



Simulating ALMA observations

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The simulators and cycle 7 proposals

Available simulators

Overview of the CASA simulator

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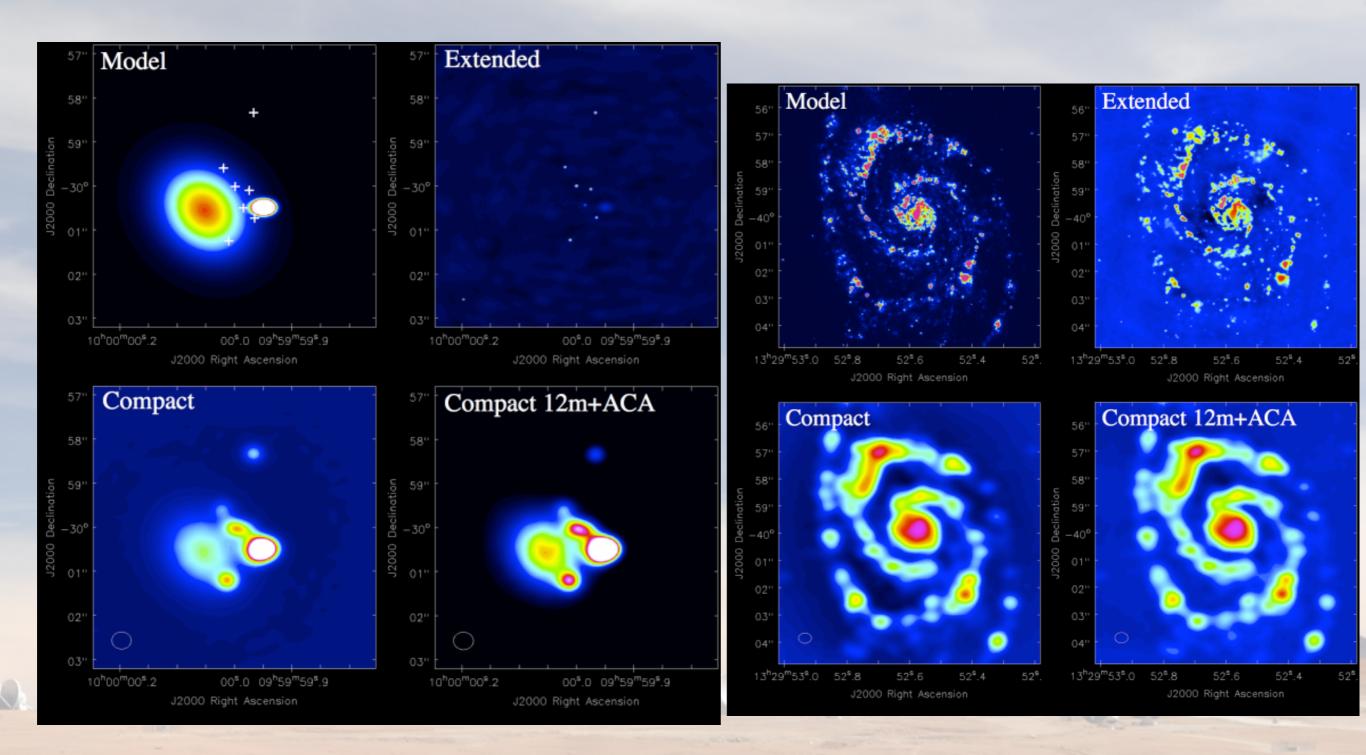
Why should I do an ALMA simulation ?

• You can try out different ALMA configurations and, for a given model, this might help you decide on the required angular resolution and maximum angular scale.

 A simulation can help support the required technical set-up in your proposal

 In particular, it can help you justify the need for complementary ACA/ TP or, indeed, ACA-only observations.

Why should I do an ALMA simulation ?



