Using spectral radiance observations to constrain cloud-drizzle-aerosol processes
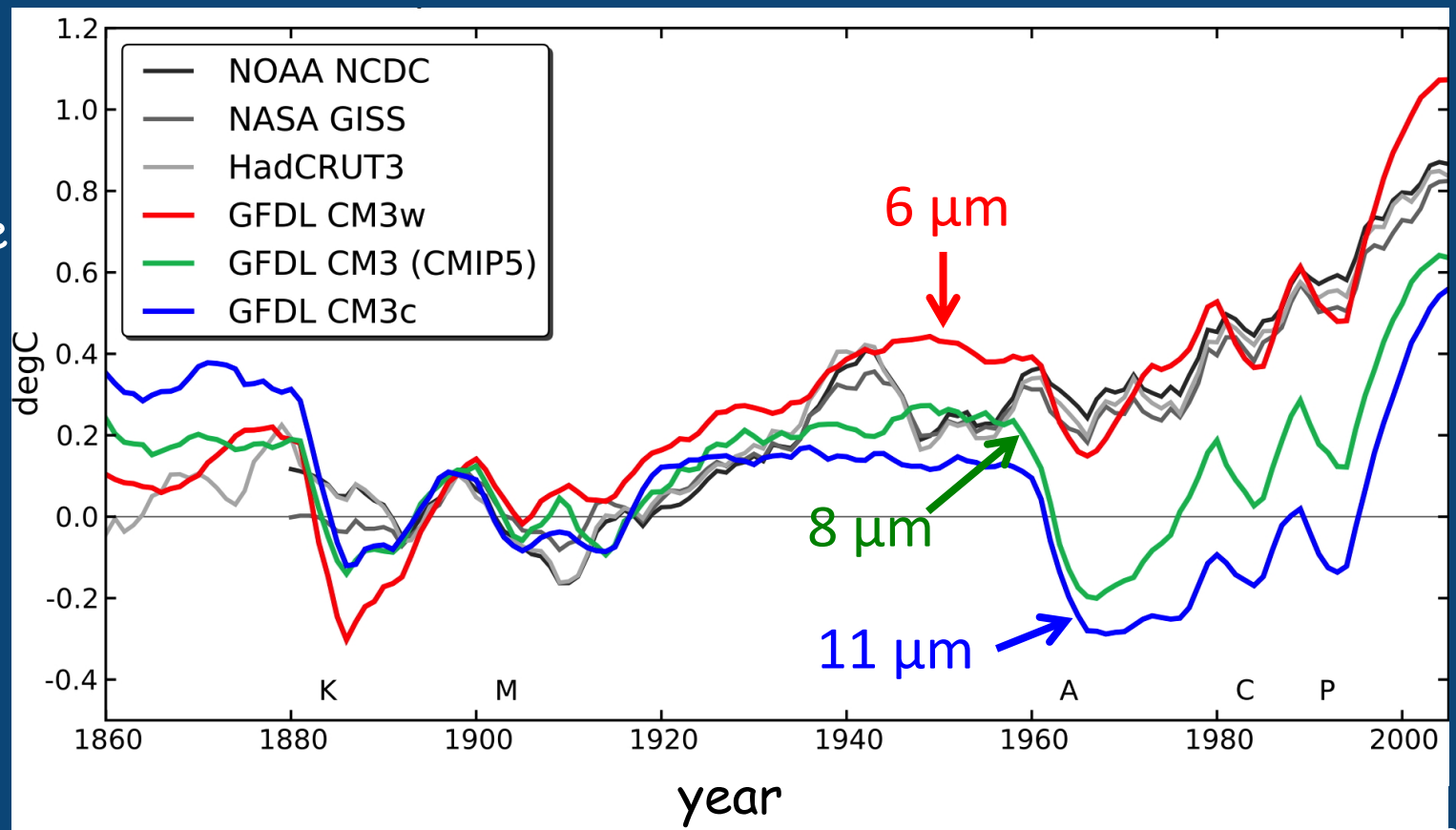
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Motivation

