LBWG memo 6

Comparison of delay calibration methods

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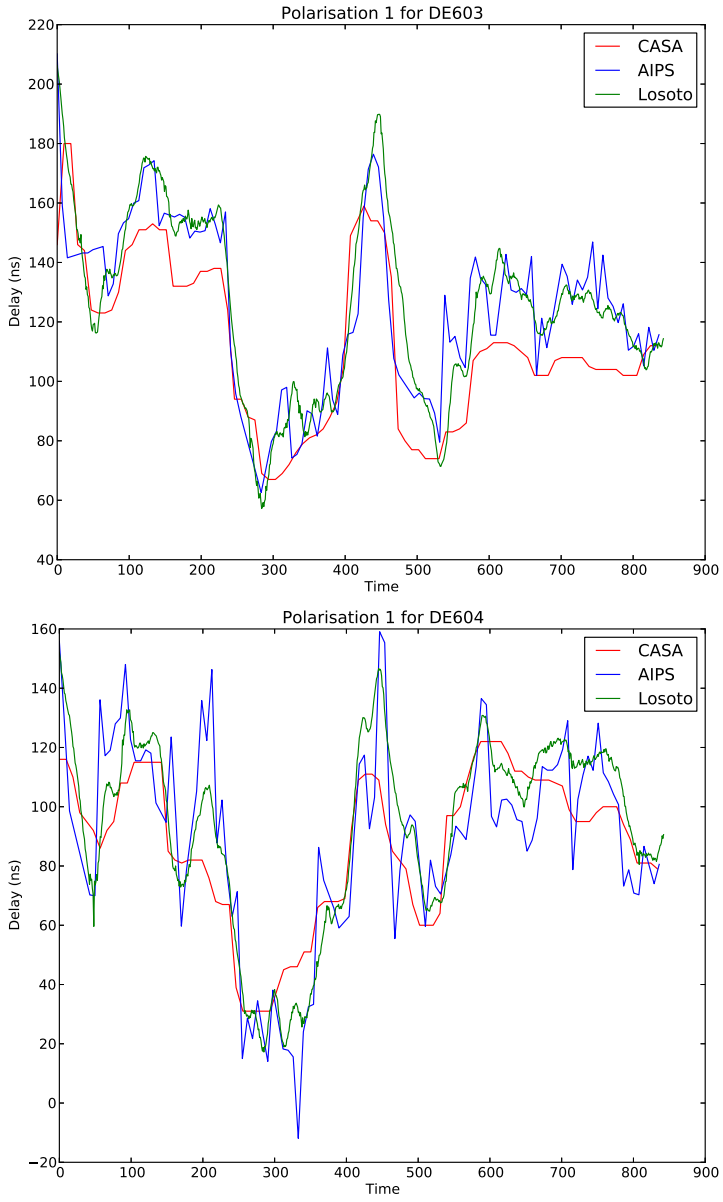
Motivation. Delay calibration on at least one in-field calibrator is required (see memo 2). There are several methods for estimating the delays as listed in the table below. The different methods have their own advantages and disadvantages. This memo reports on testing these methods for J1327+5504 in the surveys field described in LBWG Memo 1.

Method	Advantages	Disadvantages
AIPS: FRING task	• well-tested, reliable • uses info from all baselines above SNR cut • uses both delay and rate information • helps in low SNR situations	• solves for combined delays (no clock/TEC separation) • solving for multi-band delay not robust • have to convert to uvfits • very slow • AIPS may not be installed • scripting requires parseltongue
CASA gaincal 'K'	• uses MS format • reasonably fast	• Does not use rate info • Only uses baselines to ref ant • requires reasonable SNR • output is CASA cal table
LOFAR LoSoTo	• Native LOFAR software • solves for clocks and TEC separately	• can be slow • uses timesteps independently (?) i.e. no rate information

Results. Below is a comparison of the delays (combined clock+TEC) generated via the different methods, for two antennas: DE603 and DE604.



