# Objective determination of 3D cloud locations using scanning millimeter wavelength radars

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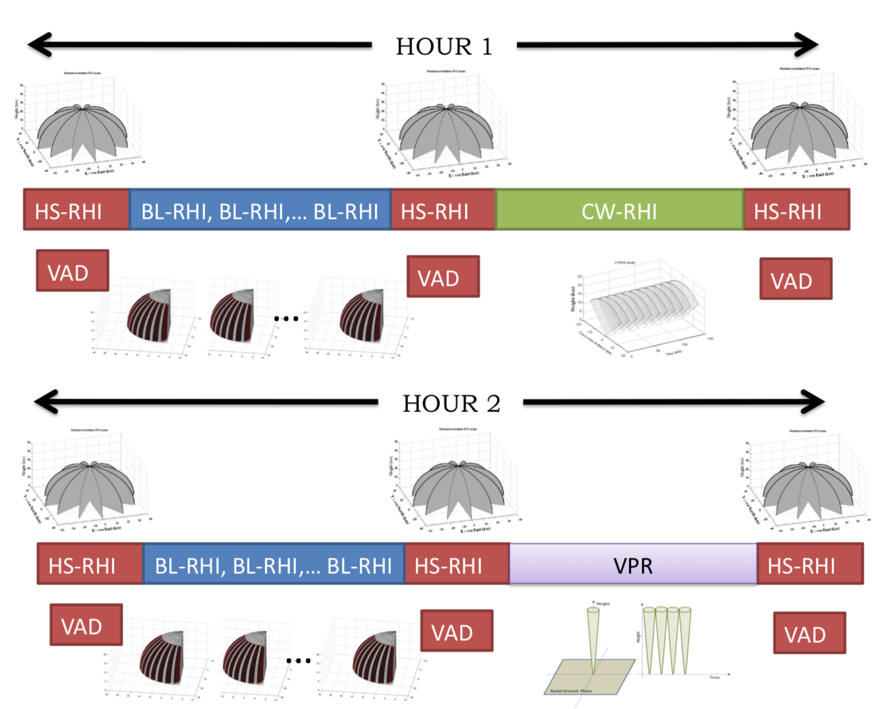
## 1. What is 3D-ARSCL?

The scanning ARM cloud radars (SACR's) are the primary instruments for the detection of cloud properties (boundaries, water content, particle size and habit, dynamics, etc.) beyond the soda-straw view. The first step before high value added products (VAP) can be developed using the multi-parametric radar measurements is the objective determination of 3D cloud locations (3D-ARSCL: Active Remote Sensing of 3D CLouds).

## 2. How the SACR's produce 3D cloud and precipitation information?



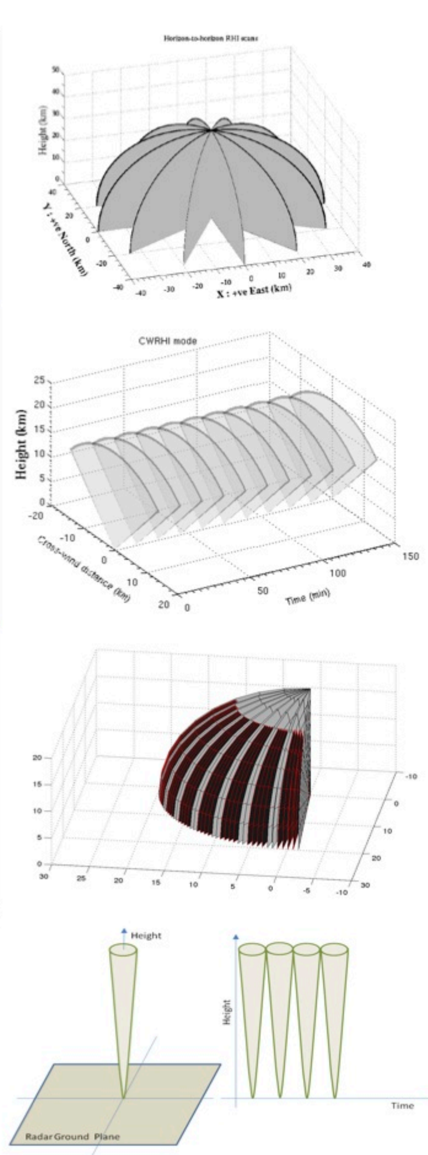

The first generation of sampling modes for the Scanning ARM Cloud Radar's (SACR's) is based on cycling (alternating) through four basic scan patterns that are designed to address different scientific objectives. An example of the how the different modes will cycle in a two hour period is shown in figure above.

