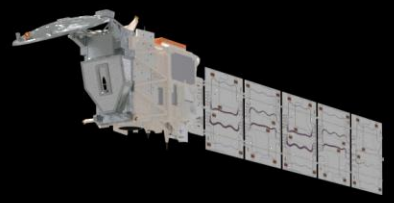
Cloud and Precipitation Retrieval for EarthCARE's Doppler Cloud Profiling Radar



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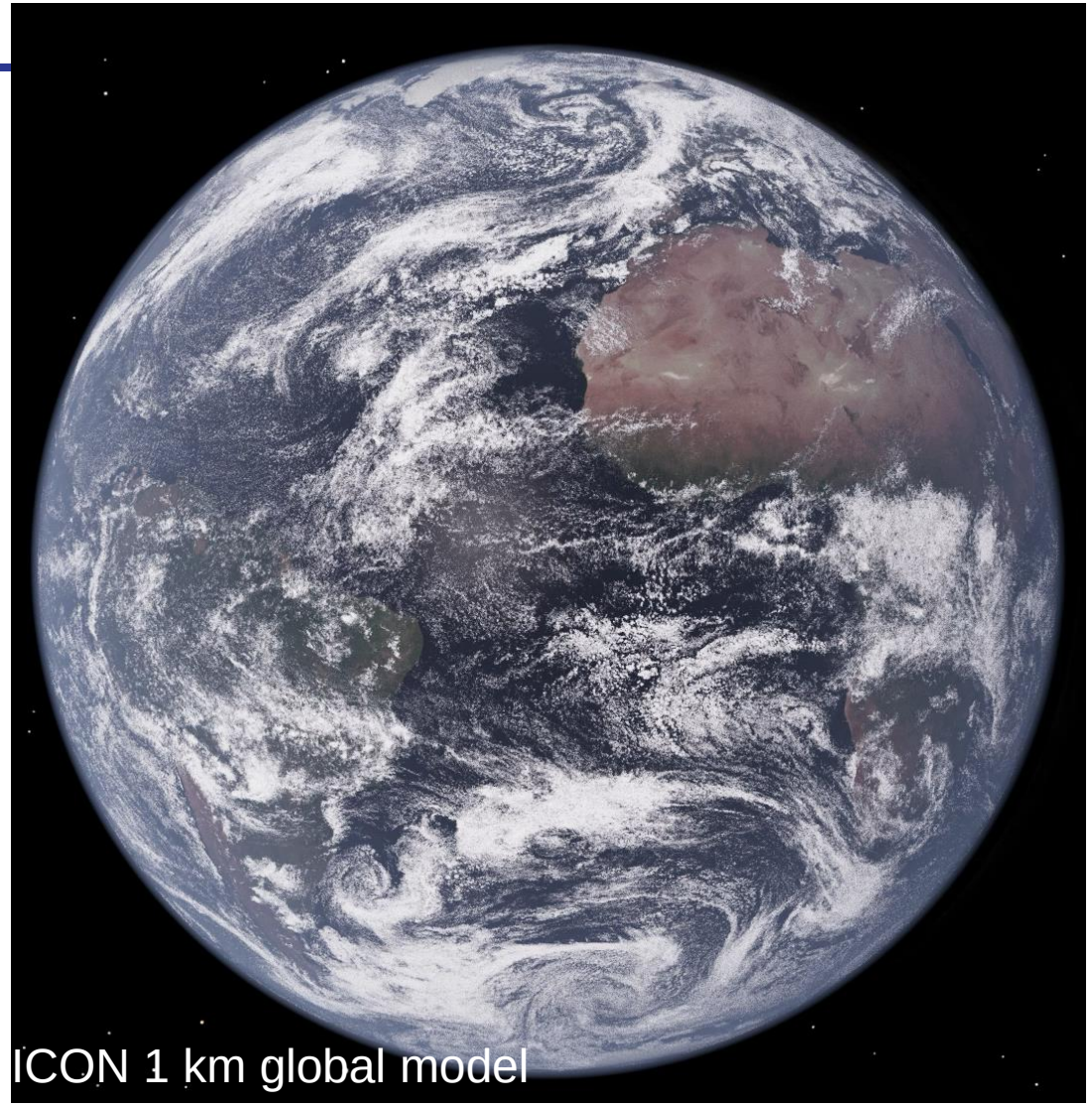
Kamil Mroz[1],
B. Puigdomènech Treserras[2],
A. Battaglia[1,4,5], P. Kollias[2,3]

