ARM Scanning Cloud Radars
Sampling Strategies Ideas and Data Products

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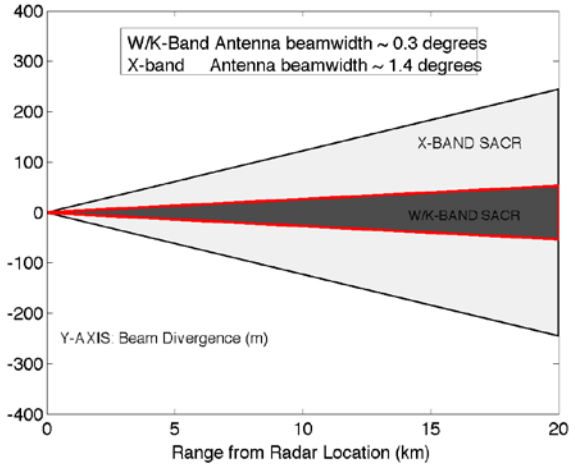
Scanning ARM Cloud Radars Overview

- SWACR
  - Limited capabilities (Azores/SGP/StormVex…)
- Ka-SACR and W-SACR on single pedestal
  - SGP
  - Barrow
  - AMF1
- Ka-SACR and X-SACR on separate pedestals
  - Darwin
  - Manus
  - AMF2



Scanning Cloud ARM Radars

Three 35/94-GHz and three 35/9.4-GHz multi-parametric radars

Reflectivity (dBZ, DWR)
35-GHz: primary cloud sensing frequency (Location)
94-GHz: LWC, WV retrievals in clouds, velocity, size retrievals in rain
9.4-GHz: LWC in drizzle, 20-50 km mapping of drizzle/light rain

Doppler (Velocity, width)
Cloud/Drizzle turbulence and shear information
Horizontal Wind Profile (VAD)

Polarimetry (LDR/SLDR for 35/94-GHz, ZDR/Φ_{DP}/ρ_{HV})
Non-spherical particles ID
Radar data quality control (e.g., insects, attenuation-correction)

Searching for clouds in 3D: Why?

3D radiative transfer issues, including calculation of radiative flux profiles

-computation of radiative fluxes for broken and complex cloud fields

Lifecycles of clouds and convective systems and cloud-aerosol interactions

-follow the life cycle of individual clouds or even cloud systems

Vertical velocity measurements in convective clouds

-critical missing measurement

Evaluation of satellite retrievals of cloud system properties

-many satellite and model pixels at the same time

Strengthen the microphysical/dynamical column retrievals

-constrain retrievals using multi-wavelength, spectra approaches

Searching for clouds in 3D: Measurement spatial/temporal requirements

3D radiative transfer issues, including calculation of radiative flux profiles

- "Frozen" 3D-structure of clouds properties (boundaries, LWC etc)
- Possible to have temporal gaps between such measurements

Lifecycles of clouds and convective systems and cloud-aerosol interactions

- "Volume-Imaging" of cloud properties (boundaries, WC, dynamics)
- Repeat several times to capture evolution/lifecycle

Vertical velocity measurements in convective clouds

-SGP/Darwin precipitation radar networks

- Vertical pointing, Doppler spectra recording

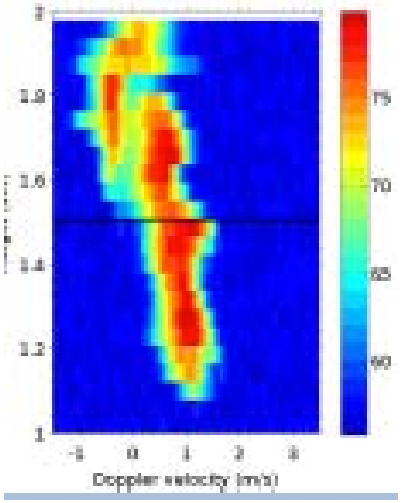
Evaluation of satellite retrievals of cloud system properties

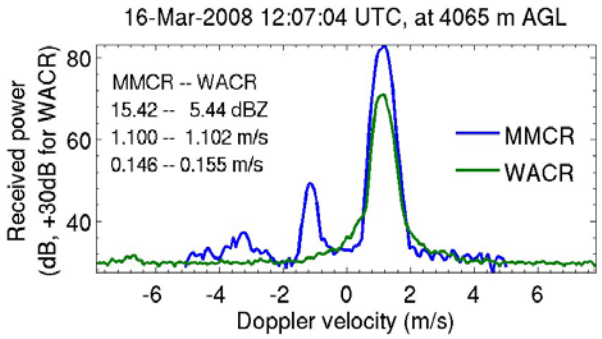
- "Frozen" 3D-structure of clouds properties (boundaries, LWC etc)
- Possible to have temporal gaps between such measurements

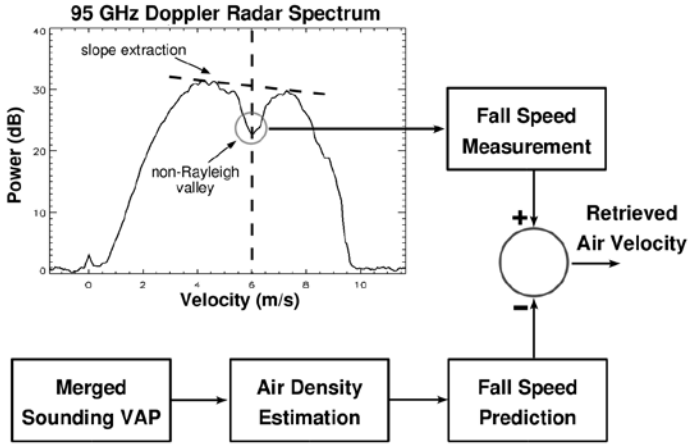
Strengthen the microphysical/dynamical column retrievals

