Cloud observations from the Arcs and EarthCARE project

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EarthCARE (Earth Clouds Aerosol Radiation Explorer)
JAXA-ESA joint mission

launch date : 2018
altitude : 393.14km
repeat cycle: 25days

1. CPR: 94GHz Doppler cloud radar

2. ATLID: 355nm high spectral resolution lidar

3. MSI : Multi-spectral imager
7channels (0.69, 0.865,
1.65, 2.21,8.8, 10.8, 12.0μm)

4. BBR: Broad band radiometer
3 views

(Illingworth et al., 2015 BAMS)

Different features of EarthCARE from A-train (CloudSat and CALIPSO)

1. **Doppler at w-band**
2. **+8dB higher sensitivity** (-36dBZ) compared with CloudSat-> better water cloud detection, better overlap with lidar ->achieve better accuracy for microphysical retrievals by radar-lidar.
3. **No contamination due to surface clutter** found in CloudSat ->to better characterize surface process and convection?.
4. **High spectral resolution lidar at 355nm**->obtain extinction. Need to connect 532nm and 355nm information.
5. short life time.

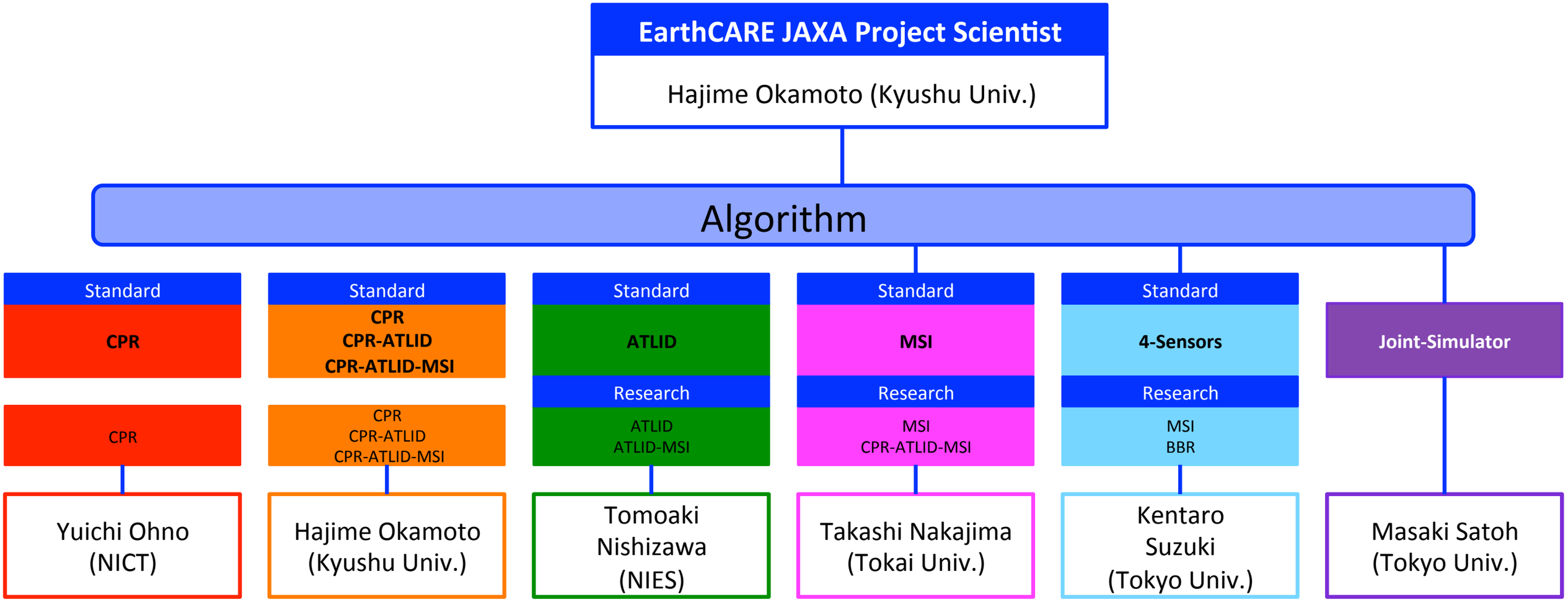
Doppler accuracy of EarthCARE CPR (Tentative) for 16km mode (PRF=7200Hz):

10km horizontal integration:
1.1m/s for -19dB (worst case).
0.6m/s for -19dB (best case).

1km horizontal integration:
1.3m/s for -14dBZ (worst case).
0.8m/s for -14dBZ (best case).
Theoretical limit =0.2m/s

H. Okamoto/A. Illingworth (co-chairs)

EarthCARE JAXA science team



CPR

CPR, CPR/ATLID, CPR/ATLID/MSI

ATLID

MSI

4 sensor (radiation)

J-Sim.

(Slide from R. Oki)

Liquid water path

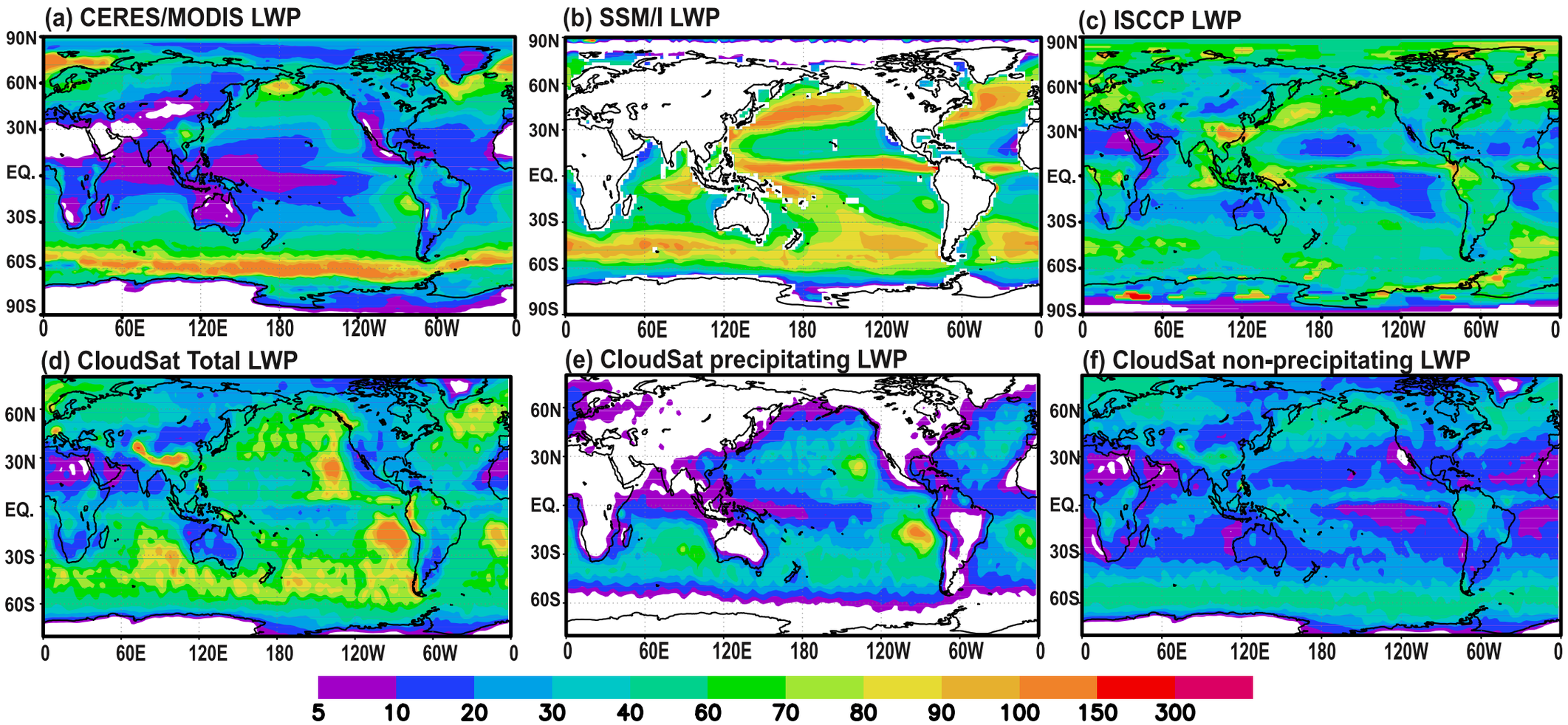


Figure 2. Multi-year mean values of cloud liquid water path (LWP; g m^{-2}) from the all-sky LWP of (a) CERES/MODIS (2001–2005), (b) SSM/I (7/2002–6/2007), (c) ISCCP (Annual mean: 2005), as well as (d) CloudSat (8/2006–7/2007) for total LWP, (e) CloudSat LWP associated with precipitation at the surface, and (f) CloudSat non-precipitating LWP.

