

ALMA simulators tutorial

Eelco van Kampen, ESO



The two ALMA simulators

Expert users: the CASA simulator: `simobserve` / `simanalyze` / `simalma`

CASA **tasks** are used to produce mock ALMA data from an input sky model (theoretical model or previous observation).

The main work is done by the `sm tool`: the tasks (Python scripts) are a user-friendly interface to this tool with additional work done on plotting and analysis

Novice users: the web-based OST (webtool hosted by the UK ARC)

The OST (Observation Support Tool) is a webtool that also uses the `sm tool` underneath the hood, but is simplified (hence faster) and restricted, with a website acting as a GUI to set parameters and run the simulation

simobserve / simanalyze / simalma

What's new in CASA 4.3 ?

- tasknames have **not** been changed. Yay !
- improvements to *simalma*, which is now no longer earmarked as 'experimental'

Note that *simalma* :

- only works for ALMA configurations
- runs in 'dry mode' (drymode=True) by default

For details, type 'help simalma' in CASA, or check out the casaguides on simulations at <http://casaguides.nrao.edu>



on-line guide to simulation using CASA

Goto casaguides.nrao.edu and click on ‘Simulating Observations’ to get to:

The screenshot shows a web browser window with the URL casaguides.nrao.edu/index.php?title=Simulating_Observations_in_CASA_4.3 in the address bar. The page content is as follows:

Simulating Observations in CASA 4.3

This guide describes steps used to simulate interferometric observations in CASA.

The [Guide to Simulating ALMA Data](#) gives an introduction to simulations, with examples and a discussion of their relevance to ALMA observing proposals

This guide is applicable to CASA version 4.3. For older versions of CASA please see [Simulating Observations in CASA 4.2](#).

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Simulating Interferometric Observations in CASA

Simulating interferometric observations in CASA proceeds in the following steps:

1. Make a model image. The model image is a representation of the sky brightness distribution that you would like to simulate observing, stored initially as a FITS file.
[There are several paths to making the FITS file discussed below](#)

The OST (Observation Support Tool)

The screenshot shows the ALMA Observation Support Tool (OST) interface. At the top, there's a header bar with the URL "almaost.jb.man.ac.uk". Below the header is a banner featuring the ALMA logo and the text "EUROPEAN ARC ALMA Regional Centre || UK" on the left, and "ALMA Observation Support Tool" on the right. A photograph of the ALMA antenna array is visible in the background of the banner. The main content area has a light blue header with navigation links: "OST", "NEWS", "HELP", "QUEUE", "LIBRARY", and "ALMA HELPDESK". A message "Updated: Important information on OST output." is displayed. The interface is divided into several sections: "Array Setup", "Sky Setup", and "Observation Setup". Each section contains input fields and descriptive text boxes. For example, in "Array Setup", there's a dropdown for "Instrument: ALMA" and a note "Select the desired ALMA antenna configuration.". In "Sky Setup", there are fields for "Source model: OST Library: Central point source" and "Upload: Choose File No file chosen", along with notes about source models and file uploads. In "Observation Setup", there are fields for "Observing mode: Spectral Continuum" and "Central frequency in GHz: 93.7", with notes about spectral or continuum observations and frequency ranges.

almaost.jb.man.ac.uk

Apps ADS astro-ph ESO ESO-ERP ALMA ESO Science Imported Synths BBC Other Bookmarks

ALMA

EUROPEAN ARC
ALMA Regional Centre || UK

ALMA Observation Support Tool

ALMA Observation Support Tool

Version 3.0

OST NEWS HELP QUEUE LIBRARY ALMA HELPDESK

Updated: Important information on OST output.

Array Setup:

Instrument: ALMA Select the desired ALMA antenna configuration.

Sky Setup:

Source model: OST Library: Central point source Choose a library source model or supply your own.

Upload: Choose File No file chosen You may upload your own model here (max 10MB).

Declination: -35d00m00.0s Ensure correct formatting of this string (+/-00d00m00.0s).

