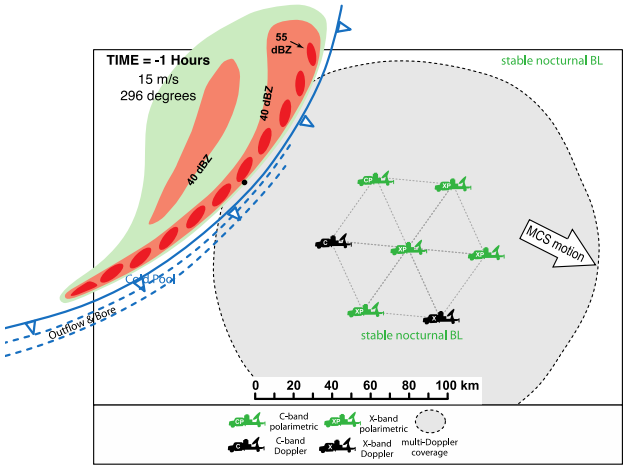
PECAN: Mobile Radar Deployments

Available Assets: Mobile Radars



– Multiple-Doppler Hexagon

- 7 radars
  - 2 C-band radars (2 SMART-Rs) (1 SR is DP)
  - 5 X-band radars (3 DOWs, NOXP, MAX)
    - » Of which, 4 (2 DOWs, NOXP, MAX) are dual polarization

– Not in Hexagon

  - X-band rapid-scan (RAXPOL, dual-polarization)

SMART-R Specs

Transmitter	C-Band 250kW peak power, four selectable pulse durations (0.3-2.5 µs) Selectable PRF: 300-3000 Hz
Antenna	1.5-deg beamwidth 30 degrees / second
Data	Z, V, SW, RhoHV, ZDR 2048 gates, 62.5 m gate length, clutter filtering, staggered PRF
Polarization	SR1 single SR2 dual-pol
Archive	Data burned to writeable CD-ROM

DOW6 DOW7 Specs

Transmitter	X-band 2x 250kW peak power, Pulse duration from 0.2 µs – long duration PRF: 300 – 5000 Hz
Antenna	0.9-deg beamwidth 50 degrees / second
Data	Z,V, SW, RhoHV, ZDR, PhiDP, KDP in dual-45 mode (LDR in H + 45 mode, not in PECAN) ~2000 gates 15, 30, 45, …, long m gate length, clutter filtering, staggered PRF, each PRT's data stored separately Full time series (IQ) (~1 TB per IOP per DOW) TITAN processing, real time upload of CFRADIAL
Polarization	Dual-Polarization, dual-frequency
Archive	Internal RAID (several TB), mirrored external USB3 Raid (1-16 TB)

DOW8 (Not "Rapid-Scan" for PECAN) Specs

Transmitter	250kW peak power, Pulse duration from 0.2 µs – long duratio PRF: 300 – 5000 Hz
Antenna	0.9-deg beamwidth 50 degrees / second
Data	Z,V, SW, ~2000 gates 15, 30, 45, …, long m gate length, clutter filtering, staggered PRF, each PRT's data stored separately Full time series (IQ) (~1 TB per IOP per DOW) TITAN processing, real time upload of CFRADIAL
Polarization	Single Polarization
Archive	Internal RAID (several TB), mirrored external USB3 Raid (1-16 TB)
Wx Obs	Possibly 14 m Wx mast, T, RH, Wind, Pressure, 1 Hz

NOXP (NSSL) Specs

Transmitter	X-Band 250kW peak power, Pulse Duration: PRF: 2500 Hz (Vortex2)
Antenna	0.9-deg beamwidth 30 degrees / second
Data	Z, V, SW, ZDR, RhoHV, PhiDP?, KDP? 75 m gate spacing (Vortex2)
Polarization	dual-pol
Archive	??

MAX (U Alabama) Specs

Transmitter	250kW peak power, four selectable pulse durations (0.4, 0.8, 1.0, 2.0 µs) Selectable PRF: 250-2000 Hz
Antenna	0.95-deg beamwidth 30 degrees / second
Data	Z, V, SW, ZDR, RhoHV, PhiDP, KDP, LDR
Polarization	dual-pol
Archive	?

RAXPOL (OU) Specs

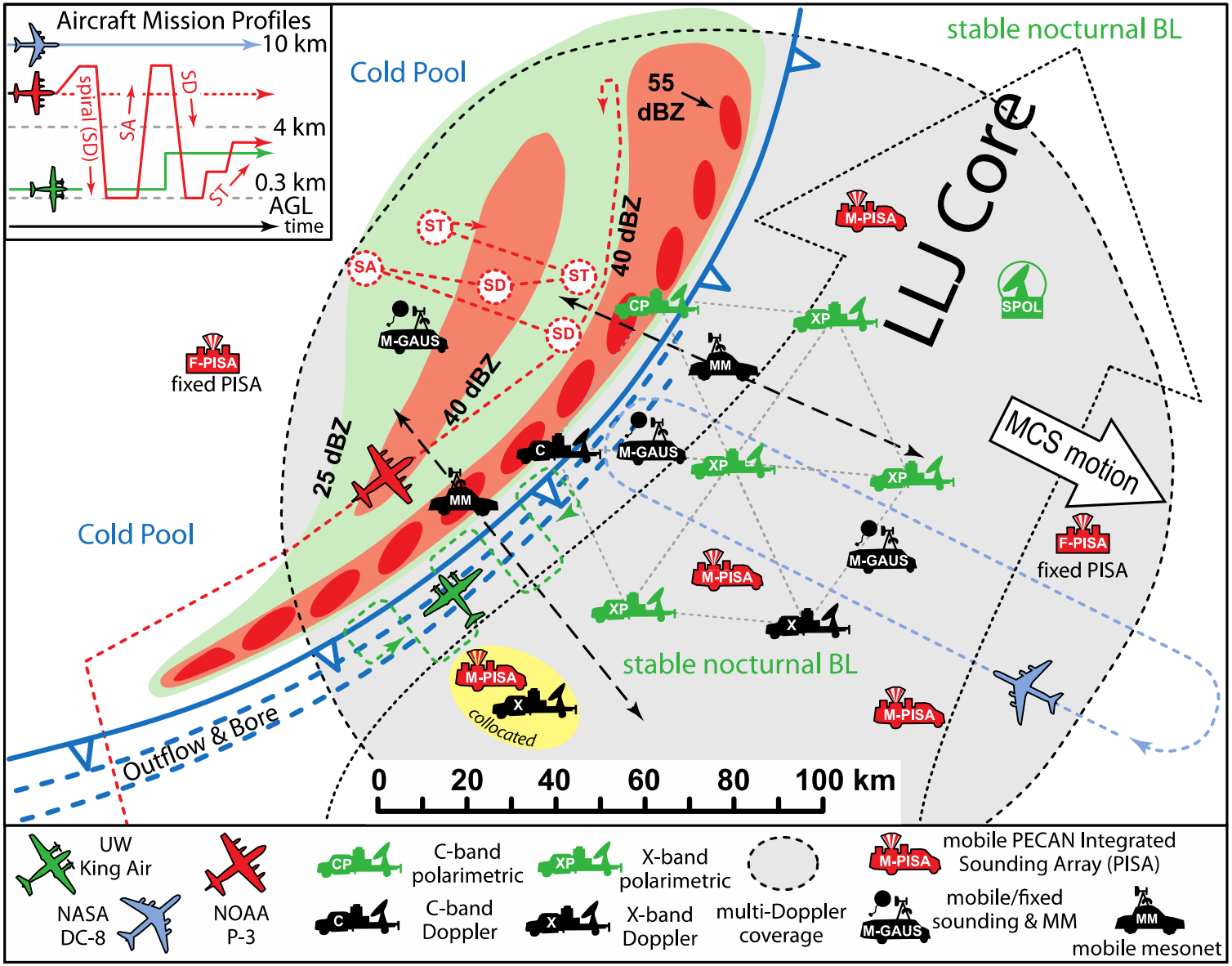
Transmitter	X-band 20kW peak power, 200 W average power Pulse width: 0.1-40 µs Selectable PRF: 1000-10000 Hz
Antenna	1.0-deg beamwidth 180 degrees / second
Data	Z, V, SW, ZDR, RhoHV, PhiDP?, KDP? 7.5 – 75 m gate spacing
Polarization	dual-pol
Archive	?

Mobile Operations and Repair Center (MORC) (CSWR)

Platform	Sprinter van
Masted Comms and Wx	Wx instruments VHF radios, cell, satellite 14-18 m mast (to be installed winter 2014)
Archiving	Workstations (several) for archiving, QC, etc. in field
Coordination	Workstations (several) for coordination, etc. in field
Scientist Capacity	3 in rear, 1 in front, 1 driver (max seat-belted crew = 5)

MORC likely deployed for missions where DOWs do not return to Hays

Mobile Radar (hexagon) + All Assets



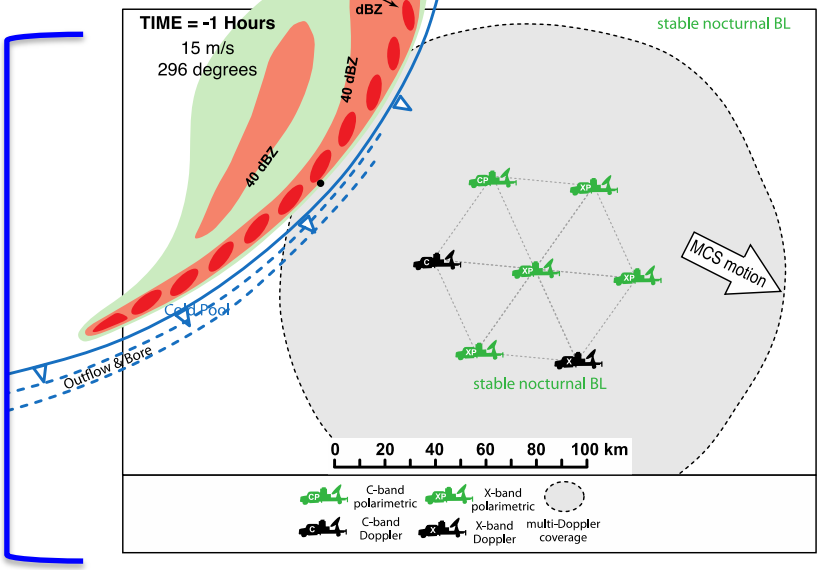
Example during an MCS Deployment

The Hexagon

Baselines: 30-35 km
"Diameter": 60-70 km. Can be rotated.

For MCS IOP:

- SR's (C-band are upstream),
- DOWs are in 2nd line,
- MAX, NOXP are "east"

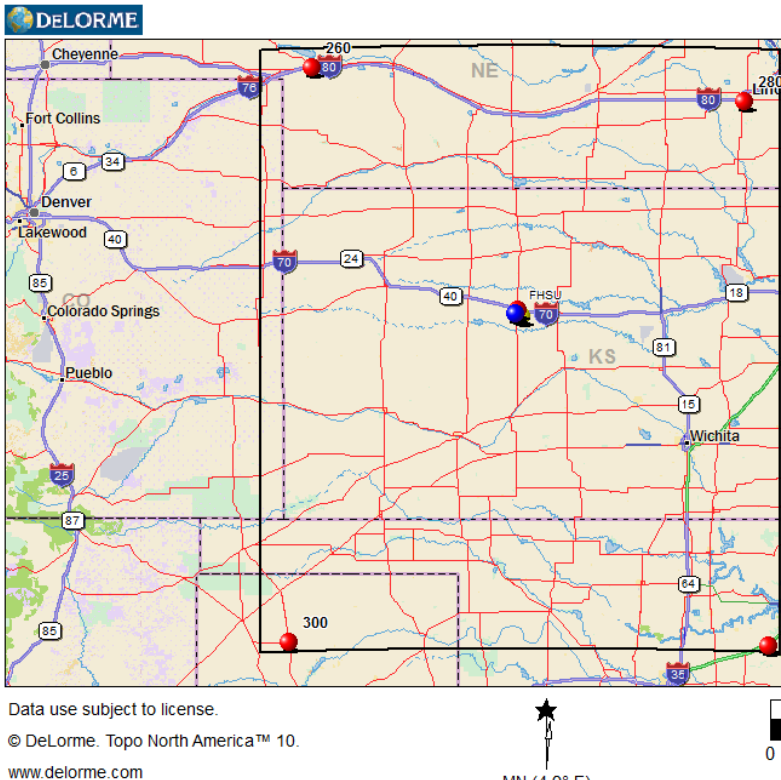


Start time of data collection ~ 9pm. (earlier?)

- Typical distance 150-200 miles. 2.5 – 3 hours
- Distance to sites as much as 300 miles ~5 hours
- Worst case is 360 miles at extreme SE ~ 6 hours
- Set up time and warm up ~ 0.5 hours

Departure from Hays 2:30pm – 6:30pm
Typically ~ 5pm.

Radars are stationary during IOP. No "chasing".