(Li et al., GRL 2008)

Liquid water retrieval by lidar

Retrieval of vertical microphysical structure form CALIPSO β and δ

- super-cooled layer (mixed phase)
- bimodal size distribution

- CloudSat standard water cloud microphysics: LWC/IWC partition based on temperature (Austin et. al., 2006 etc)

- CALIPSO: phase discrimination (Yoshida et al., 2009, Hu et al., 2007)

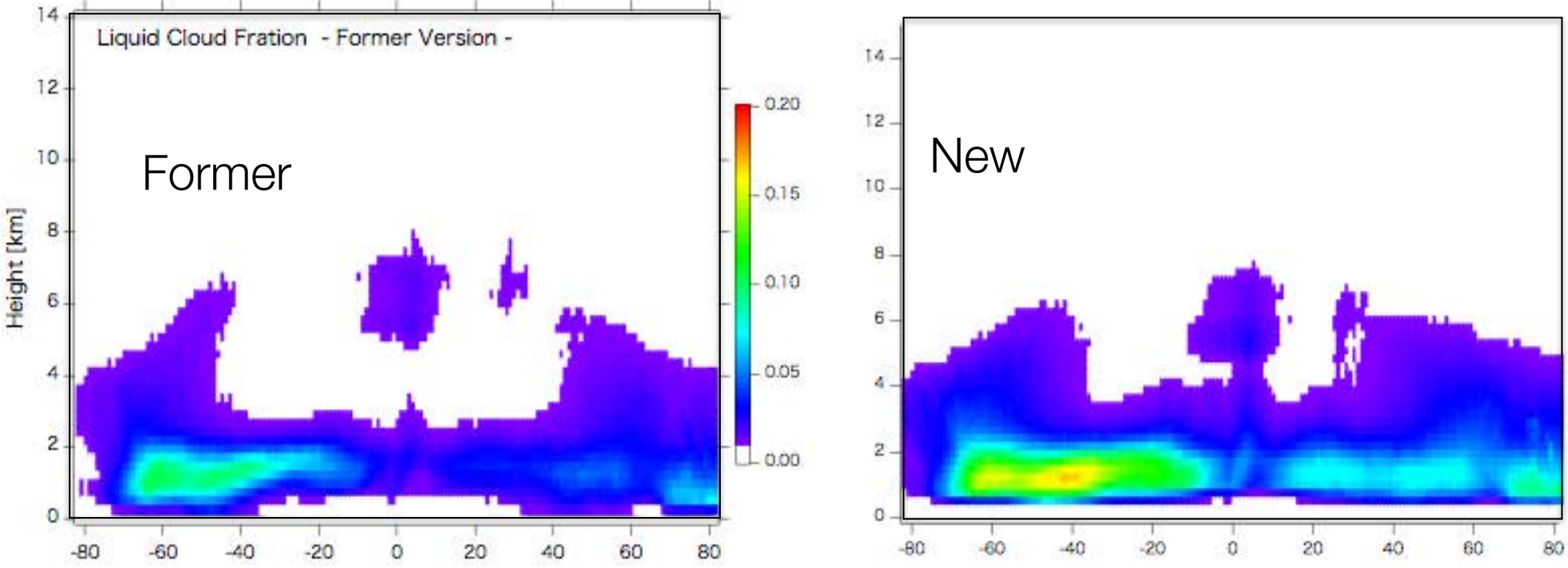
- CALIPSO water cloud retrieval

  CALIPSO+MODIS (Hu et al.,) τ and LWC from layer integrated depolarization ratio.

Refined cloud mask scheme: KU-mask

Determination of strongly attenuating and fully attenuated pixel in lidar cloud mask

Liquid cloud fraction from CALIPSO



Latitude

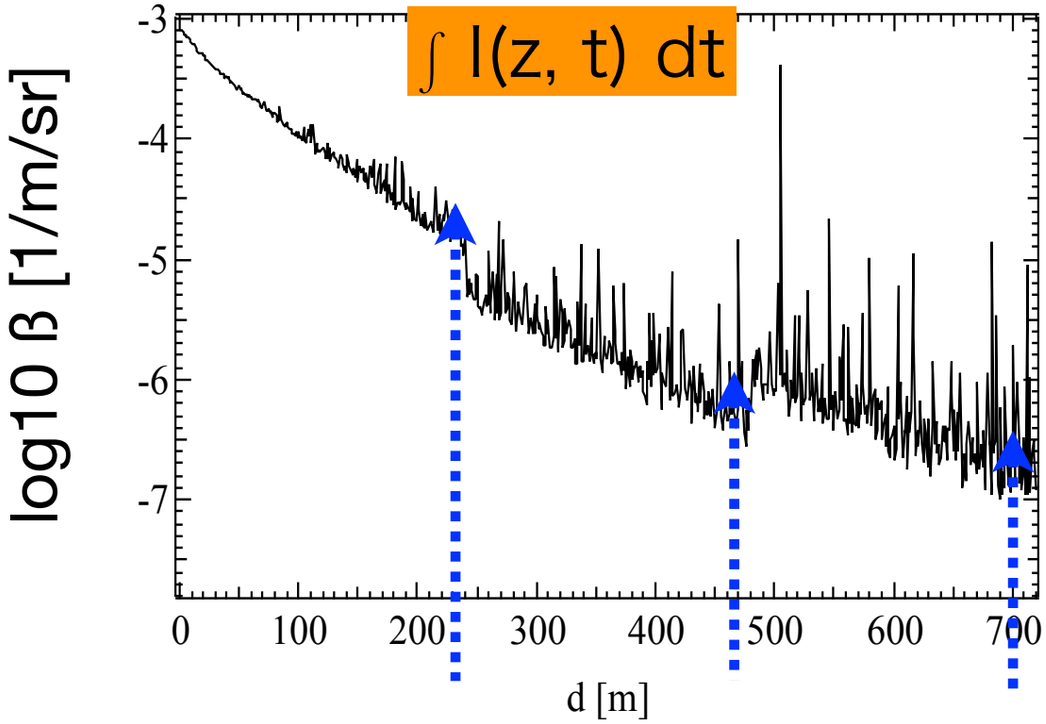
Latitude

(S. Katagiri)

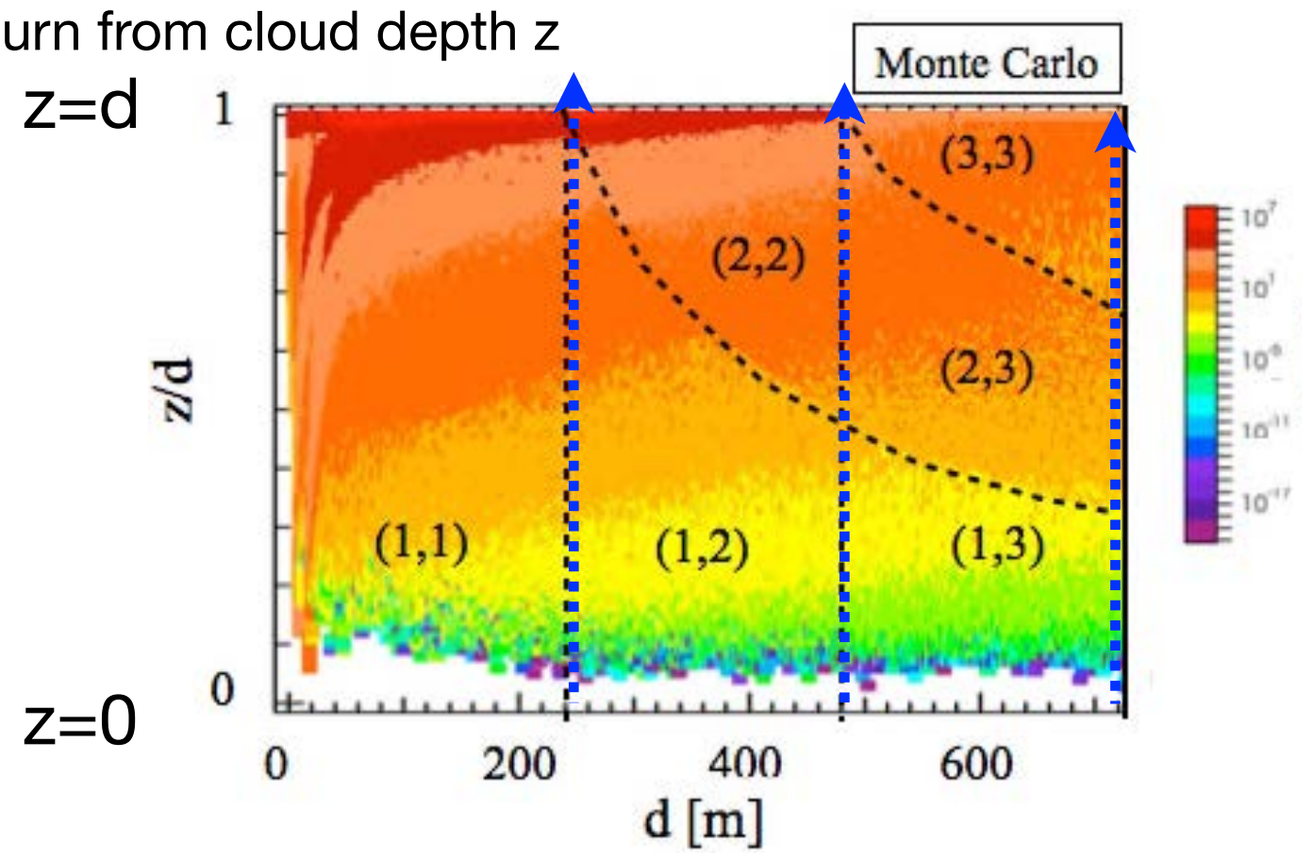
Analysis of lidar depolarization

Inversion for inhomogeneous cloud microphysics

- Monte Carlo-base LUT method



apparent penetration depths

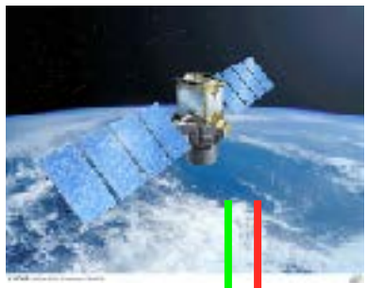


apparent penetration depths

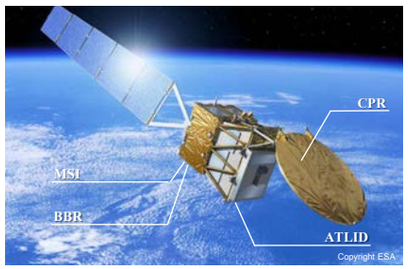
(sato et al., ILRC 2016)