[1]National Centre for Earth Observation, UK;
[2]McGill University, Canada; [3]Stony Brook University, USA;
[4]Politecnico of Turin, Italy;
[5]University of Leicester, UK

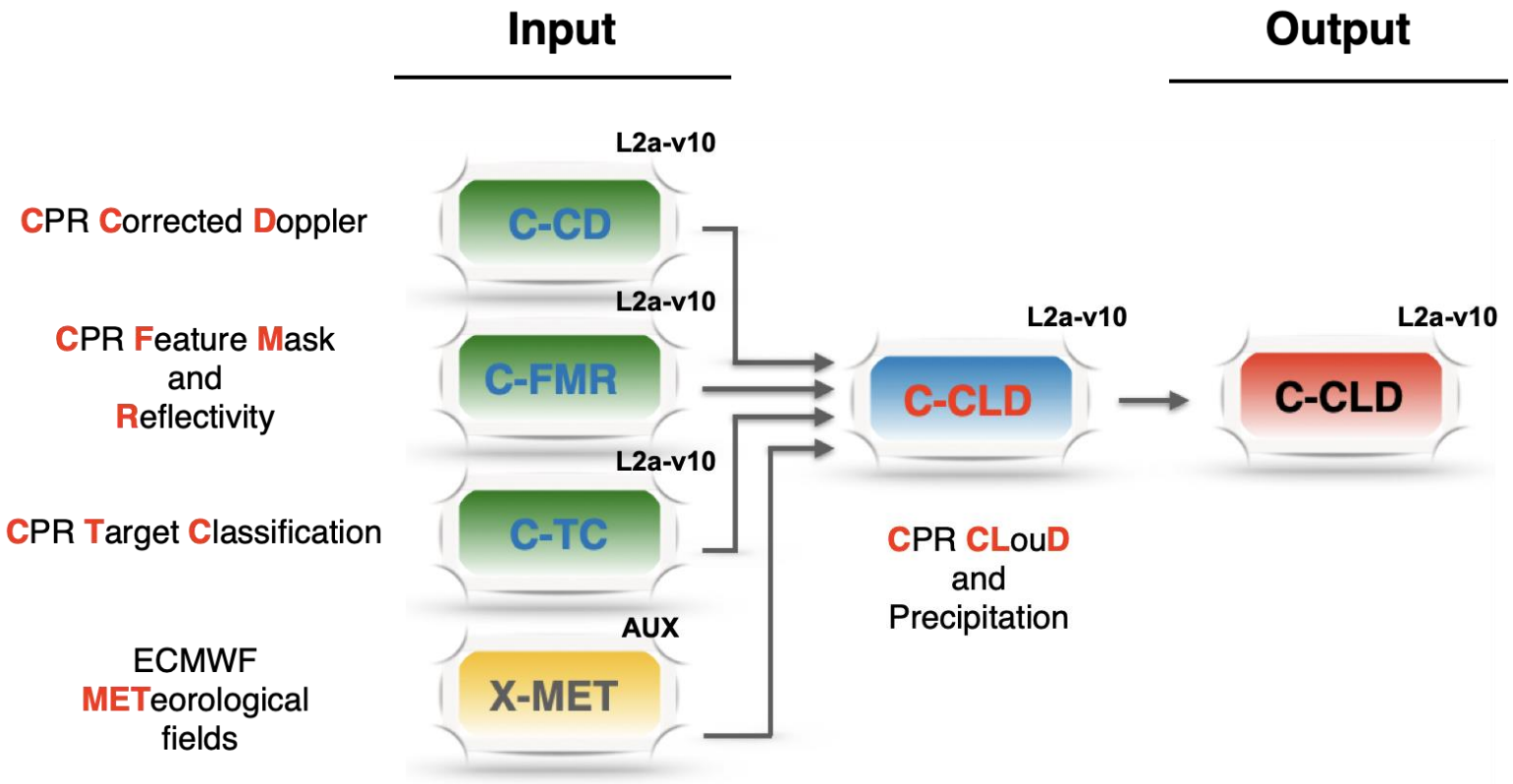
Motivation

- Resolution of Earth System Models increases
- Global forecasting system at ECMWF currently operates 9 km, 4.5 and 2.8 km resolutions are tested
- Need for validation of high-resolution parametrization