- Knowledge of cloud/precipitation properties and processes is essential for understanding our climate and for reducing the uncertainty in climate change prediction
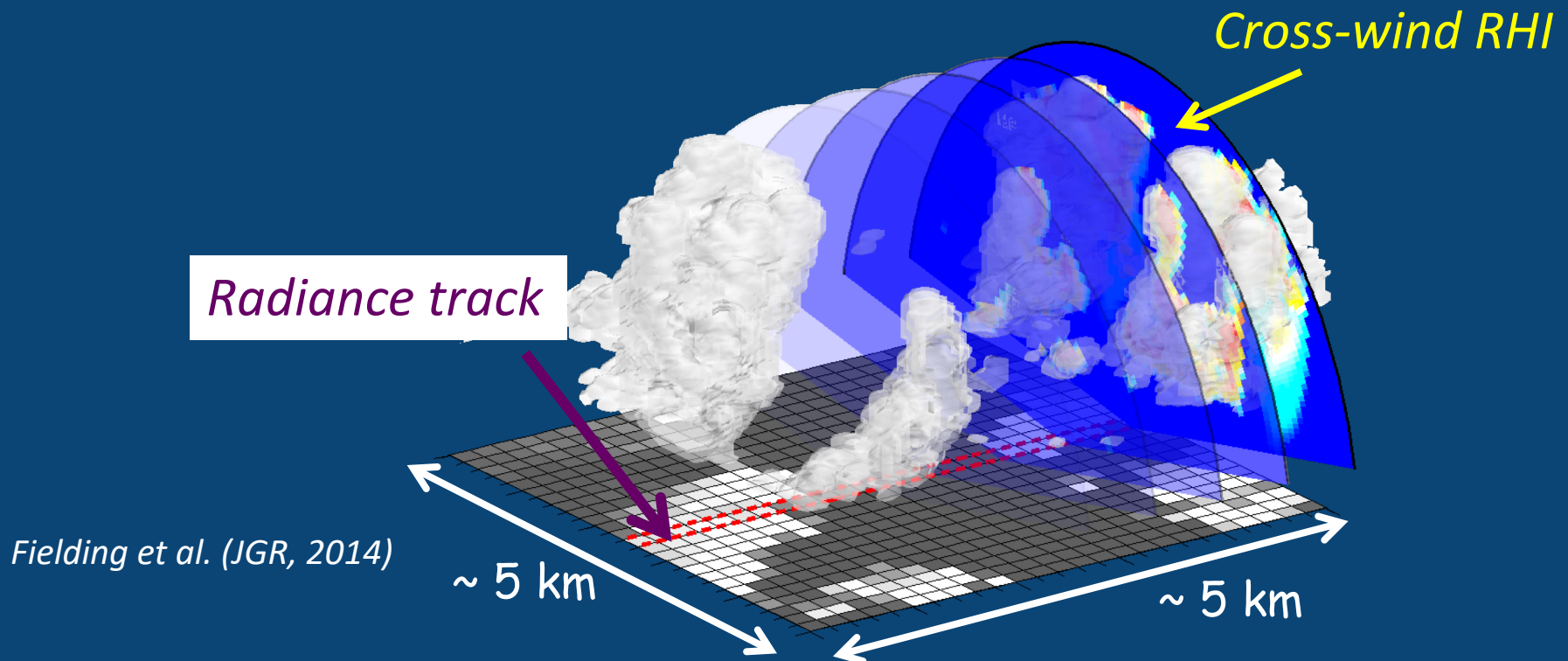
Temperature anomaly

Golaz et al. (GRL, 2013)

Ensemble Cloud Retrieval (ENCORE)

- Combine (scanning) cloud radar, lidar and **zenith radiances**

- Use the Iterative Ensemble Kalman Filter as an optimal estimation framework

Cross-wind RHI

Radiance track

Fielding et al. (JGR, 2014)

~ 5 km

~ 5 km

3

Zenith radiance – Cloud mode observations

Normal aerosol mode
(sun-seeking)