Development of a physical model

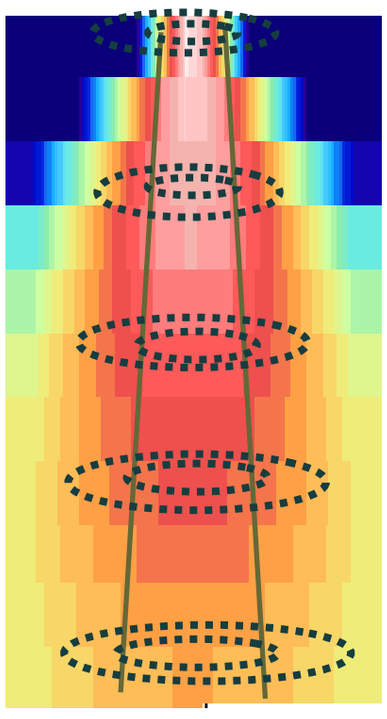
CALIPSO (NASA)

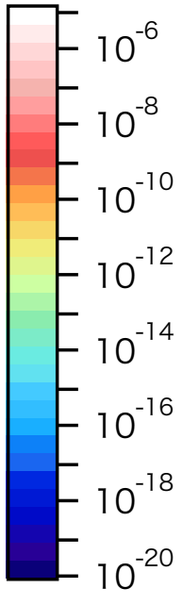


EarthCare ATLID(jaxa-esa)

