3D Microphysics Tomography by Spaceborne Multiview Polarimetry
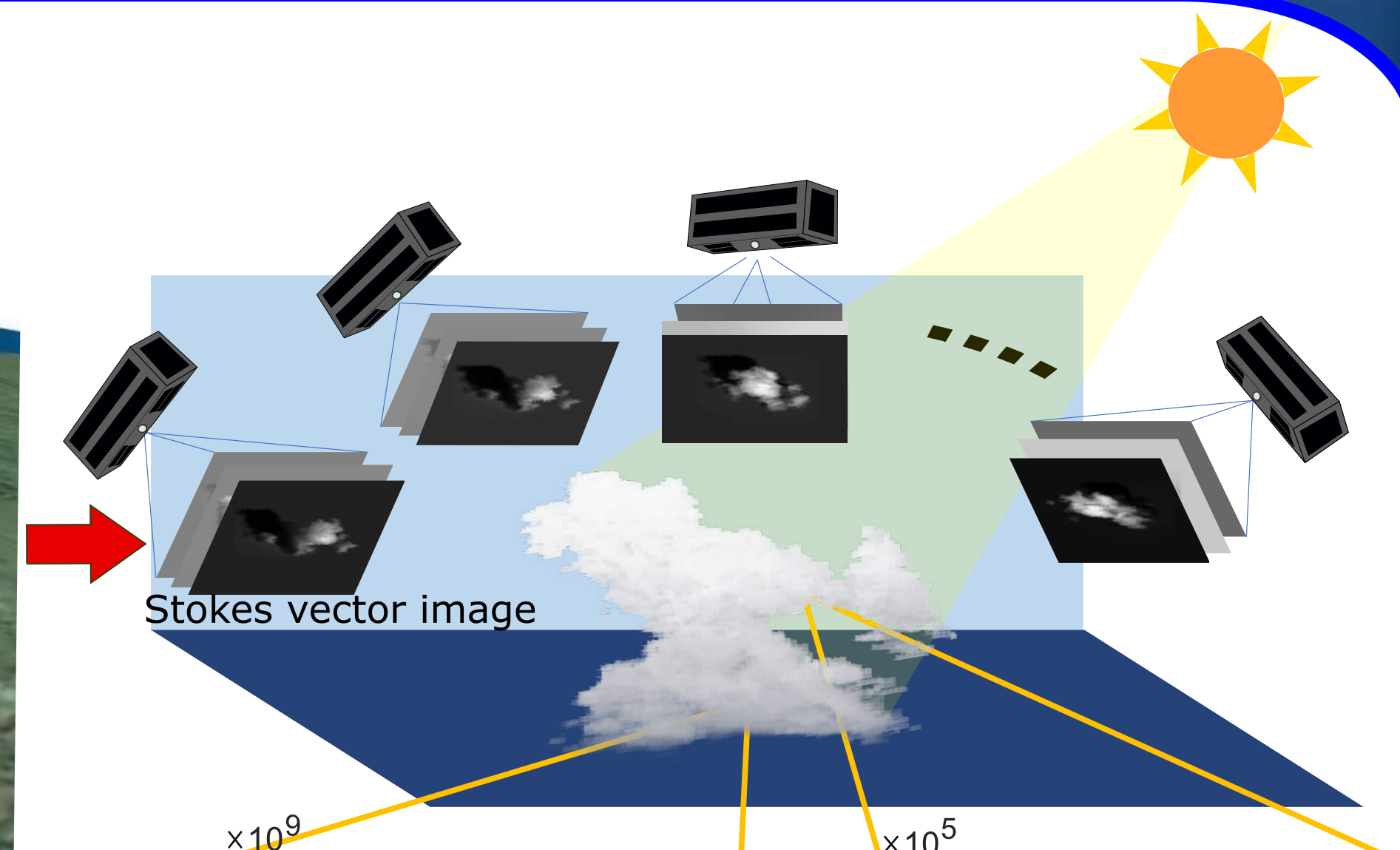