

Estimating Precipitation Variability using Airborne HIWRAP Observations

Christopher R. Williams

Ann & H.J. Smead Dept. of Aerospace Engineering Sciences
University of Colorado Boulder

Colorado Center for Astrodynamics Research (CCAR)

PMM Proposal will include future Collaborations with

Gerald Heymsfield

NASA Goddard Space Flight Center

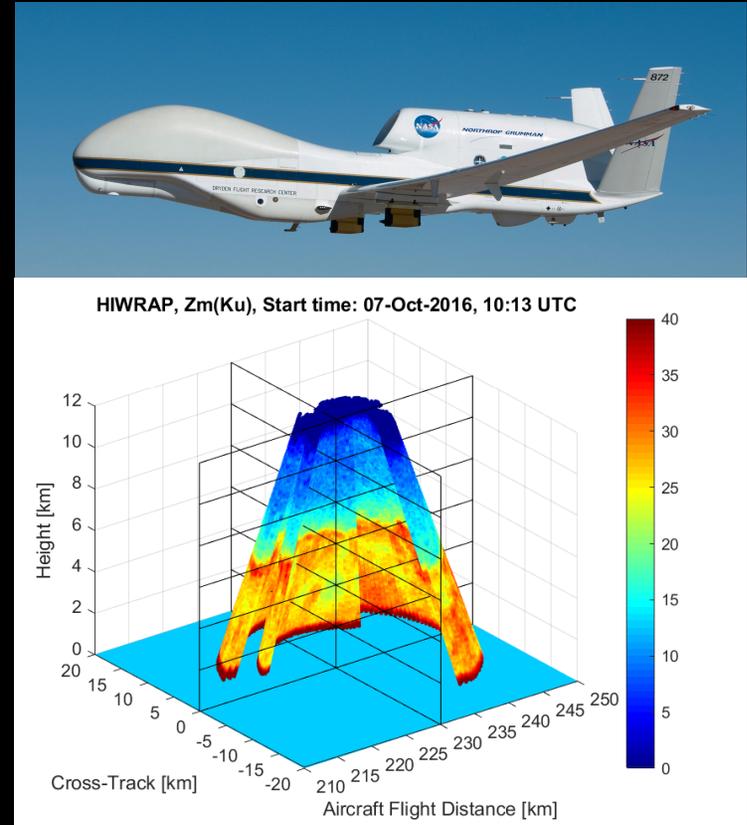
Stephen Durden and Simone Tanelli

NASA Jet Propulsion Laboratory



University of Colorado
Boulder

Support: NASA Global Precipitation Measurement (GPM)

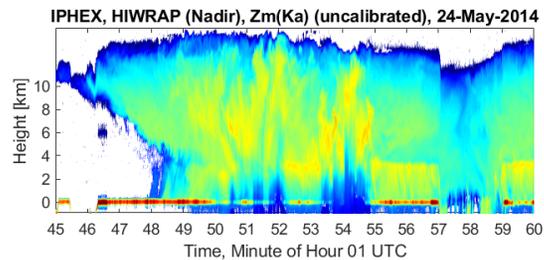
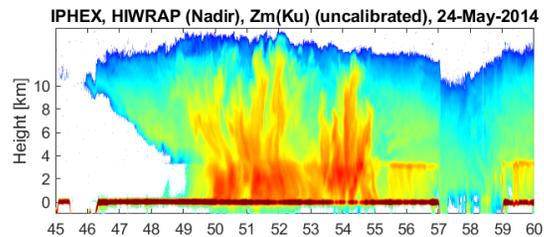


HIWRAP: ER2 vs. Global Hawk Deployments

ER2 – Nadir Pointing
IPHEX and OLYMPEX



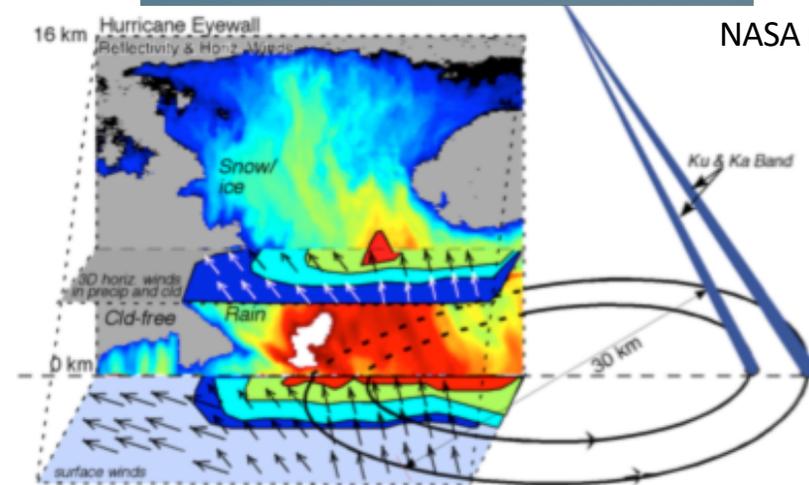
NASA photo



Global Hawk – Conical Scanning
NASA/NOAA SHOUT, HS3, GRIP



NASA photo



Li et al. 2016

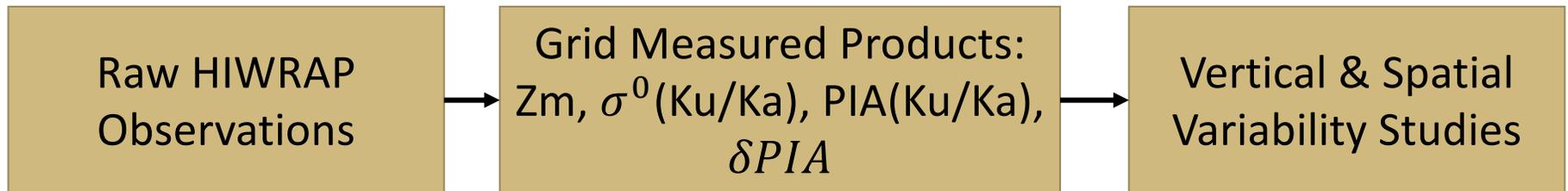
Research Objectives

Long Term Research Interests

- Study connections between dynamics & microphysics
 - Vertical motion \Leftrightarrow vertical structure of precipitation
 - Evolution of DSD – Evaporation, breakup/coalescence, size sorting
- Study spatial precipitation variability
 - Understand impact of non-uniform beam filling (NUBF) on GPM products

Specific PMM Research Objectives using Aircraft Observations

1. Quantify precipitation variability within DPR Field-of-View
2. Assess the impact of precipitation variability on GPM products



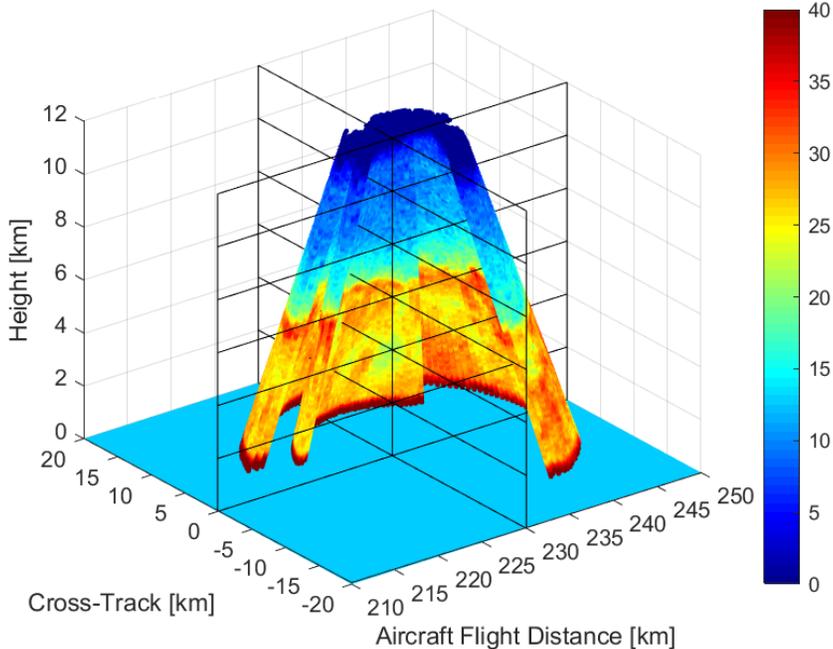
Conical Scan – Understanding Slant Observations

