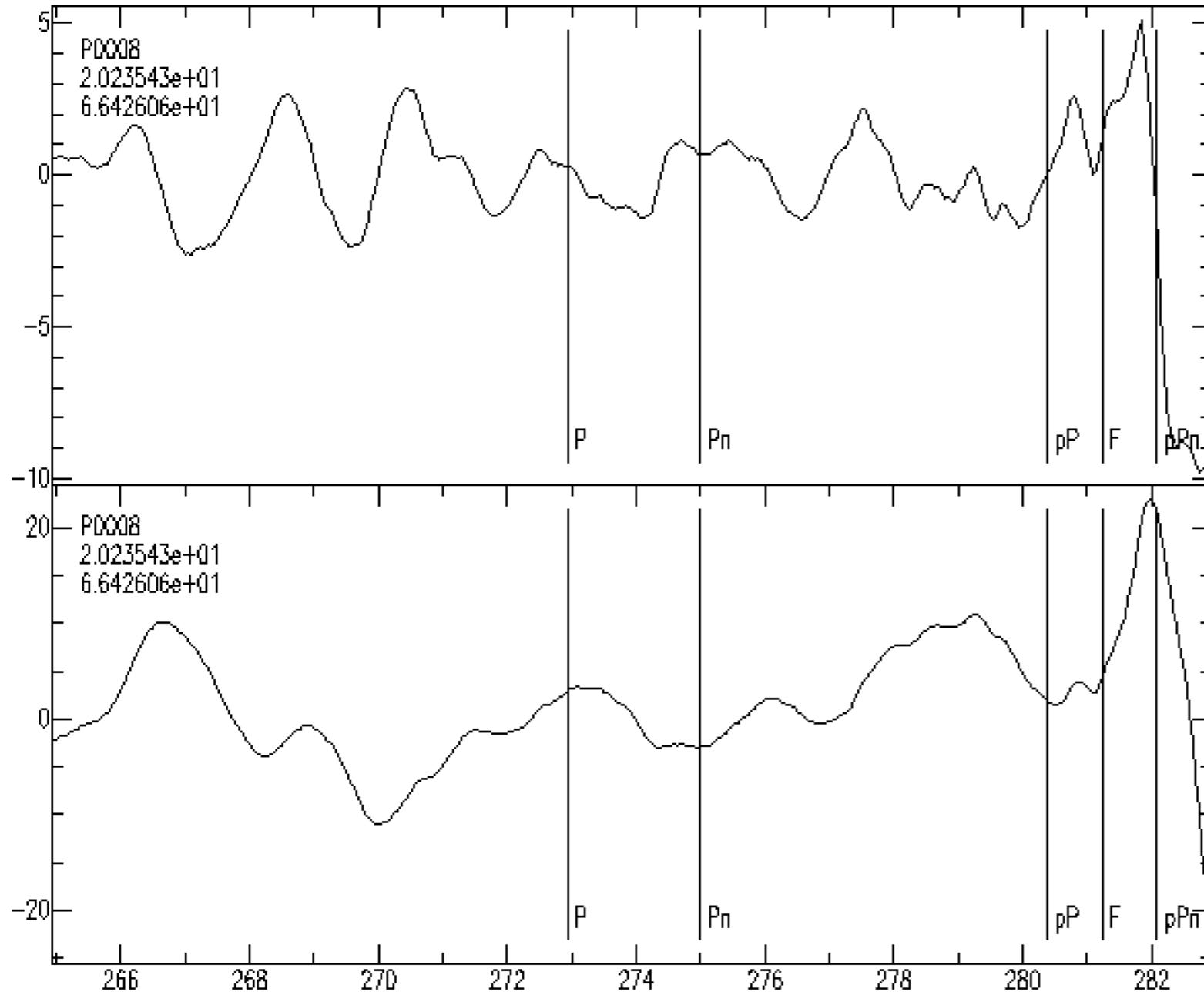


In FUTU, at 13.9 deg,
AK135 predicts two
arrivals (Pn and P).

The ppt showed only
P, not Pn! - so if the
onset is Pn, it is late,
not early

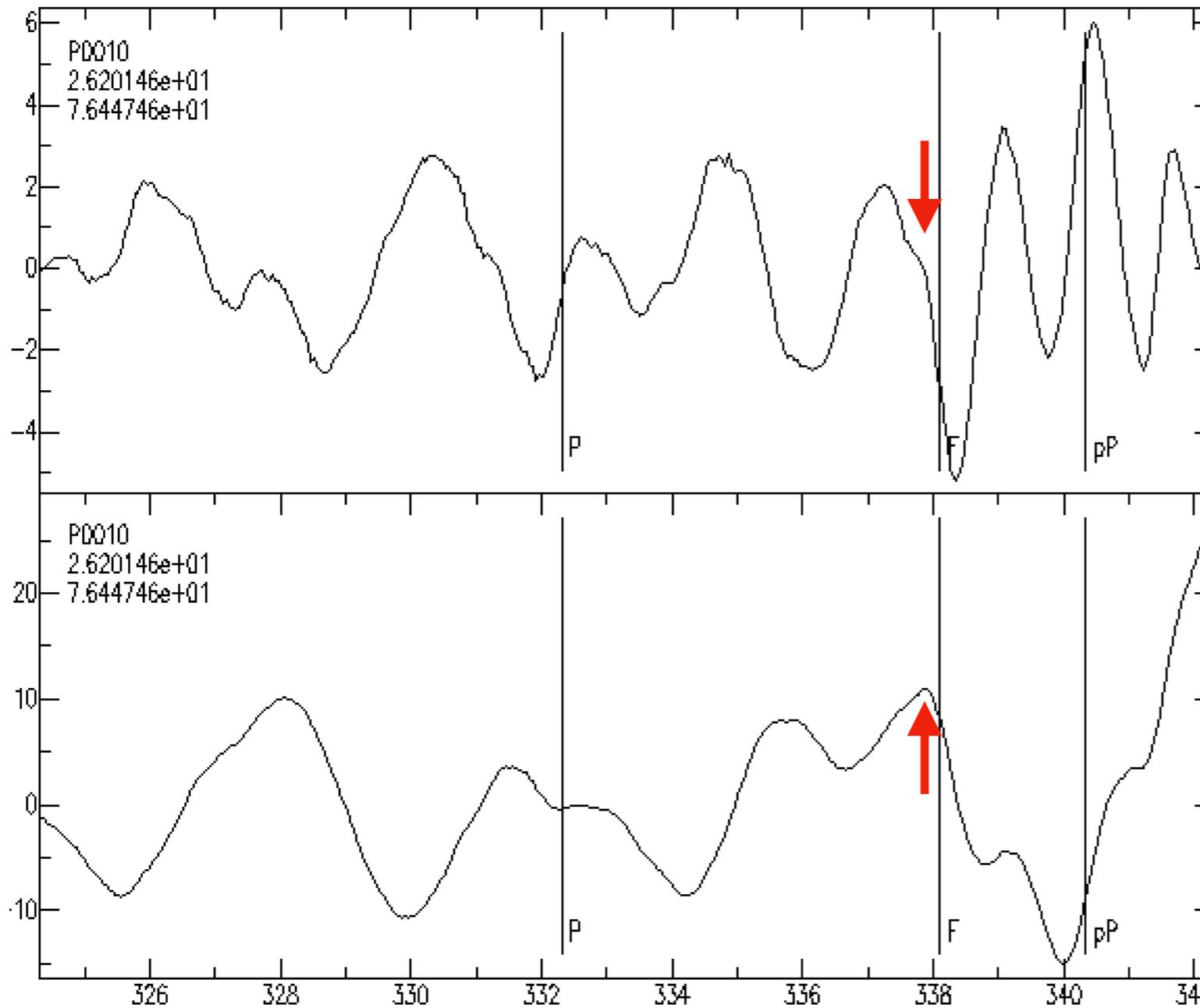
We probably see only
the P, followed by pP
(not predicted but time
difference should again
be about 6s).

I therefore also accept
the onset (red arrow)



08 is at 20.2 deg and azimuth 66, near the white area of the polarity plot

For 08 we are in or near the node of the radiation pattern.
There is no onset clearly visible and I dare not pick this one.



08 is predicted negative.

