Suggestions for SWACR Scanning Procedures during the AMF2 STORMVEX Field Deployment

Sergey Y. Matrosov

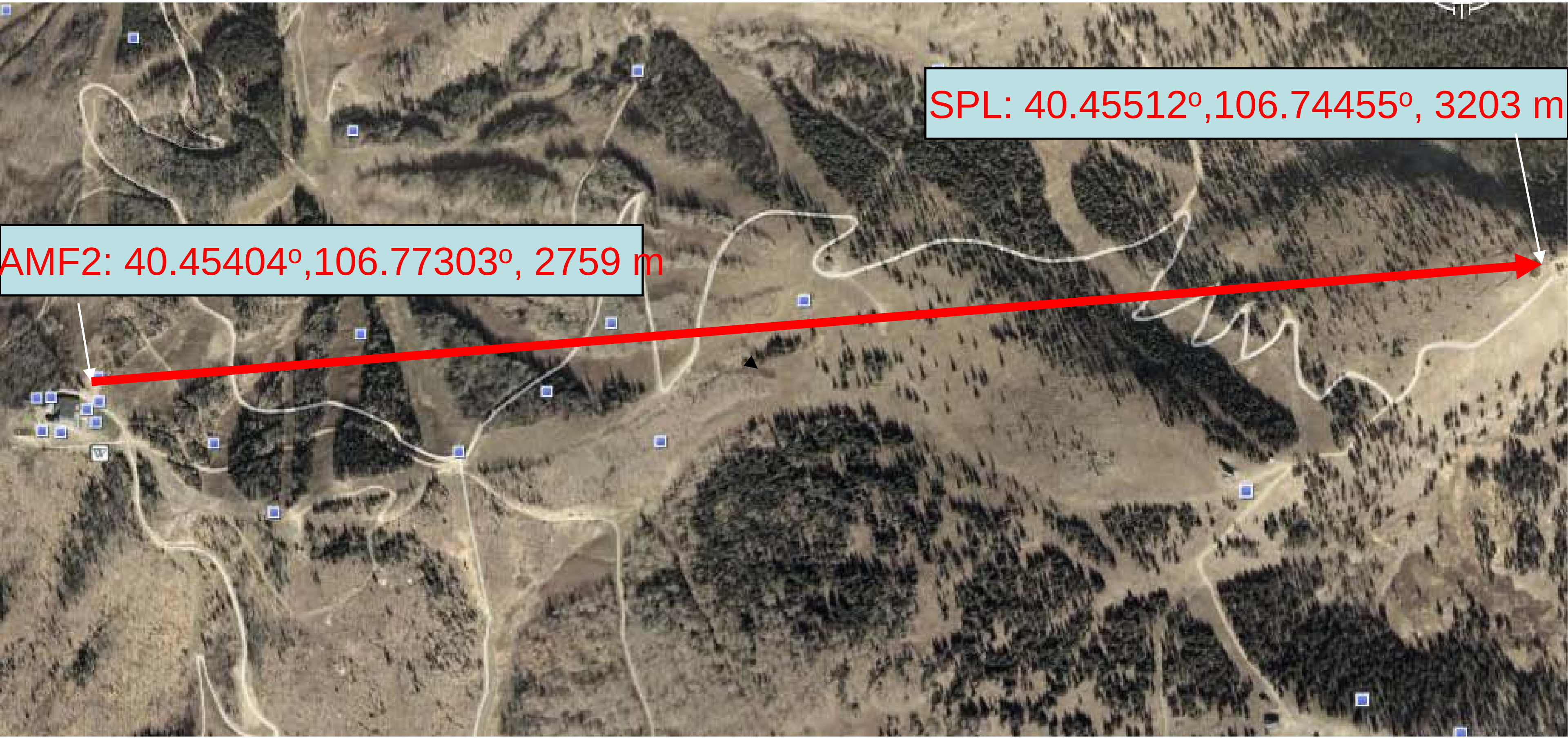
StormVEx – The Storm Peak Lab Cloud Property Validation Experiment

AMF2 deployment (October 2010-April 2011) on a slope of the Storm Peak (Steamboat Springs, Colorado)

Main objective: in conjunction with AMF2 operational measurements to provide a continuous correlative in situ data set on cloud, precipitation and aerosol microphysical properties in a region of complex terrain

It will be the first ARM deployment where polarimetric cloud radar measurements will really matter and be used quantitatively for the purpose of ice particle habit studies

Relative locations of the AMF2 and the Storm Peak Lab



AMF2 - SPL distance: 2.4 km   AMF2-SPL azimuth: 87.2°, AMF2-SPL elevation: 10.4°


AMF2

SWACR scanning procedures should be versatile enough to satisfy different objectives

