Notes on the proxy cable cal

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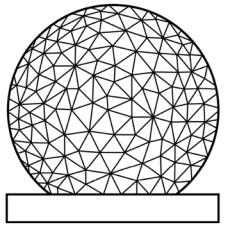
TOW Correlator Workshop May 4-5 2023



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proxy cable cal

The phase calibration system measures phase shifts from the phase cal generator (physically close to the receiver) to the Digital Back End.

But the 5MHz maser signal used by the phasecal is generated from far away (can be ~100 meters) – we need to measure the phase / delay due to that distribution system!

Different methods to do this:

Stations with "CDMS" (in the station logs, units are psec):
NyAlesund, Onsala-SW, Onsala-NE, Yebes

Stations with a "cable" system (in the station logs, units are 1ps/2.5e6):
Westford, Wettzell

Stations with only proxy cable cal:
GGAO, MGO, Kokee, Hobart, Ishioka, Katherine

* Kokee & MGO have "cable" systems but the output is not (yet) connected to the station logs

proxy cable cal

Step 1: run `pcc_generate.py`!

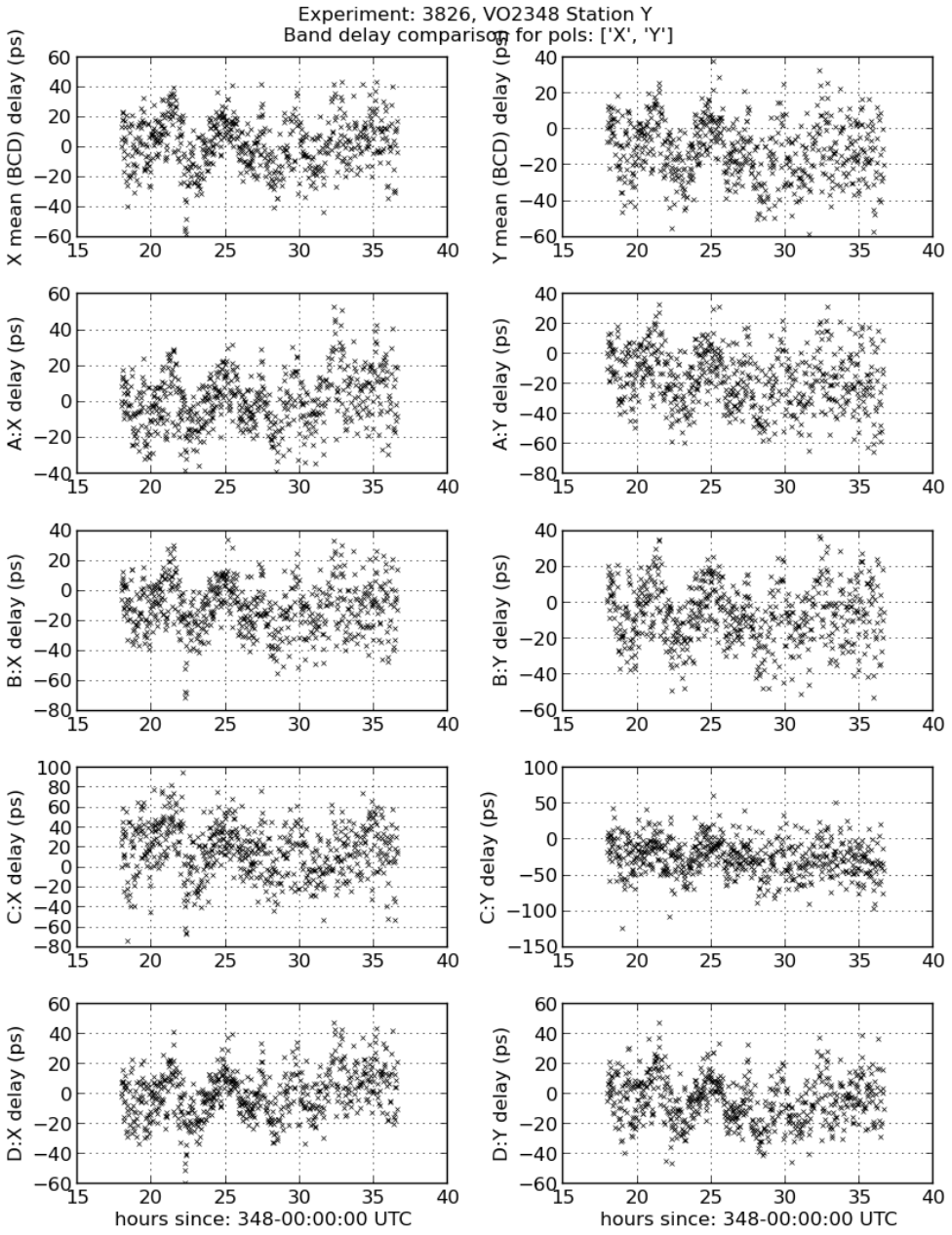
This fits the phase of the phasecal tones and calculates the delay for each band.

Output is files with the best-fit delay to the phasecal tones for each band (A,B,C,D) and polarization (X,Y), as well as plots.

Then, select band-polarization pairs to use for the delay calculation.

- Don't use band A at GGAO, MGO, Kokee; they use a different type of cable that will give incorrect delays.

Step 2: pcc_select.py averages the selected band-pols for each scan and generates PCMT files.



select_bandpols.py

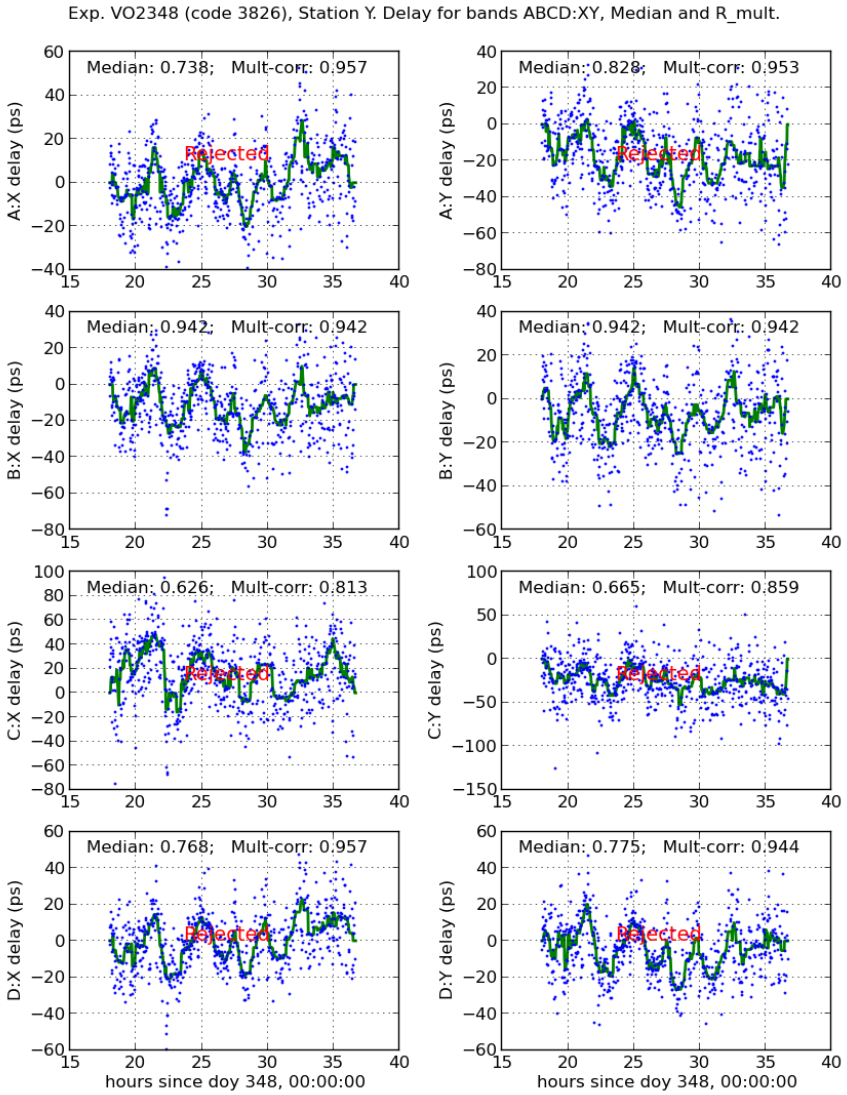
Which band-pol combinations to choose?

- Pick the ones most in agreement; variations in the 5MHz phase should be common to all.

`select_bandpols.py` tool from Leonid Benkevitch

Available in the HOPS codebase, and also from:
https://github.com/benkev/vgos

Measures the cross-correlation of the delay in the bands/pols, and selects band-polarization combinations that agree above a threshold. I usually choose a threshold of 0.9.




```
$ select_bandpols.py -s H -d . -o pltH/ -m 0.9
```

…from the folder with the output of pcc_generate.py, and repeat for each station. Output is the recommended selection of bands/pols.

proxy cable cal

Ok, that's how we generate the proxy cable calibration delay corrections…

…but are they correct? For the stations with CDMS, do they agree?

Let's examine:

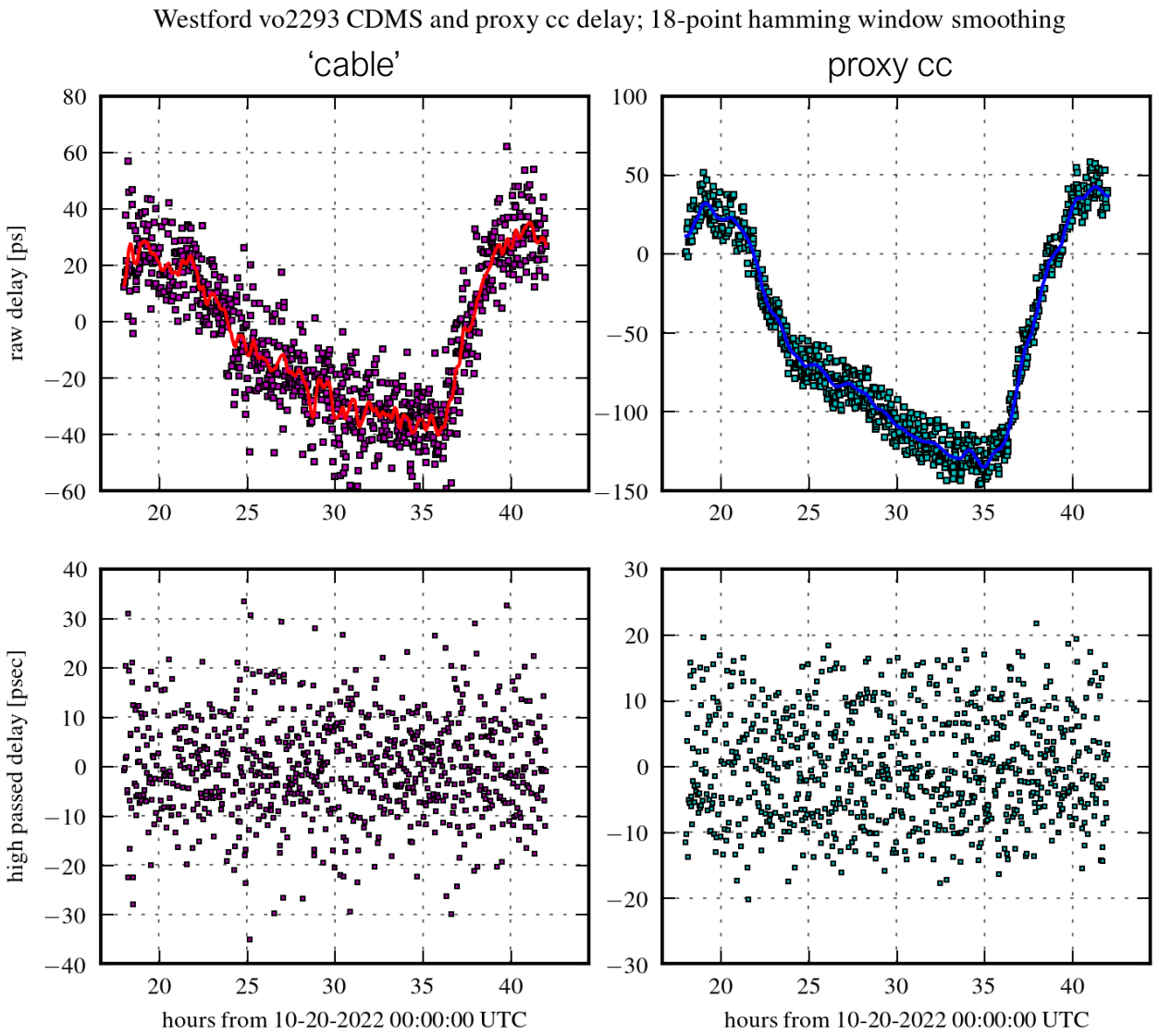
- Westford (VO2293)
- NyAlesund (VO2293)
- Onsala-SW (VO2348)
- Onsala-NE (VO2293)
- Yebes (VO2293)
- Wettzell (VR2205)

Westford: comparison with CDMS

It's helpful to separate the long-timescale variation (due to temperature) from short-timescale variation (telescope orientation, cable stress, etc).

Raw data with a smoothing function (18-pt hamming window)

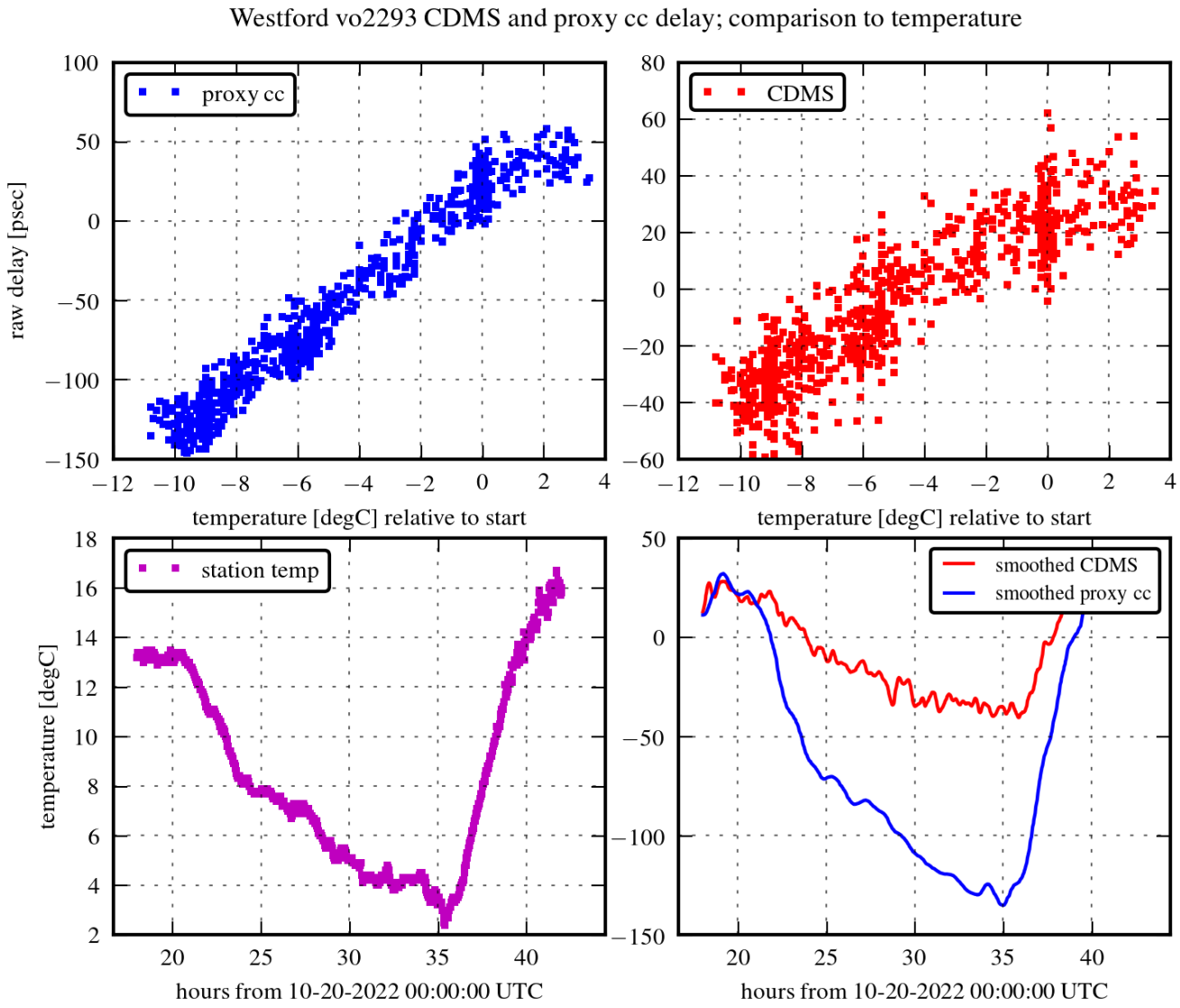
Data after subtracting the smoothed data



Westford: comparison with CDMS (temperature)

It's helpful to separate the long-timescale variation (due to temperature) from short-timescale variation (telescope orientation, cable stress, etc).

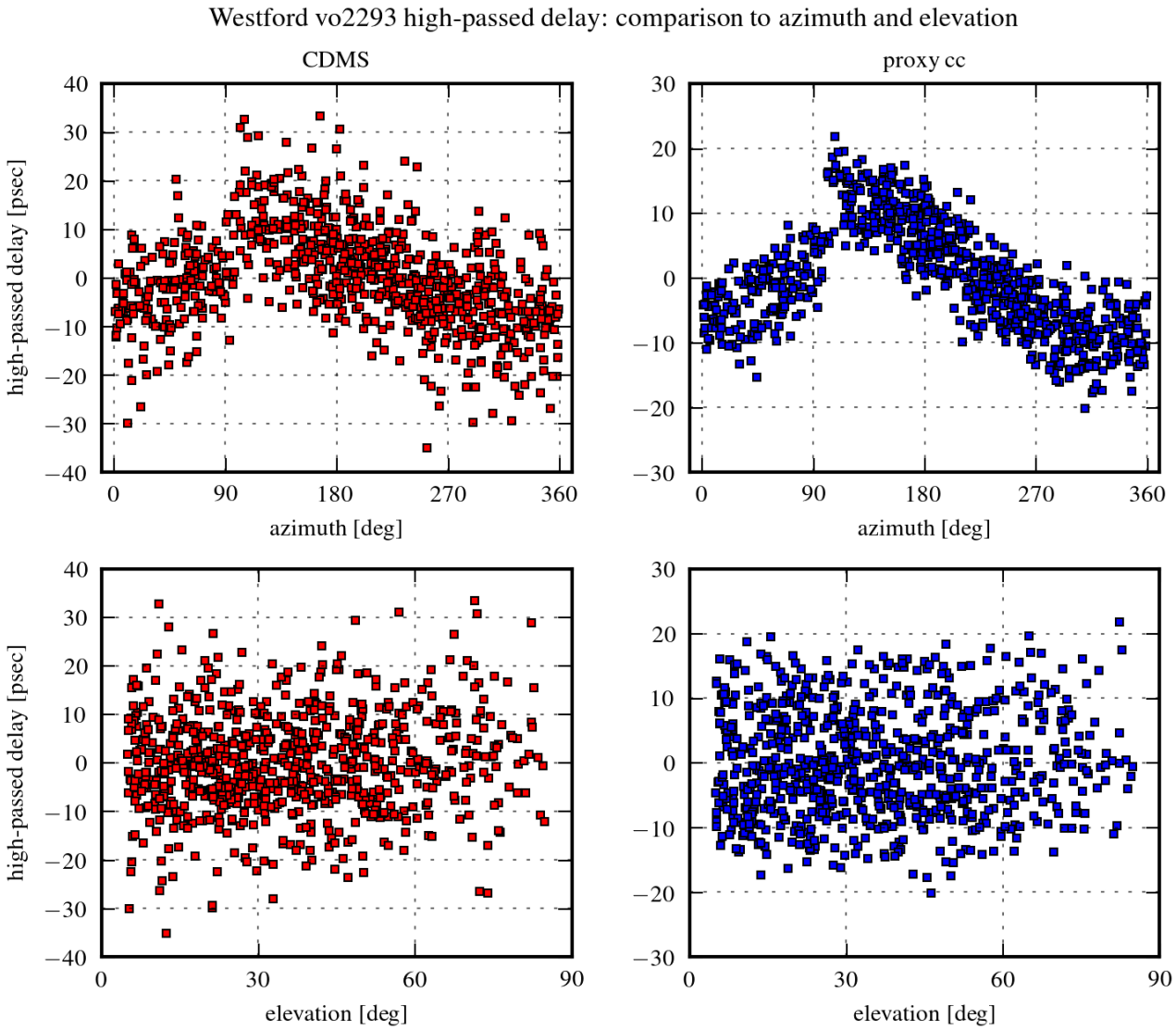
Westford usually has a clear linear correlation with temperature. The magnitude of the proxy cc is twice the CDMS.



