Advancing the Use of ARM Observations for Large-Scale Earth System Model Development

Breakout session

Co-organized by Katia Lamer, Daniel Feldman, Jiwen Fan and Shaocheng Xie

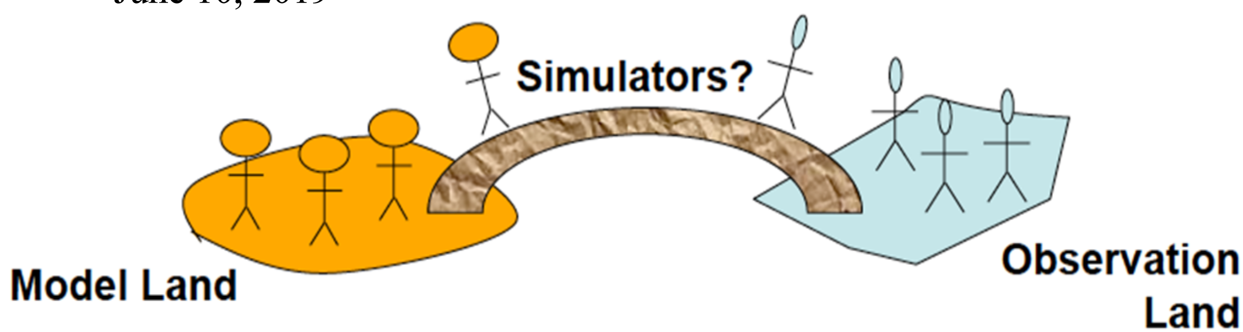
2019 ARM/ASR PI meeting

Rockville, Maryland

June 10, 2019

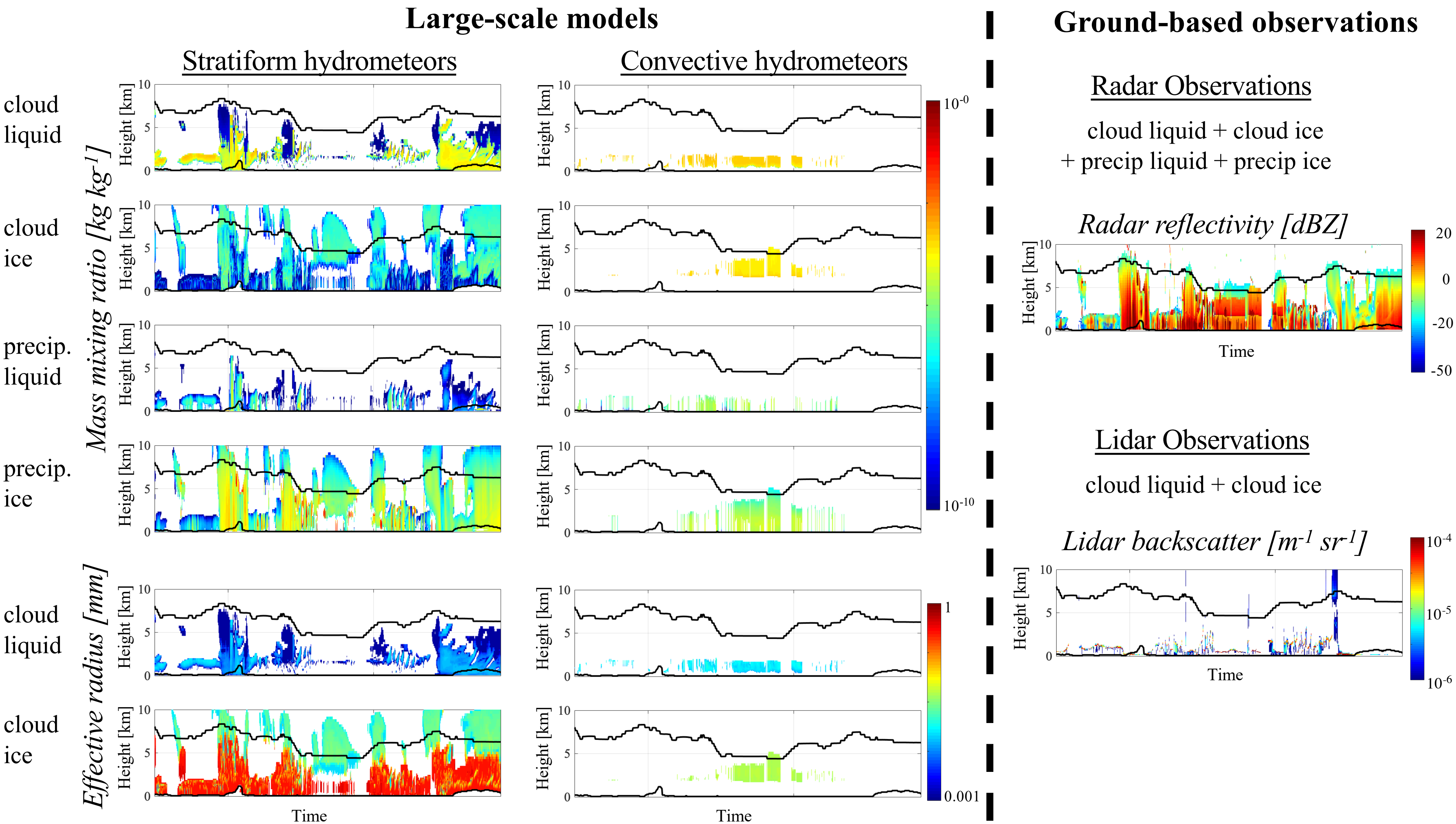
ASR Atmospheric System Research

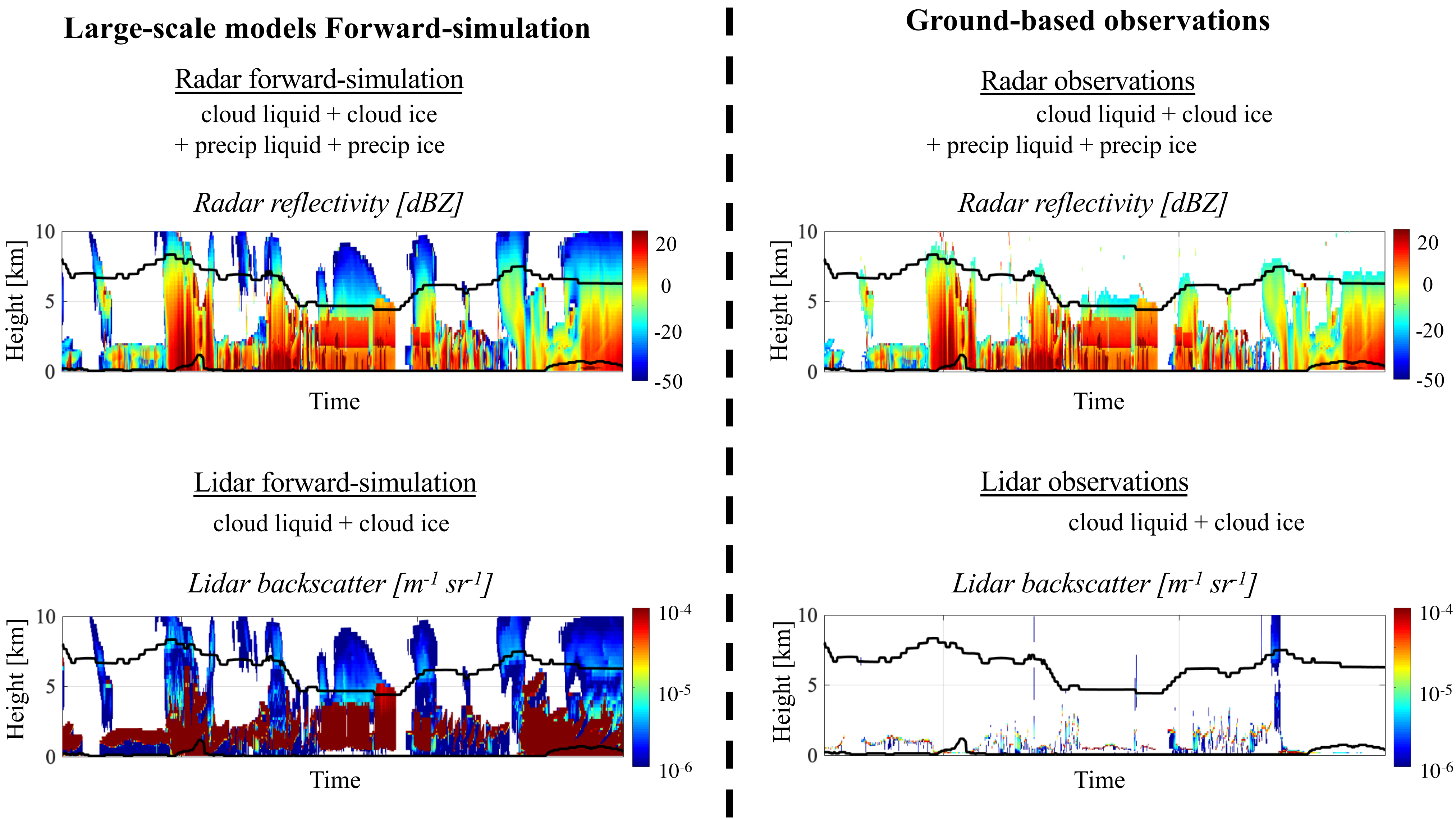
ARM Atmospheric Radiation Measurement



Challenges in the intercomparison of ground-based observations and large-scale models

	Large-scale models	**Ground-based observations**
Definition	Fractional area coverage Mass-weighted hydrometer properties	Size-related hydrometeor properties
Detection	All hydrometeor are simulated Presence of numerical noise	Only a fraction of all hydrometeor is detectable Detection limitations are instrument specific Presence of instrument noise
Scale/representativeness	Domain average quantities Or PDFs 100 km x 100 km x 30 min domain	Point observations ~2s resolution Or small domain ~40-60 km x 5 min
