

Uncertainties in precipitation estimates from space-borne radar observations

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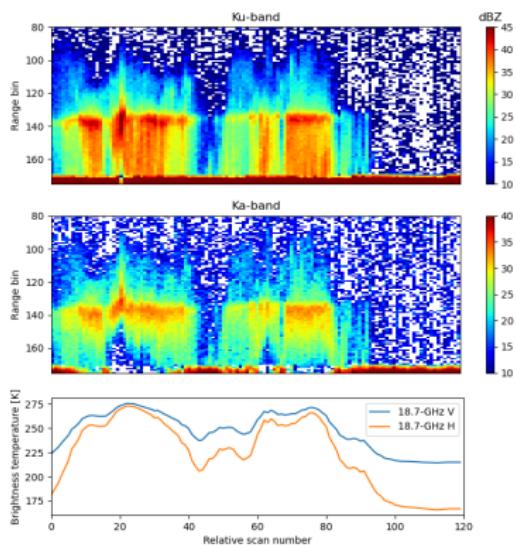
NASA Goddard Space Flight Center and Morgan State University

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Sources of uncertainties

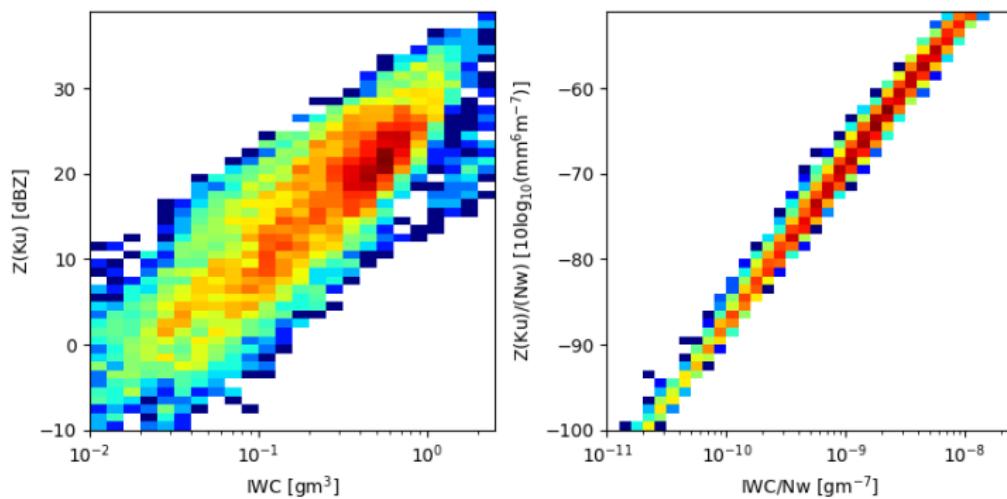
Major sources of uncertainty include:

- ▶ Variability in the Z-R relationships
- ▶ Attenuation in the observed radar reflectivity
- ▶ Variability in the radar beam footprint
- ▶ Ground clutter



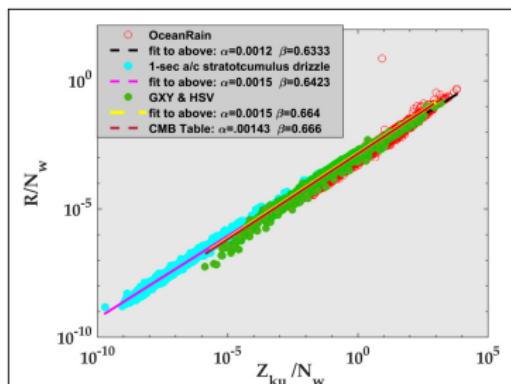
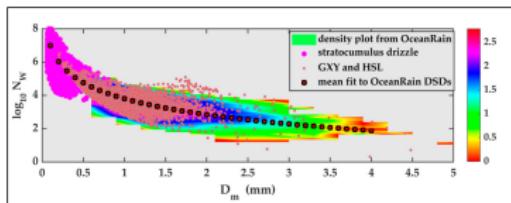
Variability in the Z-Precipitation Rate relationships

- ▶ At least 2 parameters are required to describe Particle size distributions (PSDs).
- ▶ Consequently, the Z-Precipitation Rate relationships require at least 2 parameters. The generalized PSD intercept, $N_w = \frac{4^4}{\pi \rho_w} \frac{PWC}{D_m^4}$, greatly simplify Z-Rate relationships.



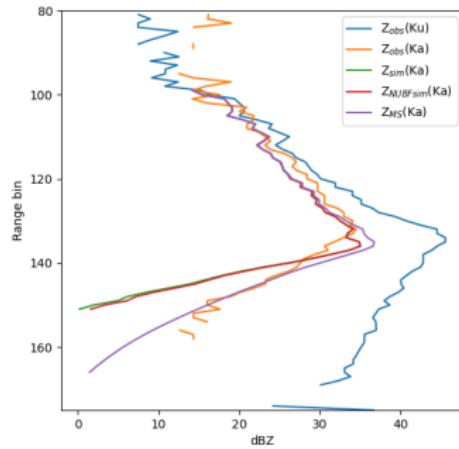
The N_w problem. General considerations

- ▶ The N_w parameter greatly simplifies the formulation, but not the problem.
- ▶ It does not solve it though, as N_w still needs to be estimated independently of the radar observations.
- ▶ Ground observations may be used to impose constraints on N_w .
- ▶ However, such constraints are not very effective for PSD characterized by large mean particle sizes D_m .



