An Approach for Reducing Errors Caused by Non-Uniform Beam-filling

Robert Meneghini
NASA/GSFC, Greenbelt, MD

Liang Liao
GESTAR/MSU, Greenbelt, MD

Hyokyung Kim
GESTAR/MSU, Greenbelt, MD

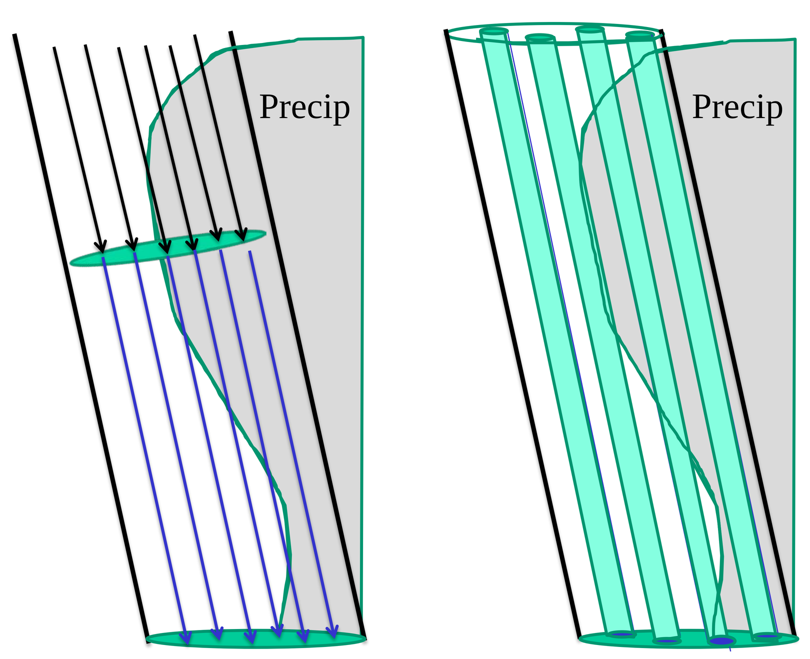
Introduction

Motivation

- Attenuation & NUBF are closely linked
- Attenuation effects exacerbate the NUBF problem
- As such, the problem is more severe at Ka-band than at Ku-band
- If we had higher resolution data, retrieval errors would decrease

Approach

- Using ancillary data (in adjacent/interleaved/oversampled FOV's) interpolate both PIA & Z_m to higher resolution columns
- Normalize the interpolated fields to satisfy the initial conditions
- In this higher resolution space, solve for hi-res Z(x,y,z) over the multiple columns using traditional methods



Some Equations

$$A(\theta)=2\int_0^{r_s} k(\theta,s)ds \approx \langle P_s(No\,Rain,\theta)\rangle - P_s(Rain,\theta)$$

$$A(\theta)=-q^{-1}\log\left[\frac{\iint G^2(x,y)\sigma_R^0(x,y)\exp[-2q\int_0^{r_s}k(s;x,y))ds]\,dx\,dy}{\iint G^2(x,y)\sigma_{NR}^0(x,y)\,dx\,dy}\right]$$

$$let\ \ g=G^2 / \iint G^2(x,y)\,dx\,dy; \quad a(\theta;x,y)=2\int_0^{r_s} k(\theta,x,y;s))ds$$

$$assume\ \sigma_{NR}^0=\sigma_R^0; \ \ (note\ that\ q=0.2303)$$

$$A(\theta)=-q^{-1}\log[\iint_{FOV} g(x,y)\exp(-qa(\theta;x,y))\,dx\,dy] \quad (1)$$

if beam is uniformly filled, $A(\theta)=a(\theta)$

More Eq's

Similarly

$$Z_{m,dB}(h)=q^{-1}\log[\iint_{FOV} g(x,y)z_m(x,y;h)dxdy] \quad (2)$$

Note that near the surface, the hi-res fields are related by

$$z(x,y)=z_m(x,y)\exp(-qa(x,y))$$

where $z(x,y)$ *is the hi-res, atten-corrected reflect factor*

Replace high-res fields with the interpolated fields along with adjustment factors

$$a(x,y)\to\tilde{a}(x,y)+\delta_a$$

$$z_m(x,y)\to\delta_{z_m}\tilde{z}_m(x,y)$$

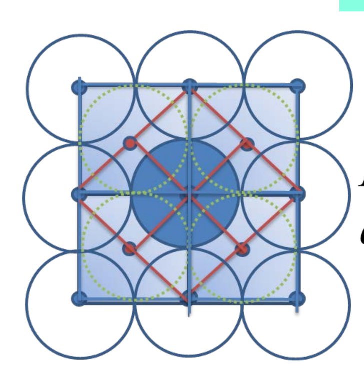
adjust δ_a *and* δ_{z_m} *so that* (1) *and* (2) *are satisfied*