**HS-RHI**
Hemispheric Sky Cross Sections
6 - Horizon-to-Horizon scans
Duration: 3 min
Repeat: Every 30 min
**All-cloud-conditions mode**

**CW-RHI**
Cross-Wind Range Height Indicator
Requires wind direction input
Repeat Horizon-to-Horizon scan
N-times
Duration: 15 min to 60 min
**Best scan strategy for high clouds**

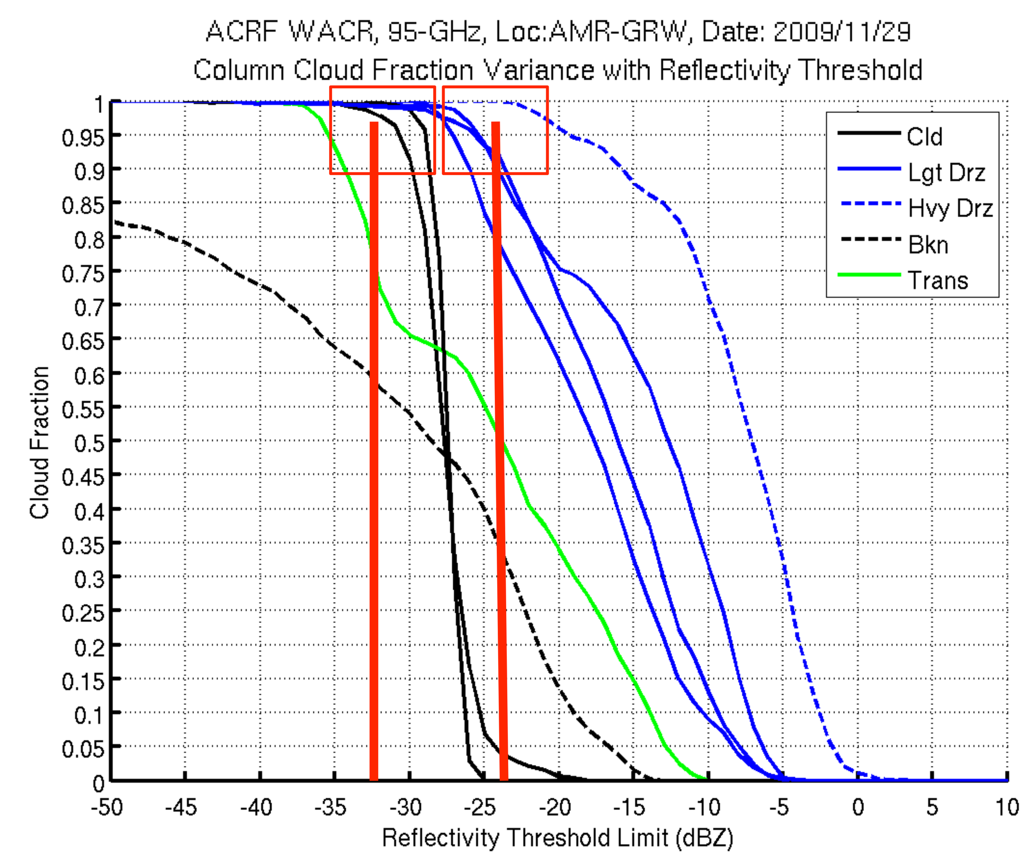
**BL-RHI**
90° azimuth sector around wind direction. 2° azimuth resolution
Duration: 5 min
Repeat: 3-6 times (lifecycle)
**Best scan strategy for low clouds**

**VPR**
Vertically pointing mode
All modes visit zenith frequently
Collection of Doppler spectra
Duration: always in rain
**Best scan strategy for precipitation**