The three different methods find pretty much the same delays. This means we can use the native LOFAR tools (LoSoTo) to find the delays, and avoid all the requirements to have AIPS installed, convert to uvfits, etc. In principle the LOFAR tools should have more accurate values for delays, as we use the clock/TEC separation in LoSoTo, which models the frequency dependence of the ionosphere (TEC) and clocks separately. This hasn't been done in AIPS for this dataset – I have divided the bandwidth into IFs and found independent solutions in each of those.

Delay calibration with NDPPP + LoSoTo. This test has been conducted with the primary delay calibrator for P205+55, J1327+5504. There are two parts to the delay calibration: (1) the NDPPP gaincal to solve for the diagonal gains, and (2) the LoSoTo post-processing of the solutions to solve for the dispersive and non-dispersive delays. There is also the issue of a starting model for the delay calibrator; previous tests showed that for a bright, primary delay calibrator this is fairly robust to using either a point source or FIRST-generated skymodel. Here we assume a point source for the delay calibration.

(1) NDPPP gaincal. The default averaging in the pipeline for the delay calibrator is 2 channels per subband and 8 seconds. Too much averaging can cause de-correlation of the phases within a subband; I therefore ran NDPPP `gaincal` with the following relevant parameters:

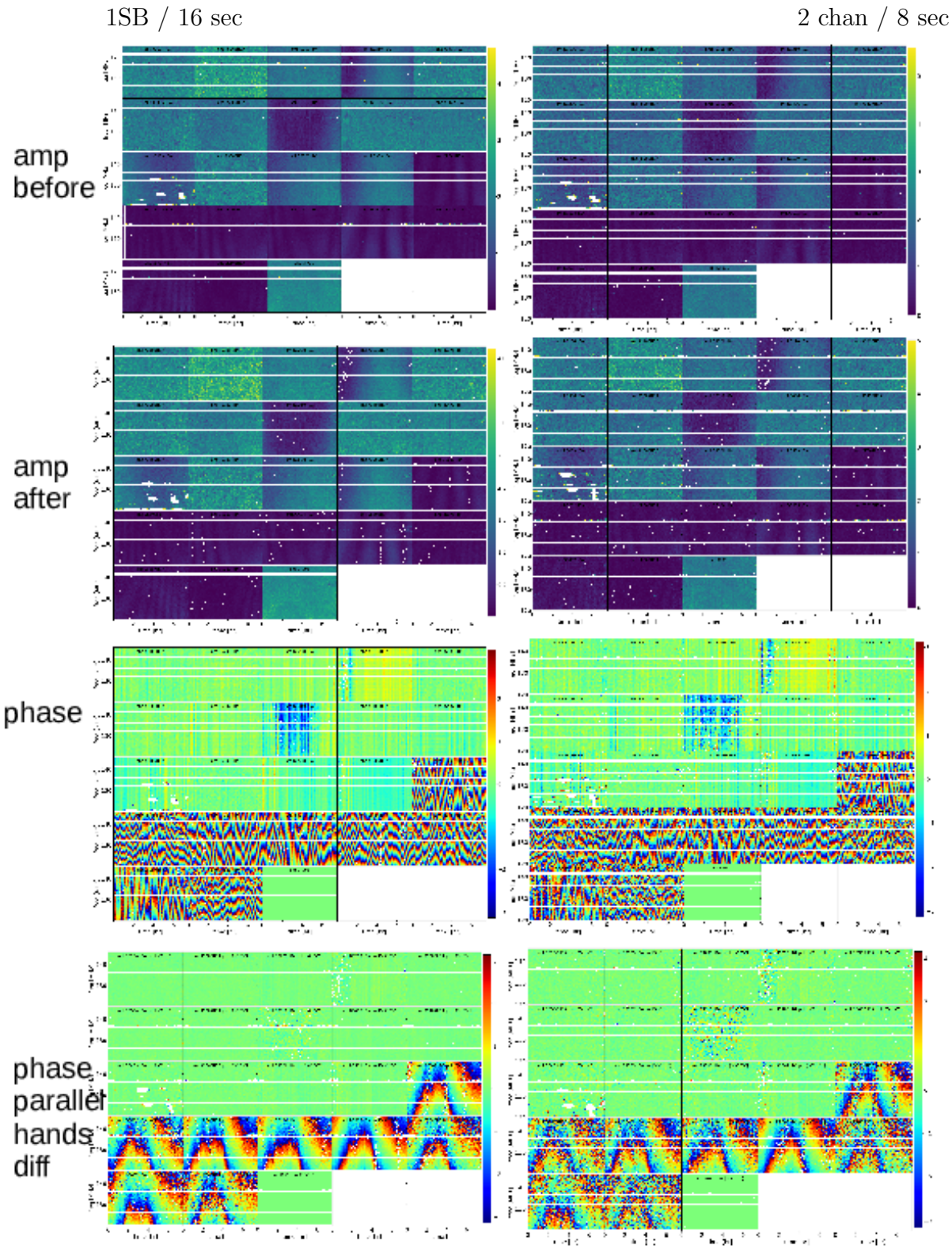
```
gaincal.caltype=diagonal
gaincal.nchan=1 # or 2
gaincal.solint=1 # or 2
gaincal.parmdb=output.h5
gaincal.sourcedb=sky
gaincal.usebeammodel=False
```

