# The GPM Dual-Frequency Dual-Polarized Doppler Radar (D3R)

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# Introduction

- **The Ka/Ku-band D3R** is being developed as part of the ground validation activities for NASA’s **Global Precipitation Mission (GPM)** .

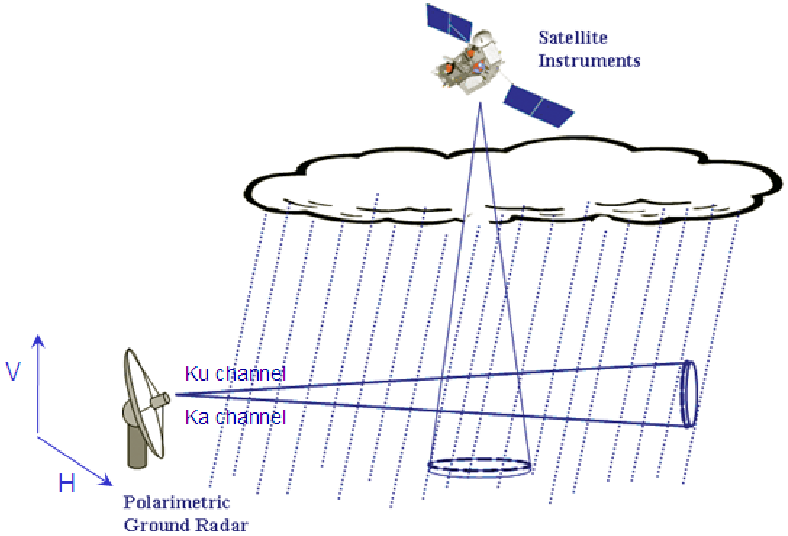
# Introduction

- The GPM satellite will deploy a **dual-frequency precipitation radar (DPR).** The DPR is expected to provide improved characterization of rain drop size distribution (DSD), as well as rainfall rate estimation from a combination of Ku-band and Ka-band radar measurements. In contrast to TRMM, the dual-frequency retrieval methods will use two DSD parameters to characterize the precipitation medium (Iguchi et al 2003). The underlying precipitation structures, hydrometeors and DSDs dictate the type of models or retrieval algorithms that can be used to estimate precipitation.

# Introduction

• Having a dual-frequency radar on the ground, with the potential for in-situ observations, provides an excellent opportunity to develop microphysical and system models for retrievals. Therefore an aligned-beam system consisting of Ku and Ka bands will be very useful as a ground validation tool.

• Furthermore, if this system can be dual-polarized, then it will have the capability of being a self-consistent cross-validation tool. The full suite of dual-frequency, dual polarization measurements, will also enhance our understanding of the interaction between the microphysics and electromagnetics that generate the observations of DPR for different types of precipitation.



# Characteristics of D3R

The important characteristics of the ground based Dual-frequency Dual-polarized Doppler radar being developed by the NASA GPM Ground Validation program are as follows:

## System

1- A fully polarimetric dual-frequency, Doppler radar.

2- Maximum range of 30 km.

3- The two nominal frequencies are 13.91 GHz and 35.56 GHz.

4- Design sensitivity is -10 dBZ at 15 km for both frequencies.

5- Scanning radar system, full 360 degree in Azimuth and full 90 degree scan in Elevation.

6- Two antennas mounted on a single pedestal, to eventually migrate to a single aperture system. Single aperture antenna is under development.