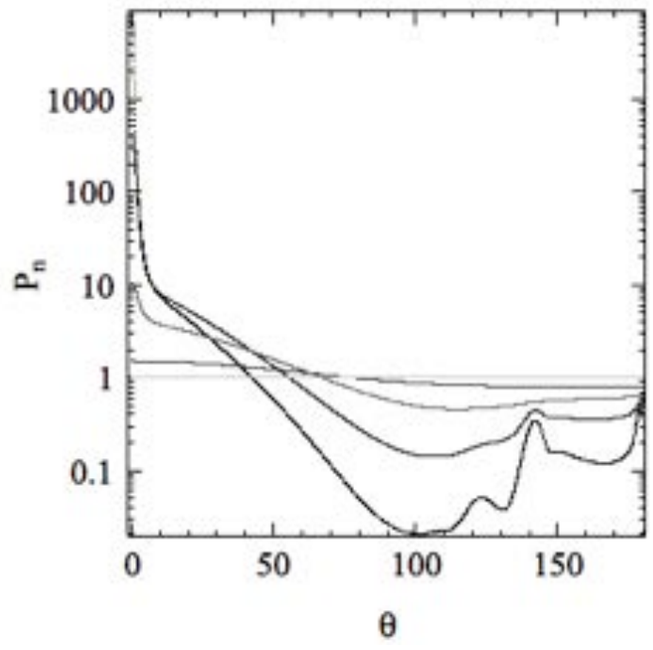


ß, δ



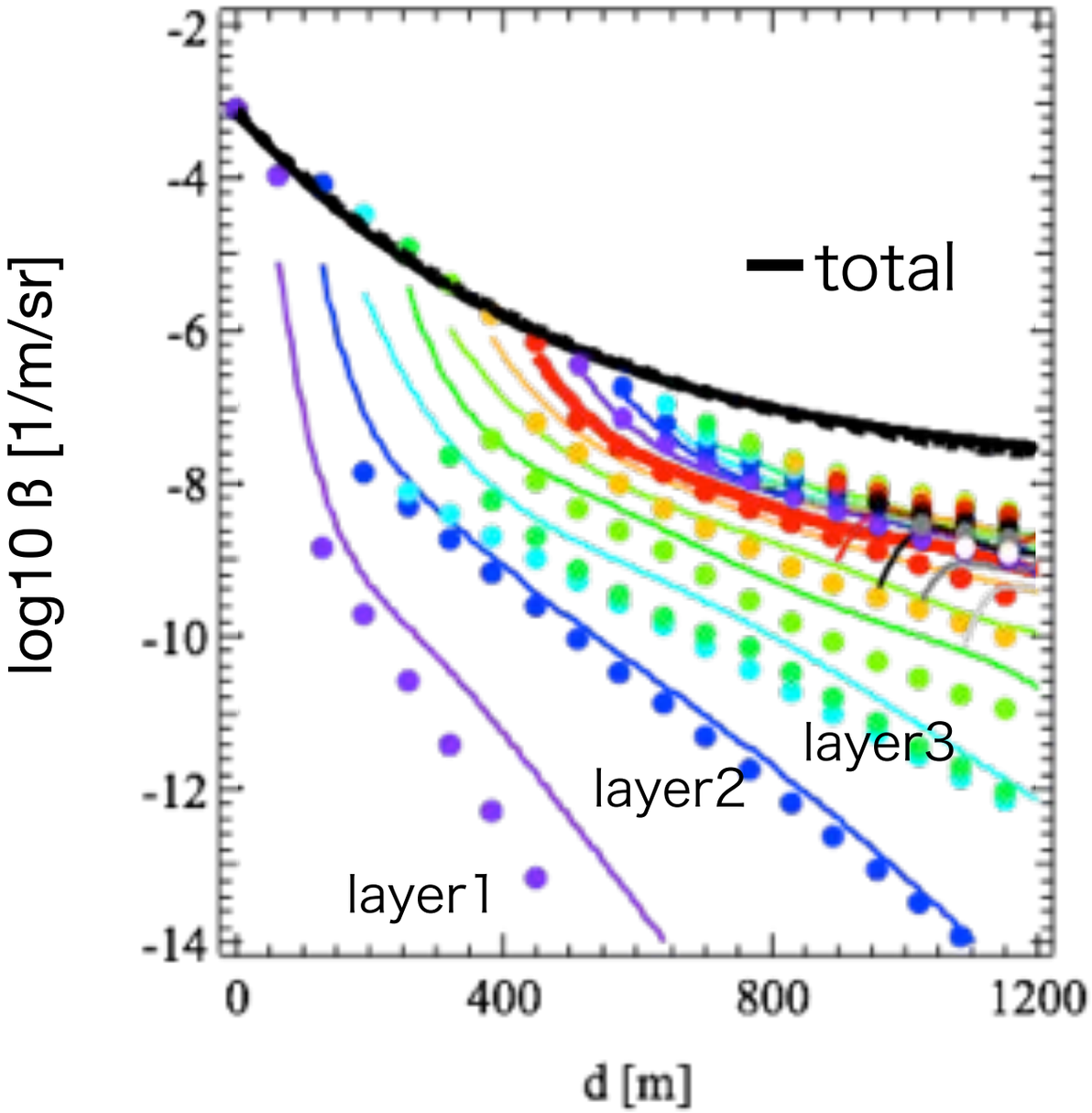


applicable to different lidar systems and inhomogeneous cloud layers



$$I(t) = I_{reduced}(t) + I_{diffused}(t,z)$$

Performance: attenuated backscattering coefficient

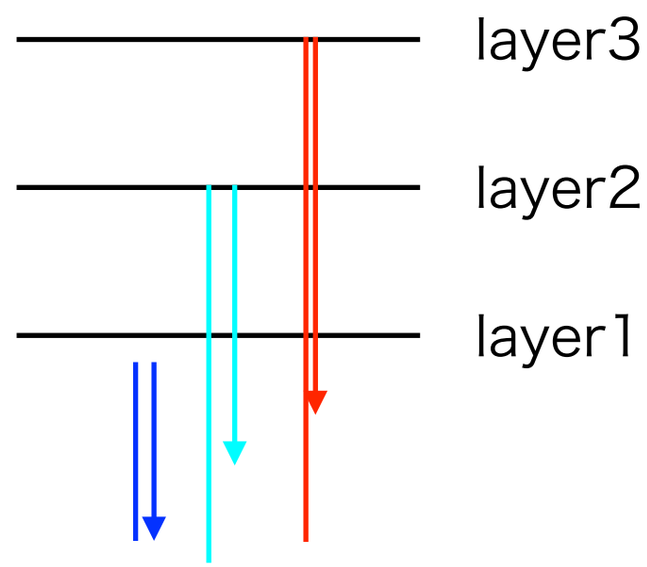


apparent penetration depths

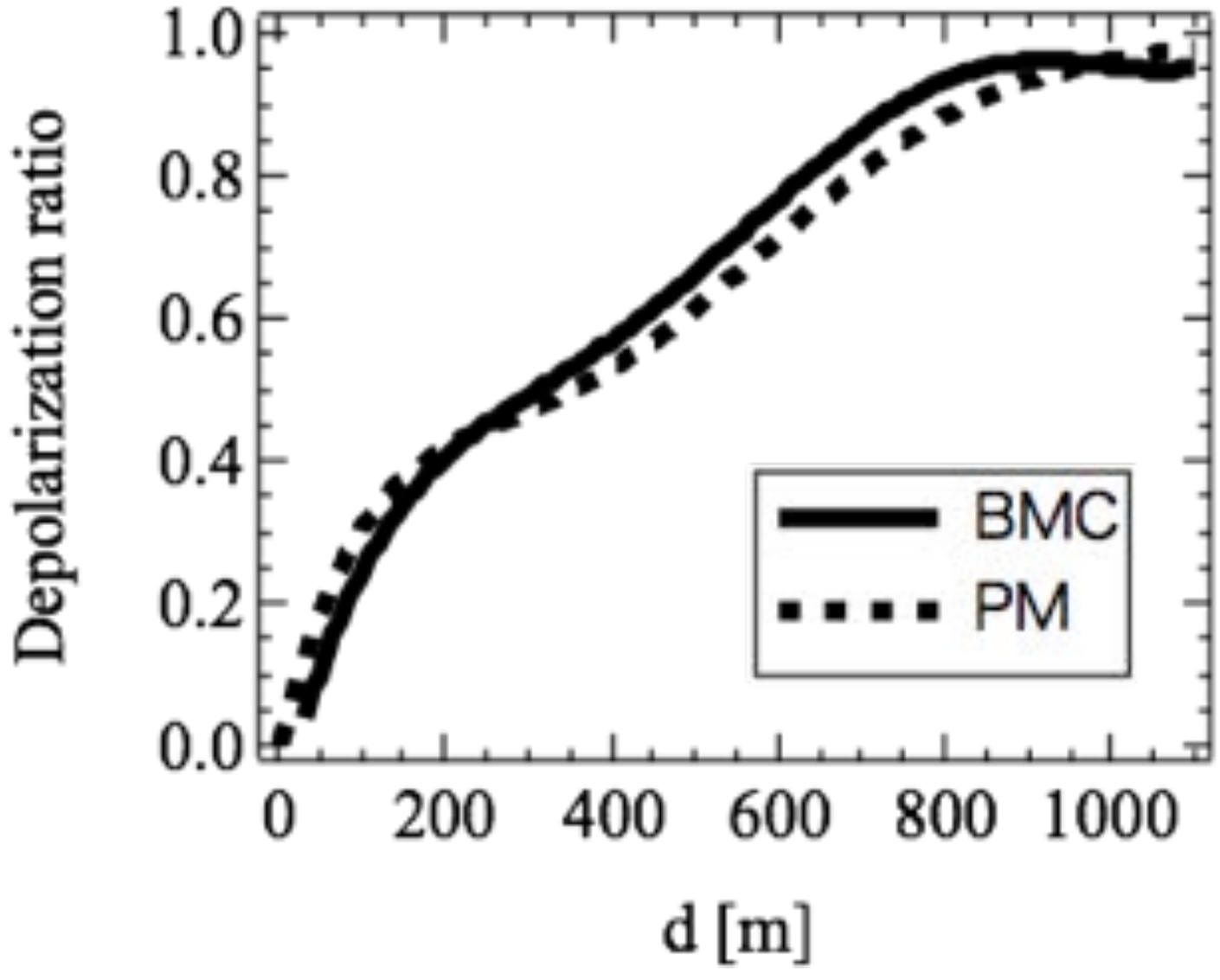
model

Monte Carlo

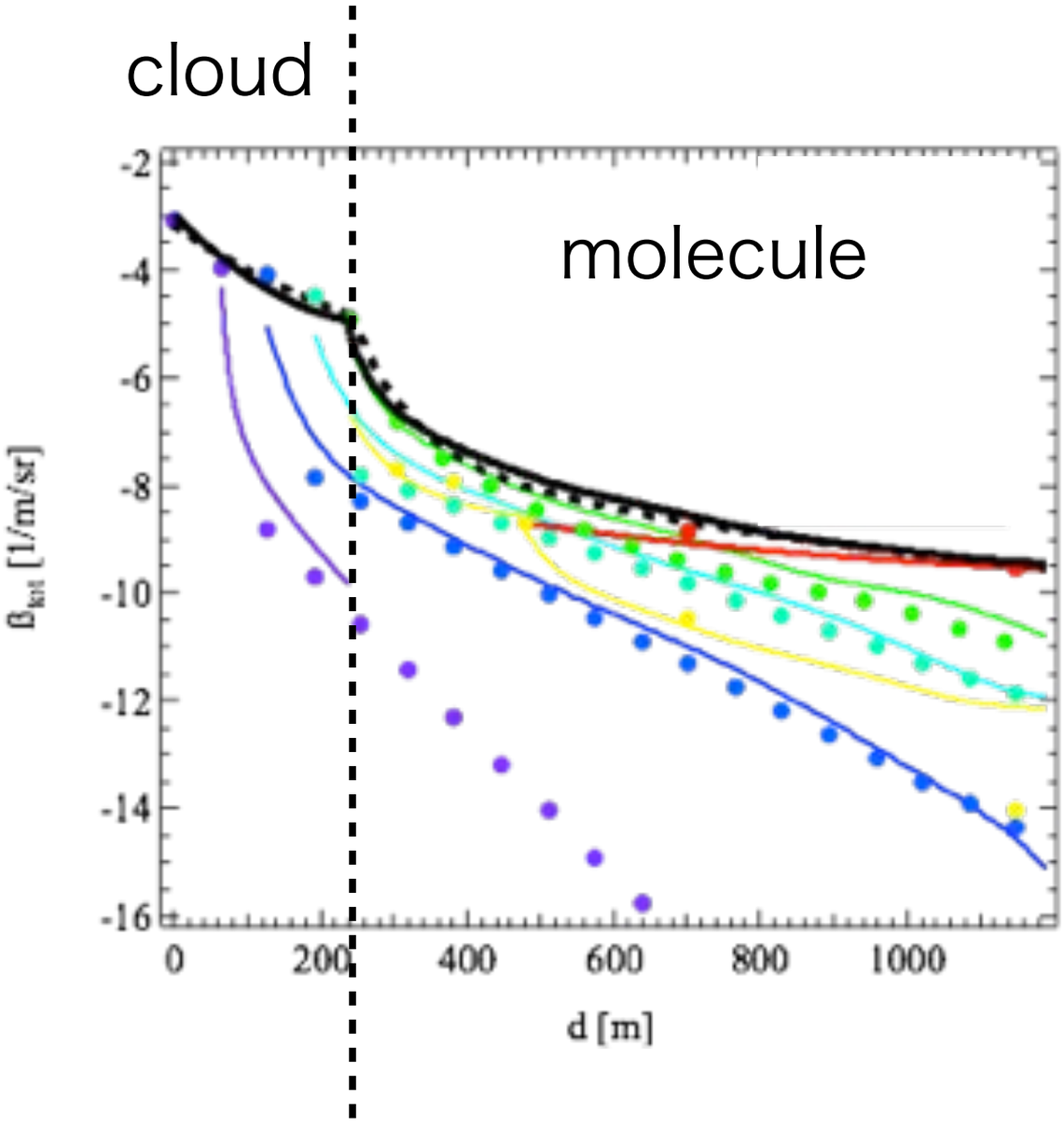