Statistical significance	Perturbations Sensitivity to parameters	Partial uncertainty quantification In retrieval space In forward-simulation space


Large-scale models
Stratiform hydrometeors
Convective hydrometeors
Ground-based observations
Radar Observations
cloud liquid + cloud ice
+ precip liquid + precip ice
Radar reflectivity [dBZ]
Lidar Observations
cloud liquid + cloud ice
Lidar backscatter [m-1 sr-1]
cloud liquid
cloud ice
precip. liquid
precip. ice
Mass mixing ratio [kg kg-1]
Effective radius [mm]
Height [km]
Time


Large-scale models Forward-simulation
Radar forward-simulation
cloud liquid + cloud ice
+ precip liquid + precip ice
Radar reflectivity [dBZ]
Height [km]
Time
Lidar forward-simulation
cloud liquid + cloud ice
Lidar backscatter [m-1 sr-1]
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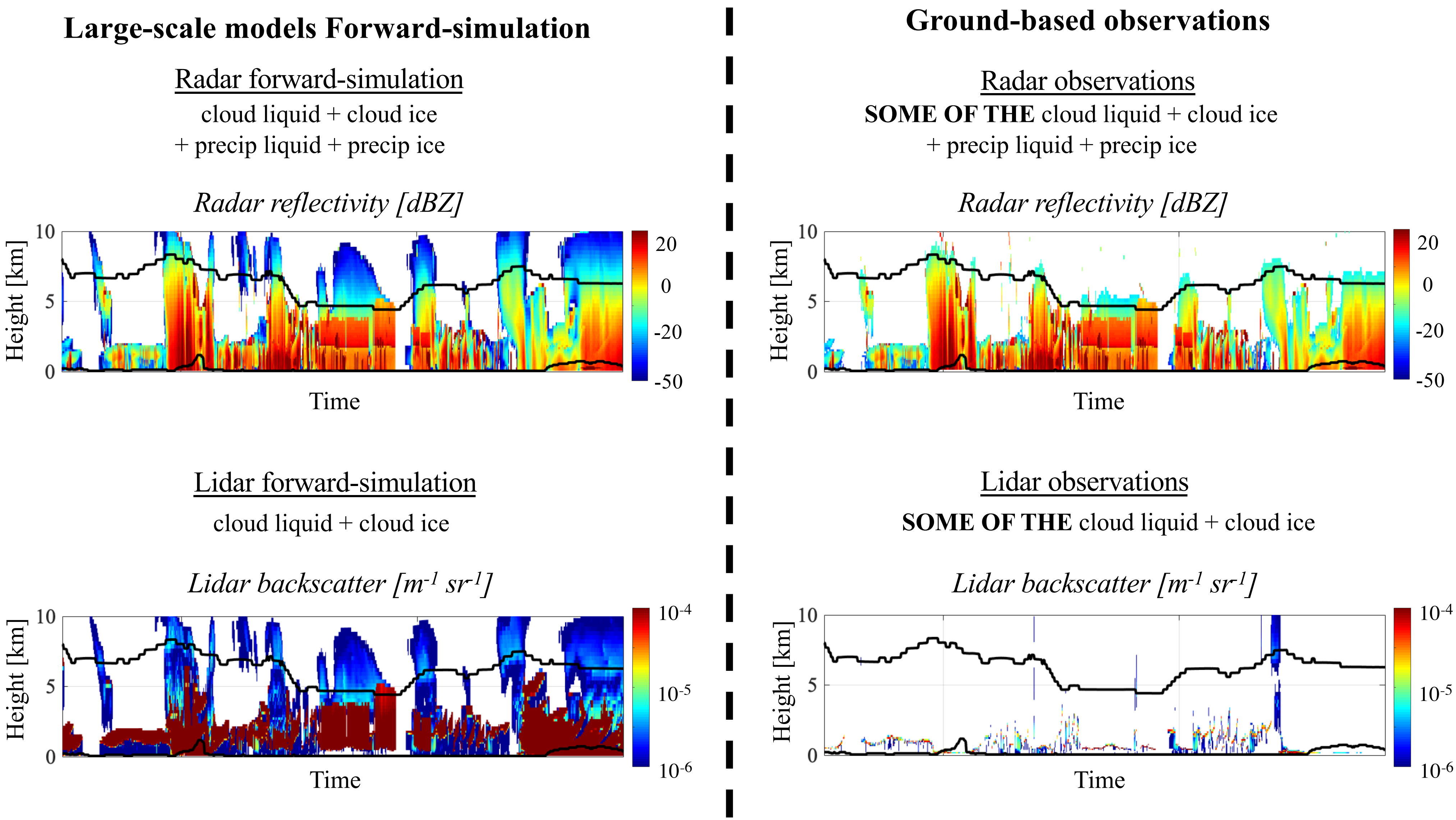
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SOME OF THE cloud liquid + cloud ice
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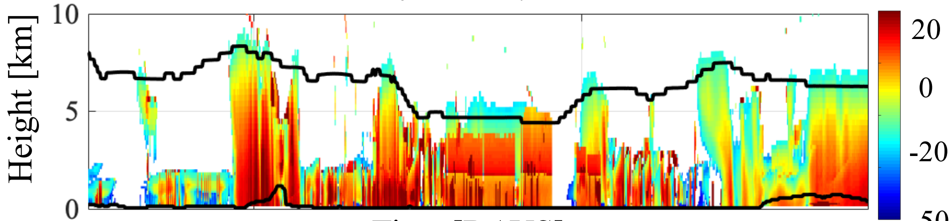
Height [km]
Time

