Testing Source Finders with Simulated Maps

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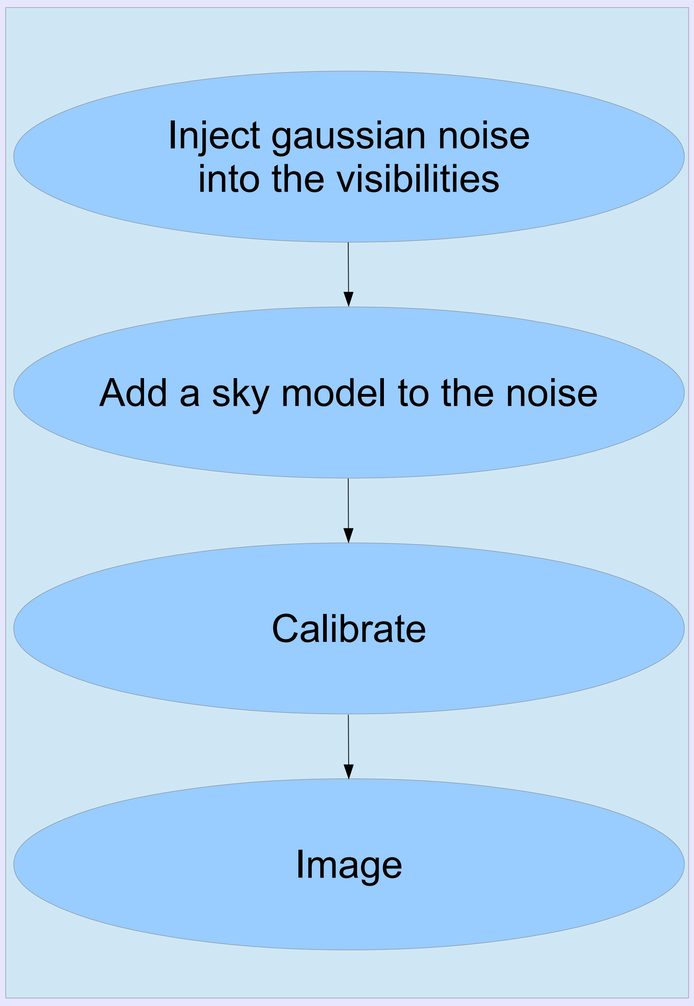
INTRODUCTION

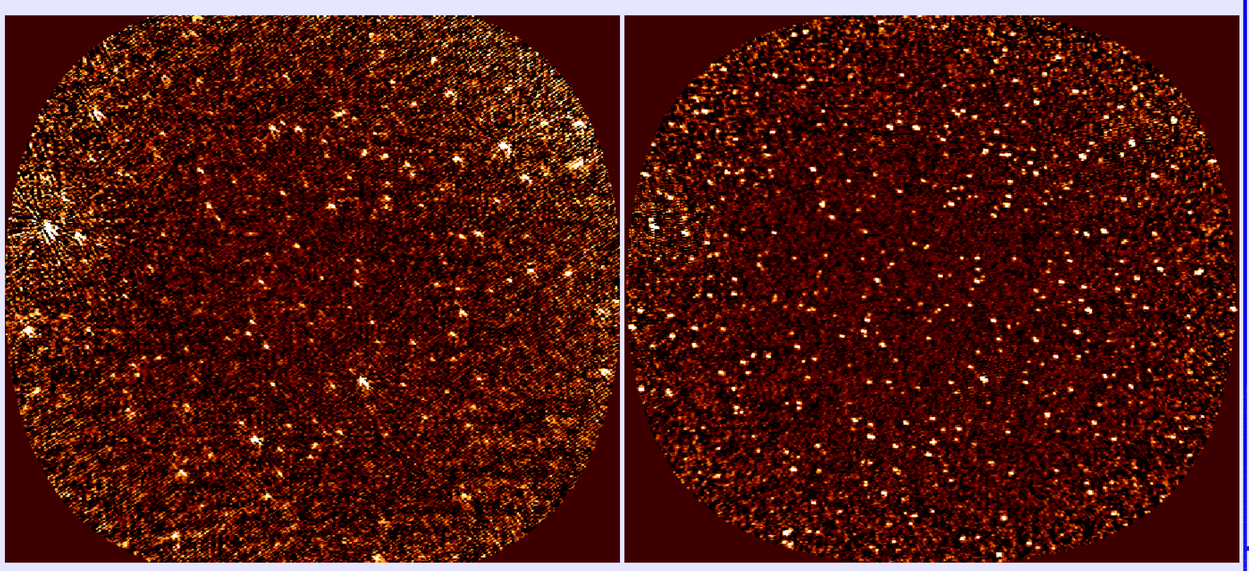
Data analysis software can be most accurately tested with simulated data where the output one should get is known a priori. For this purpose we have developed a procedure to generate simulated maps with several characteristics of real LOFAR data. We use these simulated maps to test the LOFAR source finding tools, PyBDSM and PYSE, especially their effectiveness and accuracy free from any calibration issues or other effects present in real LOFAR data.