source: CASA simulator pages

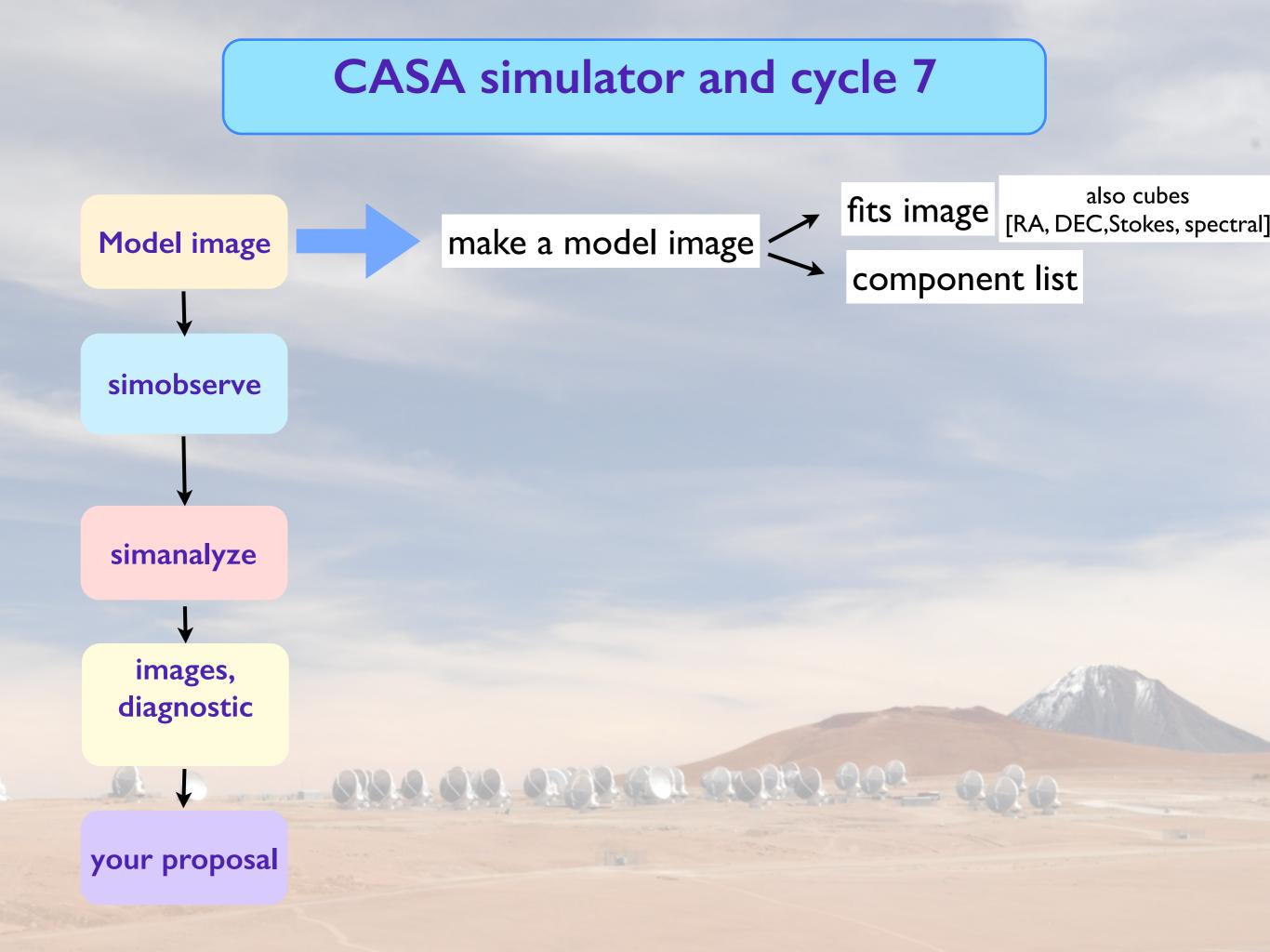
Available simulators

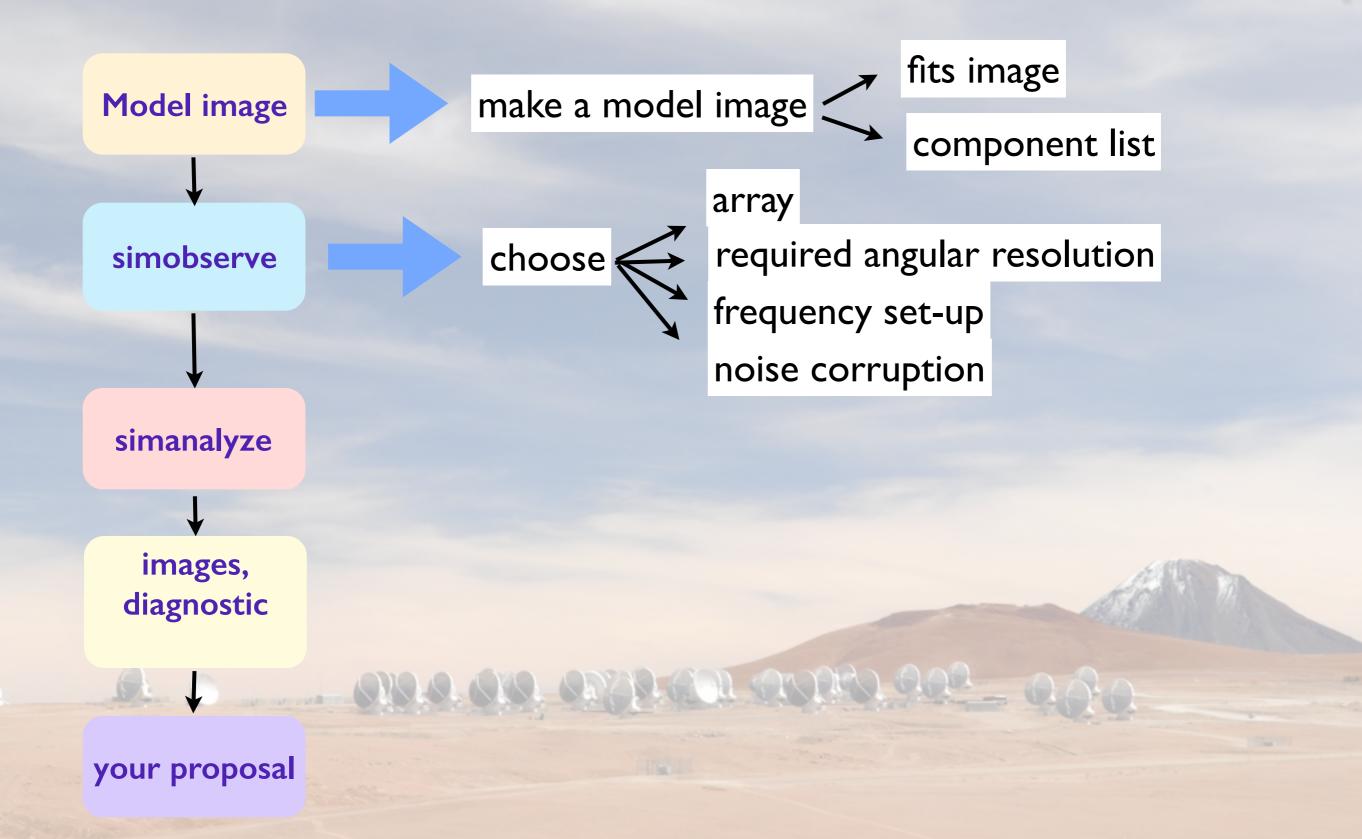
CASA simulator

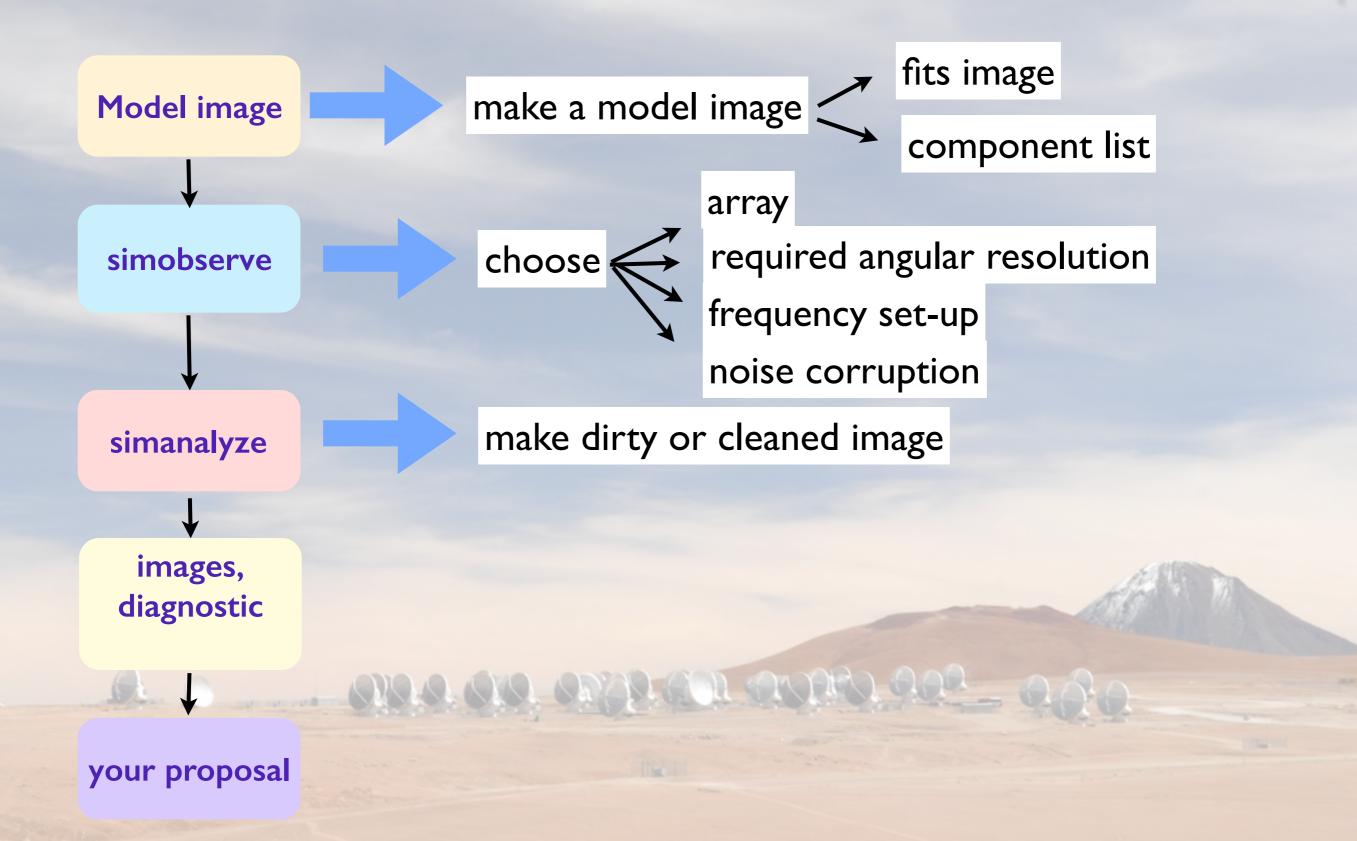
ALMA Observation Support tool

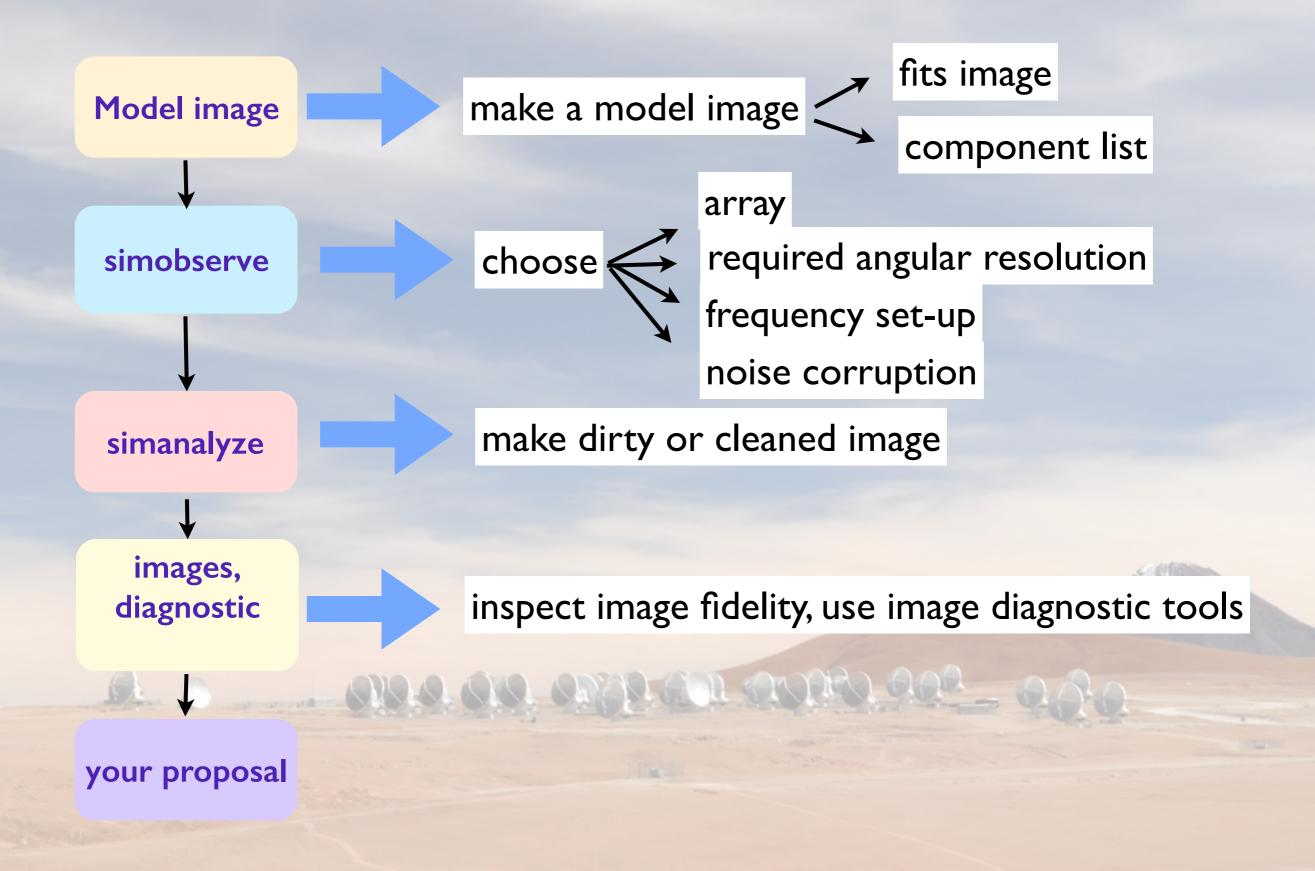
| roject | = | 'sim' | | root prefix for output fil | e names |
|----------------|---------|----------------|-----------|----------------------------|---|
| kymodel | | Odor.fits' | | model image to observe | |
| inbright | | 0.06mJy/pixel' | | | f brightest pixel e.g. "1.2Jy/pixel" |
| indirection | | | | | e.g. "J2000 19h00m00 -40d00m00" |
| incell | = '0 | .15arcsec' | # | | |
| incenter | = | '230GHz' | # # | | r channel e.g. "89GHz" (required even for |
| inwidth | = | '2GHz' | # | set new channel width e.g. | "10MHz" (required even for 2D model) |
| omplist | = | | # | componentlist to observe | |
| etpointings | = | True | | | |
| integration | = | '600s' | | integration (sampling) tim | |
| direction | = | | | "J2000 19h00m00 -40d00m00" | |
| mapsize | = | ['', ''] | | angular size of map or "" | to cover model |
| maptype | | opographic' | # | hexagonal, square, etc | |
| pointingspacir | 1g = | | # | spacing in between pointin | gs or "0.25PB" or "" for 0.5 PB |