Westford: comparison with CDMS (telescope position)

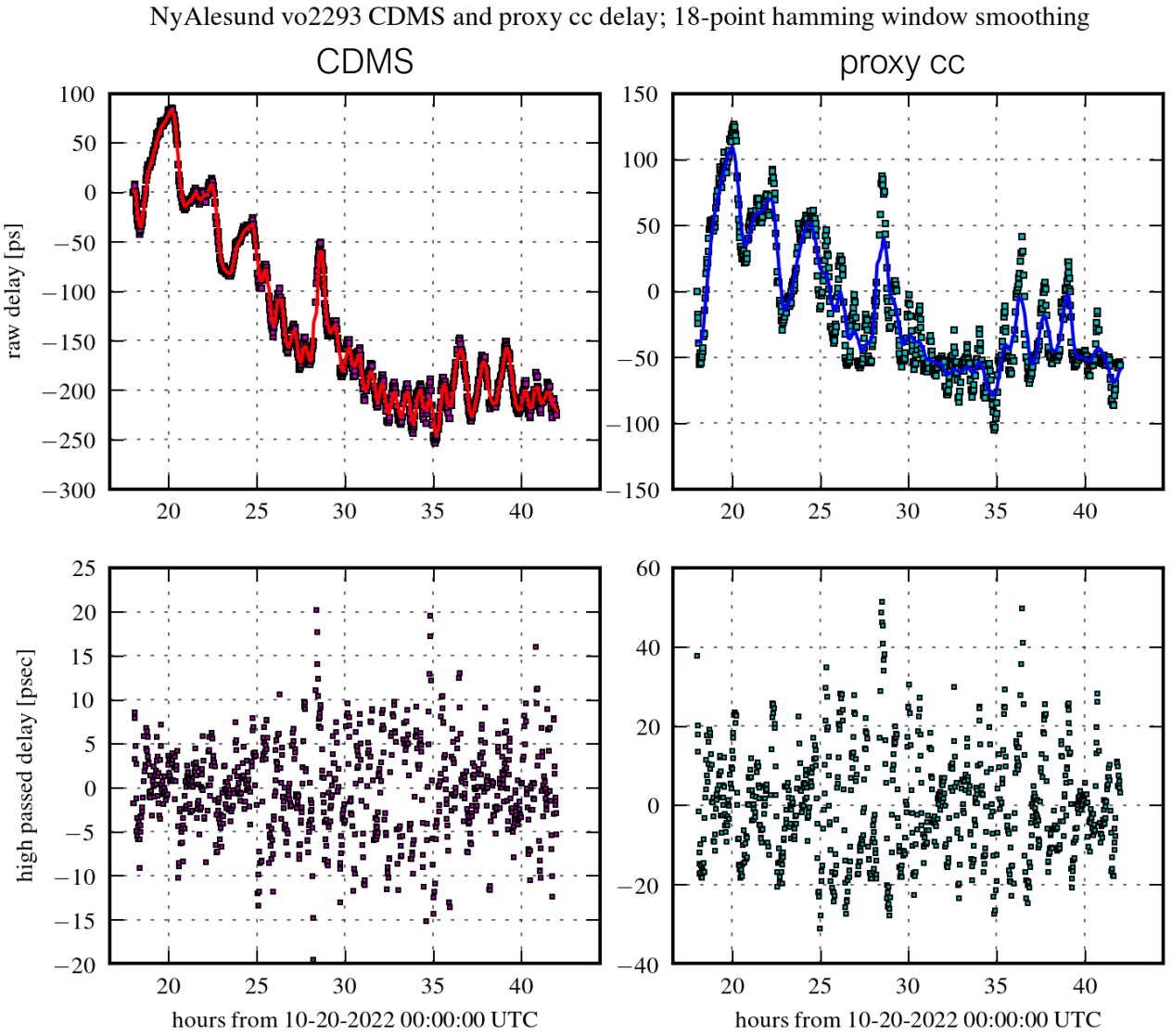
It's helpful to separate the long-timescale variation (due to temperature) from short-timescale variation (telescope orientation, cable stress, etc).

Rapid changes in the delays are correlated with antenna azimuth, as expected. The magnitudes are about the same. Good! This makes sense.



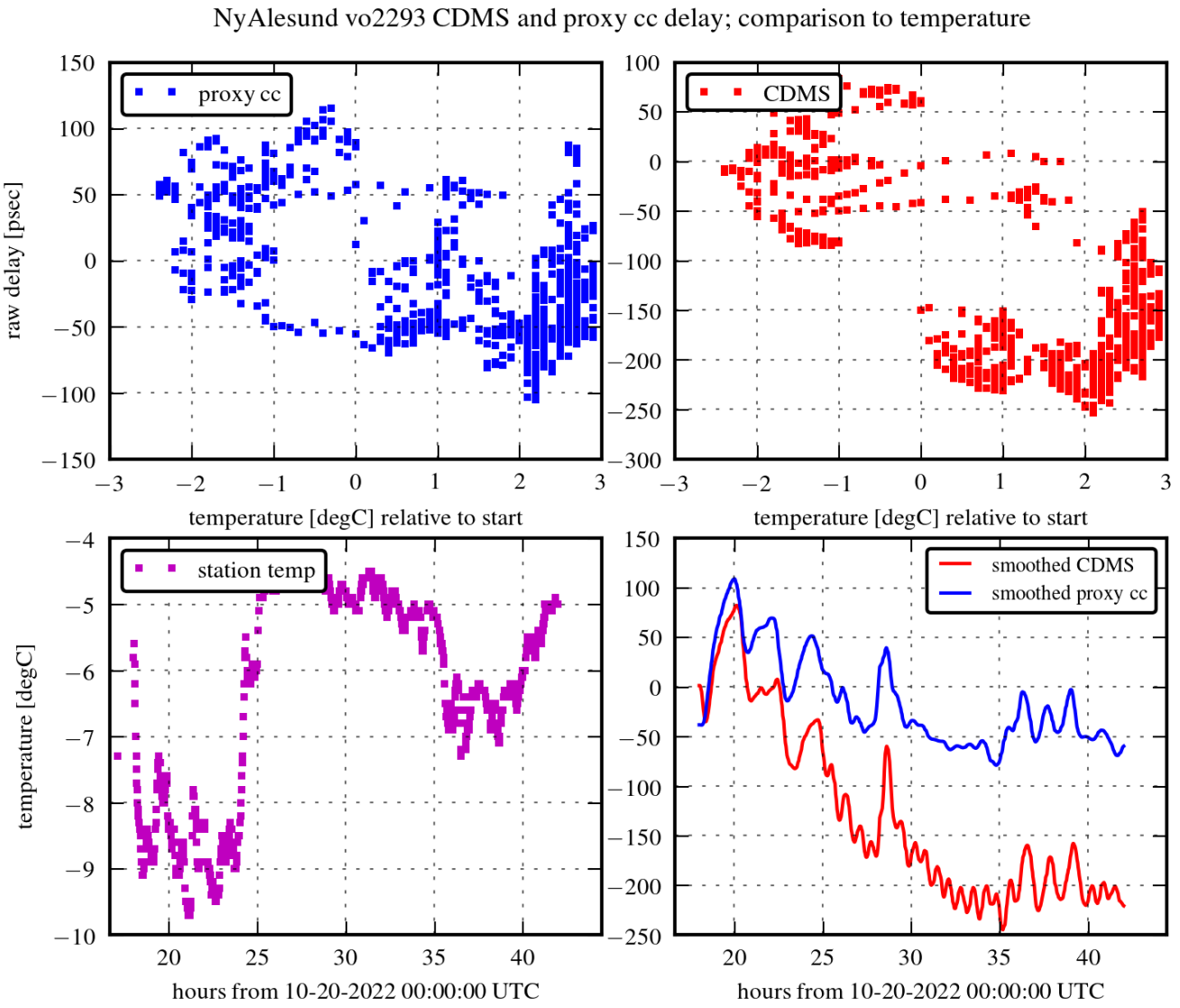
NyAlesund: comparison with CDMS

The data from NyAlesund have different amplitudes, on both short and long timescales.



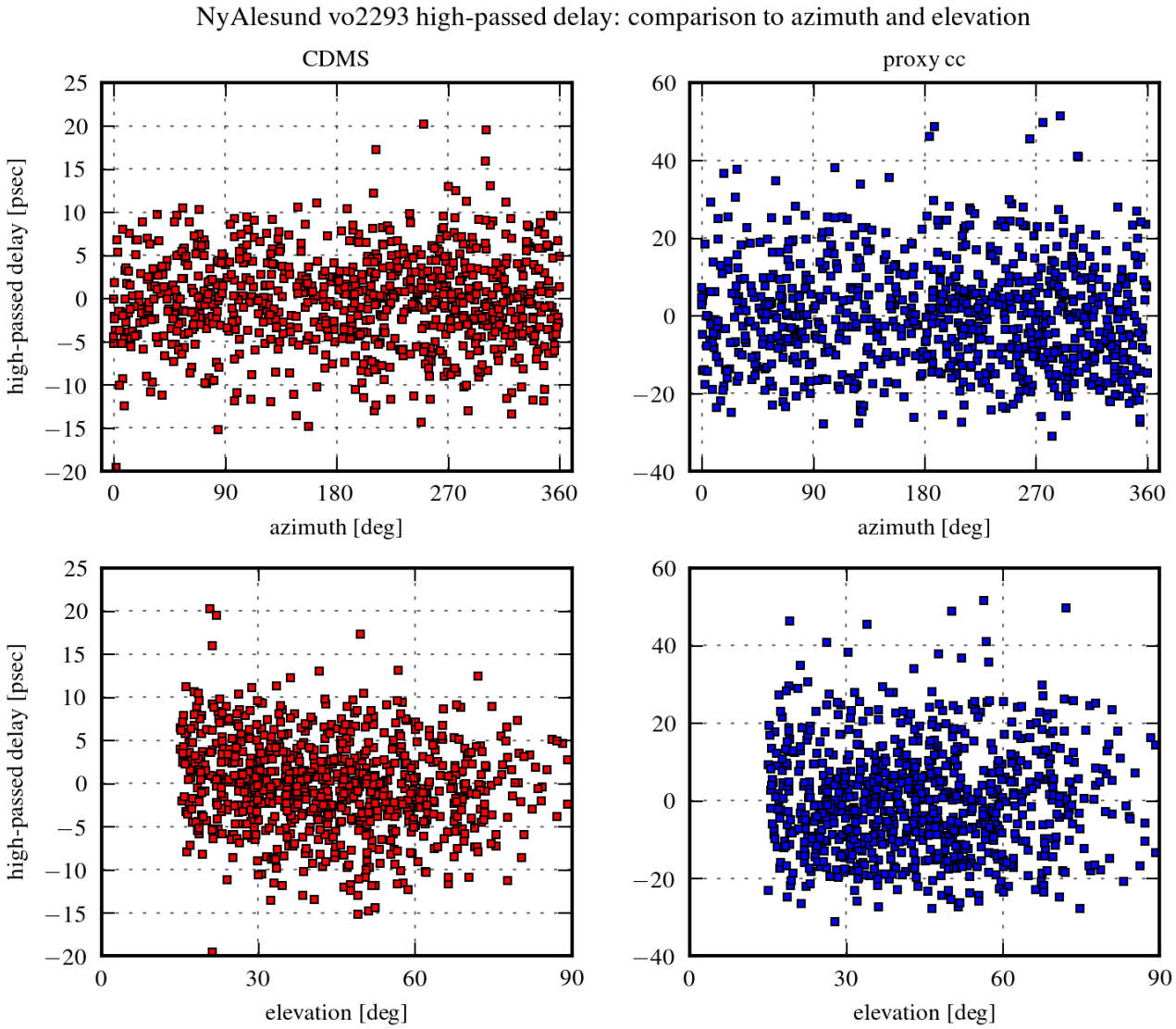
NyAlesund: comparison with CDMS (temperature)

No correlation long-timescale correlation with the temperature reported in the station log, but that's not a problem.