CURRENT STRATEGY TO PRODUCE SIMULATED MAPS

- Start from an existing LOFAR observation to have the gains in place.
- Generate a sky model:
  - from catalogs;
  - with fake sources at random positions , assuming a power law distribution of fluxes.
- Input gaussian noise into the visibilities and add the simulated sources.
- Calibrate using BBS and image using the AWimager.



COMPARING REAL DATA & SIMULATED MAPS



To test the consistency of our method we have compared real LOFAR maps with simulated maps.
Here we show an example of an MSSS map of the field L184+46 (on the left) and a simulation of that same field (on the right).

In the simulated map the noise in the central region is 130 mJy/beam while in the real one it is 200 mJy/beam.

In the real image artifacts around a very bright source at the edge of the map appear and also other artifacts are present like stripes.
These effects are not there in the simulated map because they are due to calibration issues.

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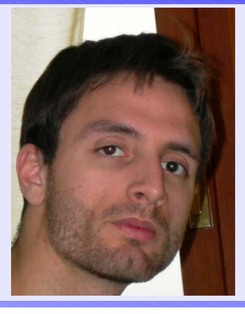
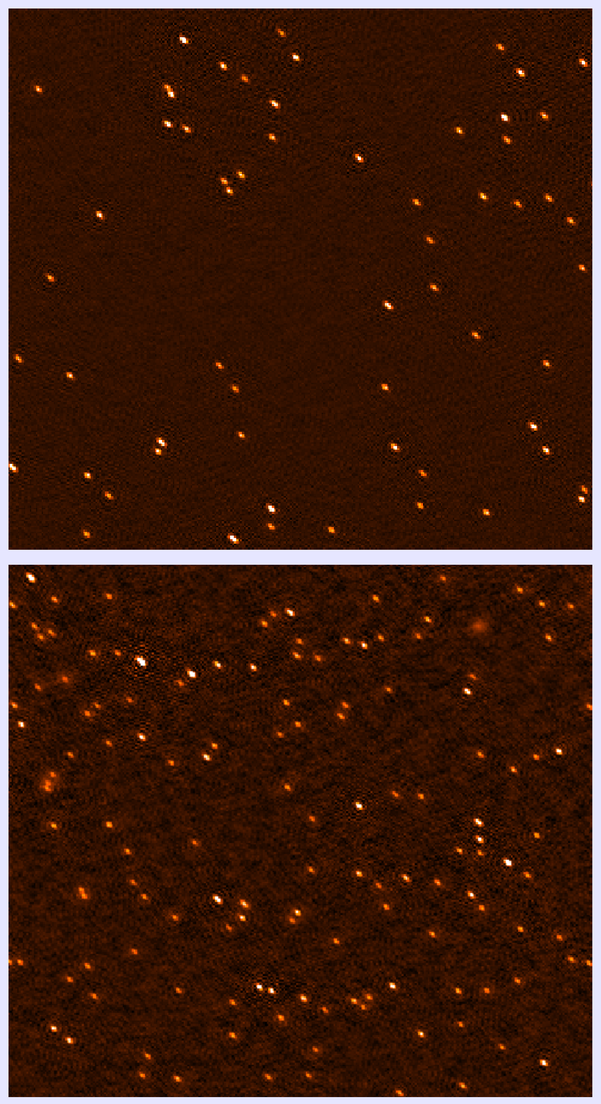