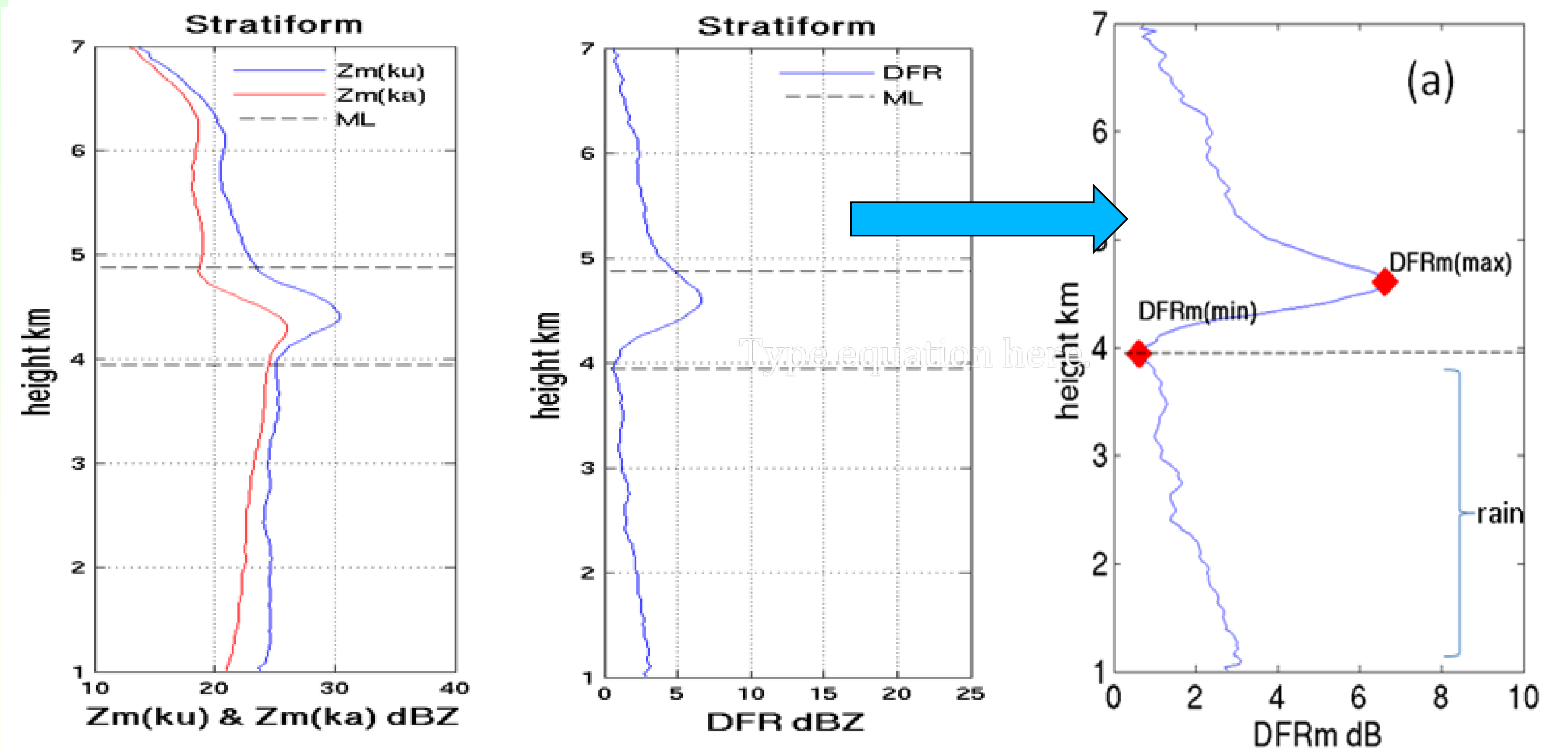
7- The radar to be computer controlled, from a remote location using commodity internet connections, typical interfaces, as well as pipe the display using commodity internet service.

8- Data will be archived in NetCDF format.