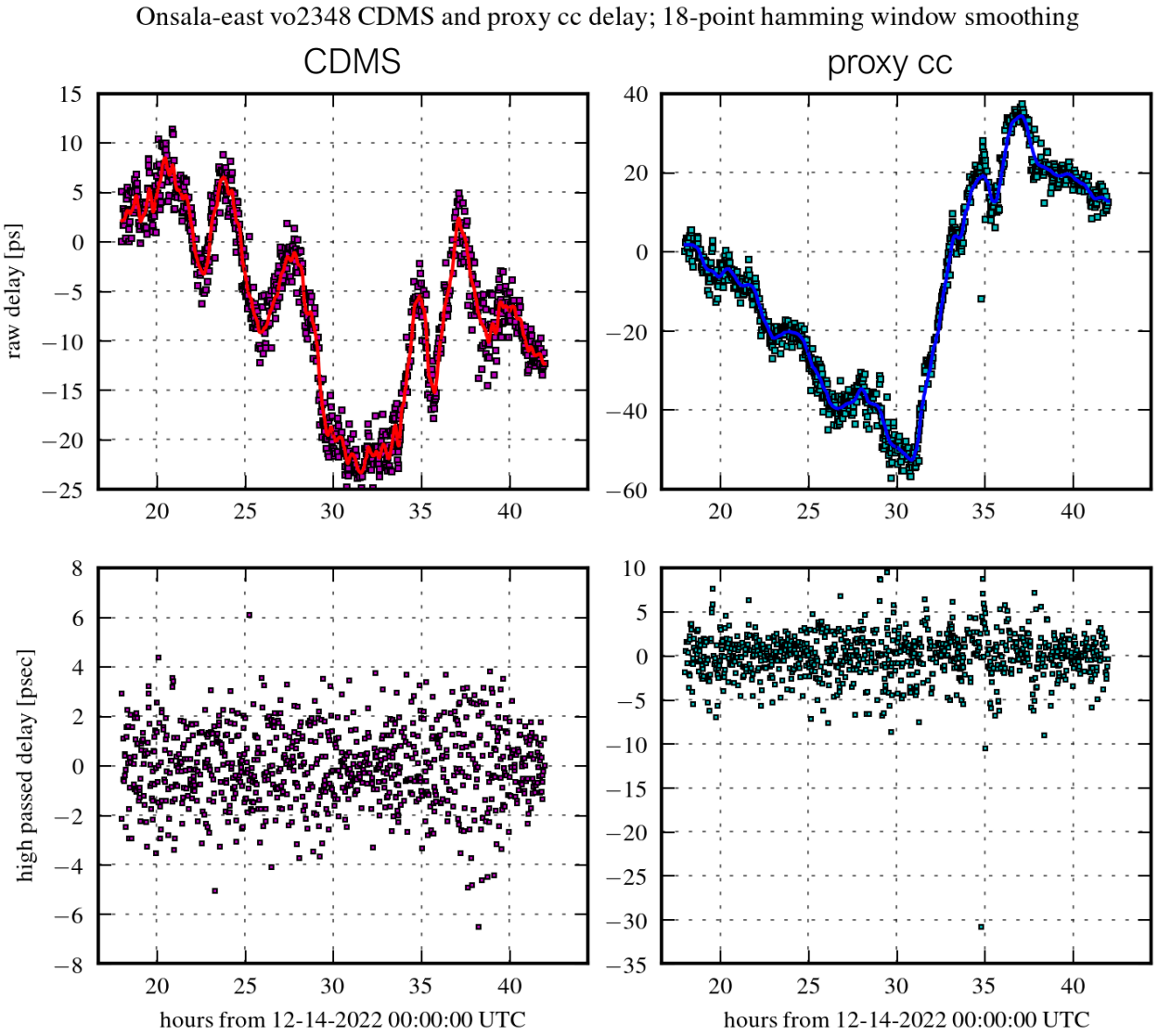
NyAlesund: comparison with CDMS (telescope position)

No short-timescale correlation with telescope position, but the delay correction from CDMS is small.



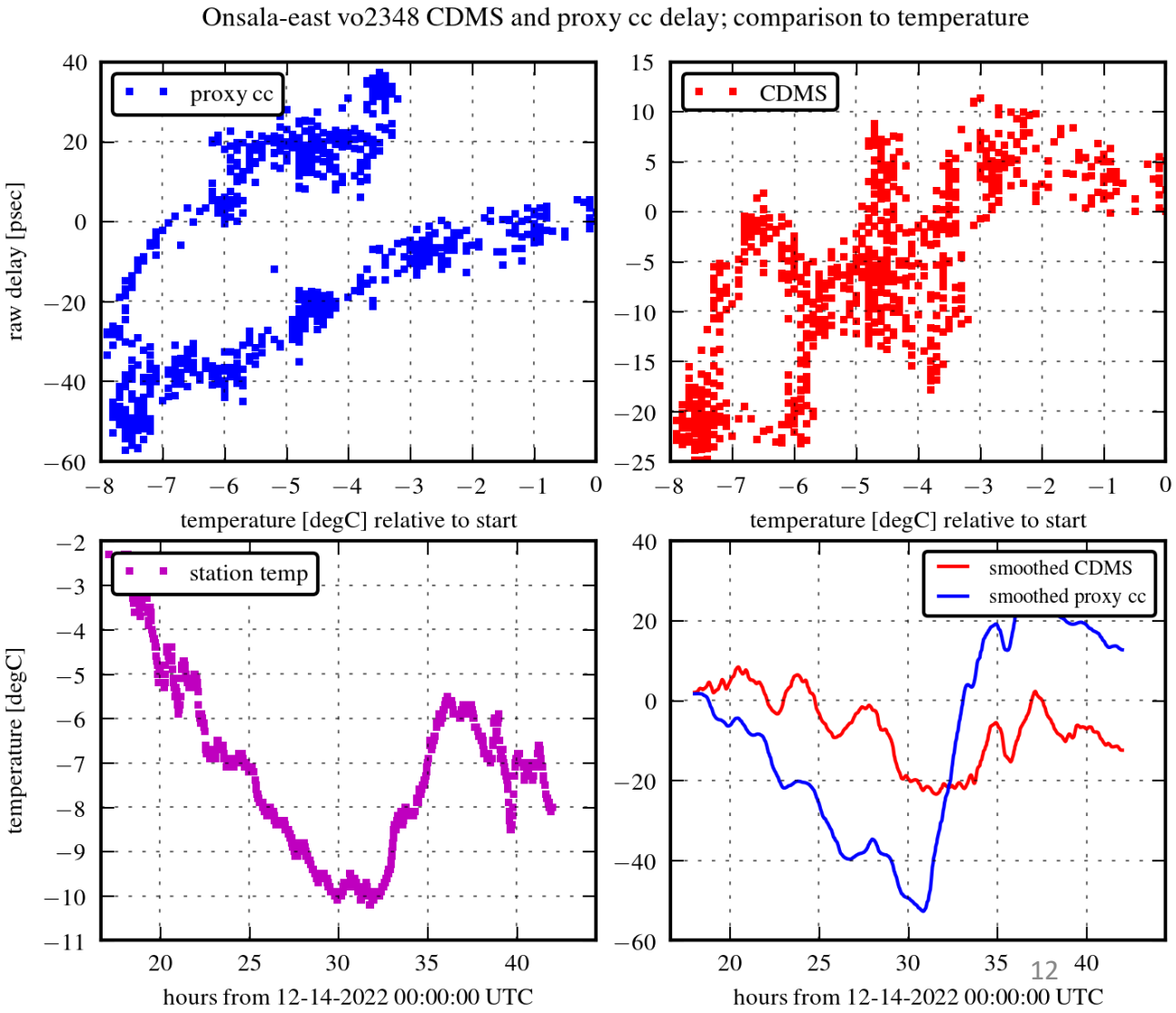
Onsala-East: comparison with CDMS

The delay at the Onsalas is typically small; the short-timescale variation is usually just a few picoseconds.