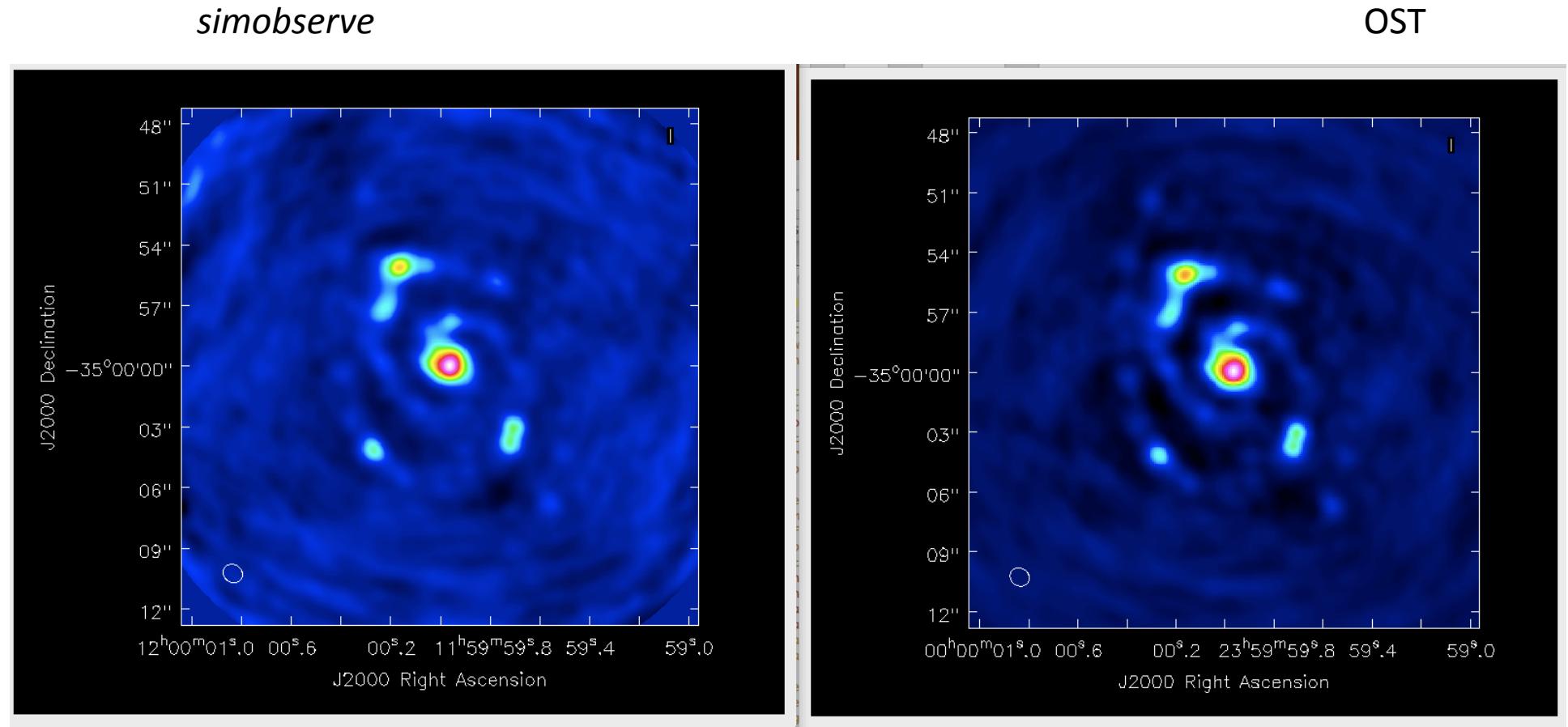
Image peak / point flux in mJy 0.0 Rescale the image data with respect to new peak value.
Set to 0.0 for no rescaling of source model.

Observation Setup:

Observing mode: Spectral Continuum Spectral or continuum observations?

Central frequency in GHz: 93.7 The value entered must be within an ALMA band.

simobserve versus OST: images



M51@z=0.5, Early Science configuration, band 6

Note for proposers

In general, because the ALMA Sensitivity Calculator (ASC) will be used for the technical assessment of ALMA proposals, only values from the ASC should be used to estimate exposure times in ALMA proposals.

Representative Cycle 3 antenna configurations are included in CASA 4.3 and the OST, but the actual configuration could differ somewhat when the observation is scheduled.

General comments

There are two types of input models:

- a theoretical model (a science simulation)
- a previous observation, in the same waveband or a related one

In the first case the input image is noise free, in the second case it is not. Therefore the noise estimated by *simobserve* or the OST comes on top of the original noise, and could result in overestimation.