Large-scale models Forward-simulation with Instrument model

Ground-based observations

<u>Radar forward-simulation</u>

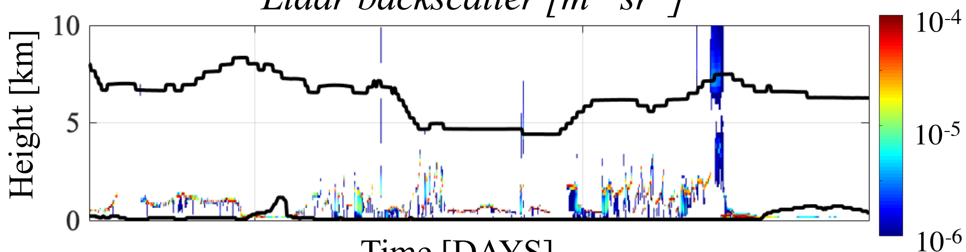
Radar reflectivity [dBZ]



Time [DAYS]
EVERY 30 MIN

<u>Lidar forward-simulation</u>

Lidar backscatter [m^{-1} sr^{-1}]

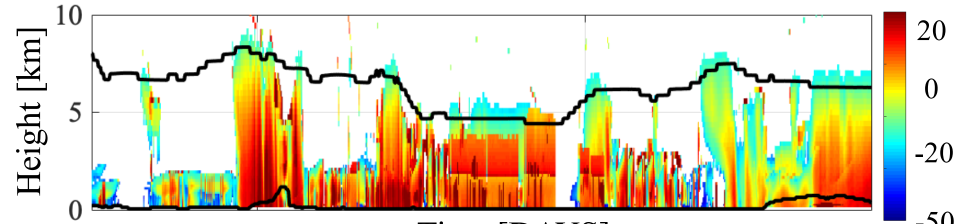


Time [DAYS]
EVERY 30 MIN

<u>Radar observations</u>

SOME OF THE cloud liquid + cloud ice + precip liquid + precip ice

Radar reflectivity [dBZ]

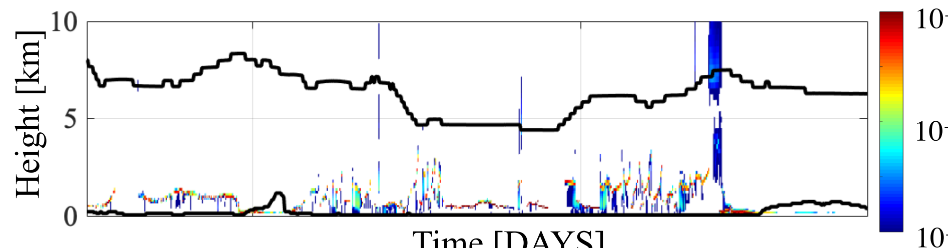


Time [DAYS]
EVERY 2 s

<u>Lidar observations</u>

SOME OF THE cloud liquid + cloud ice

Lidar backscatter [m^{-1} sr^{-1}]



Time [DAYS]
EVERY 2 s

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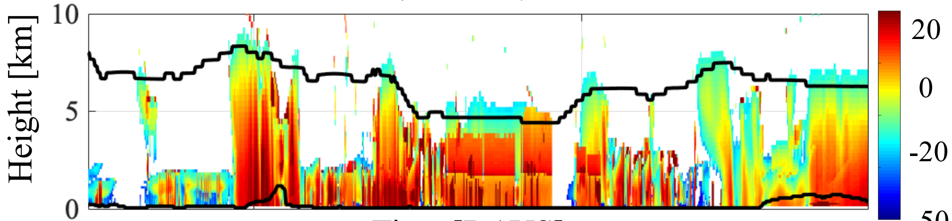
Large-scale models Forward-simulation with Instrument model

Radar forward-simulation

FOR A 2º x 2.5º LAT x LON GRID BOX
ROUGHLY 100 KM x 100 KM

Radar reflectivity [dBZ]



Time [DAYS]
EVERY 30 MIN

Lidar forward-simulation

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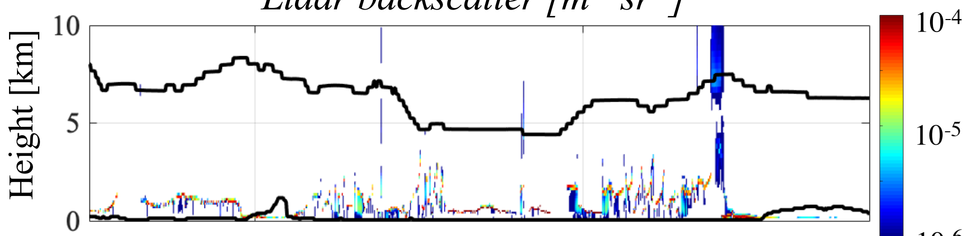
ROUGHLY 100 KM x 100 KM

Lidar backscatter [m^{-1} sr^{-1}]