color: maximum penetration depths

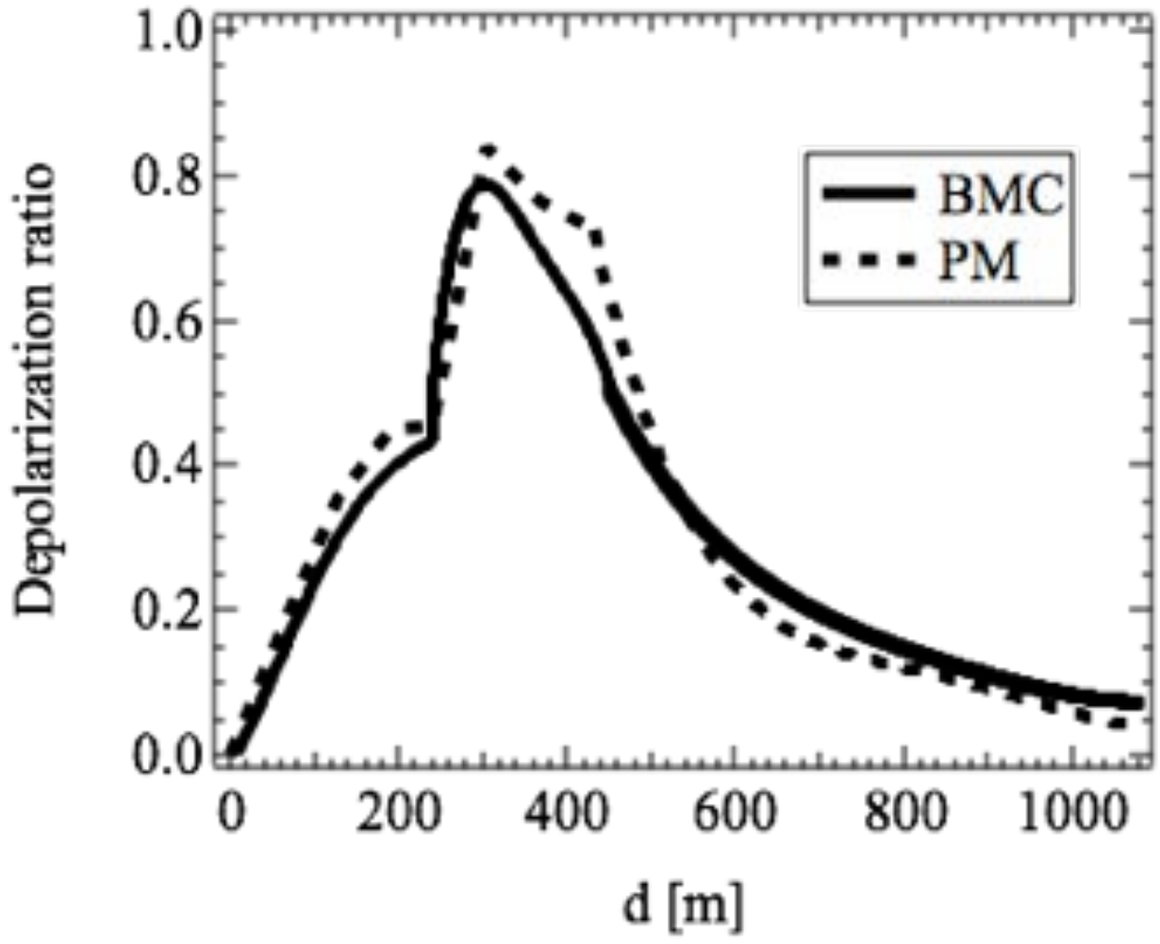


Performance: depolarization ratio



Return from molecule layer beneath cloud base

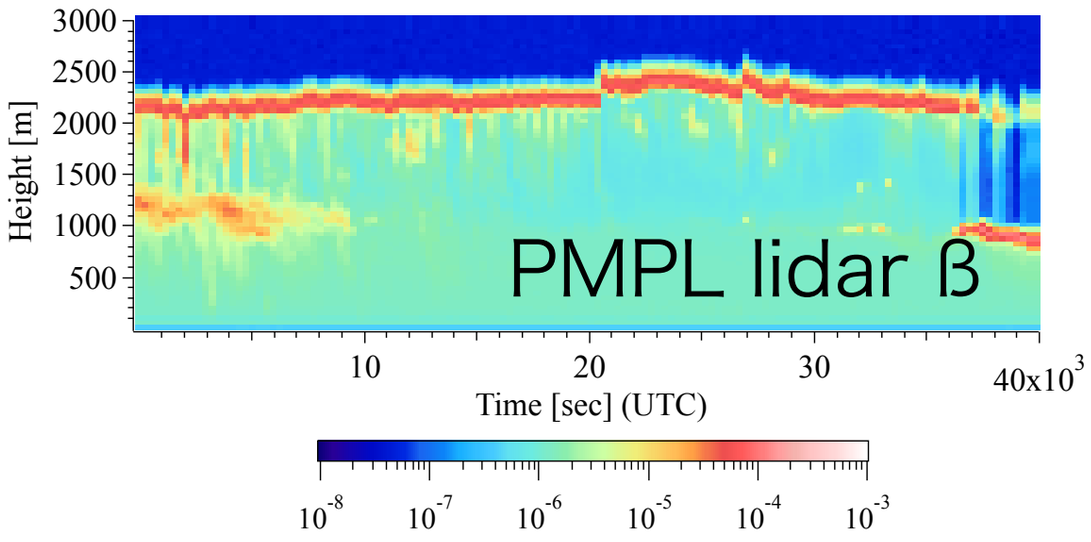


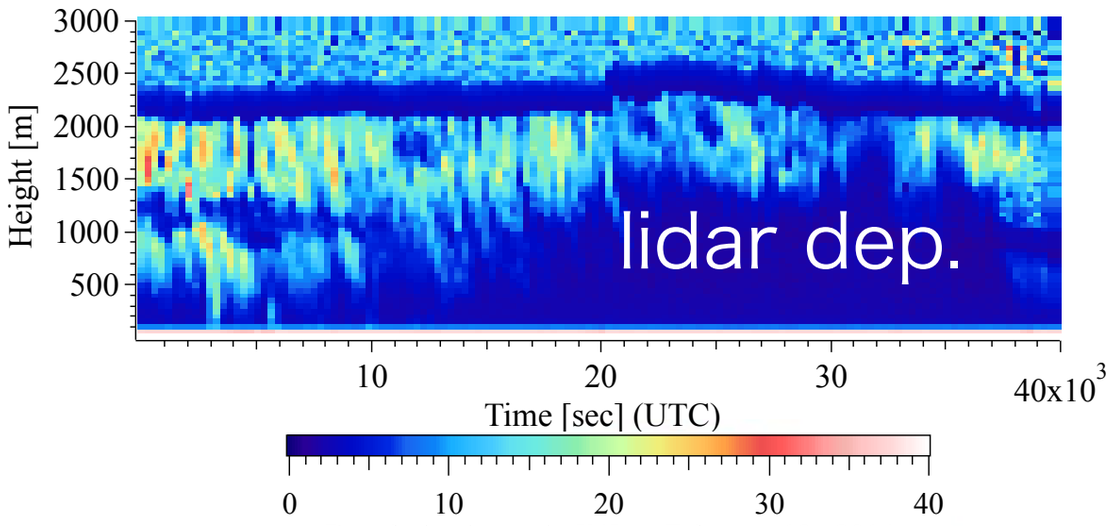


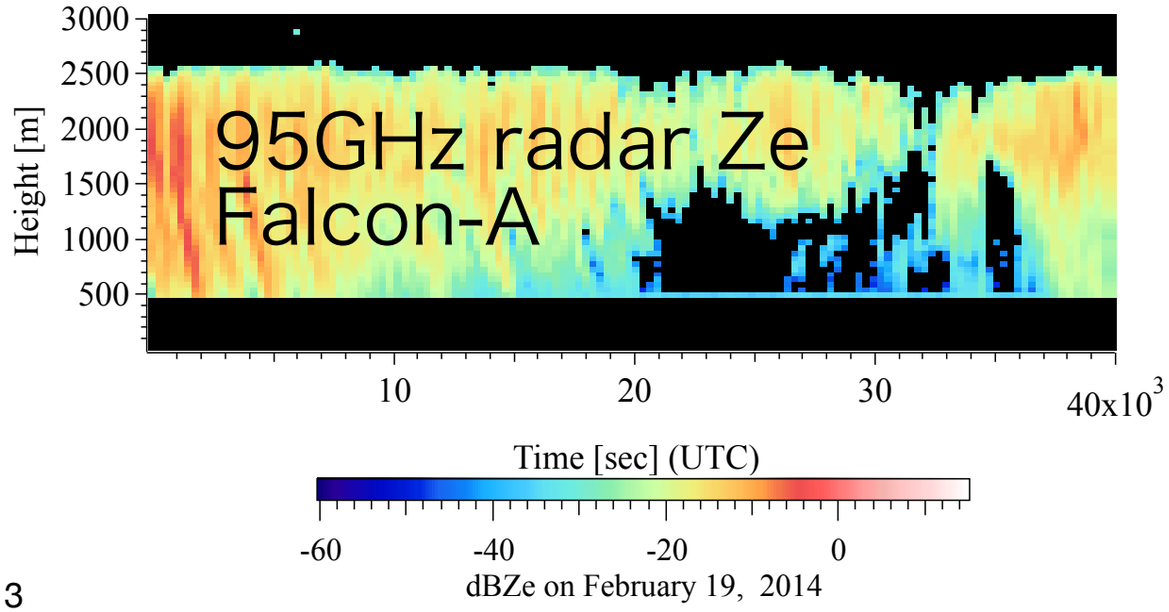
ARCS: Arctic Challenge for Sustainability Project 2015-2020

(NIPR, JAMSTEC, Hokkaido University and cooperation with other institutions)