Cloud mode
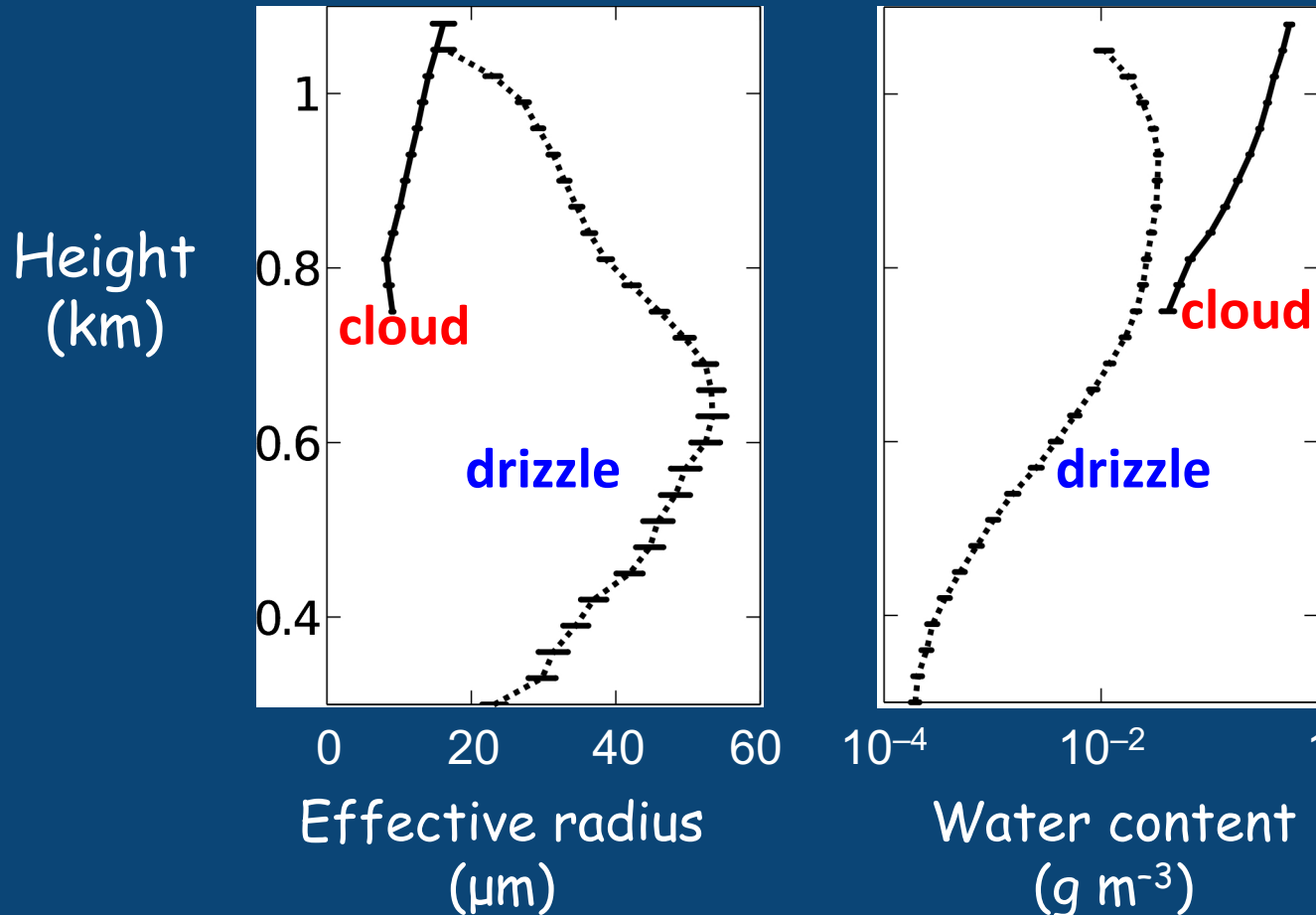(zenith-pointing)

*Shortwave spectrometer
data (continuous)*

*10 measurements in 90 sec,
at most every 15 min*

4

The synergistic dataset has been used to retrieve tropical and subtropical low clouds

- Non-precipitating low clouds in the AMF Azores and Ascension Island deployments and the EU DACCIWA campaign
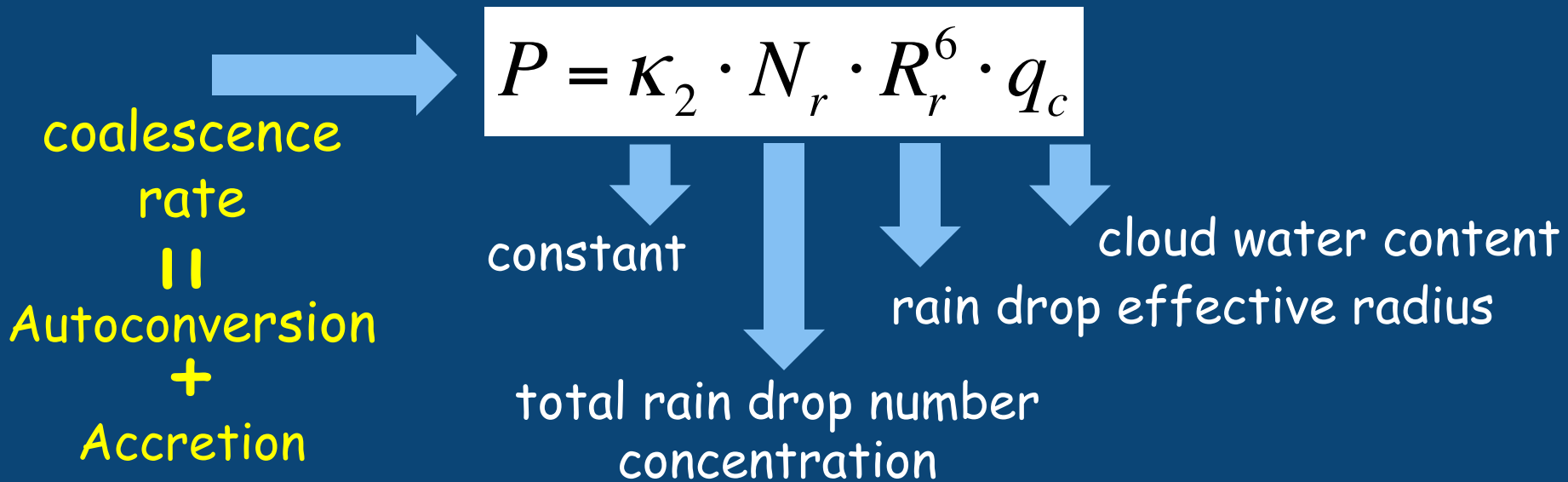
- Precipitating clouds in the MAGIC and ACE-ENA campaigns