Conical Scanning: 30° & 40° off-nadir

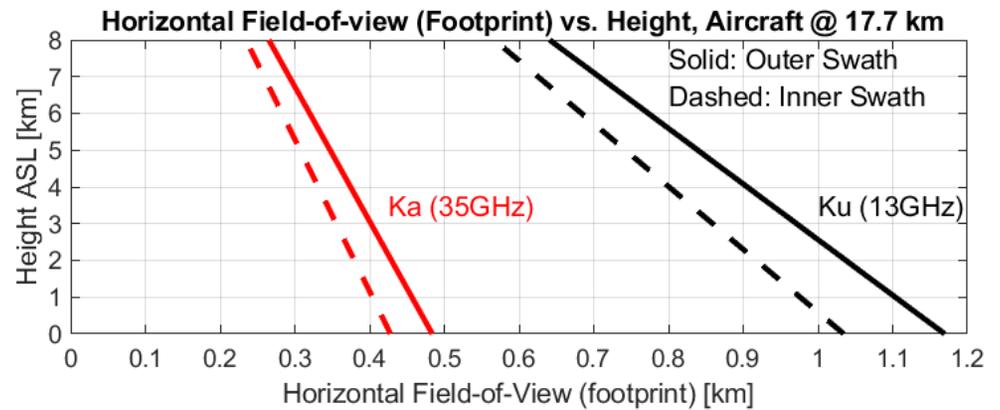
Aircraft altitude: ~18 km

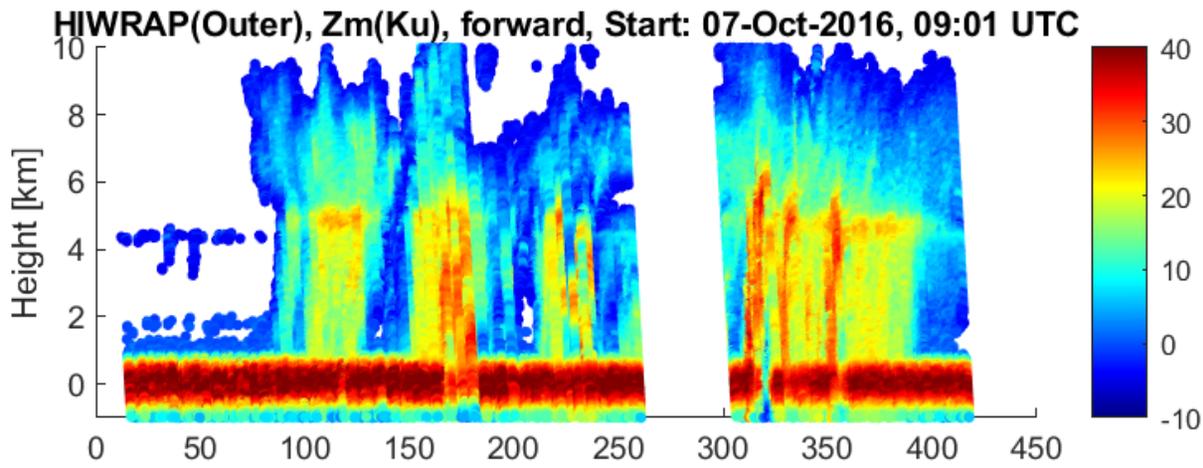
Measured Ku-band Reflectivity, Z_m

07-Oct-2016, 10:13 UTC



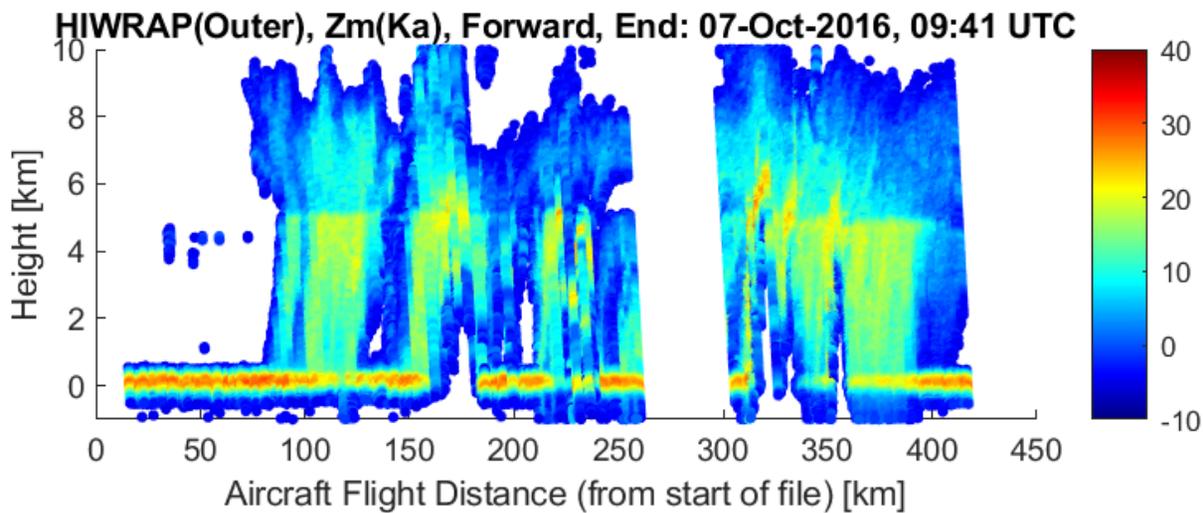
	<u>Ku-Band</u>	<u>Ka-Band</u>
Frequencies	13.9/13.5	35.6/33.7
Range resolution	75 m	75 m
Beam widths (deg)	1.9°	1.2°
Surface footprint	~1 km	~ 0.4 km