# List of Measured and Derived Products

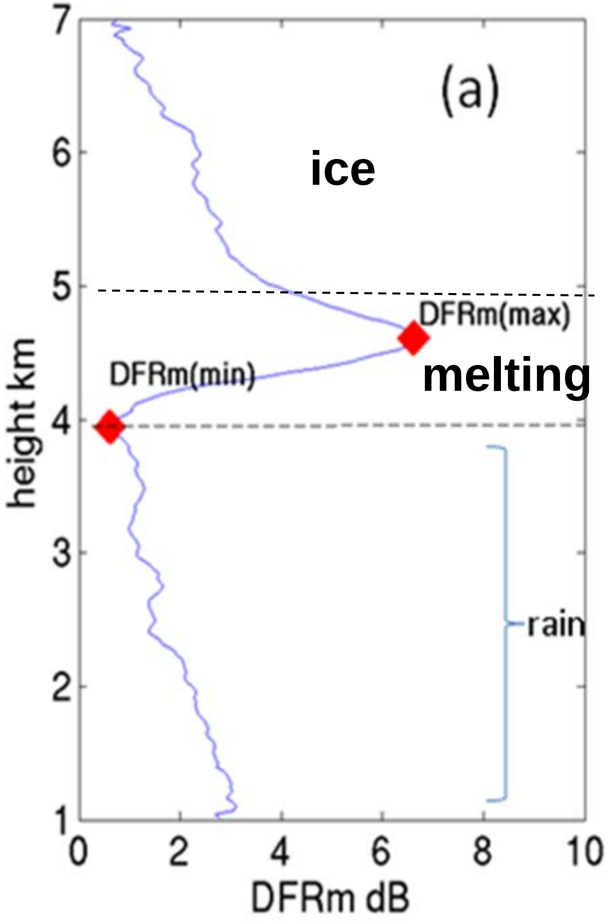
| Measured Products | Symbol | Frequency | Comments |
|---|---|---|---|
| Reflectivity | $Z$ | Ka and Ku | Attenuated and corrected |
| Differential Reflectivity | $Z_{DR}$ | Ka and Ku | Attenuated and corrected |
| Differential Propagation Phase | $\phi_{dp}$ | Ka and Ku | |
| Specific Differential Phase | $K_{dp}$ | Ka and Ku | |
| Co-polar Correlation Coefficient | $\rho_{co}$ | Ka and Ku | |
| Linear Depolarization Ratio | LDR | Ka and Ku | Attenuated and corrected |
| Cross-polar Correlation Coefficient | $\rho_{cx}$ | Ka and Ku | |
| Radial Velocity | $v$ | Common to both | |
| **Derived Products** | | | |
| Rainfall Rate | R | | Various algorithms |
| Drop Size Distribution | DSD | | Various algorithms |

# Typical vertical profile of reflectivity and dual frequency ratio for stratiform rain




$$DFR_m = Z_m(Ku) - Z_m(Ka)$$

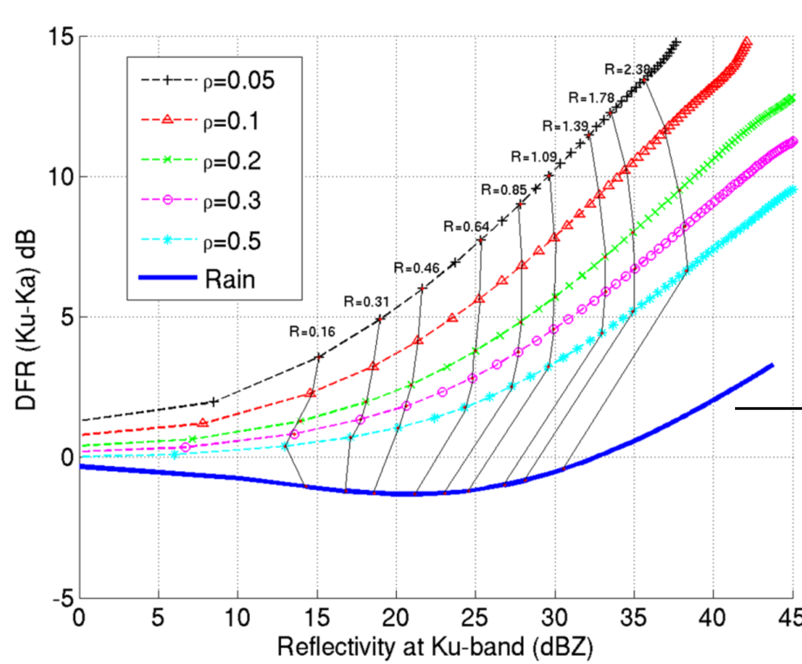
# Microphysical explanation of the vertical profile of Dual frequency ratio




$$DFR_m = Z_m(Ku) - Z_m(Ka)$$
$$= (Z_e(Ku) - PIA(Ku)) - (Z_e(Ka) - PIA(Ka))$$
$$= DFR + (PIA(Ka) - PIA(Ku))$$