| bsmode | = | 'int' | | observation mode to simula | |
| | | | # | [int(interferometer) sd(s | |
| antennalist | = '/ | usr/lib64/casa | py/s # | | .cycle0.compact.cfg' # interferometer |
| refdate | - '7 | 012/05/21' | | 1 | critical unless concatting simulations |
| hourangle | | transit' | | | center e.g3:00:00, or "transit" |
| totaltime | _ | '7200s' | | total time of observation | |
| caldirection | _ | 12005 | | pt source calibrator [expe | |
| calflux | 2 | '1Jy' | # | pt source catibrator (expe | Time(reac) |
| Catitux | - | 15 y | | | |
| hermalnoise | = | | | | m tsys-manual ""] |
| eakage | - | 0.0 | | | rometer only) |
| raphics | _ | 'both' | | and the second second | age to [screen file both none] |
| erbose | _ | False | | | age to [sereen[rite]both[hole] |
| verwrite | _ | True | | State State | th \$project |
| SVNC | _ | False | | | e started using simobserve() |
| sync | - | racse | | | e started using simobserve() |
| | | | | | 6440 00000 (D.C. |
| | | | | | |
| | and and | | | | |
| | | - | | CASA | And the second |
| | | | | | |
| | | | | Common Astronomy | and the second se |
| | | | | Software Applications | |
| | | | | | CONTRACTOR OF A DESCRIPTION OF A DESCRIPTION OF A DESCRIP |
| | | | | | |