Both *simobserve* and the OST are based on the sm tools in CASA, but do not include the same noise terms, and have different default clean parameters.

Default *simobserve* parameters

In CASA, type:

```
default('simobserve')
```

```
inp
```

```
# simobserve :: visibility simulation task
project      = 'sim'          # root prefix for output file names
skymodel     = ''             # model image to observe
complist     = ''             # componentlist to observe
setpointings = True           # integration (sampling) time
    integration = '10s'         # "J2000 19h00m00 -40d00m00" or "" to center on model
    direction   = ''
    mapsize     = ['', '']       # angular size of map or "" to cover model
    maptype     = 'ALMA'         # hexagonal, square (raster), ALMA, etc
    pointingspacing = ''        # spacing in between pointings or "0.25PB" or "" for ALMA default INT=lambda/D/sqrt(3),
                                # SD=lambda/D/3

obsmode      = 'int'          # observation mode to simulate [int(interferometer)|sd(singledish)|"(none)"]
    antennalist = 'alma,out10.cfg' # interferometer antenna position file
    refdate    = '2014/05/21'      # date of observation - not critical unless concatenating simulations
    hourangle   = 'transit'       # hour angle of observation center e.g. "-3:00:00", "5h", "-4.5" (a number without units
                                # will be interpreted as hours), or "transit"
    totaltime   = '7200s'         # total time of observation or number of repetitions
    caldirection= ''             # pt source calibrator [experimental]
    calflux     = '1Jy'          

thermalnoise = 'tsys-atm'     # add thermal noise: [tsys-atm|tsys-manual|""]
    user_pvw   = 0.5            # Precipitable Water Vapor in mm
    t_ground   = 269.0           # ambient temperature
    seed        = 11111          # random number seed

leakage      = 0.0             # cross polarization (interferometer only)
graphics     = 'both'          # display graphics at each stage to [screen|file|both|none]
verbose      = False           # verbose output
overwrite    = True            # overwrite files starting with $project
```

Default *simanalyze* parameters

In CASA, type:

```
default('simanalyze')
```

```
inp
```

```
# simanalyze :: image and analyze measurement sets created with simobserve
project      = 'sim'          # root prefix for output file names
image        = True           # (re)image $project.*.ms to $project.image
vis          = 'default'       # Measurement Set(s) to image
modelimage   = ''             # lower resolution prior image to use in clean e.g. existing total power image
imsize       = 0               # output image size in pixels (x,y) or 0 to match model
imdirection  = ''             # set output image direction, (otherwise center on the model)
cell         = ''             # cell size with units e.g. "10arcsec" or "" to equal model
interactive  = False          # interactive clean? (make sure to set niter>0 also)
niter        = 0               # maximum number of iterations (0 for dirty image)
threshold    = '0.1mJy'        # flux level (+units) to stop cleaning
weighting    = 'natural'       # weighting to apply to visibilities. briggs will use robust=0.5
mask         = []              # Cleanbox(es), mask image(s), region(s), or a level
outertaper   = []              # uv-taper on outer baselines in uv-plane
pbcor        = True            # correct the output of synthesis images for primary beam response?
stokes       = 'I'             # Stokes params to image
featherimage = ''             # image (e.g. total power) to feather with new image

analyze      = False           # (only first 6 selected outputs will be displayed)
graphics     = 'both'          # display graphics at each stage to [screen|file|both|none]
verbose      = False           # verbose output
overwrite    = True            # overwrite files starting with $project
dryrun       = False           # only print information [experimental; only for interferometric data]
logfile      = ''             # log file
```