Ground-based lidar and 95GHz radar obs. started at Ny-Alesund since 2013

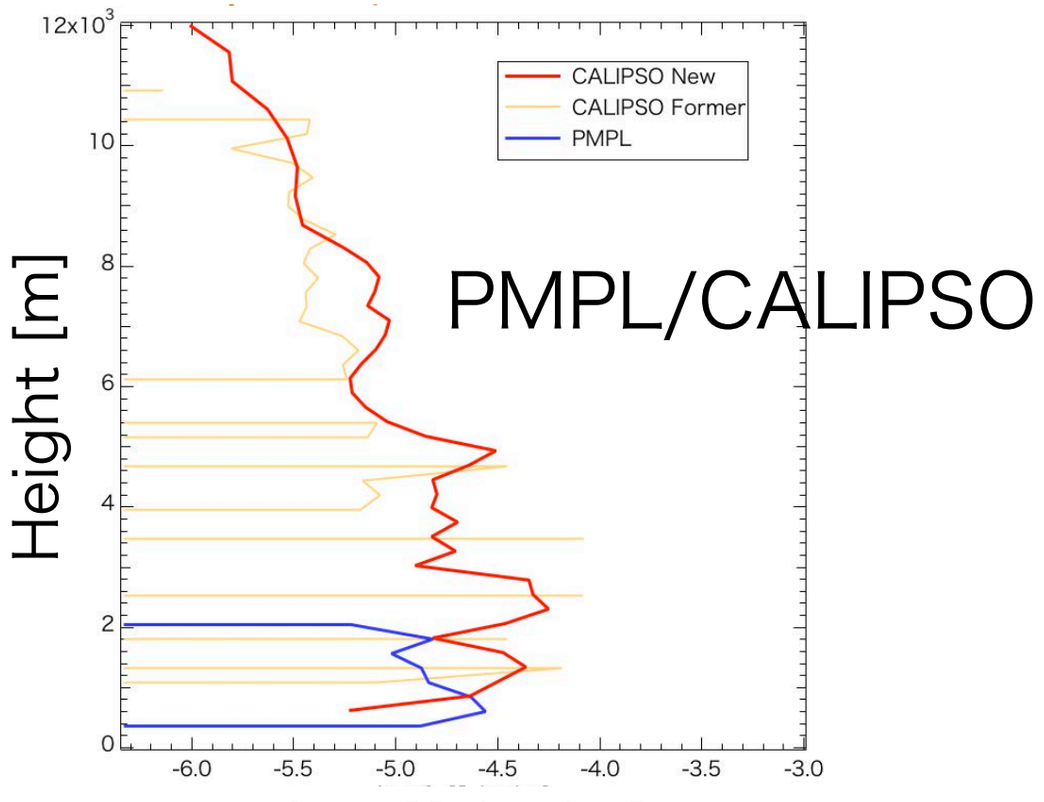






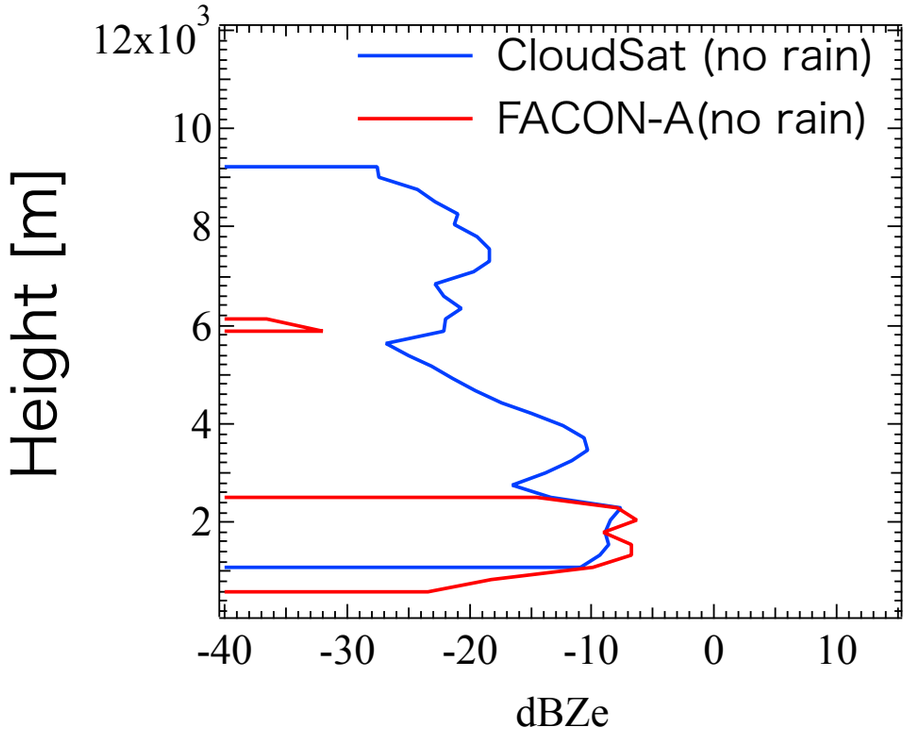
Comparison with PMPL/FALCON-A and CloudSat/CALIPSO