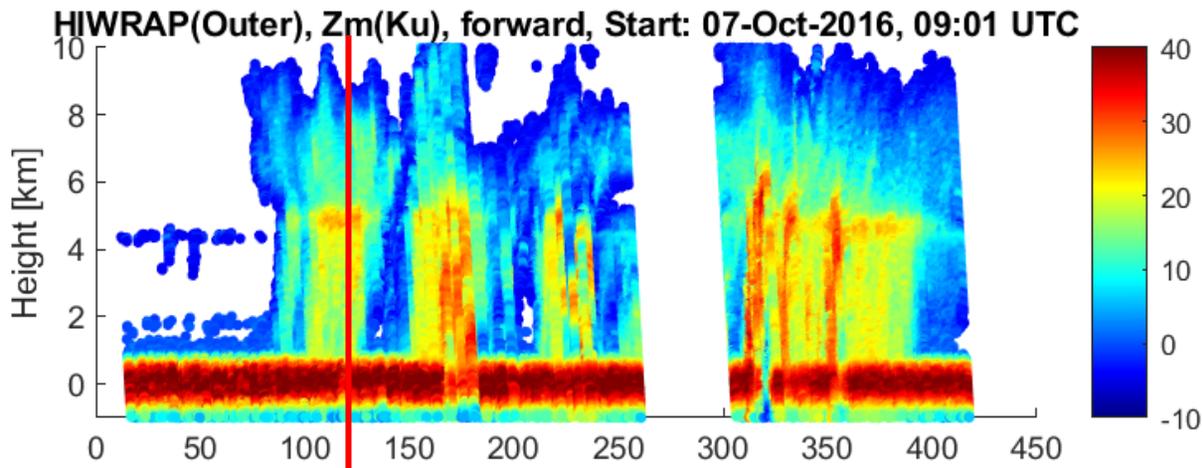


Vertical Cross-Section
Along Flight, **Forward Rays**

Measured Reflectivity, **Ku**

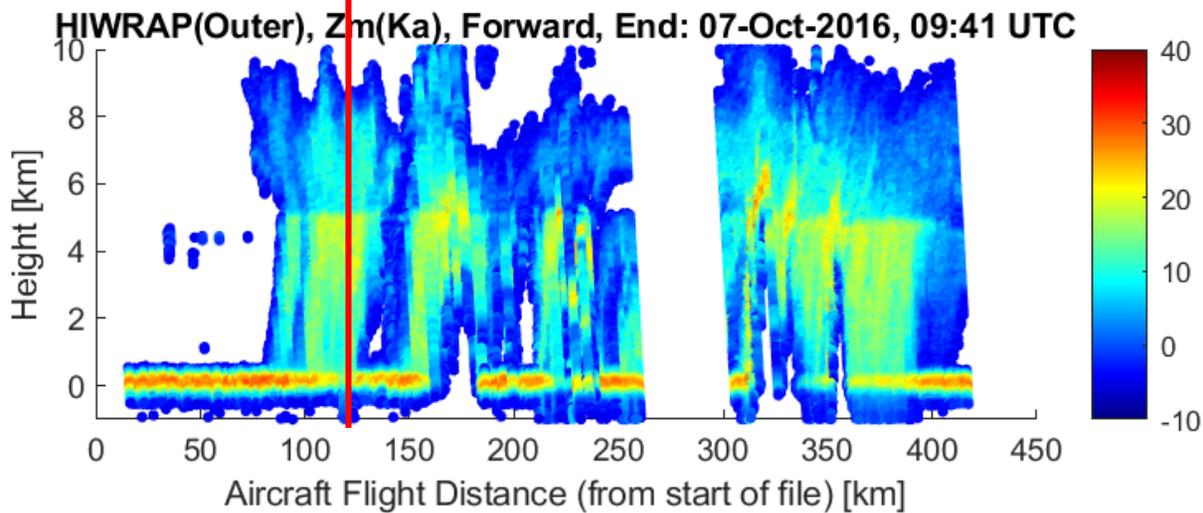


Measured Reflectivity, **Ka**

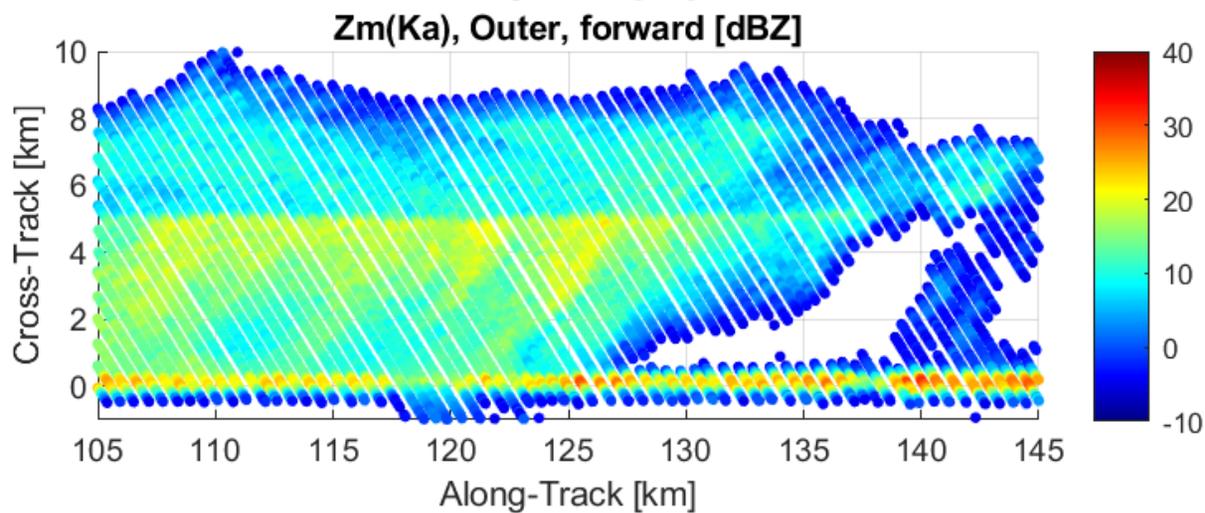
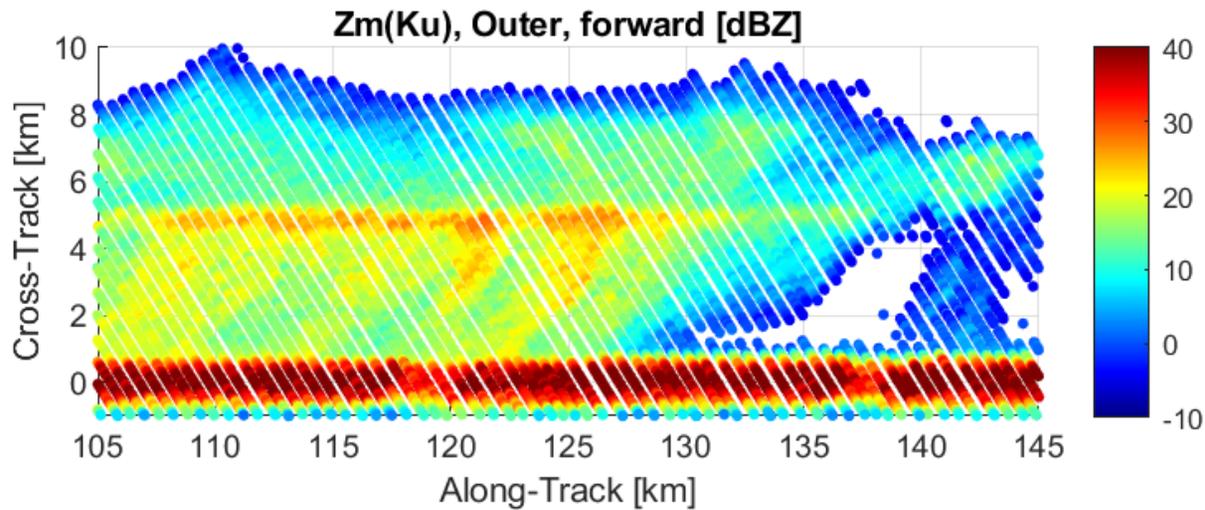


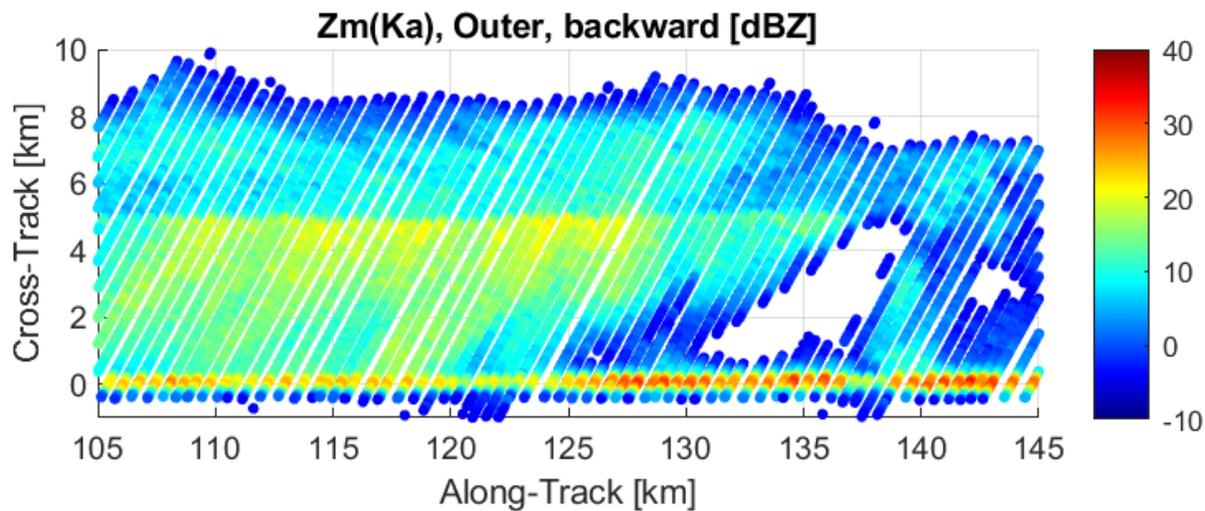
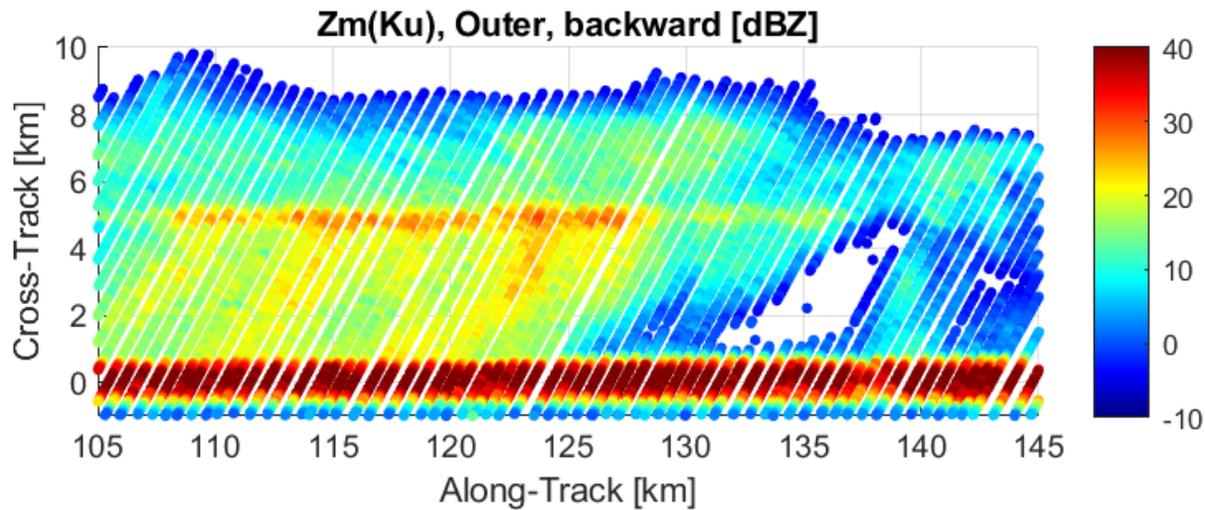
Vertical Cross-Section
Along Flight, **Forward Rays**