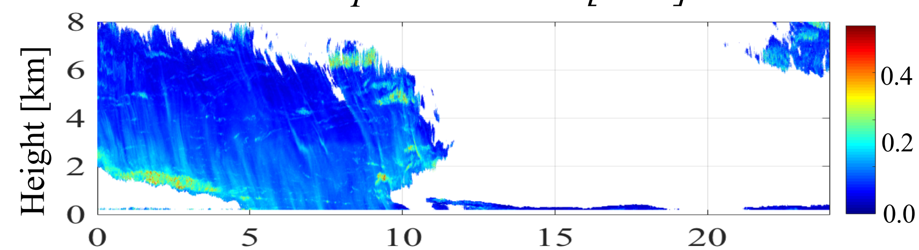
Time [DAYS]
EVERY 30 MIN

Ground-based observations

Radar observations

FOR A PENCIL BEAM

Radar spectrum width [m s^{-1}]



Time [HOURS]
EVERY 2 S

Large-scale models Forward-simulation with Instrument model

Radar forward-simulation

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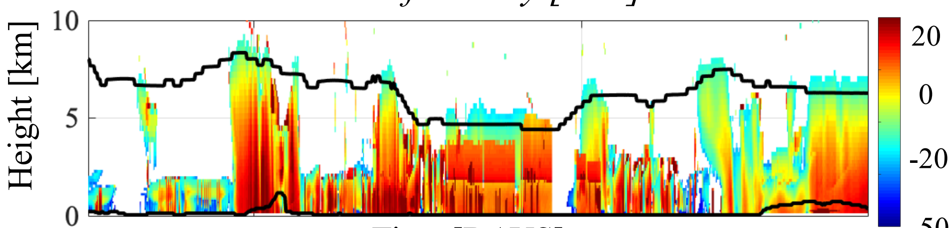
Radar reflectivity [dBZ]

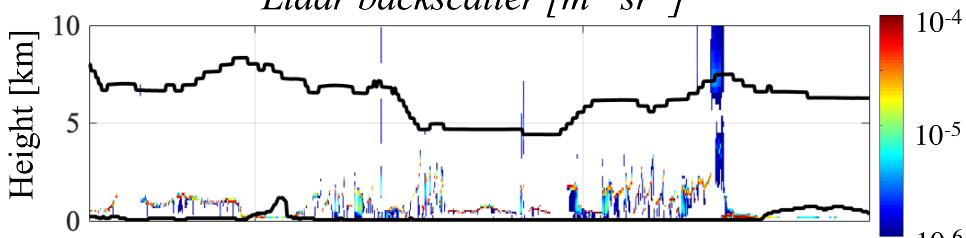


Time [DAYS]
EVERY 30 MIN

Lidar forward-simulation

FOR A 2º x 2.5º LAT x LON GRID BOX
ROUGHLY 100 KM x 100 KM

Lidar backscatter [m^{-1} sr^{-1}]

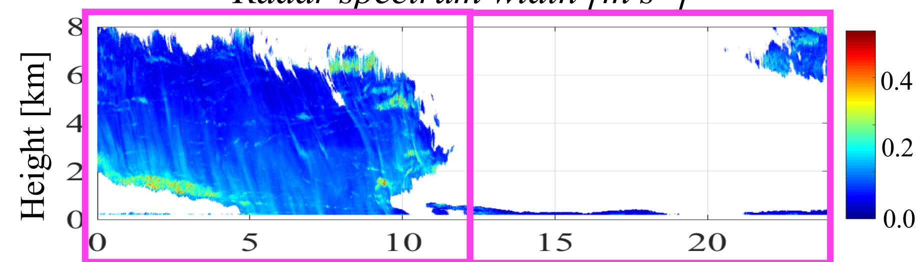


Time [DAYS]
EVERY 30 MIN

Ground-based observations

Radar observations
FOR A PENCIL BEAM

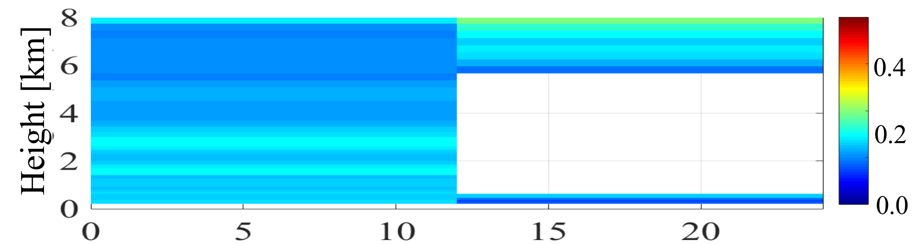
Radar spectrum width [m s^{-1}]



Time [HOURS]
EVERY 2 S

Roughly the wind should take **12 hrs** to advect hydrometeor forming within 100 km from the site

?DEGRADED?



Time [HOURS]
EVERY 12 HRS

Challenges in the intercomparison of ground-based observations and large-scale models

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Agenda

1:40-1:50 Comparison of vertically pointing and scanning observations for the retrieval of domain average light precipitation rate – Katia Lamer

1:50-2:05 Using CPOL data as an observational target for E3SM – Robert Jackson

2:05-2:20 Evaluation of simulated convective cloud system and precipitation using ARM data in combination with NEXRAD and GPM data – Jiwen Fan

2:20-2:35 Evaluation of parameterizations of mesoscale convective organization in Earth System Models – Daehyun Kim

2:35-2:50 ENA observations of boundary layer clouds and atmospheric condition relationships: application to CAM6 evaluation – Catherine Naud

2:50-3:05 Experiences with LASSO and CMDV-MCS for Bridging the Observation–Model Divide – William Gustafson

3:05-3:30 Discussion

Characterization of Shallow Oceanic Precipitation using Profiling and Scanning Radar Observations at the Eastern North Atlantic ARM Observatory

Katia Lamer
City University of New York, The City College

In collaboration with
Bernat Puigdomènech Treserras, Zeen Zhu,
Bradley Isom, Nitin Bharadwaj, and Pavlos Kollias