Conrad days PECAN radars: Sit and Spin

HAYS Offers: Sip and Spin

Bar and Laundromat

The Hexagon

Scanning Strategies:

MCS:

- Top angle: 50 degrees ~ 15 km AGL @ 15 km range
- 5 minute volumetric updates
- NOXP, SR1, SR2, MAX, DOW8: 30 deg/s
- 24 tilts
- DOW6, DOW7: 45 deg/s
- 36 tilts (and zenith calibration sweeps)

Clear Air Mode (e.g., CI, Bore, and before MCS reaches the hexagon):

- Top angle: 30 degrees = 3km AGL @ 12 km range
- 10 minute volumetric updates
- ½ - 1 degree elevation increments
- 31 or more tilts for all radars
- 20 deg/sec scans more pulses/beam for better sensitivity

Everyone analyzing radar data has to count on all 7 radars:

- **Critical that all 7 radars are synched**
- **Critical that all 7 radars scan 360 deg full IOP, in modes requested by Radar Coord**

The Hexagon

Radar Coordinator duties (details being discussed)

- following consensus of PI's or Mission Scientist, or Governor of Kansas, decides hexagon location (Ziegler talk) and configuration (MCS, CI, Bore)
- in Hays or in a hexagon radar.
- coordinates with radar Pis and crews to ensure that hexagon is properly executed
- coordinates any en route changes to hexagon with PIs and/or MS
- establishes scan modes and changes of scan modes and coordinates this with radars.
- warns radars of safety hazards
- communicates end of operations to radars
- ensures that all radar teams get to lodging locations ("takes attendance")

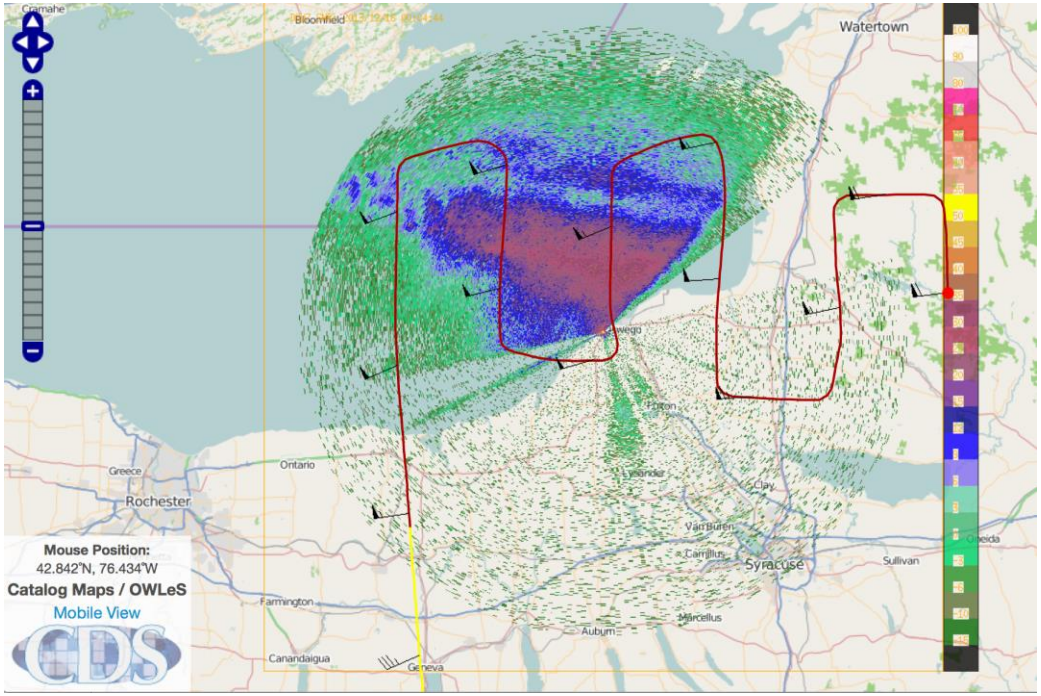
The Hexagon

Communications

- Verizon cellular is pretty good in Kansas.
- 2nd carrier could fill Verizon holes (ATT/Sprint)
- DOW6 and DOW7 with 18 m masts and high power VHF may be able to talk to others in hexagon.
- Real Time Radar Data to EOL Field Catalog
- SR (C-band) data and DOW7 (central) data highest priority for mission planning.
- 88D and EOL Field Catalog radar imagery probably good enough to warn of rare events where evacuation might be necessary
- Evacuation only in very rare circumstances

Mobile Radar Data during PECAN:

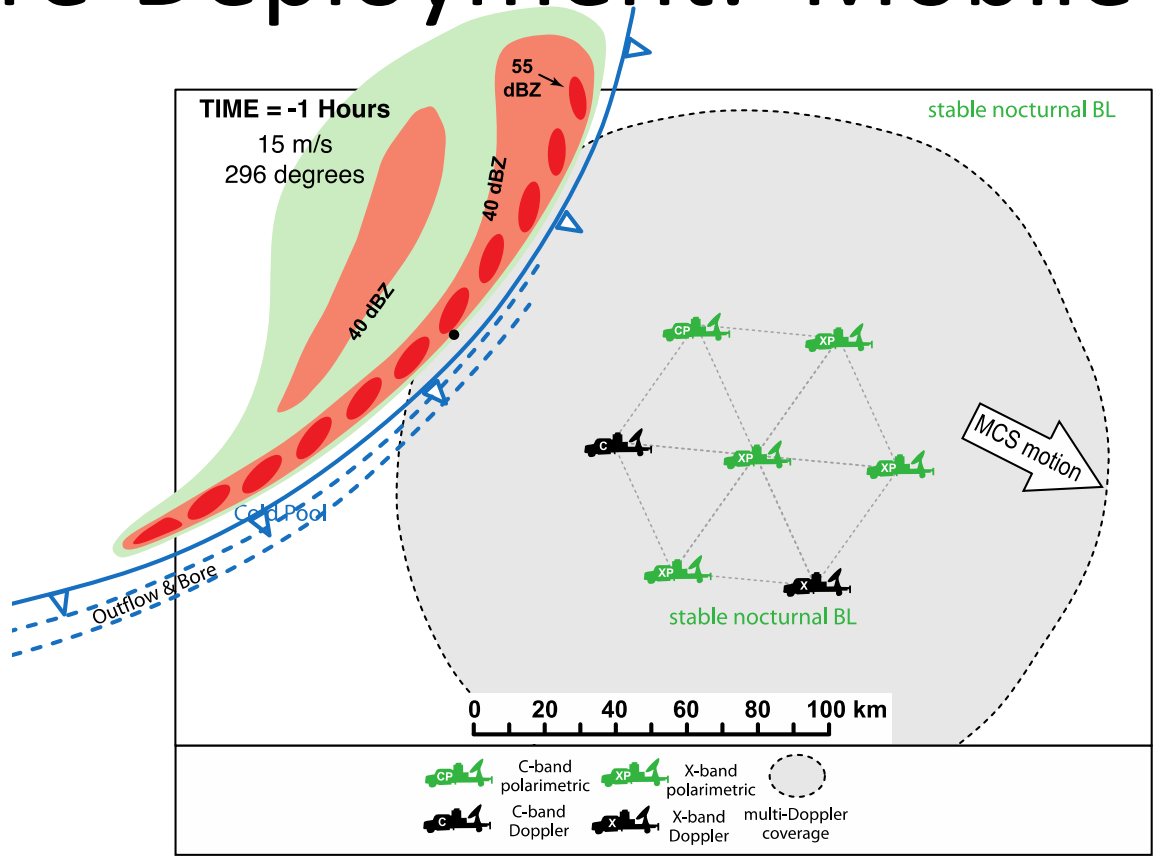
- Real-time display on NCAR field catalog of data from several radars (DOWs, SRs)



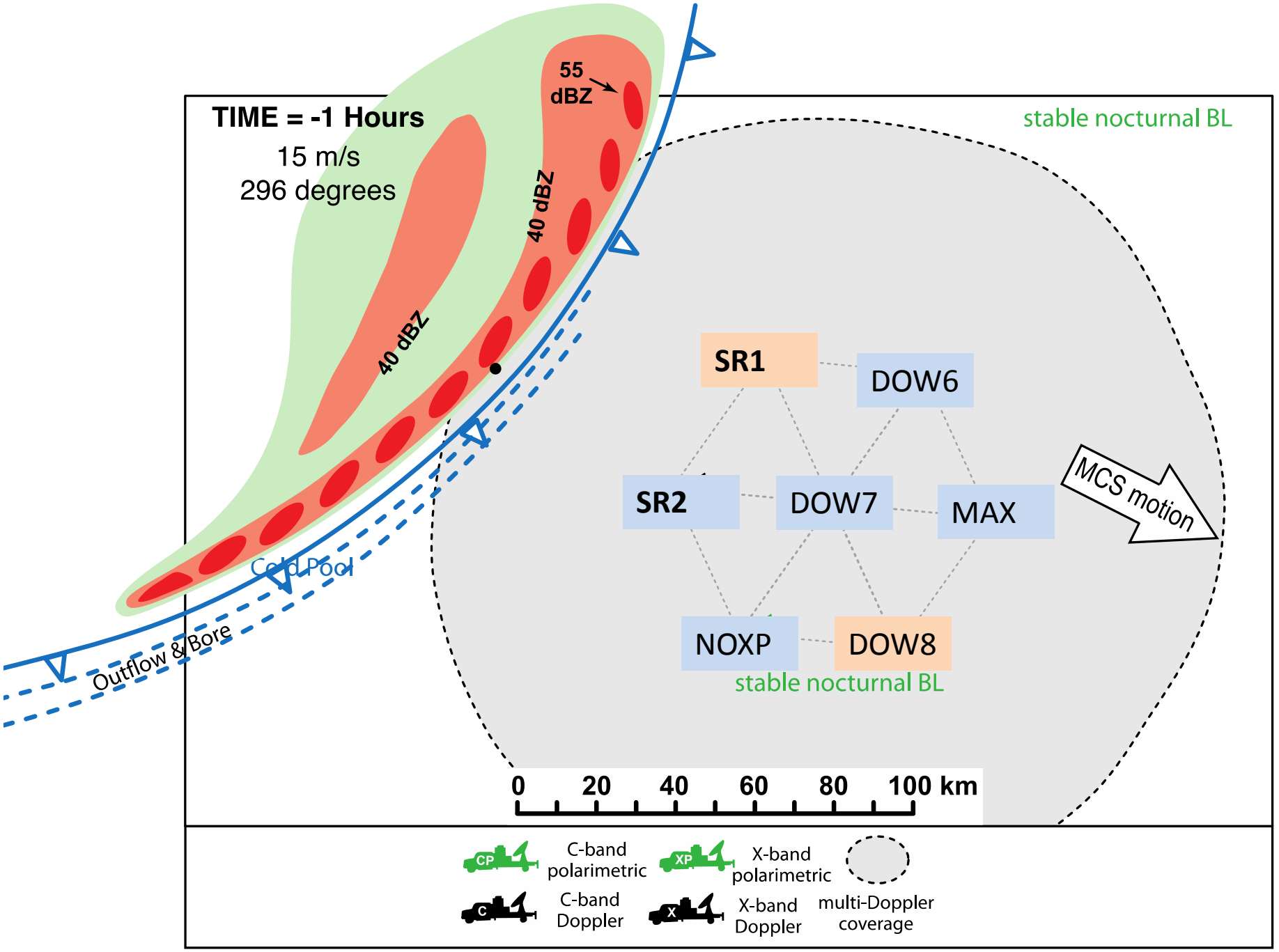
Mobile Radar Data after PECAN:

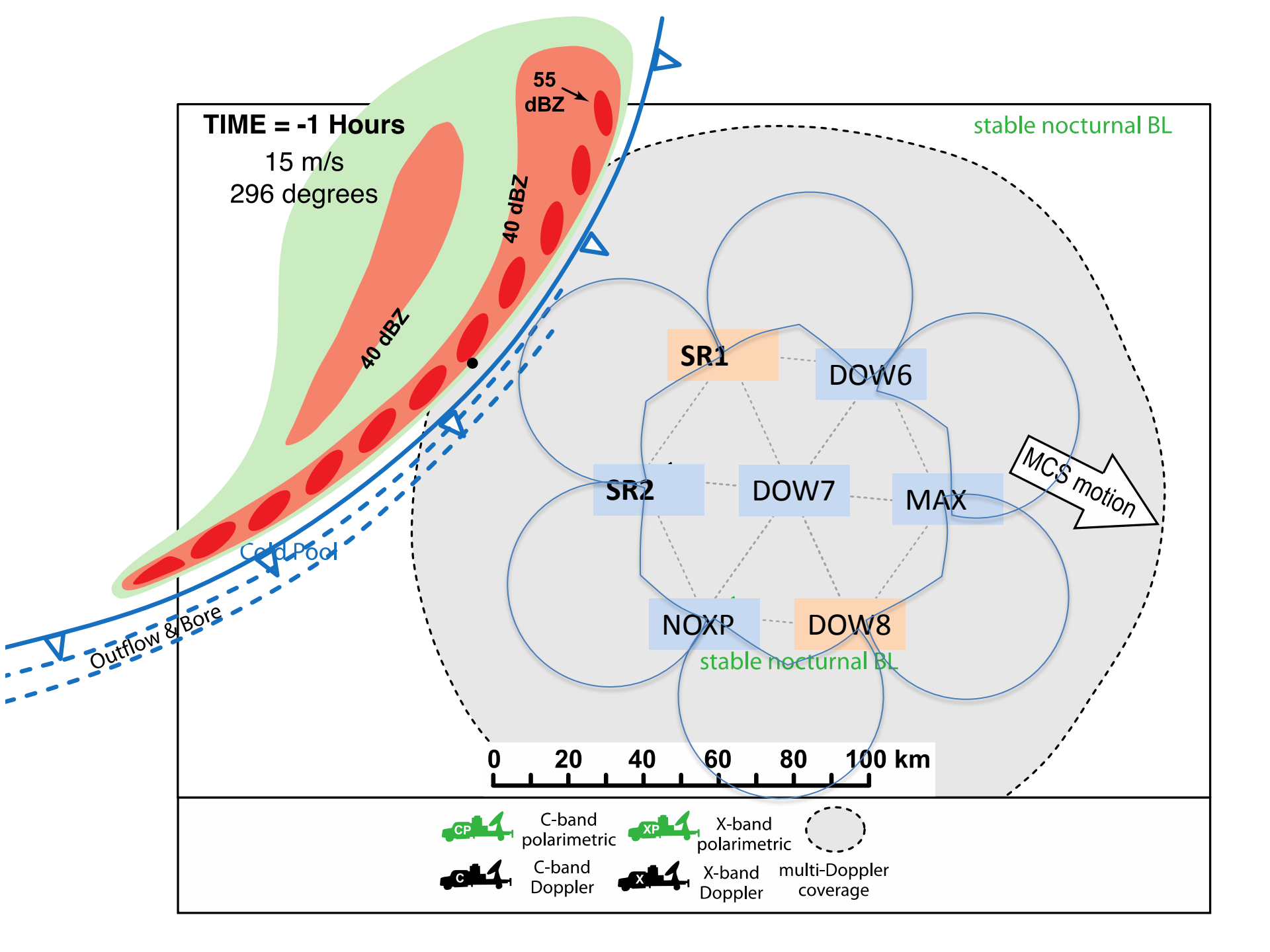
- Quick-look from all radars (1-deg?) before final, QC-ed data available
- DORADE (compliant) format
- All QC-ed radar data at sites available to PECAN Pis.

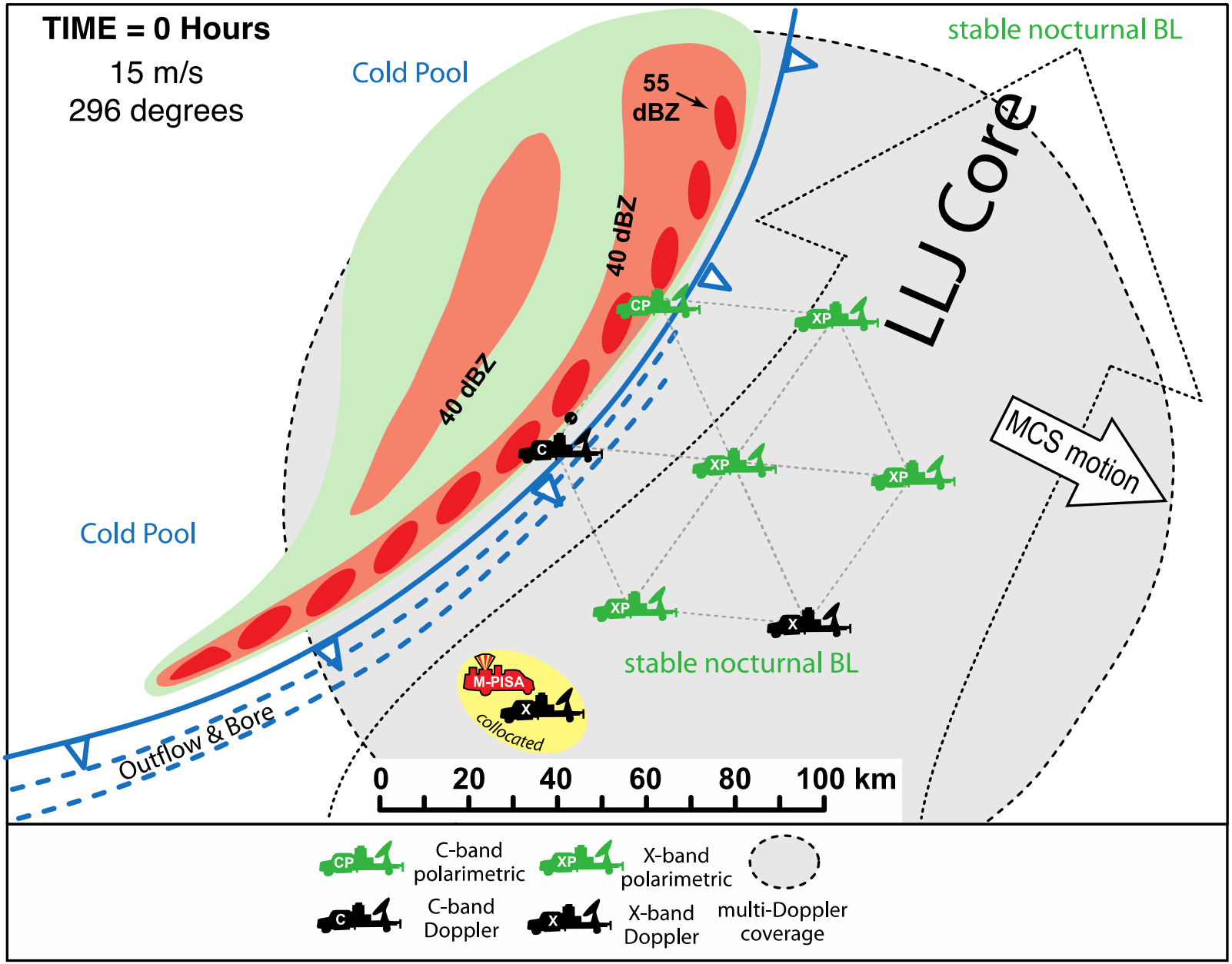
MCS Pre-Deployment: Mobile Radars

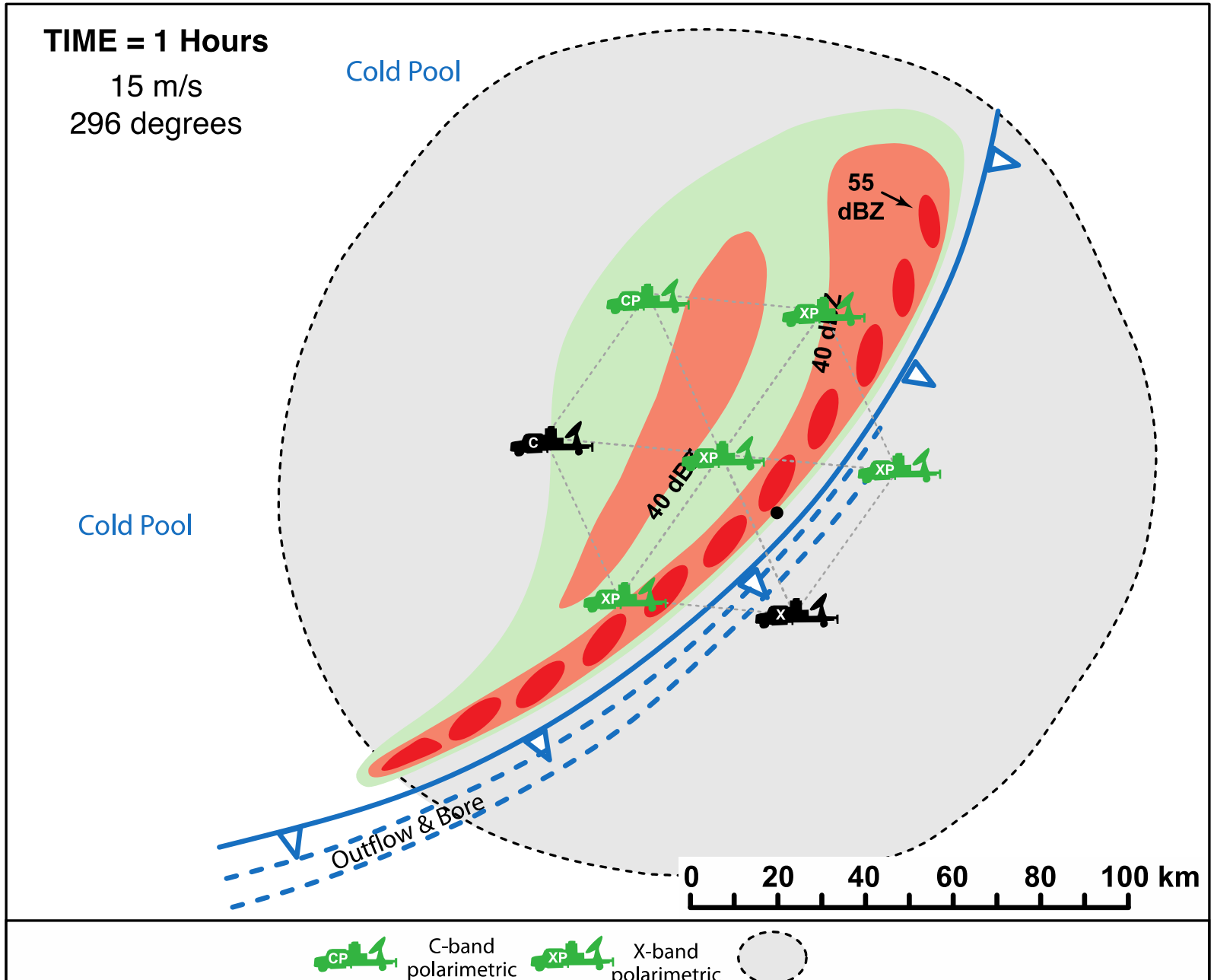


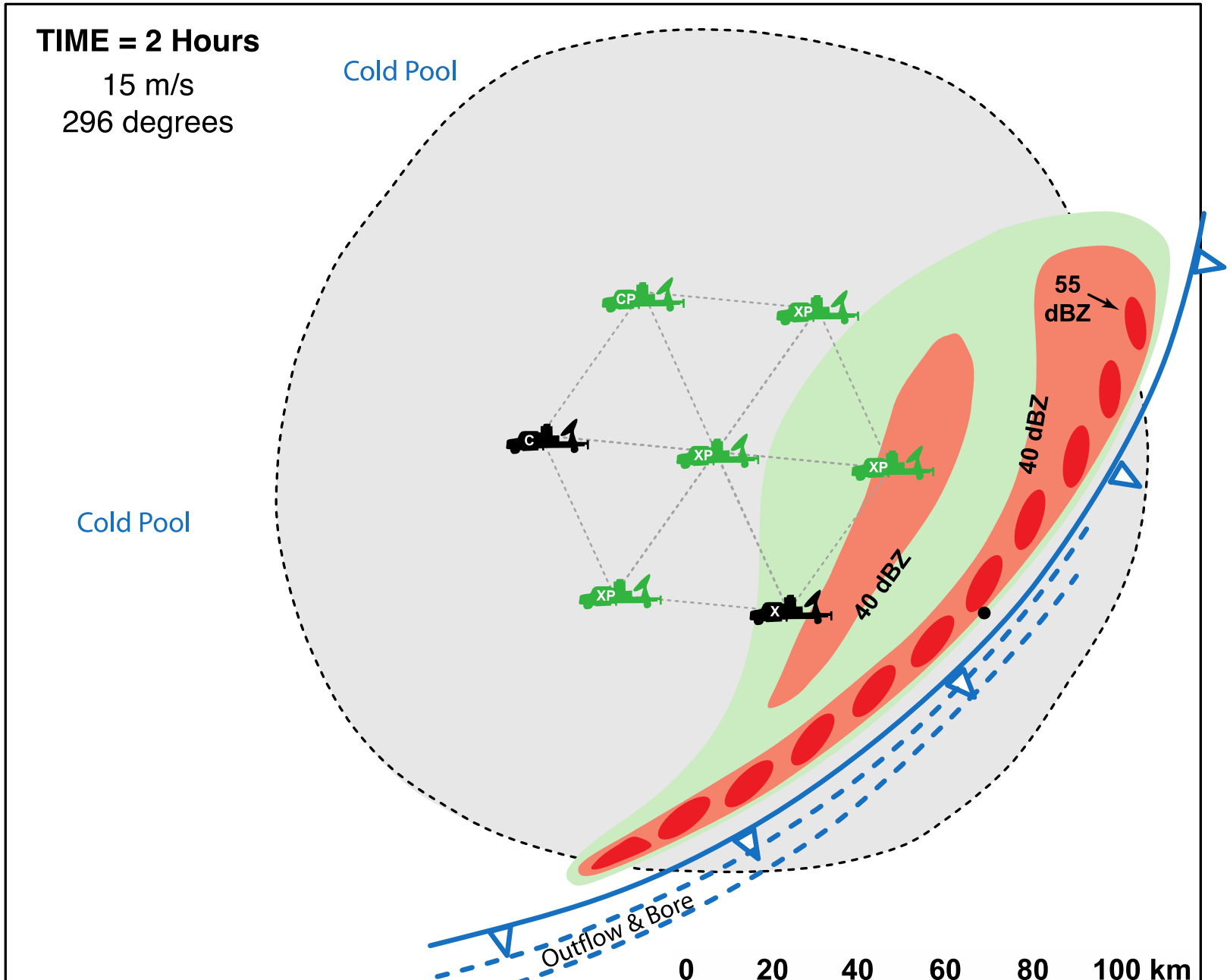
- Western-most radars need to be in position (and ready to operate) at -1.5 to -1.0 hours (3600 s x 15 m/s)
  - Can "cheat" towards the deployment direction, even before final forecast decision
  - Perhaps allows dinner, and/or pre-sunset deployment, etc.