EXAMPLES OF SIMULATED MAPS

We have created several simulations with different characteristics, changing the number of sources (to test the deblending), their intensity and their shape (point or gaussian).

Here we show two examples. The image on the top is part of a simulation including 200 point sources in a radius of 4 degrees from the pointing center with fluxes between 2 and 10 Jy.

The image on the bottom is part of a simulation including 400 sources in a radius of 4 degrees from the pointing center with fluxes between 1 and 100 Jy. 70% of them are point sources whereas 30% are extended sources.

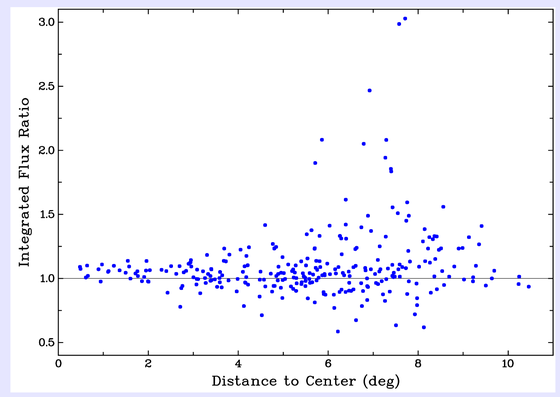


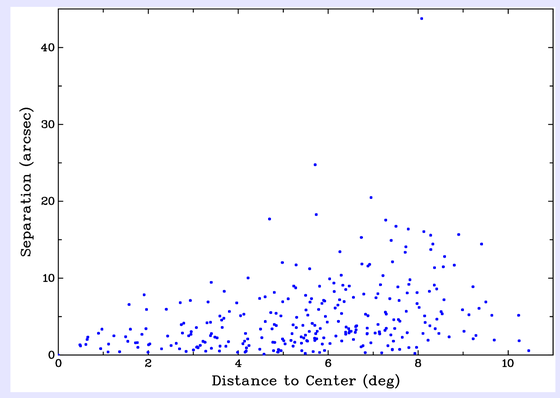
SOURCE FINDING ON SIMULATED DATA

We have run the source finder software tool PYSE, developed by the Transient Key Project, on simulated maps.
Here we focus mainly on the flux recovery and on the position of the extracted sources.

In the upper panel you can see the integrated flux ratio between the PYSE output and the sky model flux. The flux ratio is about 1 till 4 degrees from the pointing center. This is because the FWHM of the station beam has that size.

In the lower panel we show the distance between the position recovered by PYSE and the one given in the catalog. You can see that all of the sources but one have an offset of less than 20 arcsec (pixel size = 30 arcsec/pixel).





FUTURE WORK

- Ionospheric 3D effects are not yet in place. This would be needed to simulated the positional error we see in real maps.

- De-calibrate the injected noise is not yet in place. This is needed to simulate the full calibration typically performed with real data. To avoid the problem due to the de-calibration of the noise we are currently not doing the calibration step in our tests setting the gains to 1 in order to focus on the flux and position recovery only.

CONCLUSIONS

We developed a method to simulate LOFAR data. Our main goal it to test the performance of our source finder tools on maps without any problem due to calibration issues. Future developments will include the possibility to include all the calibration effects (and solutions) and a 3D representation of the ionosphere to test the position error than can cause problems with the source association.