Intrinsic Dual frequency ratio

$(PIA(Ka) - PIA(Ku)) > 0$




ice

rain

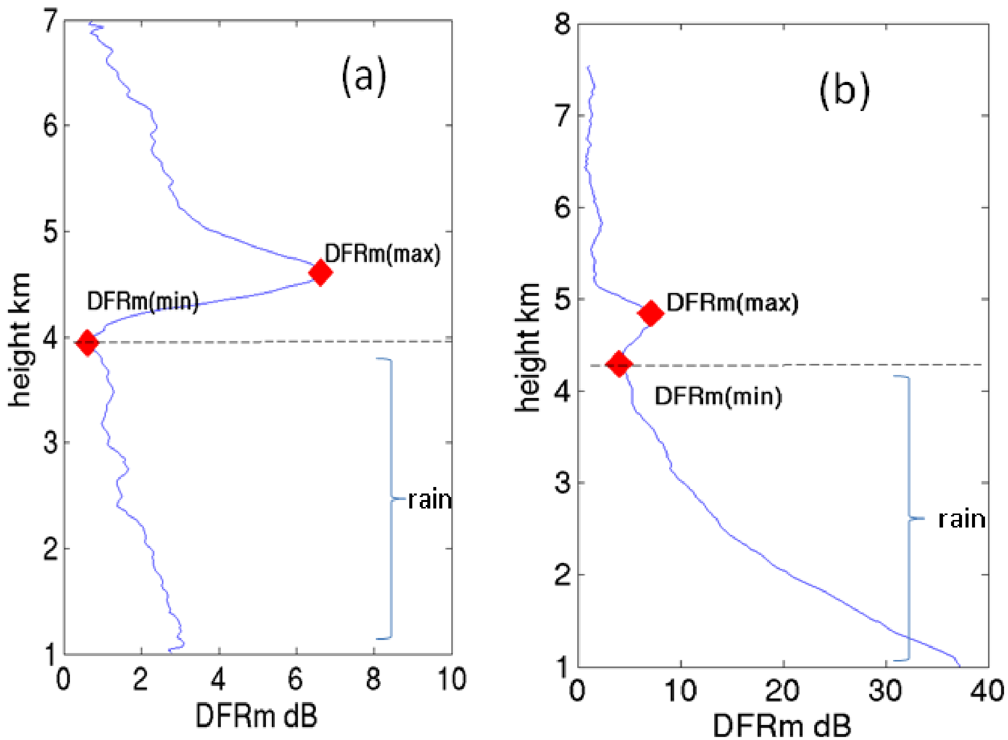
1) In Ice region, DFRm is mainly dominated by non-Rayleigh scattering effect. From DFR versus Ze(Ku) plot, when Ze(Ku) increases, intrinsic DFR increases.

2) In melting region, DFRm is composed by both non-Rayleigh effects and attenuation effects. But the obvious decrease of DFRm in the melting bottom region indicate that non-Rayleigh scattering effect still dominated the trend. From DFR versus Ze(Ku) plot, the jump of the DFRm in the melting bottom region is related to the density of ice and melting layer model.

3) In the rain region, DFRm trend is more linear and continues increasing when approaching the surface. This indicates that DFRm is dominated by the attenuation difference.