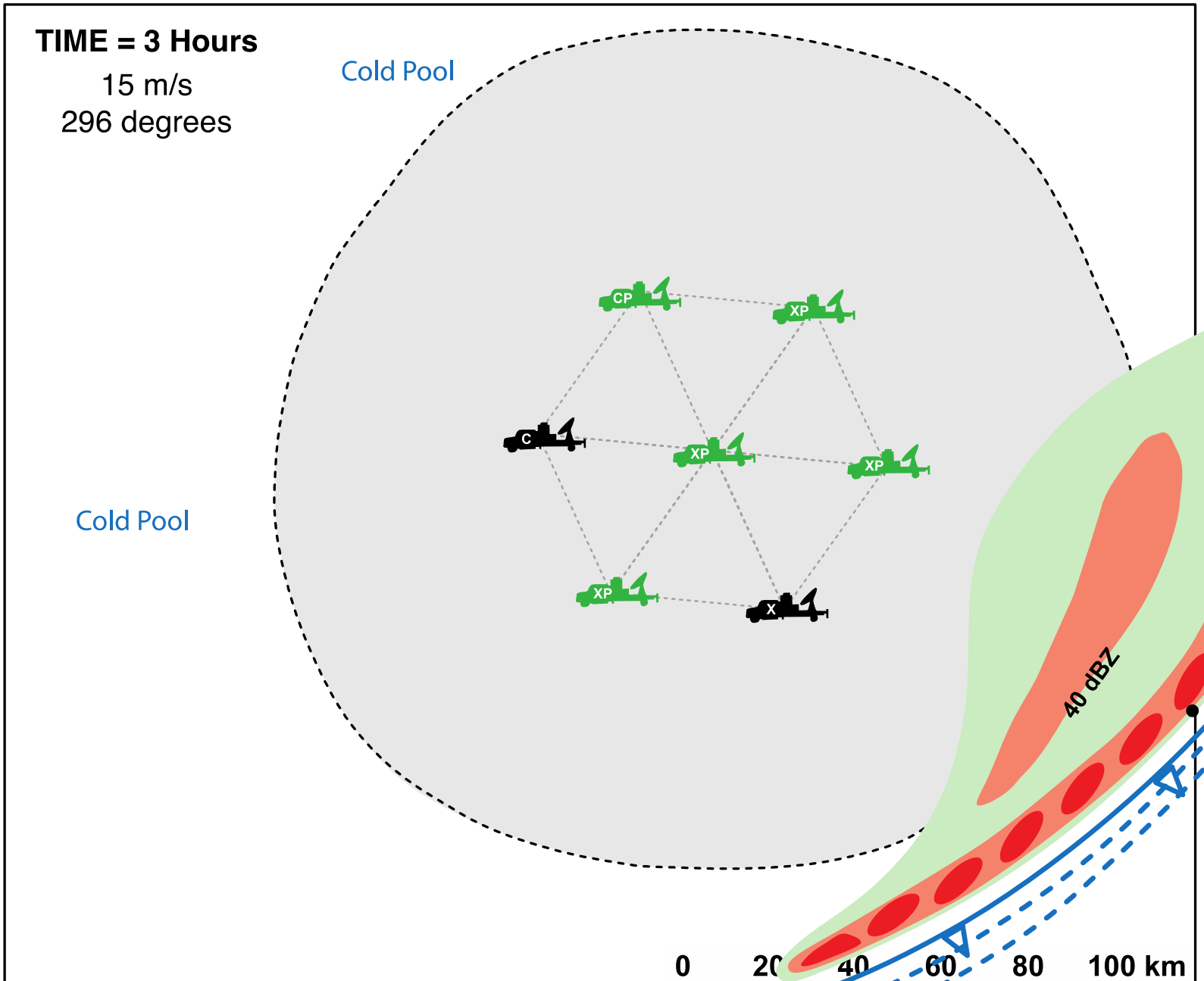

TIME = -1 Hours
15 m/s
296 degrees
55 dBZ
40 dBZ
40 dBZ
Cold Pool
Outflow & Bore
stable nocturnal BL
SR1
DOW6
SR2
DOW7
MAX
MCS motion
NOXP
DOW8
stable nocturnal BL
0 20 40 60 80 100 km
CP
C-band polarimetric
XP
X-band polarimetric
C
C-band Doppler
X
X-band Doppler
multi-Doppler coverage


TIME = -1 Hours
15 m/s
296 degrees
55 dBZ
40 dBZ
40 dBZ
stable nocturnal BL
SR1
DOW6
SR2
DOW7
MAX
MCS motion
NOXP
DOW8
stable nocturnal BL
Cold Pool
Outflow & Bore
0 20 40 60 80 100 km
CP
C-band polarimetric
XP
X-band polarimetric
C
C-band Doppler
X
X-band Doppler
multi-Doppler coverage


TIME = 0 Hours
15 m/s
296 degrees
Cold Pool
55 dBZ
40 dBZ
40 dBZ
stable nocturnal BL
LLJ Core
MCS motion
CP
XP
C
XP
XP
XP
X
Cold Pool
stable nocturnal BL
M-PISA
X
collocated
Outflow & Bore
0 20 40 60 80 100 km
CP
C-band polarimetric
XP
X-band polarimetric
C
C-band Doppler
X
X-band Doppler
multi-Doppler coverage


TIME = 1 Hours
15 m/s
296 degrees
Cold Pool
Cold Pool
55 dBZ
40 dBZ
40 dBZ
CP
XP
C
XP
XP
XP
X
Outflow & Bore
0
20
40
60
80
100 km
CP
C-band polarimetric
XP
X-band polarimetric


TIME = 2 Hours
15 m/s
296 degrees
Cold Pool
Cold Pool
CP
XP
C
XP
XP
XP
X
55
dBZ
40 dBZ
40 dBZ
Outflow & Bore
0
20
40
60
80
100 km


TIME = 3 Hours
15 m/s
296 degrees
Cold Pool
Cold Pool
CP
XP
C
XP
XP
XP
X
40 dBZ
40 dBZ
0
20
40
60
80
100 km

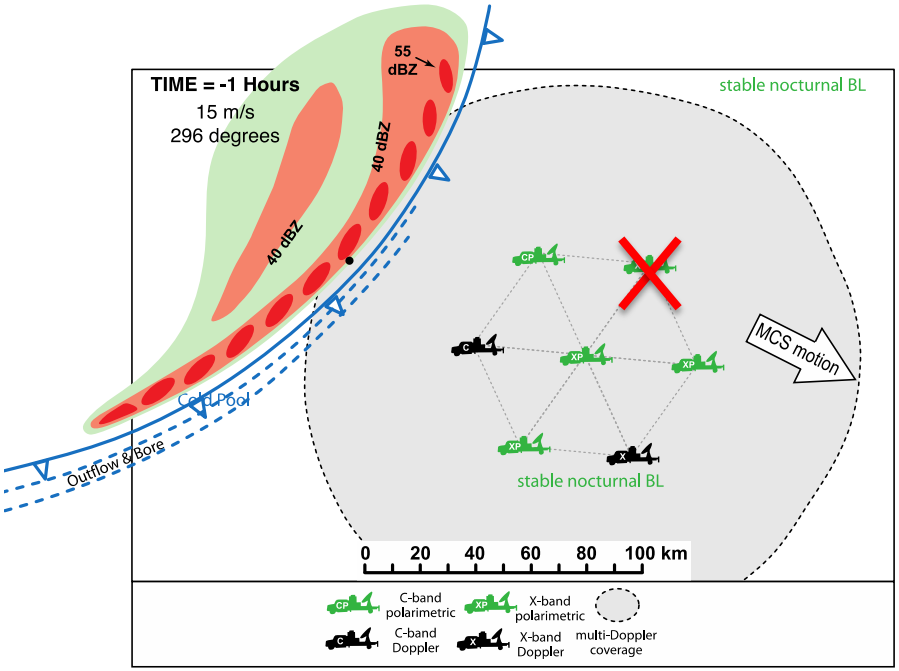
MCS (and other mission) Adaptability:

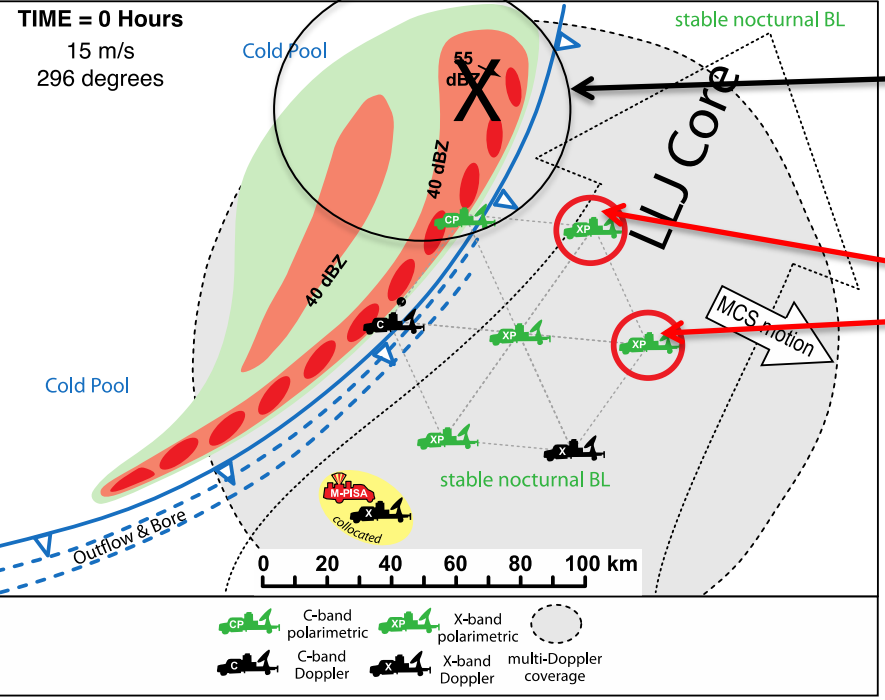
- Can radars adjust?
  - Western (overtaken or soon-to-be overtaken) radars probably cannot adjust
  - Eastern/Downstream radar(s) may have some flexibility in changing forecast
    - Out of the precipitation (dry roads)
    - E.g., If traveling ~45 mph, could travel ~70 km to the south in ~ 1 hour

- What if a radar is unavailable prior to IOP?

- What if radar breaks during IOP?

  - Pentagon?
  - Hexagon with hole?
  - Rectangle?
  - RAXPOL?