2019 ARM/ASR PI meeting
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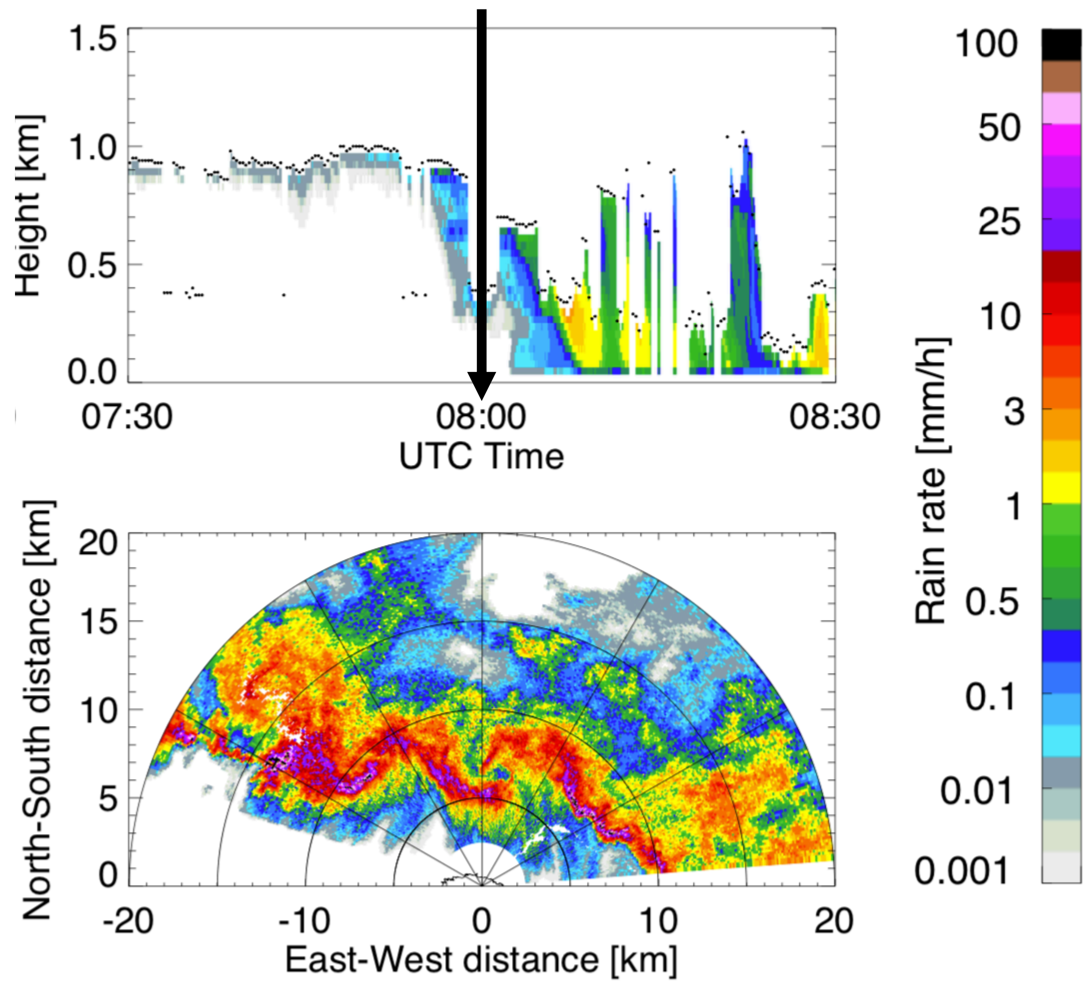
ARM
Atmospheric Radiation Measurement

ASR
Atmospheric System Research

Observations/Retrieval of Light Precipitation Rate

KAZR2
Vertically pointing observations
Rain rates retrieved using the *O'Connor et al.* (2005) radar-lidar technique on calibrated backscatter observations

Now available as a PI product in the ARM archive



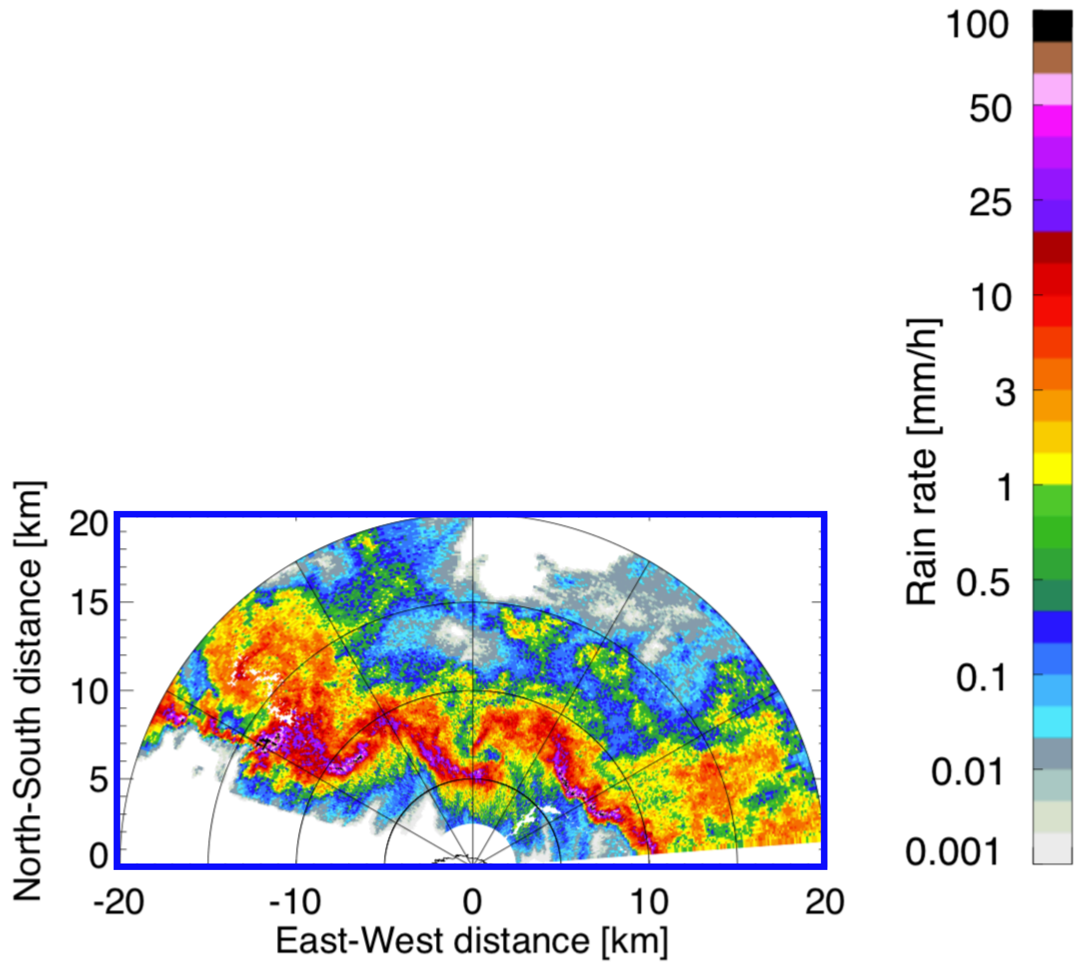
XSAPR2
1º elevation PPI scan covering ~ 2,500 km²
Rain rates retrieved using the *Lamer et al.* (2019) adaptive Z-R technique on calibrated radar reflectivity observations