Default *simalma* parameters

In CASA, type:

```
default('simalma')
```

```
inp
```

```
# simalma :: Simulation task for ALMA
project      = 'sim'          # root prefix for output file names
dryrun       = True           # dryrun=True will only produce the informative report, not run simobserve/analyze
skymodel     = ''             # model image to observe
complist     = ''             # componentlist to observe
setpointings = True           # integration (sampling) time
integration  = '10s'          # integration (sampling) time
direction    = ''             # "J2000 19h00m00 -40d00m00" or "" to center on model
mapsize      = ['', '']        # angular size of map or "" to cover model

antennalist  = ['alma,cycle1.1.cfg', 'aca,cycle1.cfg'] # antenna position files of ALMA 12m and 7m arrays
hourangle    = 'transit'       # hour angle of observation center e.g. -3:00:00, or "transit"
totaltime    = ['20min', '1h'] # total time of observation; vector corresponding to antennalist
tpnant      = 0               # Number of total power antennas to use (0-4)
pwv          = 0.5            # Precipitable Water Vapor in mm, 0 for noise-free simulation
image        = True            # image simulated data
imsize       = 0               # output image size in pixels (x,y) or 0 to match model
imdirection  = ''              # set output image direction, (otherwise center on the model)
cell         = ''              # cell size with units or "" to equal model
niter        = 0               # maximum number of iterations (0 for dirty image)
threshold    = '0.1mJy'        # flux level (+units) to stop cleaning

graphics     = 'both'          # display graphics at each stage to [screen|file|both|none]
verbose      = False           # verbose output
overwrite    = False           # overwrite files starting with $project
```

Antenna configurations

Antenna configurations are simple text files, listing all antennas that are part of the array of choice. Many come with CASA, and can be found in the CASA repository directory in the subdirectory data/alma/simmos

For example, to select ALMA full science configuration #20, use (in simobserve)

```
> antennalist='alma.out20.cfg'
```

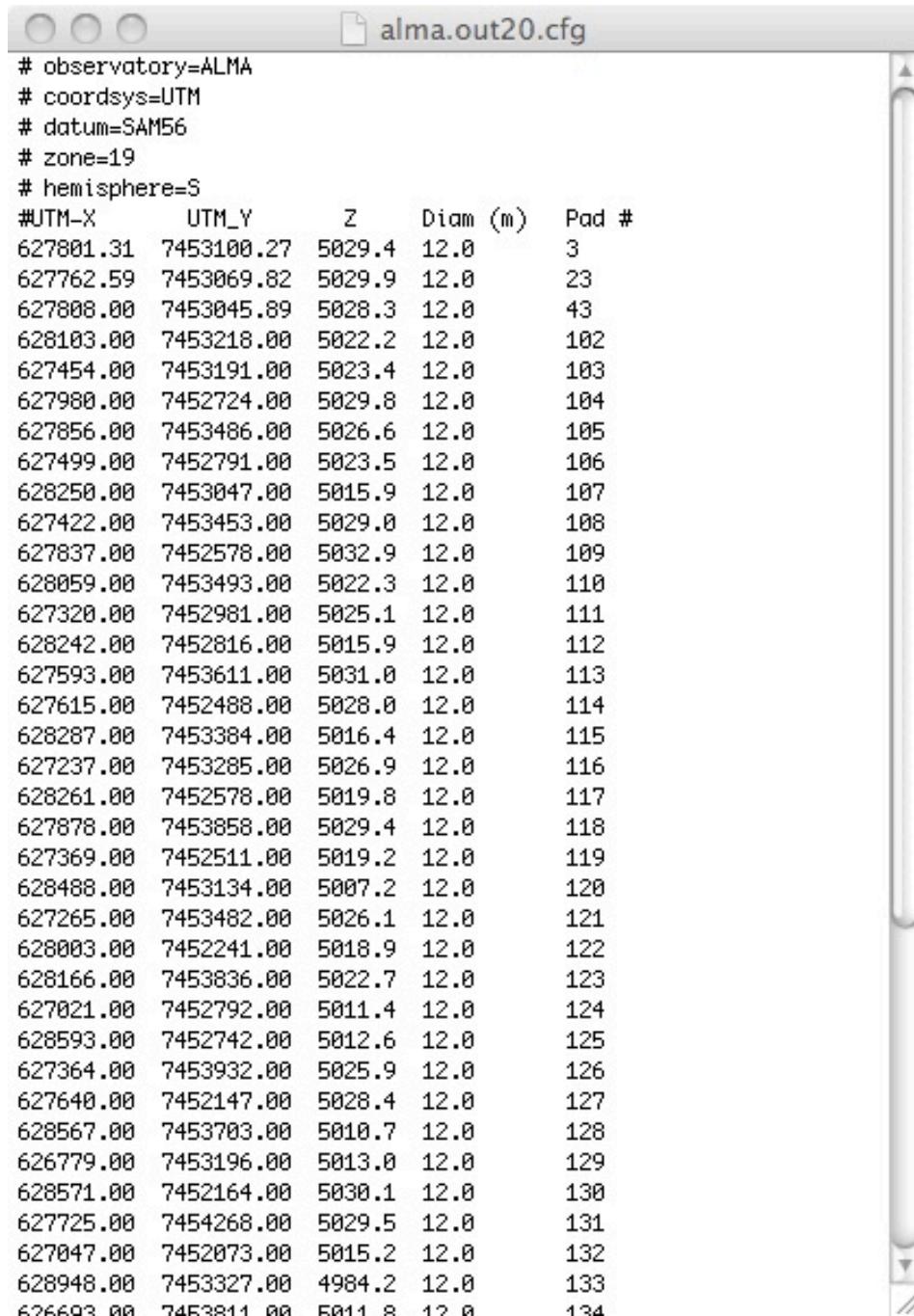
One can also choose a configuration corresponding to a certain resolution, eg:

```
> antennalist = "alma;0.05arcsec"
```