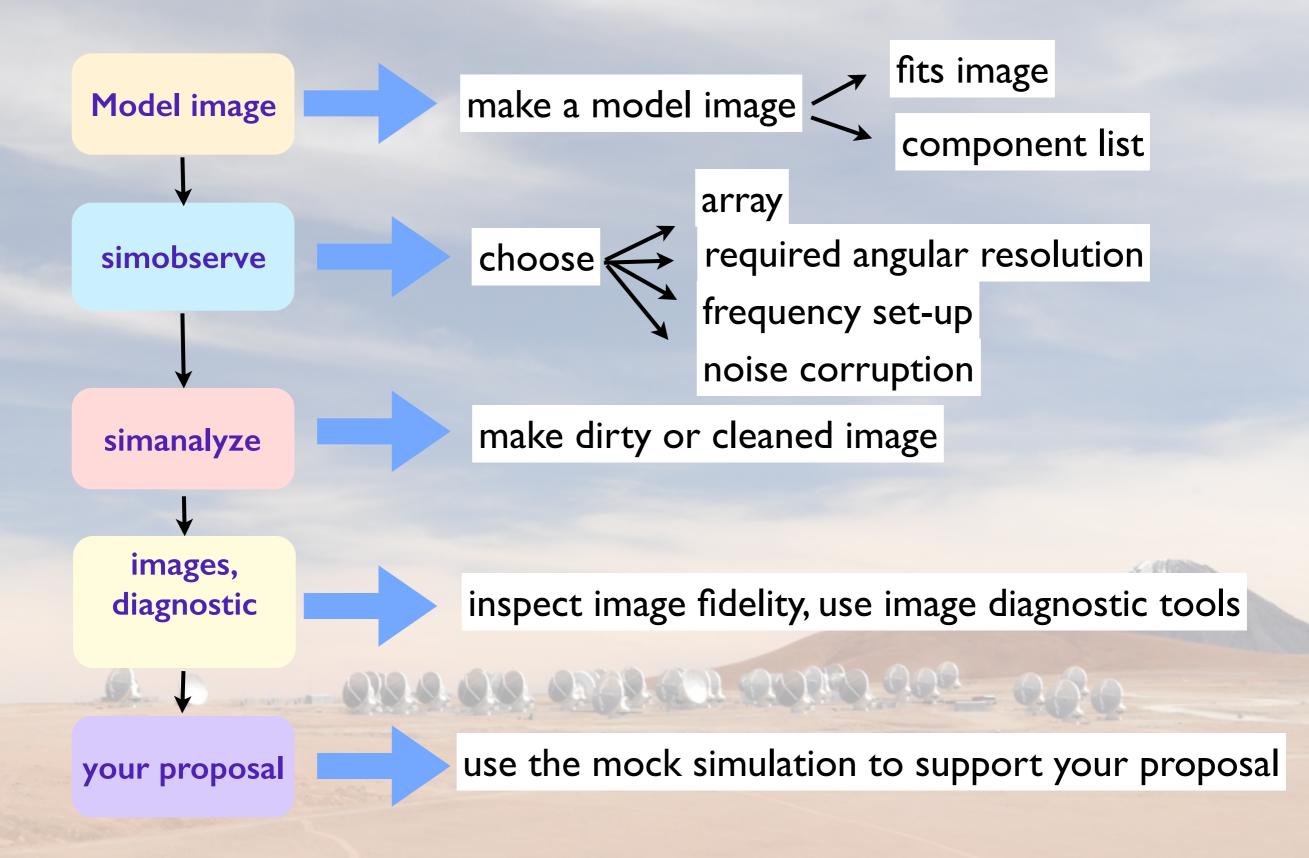
| EUROPEAN ARC ALMA Regional Centre UK ALMA Observation S | ALMA Observation Su |
|--|--|
| | |
| OST NEWS HELP QUEUE LIBRARY ALMA HELPDESH | (|
| Important information on the new OST version. | |
| Array Setup: | |
| Instrument: ALMA \$ | Select the desired ALMA antenna configuration. |
| Sky Setup: | |
| Source model: OST Library: Central point source + | Choose a library source model or supply your own |
| Upload: Choose File no file selected | You may upload your own model here (max 10MB) |
| Declination: -35d00m00.0s | Ensure correct formatting of this string (+/-00d00m0 |
| Image peak / point flux in mJy + 0.0 | Rescale the image data with respect to new peak v |
| | Set to 0.0 for no rescaling of source model. |
| Observation Setup: | |
| Observing mode: OSpectral Continuum | Spectral or continuum observations? |
| Central frequency in GHz: 93.7 | The value entered must be within an ALMA band. |
| Bandwidth in MHz +: 32 | Select the total bandwidth for continuum observation |
| | Enter 7.5 GHz to select ALMA recommend full conti |
| Number of polarizations: 2 + | This affects the noise in the final map. |
| Required resolution in arcseconds: 1.0 | OST will choose array config based on this value if |
| Pointing strategy: Mosaic + | Selecting single will apply primary beam attenuation |
| On-source time in hours ÷ : 3 | Per pointing for mosaics. |
| Start hour angle: 0.0 | Deviation of start of observation from transit. |