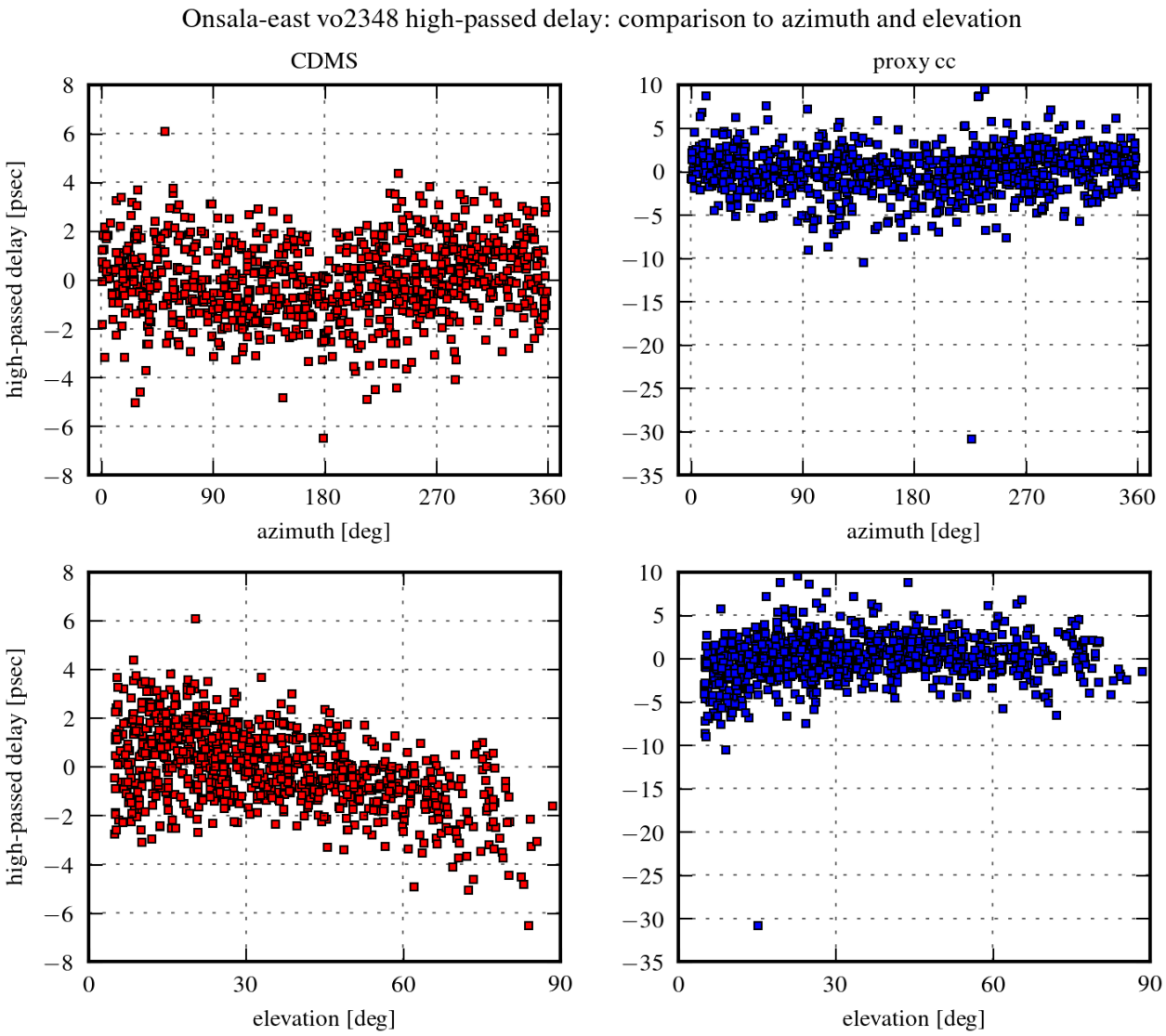
Onsala-East: comparison with CDMS (temperature)

Oe delay corrections are not correlated with temperature.



Onsala-East: comparison with CDMS (telescope position)

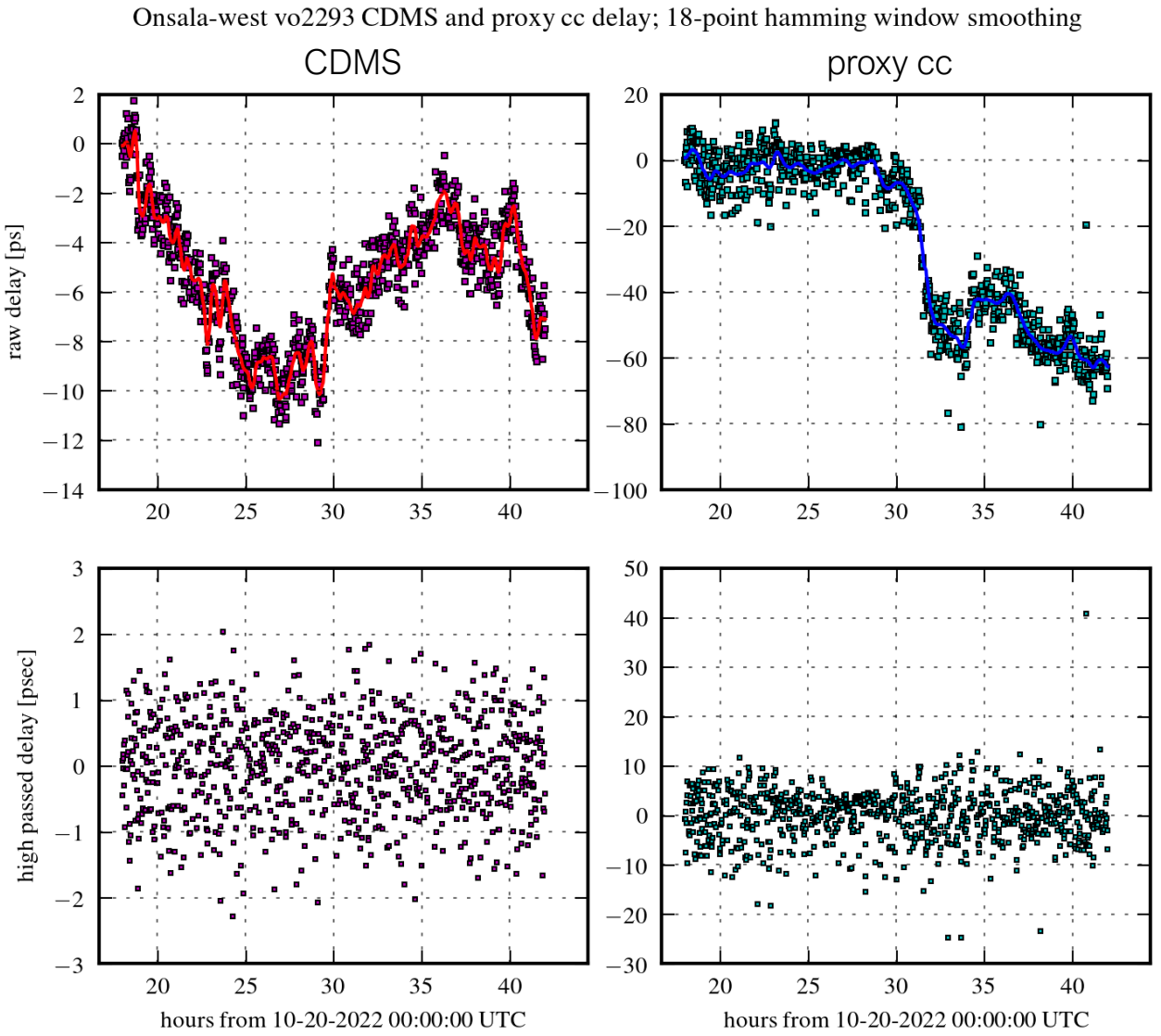
There's some correlation to antenna position, and the delays are very small (because of the type of cabling?)



Onsala-West: comparison with CDMS

Raw data with a smoothing function (18-pt hamming window)

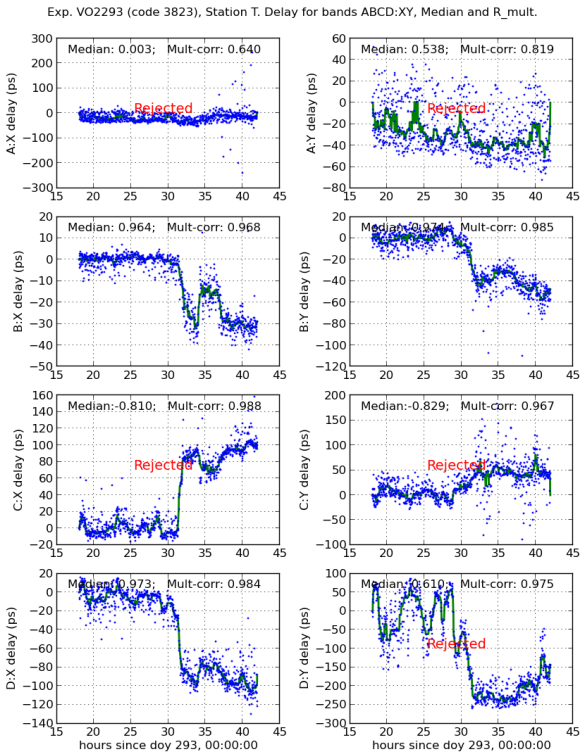
Data after subtracting the smoothed data

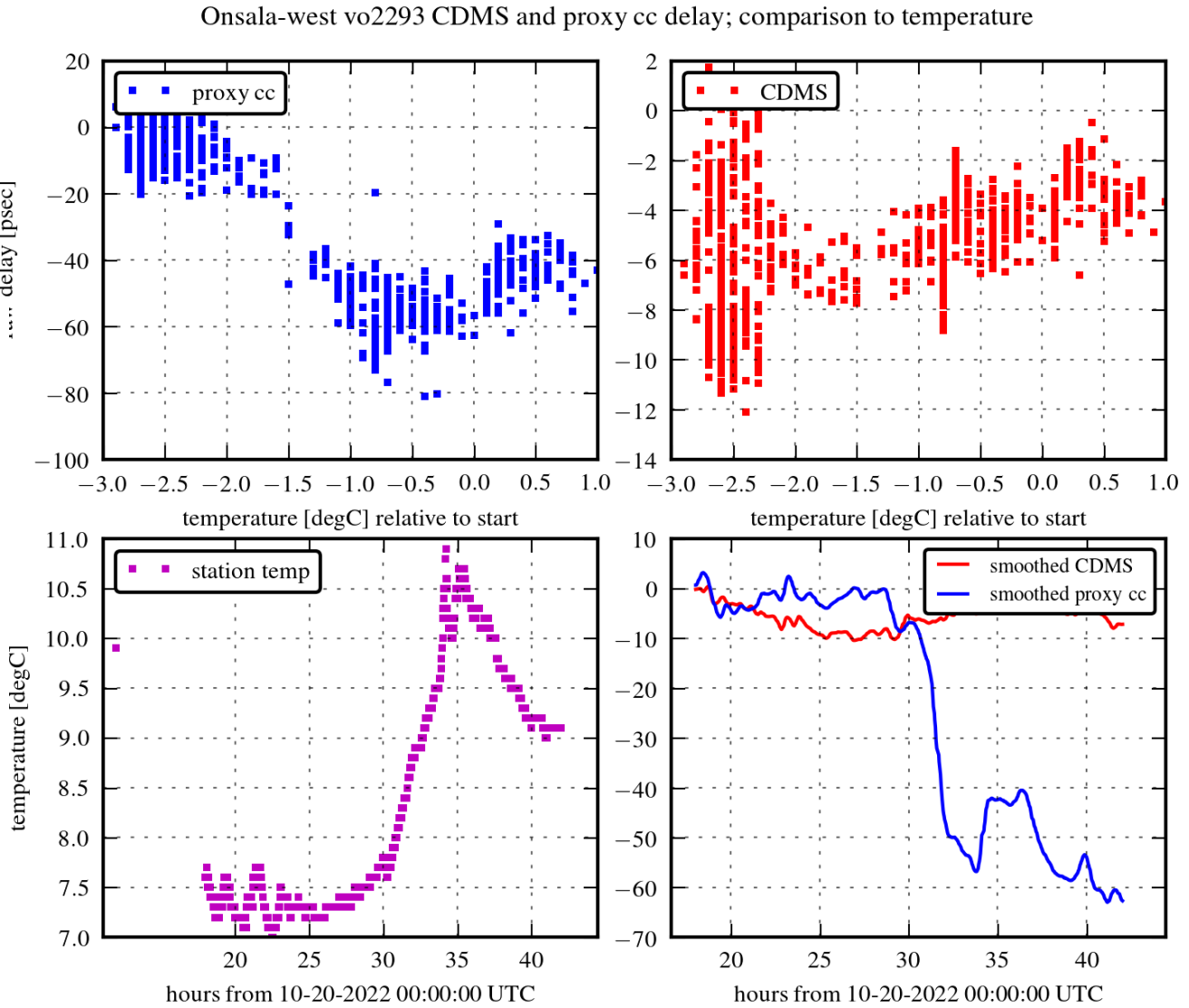


Onsala-West: comparison with CDMS (temperature)

Again, the proxy cc delay is much larger than what's measured by CDMS!