C-CLD overview

- Only the CPR data utilized:
  - ➢ C-FMR reflectivity
  - ➢ C-CD Doppler velocity
  - ➢ C-TC classification
- The algorithm is based on a profile-by-profile approach
- It is based on the Optimal Estimation framework
- Vertical distribution of 2 microphysical parameters is determined, i.e., water content and characteristic size



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Kamil Mroz | kamil.mroz@le.ac.uk | NCEO, University of Leicester

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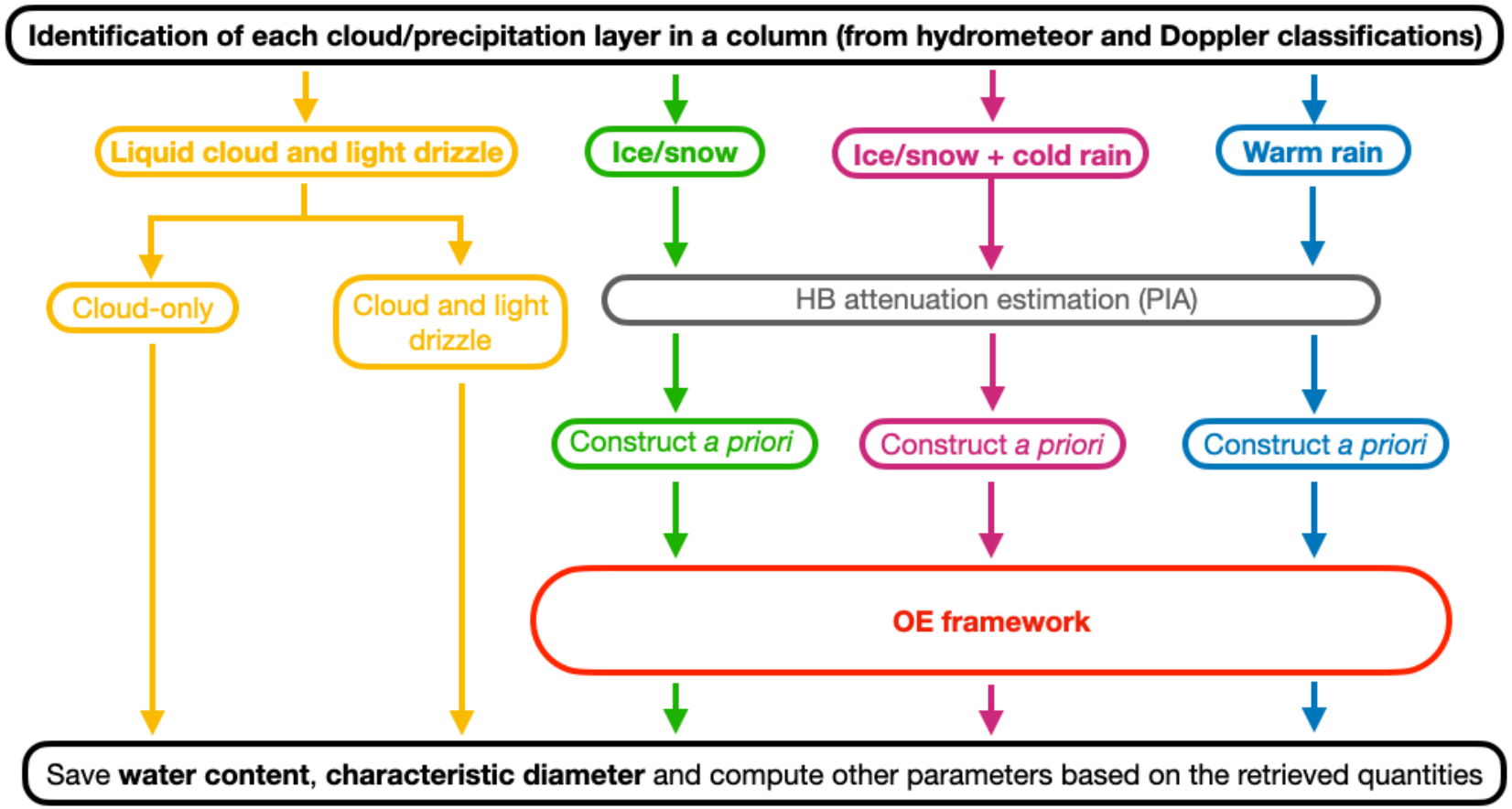
C-CLD overview