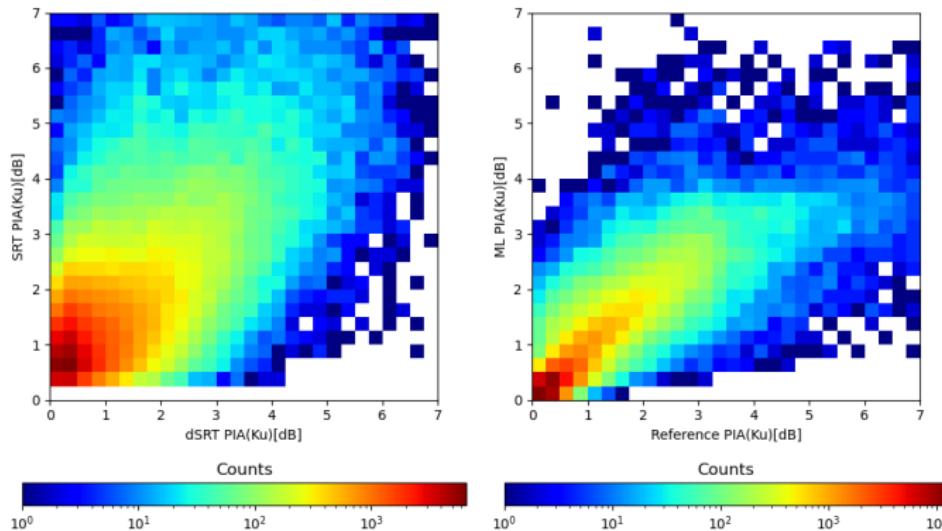
The N_w problem. Radar profiling considerations

- ▶ Additional constraints can be imposed by using radar by considering N_w in the radar profiling context.
- ▶ That is, the attenuation correction process needs to be consistent with the N_w parameter. $Z(r) = Z_m(r)/PIA$
 $PIA = (1 - \epsilon(N_w)q \int_0^r Z_m^\beta(s)ds)^{1/\beta}$
- ▶ The analytical PIA needs to be consistent with the SRT PIA estimate and Ka-band reflectivity observations when available.



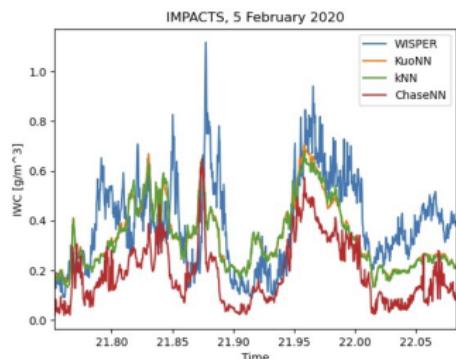
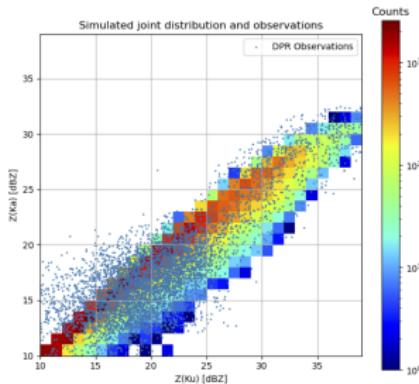
The N_w problem. Further considerations

- ▶ Surface Reference Technique (SRT) PIA is a useful piece of information when reliable.
- ▶ Dual SRT PIA is more reliable than single SRT PIA, except for heavy convection.
- ▶ Over oceans SRT PIA estimates are significantly more reliable than over land.
- ▶ For snow and light rain, SRT PIA estimates are not reliable.



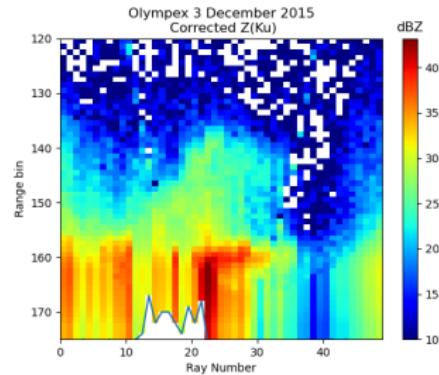
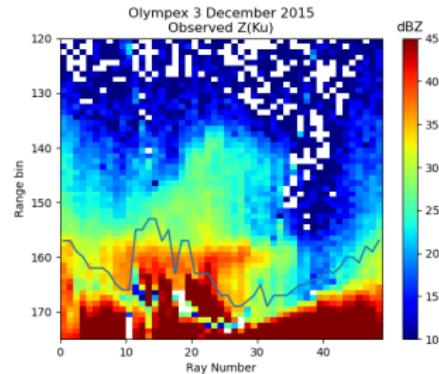
Snow estimation issues

- ▶ The variability of N_w is still a problem, but there is very little attenuation in snow to use the PIA as a constraint.
- ▶ When dual frequency observations are available, D_m and hence N_w may be estimated from the dual frequency reflectivity ratio (DFR).
- ▶ However, the DFR may be very noisy.
- ▶ More robust methods, i.e. Machine-Learning based, may be used to derive to incorporate "in-situ" information and provide more accurate estimates.