-Vertical pointing, Doppler spectra recording

Vertical pointing, Doppler spectra recording





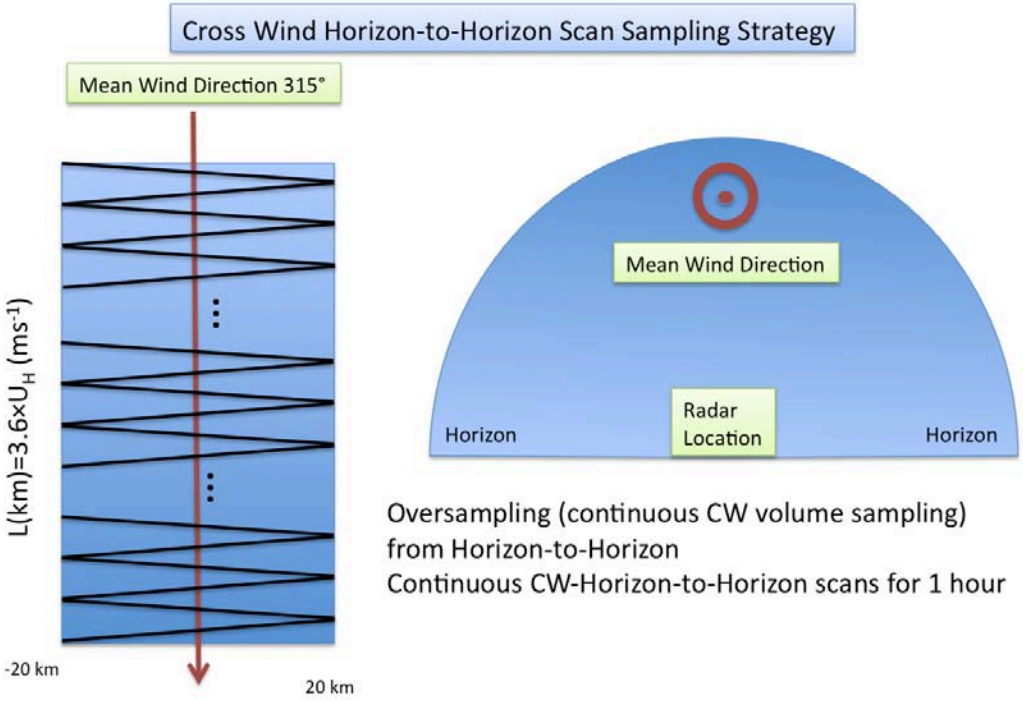


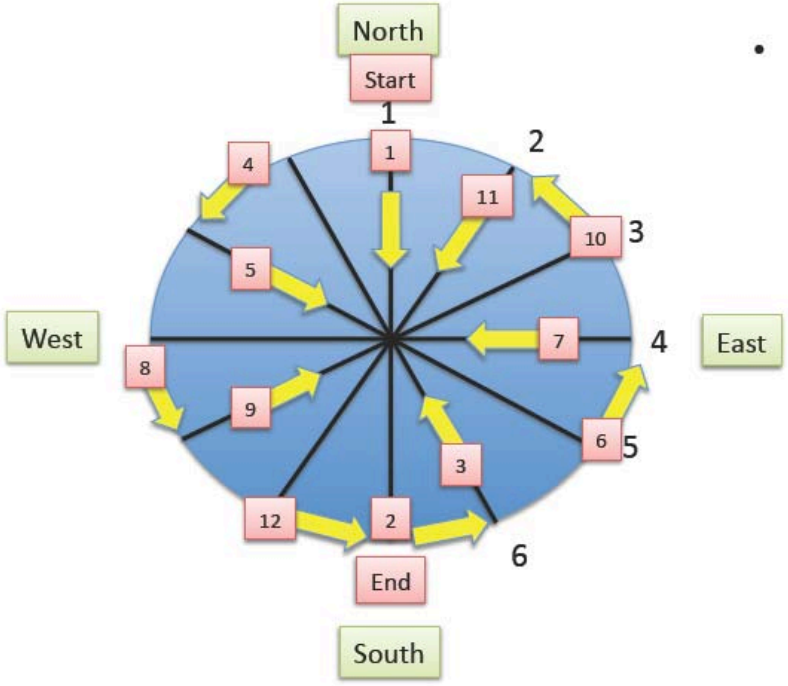
Collocation with MMCR desirable but no necessary since 35-GHz frequency is available
Fast temporal (2 sec) and spatial sampling (30 m)
Co/cross Doppler spectra
Collocation with 2-DVD highly desirable
Single mode or MMCR-like sampling strategy?