An example of persistent Sc deck with drizzle

UTC (hrs)
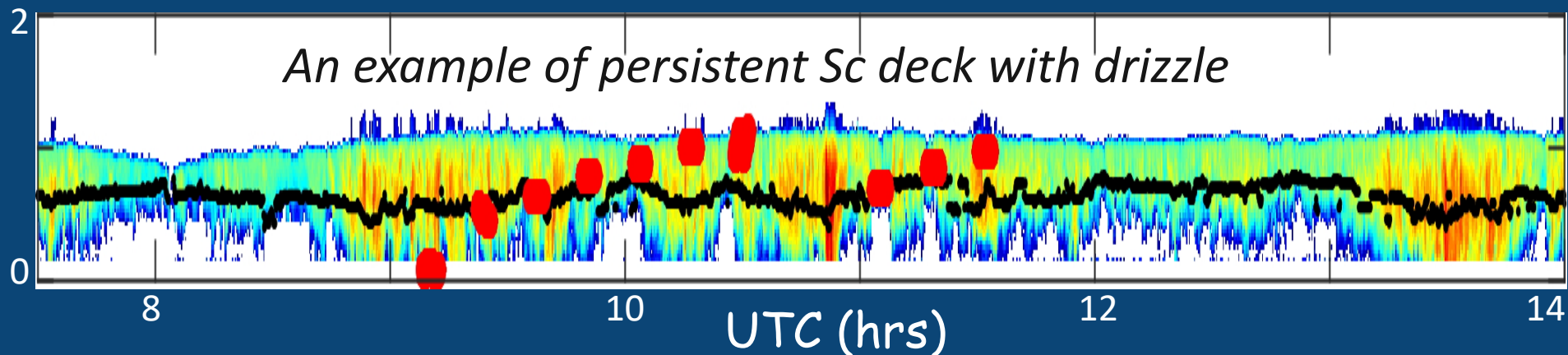
Opportunity for evaluating warm rain microphysics schemes

Height (km)

cloud

drizzle

Effective radius (μm)

cloud

drizzle

Water content (g m⁻³)

Fielding et al. (AMT, 2015)

Observational constraints for warm rain formation

- Use the continuous collection equation to describe the growth of drops by falling through smaller droplets [Stephens and Haynes, 2007]

coalescence rate

$$P = \kappa_2 \cdot N_r \cdot R_r^6 \cdot q_c$$

constant

cloud water content

rain drop effective radius

total rain drop number concentration

=

Autoconversion

+

Accretion

$$P_{obs} = A_u + A_c = C_1 \cdot q_c^a \cdot N_c^b + C_2 \cdot q_c^c \cdot q_r^d$$