## 3. Challenges

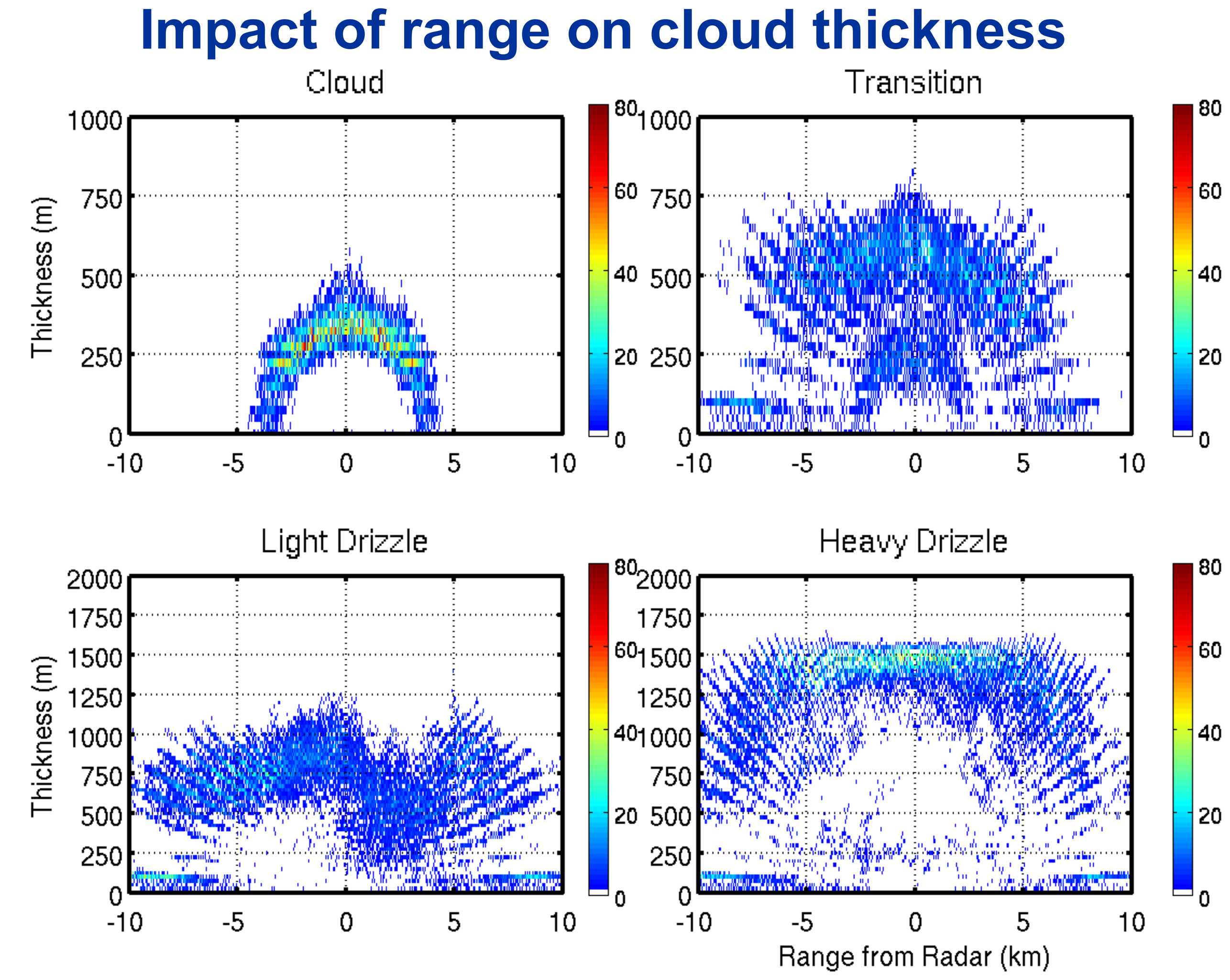
The transition from the profiling view to 3D contains several challenges. First, in 3D, the radar-lidar instrument synergy is not available and the determination of the cloud locations will be based on radar data only. Second, due to fast scanning, the ability to operate modes with different sensitivity is limited and we will have to address the reduction in sensitivity with range.