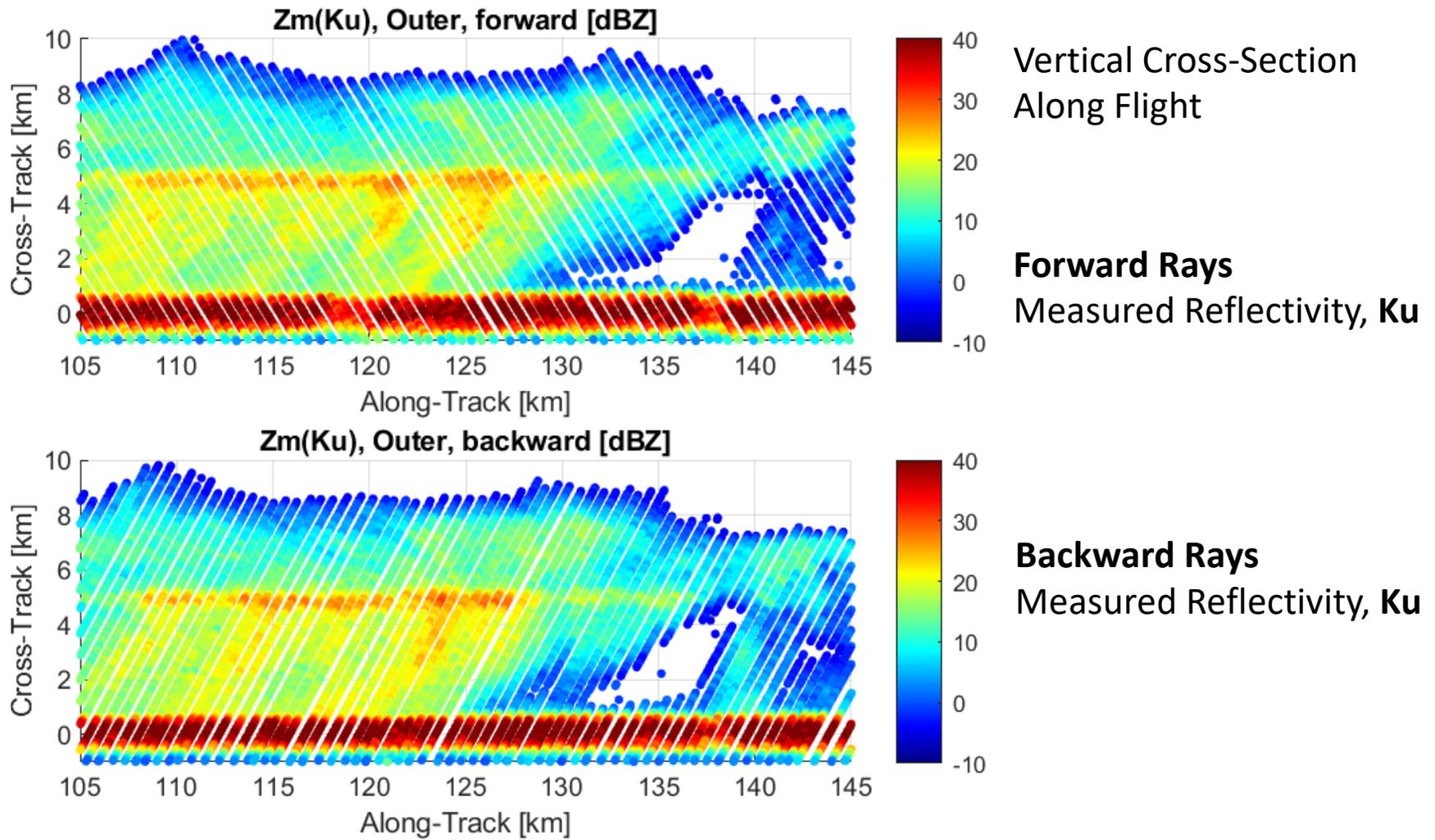
Measured Reflectivity, **Ku**

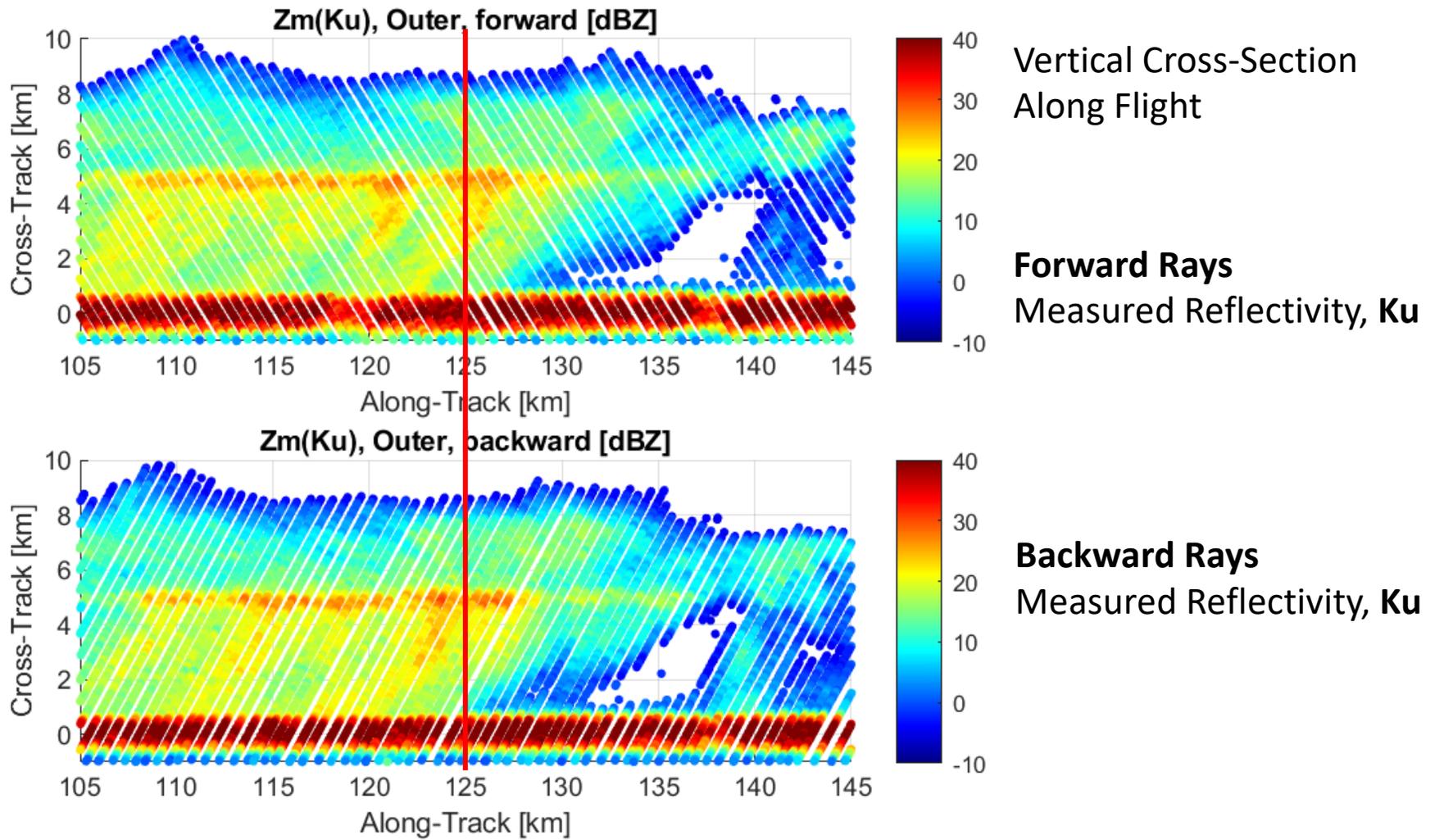


Measured Reflectivity, **Ka**

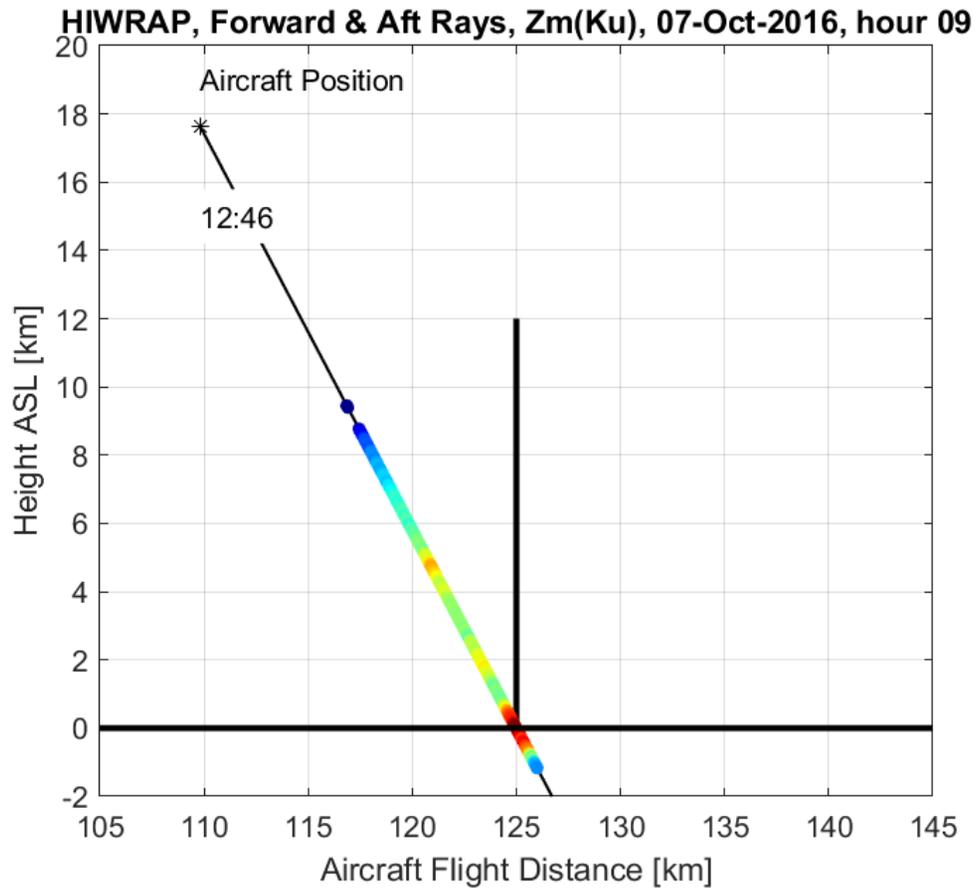






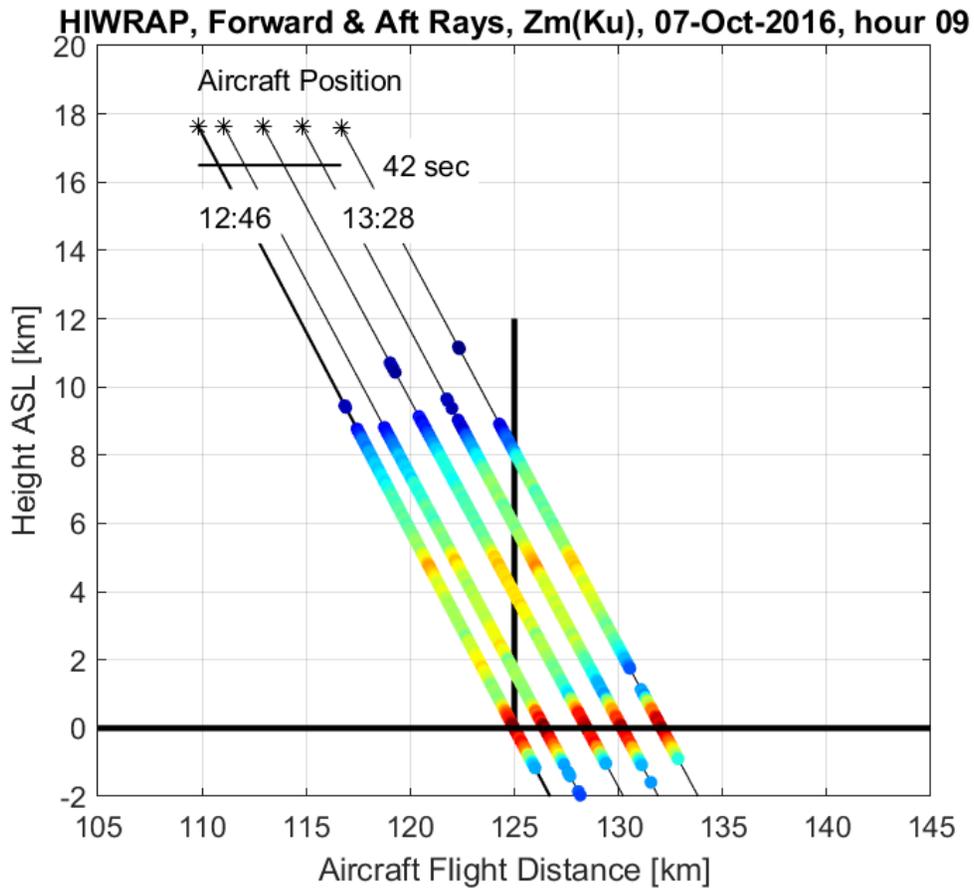


Forward and Aft Ray Processing – Along Track



First Ray intersects surface at 125 km

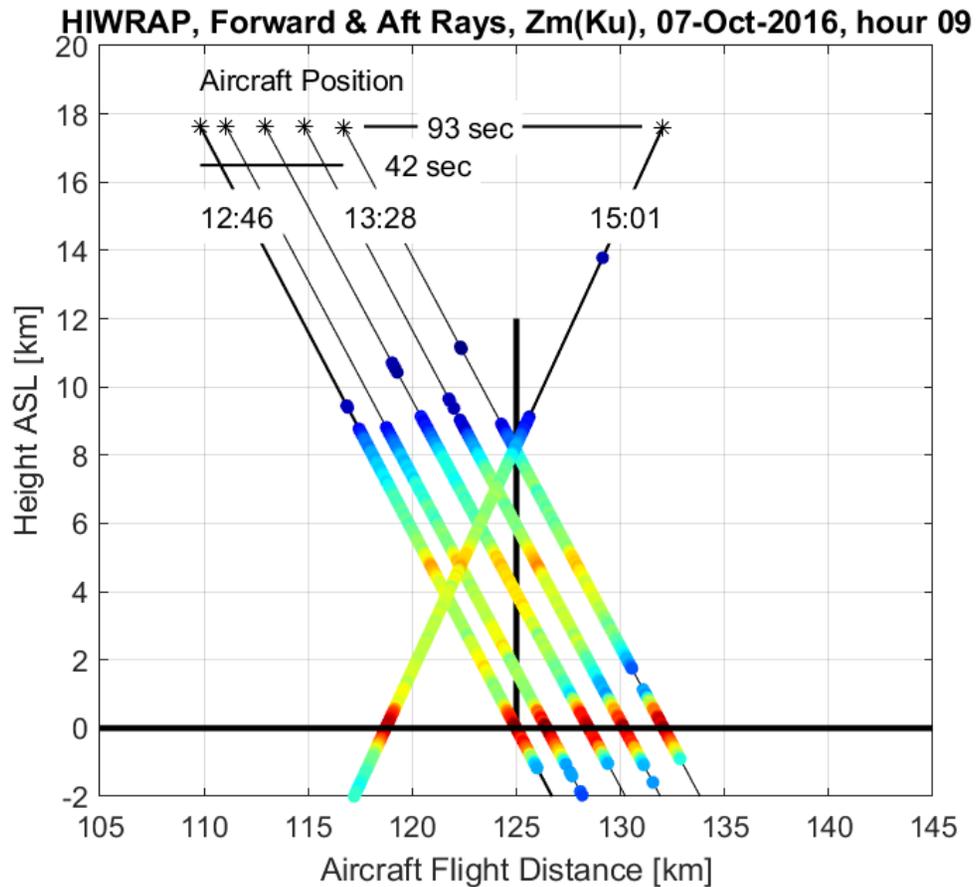
Forward and Aft Ray Processing – Along Track



First Ray intersects surface at 125 km