Observational constraints for warm rain formation

- New versus KK autoconversion + accretion rates
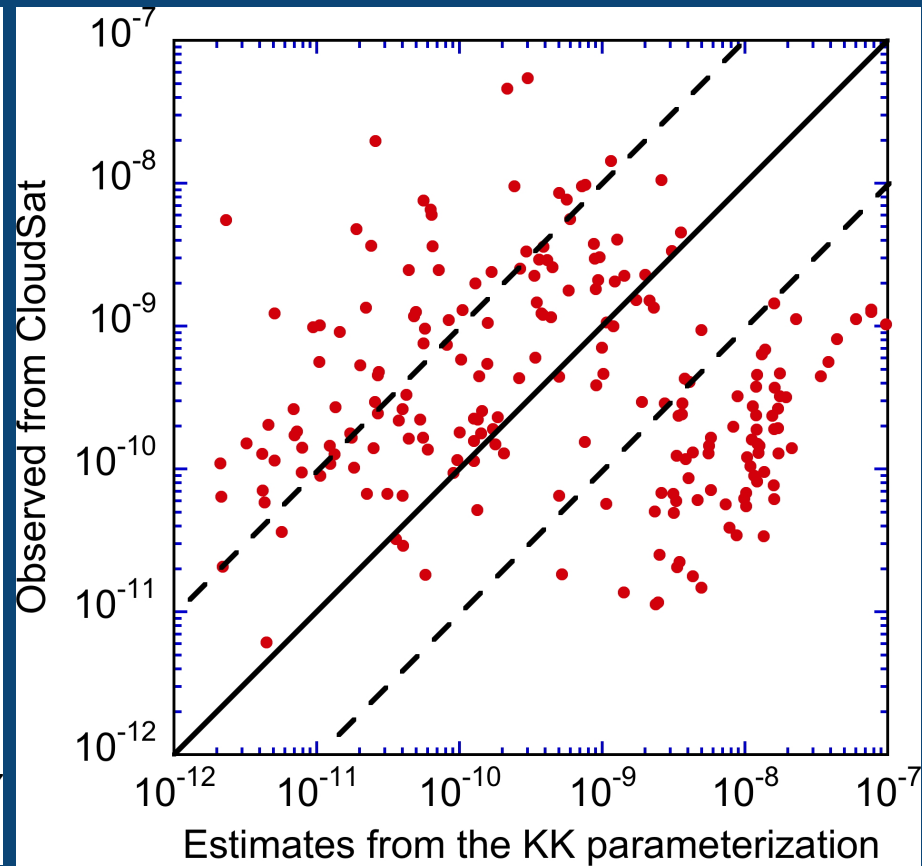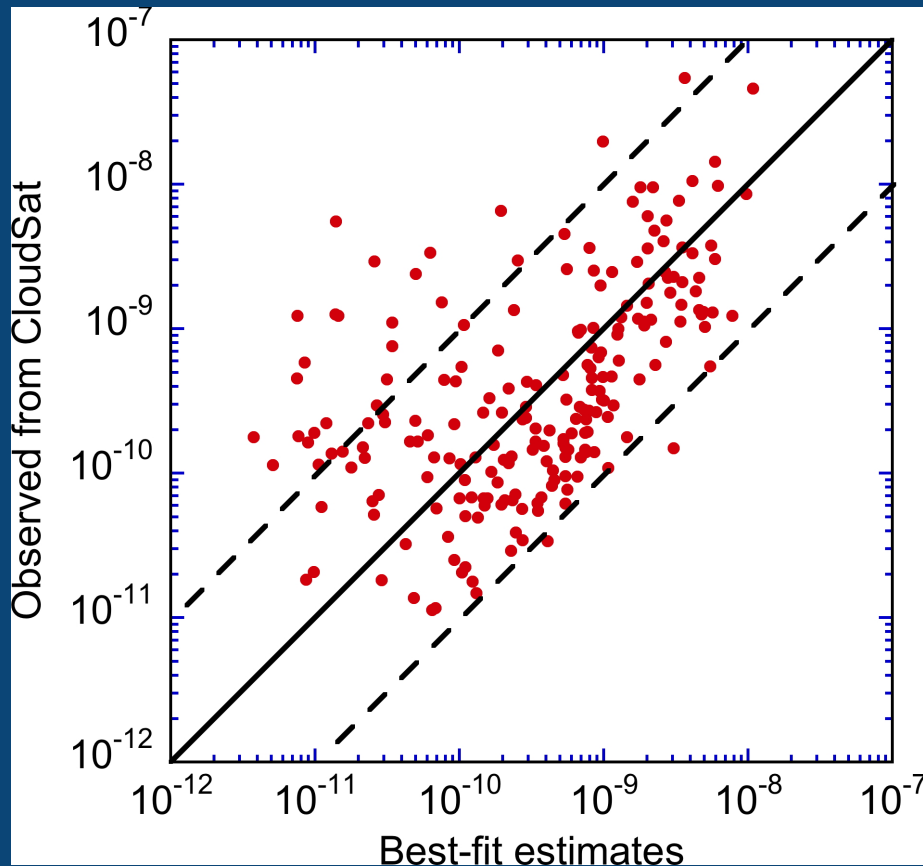
Summary

- Zenith radiance measurements play an important role in synergistic type of retrieval methods, allowing us to better constrain cloud and drizzle properties

- Detailed cloud macro- and microphysical properties not only "close" radiation better, but will also lead to improved process-level understanding