**Minimum Detectable dBZ = *f*(range)**

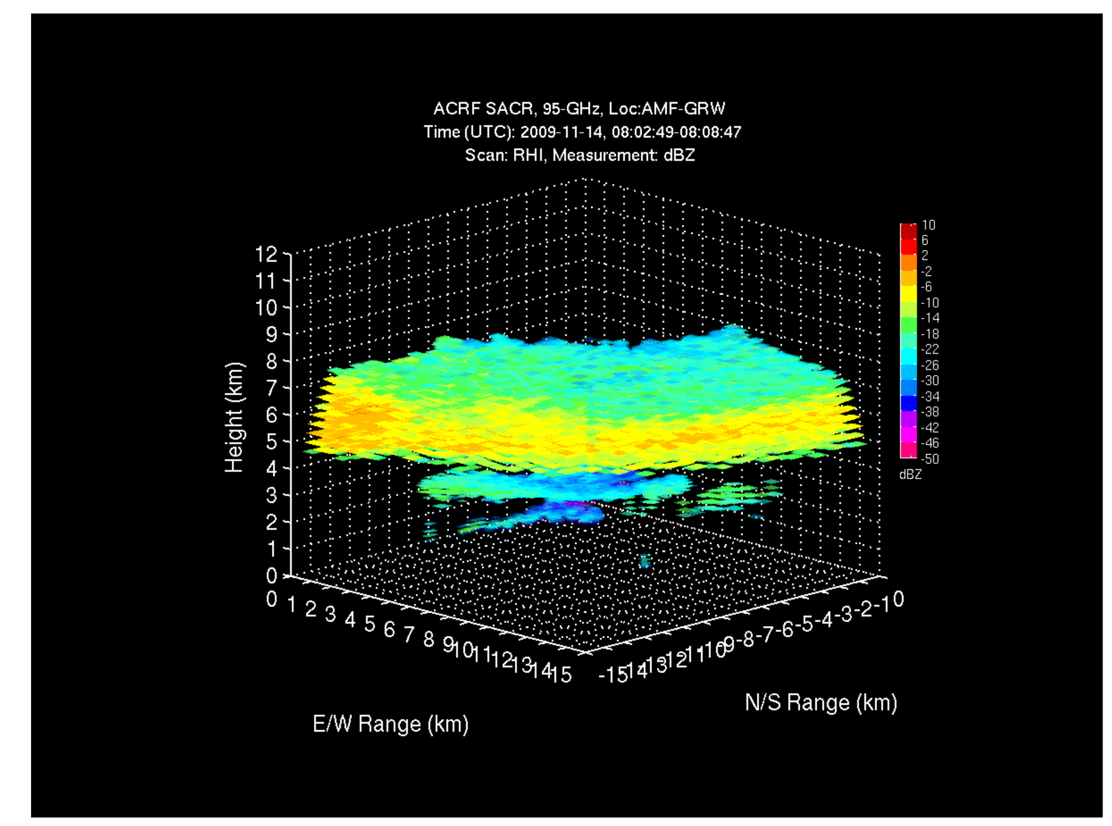
It is apparent that horizontal cloud fraction CF(x,y) depends on the radar sensitivity which is a function of range. Using information from the profiling radars we can: i) assess the low bias introduction to CF(x,y) with range and ii) identify a radar reflectivity value (i.e. using the $\Delta CF/\Delta Z_{thr}$) that provides acceptable horizontal cloud fraction structure. This could lead to variable domain 3D gridded products. Different products could also lead to different 3D gridded domains. For example, if we want to map 3D drizzle structures, a large domain is possible.

**Impact of range on cloud thickness**




## 4. Gridding of SACR observations

The coordinate system transformation is expected to ease the use of the scanning millimeter-wavelength radar data by the ARM user community. However, gridding cloud radar data is challenging especially if we consider the sparseness of radar observations with distance from the radar and the scales of clouds relevant to ASR scientific objectives.




## 5. Spatial interpolation functions

The 3D structure of cloud entities differs drastically from the 3D structure of precipitation as captured by scanning weather radars.

Cloud fraction statistics over the ARM sites have clearly demonstrated that cloudiness is associated with two dominant modes: clear or very low cloud fraction (10-20%) or overcast (100%).

We are working on adaptive spatial weighting functions that will depend on information on cloud fraction and radar reflectivity variability at each height from the the SACR polar radar data at each height in the atmosphere.