Processing tools:
-ARSCL (moments, boundaries)
-Micro-ARSCL (Doppler spectra post-processing)

Improvements
-Water Vapor Correction
-Velocity Unfolding

"Frozen" 3D-structure of clouds properties (boundaries, LWC etc)
Possible to have temporal gaps between such measurements



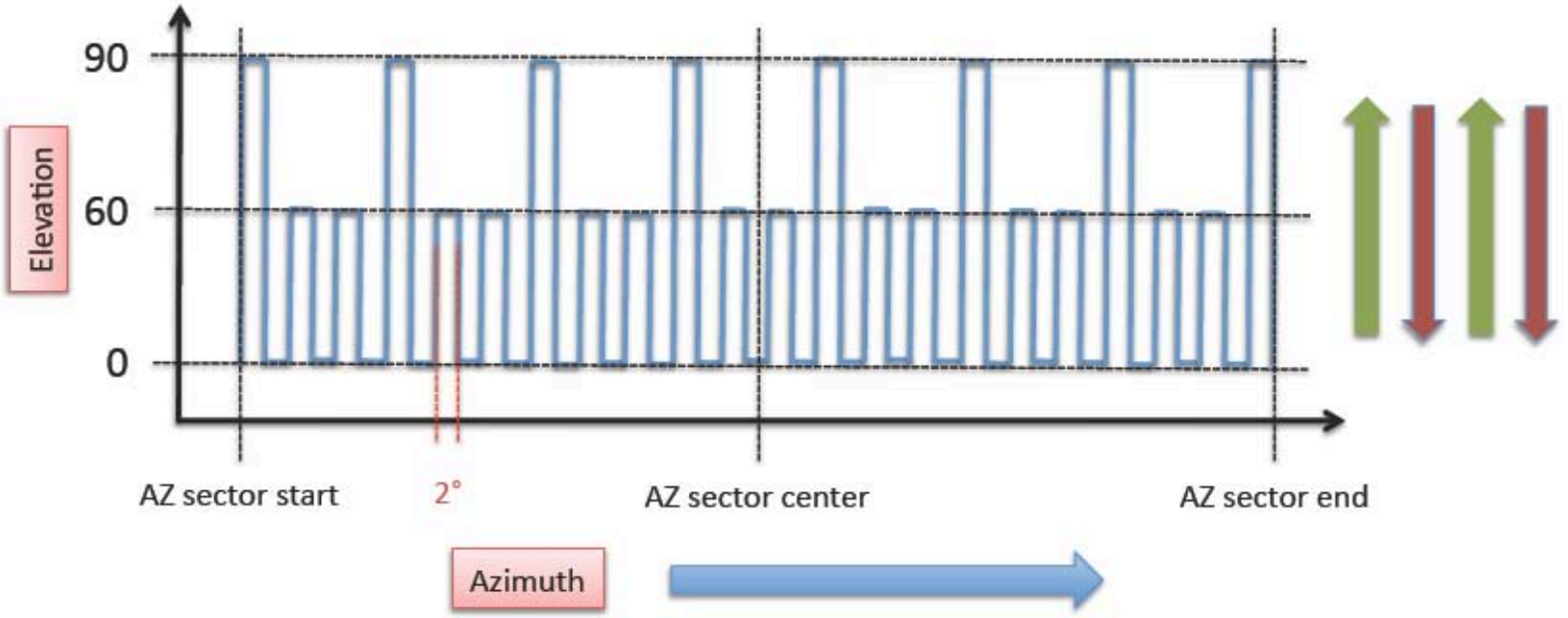


Select a particular direction (e.g., cross-wind)
Repeat Horizon-to-Horizon scan N-times
Used during SWACR deployment at Azores

Hemispheric Sky Cross Sections
N-different directions (e.g., 6)
Horizon-to-Horizon scan
Planned for SGP

"Volume-Imaging" of cloud properties (boundaries, WC, dynamics)
- Repeat several times to capture evolution/lifecycle

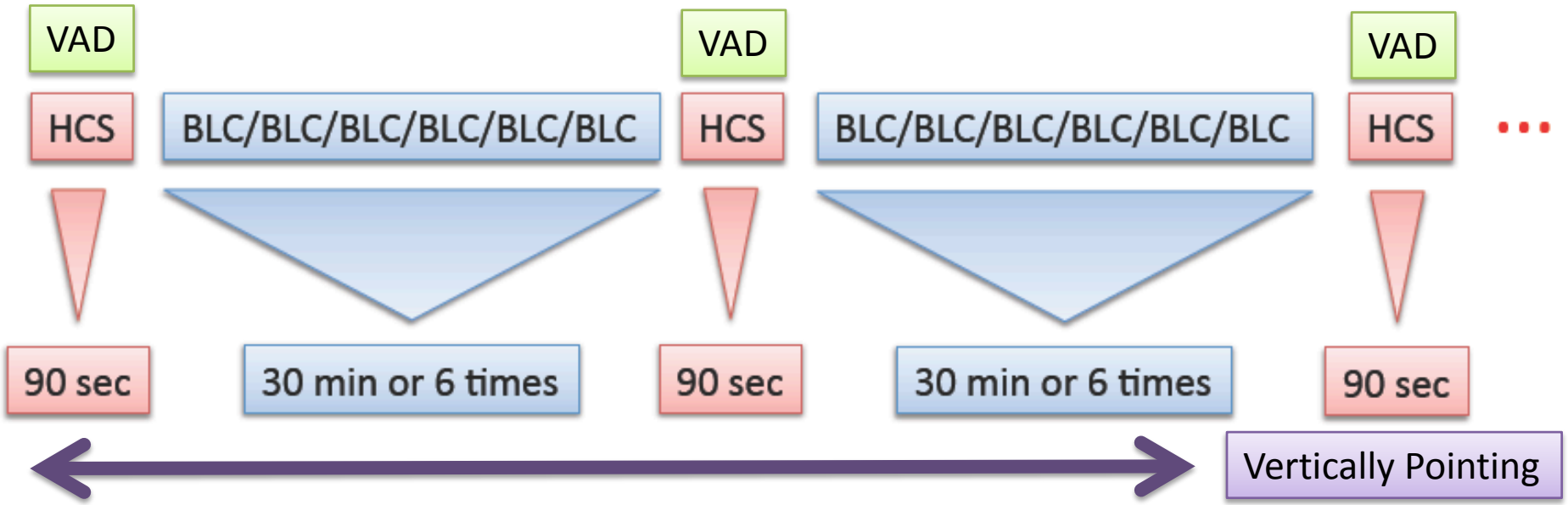
- **Azimuth sector scan**
  - centered around wind direction or location of profiling facility
  - swath: ~ 90°
  - azimuth step: 2 degrees for 0-60° elevation (high res sampling of the BL)
  - azimuth step: 10 degrees for 60-90° elevations (sampling high above the radar location)
  - maximum range: 20 km
  - range from radar we reach height of 3 km: 1.7 km
  - 2880 degrees of total scan – Target time: ~ 5 min >> 3D-ARSCL
  - repeat BLC sampling strategy N times >> Cloud Life Cycle ($ARSCL_i$, $ARSCL_{i+1}$,...$ARSCL_{i+N}$)