- C-CLD is composed of several modules
- C-TC classification is used to select the specific algorithm
- Liquid cloud and light drizzle algorithm based on the power law relationships
- Snow/cold &warm rain algorithms are based on the OE



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OE concept

The OE framework aims at balancing the information provided by:

- The CPR measurements in the entire column
- The statistical information on ground-based precipitation rates and sizes
- Continuity of estimated quantities

$$2\phi = \underbrace{[y - F(x)]^T R_Y^{-1}[y - F(x)]}_{\text{Measurement component}} + \overbrace{[x - x_a]^T R_a^{-1}[x - x_a]}^{\text{A-priori term}} + \underbrace{x^T R_S^{-1} x}_{\text{Continuity}};$$

F - forward model
y – measured reflectivity and sedimentation velocity
x – state vector
x_a – a-priori estimate of the state vector,
R_y^{-1}, R_a^{-1}, R_x^{-1} - weights

- Radar measurements in snow are simulated using a scattering dataset that correspond to realistic snowflake shapes
- Rain is simulated with T-matrix approximation
- A-priori estimates are based on in-situ measurements

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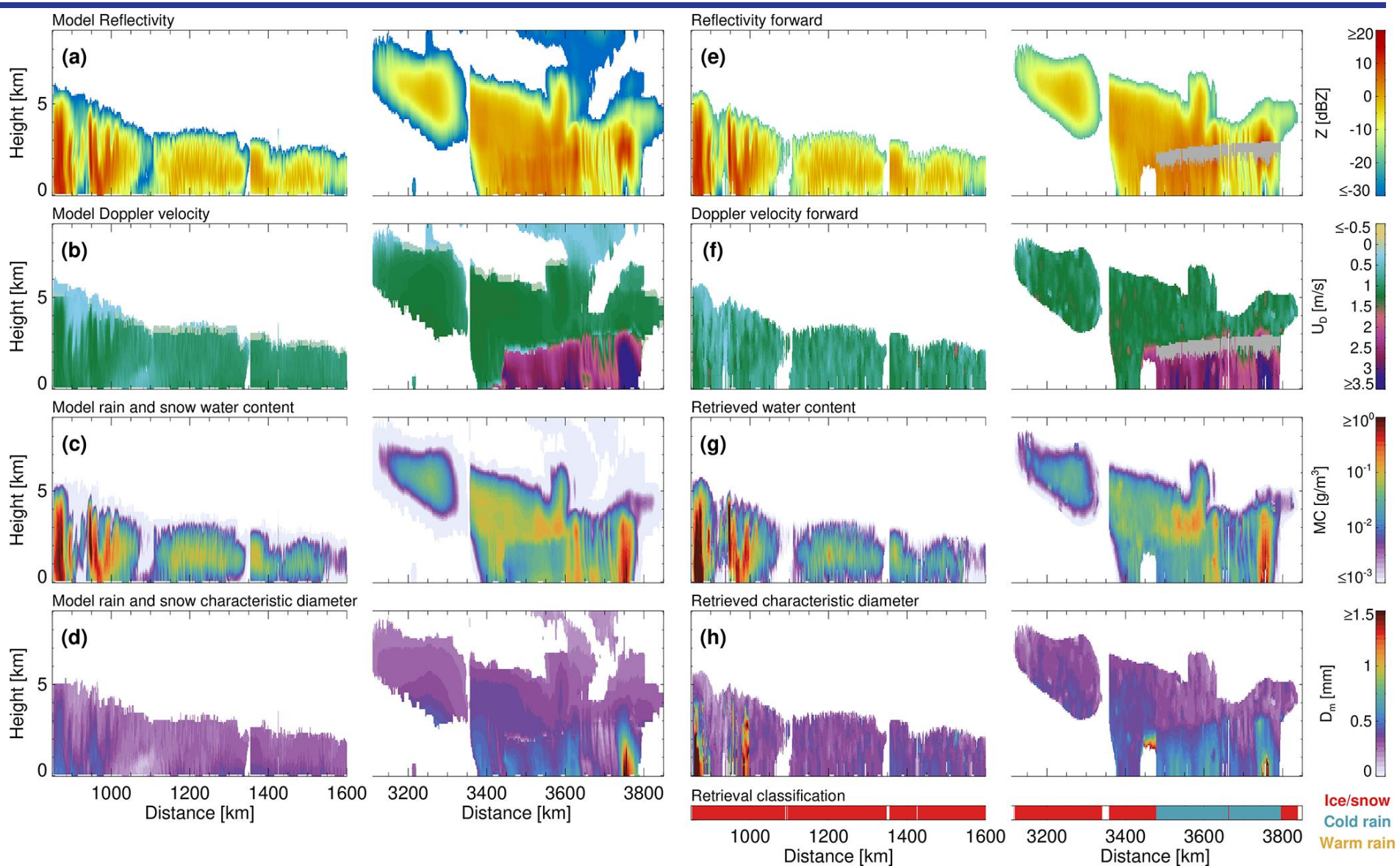
Validation: GEM simulations