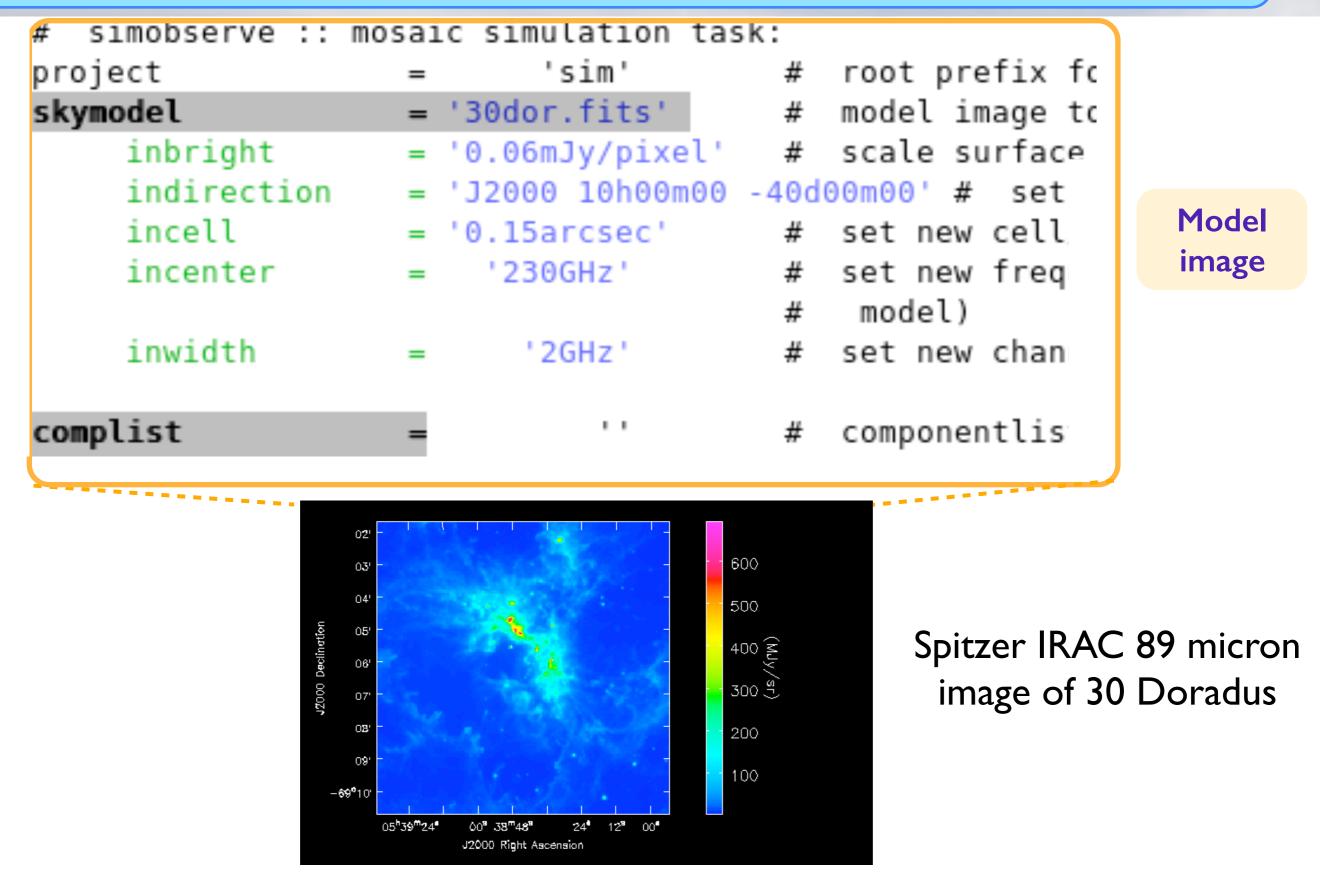








| <pre># simobserve :: mo</pre> | osai | | | |
|-------------------------------|------|------------------|-------|---|
| project | | 'sim' | | root prefix for output file names |
| skymodel | = | '30dor.fits' | # | model image to observe |
| inbright | = | '0.06mJy/pixel' | # | scale surface brightness of brightest pixel e.g. "1.2Jy/pixel" |
| indirection | = | 'J2000 10h00m00 | -40d | 00m00' # set new direction e.g. "J2000 19h00m00 -40d00m00" |
| incell | = | '0.15arcsec' | # | set new cell/pixel size e.g. "0.1arcsec" |
| incenter | = | '230GHz' | # | set new frequency of center channel e.g. "89GHz" (required even for |
| | | | # | model) |
| inwidth | = | '2GHz ' | # | set new channel width e.g. "10MHz" (required even for 2D model) |
| | | | | |
| complist | = | | # | componentlist to observe |
| setpointings | = | True | | |
| integration | = | '600s' | # | integration (sampling) time |
| direction | = | | # | "J2000 19h00m00 -40d00m00" or "" to center on model |
| mapsize | = | ['', ''] | # | angular size of map or "" to cover model |
| maptype | = | 'topographic' | # | hexagonal, square, etc |
| pointingspacir | ng = | | # | spacing in between pointings or "0.25PB" or "" for 0.5 PB |
| | | | | |
| obsmode | = | 'int' | # | observation mode to simulate |
| | | | # | [int(interferometer) sd(singledish) ""(none)] |
| antennalist | = | '/usr/lib64/casa | apy/s | <pre>table/data/alma/simmos/alma.cycle0.compact.cfg' # interferometer</pre> |
| | | | # | antenna position file |
| refdate | = | 2012/05/21 | # | date of observation - not critical unless concatting simulations |
| hourangle | = | 'transit' | # | hour angle of observation center e.g3:00:00, or "transit" |
| totaltime | = | '7200s' | # | total time of observation or number of repetitions |
| caldirection | = | | # | pt source calibrator [experimental] |
| calflux | = | '1Jy' | | |
| | _ | | | |
| thermalnoise | = | | # | add thermal noise: [tsys-atm tsys-manual ""] |
| leakage | = | 0.0 | # | cross polarization (interferometer only) |
| graphics | = | 'both' | # | display graphics at each stage to [screen file both none] |
| verbose | = | False | | |
| overwrite | = | True | | overwrite files starting with \$project |
| | | | | |
| async | = | False | # | If true the taskname must be started using simobserve() |



https://casaguides.nrao.edu/index.php/Simulation_Guide_for_New_Users_(CASA_4.4)

interferometer (int) or single-dish (sd)

| | | • | | |
|-------------|-----|----------------|--------|---|
| obsmode | = | 'int' | # | observation mode to simulate |
| | | | # | [int(interferometer) sd(singledish) ""(none)] |
| antennalist | = ' | /usr/lib64/cas | apy/st | table/data/alma/simmos/alma.cycle0.compact.cfg' |