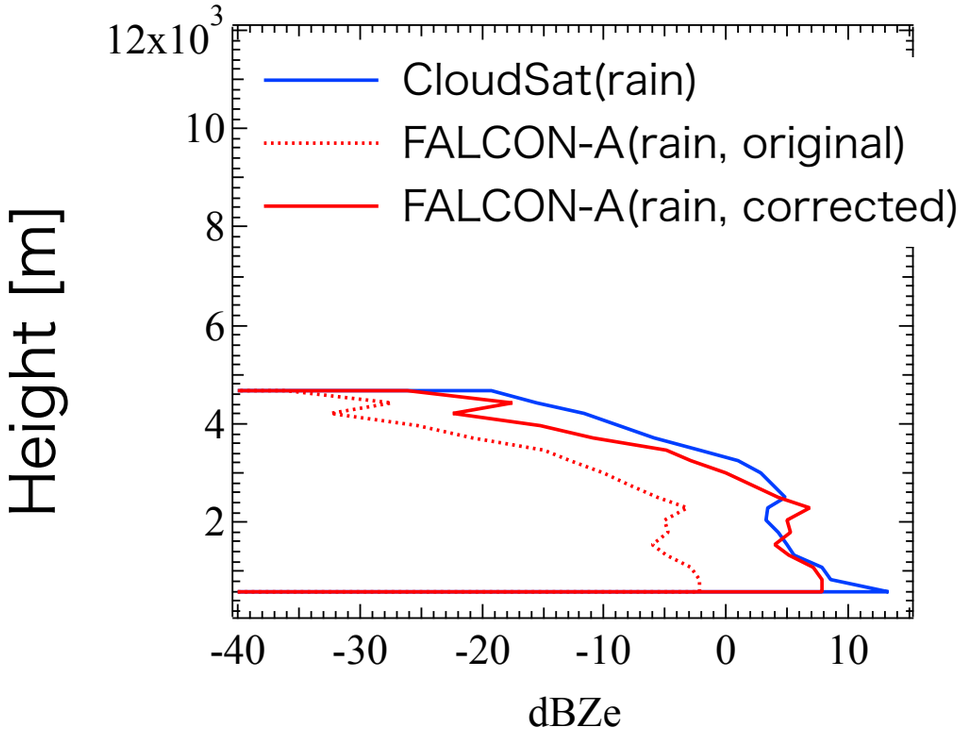
candidate for EarthCARE validation site



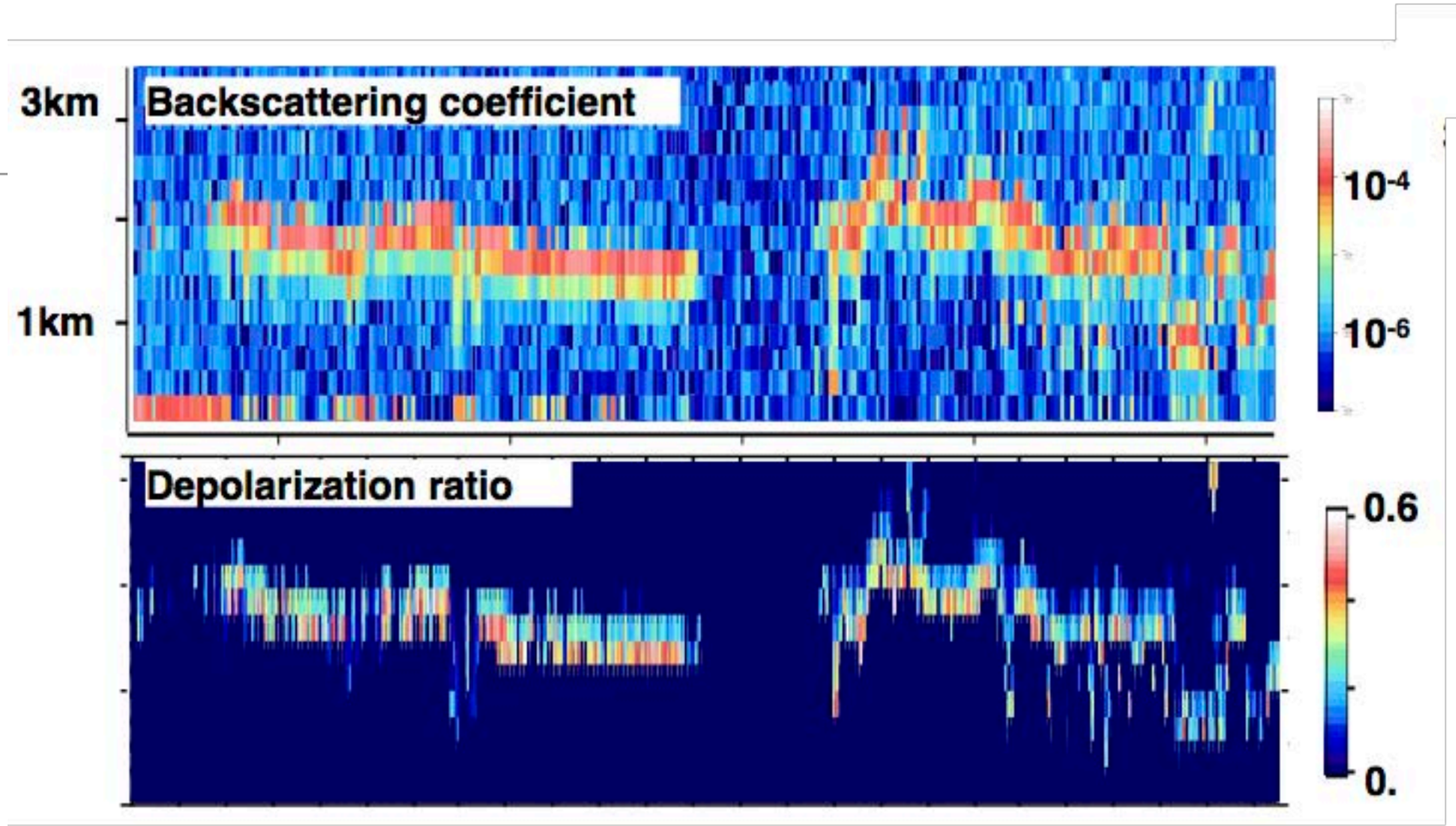
PMPL/CALIPSO

FALCON-A/CloudSat





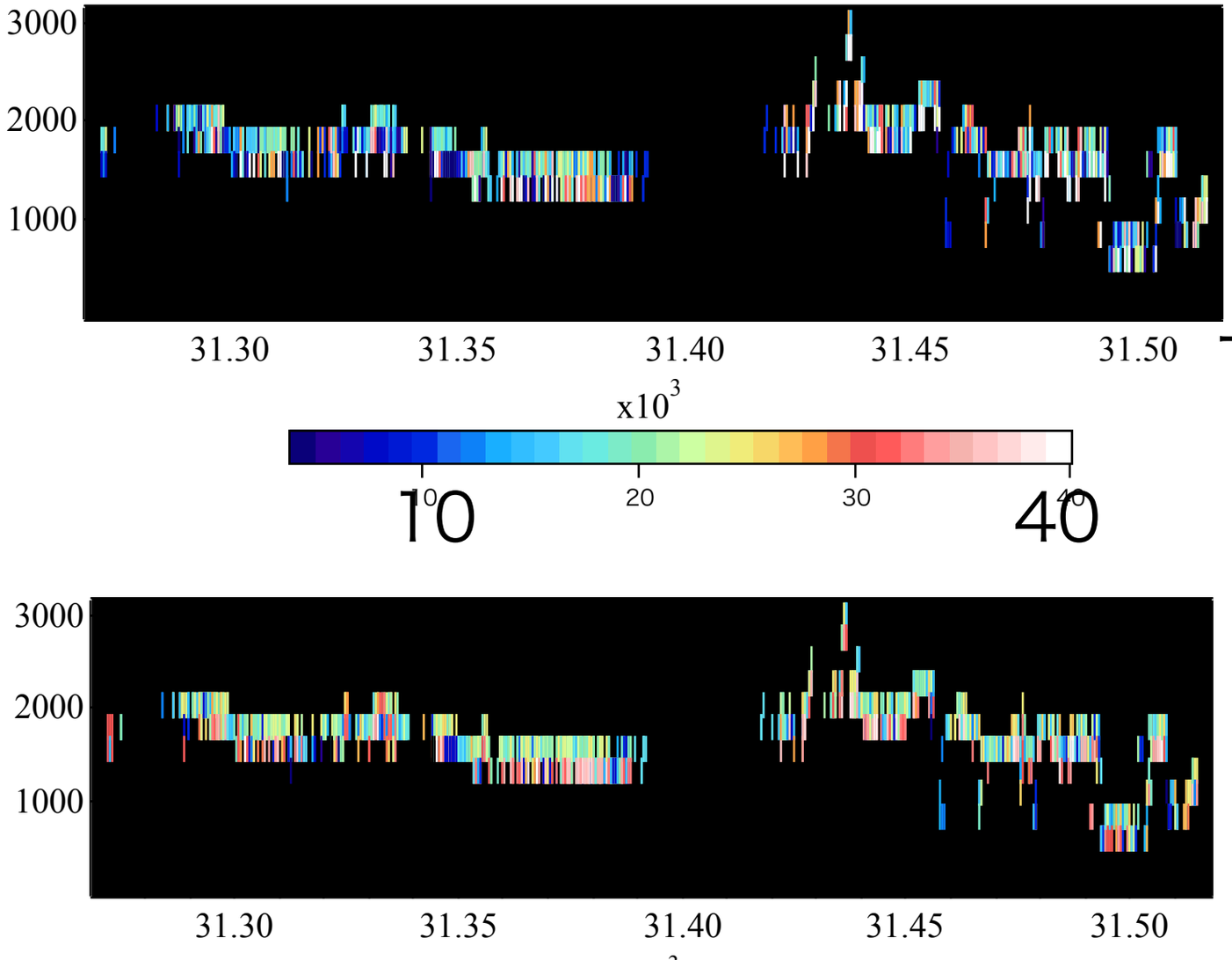
Arctic



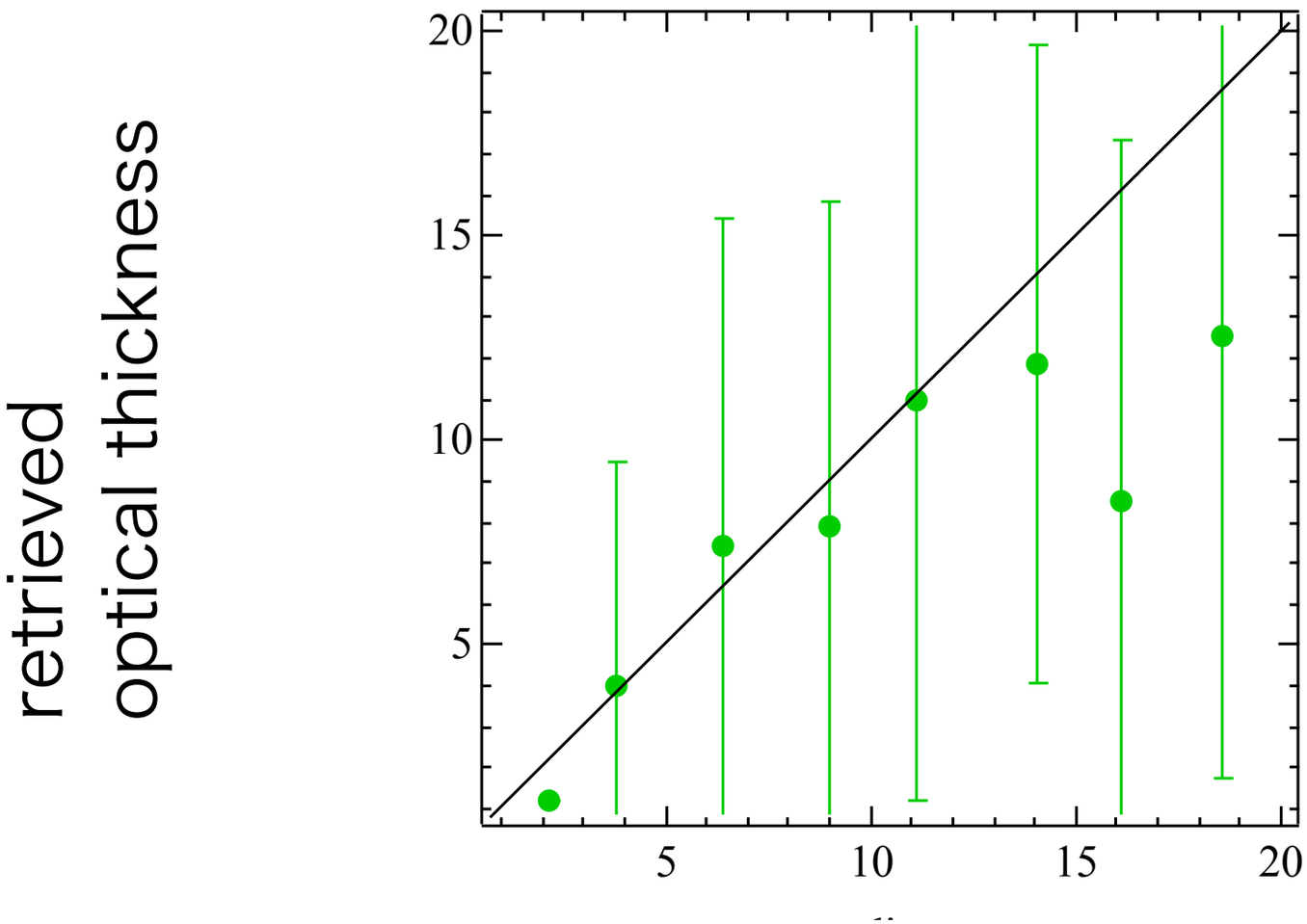
CALIPSO

KU-Type
(old mask)