The suggested scan table (the sequence of 5 scans/pointings) (~24 min):

1. A 360^o surveillance scan at el=11^o or some other angle (1.5 min)

2. A 360^o VAD scan at el=75^o (0.75 min)

3. Vertical pointing (15 min)

4. Over the top RHI scan at az=87.2^o (1.5 min)

5. Fixed beam pointing in the SPL direction (el=11^o, az=87.2^o) (5 min)

1. A 360º surveillance scan at el=11º (1.5 min)

Purpose: to get an area coverage of the event
to estimate horizontal inhomogeneity of echoes

Unambiguous Doppler velocity: ~ 7.9 m/s (PRF=10 kHz)
Unambiguous range: ~ 15 km (PRF=10 kHz)
Unambiguous Doppler velocity: ~ 4 m/s (PRF=5 kHz)
Unambiguous range: ~ 30 km (PRF=5 kHz)

Doppler moments measurements at two polarizations
Doppler spectra are not recorded when scanning but
spectral processing is used for Doppler moment estimations.

Questions: Will the 11º beam elevation clear the obstacles/buildings ?
Do we need lower elevation surveillance coverage ?
(given that for el=11º, at 15 km the radar beam will
be higher than the AMF2 by 2.9 km)

scan rate: 4º/sec (~10 beams per second), PRF=10 kHZ, number of pulses per beam: 1024 (512 co-polar and 512 cross-polar), 32 FFT points, 16 spectral averages per pol, 45 m gate spacing. This will correspond to sensitivity of about -20 - -25 dBZ @ 10 km.

2. A 360^o VAD scan at el=75^o (0.75 min)

Purpose: to get a vertical profile of horizontal winds

(at this elevation horizontal wind velocity folding happens at 32 m/s for 10 KHz PRF)

scan rate: 8^o/sec (~10 beams per second), PRF=10 kHZ, number of pulses per beam: 512 (256 co-polar and 256 cross-polar), 32 FFT points, 16 spectral averages per pol, 45 m gate spacing.

3. Vertical beam pointing (15 min)

Purpose: it is the main mode for retrievals (Z-IR, Z-V, Doppler moments)

retain the vertical measurement mode from SGP WACR
(dwell time ~ 2 sec, 256 FFT, 160 spectral averaging resulting in
sensitivity of about -35 dBZ @ 10 km)

4. Over the top RHI scan at az=87.2^o (1.5 min) between elevations 5^o and 175^o (times 2)

Purpose: to get a polarimetric information about hydrometeors which can be used for estimates of particle shapes/habits

to get vertical profiles of Z over SPL (for retrievals and comparisons with vertical profiles of Z over AMF2)

to get instantaneous cross vertical sections of the event in the AMF2 – SPL plane

scan rate: 4^o/sec (~10 beams per second), PRF=10 kHz, number of pulses per beam: 1024 (512 co-polar and 512 cross-polar), 32 FFT points, 16 spectral averages per pol, 45 m gate spacing. This will correspond to sensitivity of about -20 – -25 dBZ @10km.

5. Slant beam pointing over SPL (el=11^o, az=87.2^o) (5 min)

Purpose: provides “collocated” radar and in situ measurements at SPL

(dwell time ~ 2 sec, 256 FFT, 160 spectral averaging)

Questions about the polarization state for SWACR scanning data

SWACR transmits linear polarization signals and measures alternatively co-polarized and cross-polarized returns (one receiver is employed), SWACR polarization measurable is Depolarization Ratio:
DR = logarithmic difference between cross-polarized and co-polarized echos

Traditionally Horizontal-Vertical (HV) polarization basis is used for airborne and ground based polarimetric W-band radars

*For vertical beam measurements: the choice of polarization basis/state does not matter

*For scanning measurements: (low beam measurements) co-polar returns differ little as a function of polarization but cross-polar returns and thus DR varies strongly depending on the radar polarization basis

Some polarization bases (states) other than H-V are more beneficial for the purpose of particle types identification (i.e., planar vs. columnar vs. irregular vs. spherical) and estimating their aspect ratios

DR in the H-V polarization basis (HLDR) depends on particle density, aspect ratio and (strongly) orientation

DR in the circular polarization basis (CDR) depends on particle density, aspect ratio and (very weakly) orientation

DR in the slant 45° polarization basis (SLDR) depends on particle density, aspect ratio and (weakly) orientation

Besides: cross-polar signals in CDR and SLDR are stronger than in HLDR (sensitivity)