# Typical vertical profile of Stratiform rain and Convective rain

Two DFR index can be used in Stratiform rain and Convective rain classification




$V1 = DFR_m(max) – DFR_m(min)$

$V2 = mean\ (DFR_m\ (rain))$

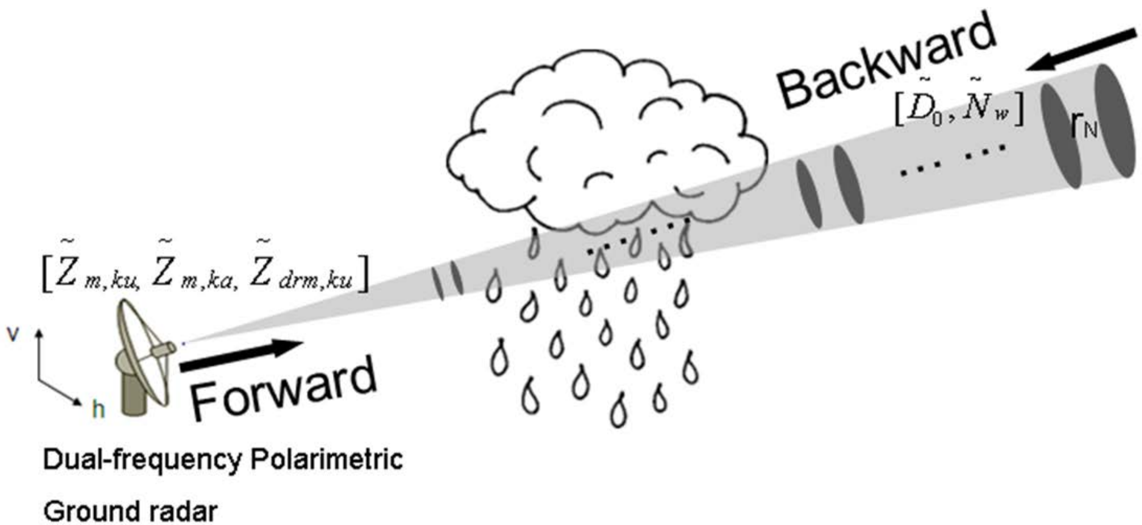
(Normalized with rain height)

Define Ratio= V1/V2

# Drop Size Distribution parameters retrieval for rain region

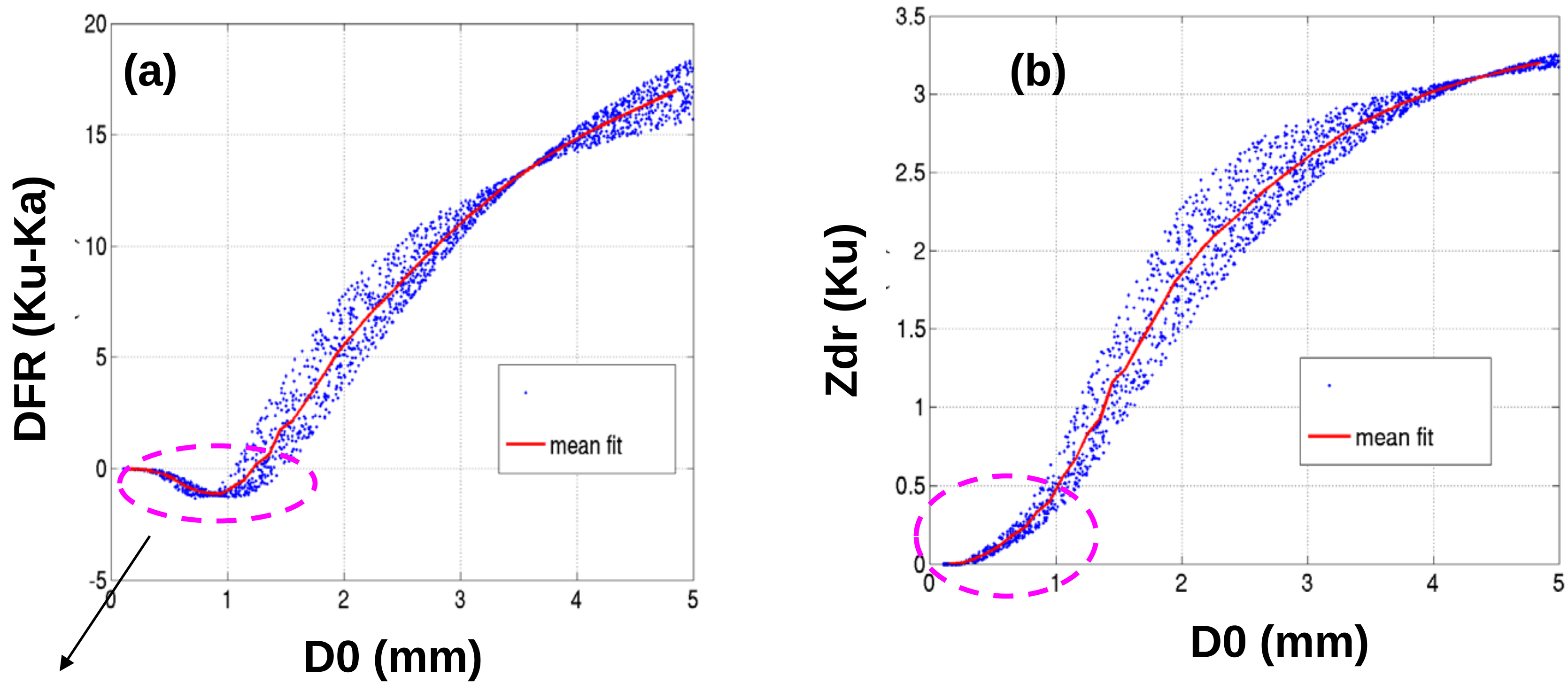
## Principle:

**Combining the advantage of the dual-frequency algorithm by using parameter DFR (dual-frequency ratio) and dual-polarization algorithm with parameter Zdr (differential reflectivity) in the retrieval.**



# Algorithm Description: theoretical basis

Rain region ➔ combined method




**Double solution problem**

(a) DFR vs $D_o$ for rain using Andsager and Beard-Chung (ABC) model with $-1 < \mu < 5, T = 10$ (b) $Z_{dr}$ vs $D_o$ using the same model .

$$DFR = Z_e(K_u) - Z_e(K_a)$$ -------- Dual frequency ratio



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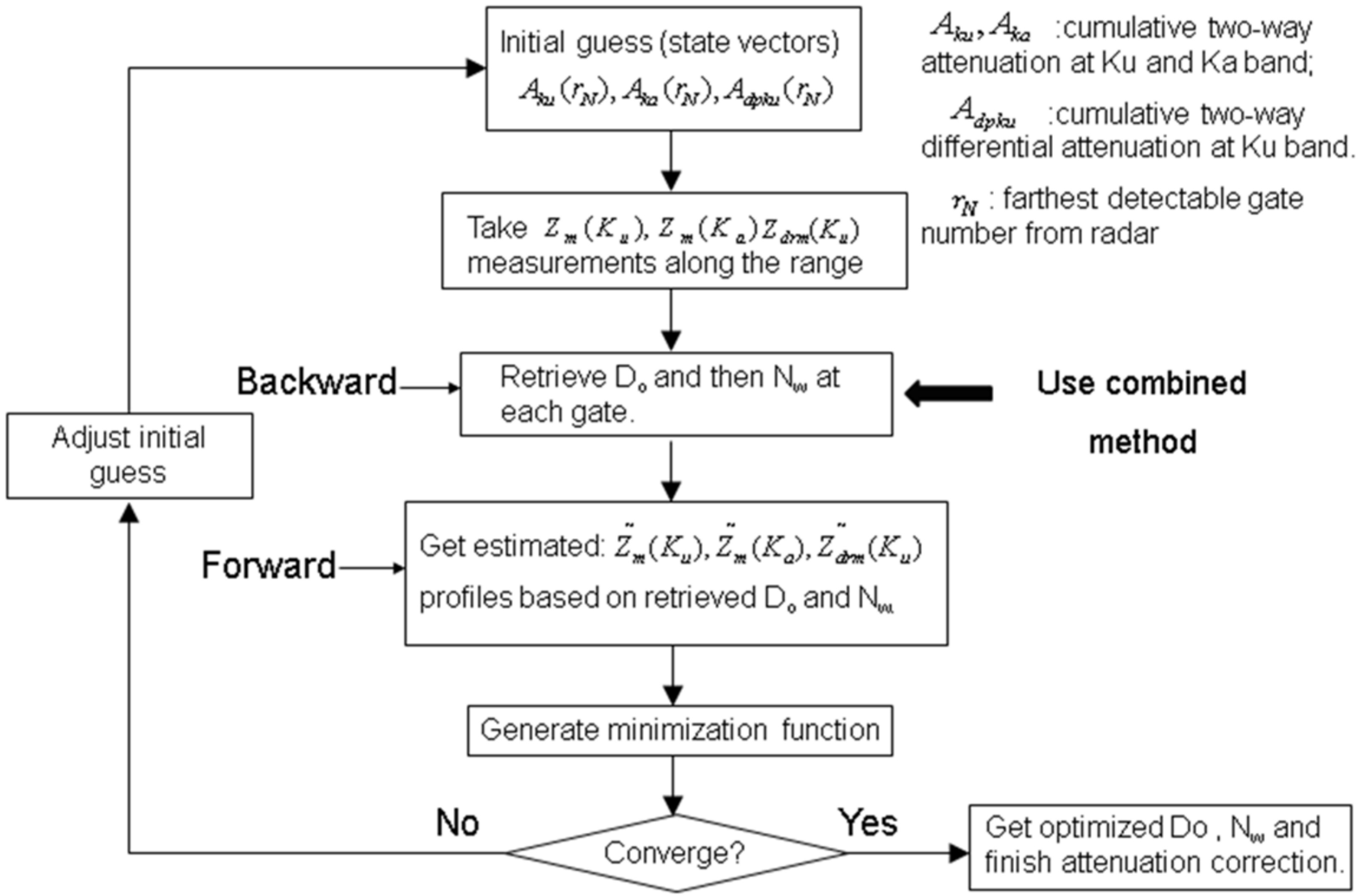
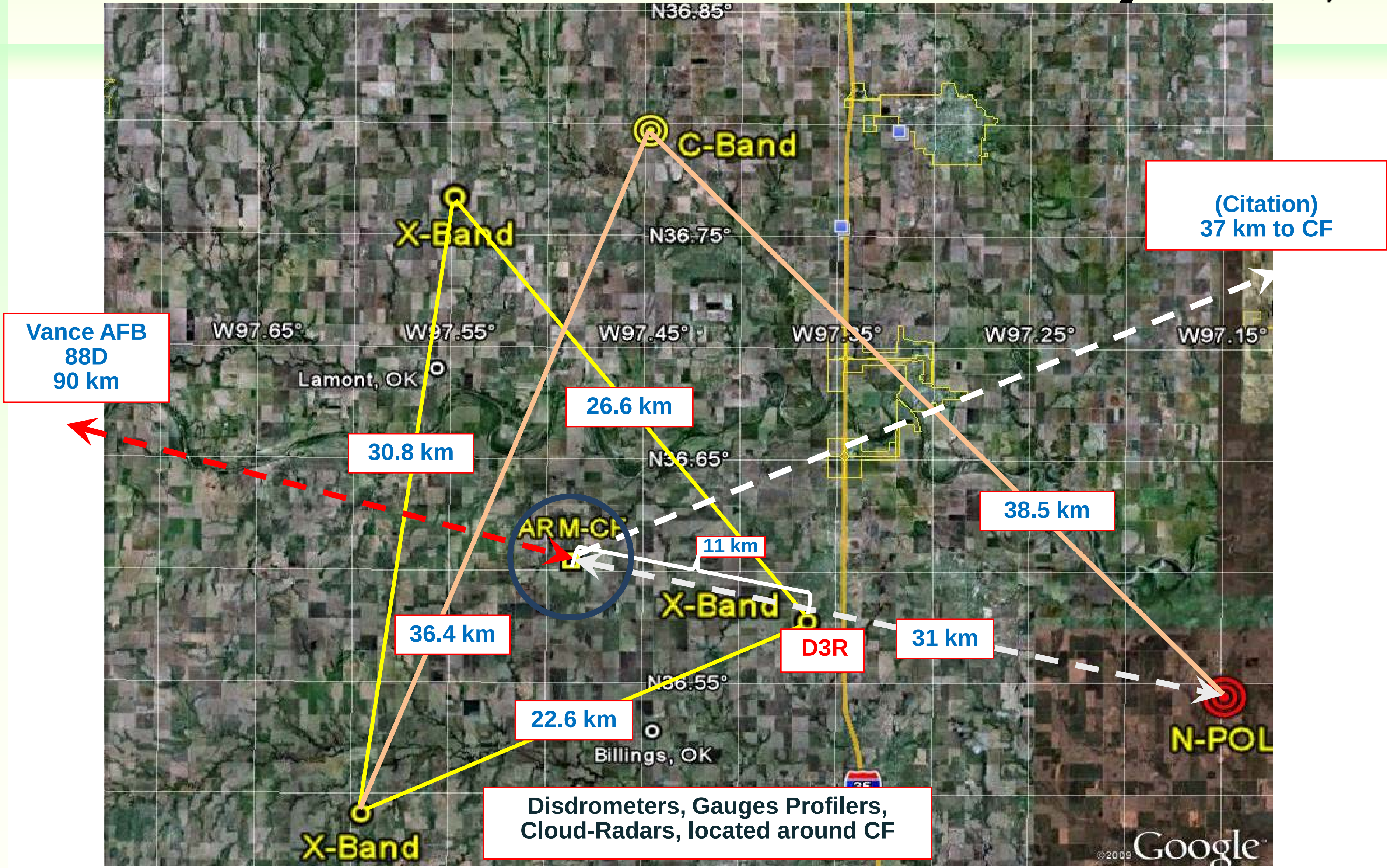
# Flow chart of the algorithm