Cycle 7 representative configurations files

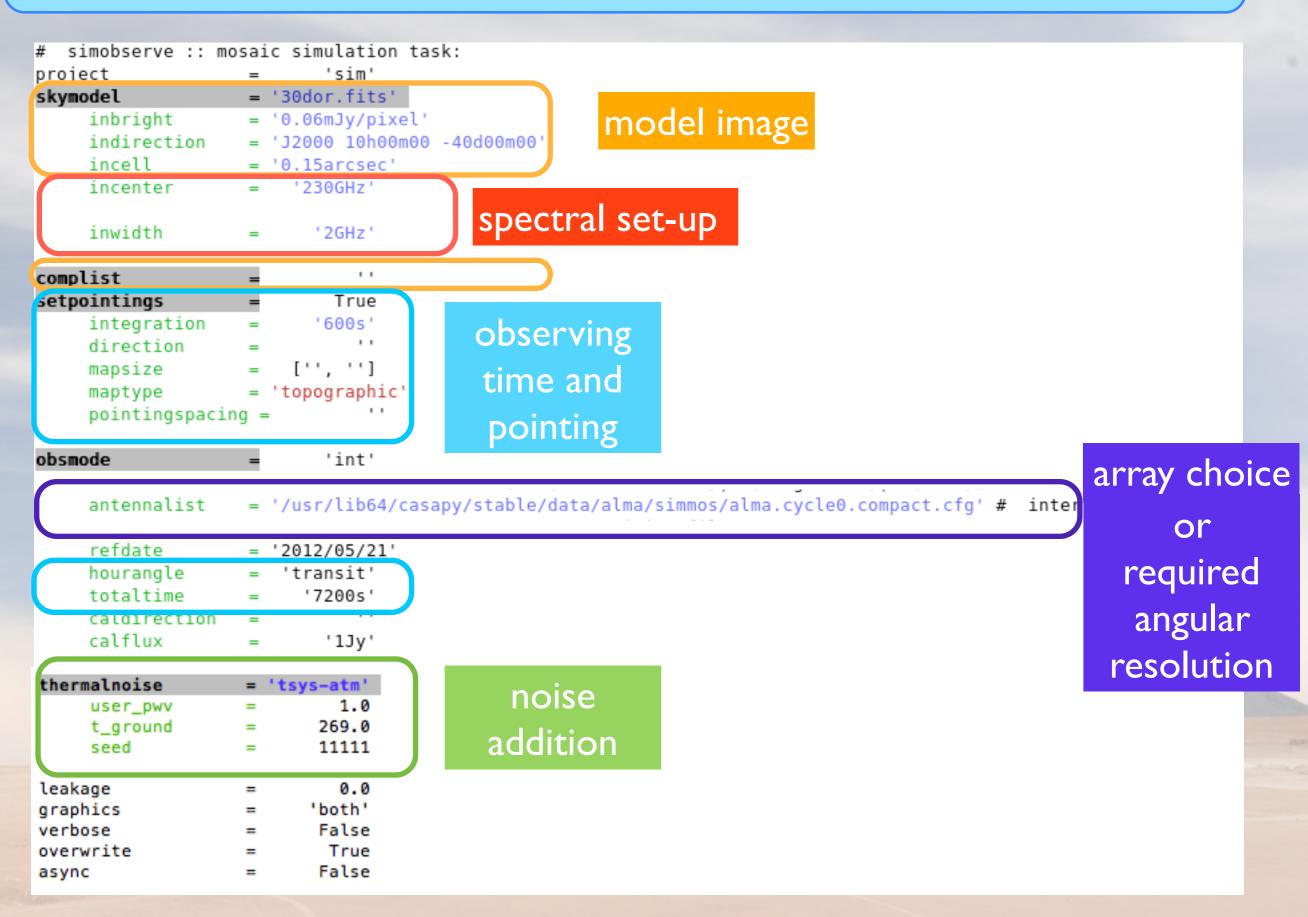
https://almascience.eso.org/documents-and-tools/cycle7/alma-configuration-files

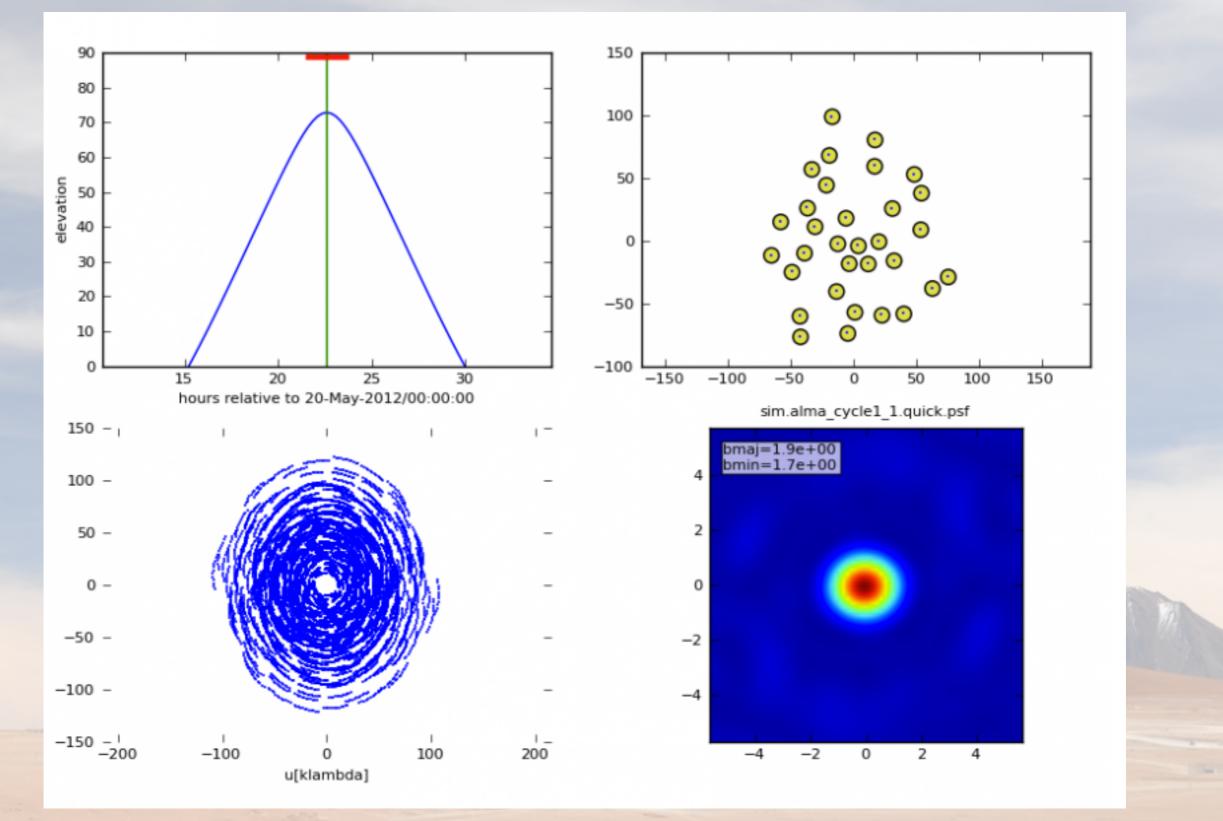
or, give the required angular resolution "alma;0.5arcsec" (only works for full ALMA !)