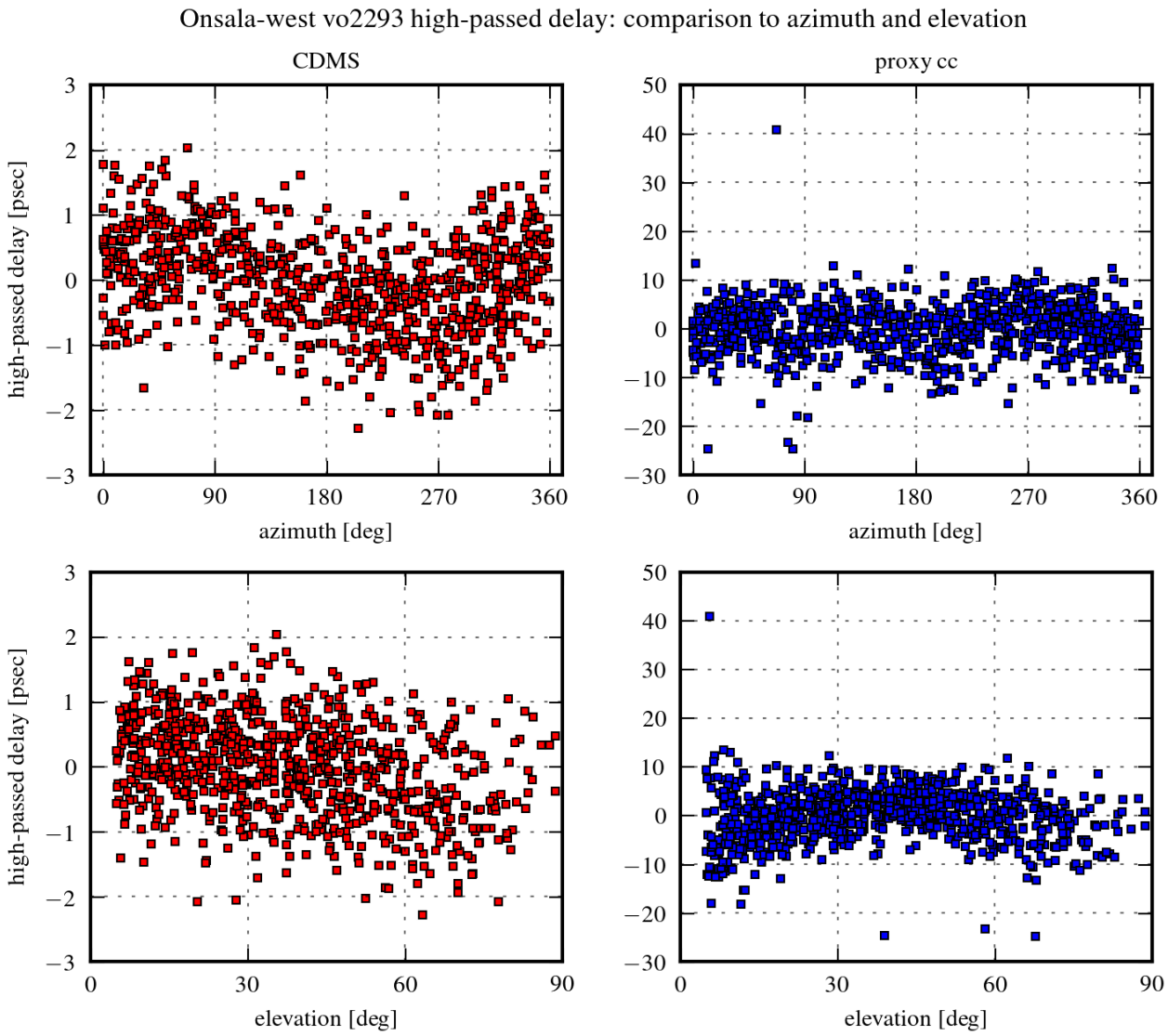
Not sure what proxy cc is telling us here. Agreement between the different band-pols is not good. Issue with phasecal?





Onsala-West: comparison with CDMS (telescope position)

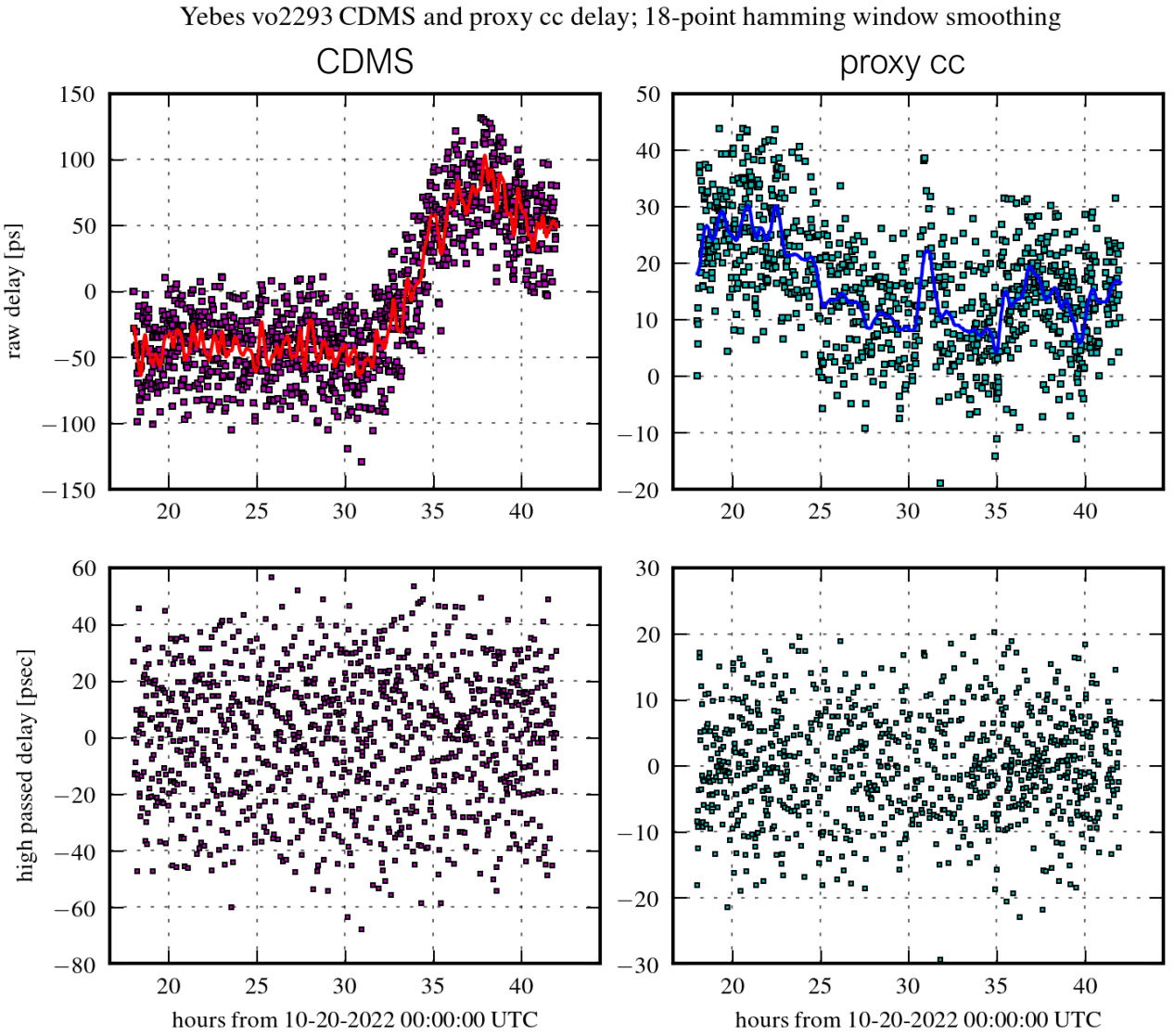
CDMS correlated with antenna azimuth, but proxy cc is much larger.