SWACR/SACR Scan Strategies (2nd revision)

- Use only two scanning strategies
  - BLC sampling strategy (BLC)
    - Repeat 6 times ~ 30 min
    - Azimuth centers:
      - 315 for northwesterly flow (post frontal) >>> BLC-NW
      - 225 for southwesterly flow (pre-frontal) >>> BLC-SW
      - Can we "program" both angles and let the local ARM infrastructure decide on the angle depending on the low-level wind direction?
  - Hemispherical Sky Cross Sections (HCS)
    - Repeat once every 30 min

Emphasis on flexibility (PI-driven) mode sequence



S-WACR deployment at Azores
Prelude for SACR continuous observations

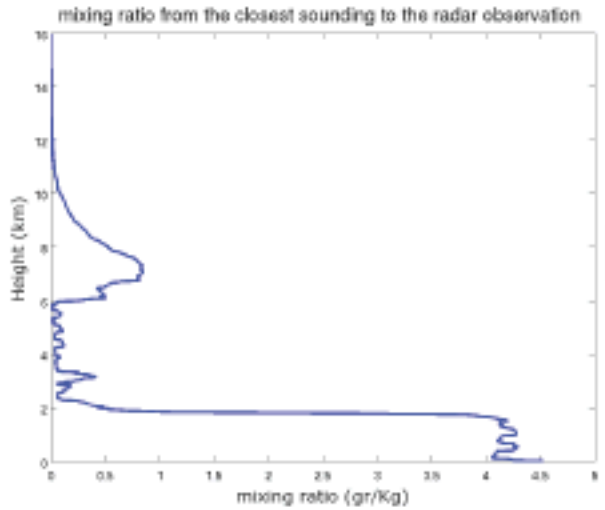
The deployment of the Scanning W-Band ARM Cloud Radar (SWACR) during the AMF campaign at Azores signals the first deployment of an ARM Facility-owned scanning cloud radar and offers a prelude for the type of 3D cloud observations that ARM will have the capability to provide at all the ARM Climate Research Facility sites by the end of 2010. The primary objective of the deployment of Scanning ARM Cloud Radars (SACRs) at the ARM Facility sites is to map continuously the 3D structure of clouds and shallow precipitation and to provide 3D microphysical and dynamical retrievals for cloud life cycle and cloud-scale process studies

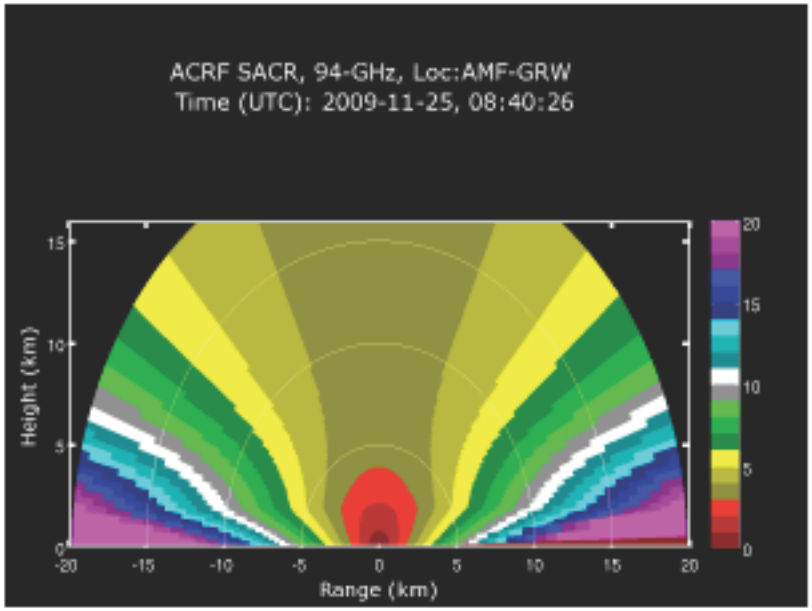
The new scanning radar (foreground) joins the ARM Mobile Facility instrument suite operating on Graciosa Island