Use modified interpolated fields in standard retrieval equations to get Z(x, y, z) at interpolated resolution

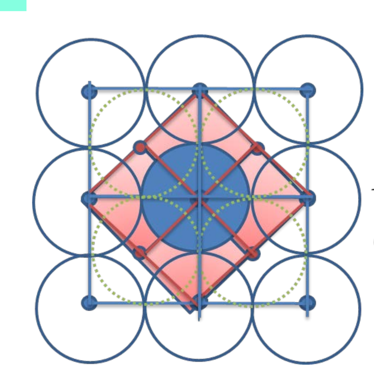
Geometries

We use a bilinear interpolation which requires choosing rectangles that cover the central field of view

Near-Nadir

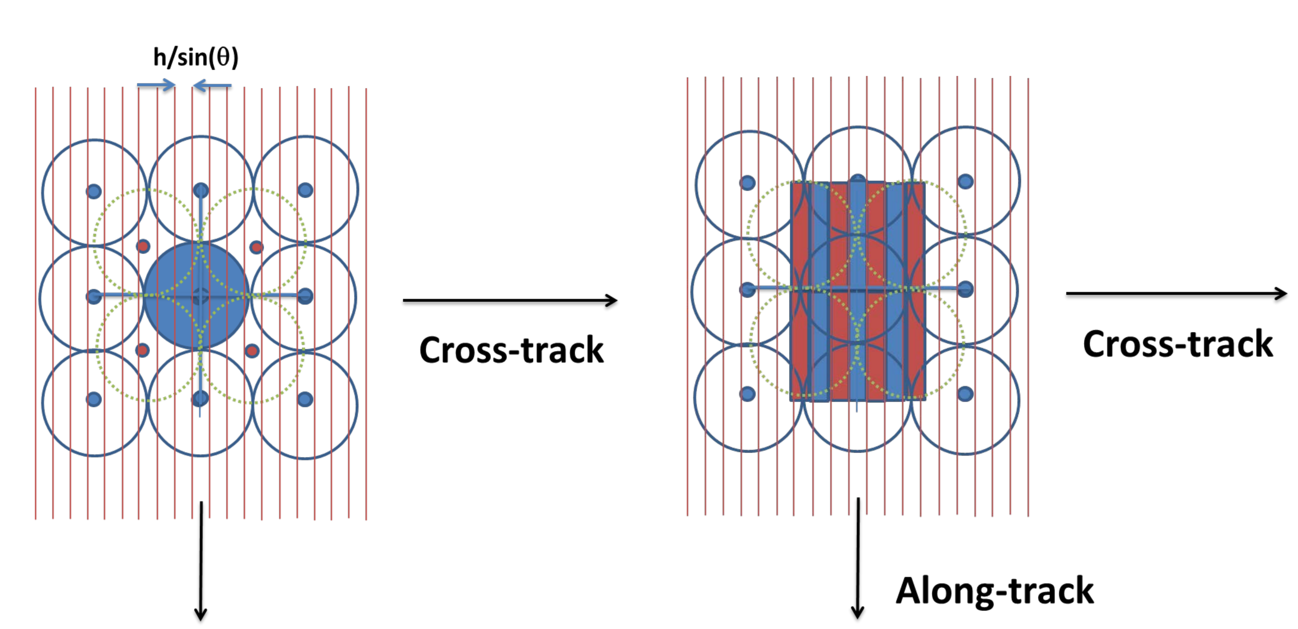


Without Interleaved data