It was proposed to use the slant 45° polarization basis (SLDR) in StormVEx (it is easier to implement than circular polarization basis)

Studies of ice hydrometer habits using DR measurements with the NOAA K_a-band radar an example for planar crystals (in a weak precipitating cloud):

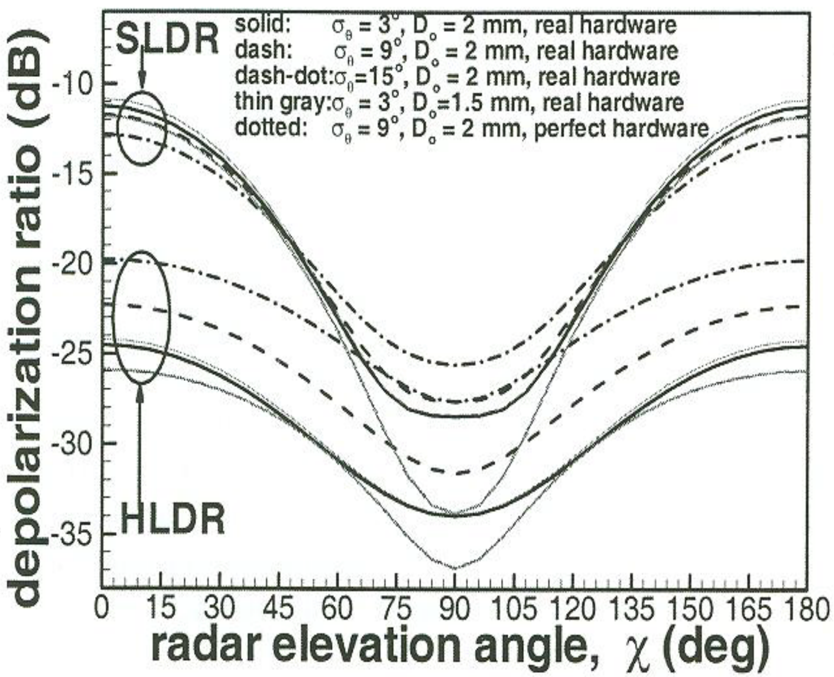
Cross-pol signal in SLDR is much stronger than HLDR for slant beams.

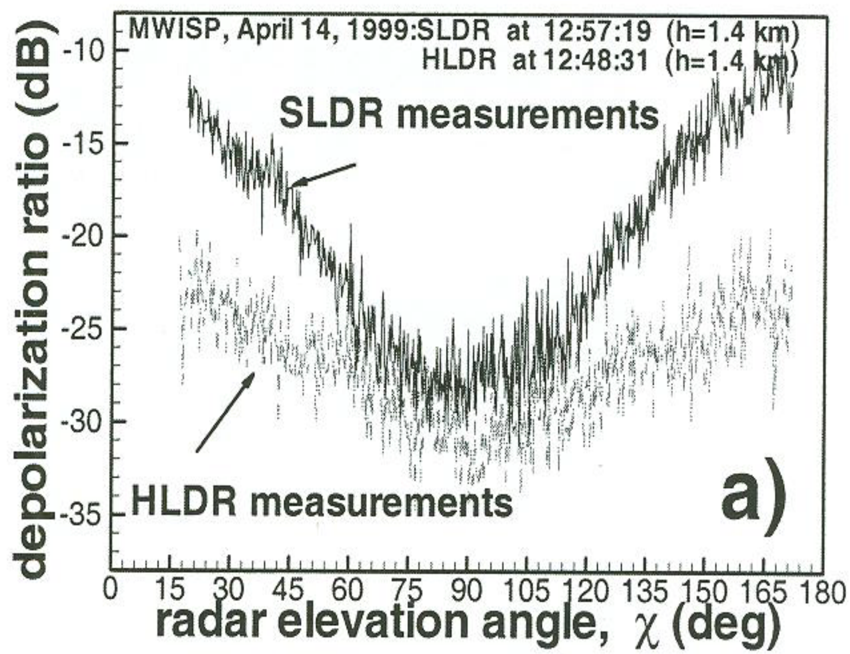
Almost no dependence on particle flutter in SLDR (beam tilts 40^{O}-50^{O})

Strong dependence on particle flutter in (HLDR for all beam tilts)

Measurements (below) confirm theoretical predictions (right). HLDRs are noisier than SLDRs (and weaker by more than 10 dB for low tilt data which are most informative

If both SLDR and HLDR are available then shape and flutter influences can be decoupled





What will be the polarization state for SWACR during StormVEx?