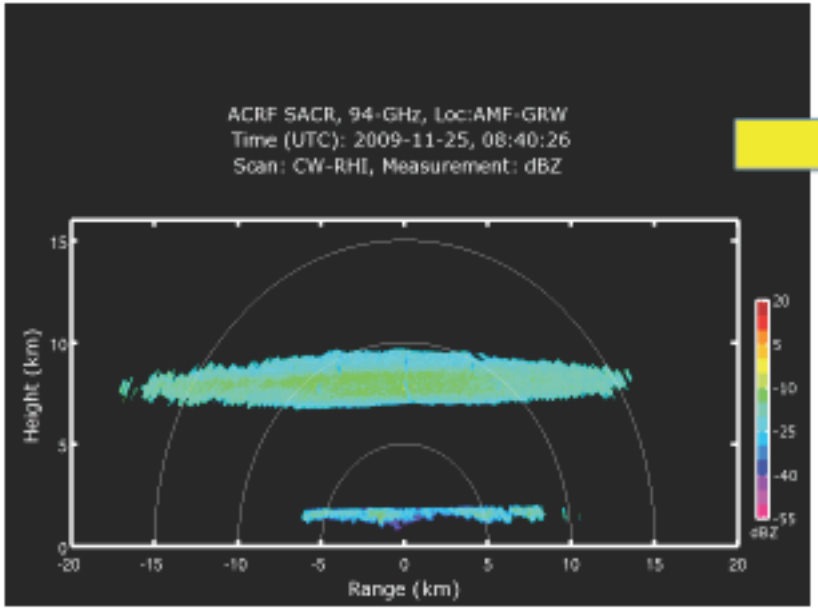
Standard Processing (at the radar data coordinate system)
-Significant Detection Mask
-Water vapor attenuation correction
-Doppler Velocity Unfolding

