



What is Remcloud, and how could it reduce phase RMS?

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Remcloud refers to a python routine, `remove_cloud`, which is available for use in CASA with ALMA data, with the purpose of improving water vapor modeling and thereby phase calibration under certain conditions.

The standard procedure to model and calibrate out phase delays due to water vapor is carried out by the `wvrgcal` CASA routine. This routine uses data from the ALMA water vapor radiometers (WVRs) to model the atmospheric water content due to water in the gaseous form, which gives rise to spectral emission lines. For the vast majority of observations undertaken at ALMA this provides an accurate sky model which allows excellent antenna phase offset corrections resulting in well calibrated images. In addition to the spectral emission lines due to gaseous water, however, liquid water can also arise in the atmosphere (ie, clouds), which gives rise to a sloped continuum emission component.

This continuum emission is not accounted for in the standard `wvrgcal` calibration. As a result, when significant cloud emission is present, the standard phase calibration may be sub optimal and resulting images may not reach their ideal sensitivity. Initial investigations suggest that this is rare, and that only a few percent of all execution blocks benefit significantly from the more complicated water vapor modeling of `remcloud`. For this reason `remcloud` has not yet been implemented in the standard ALMA calibration procedures, although it may occasionally be used on a case by case basis, in which case its application will be clearly noted in the QA2 text delivered to the PI.

Observations which may benefit from `remcloud` correction, include those execution blocks which were observed under conditions with precipitable water vapor in excess of 1.5 mm, and for which the antenna phase correction factor calculated by the standard `wvrgcal` routine is small. As discussed in section 11.3 of the Cycle 8 and later technical handbooks, execution blocks which fall into this category of potentially being aided by `remcloud` are indicated in their QA0 reports (available through SnooPI) with the comment "Try REMCLOUD to reduce phase rms". Additional QA0+ reports may also note the phase rms values estimated for the science source using no water vapor correction, the standard `wvrgcal` correction, and the `remcloud` correction, along with images resulting from the best of the three options.

Beginning in Cycle 9, if the QA0 report recommends the use of `remcloud` for an execution block, it will be run on the execution block during the QA2 process. The resulting `wvrgcal` solution with `remcloud` will be compared to the original `wvrgcal` solution from the standard

pipeline. If the use of remcloud improves the wvrgcal solution sufficiently, the delivered data will include the remcloud correction. The QA2 report will clearly indicate whether this correction is included. For Cycle 8, if the use of remcloud is recommended by the QA0 report, it is at the discretion of the primary investigator or data user whether to attempt to use it. If they choose to do so, the remcloud routine may be accessed from within CASA with the casarecipes module for CASA 6 onward, and from the recipes module for some prior versions of CASA.

In CASA 6 onward:

```
from casarecipes import remove_cloud as rc
```

or

```
import casarecipes.remove_cloud as rc
```

In CASA 5:

```
import recipes.remove_cloud as rc
```

Remcloud should be applied to measurement sets prior to running wvrgcal. When run, remcloud produces a phase offsets table on output. Its syntax is given below:

```
rc.remove_cloud(vis=[FILENAME.MS], offsetstable=[OUTPUTTABLE])
```

The resulting offsets table can then be supplied to wvrgcal for application using the 'offsetstable' keyword.

If application of remcloud is attempted by a data user, the resulting images should be compared carefully to the images produced using the standard water vapor calibration to ensure that the results have improved.

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