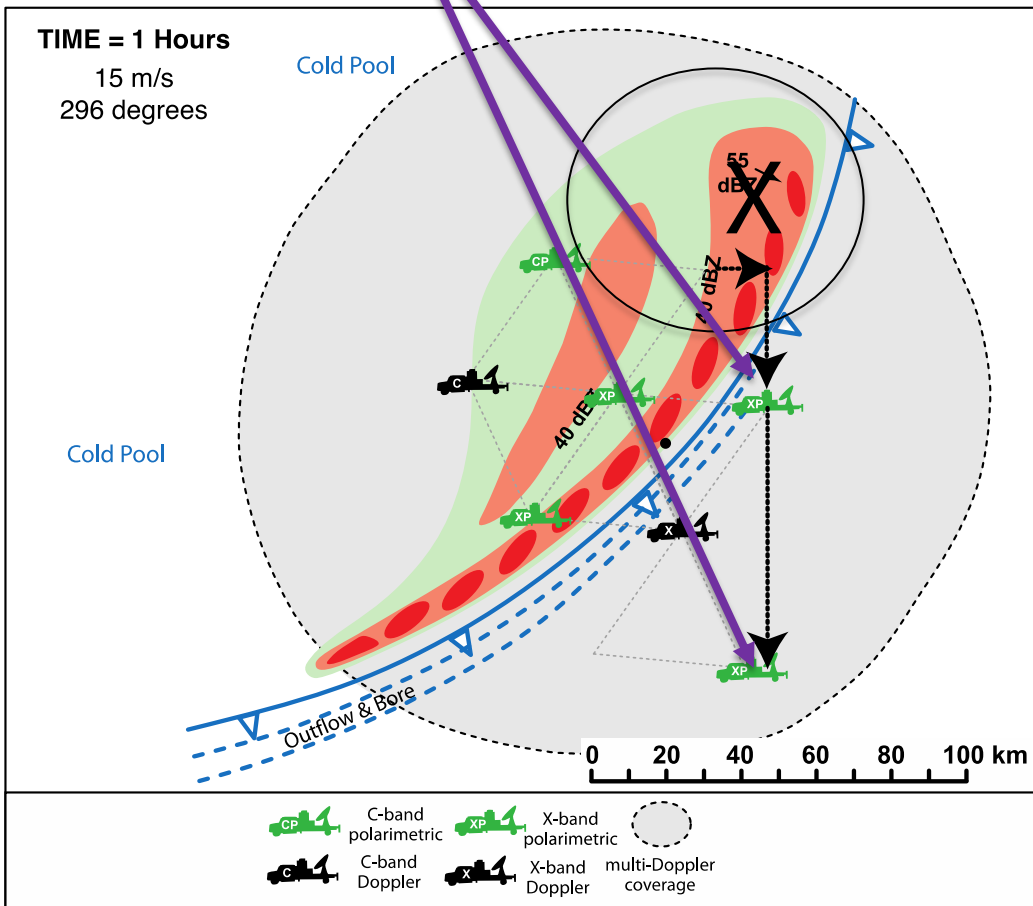




Example: Northern part not interesting – Really want to be south

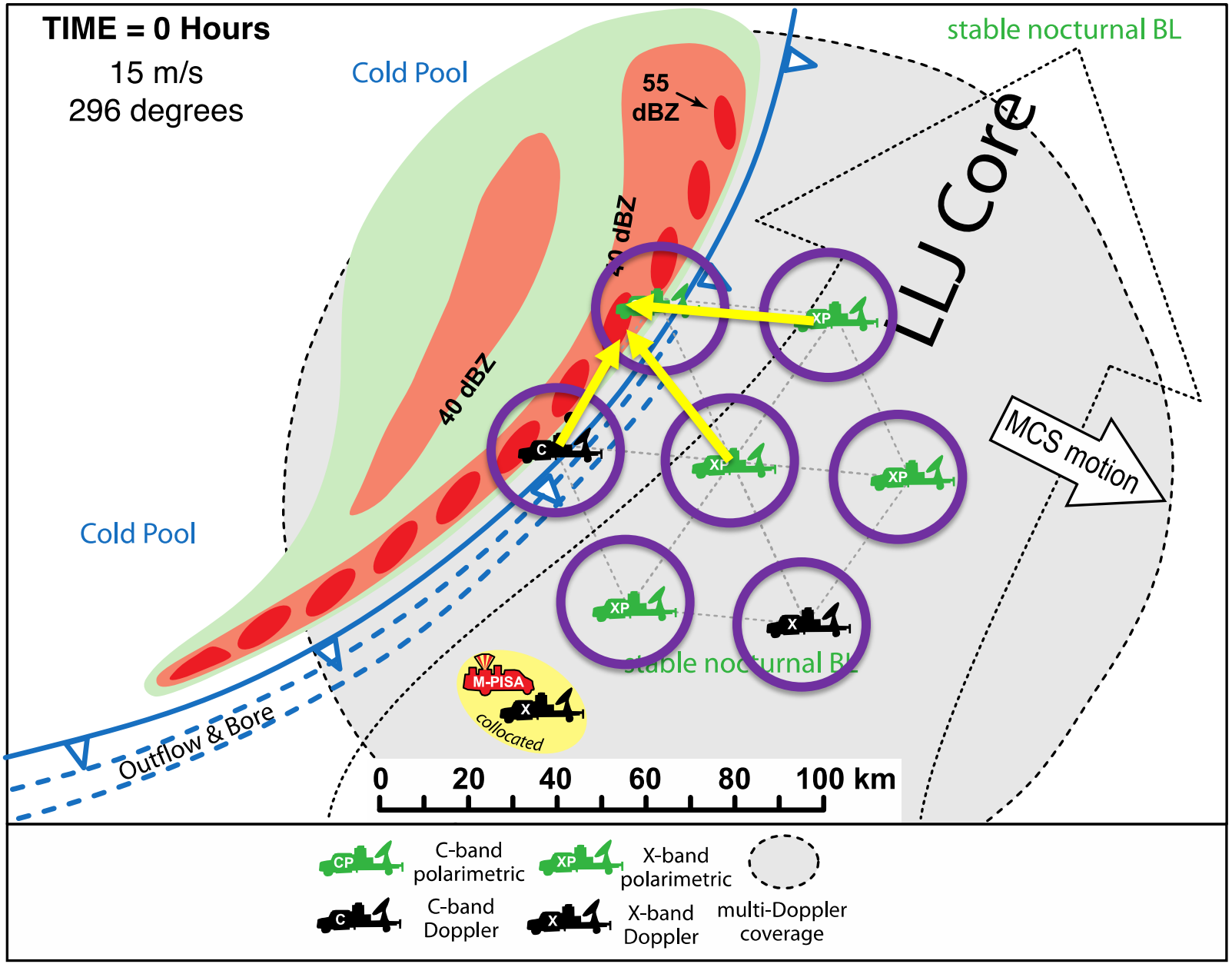
Move these radars

Each one to the south



MCS (and other mission) Adaptability:

“Dead” Zones at 15 km AGL assuming 50 degree to elevations



Lowest Radar Observation level

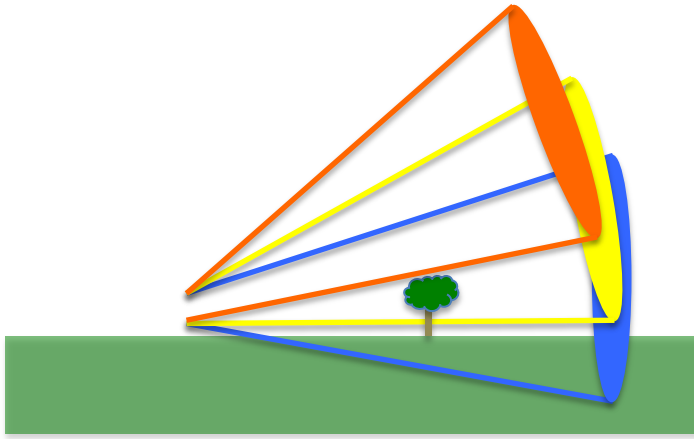
- Lowest Beam
  - No terrain/foliage/structure blockage
    - Lowest untruncated beam

      ~0.5 deg for 1 deg bw X-band,

      (~0.8 deg for 1.5 deg bw C-band)

      Minimum observation height:
      - Range 20 km -> ~200 (300) m AGL
      - Range 50 km -> ~600 (850) m AGL
  - Light Blockage 1 degree
    - Lowest untruncated beams 1.5 (1.8) deg

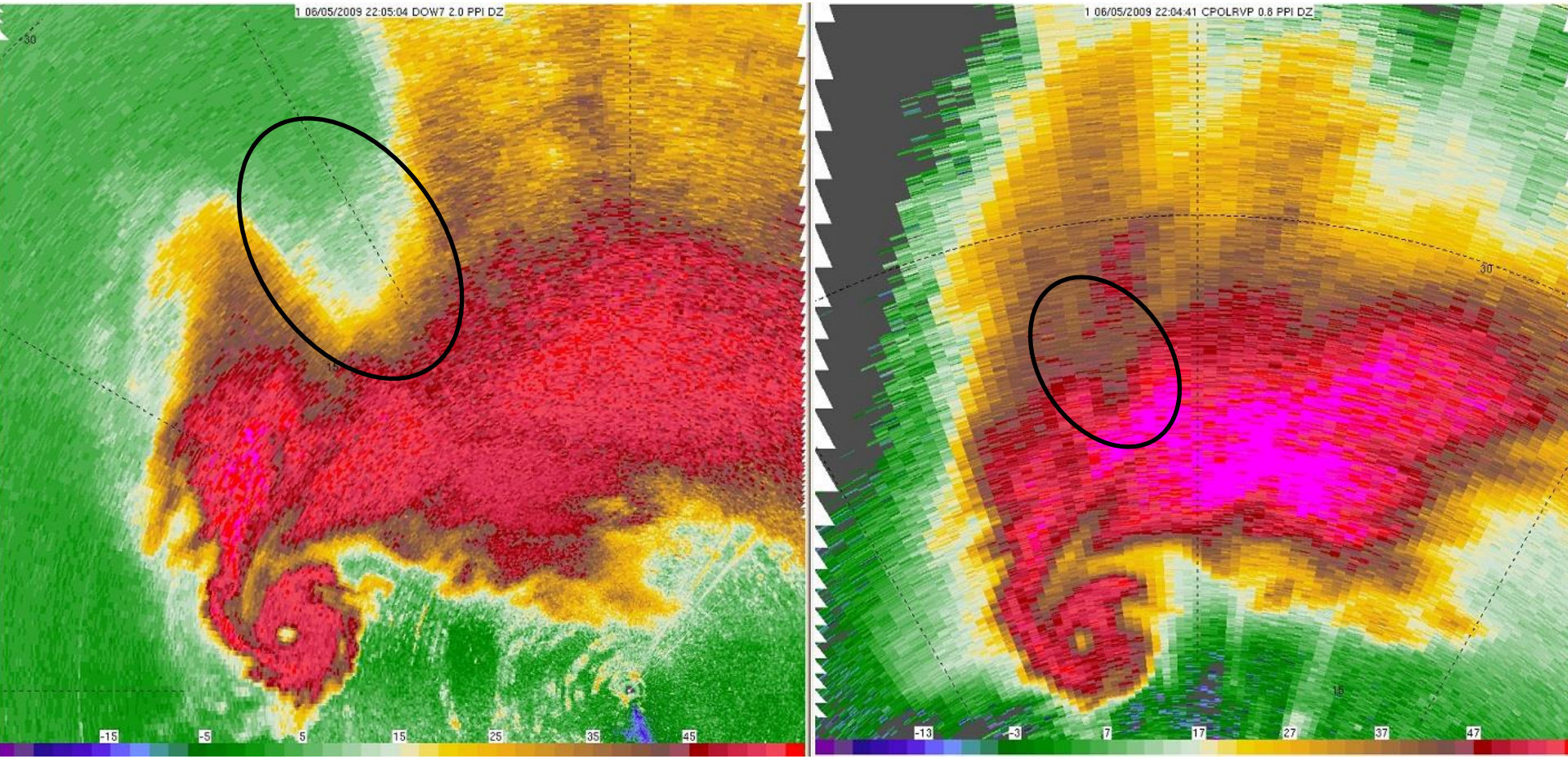
      Minimum observation height:
      - Range 20 km -> ~550 (650) m AGL
      - Range 50 km -> ~1.5 (1.7) km AGL



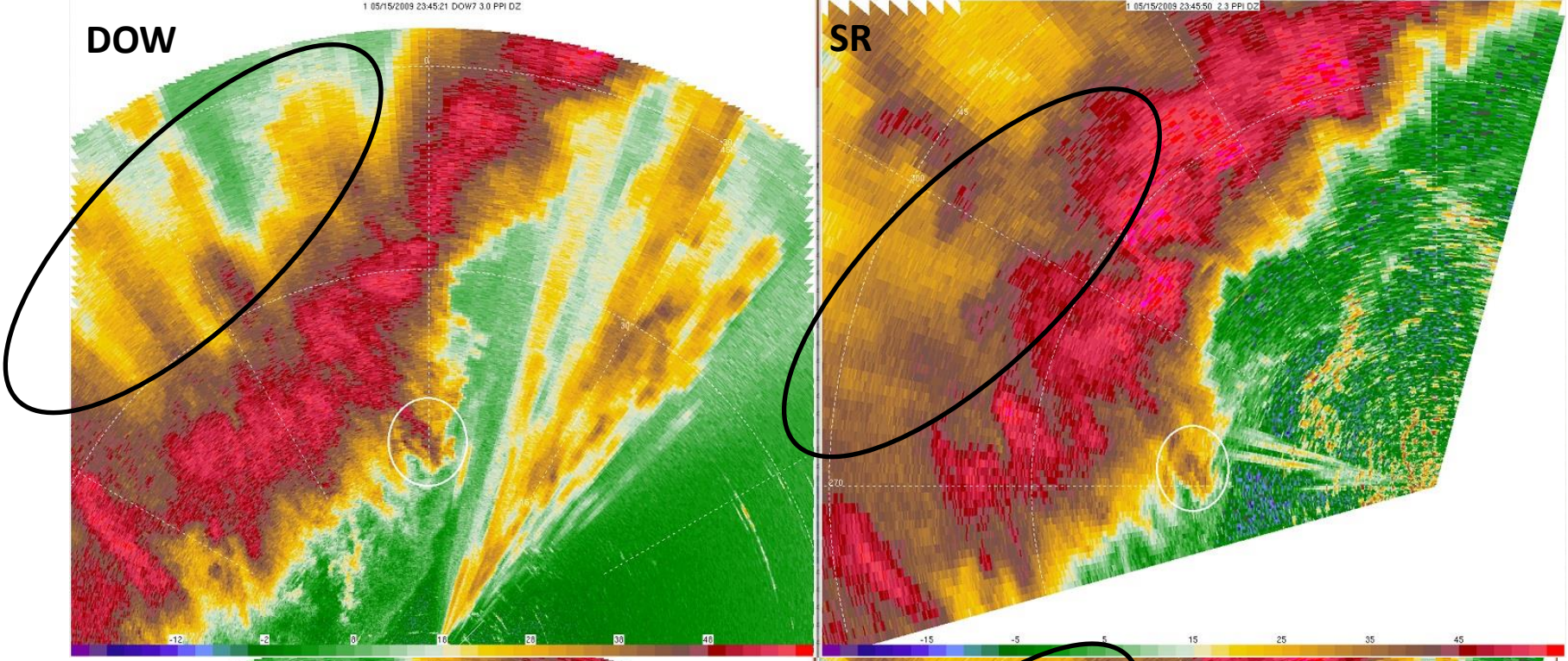
Attenuation is bad at C-band
And really bad at X-band