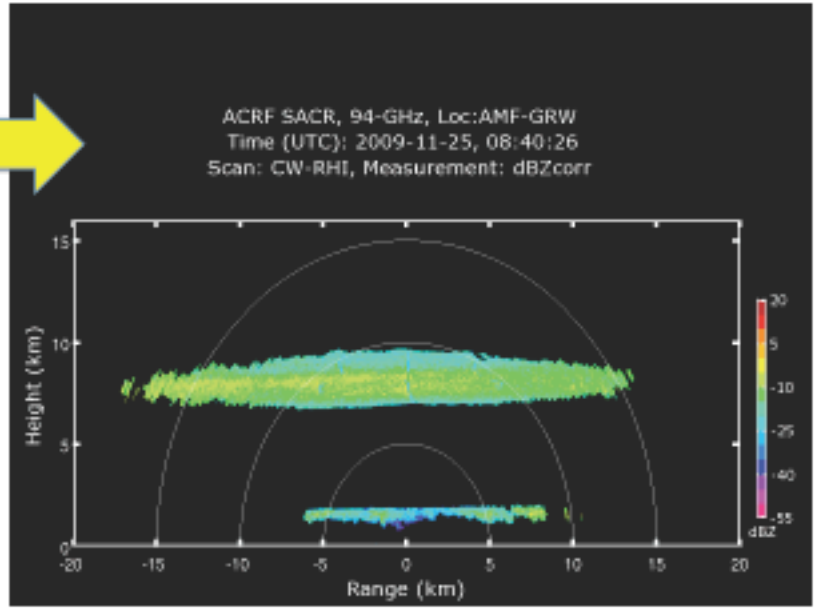
Visualization

Water vapor attenuation correction

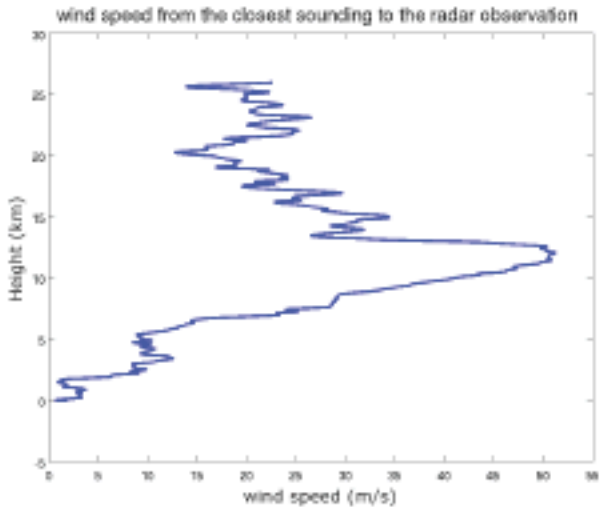


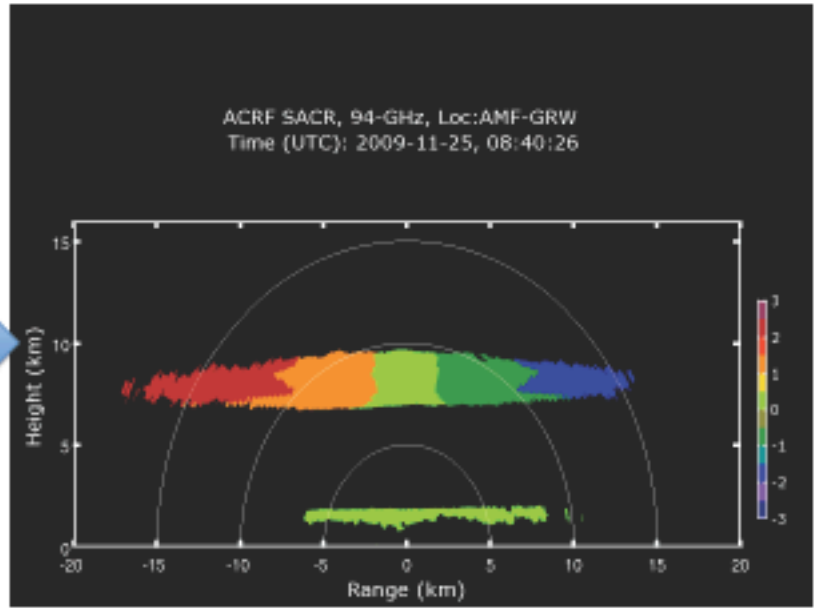


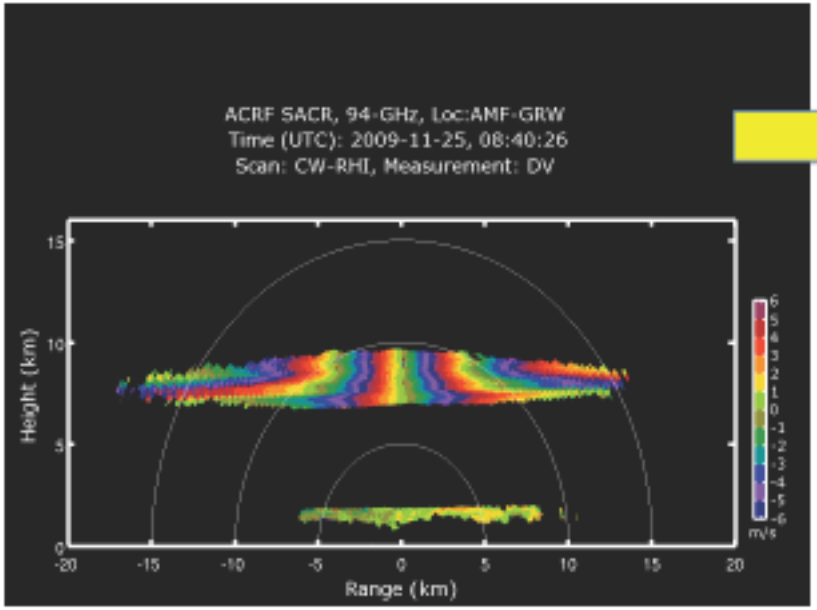


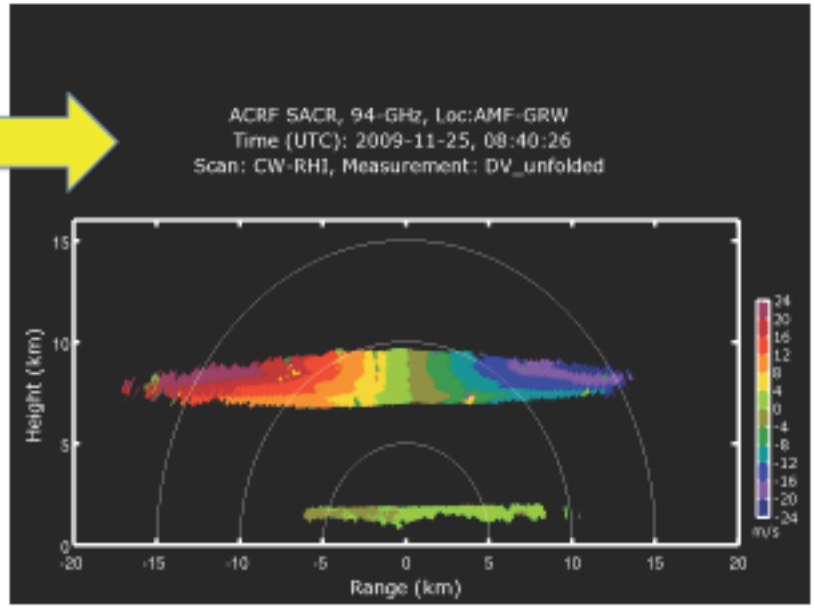


Doppler Velocity Unfolding