I ran two tests: one with `nchan` and `solint` both set to 1; this finds a solution for every channel and every 8 seconds; and with these parameters both set to 2; this finds one solution per subband and per every 16 seconds.

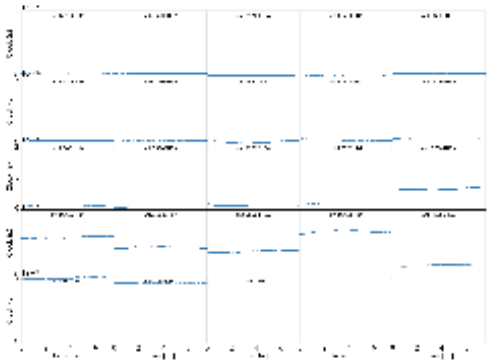
(2) LoSoTo post-processing. I used the LoSoTo parset from prefactor V3.0. This parset runs the following steps:

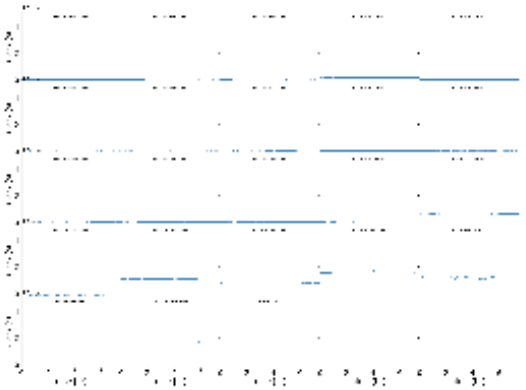
1. plot amplitudes
2. flag amplitudes + extend flags
3. plot flagged amplitudes
4. re-weight the amplitudes
5. plot phases
6. plot difference between phases in parallel hands
7. plot amplitude again (not sure why? but it seems different)
8. make a backup copy of the phases to another soltab
9. clock / TEC fitting
10. plot clock
11. plot dTEC
12. subtract clock and tec from phases
13. plot phase residuals

In the following plots, you can see that the 2 chan / 8 sec solution intervals are poorer than when solving in a solution interval of 1SB/16 sec. This is most clear in the TEC comparison, where the algorithm has failed to find TEC solutions for the UK and SE stations, and most of the time for the FR station.