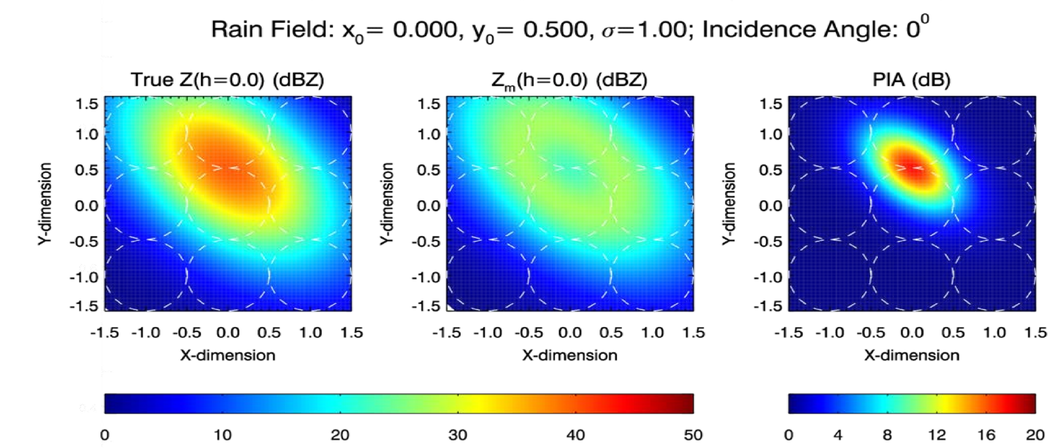


With Interleaved data

Off-Nadir

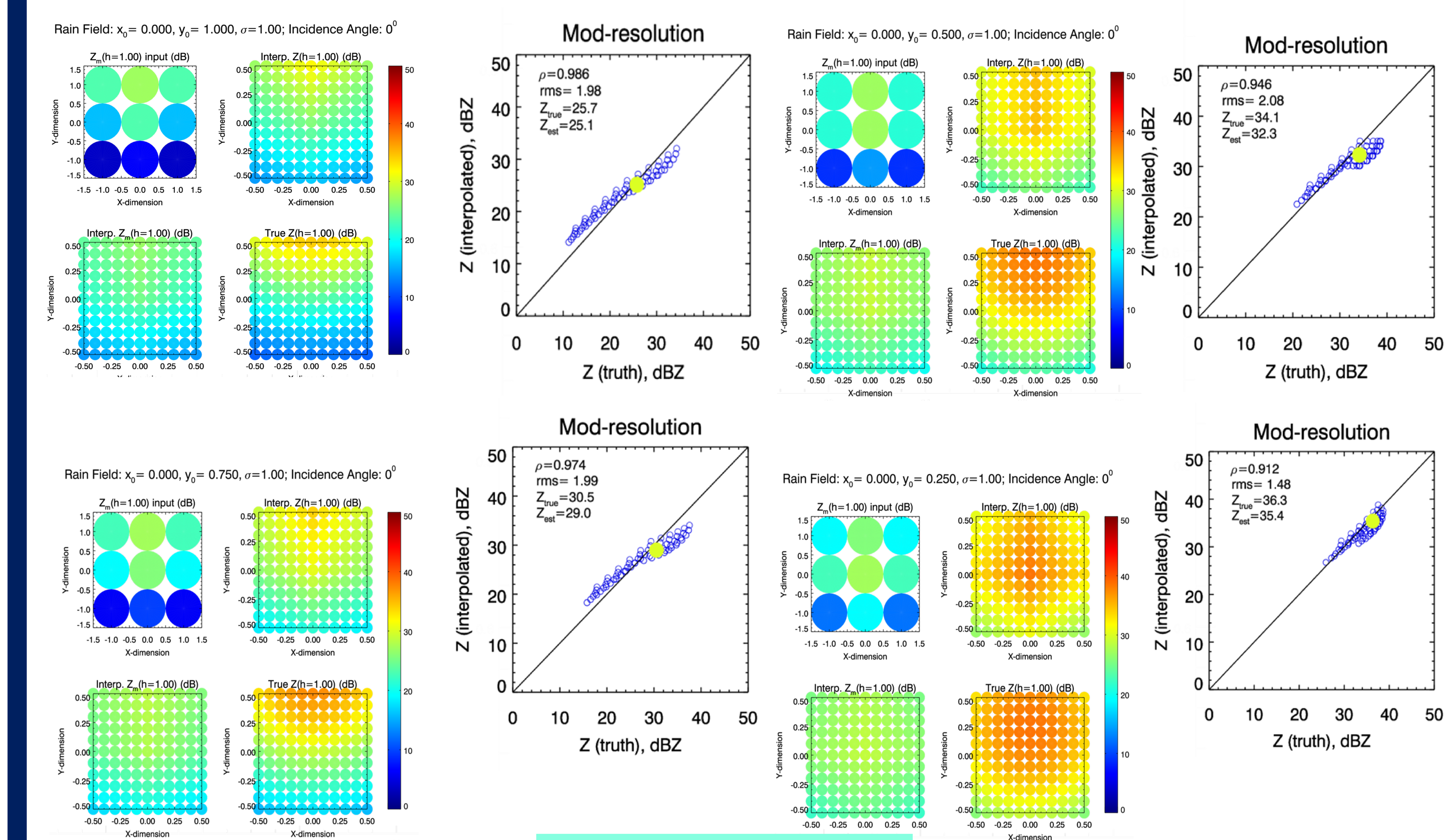


Results

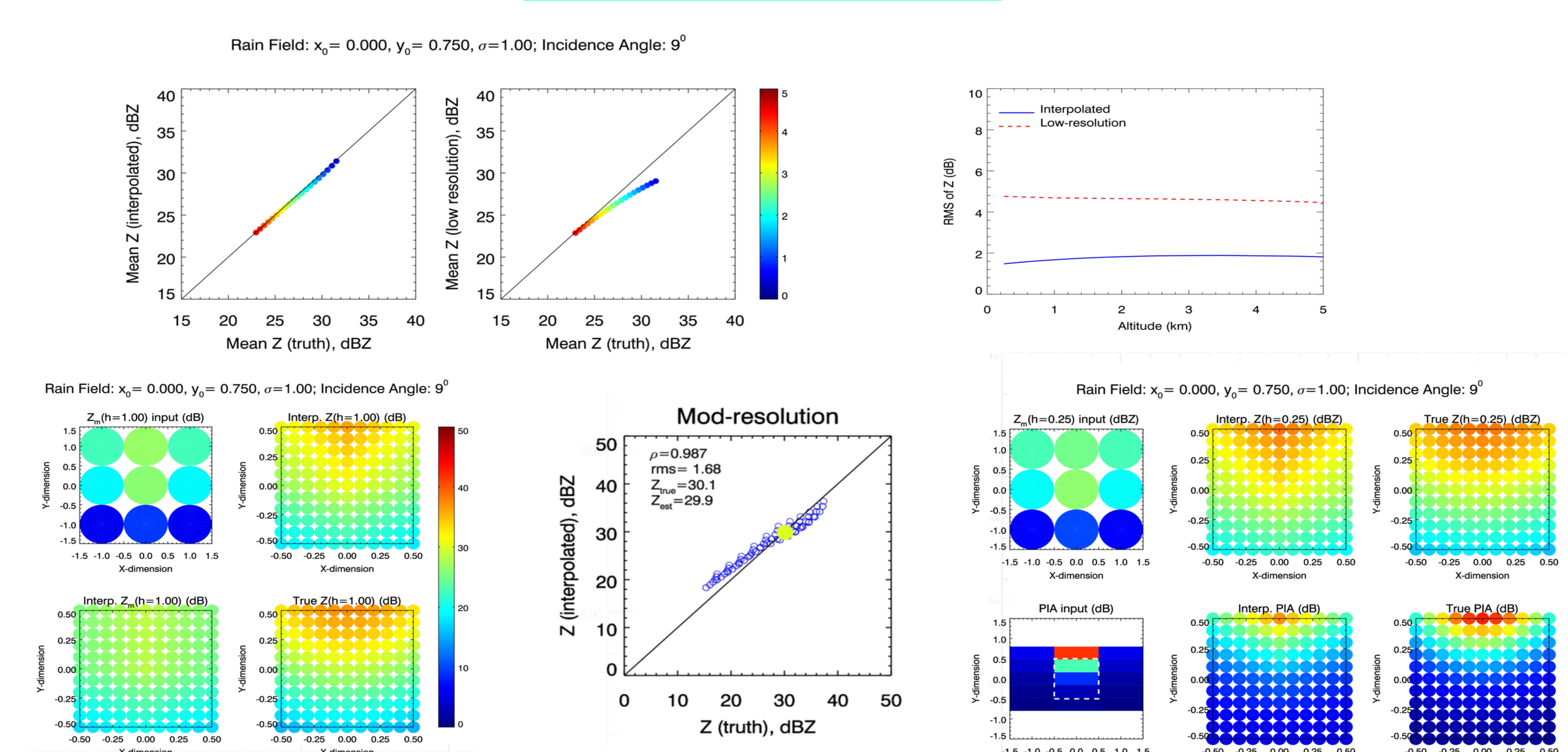


Example of high-resolution fields using a 2D Gaussian storm model

Nadir Examples



Off-Nadir Example



Summary

- The procedure gives some improvement, usually modest, over coarse resolution estimate
  - Greater reduction in rms error than in bias
  - Degree of improvement is non-uniform, however
- Bilinear interpolation has been used
  - Kriging & other geospatial methods might provide better results, esp when using interl. Ka-band data
- To understand the method, a very simple storm model is used
  - MRMS data are being used to get a more realistic assessment of the approach