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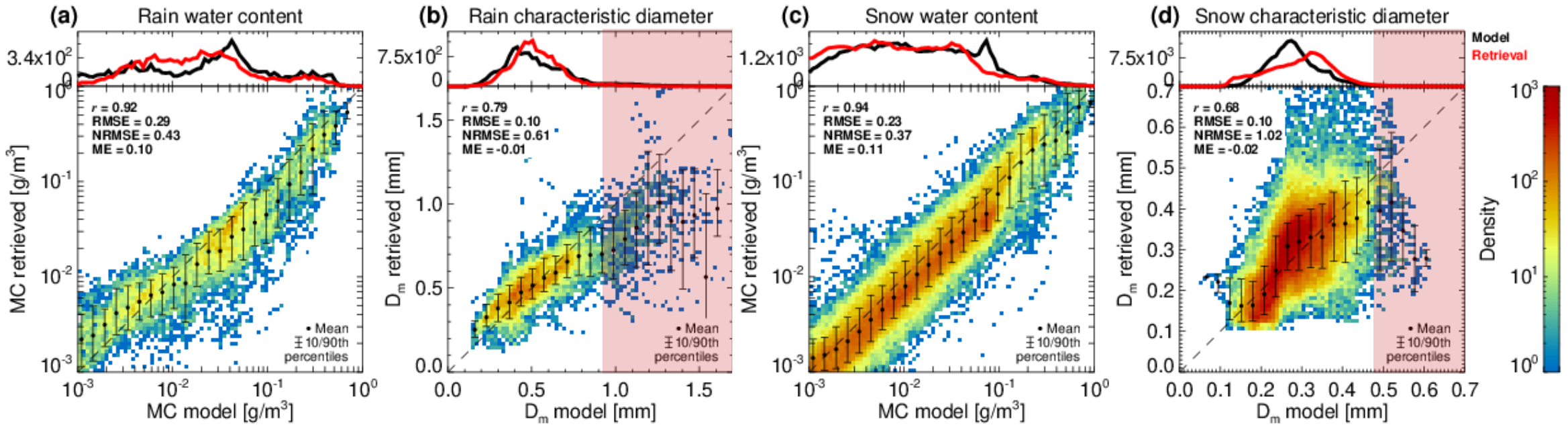
Validation: GEM simulations



- Underestimate for large raindrop sizes
- Insufficient number of the validation points for large