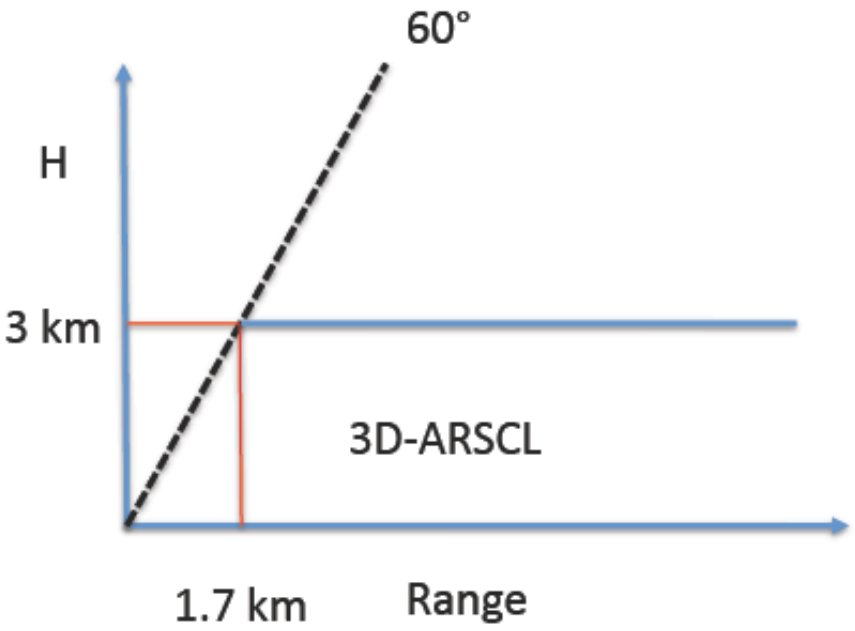


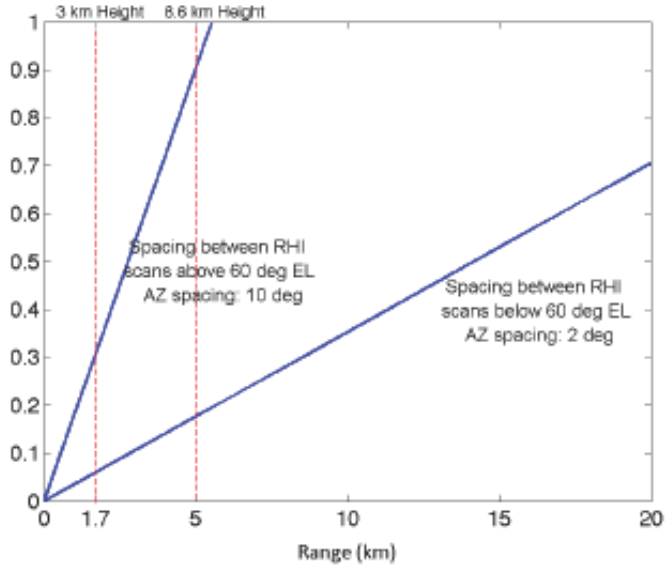




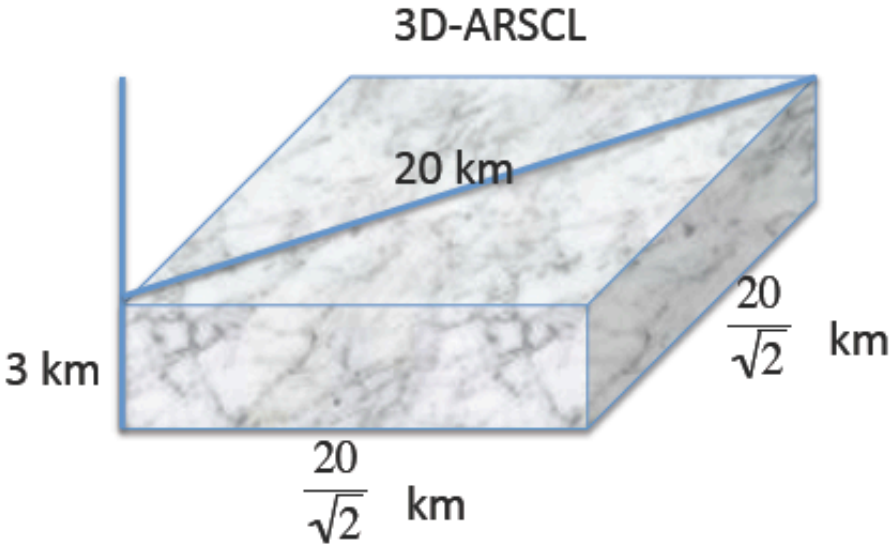


BLC Sampling Strategy (0-3 km)

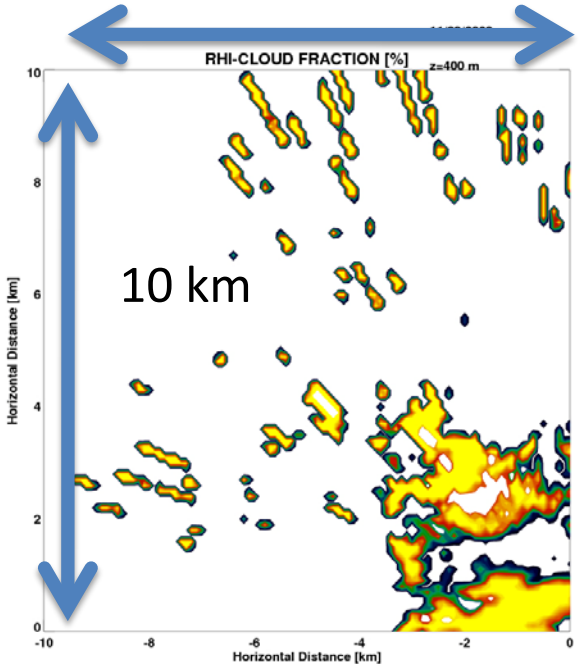




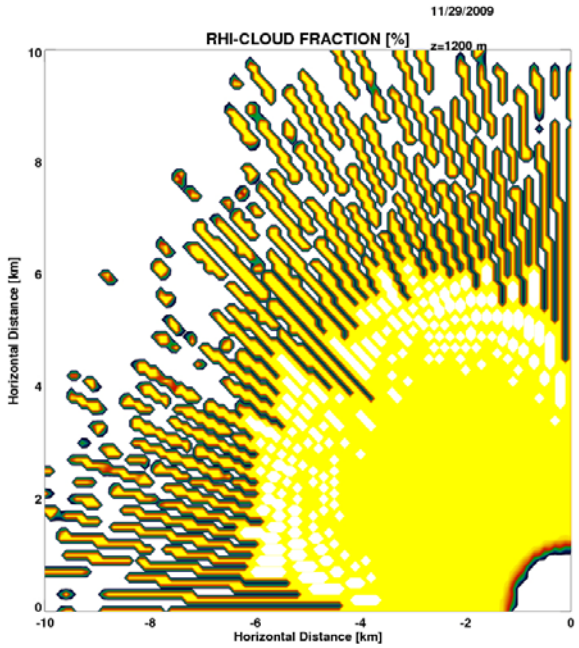
3D-ARSCL will be also computed at heights above 3 km for EL less than 60 deg