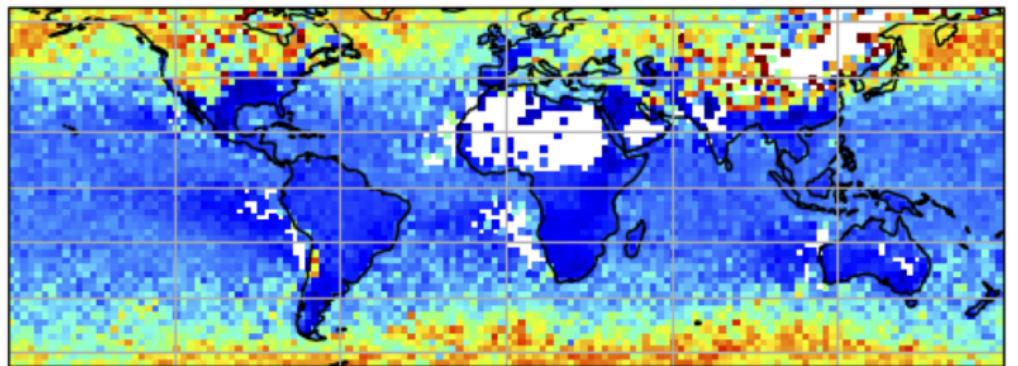
Ground Clutter

- ▶ Ground clutter is strong echo in the radar observation caused by the ground.
- ▶ It can extend up to 2.0 km above the surface and completely obscure the precipitation echo.
- ▶ Nadir observations are minimally affected and can be used in the development of statistical clutter mitigation methodologies, e.g.
 $p\text{Rate}(z < z_{cf}) = p\text{Rate}(z_{cf}) \times p\text{Rate}_{mean}(z) / p\text{Rate}_{mean}(z_{cf})$

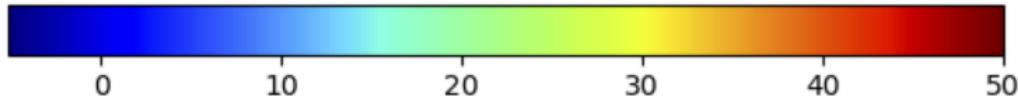


Impact of Ground Clutter Correction

Relative differences between surface and near surface rates
December 2018

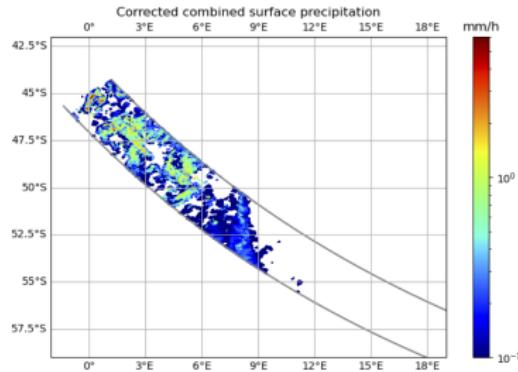
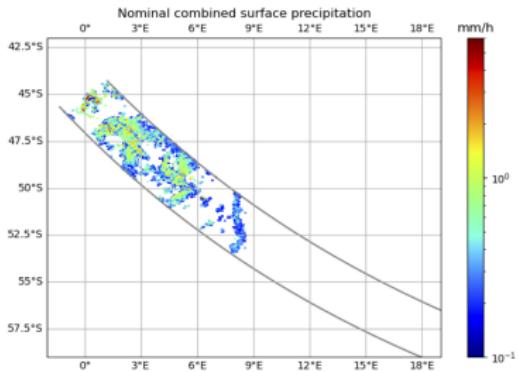


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Light Precipitation

- ▶ The DPR does not miss all the light precipitation associated with a given point in the Tb-space
- ▶ An empirical algorithm may be derived from collocated Tbs and DPR retrievals
- ▶ The empirical algorithm is to be applied only when the DPR does not detect precipitation. When estimates are greater than 0, a decision is required.



Summary and Conclusions

- ▶ Although the most accurate at the instantaneous level, space-borne radar precipitation estimates affected by multiple types of uncertainties.
- ▶ Even when dual frequency observations are available, the estimation problem is still posed.
- ▶ Parameterizations and "a priori" information derived from ground observations may be used to mitigate the uncertainties.
- ▶ However, the process is not trivial and requires a sustained long-term effort.