281

The phase pattern of a parabolic radar antenna and its impact on data quality

McGill

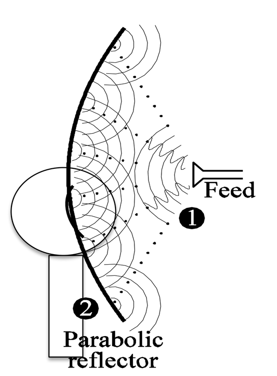
Ya-Chien Feng* and Frédéric Fabry

Department of Atmospheric and Oceanic Sciences, McGill University, Montréal, Québec, Canada

*ya-chien.feng@mail.mcgill.ca

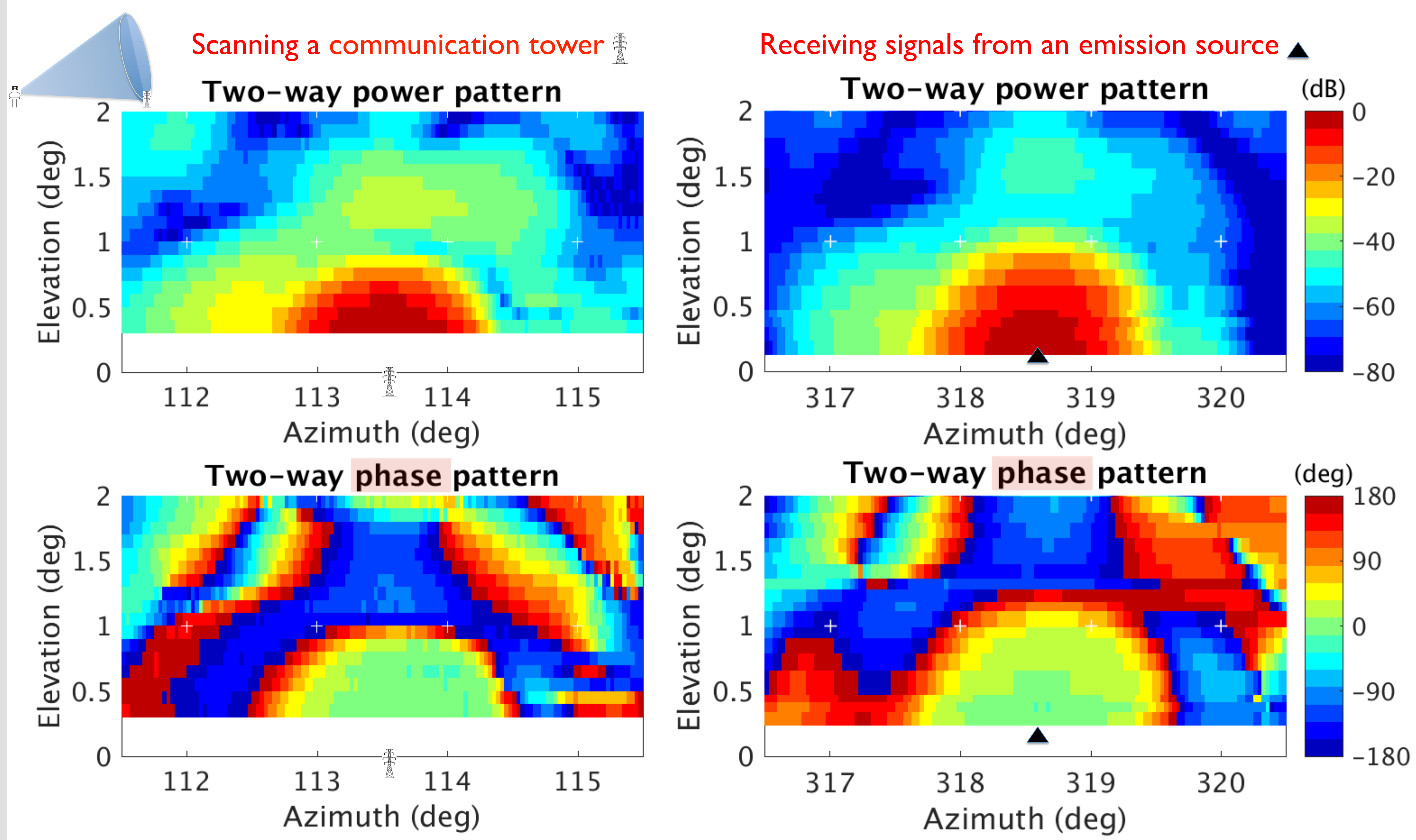
Introduction and motivation

- Radar antennas have well-known power patterns that are commonly used to understand the quality of measurements, but they also have phase patterns that are difficult to obtain and are seldom discussed in the radar meteorological community.
- Besson et al. (2013) proposed using phases returned from ground targets at two low elevations to improve the phase aliasing and temporal resolution problems of radar-refractivity estimation. But, is the phase measured from a target 1° away from the beam center the same as that measured at the center of the beam?



Theoretically, the geometry of the parabolic antenna as a reflector makes waves as plane waves within the main lobe in the far field from the radar. There is a pronounced two-way 360° phase shift between the main beam and the first sidelobe.

The power and phase patterns of the McGill parabolic radar antenna



- Data: Using high-resolution scans of an isolated ground target and of an emission source at elevation angles from 0.3° to 2° with 0.1° interval.