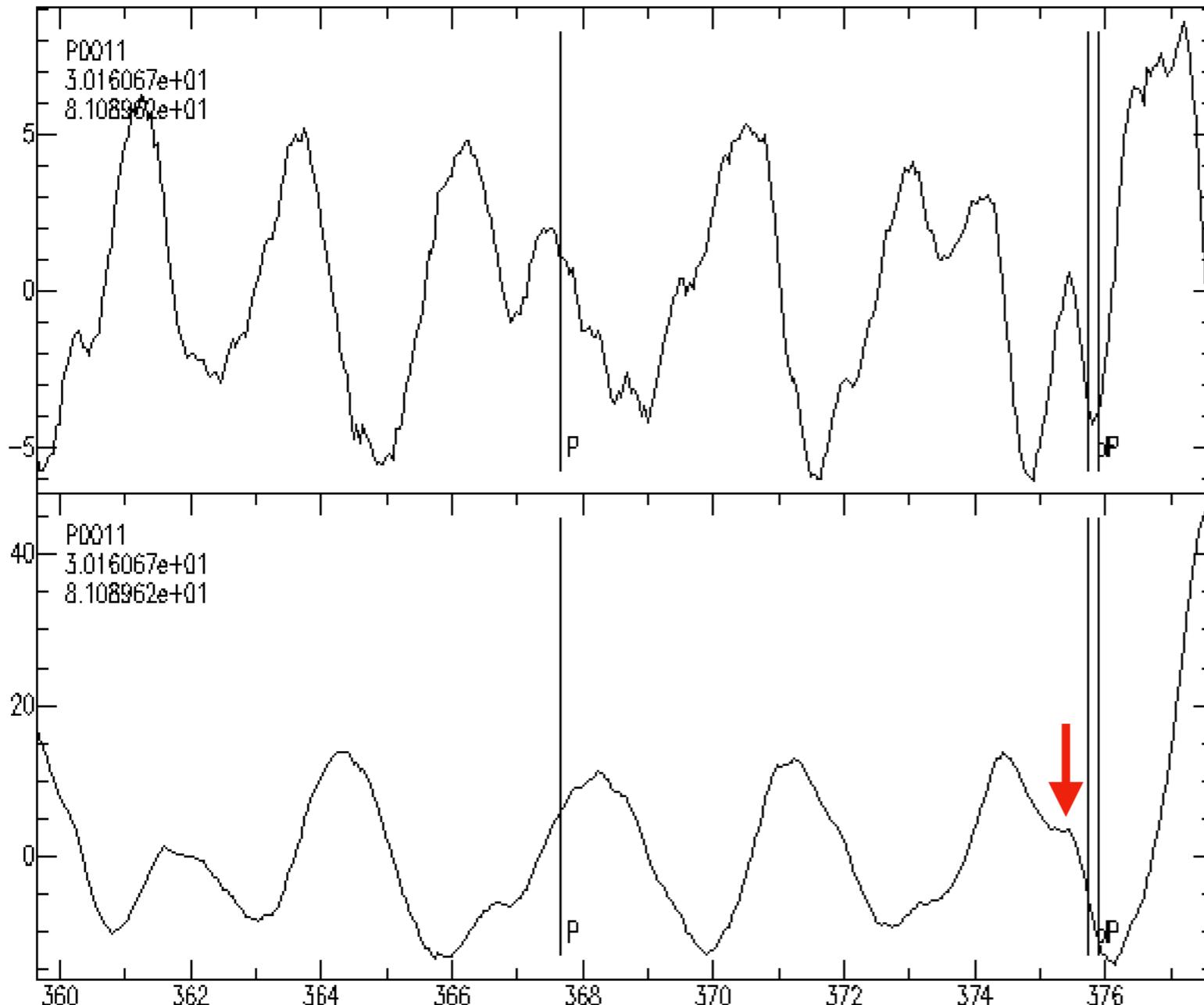
Automatic pick detects change in frequency content, but is often 0.2 or 0.3s late

We see a negative swing just before F, and it is well before predicted pP, while arrivals are never fast in this region.

I therefore accept this as an onset (red arrow).

Note: if I am wrong because of the large delay of 6s, the tomography program will reject this as an outlier.

The real danger of misidentified onsets is in the smaller errors (2-3s, say).

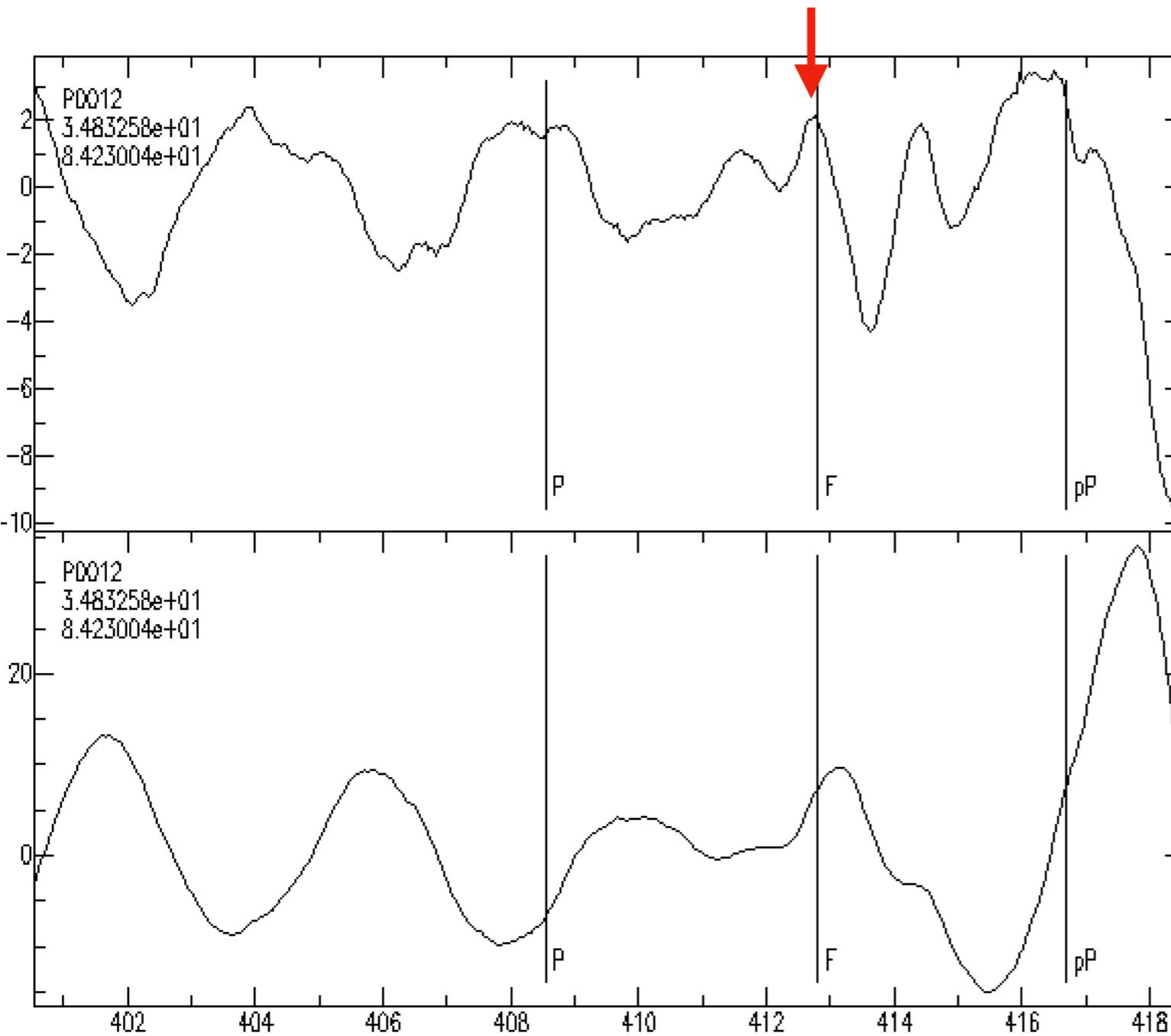


F and pP almost overlap in 11, there may be a (negative) onset just before but is it P or pP?

We are now at 30.2 deg distance, P bottoms near 670 discontinuity.

The upper mantle needs to be 2% slow to get such large delay, which is very large.

Opinions may differ if we should pick this. I vote for picking (see also note on previous slide).



12 is predicted negative,
and onset is visible in the
hipass record

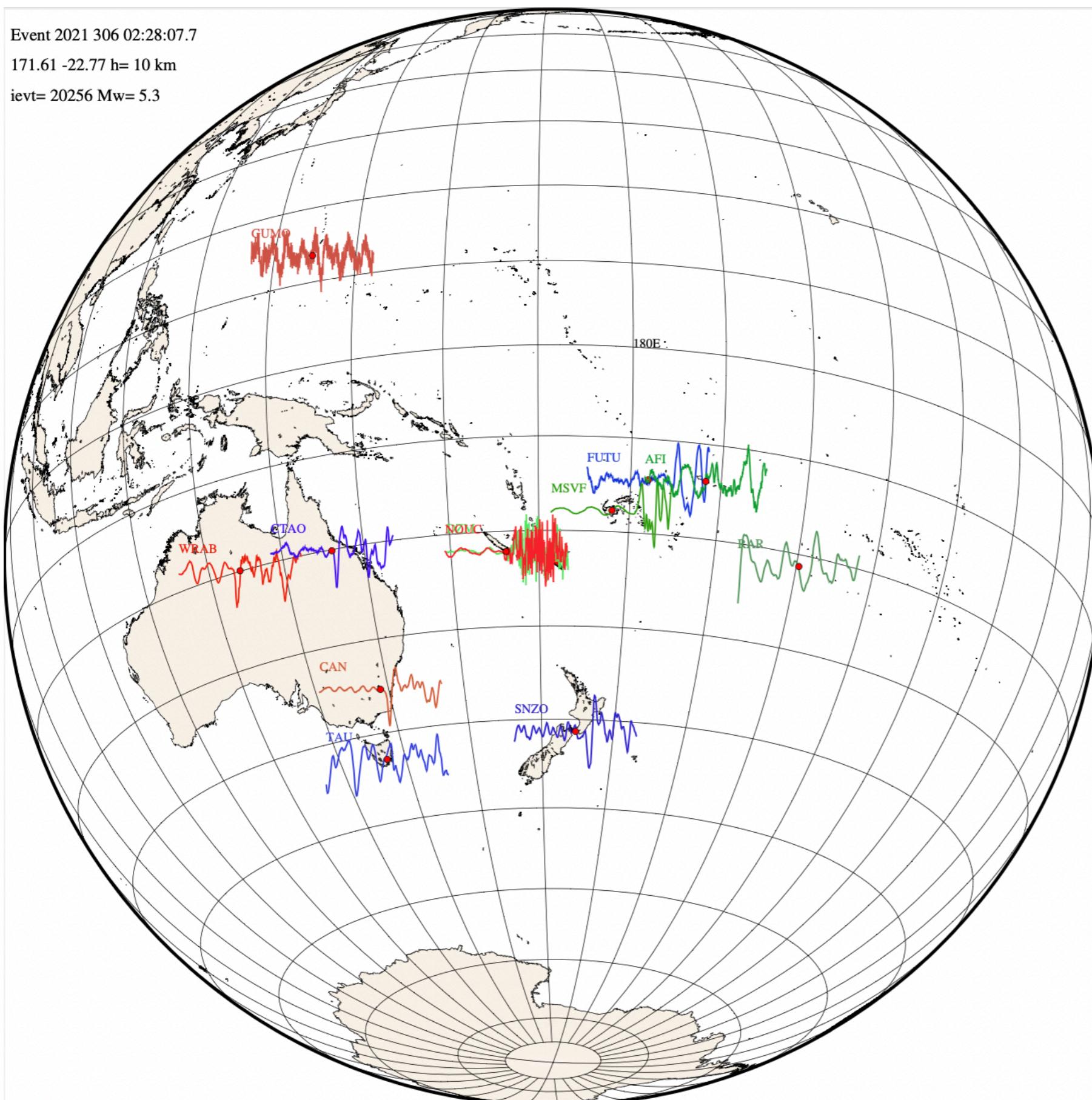
This event is present in the homework data set. I'll let you pick them all yourself and do the thinking on the other records.