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| g |
| _ |

| incenter | = | '230GHz' | |
|---------------|-------|-----------------|-----------------|
| inwidth | = | '2GHz' | spectral set-up |
| complist | = | | |
| setpointings | = | True | |
| integration | = | '600s' | |
| direction | = | | |
| mapsize | = | ['', ''] | |
| maptype | | rectangle or he | exagonal X |
| pointingspaci | ng = | | |
| | | | |
| | | | |
| the simi | ulato | or allows yo | ou to |
| | | test | observing |
| several | роі | nting scena | rios time and |
| | - | - | pointing |
| | | | |





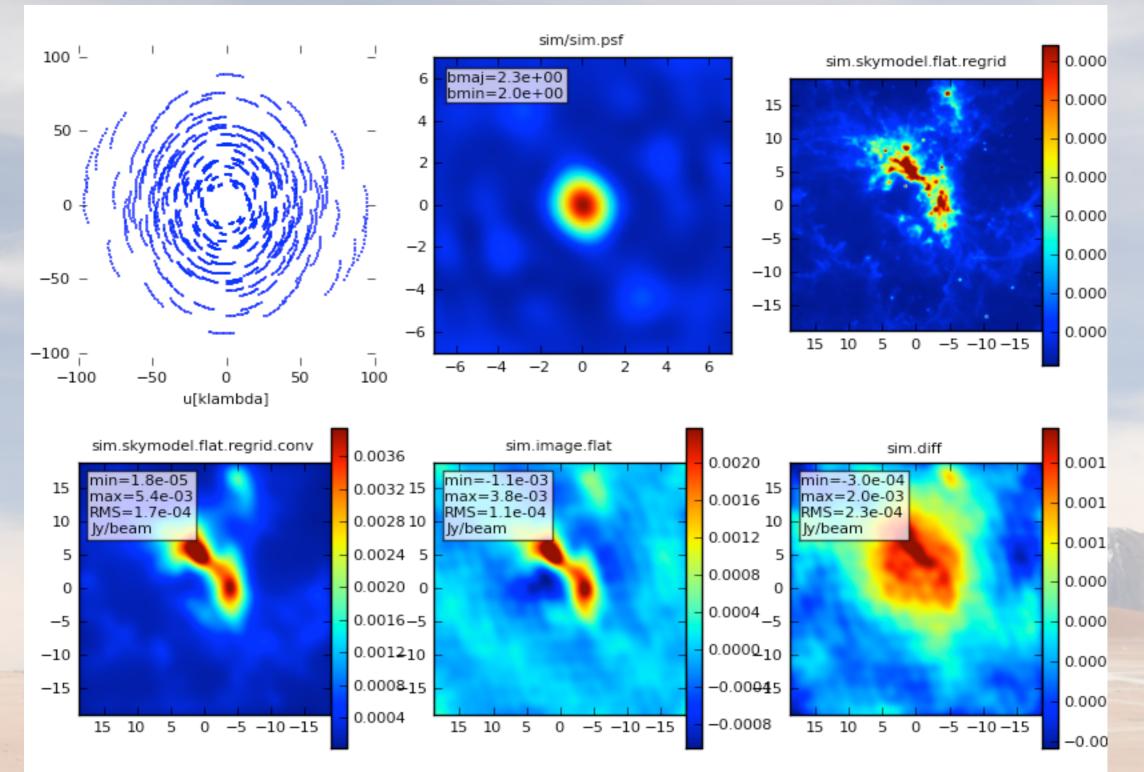
https://casaguides.nrao.edu/index.php/Simulation_Guide_for_New_Users_(CASA_4.4)

Imaging step

simanalyze

| - +0P17 | | | | |
|---|----------------------------|---|------------------|---|
| <pre># simanalyze :: in</pre> | nage | and analyze | simulat | ed datasets |
| 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 | = | | # | prior image to use in clean e.g. existing single dish 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 or "" to equal model |
| niter | = | 500 | # | |
| threshold | = | '0.1mJy' | # | flux level (+units) to stop cleaning |
| weighting | = | 'natural' | # | weighting to apply to visibilities |
| mask | = | [] | # | Cleanbox(es), mask image(s), region(s), or a level |
| outertaper | = | [] | # | uv-taper on outer baselines in uv-plane |
| stokes | = | 'I' | # | Stokes params to image |
| | | | | |
| analyze | = | True | # | (only first 6 selected outputs will be displayed) |
| showuv | = | True | # | display uv coverage |
| Shonar | | | | |
| showpsf | = | True | # | display synthesized (dirty) beam (ignored in single dish simulation) |
| | = | | # # | display synthesized (dirty) beam (ignored in single dish simulation) display sky model at original resolution |
| showpsf | = | True | | |
| showpsf showmodel | = | True True | # | display sky model at original resolution display sky model convolved with output beam display the synthesized image |
| showpsf showmodel showconvolved | = | True True False | # # | display sky model at original resolution display sky model convolved with output beam display the synthesized image |
| showpsf showmodel showconvolved showclean showresidual showdifference | = = = = | True True False True | # # # | display sky model at original resolution display sky model convolved with output beam display the synthesized image display the clean residual image (ignored in single dish simulation) display difference image |
| showpsf showmodel showconvolved showclean showresidual | = = = = | True True False True False | # # # | display sky model at original resolution display sky model convolved with output beam display the synthesized image display the clean residual image (ignored in single dish simulation) |
| showpsf showmodel showconvolved showclean showresidual showdifference showfidelity | = = = = = | True True False True False True True | # # # # | display sky model at original resolution display sky model convolved with output beam display the synthesized image display the clean residual image (ignored in single dish simulation) display difference image display fidelity |
| showpsf showmodel showconvolved showclean showresidual showdifference showfidelity graphics | = = = = = | True True False True False True True | # # # | display sky model at original resolution display sky model convolved with output beam display the synthesized image display the clean residual image (ignored in single dish simulation) display difference image |
| showpsf showmodel showconvolved showclean showresidual showdifference showfidelity graphics verbose | = = = = = = | True False True False True True 'both' False | # # # # | <pre>display sky model at original resolution display sky model convolved with output beam display the synthesized image display the clean residual image (ignored in single dish simulation) display difference image display fidelity display graphics at each stage to [screen file both none]</pre> |
| showpsf showmodel showconvolved showclean showresidual showdifference showfidelity graphics | = = = = = | True True False True False True True | # # # # | display sky model at original resolution display sky model convolved with output beam display the synthesized image display the clean residual image (ignored in single dish simulation) display difference image display fidelity |