~42 sec to “build column”
(bottom-to-top)

Forward and Aft Ray Processing – Along Track

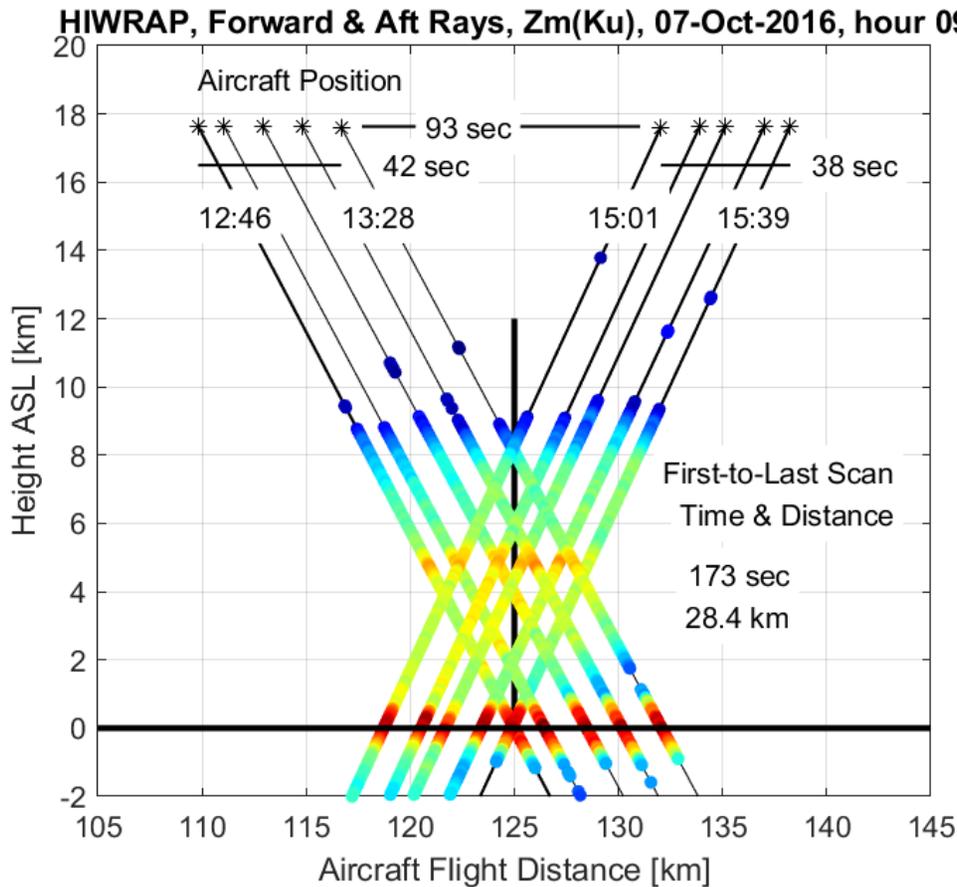


First Ray intersects surface at 125 km

~42 sec to “build column”
(bottom-to-top)

~93 sec to view with backward rays

Forward and Aft Ray Processing – Along Track



First Ray intersects surface at 125 km

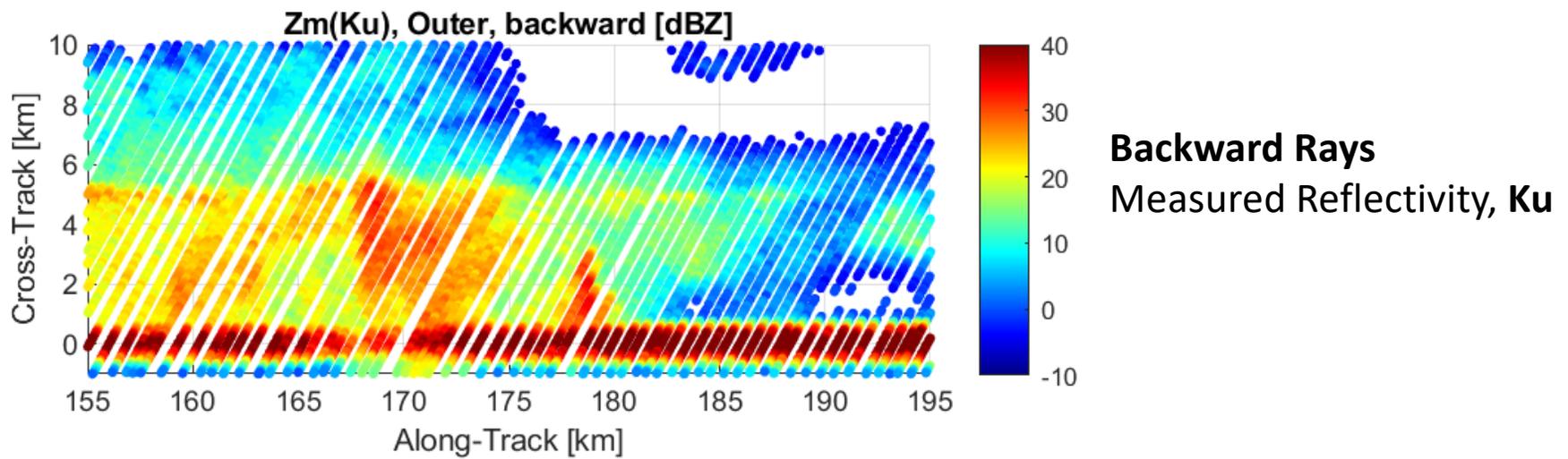
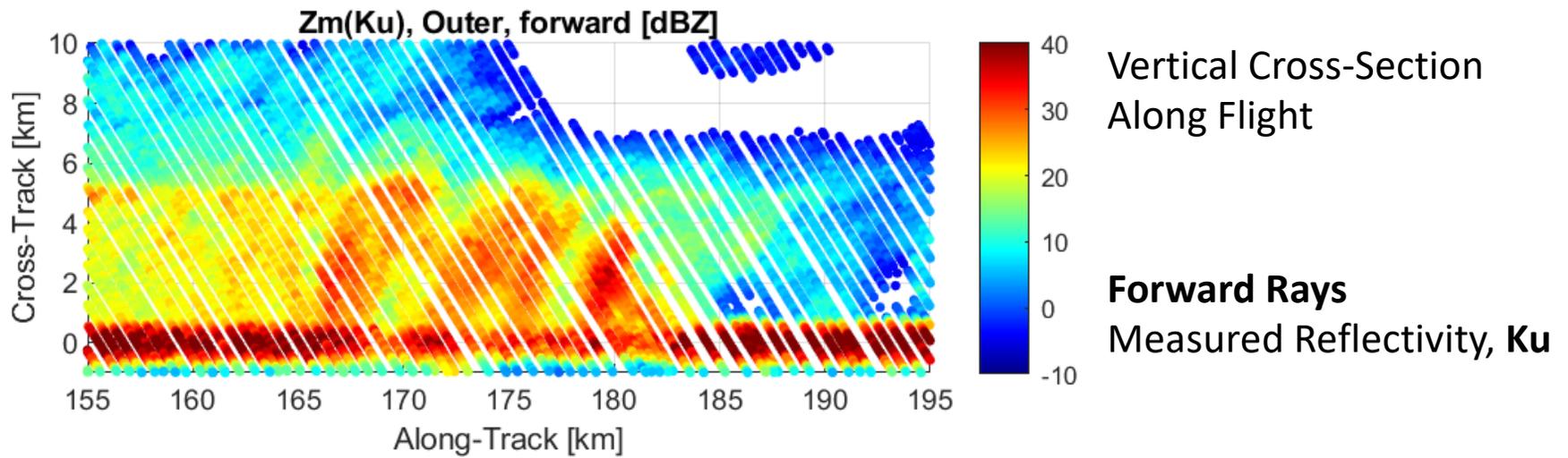
~42 sec to “build column”
(bottom-to-top)