Event 2021 306 02:28:07.7

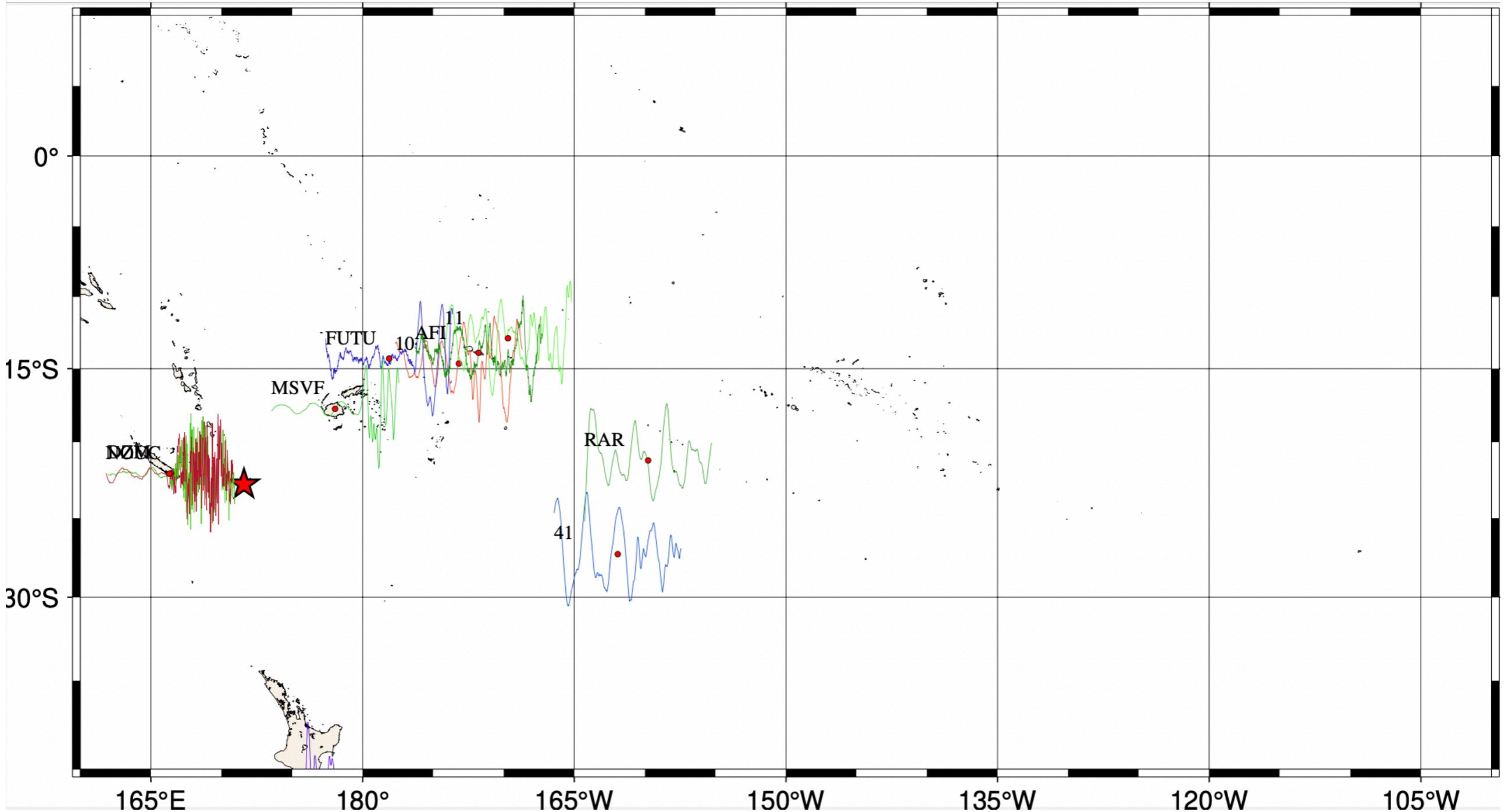
171.61 -22.77 h= 10 km

ievt= 20256 Mw= 5.3

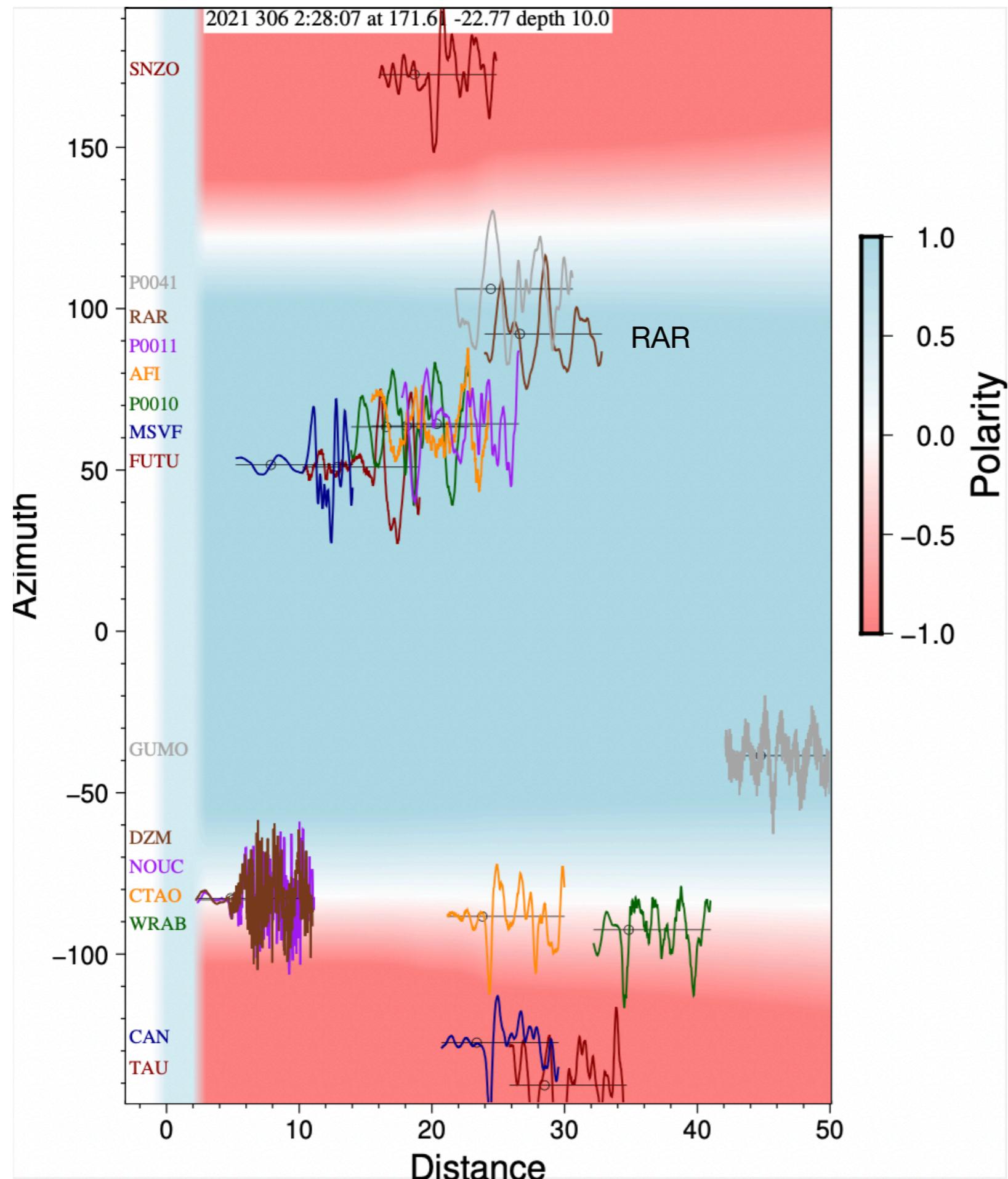
Mw=5.3 h=10 km



Shallow, with pP
2-3s after P:
Danger!