Simanalyze imaging output

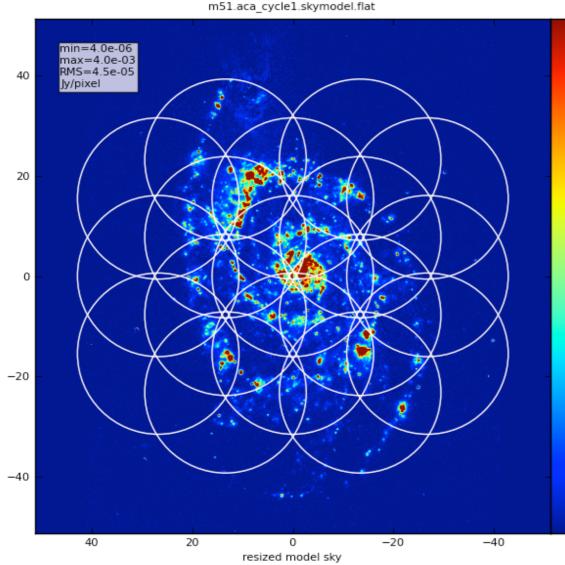


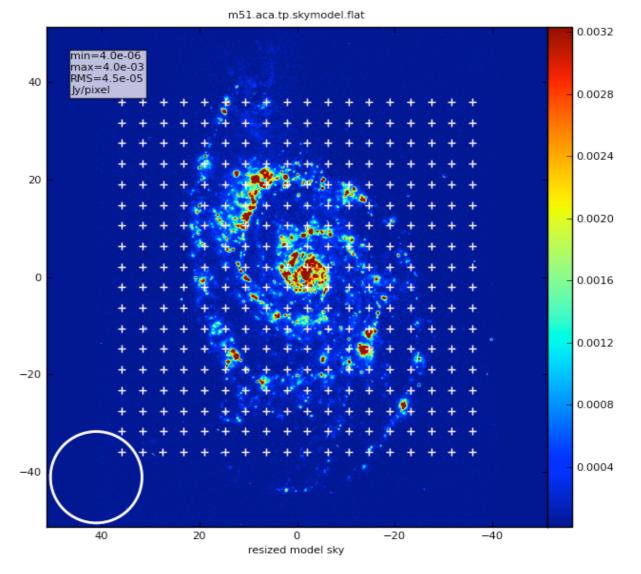
https://casaguides.nrao.edu/index.php/Simulation_Guide_for_New_Users_(CASA_4.4)

Simalma - combination of SD/ACA/ALMA during de-convolution

input model and pointing

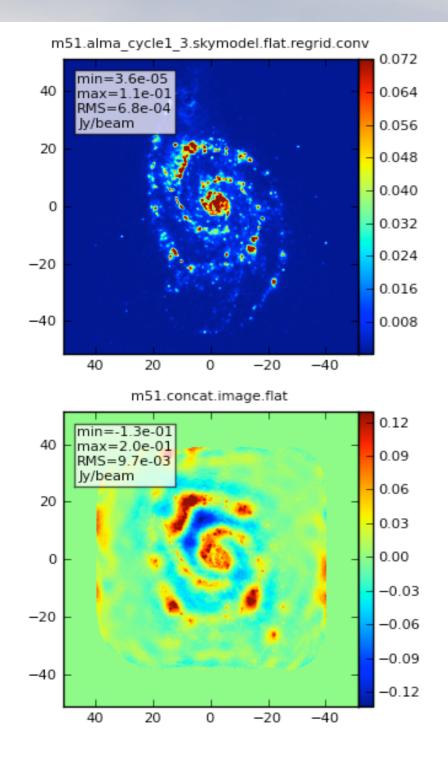
M51 input

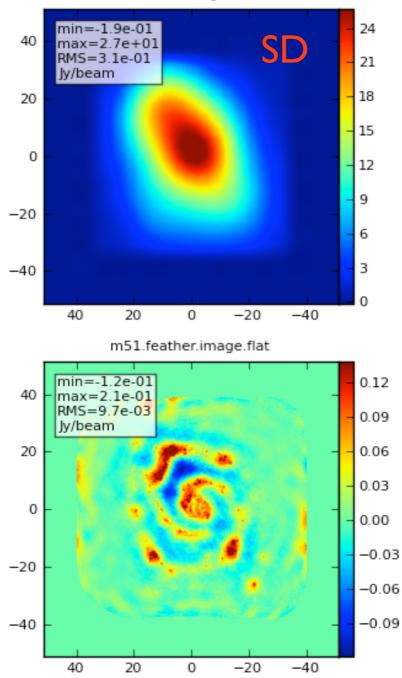




https://casaguides.nrao.edu/index.php/Simalma (CASA 4.4)

Simalma - combination of SD/ACA/ALMA during de-convolution





m51.sd.image.flat

https://casaguides.nrao.edu/index.php/Simalma_(CASA_4.4)

Useful examples

Try out the simulators and have fun using the simulations to support your proposals !

Simulation Guide for New Users (CASA 4.3)

a Spitzer SAGE 8 micron continuum image of 30 Doradus and scales it to greate

Protoplanetary Disk Simulation (CASA 4.3)

Apt that simulates a protoplanetary disk. Uses a theoretical model of dust continuum from Sebastian V. A - if you're short on time, you probably don't need to go through this one and the New Users guide, but it can

Simulation Guide Component Lists (CASA 4.3)

data based on multiple sources (using both a FITS image and a component list). If you are interested in simulating from a list of s rather than or in addition to a sky model image, then read the considerations here.

Einstein-Face (CASA 4.3)

* stated script that simulates the face of Einstein as seen by ALMA. This simulation is particularly useful for those we interferometer, but doesn't demonstrate new capabilities of the simulation tasks beyond those describ

ACA Simulation (CASA 4.3)

that use multiple configurations or use the 12-meter array in combination with the ALMA Cor vide is of particular interest to those wishing to explore using the 12-m array in combinat from multiple 12-m array configurations.

Simalma (CASA 4.3)

simplifies simulations that include the main 12-m array plus the AC those wishing to explore multi-component ALMA observations.

gatial filtering by an

36000

30000

24000

18000

12000

6000

6000

.cfg8_1n.

more complicated sims

Use the simulator tool for:

phase delay variations

gain fluctuations and drift

cross-polarization

(soon also bandpass and pointing errors) more flexibility in adding thermal noise Thermal noise addition

<u>https://safe.nrao.edu/wiki/pub/ALMA/SimulatorCookbook/</u> <u>corruptguide.pdf</u>

simple: specify simplenoise="1Jy" to get random Gaussian noise with 1Jy RMS

- tsys-atm: use environment temperatures, antenna parameters, and the aatm library to create a model of the troposphere and add random noise of the appropriate magnitude to the visibilities
- tsys-manual: specify atmospheric brightness temperature and optical depth yourself (rather than let aatm calculate it for you) and apply noise of the corresponding magnitude.