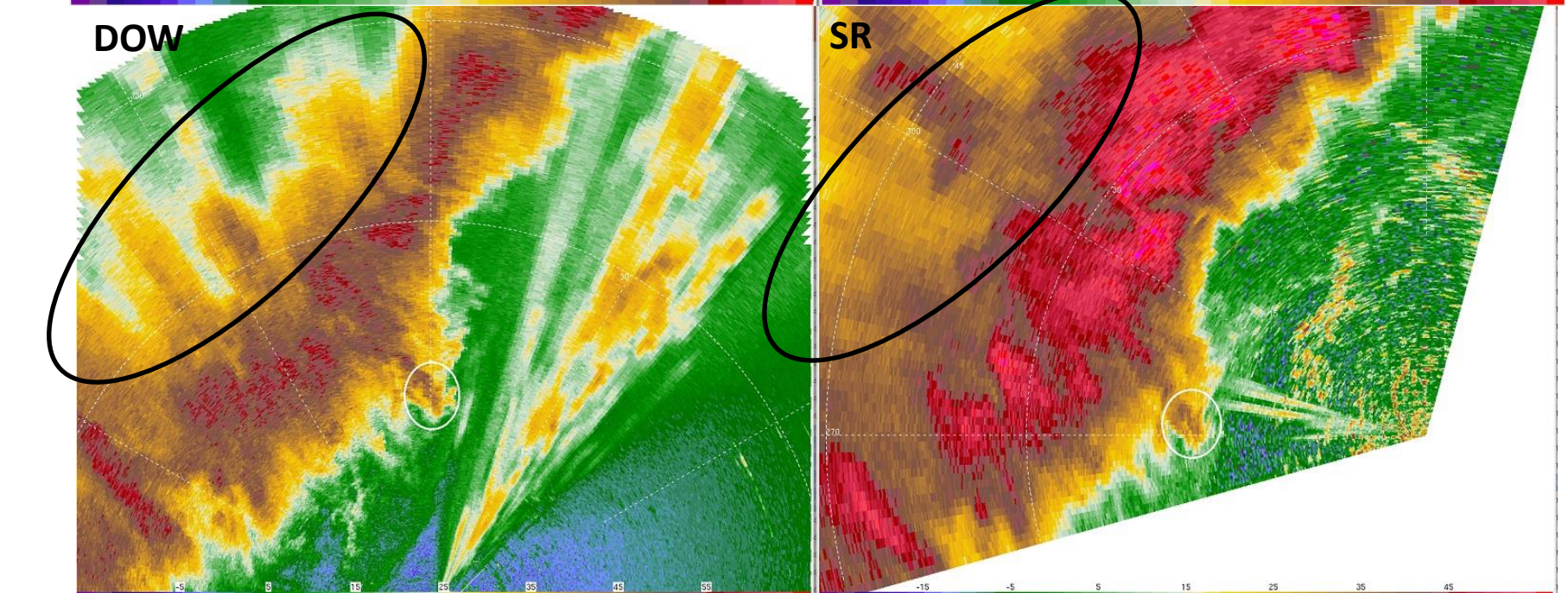
DOW

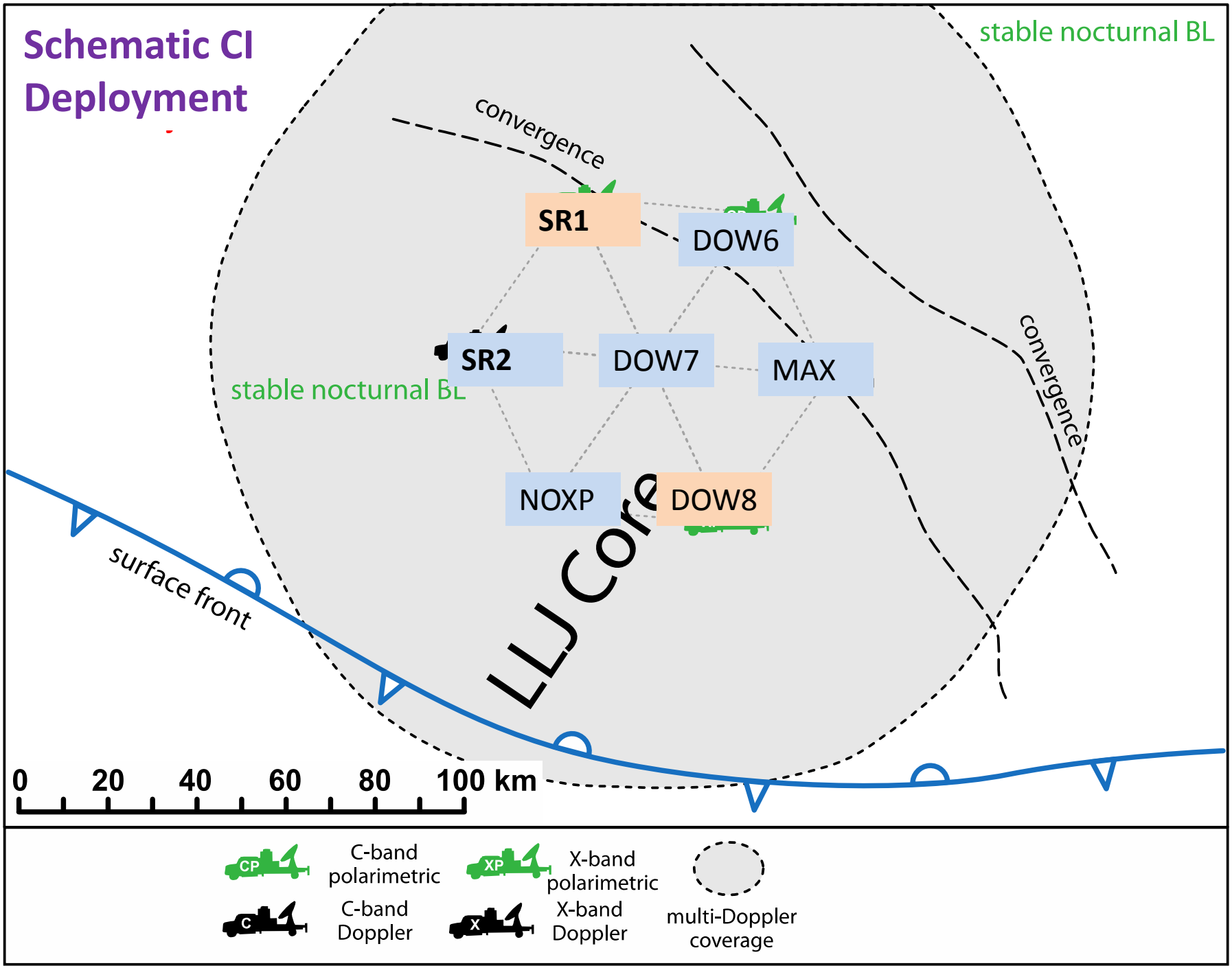
SR

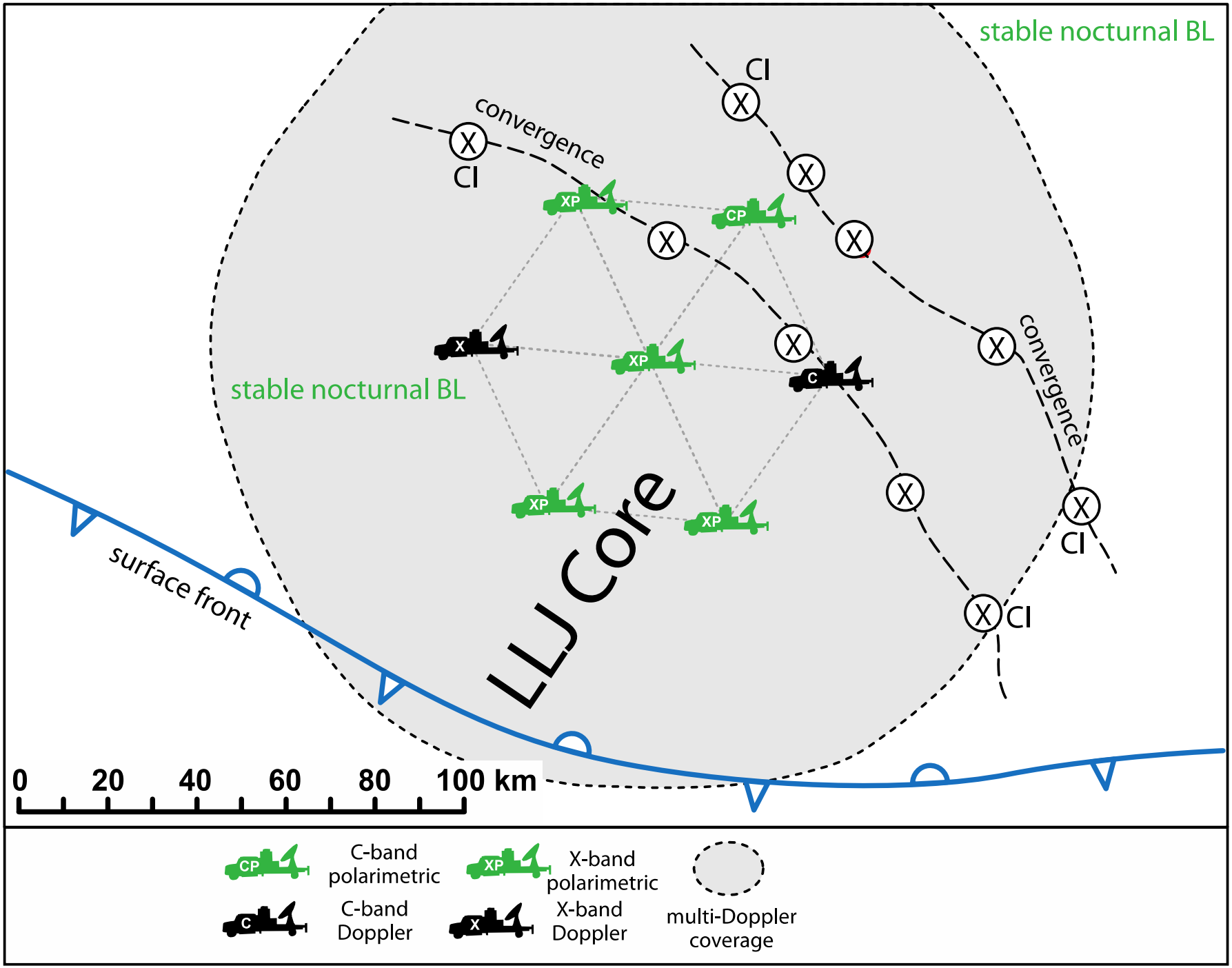


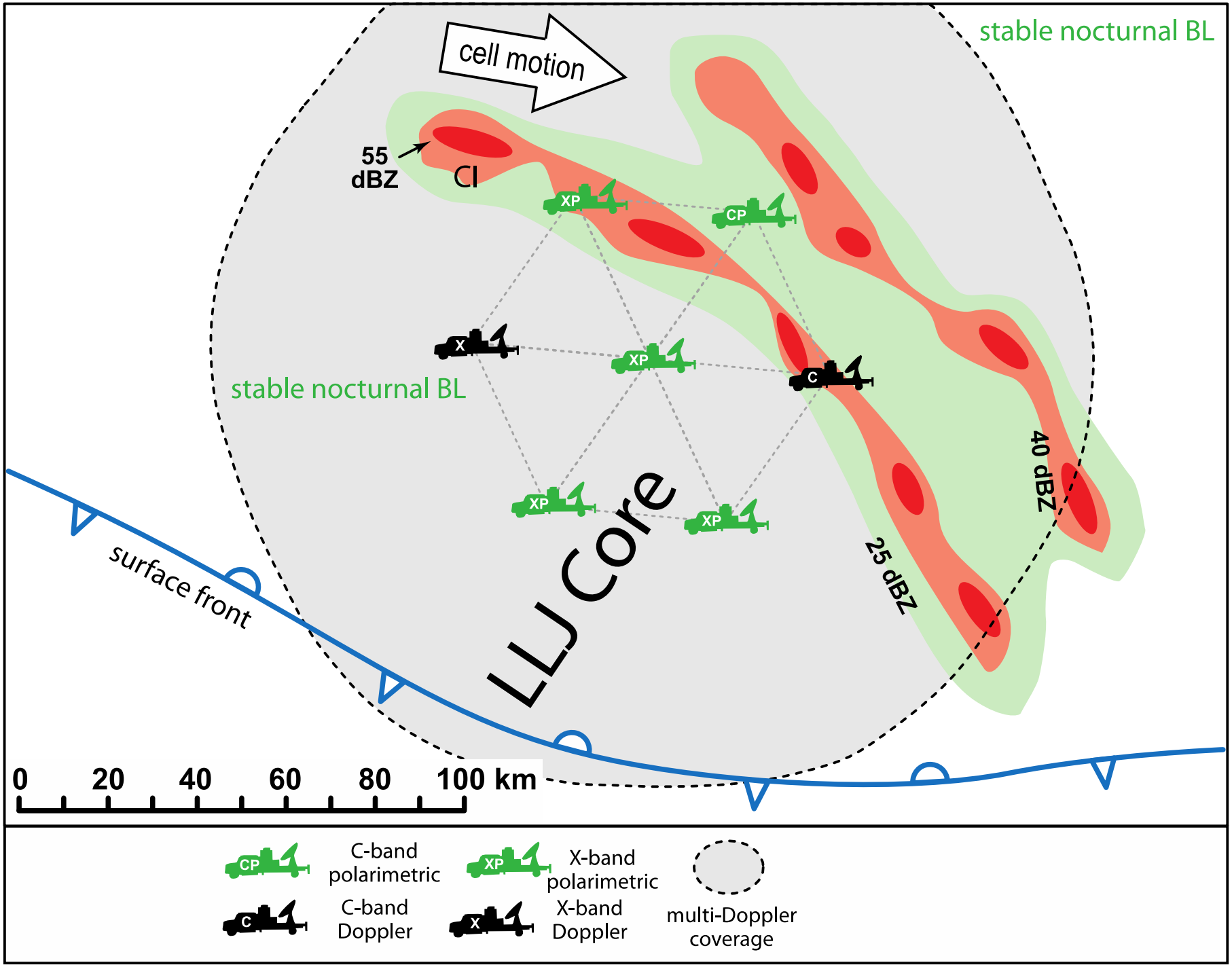
Example from Vortex2


DOW
SR


DOW
SR

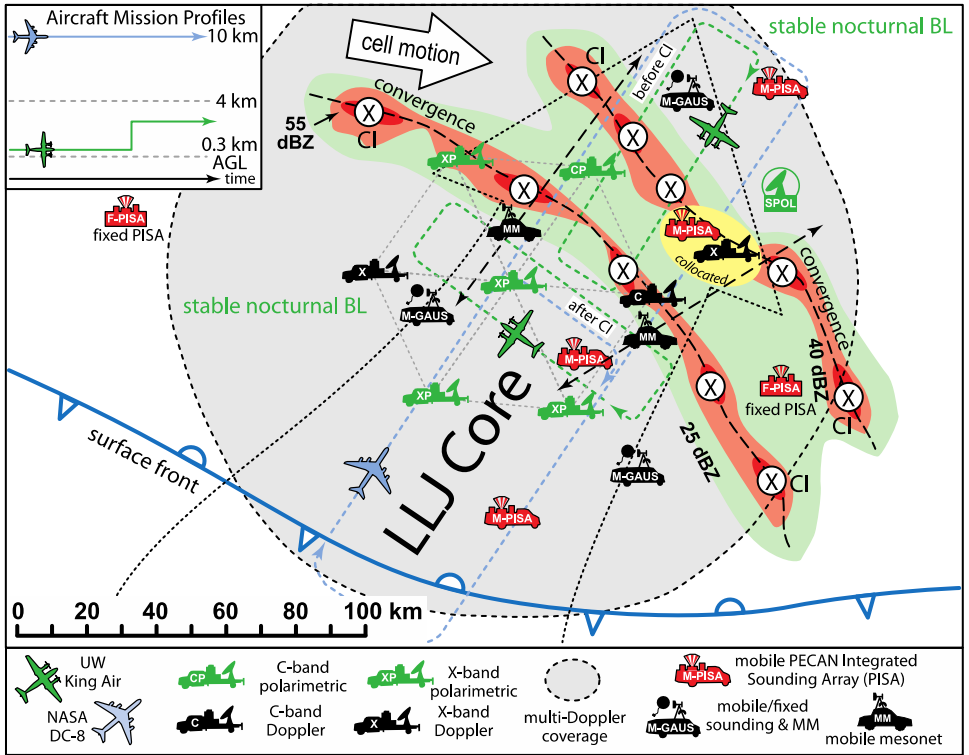

Schematic CI Deployment
stable nocturnal BL
convergence
SR1
DOW6
SR2
DOW7
MAX
stable nocturnal BL
convergence
NOXP
DOW8
LLJ Core
surface front
0 20 40 60 80 100 km
C-band polarimetric
X-band polarimetric
C-band Doppler
X-band Doppler
multi-Doppler coverage


stable nocturnal BL
CI
convergence
CI
XP
CP
X
C
stable nocturnal BL
convergence
LLJ Core
surface front
CI
CI
0 20 40 60 80 100 km
C-band polarimetric