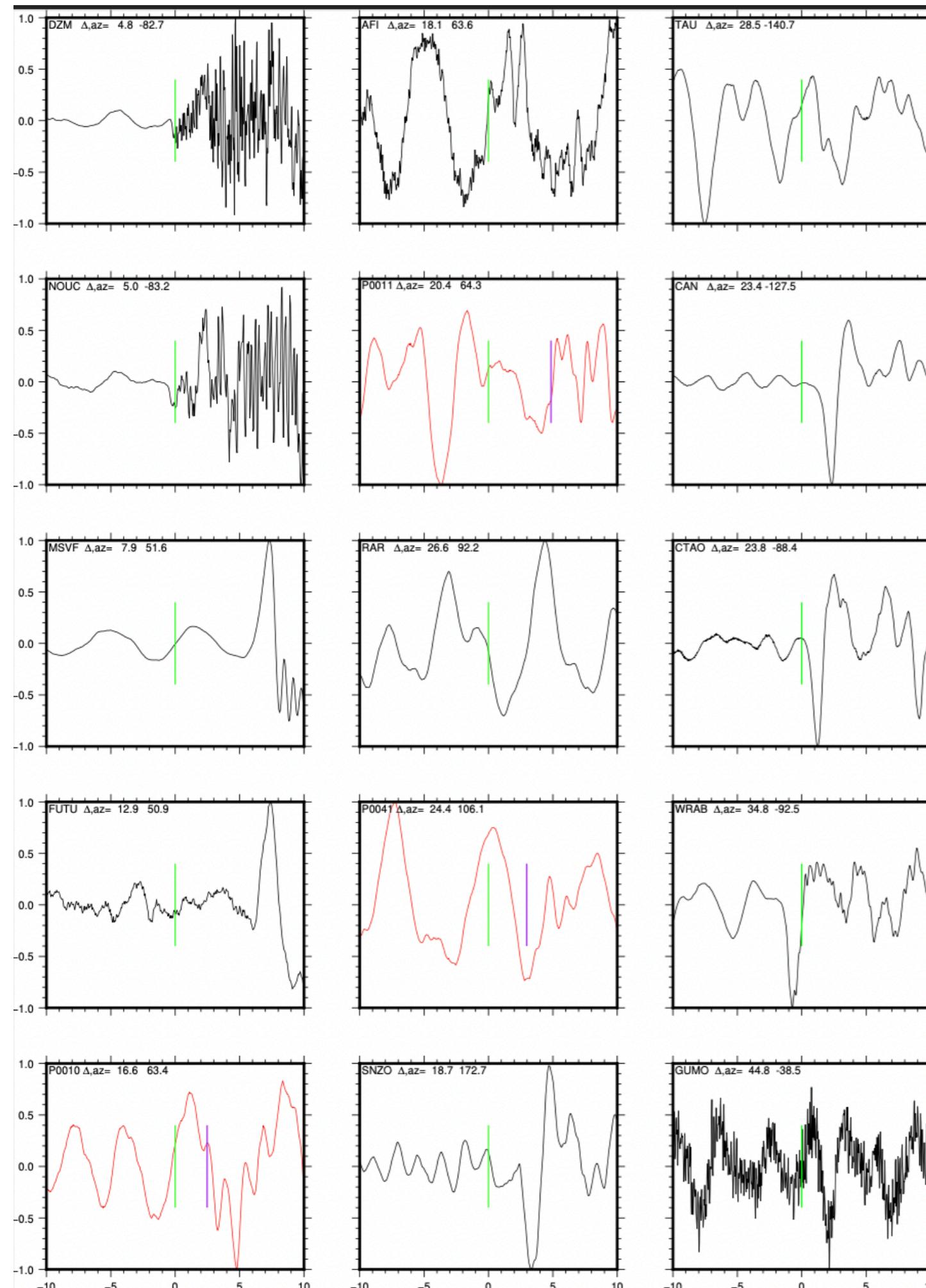


Weaker events have fewer stations. If no onset on Mermaids are found simply reject (type "j" after picking).



All Mermaids are in positive (blue) territory.

But RAR seems already in a node, so the prediction for 41 may be wrong...



First impression:

DZM, NOUC west of event are on time.

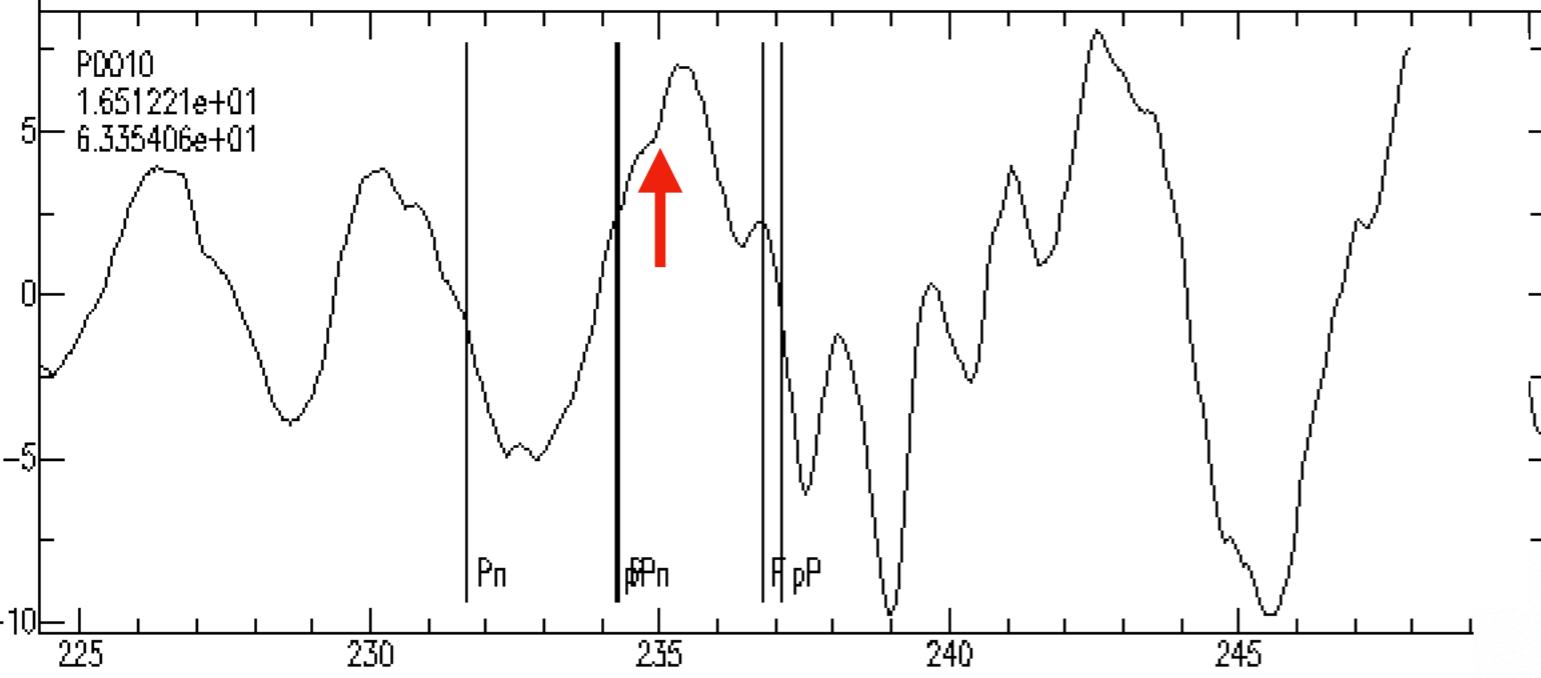
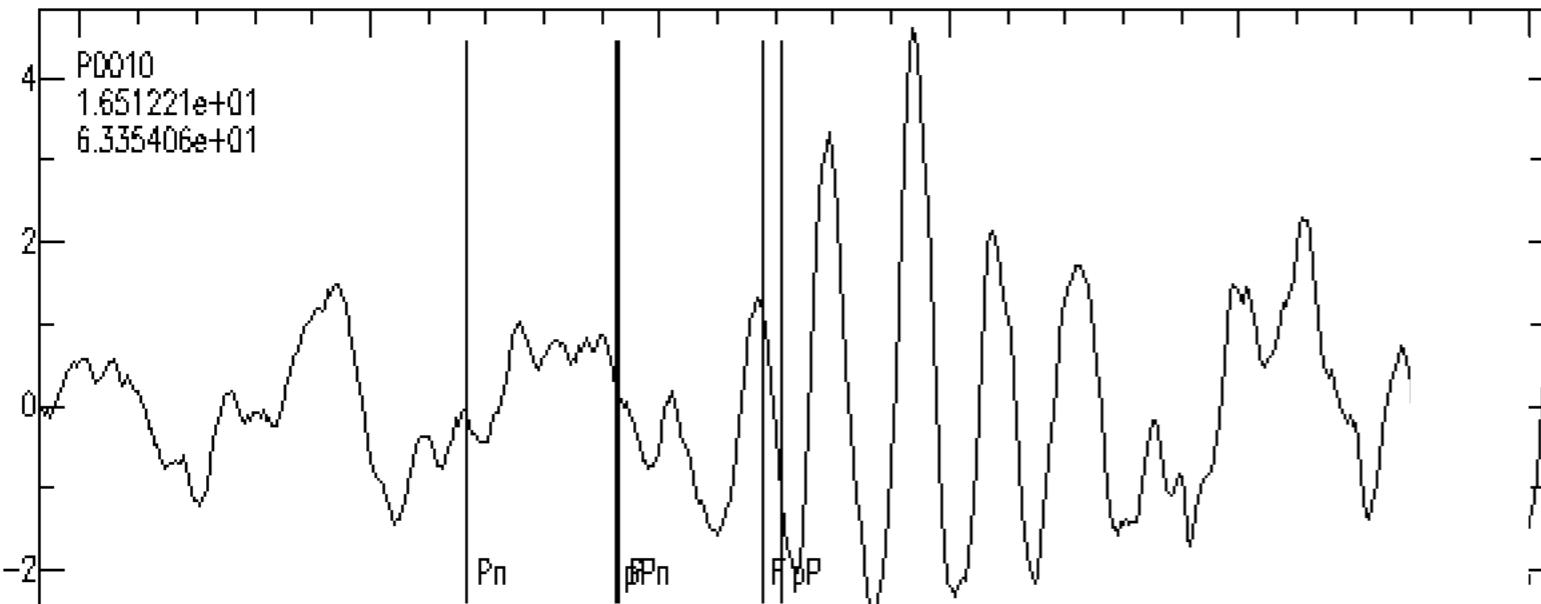
MSVF, FUTU are 5-6s late or is this pP?