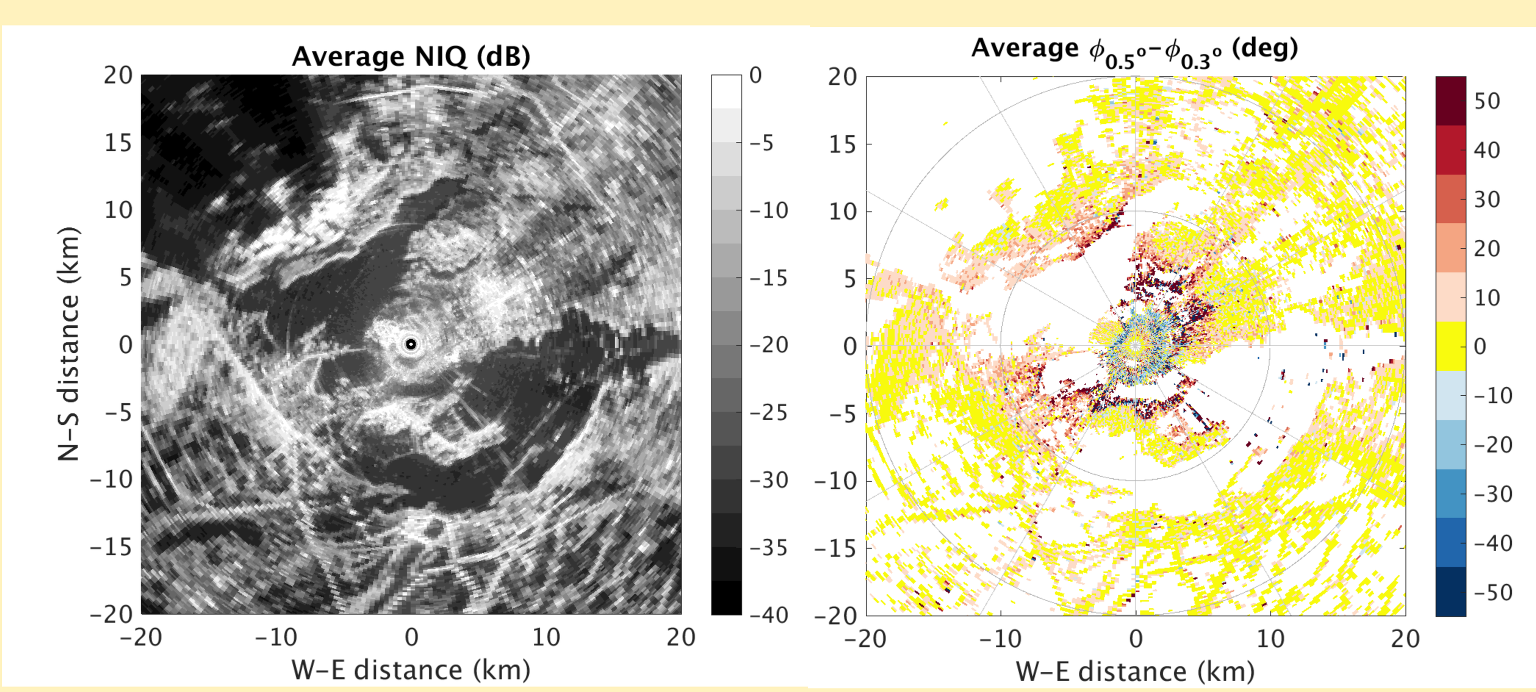
Characteristics of the McGill radar

Frequency	2.88 GHz
Pulse length	125 m
Pulse repetition frequency	1200 s^{-1}
Antenna beamwidth	0.8°
Antenna diameter	9.1 m
Antenna focal length	3.8 m
Antenna to rotating axis distance	1.65 m
Antenna rotating speed	6 rpm

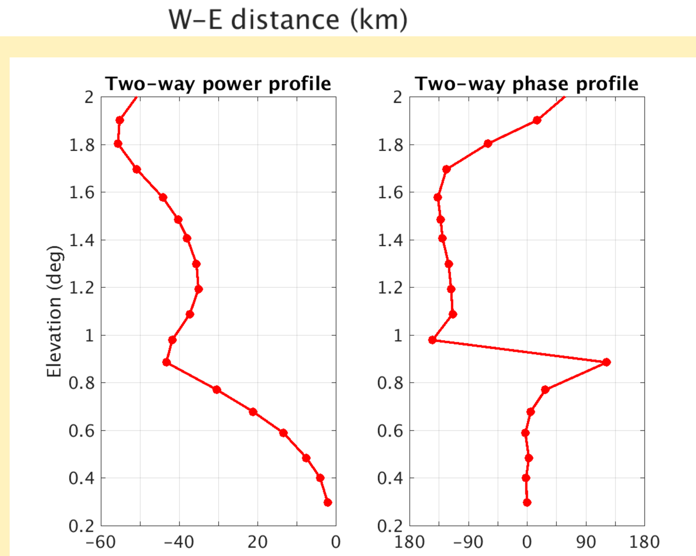
- Characteristics of the McGill parabolic antenna phase pattern: **Phases are constant in the main beam, but change significantly at the power nulls and strong power gradients.**
- For the McGill radar, the two-way phase difference between the main lobe and the first sidelobe is less than the expected 360° of perfect antenna. These anomalies might be explained by the imperfect geometry of antennas, e.g. the presence of struts, irregularities in the shape of the reflector, etc.