Yebes: comparison with CDMS

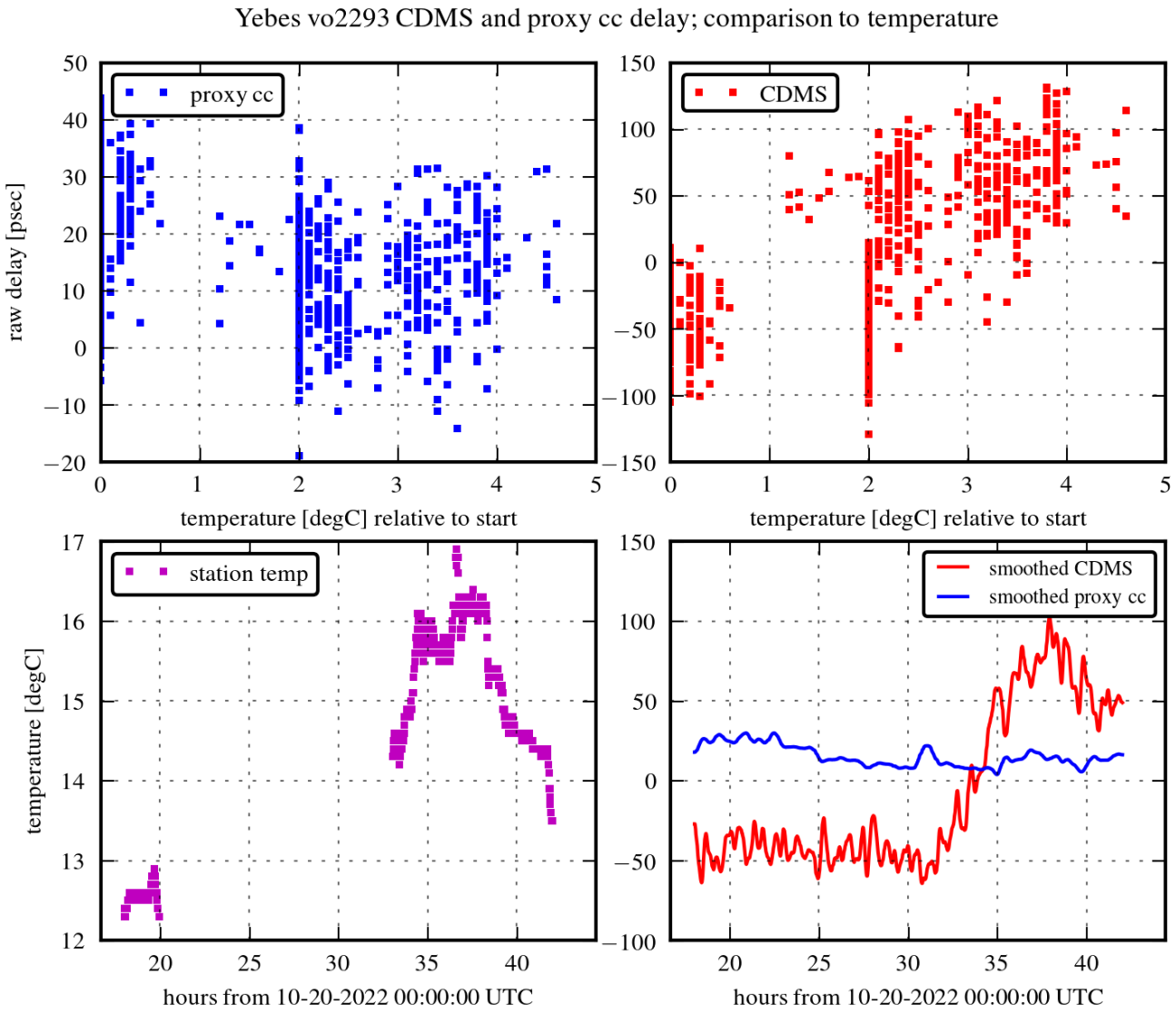
Raw data with a smoothing function (18-pt hamming window)

Data after subtracting the smoothed data



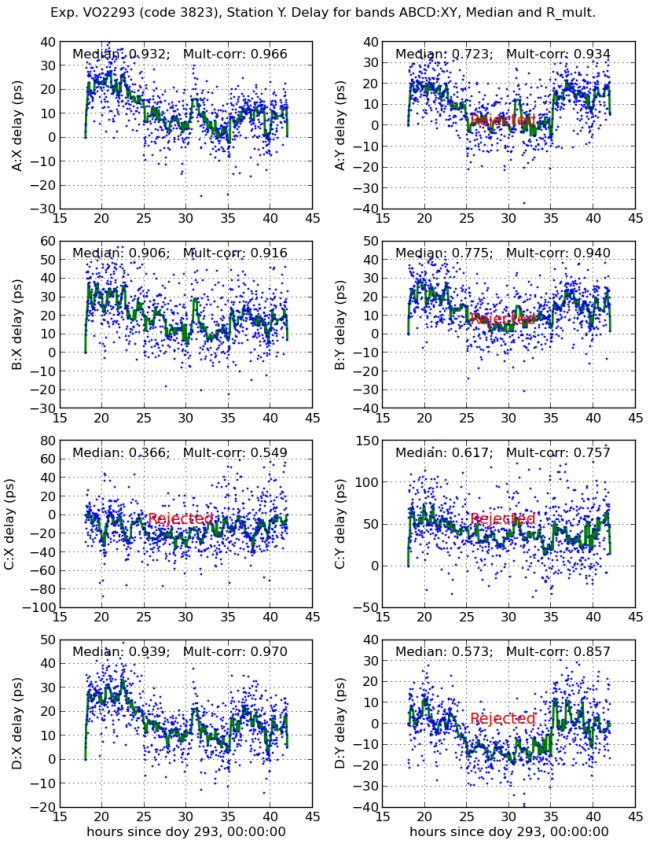
Yebes: comparison with CDMS (temperature)

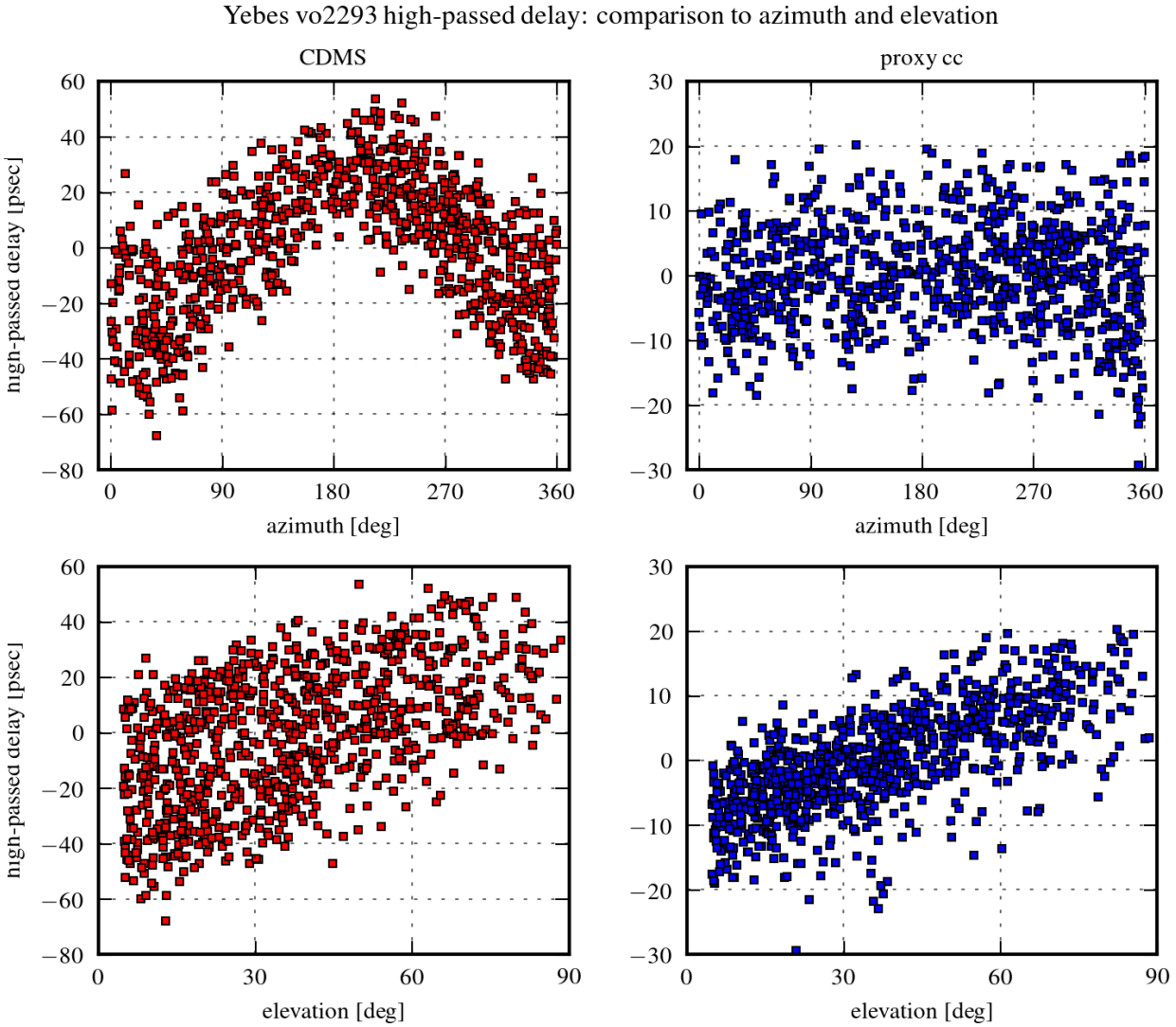
Some bad weather data.



Yebes: comparison with CDMS (telescope position)

Yebes CDMS delay is correlated with antenna position: good! Why doesn't proxy cc measure the same?