10 has automatic pick at 3s but this is *down*, not up.

AFI seems up with only 1s delay but 11 has autopick with 4s delay

Land stations SNZO, CAN, CTAO, WRAB have small residuals and predicted polarity.

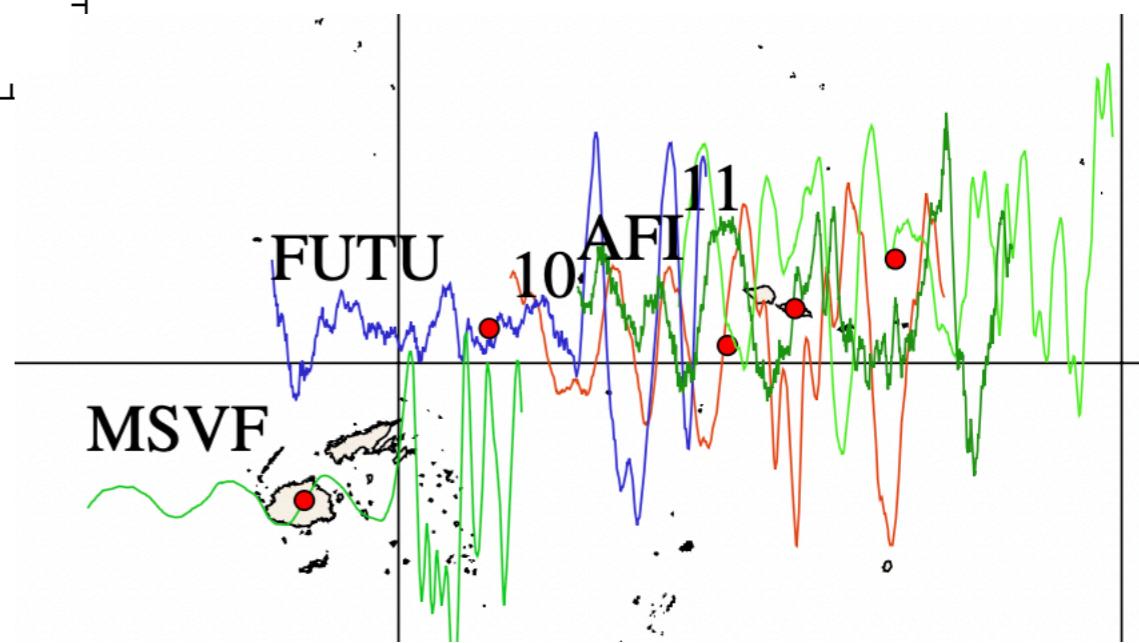
-> We can trust the polarity predictions.

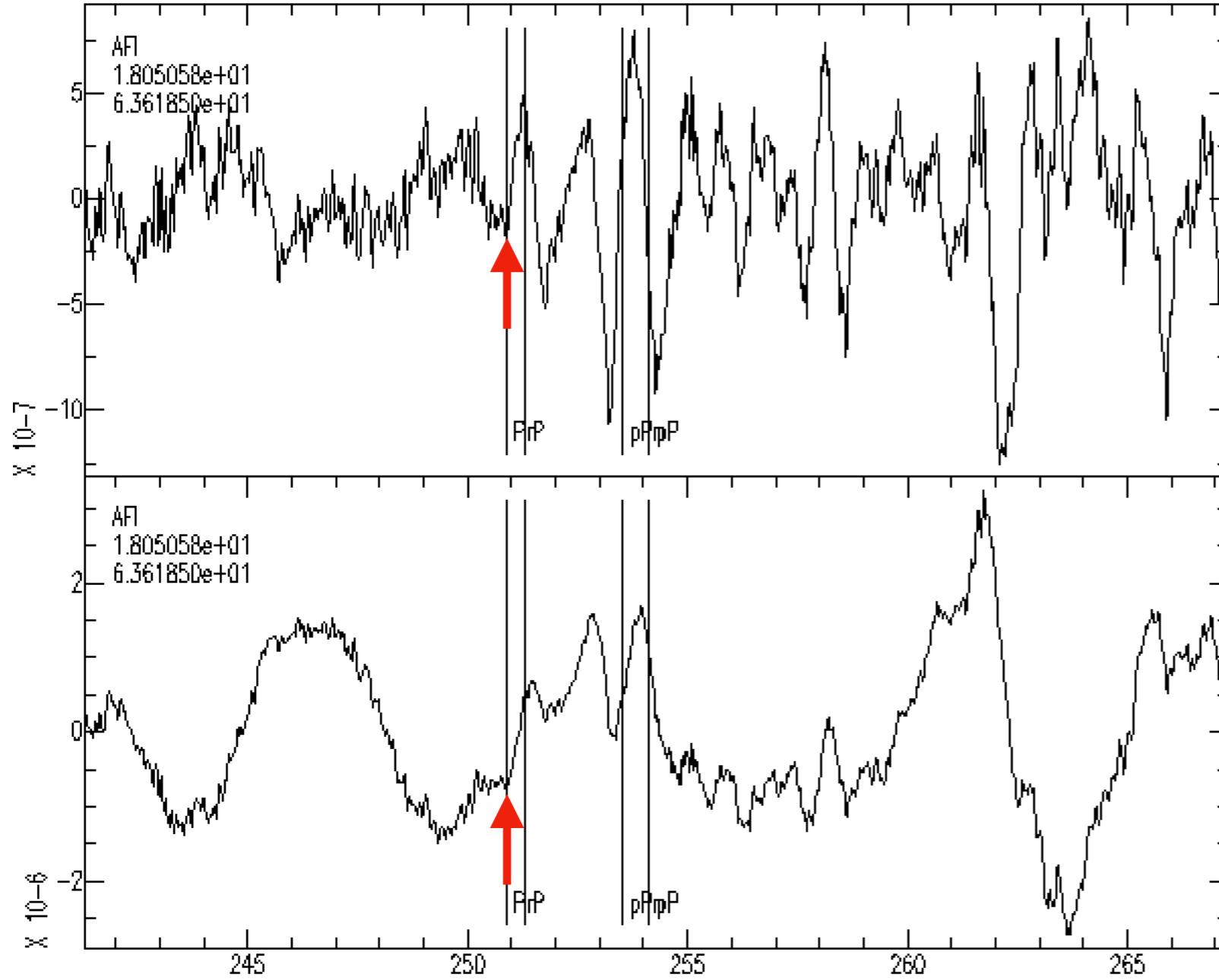


10 should be up. It is close to AFI with no delay (see next slide).

Adding the ‘Mermaid delay’ of this is consistent with a pick at the red arrow (up!).

I therefore would accept this pick.



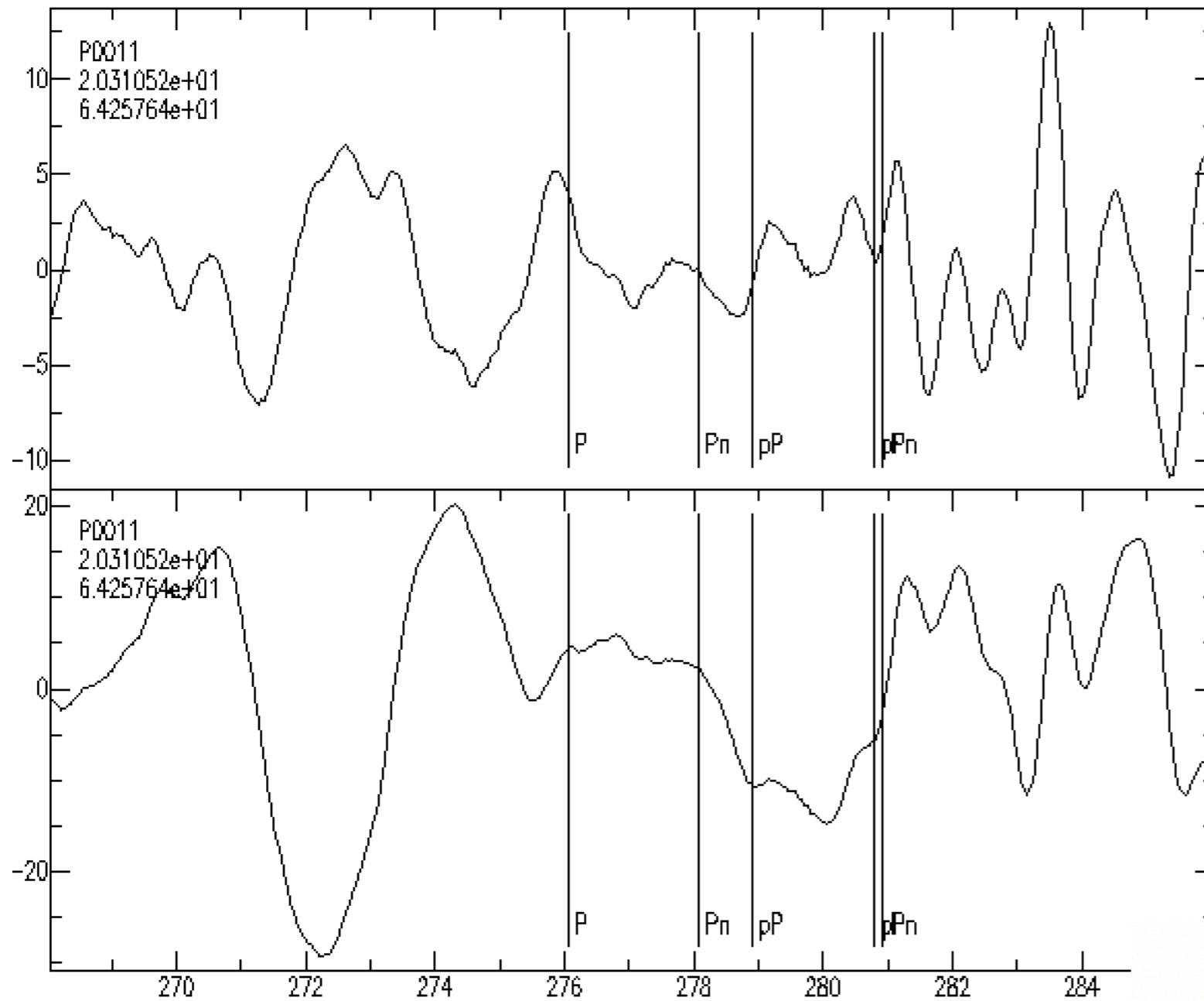


I pick AFI here because there seems to be a visible change in frequency content.