Vertical profile of supercooled liquid cloud



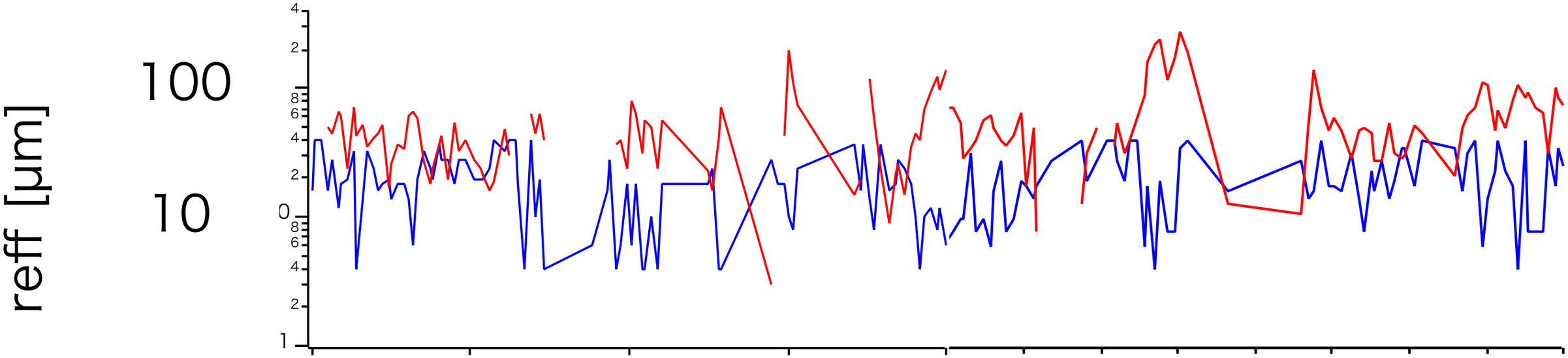
Optical thickness



Particle size

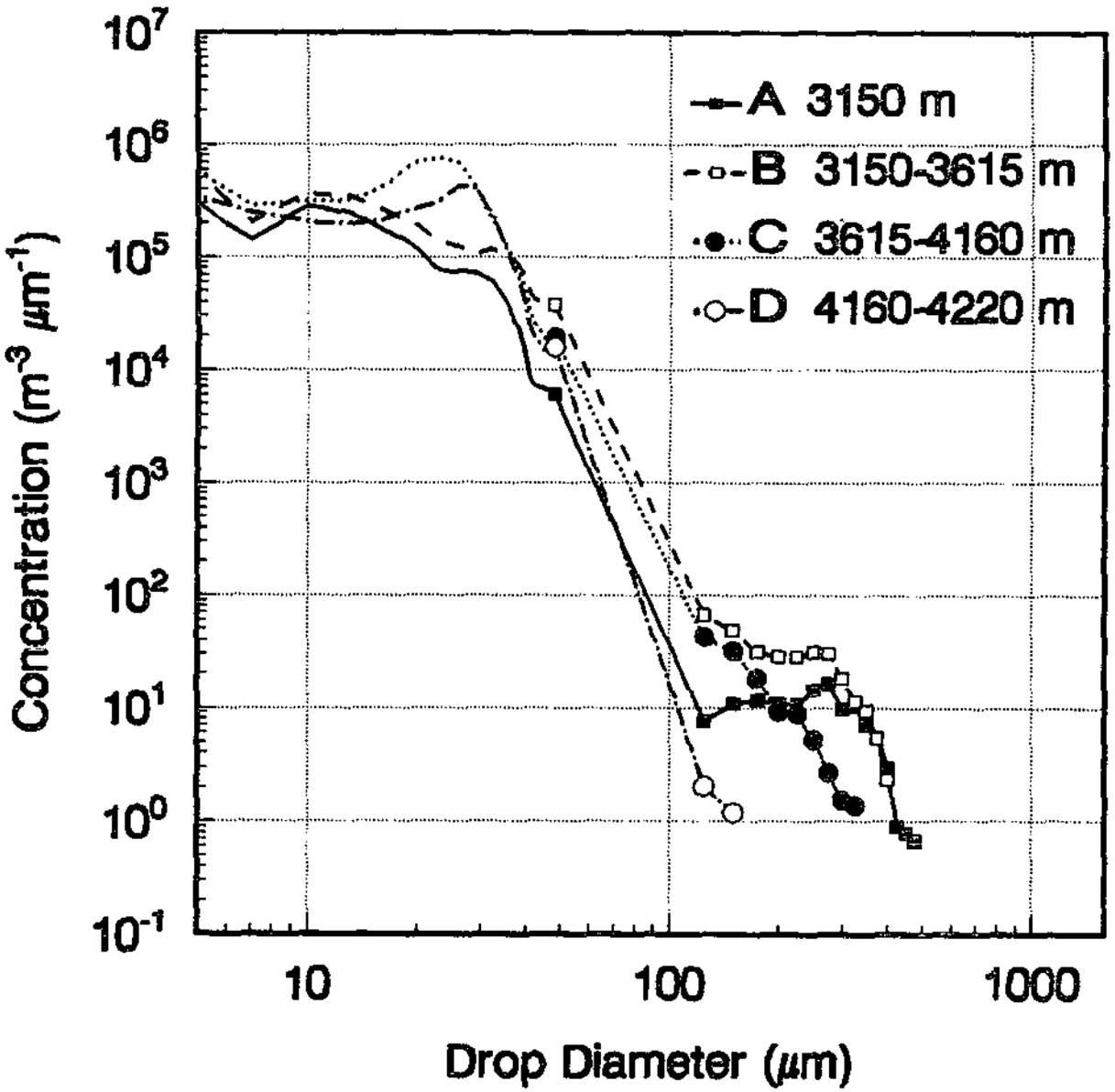
CALIOP retrieval

MODIS (2.1μm)



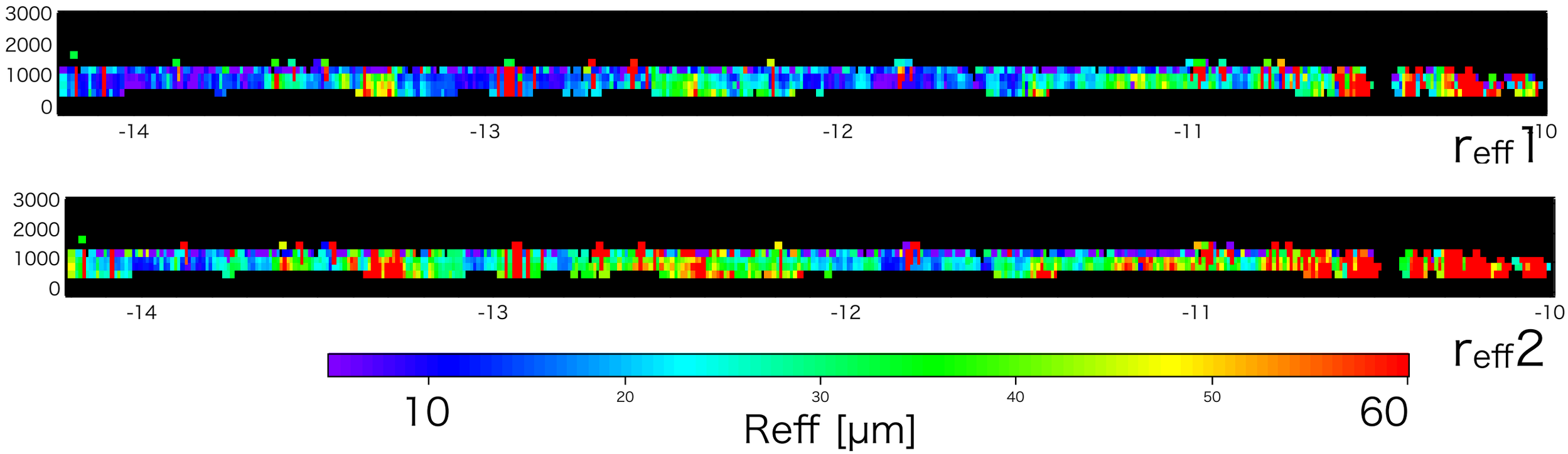
reff@2nd layer

In-situ observation of super-cooled drizzle drops



(Cober et al., 1996)

Bi-modal size distribution by CloudSat and CALIPSO



Summary

- Physical model for depolarized lidar return is developed.
- Lidar-only retrieval of water microphysics are performed along with the improved water cloud detection scheme
- Evaluation with MODIS and other sensors as well as synergy, and Information content analysis are ongoing.

Thank you