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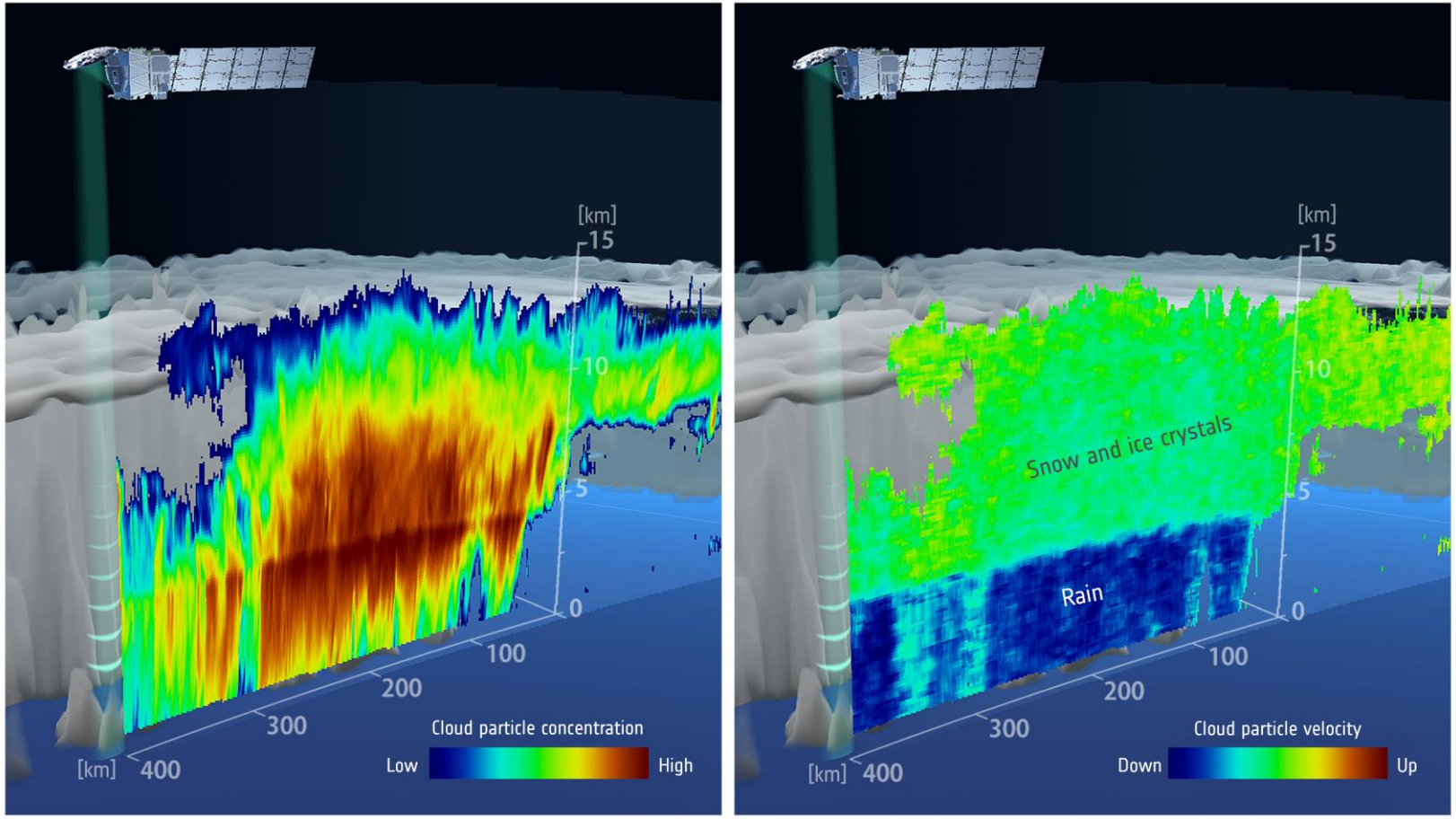
New Era: Real measurements



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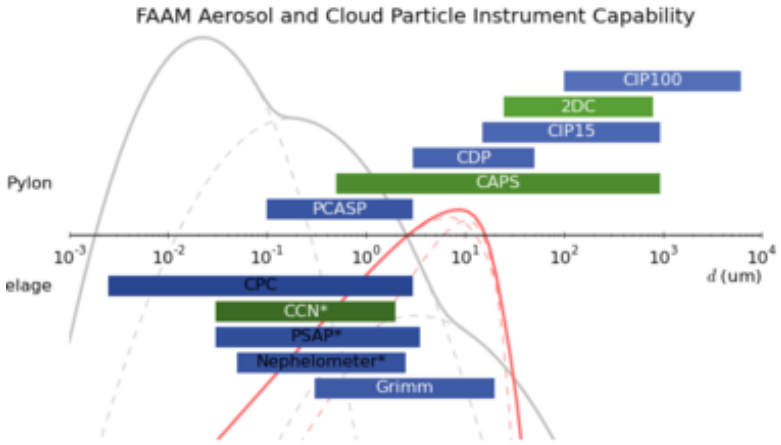
The FAAM Airborne Laboratory