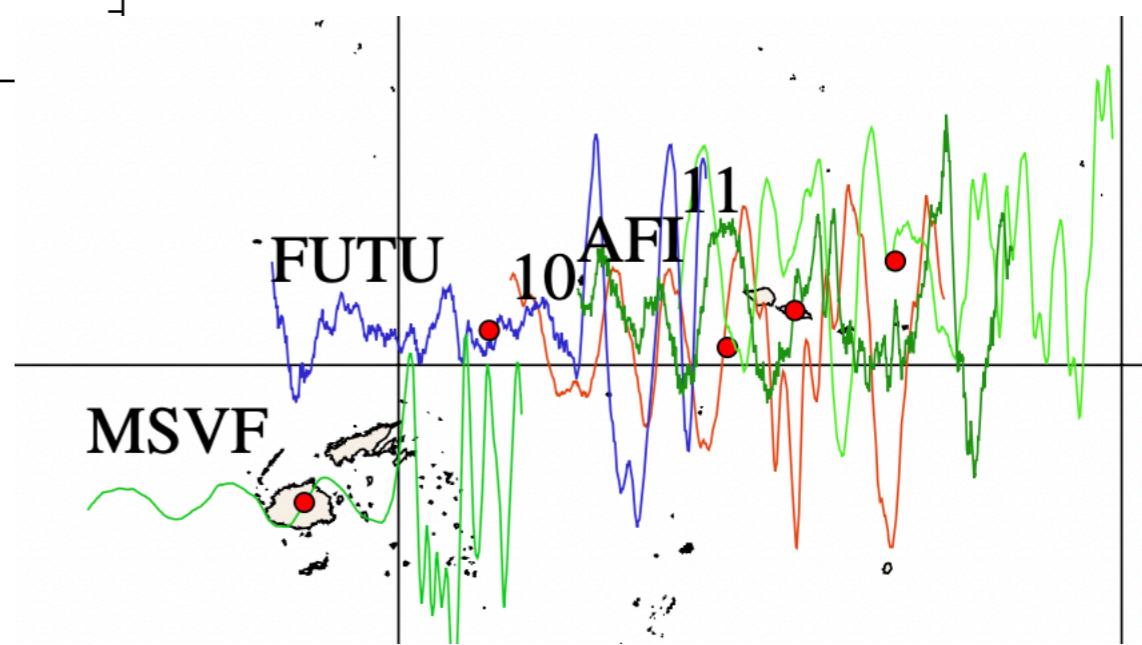
But if it was not for the attention it got for being close to Mermaid 10, I might just as well have skipped it.

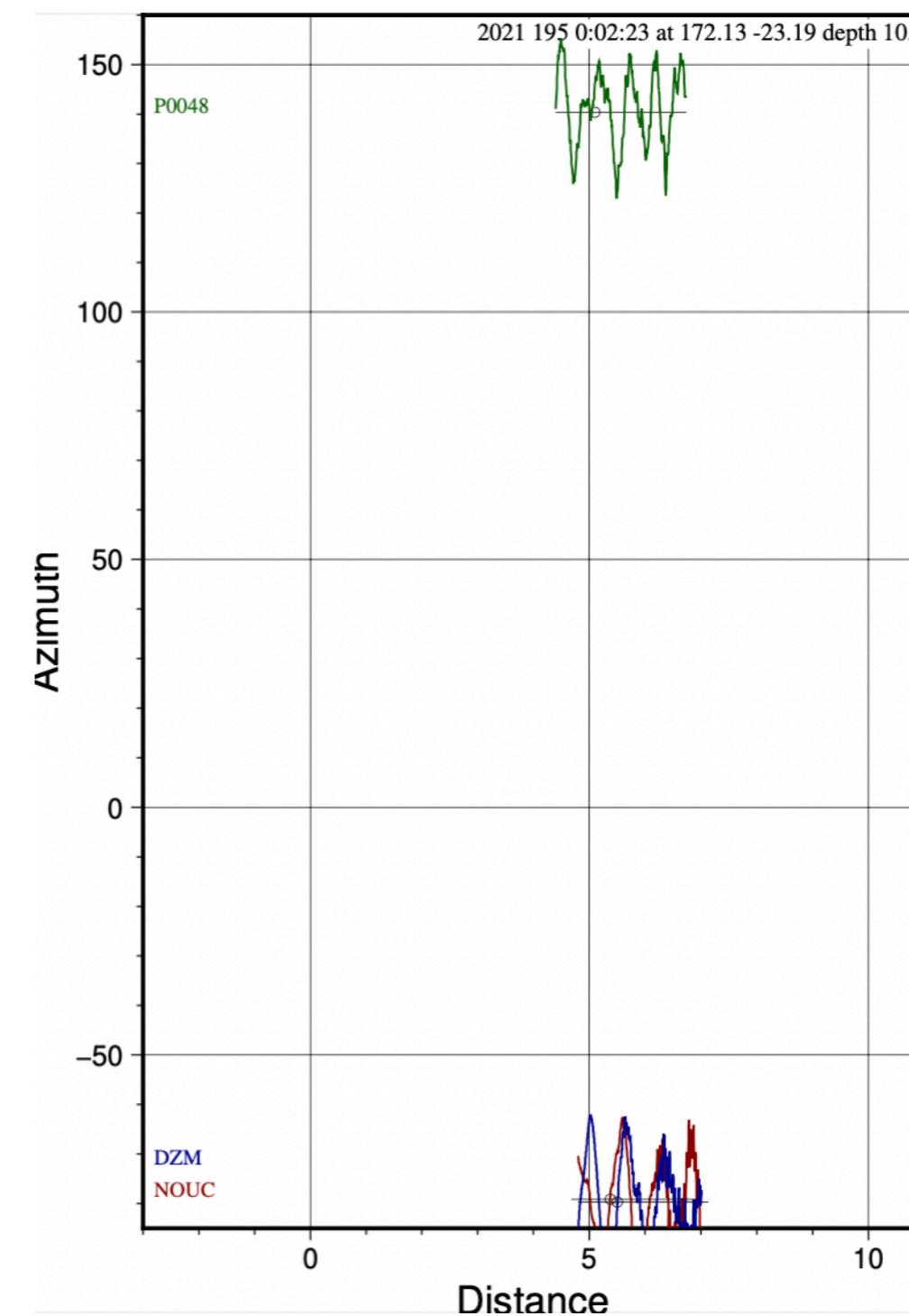
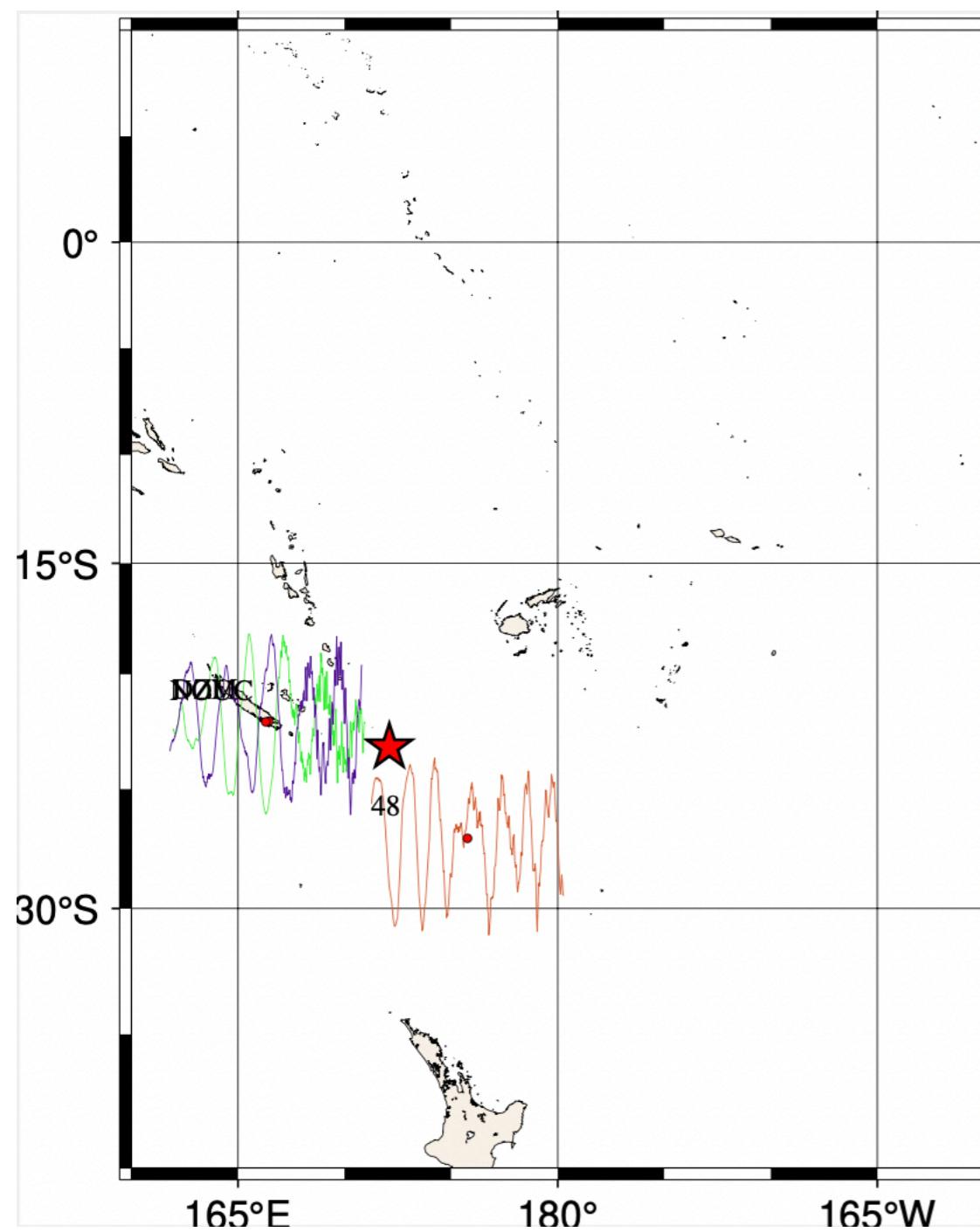
Note AK135 now has double arrivals for both P and pP