NOTE: none of the ‘full operations’ antenna configurations are official yet !!

The representative (!) Cycle 3 antenna configuration files are all included in CASA 4.3, as well as those for Cycles 0, 1 and 2 (can be useful).

Example antenna configuration for full operations (included with CASA)



The screenshot shows a text editor window titled "alma.out20.cfg". The file contains a header section with observatory, coordinate system, datum, zone, and hemisphere information, followed by a table of antenna coordinates and parameters. The table has columns for UTM_X, UTM_Y, Z, Diam (m), and Pad #.

UTM_X	UTM_Y	Z	Diam (m)	Pad #
627801.31	7453100.27	5029.4	12.0	3
627762.59	7453069.82	5029.9	12.0	23
627808.00	7453045.89	5028.3	12.0	43
628103.00	7453218.00	5022.2	12.0	102
627454.00	7453191.00	5023.4	12.0	103
627980.00	7452724.00	5029.8	12.0	104
627856.00	7453486.00	5026.6	12.0	105
627499.00	7452791.00	5023.5	12.0	106
628250.00	7453047.00	5015.9	12.0	107
627422.00	7453453.00	5029.8	12.0	108
627837.00	7452578.00	5032.9	12.0	109
628059.00	7453493.00	5022.3	12.0	110
627320.00	7452981.00	5025.1	12.0	111
628242.00	7452816.00	5015.9	12.0	112
627593.00	7453611.00	5031.0	12.0	113
627615.00	7452488.00	5028.0	12.0	114
628287.00	7453384.00	5016.4	12.0	115
627237.00	7453285.00	5026.9	12.0	116
628261.00	7452578.00	5019.8	12.0	117
627878.00	7453858.00	5029.4	12.0	118
627369.00	7452511.00	5019.2	12.0	119
628488.00	7453134.00	5007.2	12.0	120
627265.00	7453482.00	5026.1	12.0	121
628003.00	7452241.00	5018.9	12.0	122
628166.00	7453836.00	5022.7	12.0	123
627021.00	7452792.00	5011.4	12.0	124
628593.00	7452742.00	5012.6	12.0	125
627364.00	7453932.00	5025.9	12.0	126
627640.00	7452147.00	5028.4	12.0	127
628567.00	7453703.00	5010.7	12.0	128
626779.00	7453196.00	5013.0	12.0	129
628571.00	7452164.00	5030.1	12.0	130
627725.00	7454268.00	5029.5	12.0	131
627047.00	7452073.00	5015.2	12.0	132
628948.00	7453327.00	4984.2	12.0	133
626603.00	7453811.00	5011.8	12.0	134