X-band polarimetric
C-band Doppler
X-band Doppler
multi-Doppler coverage

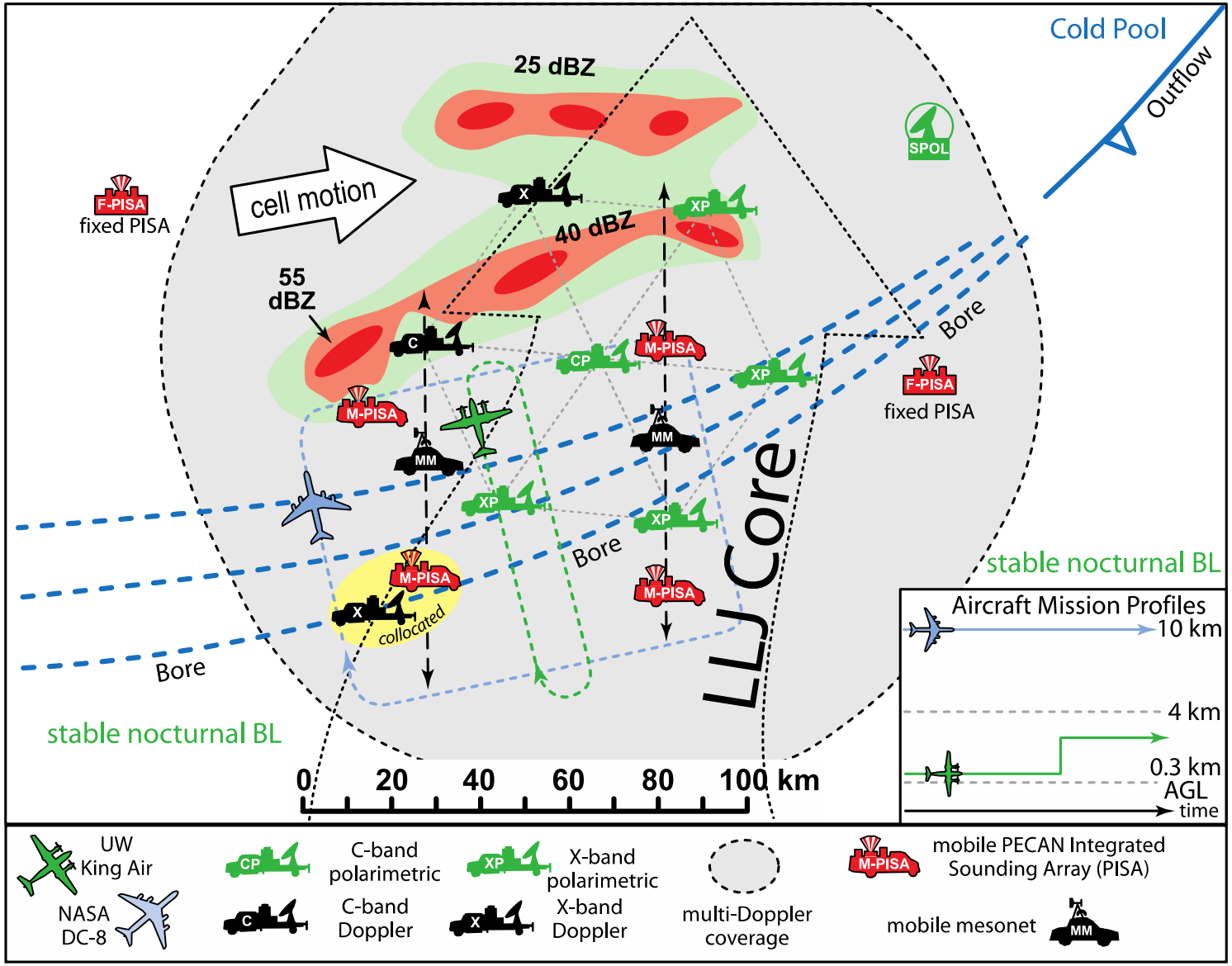

cell motion
stable nocturnal BL
55 dBZ
CI
XP
CP
X
C
stable nocturnal BL
LLJ Core
40 dBZ
25 dBZ
surface front
0 20 40 60 80 100 km
C-band polarimetric
X-band polarimetric
C-band Doppler
X-band Doppler
multi-Doppler coverage

CI Deployment

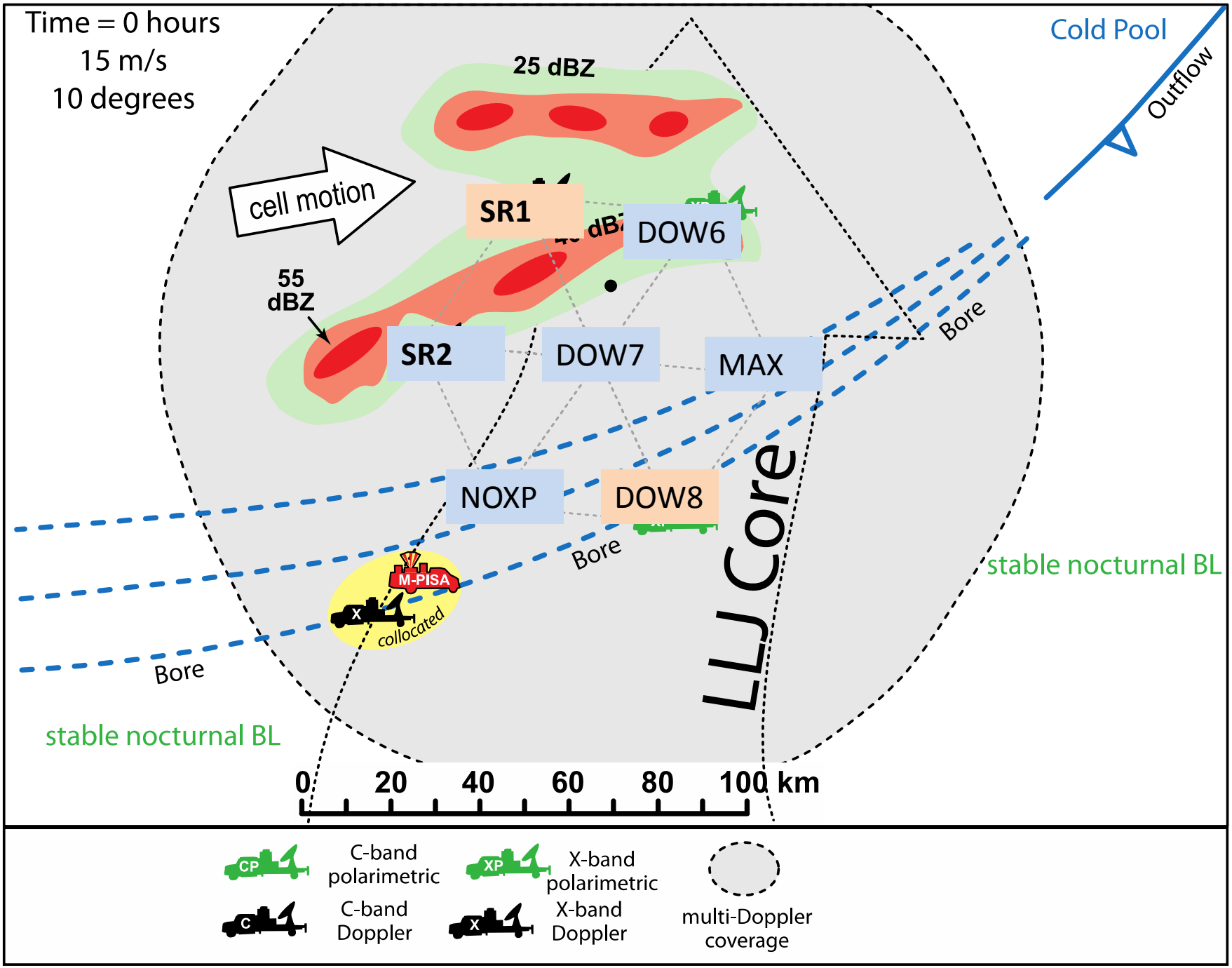
- Should radar deployment aim for the CI “bulls-eye”
  - SW radars are not optimally deployed for CI
  - But, ***are*** optimized sampling between the front and CI
  - Which X, C bands should be where in hexagon?
  - Clear air scanning mode (10 min, high sensitivity)