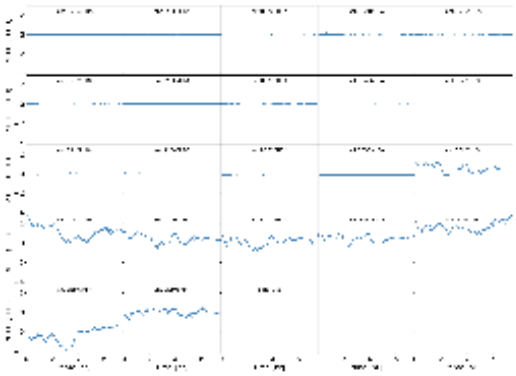

1SB / 16 sec
2 chan / 8 sec
amp before
amp after
phase
phase parallel hands diff

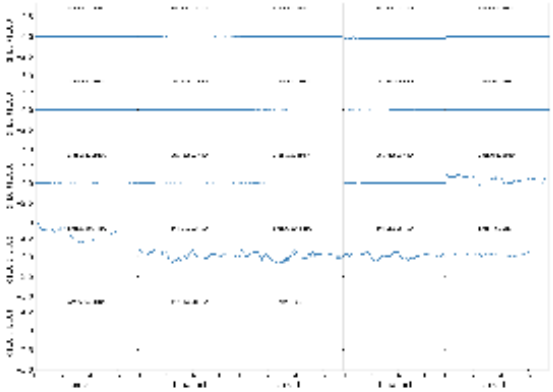
clock



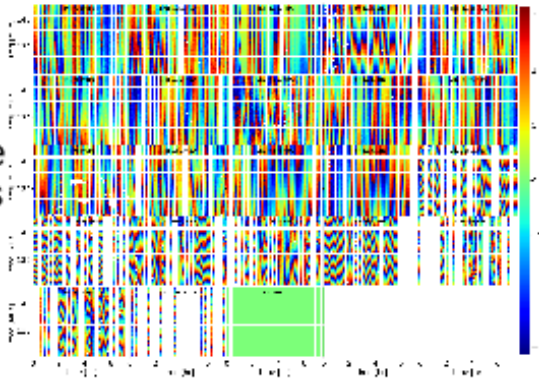


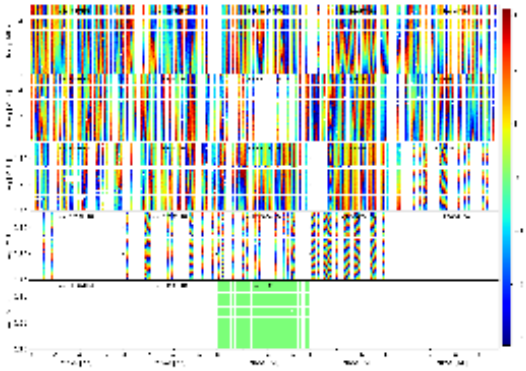
TEC



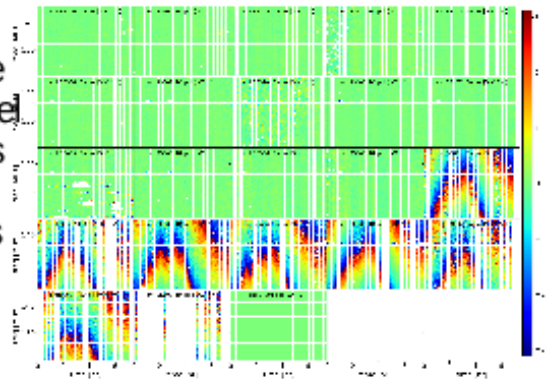


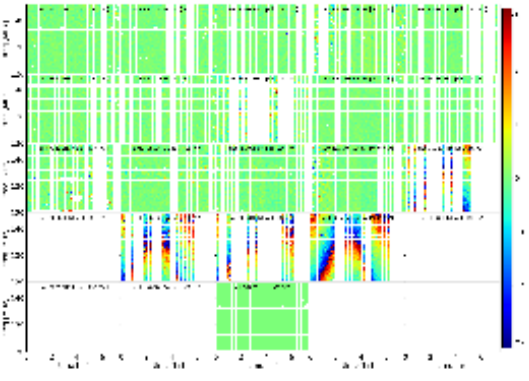
phase resids



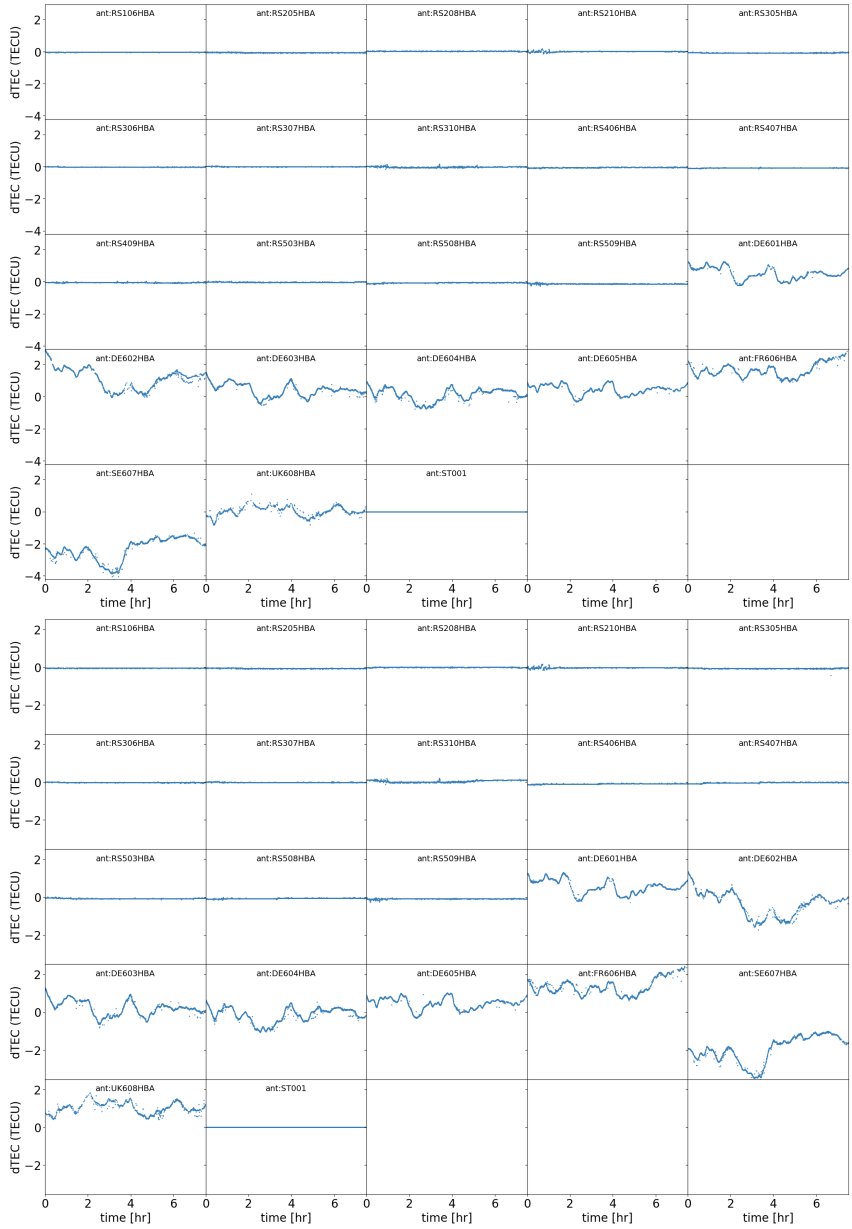


phase parallel hands diff resids





What is also obvious from the plots above is that RS409 has some issues. Removing it changes the solutions slightly, but it's not obvious that this will be helpful:



There is also an option to fit for 3rd order effects when solving for the clock/TEC. As there still appears to be coherent structure in the phase residuals, this is worth testing.