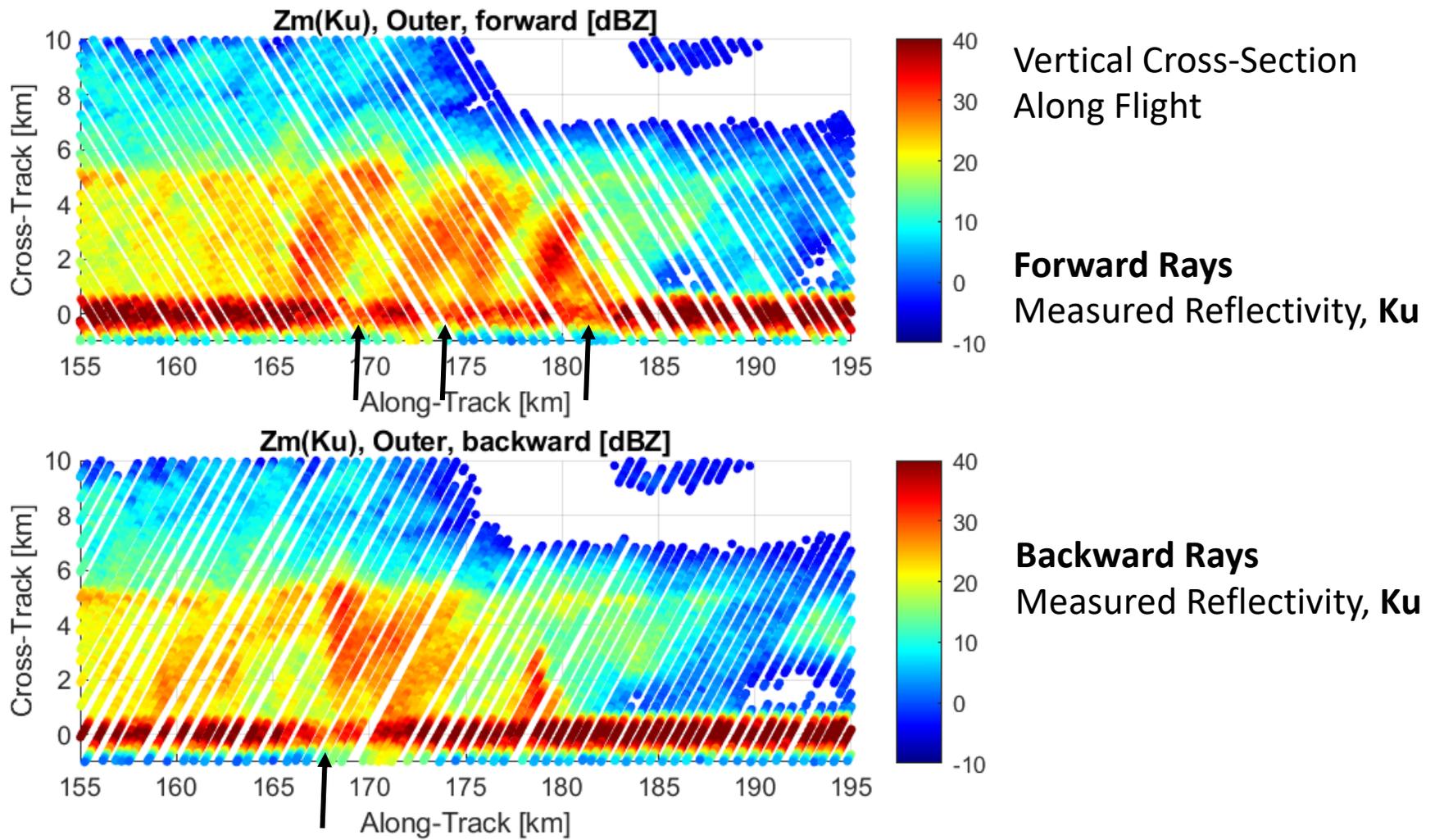
~93 sec to view with backward rays

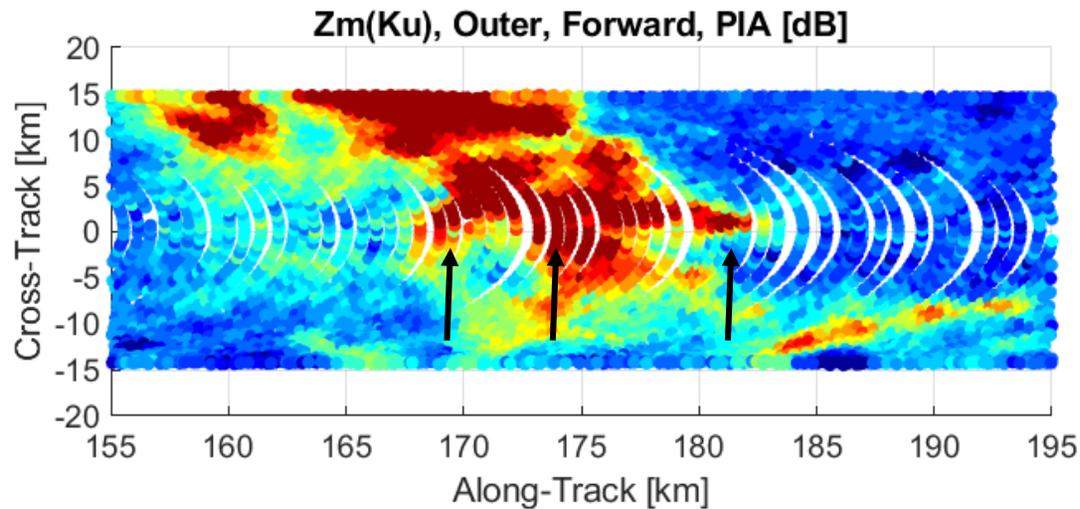
~38 sec to “build column”
(top-to-bottom)