Antenna phase pattern and data quality

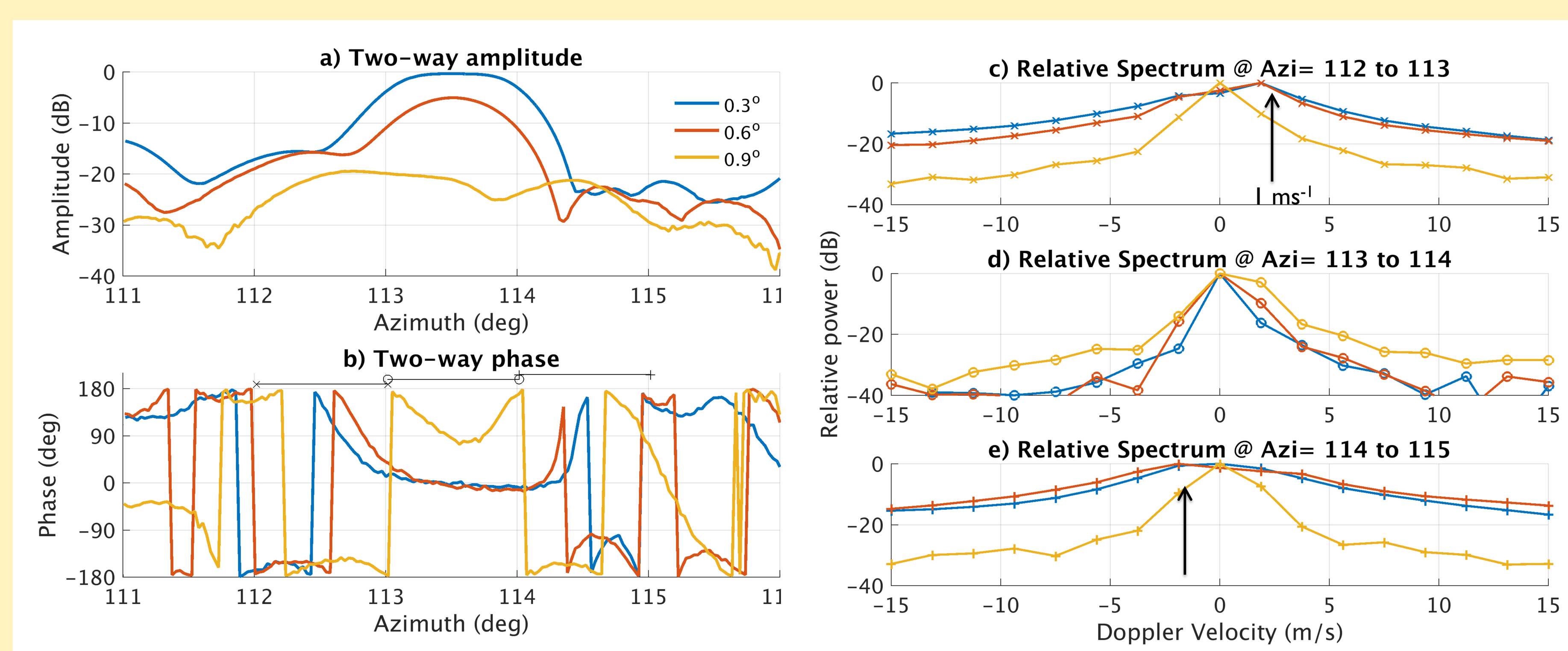
• Radar-estimated refractivity



- At close range, large differences in the phase added by the antenna introduces biases in radar refractivity estimation.
- When combining multiple antenna elevation angles, phase pattern of the parabolic antenna must be removed.



• Ground clutter mitigation and radial velocity biases



- With increasing azimuth and elevation away from the center of the main beam (113.6° azi and -0.1° ele), the Doppler velocity spectrum broadens and becomes asymmetric with a nonzero mean velocity.
- The bias of radial velocity can not be neglected at the edge of ground targets or small cloud/precipitation cells at far range whose azimuthal width is of the order of a beamwidth.

Summary

- The phase patterns obtained by two observation approaches both lead to a consistent pattern of phase within the main beam and large changes when approaching the nulls of the antenna power pattern.
- This proper knowledge on antenna phase pattern would improve:
→ The accuracy of radar-estimated refractivity through removing the bias of phase from antenna phase pattern.
→ Ground clutter mitigation technique, which generally assume a symmetric fixed-shaped (Gaussian width) clutter spectrum.
→ Estimating the radial velocity biases of point (meteorological/ground) targets.

References:
Besson, L., and J. Parent du Chatelet, 2013: Solutions for improving the radar refractivity measurement by taking operational constraints into account, doi:10.1175/JTECH-D-12-00167.1.
Feng, Y. and F. Fabry, 2016: The Imperfect phase pattern of real parabolic radar antenna and data quality. doi:10.1175/JTECH-D-16-0143.1

This project was undertaken with the financial support of the Government of Canada provided through the Department of the Environment. The views expressed herein are solely those of McGill University.