I dare not pick 11

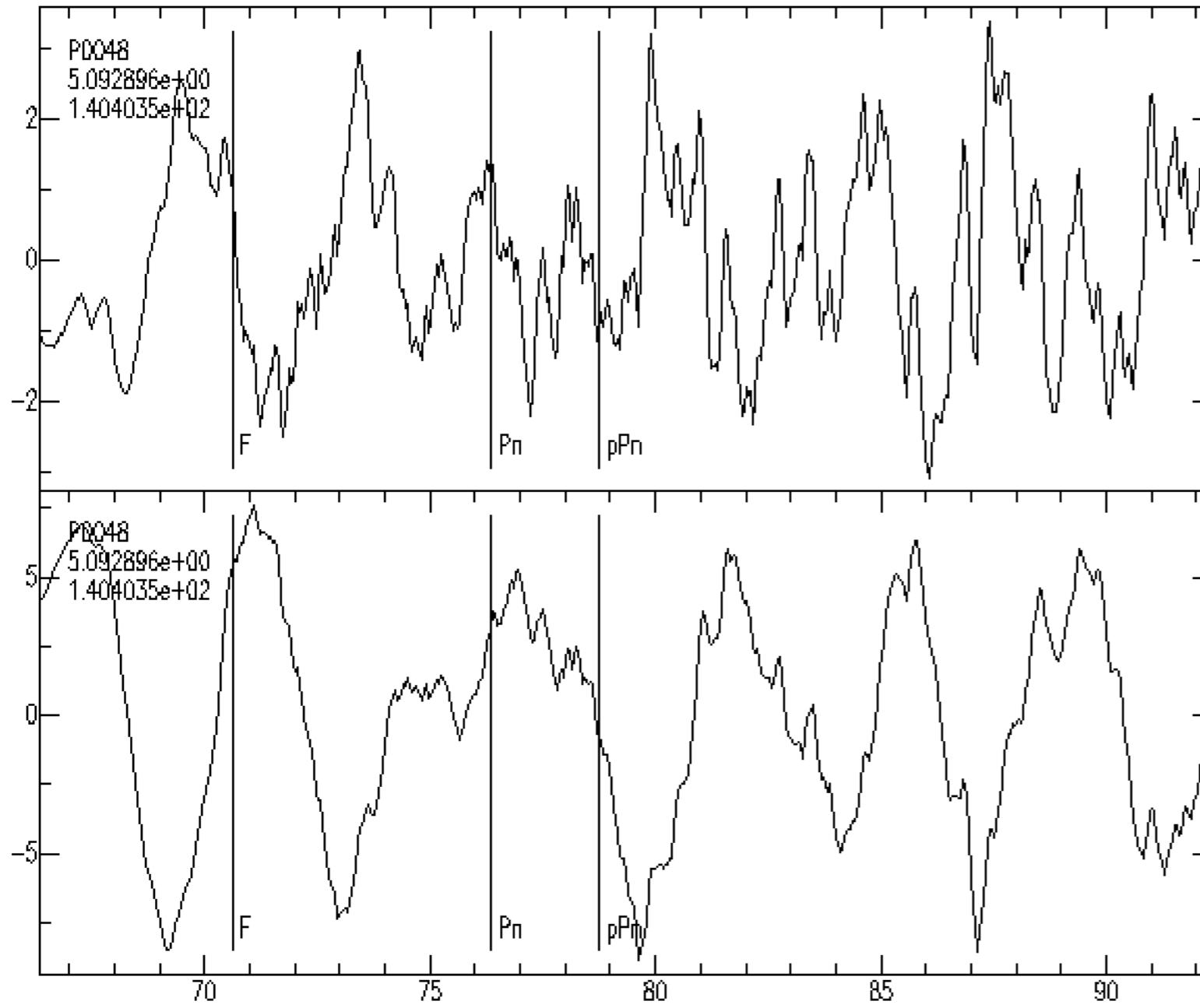


Note that the automatic picker is just after pPn (F overwrites the P), but the delay of 5s is much larger than that in AFI and the danger of picking pP instead of P is too great.





Small events may not have a published source solution. Then the distance-azimuth plot has no colours to indicate polarity.



Mermaid 48:

F indicates a change in frequency, but with a negative delay of 6s seems improbable (it requires Vp to be +8%)



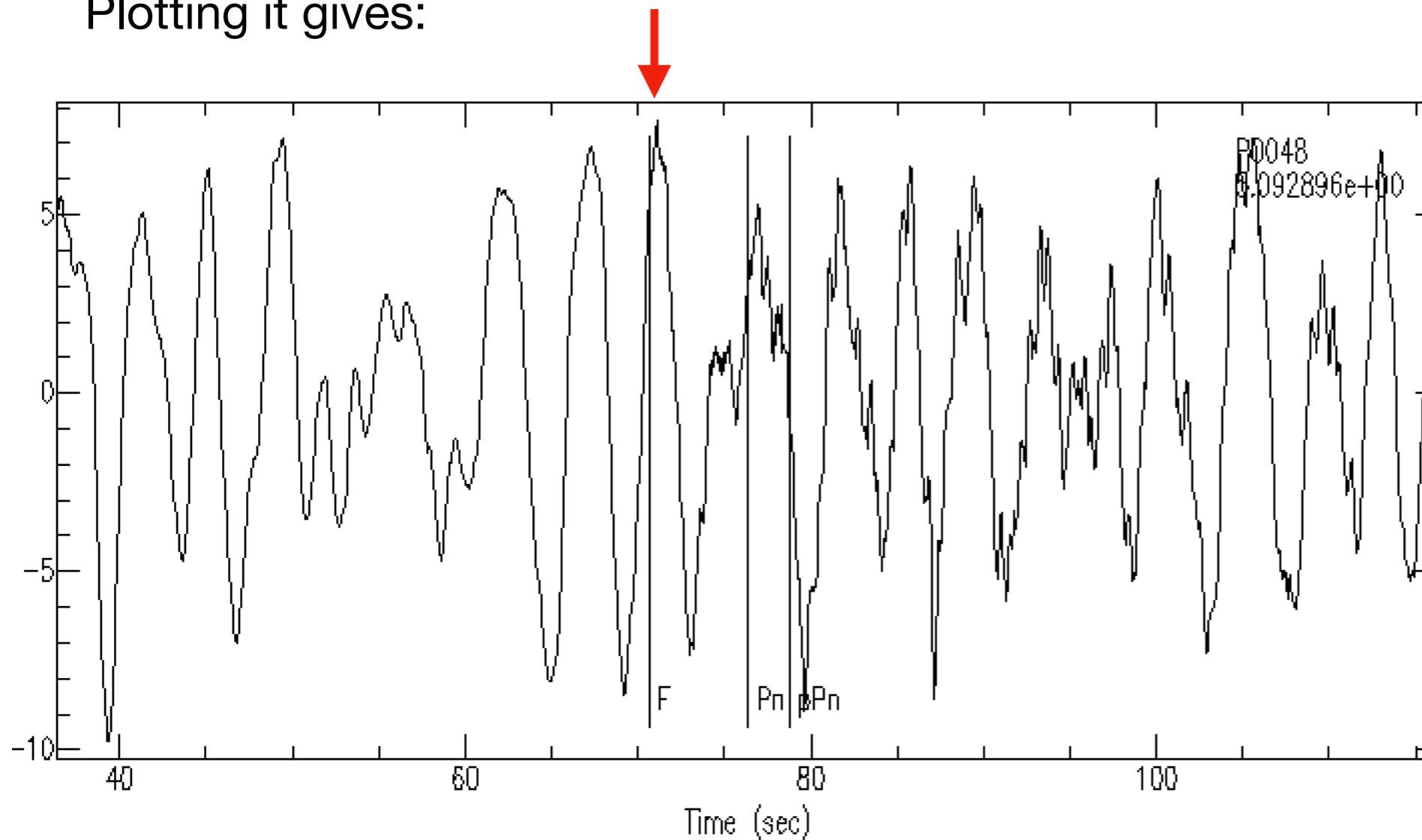
Out of curiosity, I opened up a second window and went into the Qnn directory of this event:

```
[auguste@augustes-macbook-air SPPIM % cd 2021/20210714/DATA/Q00
[auguste@augustes-macbook-air Q00 % sac
```