**About 180 sec (3 min) to view column
with forward & backward rays**

Longest time is for surface obs



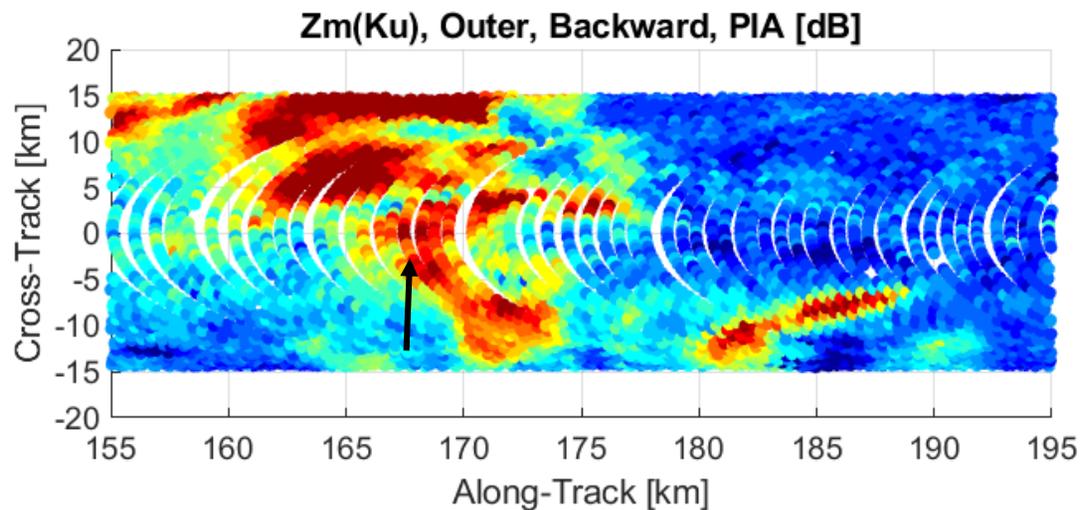




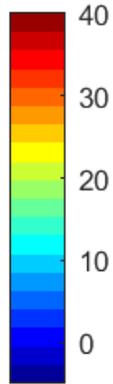
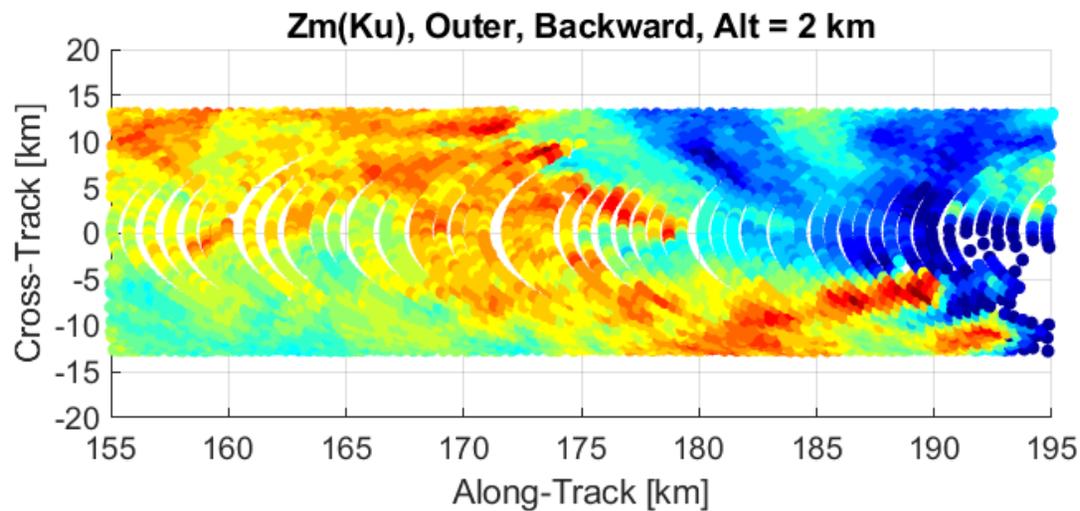
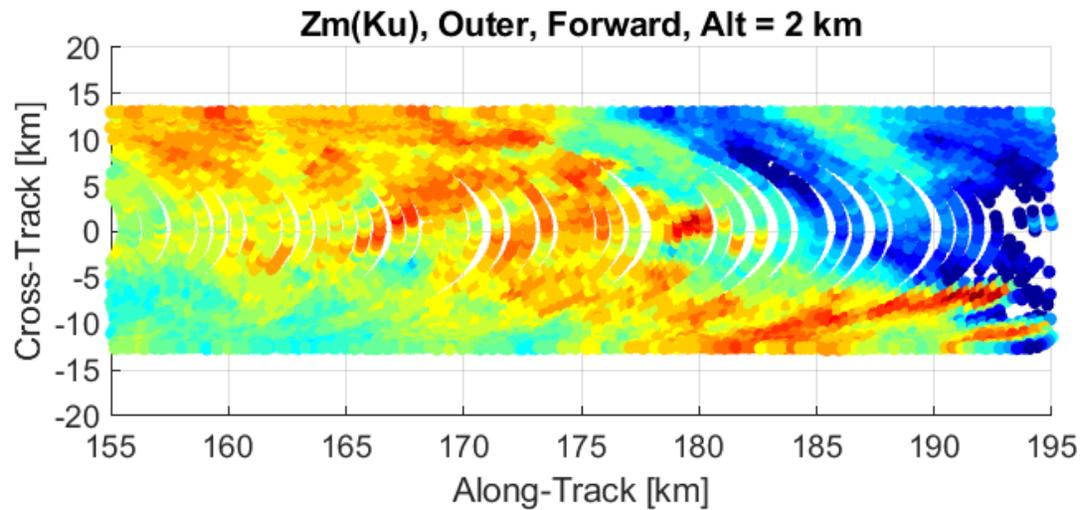
**Path Integrated Attenuation
Outer Scan**

$$PIA = \sigma^0(clear) - \sigma^0(precip)$$

$\sigma^0(clear)$ estimated using
along-track range 20-100 km



- Forward & backward rays observe different patterns...
- Slant paths are through different convective cells
- ~3 min time difference between forward and backward rays

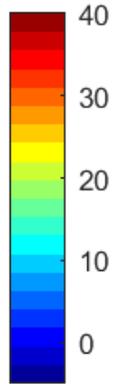
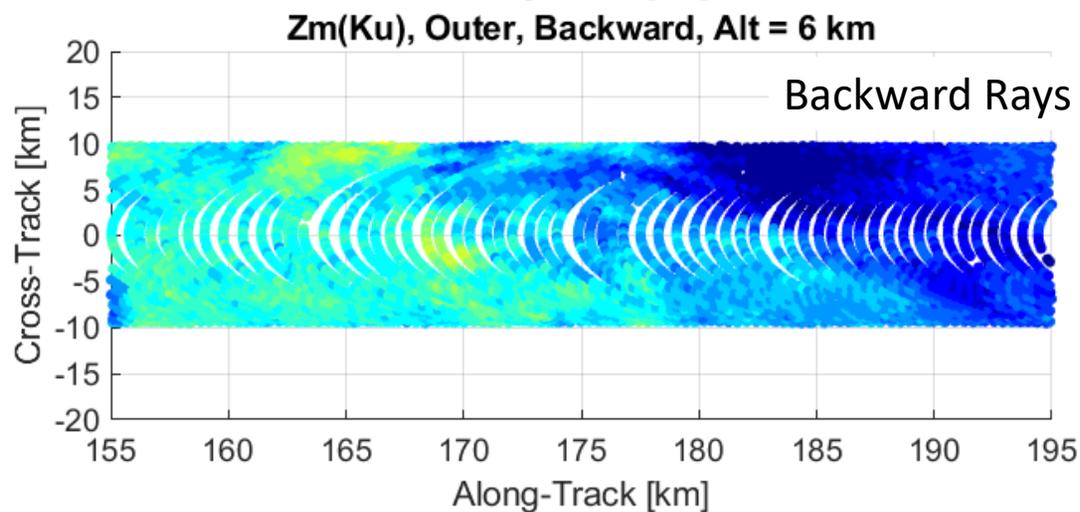
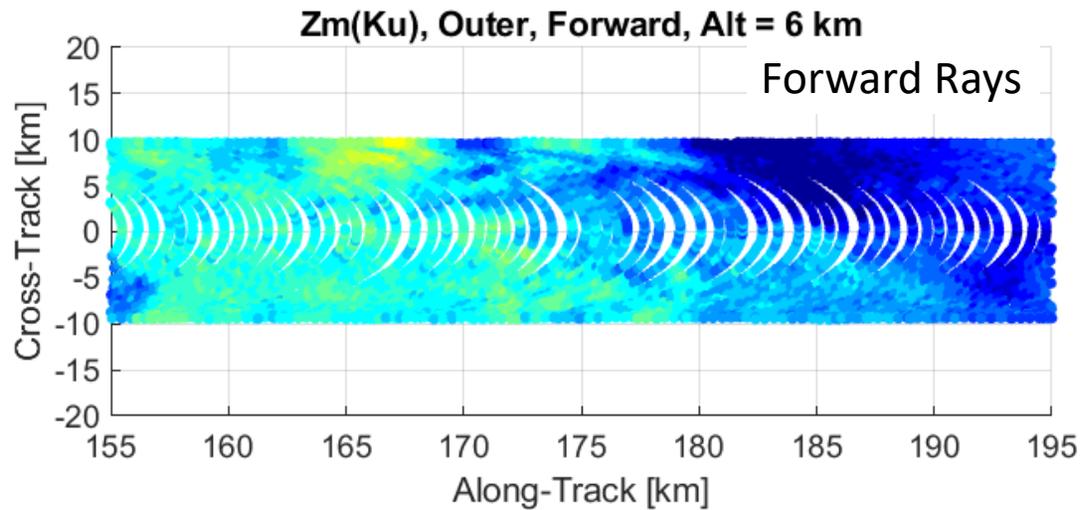


Constant Altitude: **2 km ASL**
Outer Scan

Measured Z_m (Ku)

Cross-track: +/- 14 km

- Forward & background rays observe different patterns...



Constant Altitude: **6 km ASL**
Outer Scan

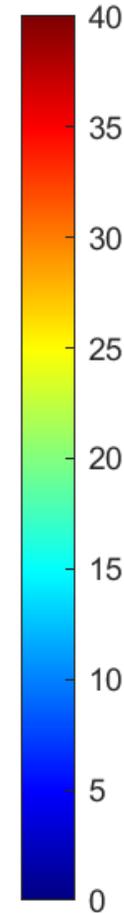
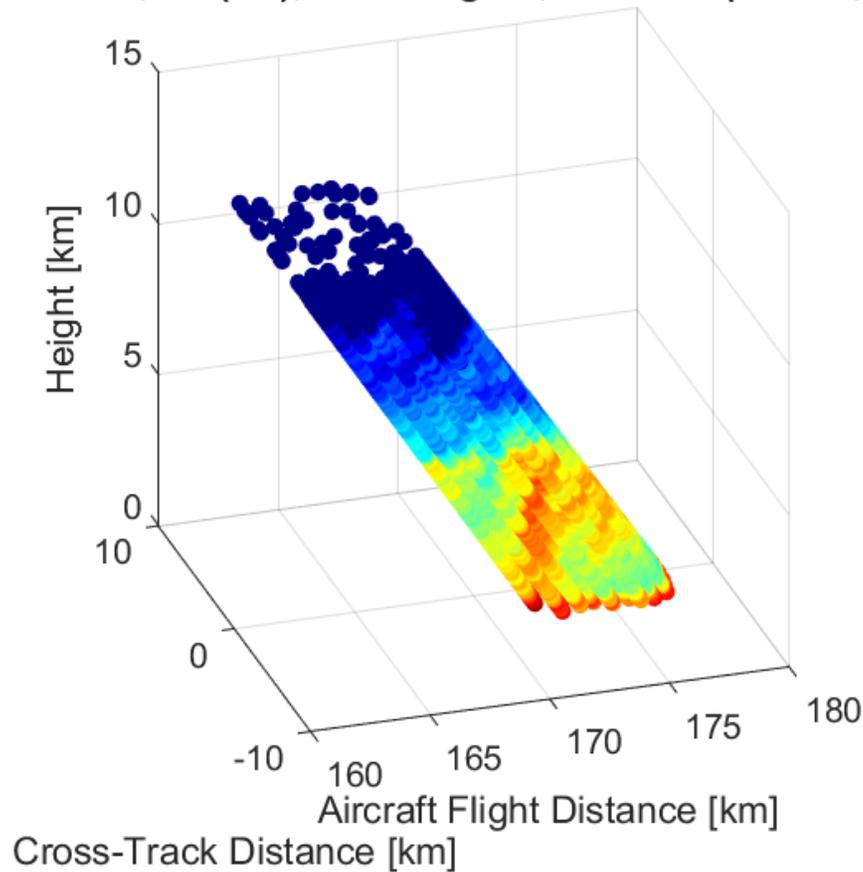
Measured Z_m (Ku)