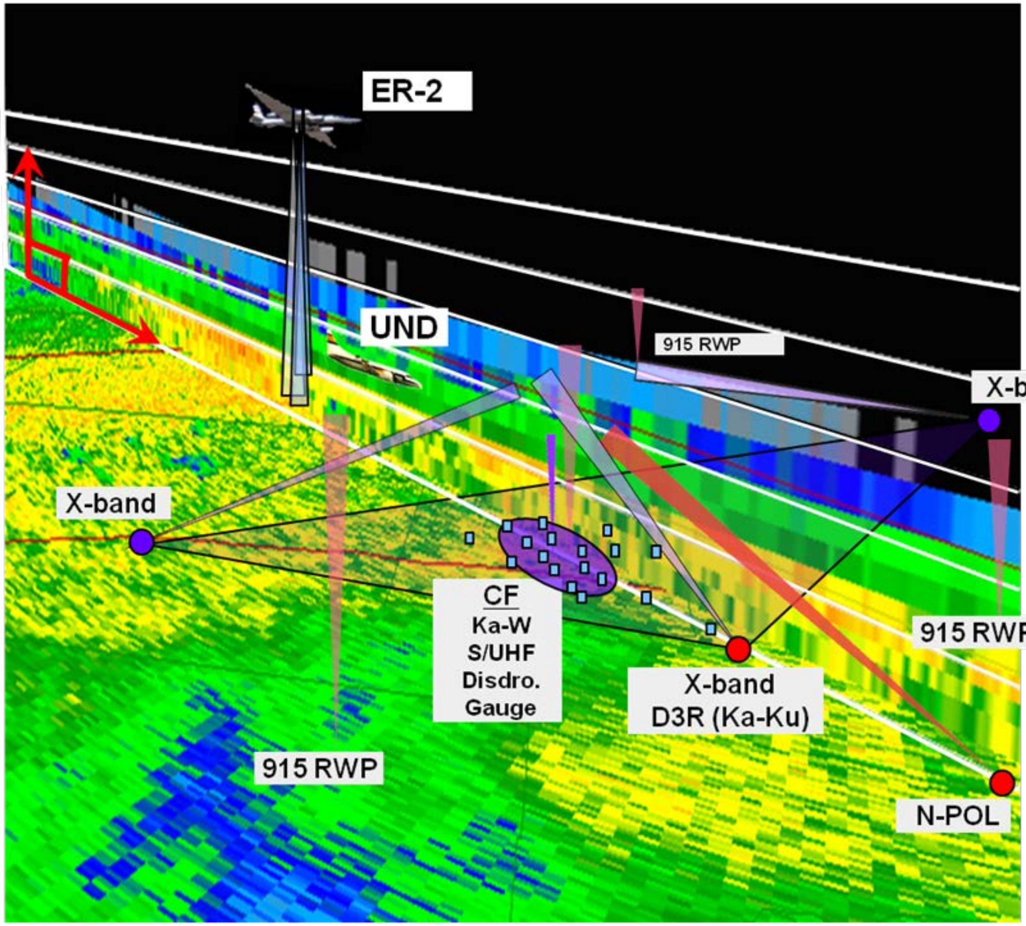
# MC3E: SGP Central Facility IOP



# MC3E: *Airborne* sampling example

- **Stacked aircraft over densely-sampled “cube of space”-**
- **Ground-Top: column emphasis.**

**One “Dream Scenario”**



***Thank you !***

Questions?