All antenna configurations included in CASA 4.3

WSRT.cfg	alma.cycle2.5.cfg	alma.out13.cfg	carma.b.cfg
aca.all.cfg	alma.cycle2.6.cfg	alma.out14.cfg	carma.c.cfg
aca.cycle1.cfg	alma.cycle2.7.cfg	alma.out15.cfg	carma.d.cfg
aca.cycle2.i.cfg	alma.cycle3.1.cfg	alma.out16.cfg	carma.e.cfg
aca.cycle2.ns.cfg	alma.cycle3.2.cfg	alma.out17.cfg	meerkat.cfg
aca.cycle3.cfg	alma.cycle3.3.cfg	alma.out18.cfg	pdbi-a.cfg
aca.i.cfg	alma.cycle3.4.cfg	alma.out19.cfg	pdbi-b.cfg
aca.ns.cfg	alma.cycle3.5.cfg	alma.out20.cfg	pdbi-c.cfg
aca.tp.cfg	alma.cycle3.6.cfg	alma.out21.cfg	pdbi-d.cfg
aca_cycle1.cfg	alma.cycle3.7.cfg	alma.out22.cfg	sma.compact.cfg
alma.all.cfg	alma.cycle3.8.cfg	alma.out23.cfg	sma.compact.n.cfg
alma.cycle0.compact.cfg	alma.out01.cfg	alma.out24.cfg	sma.extended.cfg
alma.cycle0.extended.cfg	alma.out02.cfg	alma.out25.cfg	sma.subcompact.cfg
alma.cycle1.1.cfg	alma.out03.cfg	alma.out26.cfg	sma.vextended.cfg
alma.cycle1.2.cfg	alma.out04.cfg	alma.out27.cfg	vla.a.cfg
alma.cycle1.3.cfg	alma.out05.cfg	alma.out28.cfg	vla.b.cfg
alma.cycle1.4.cfg	alma.out06.cfg	alma_cycle1_1.cfg	vla.bna.cfg
alma.cycle1.5.cfg	alma.out07.cfg	alma_cycle1_2.cfg	vla.c.cfg
alma.cycle1.6.cfg	alma.out08.cfg	alma_cycle1_3.cfg	vla.cnb.cfg
alma.cycle2.1.cfg	alma.out09.cfg	alma_cycle1_4.cfg	vla.d.cfg
alma.cycle2.2.cfg	alma.out10.cfg	alma_cycle1_5.cfg	vla.dnc.cfg
alma.cycle2.3.cfg	alma.out11.cfg	alma_cycle1_6.cfg	
alma.cycle2.4.cfg	alma.out12.cfg	carma.a.cfg	

simobserve output filenames

```
-----  
Output produced: (not all will always exist, depending on input parameters)  
To support different runs with different arrays, the names have the  
configuration name from antennalist appended.  
-----
```

```
project.[cfg].skymodel = 4d input sky model image (optionally) scaled  
project.[cfg].skymodel.flat.regrid.conv = input sky regridded to match the  
    output image, and convolved with the output clean beam  
project.[cfg].skymodel.png = diagnostic figure of sky model with pointings  
  
project.[cfg].ptg.txt = list of mosaic pointings  
project.[cfg].quick.psf = psf calculated from uv coverage  
project.[cfg].ms = noise-free measurement set  
project.[cfg].noisy.ms = corrupted measurement set  
project.[cfg].observe.png = diagnostic figure of uv coverage and  
    visibilities  
  
project.[cfg].simobserve.last = saved input parameters for simobserve task
```

Running *simobserve* interactively

- 1: start up CASA: casapy
 - 2: default("simobserve")
 - 3: inp()
 - 4: manually set the various parameters
 - 5: go() or simobserve()
- repeat 4+5

This works the same way for *simanalyze* and *simalma*

Running *simobserve* etc. using a script

1: open `yourscript.py` in your favorite editor

2: start up CASA: `casapy`

3: `execfile("yourscript.py")`

edit `yourscript.py` and repeat 3

Things you (could) need

OST: <http://almaost.jb.man.ac.uk/>

OST paper: <http://lanl.arxiv.org/abs/1106.3516>

CASA (includes *simobserve*, *simanalyze*, *simalma*): <http://casa.nrao.edu/>

Cycle 3 antenna configuration files are on the Science Portal – but included in CASA 4.3 !

CASA guides:

http://casaguides.nrao.edu/index.php?title=Simulating_Observations_in_CASA_4.3

http://casaguides.nrao.edu/index.php?title=First_Look_at_Imaging

Useful tools:

- FITS viewer/editor: for example Fv (<http://heasarc.nasa.gov/lheasoft/ftools/fv/>)

- CosmoCalc: <http://www.astro.ucla.edu/~wright/CosmoCalc.html>

Things we need

Feedback on the simulators !

- bug reports
- suggestions for improvement (always possible)
- interesting input models (for the simulation database)

Send feedback to evkampen@eso.org