Cross-track: +/- 10 km

Can construct columns:

- Clutter free surface to 6 km
- Within +/- 10 km swath

HIWRAP, Zm(Ku), 5 km Region, Center = (175km, 0km)



Change Processing Logic

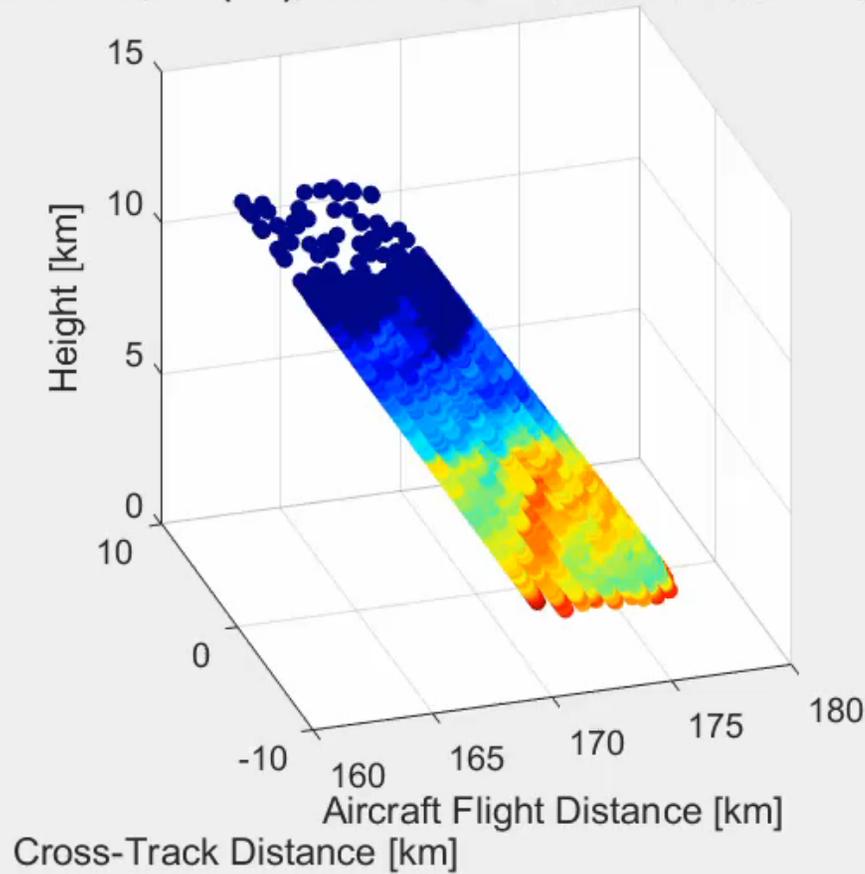
- Do not grid observations...
- Process along rays
- Aggregate at desired scale

For example:
5 km surface grid box
(on surface)

76 forward rays

Measured Reflectivity, **Ku**

HIWRAP, Zm(Ku), 5 km, 0 km



Change Processing Logic

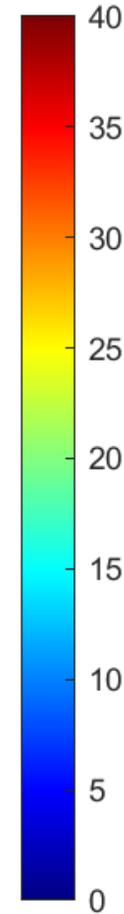
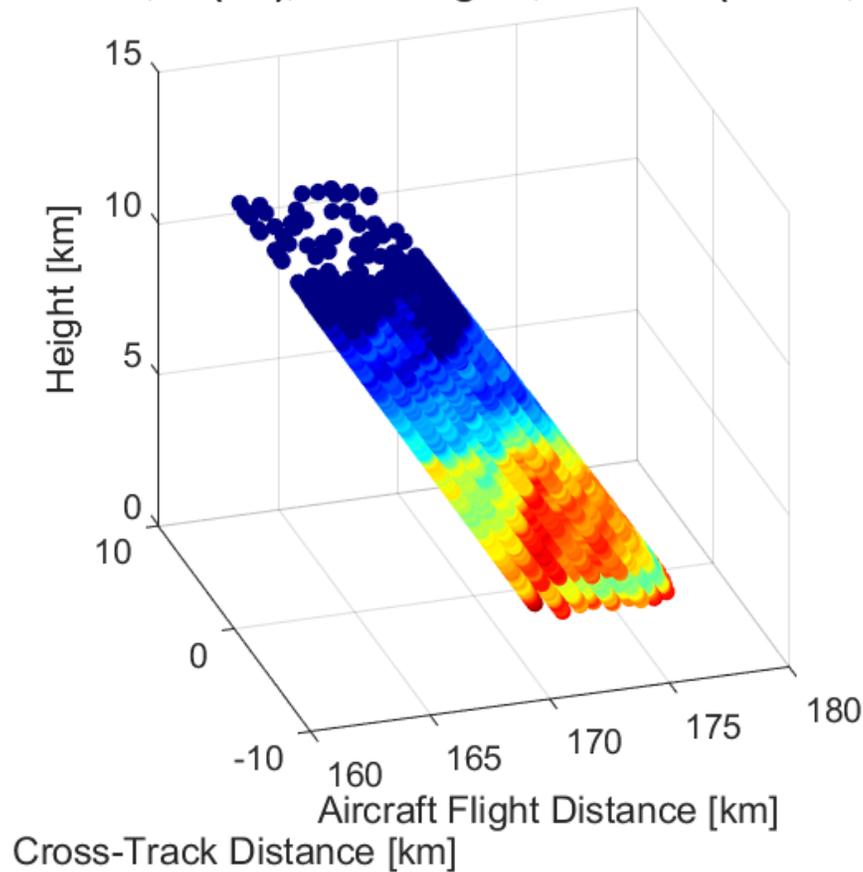
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76 forward rays

Measured Reflectivity, **Ku**

HIWRAP, Ze(Ku), 5 km Region, Center = (175km, 0km)



Change Processing Logic

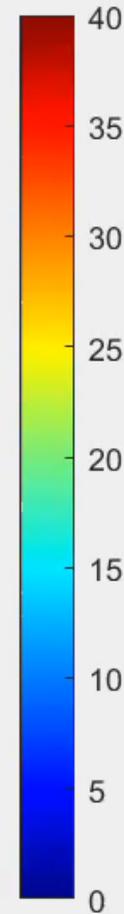
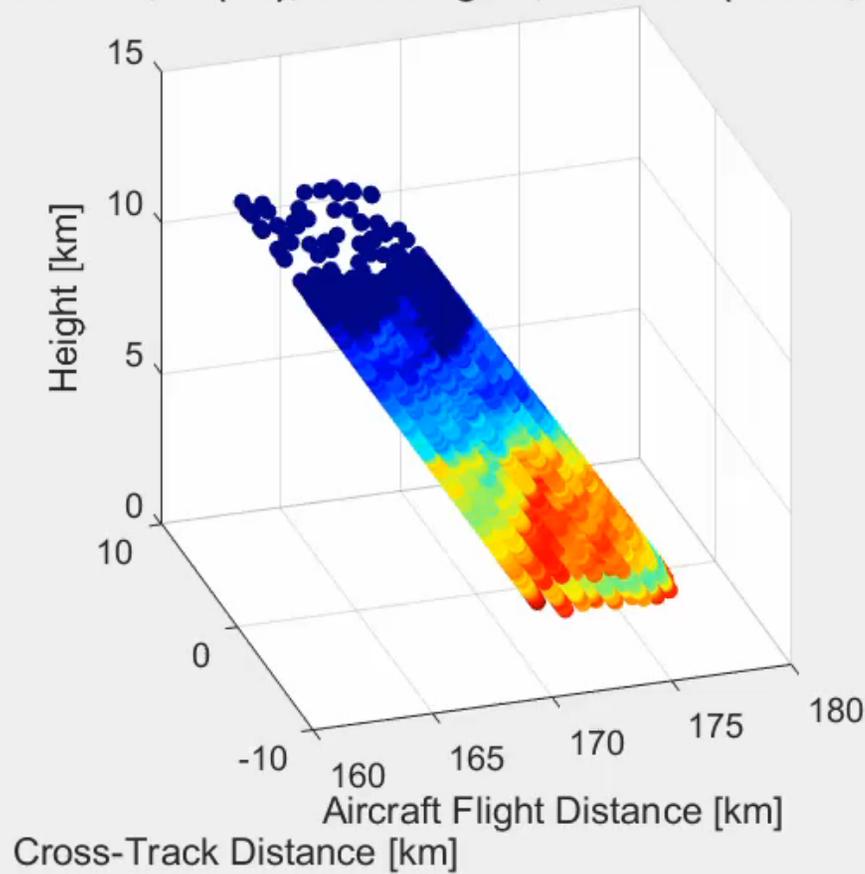
- Do not grid observations...
- Process along rays
- Aggregate at desired scale

For example:
5 km surface grid box
(on surface)

76 forward rays

- Effective Reflectivity, Ze, **Ku**
- Alpha adjusted HB
- Near Surface gate @ 1 km

HIWRAP, Ze(Ku), 5 km Region, Center = (175km, 0km)



Change Processing Logic

- Do not grid observations...
- Process along rays
- Aggregate at desired scale

For example:
5 km surface grid box
(on surface)

76 forward rays

- Effective Reflectivity, Ze, **Ku**
- Alpha adjusted HB
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Concluding Remarks

1. Time difference between Forward and Backward rays will prevent a combined multiple-look gridded data set.
Two data sets: Forward looking and Backward looking
2. Multiple view angles have different path attenuations
Perform retrievals along rays (rain rate and atten. corrected Z)
Apply DPR-like algorithms to HIWRAP rays
3. Do not grid raw data, but *aggregate* attenuation corrected products while constructing simulated radar volumes (and rays)