Data accessible upon request

Observations collected at the ENA site
Period 01/2018 to 04/2018 ~ 4 months

Estimation of Domain Average Light Precipitation Rate

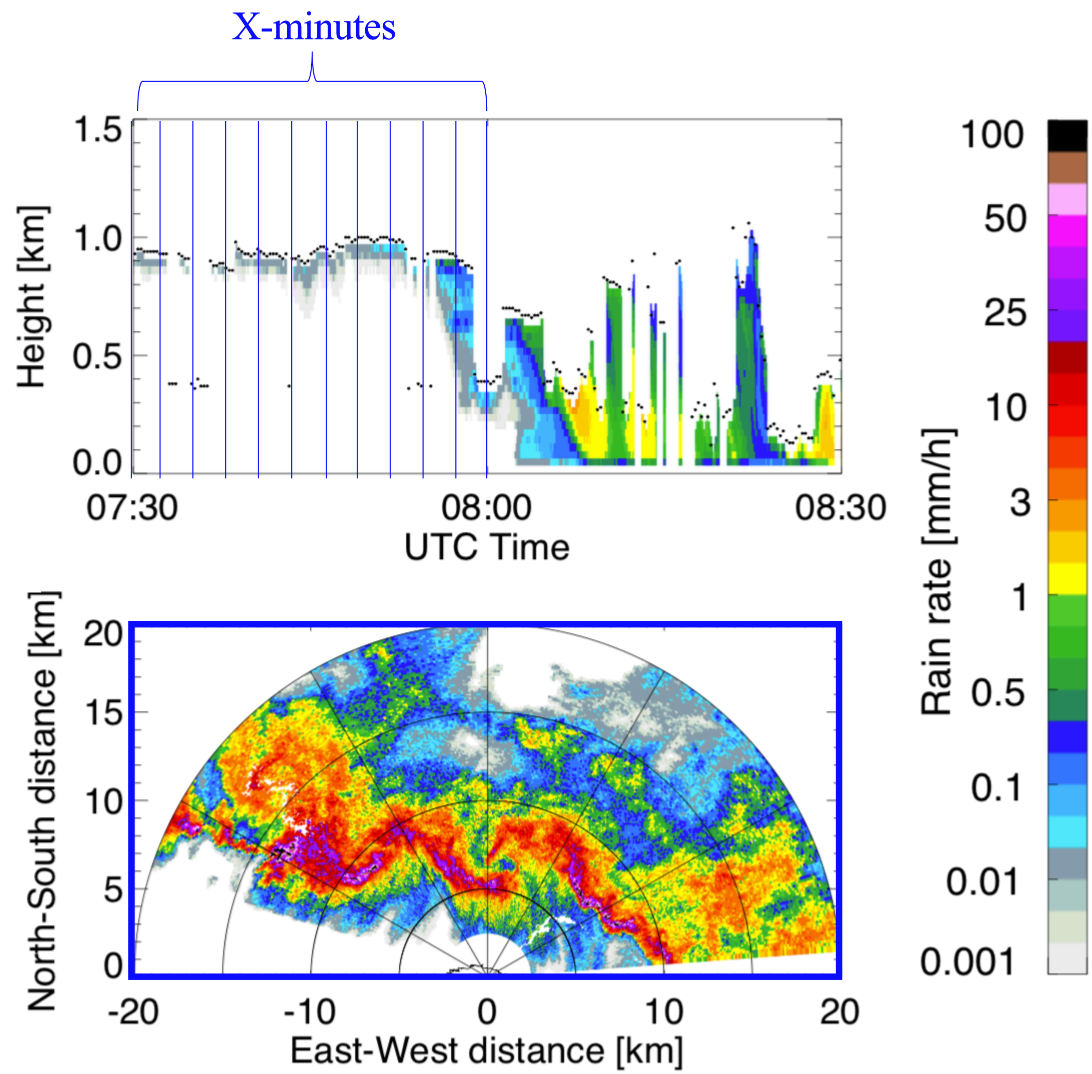
1.
Estimate a domain average rain rate
for each ~ 2,500 km^2 domain snapshot.
Domain “snapshots” are collected every
5-minutes.



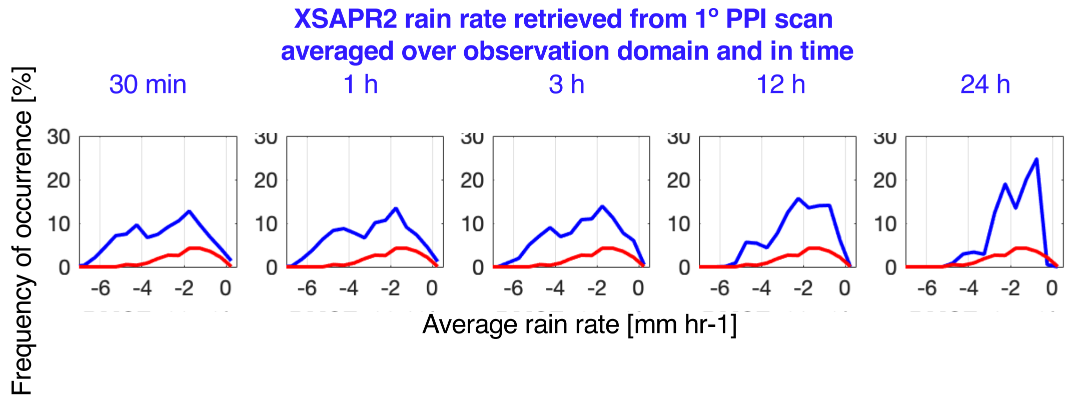
Characterizing variations in Domain Average Precipitation Rate Across Various Timescales