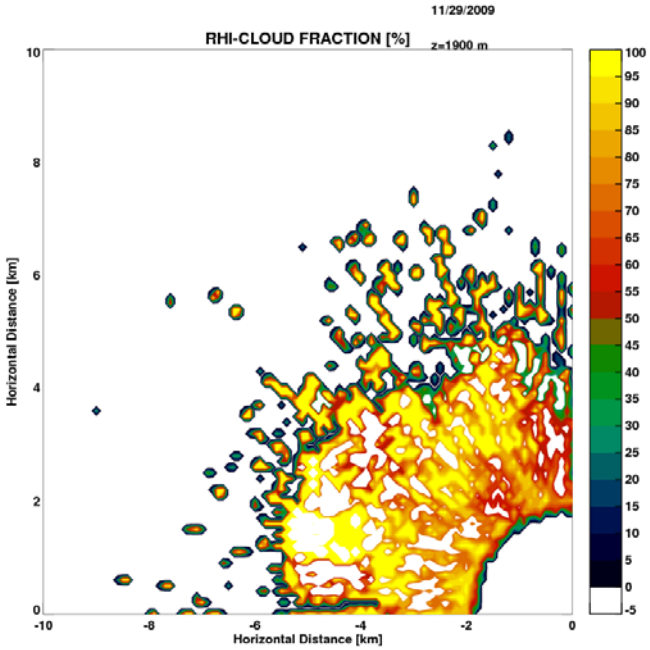
3D Gridded Cloudiness Product (Preliminary)



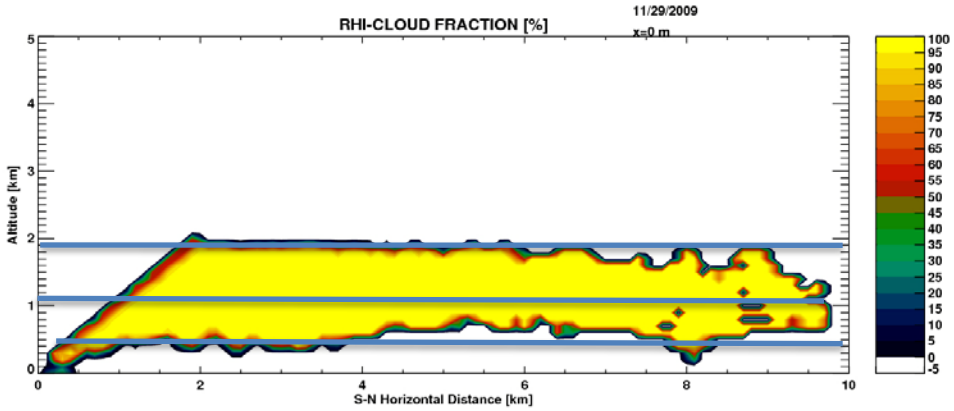
Base



Middle



Top



Grid the radar observables in XYZ (e.g. 100x100x100 m)

www.clouds.mcgill.ca/research/sacr_data.html

RADAR APPLICATIONS IN WEATHER AND CLIMATE
RESEARCH GROUP

McGill UNIVERSITY

Scanning ARM Cloud Radar at Azores: Movies and Data

Instructions

Please use the following page to view data that our Scanning ARM Cloud Radars have collected. For 3D-Active Remote Sensing of Cloud Locations, please see here **here**.

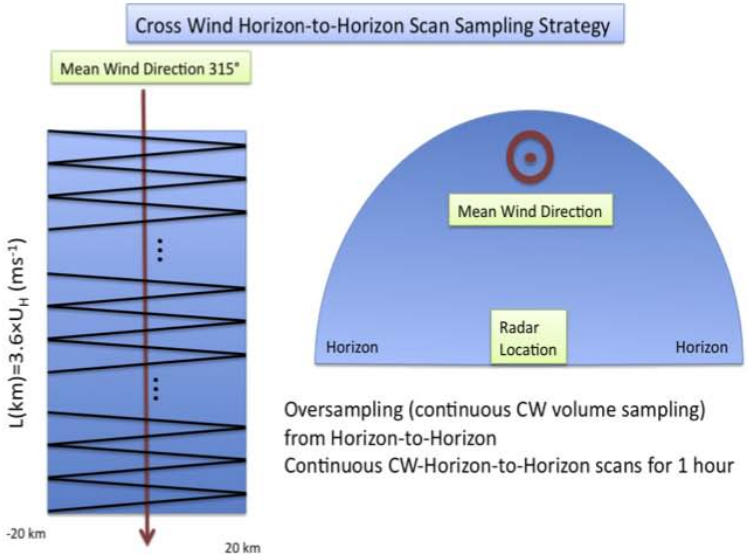
Select Movie:

Type: Reflectivity (uncorrected)

Mode: CW_RHI

Date: 20091125

Timespan:



Oversampling (continuous CW volume sampling) from Horizon-to-Horizon
Continuous CW-Horizon-to-Horizon scans for 1 hour