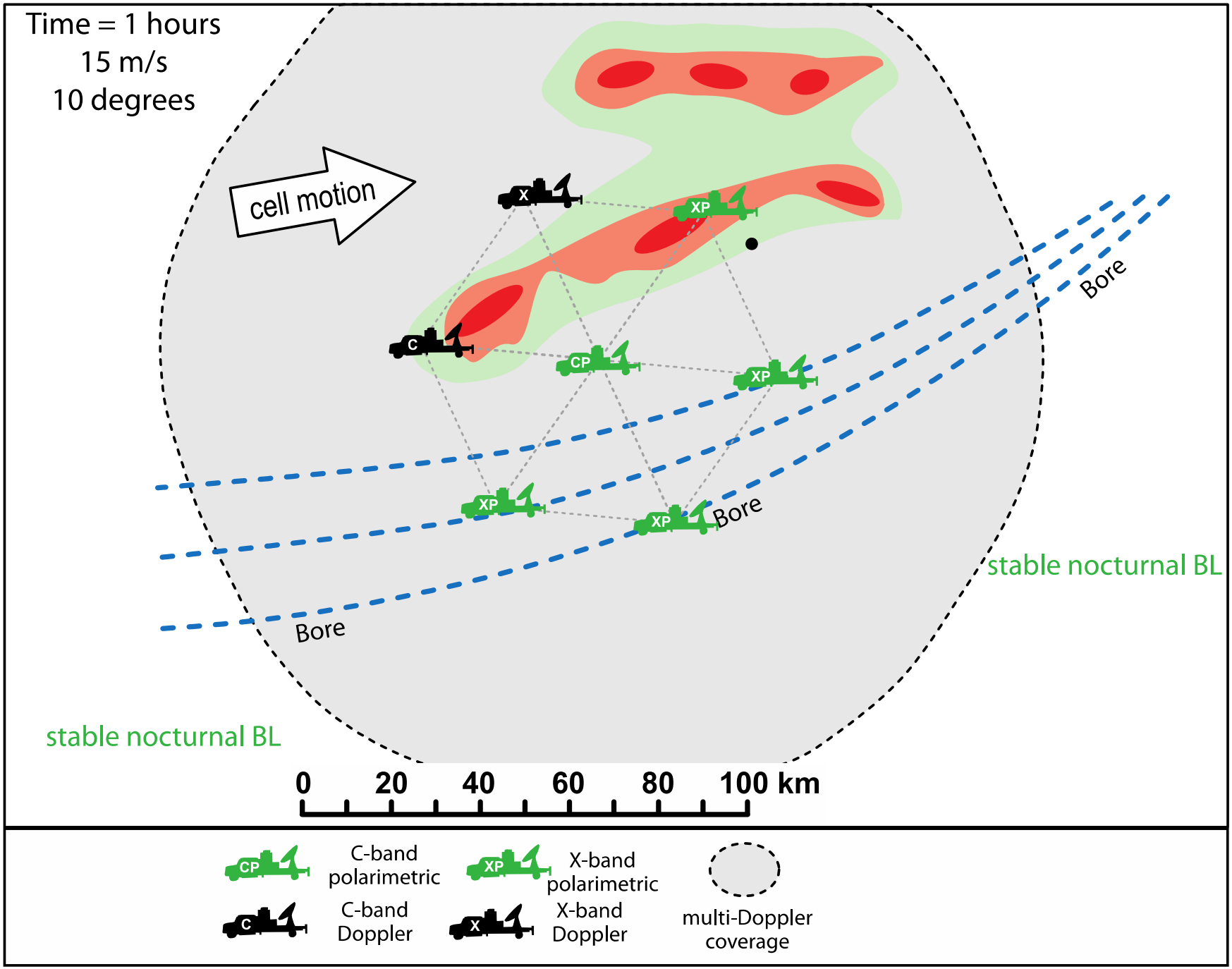


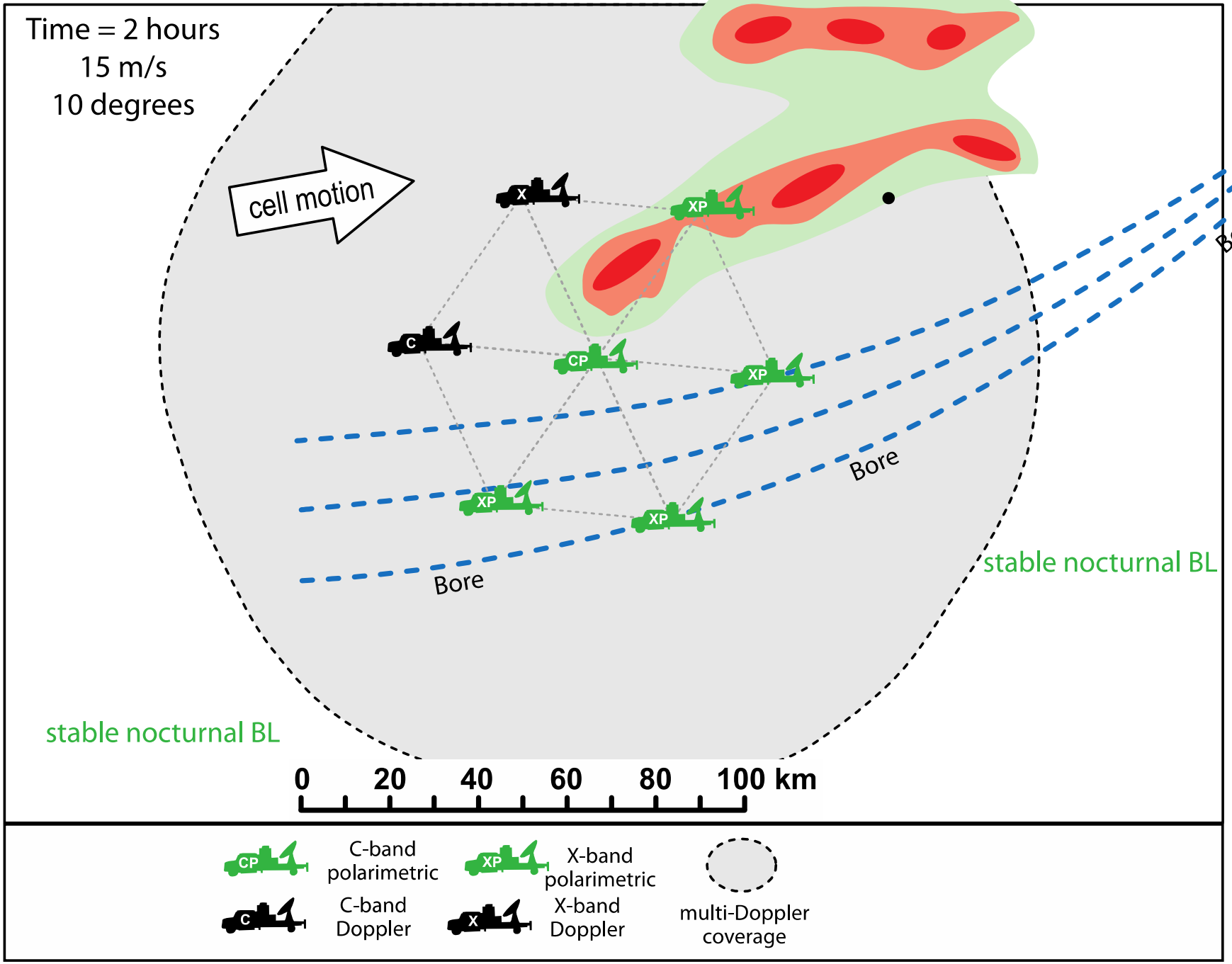
Bores: Mobile Radars

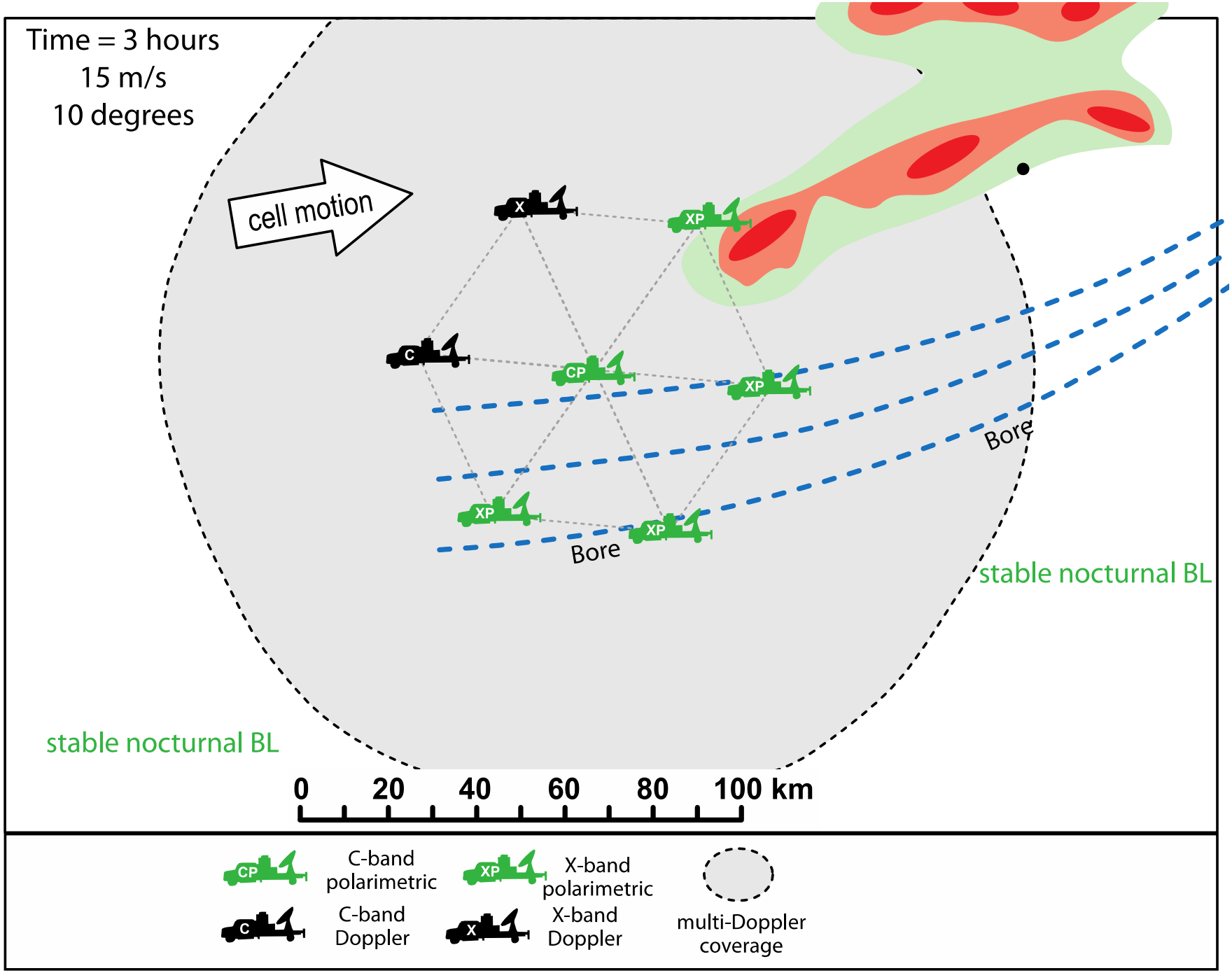


Target southern and southeast regions of MCSs


Time = 0 hours
15 m/s
10 degrees
25 dBZ
cell motion
SR1
DOW6
55 dBZ
SR2
DOW7
MAX
Bore
NOXP
DOW8
M-PISA
X
collocated
Bore
Bore
LLJ Core
Cold Pool
Outflow
stable nocturnal BL
stable nocturnal BL
0
20
40
60
80
100 km
CP
C-band polarimetric
XP
X-band polarimetric
C
C-band Doppler
X
X-band Doppler
multi-Doppler coverage


Time = 1 hours
15 m/s
10 degrees
cell motion
X
XP
C
CP
XP
XP
XP
Bore
Bore
Bore
stable nocturnal BL
stable nocturnal BL
0
20
40
60
80
100 km
CP
C-band polarimetric
XP
X-band polarimetric
C
C-band Doppler
X
X-band Doppler
multi-Doppler coverage


Time = 2 hours
15 m/s
10 degrees
cell motion
X
XP
C
CP
XP
XP
XP
Bore
Bore
stable nocturnal BL
stable nocturnal BL
0
20
40
60
80
100 km
CP
C-band polarimetric
XP
X-band polarimetric
C
C-band Doppler
X
X-band Doppler
multi-Doppler coverage


Time = 3 hours
15 m/s
10 degrees
cell motion
X
XP
C
CP
XP
XP
XP
Bore
Bore
stable nocturnal BL
stable nocturnal BL
0
20
40
60
80
100 km
CP
C-band polarimetric
XP
X-band polarimetric
C
C-band Doppler
X
X-band Doppler
multi-Doppler coverage

Bore Deployment

Which X, C bands should be where in hexagon?

Smaller hexagon?

Clear Air Scanning Mode (10 minutes, high sensitivity)