2.
To characterize domain-average precipitation rate changes across different timescales

Average X-minutes worth of domain average rain rates

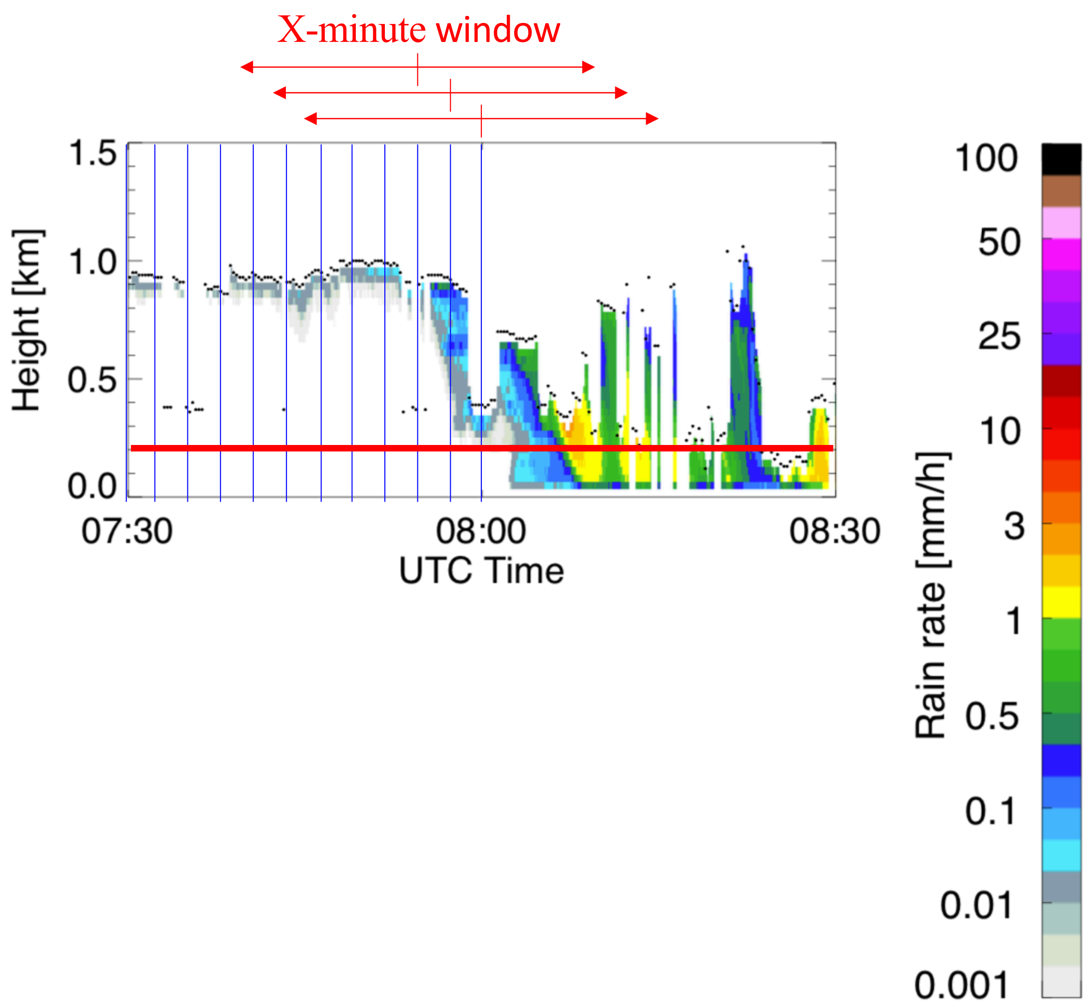


Characterizing variations in Domain Average Precipitation Rate Across Various Timescales

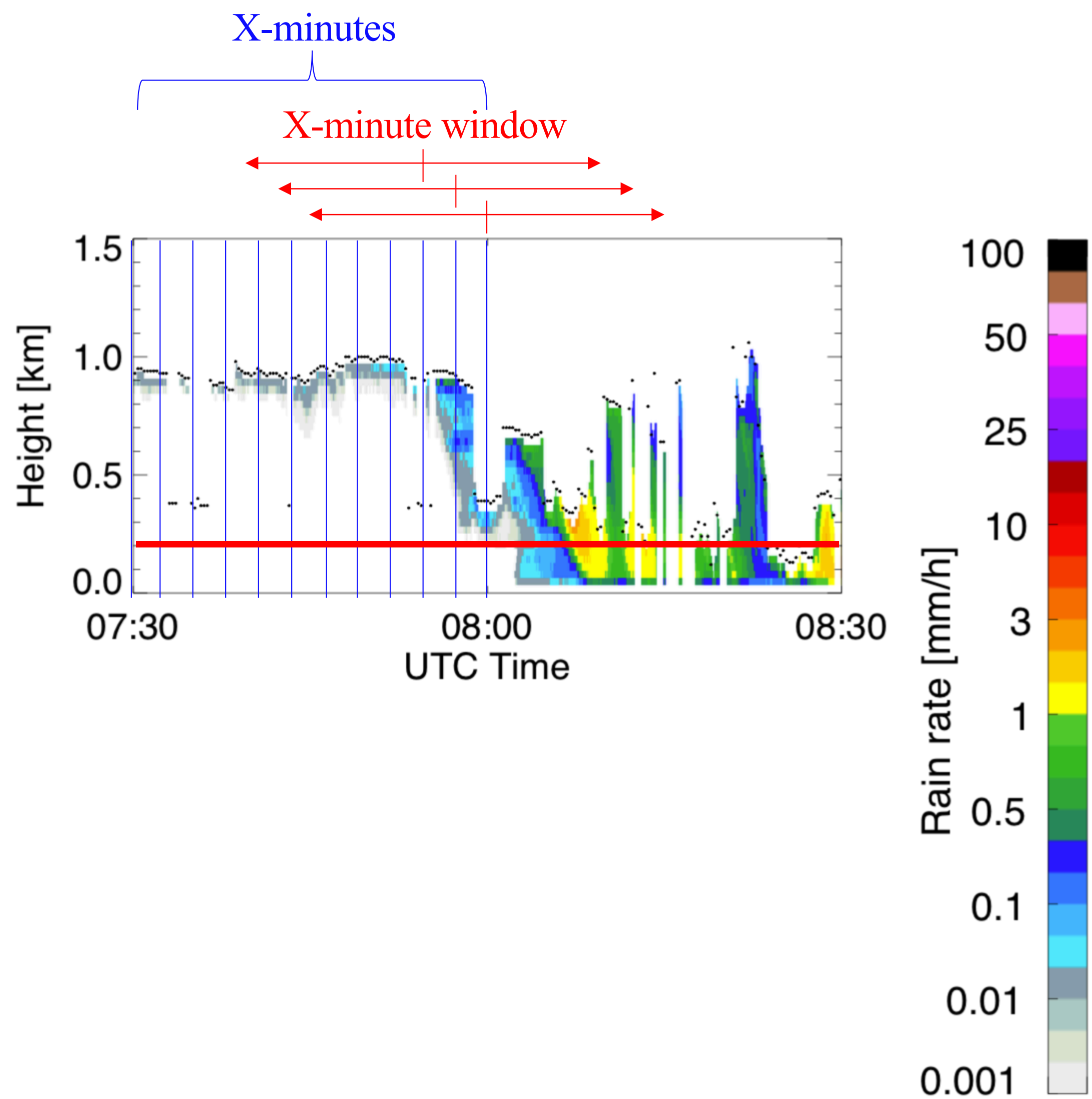


Estimating a Proxy for Domain Average Light Precipitation Rate Using Zenith observations