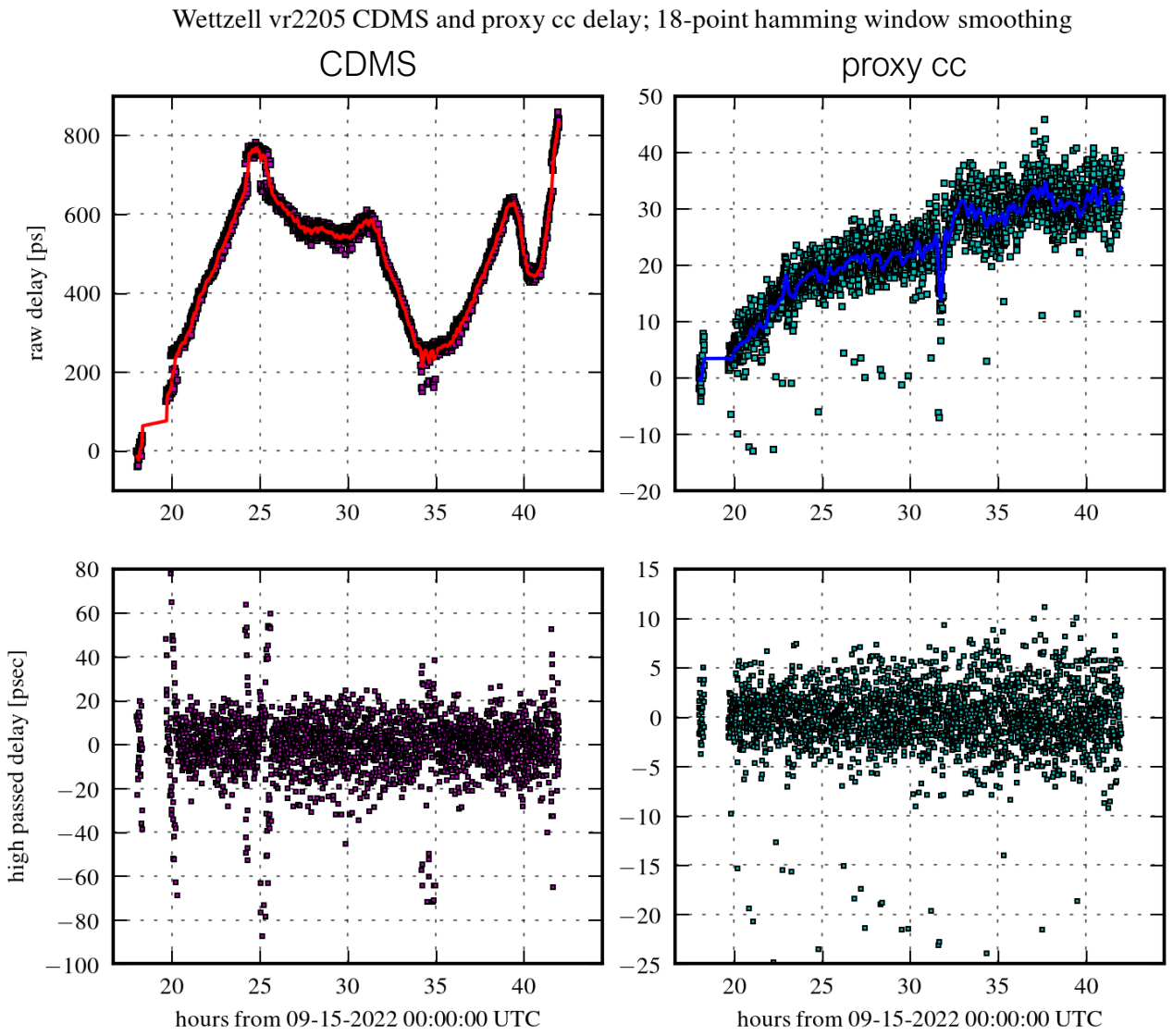




Wettzell: comparison with CDMS

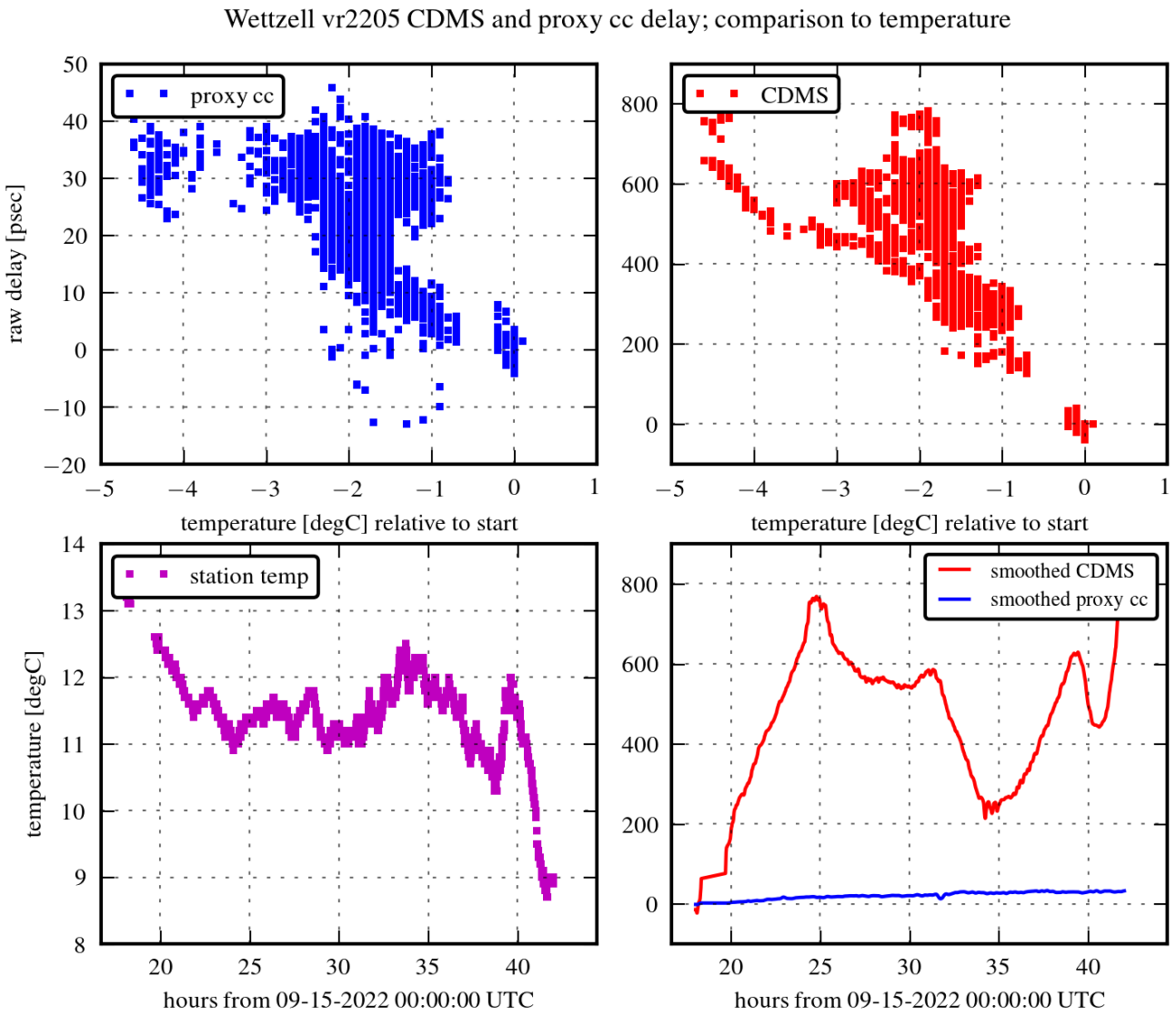
Raw data with a smoothing function (18-pt hamming window)

Data after subtracting the smoothed data



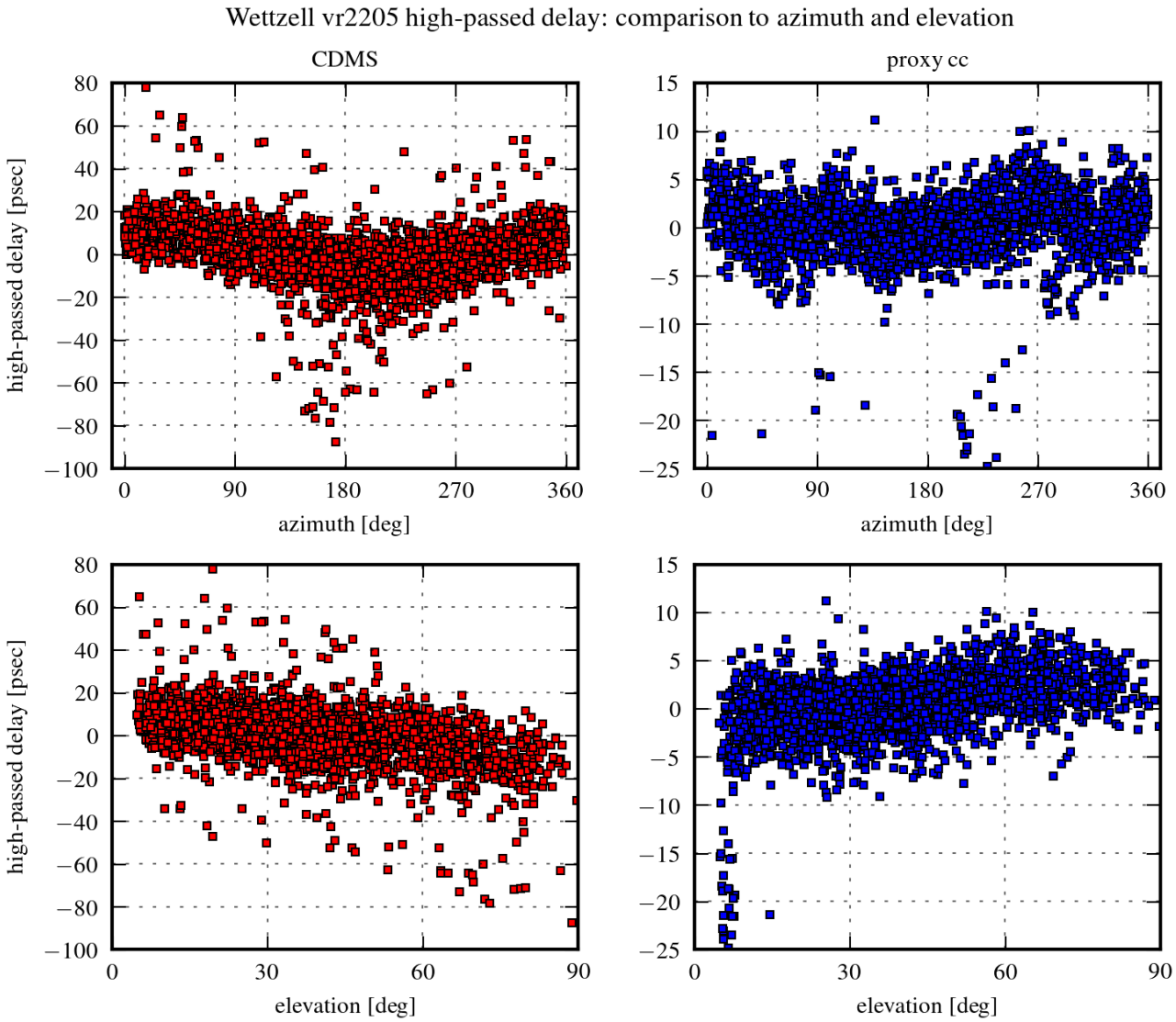
Wettzell: comparison with CDMS (temperature)

The CDMS delay correction is huge, but that is absorbed by the piecewise-linear clock approximation in the geodetic model.



Wettzell: comparison with CDMS (telescope position)

Wettzell in VO2293 has incomplete data, but these figures are about the same.



proxy cable cal: summary

Stations where….

…short-timescale proxy cc is much larger amplitude than CDMS:	NyAlesund, Oe, Ow
…long-timescale variation of CDMS is…	
...much larger than proxy cc:	Wettzell, Yebes, NyAlesund
...much smaller than proxy cc:	Westford, Oe, Ow
…both CDMS and proxy cc are correlated to antenna azimuth:	Westford
…proxy cc signal in different band-pols tends to agree:	NyAlesund, GGAO, Kokee, MGO, Westford
…band-pols are typically very different:	Wettzell, Hobart, Yebes, Oe, Ow

proxy cable cal & CDMS: what's the right answer?

We have two clocks that tell two different times…is there a way to determine the right answer? Should we need to provide both options to the geodetic analysts?

- Not clear if analysts have the ability to choose? (Sergei: "the files with CDMS or PCMT data are not available for public access")
- If they do, are they aware they should check which is optimal?
- Have to edit the wrapper file in nuSolve v0.8.

It seems like the magnitudes of the proxy cc or CDMS corrections sometimes disagree. Is this a problem for stations that only have proxy cc?

Can we perform a sanity check: flip the sign of the correction and see if the geodetic residuals get worse?