- Based at Cranfield Airport at Cranfield University
- BAE-146-301 large research aircraft
- Altitude: from 30m over water (150m over land) to 11km
- The aircraft can carry up to 4 tones of scientific equipment
- **Cloud physics instrumentation** : droplet counters, imaging probes covering sizes from 3um to 6.2mm , bulk ice and water content (Nevzorov & TWC probe)
- Aerosol, Meteorology, Chemistry instrumentation

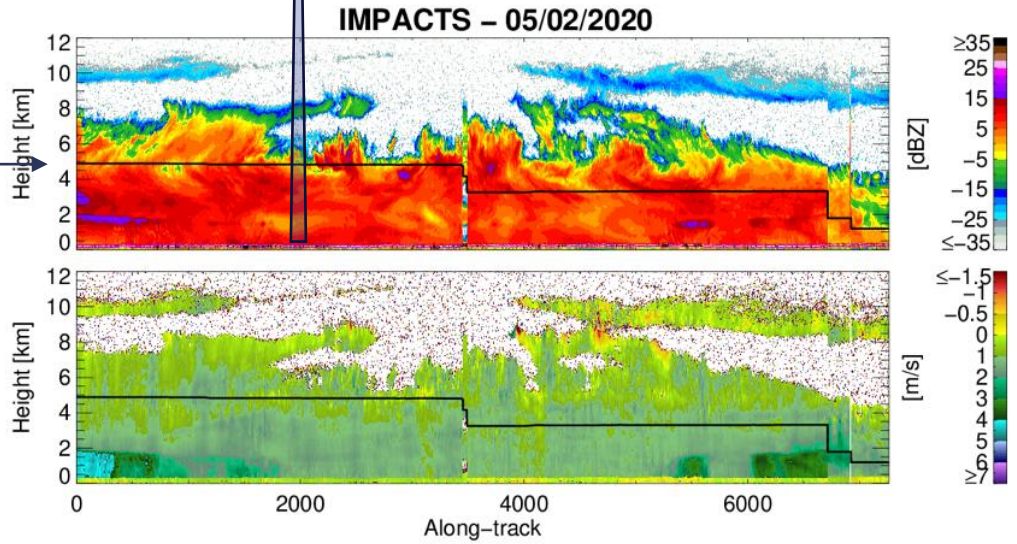


Campaign Objective

- Collect aircraft measurements of clouds and aerosols
- At least 34 h of flights
- Within 20 minutes of the EarthCARE track
- at least 120 km long
- prioritise runs beneath EarthCARE
- Sample wide range of meteorological conditions (not covered by GEM simulations)

CPR;
ATLID;
MSI;
BBR

PCASP;
CDP;
CIP-15, CIP-100;
Nevzorov;
Broadband radiometers



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Conditions of particular interest

- Continental aerosol – its properties derived primarily from ALTID
- Broken cumulus – drizzle free, low Z regime
- Marine stratocumulus – CPR dominated by drizzle
- Large-scale rain – evaluation of information content of Doppler data
- Snow above the melting layer – embedded supercooled layers causing attenuation and affecting snow density – CPR Doppler sensitivity
- Altocumulus – mixed phase cloud with supercooled layer on top
- Convective clouds – retrieval uncertainty in challenging conditions

Kamil Mroz | kamil.mroz@le.ac.uk | NCEO Leicester

Conclusions and Future work

- C-CLD is a cloud-precipitation retrieval based on the OE framework
  - ➢ Low reflectivity regime
  - ➢ Explore potential for horizontal continuity, i.e., diverge from a profile-to-profile approach
- Validation campaigns need to focus on weather conditions not included in GEM simulations:
  - ➢ Large particle sizes
- C-CLD algorithm was applied to stratiform precipitation only; it must be tested for convective profiles

Kamil Mroz | kamil.mroz@le.ac.uk | NCEO, University of Leicester