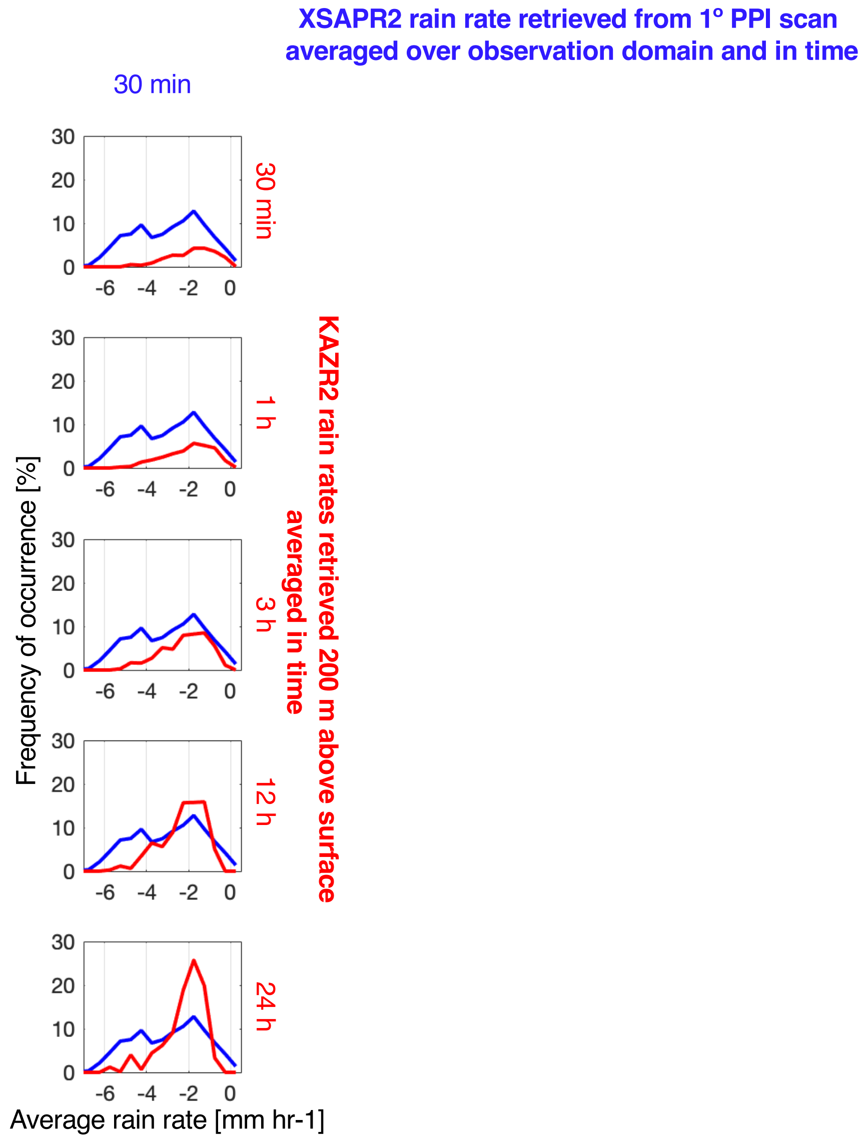
1.
Centered on each X-SAPR2 domain snapshot estimate the average rain rate observed by KAZR2 at 200m in a X-minute time window



2.
Average the same X-minutes worth of "domain" average rain rates as used when treating the XSAPR2 observations



Characterizing variations in Domain Average Precipitation Rate Across Various Timescales



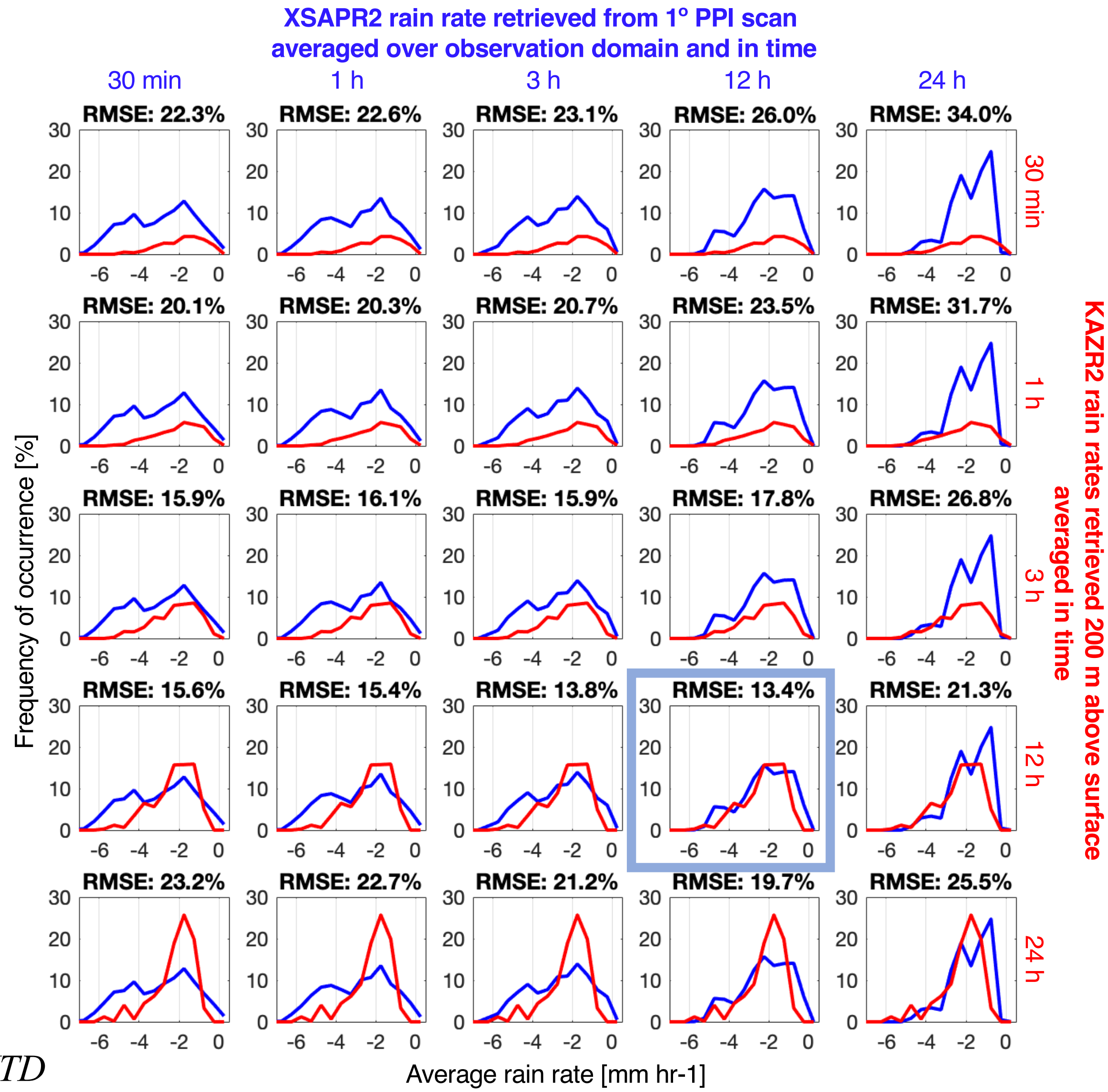
Can point observations be used to characterize the temporal variability of near surface rain rate over a ~ 2,500 km^2 domain?

Based on 4-months of ENA observations

- ✓ Low-level precipitation rate statistics only converge when characterizing long-term (12-hourly) variability

  KAZR2 observations collected in 12-h windows around each XSAPR2 scan are needed to capture the ~ 40 km radius domain

- ✓ Scanning sensors are better suited to document sporadic and horizontal inhomogeneous precipitation
- ✓ Zenith-pointing radars more suited for precipitation that varies rapidly with height for instance owing to an active evaporation process



More details in Lamer et al. (2019) available in AMTD