Mermaid sac files have their number followed by underscore (here: 48_) so I read 48 in as follows (and set the times of the plot window to P +/- 40s):

```
[SAC> r *48_*
20210714T000205.0048_60EF4ED6.MER.DET.WLT5.sac
[SAC> xlim t0 -40 t0 +40
```

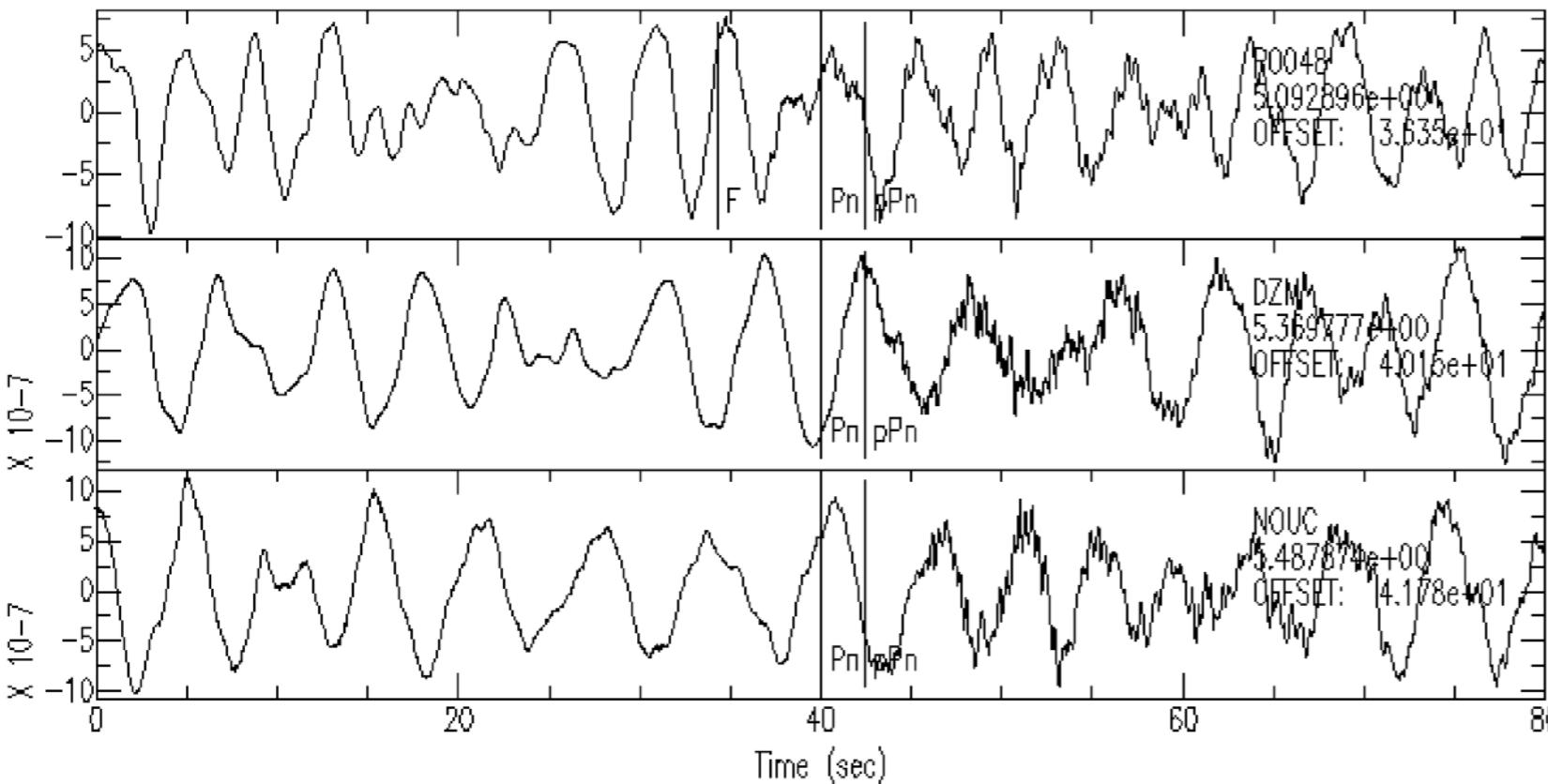
Plotting it gives:



To my surprise, F seems to be right in picking the arrival

Next, I read all three seismograms and plotted them with P lines up (using **p1 rel**)

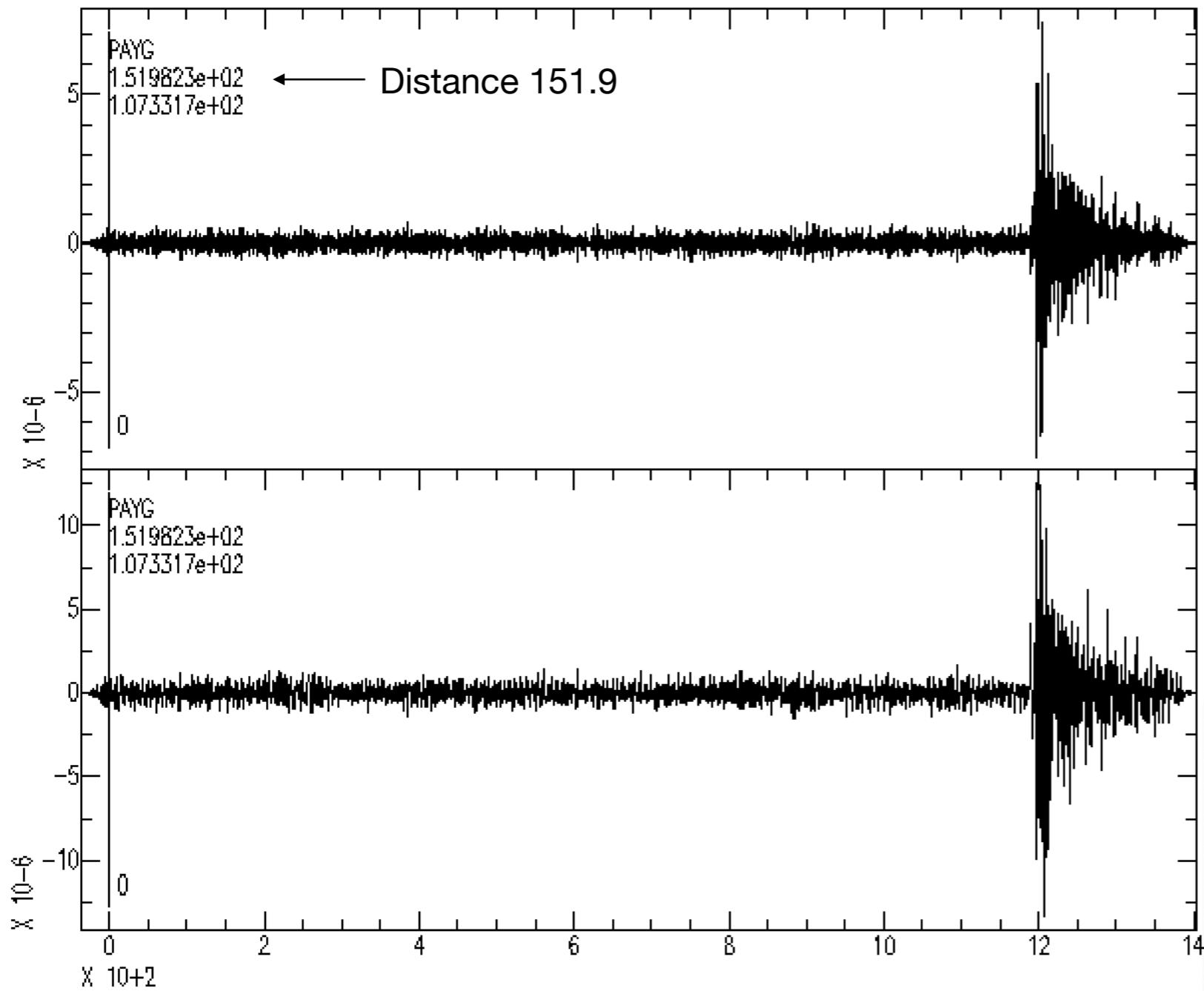
```
[SAC> r *sac *SAC ]  
20210714T000205.0048_60EF4ED6.MER.DET.WLT5.sac G.DZM.00.BHZ.M.2021.195.000200.SA  
C G.NOUC.00.BHZ.M.2021.195.000200.SAC  
[SAC> p1 rel ]  
SAC>
```



In all three there is a clear change of frequency that seems ‘pickable’

Hypothesis: stations west of the quake have biased hypocenter determination, but 48 is a rare station east. In this case the ‘event correction’ during tomographic inversion will be large and the negative delay in 48 will be much smaller.

Why do we not see a small window around predicted P?



Answer: this station PAYG is at 151.9 deg - what we are seeing here is PKP.

Do not pick PKP!

A new script: repick

repick allows you to start from scratch for any event picked earlier without messing up the administration in file *rundopicks*

To run it, you must look up the address of the Qnn directory for that event. Then from the base directory type:

`repick qnndirectory`

for example: `repick 2021/20211219/DATA/Q00`

If you use *repick* you must again pick all your earlier picks (the A pointer tells you where you picked last time)

Homework

- Untar Course2.tar: `tar -xvf Course2.tar`
- Remove the ADDTOS directory: `rm -fr ADDTOS/`
- copy: `cp rundopicks.Course2 rundopicks`
- and start picking using pnext, just as before