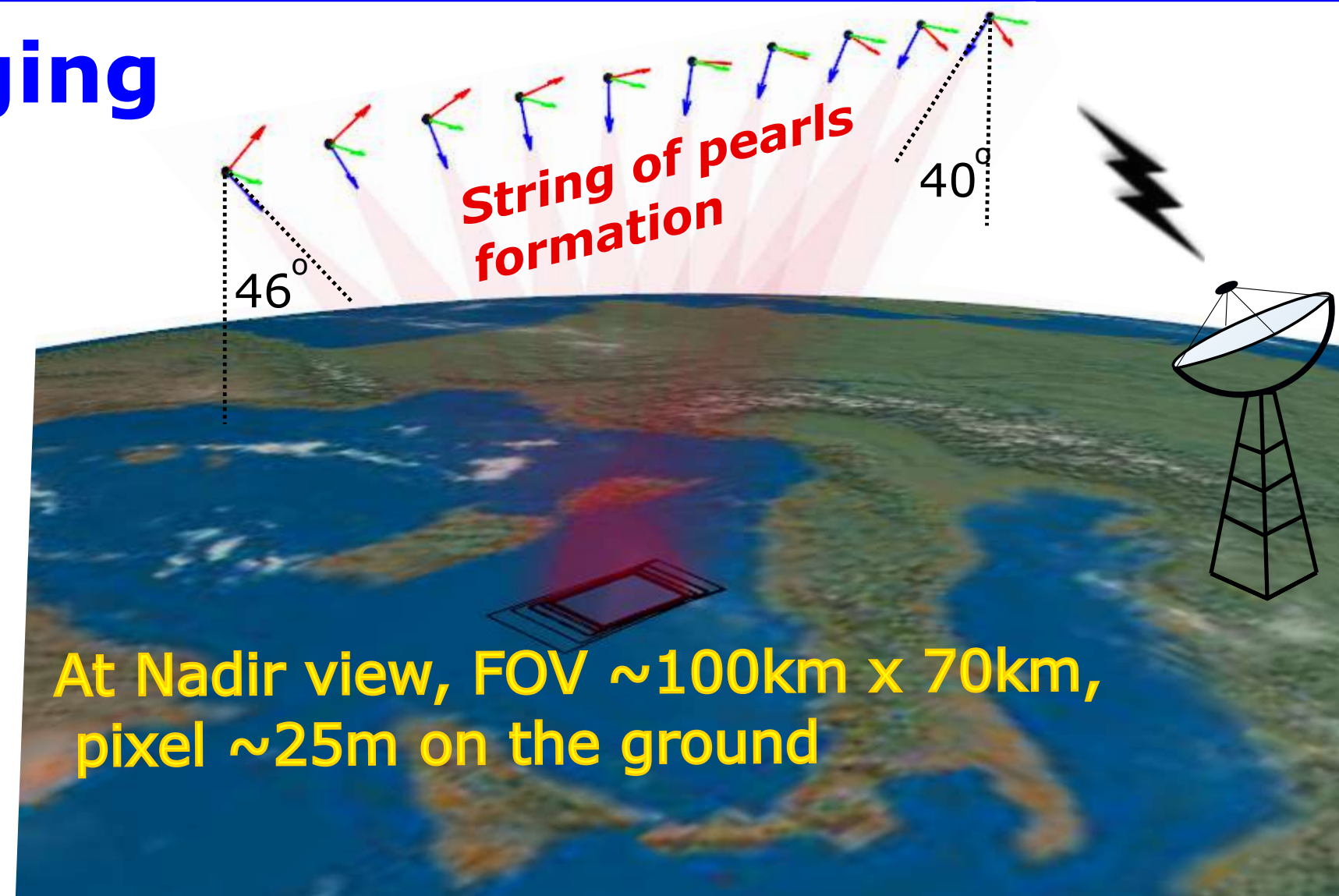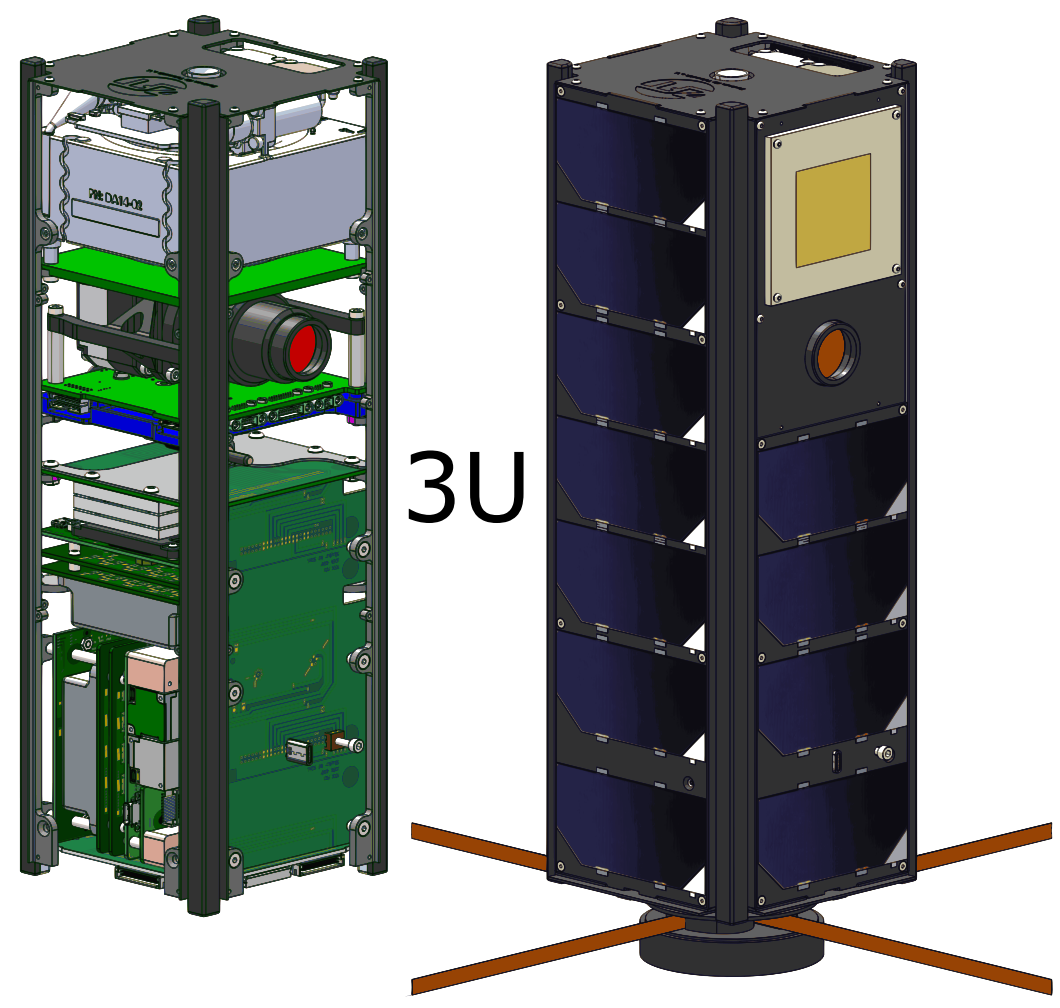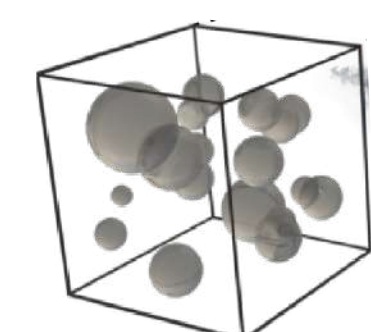
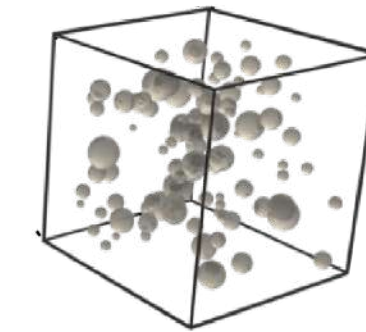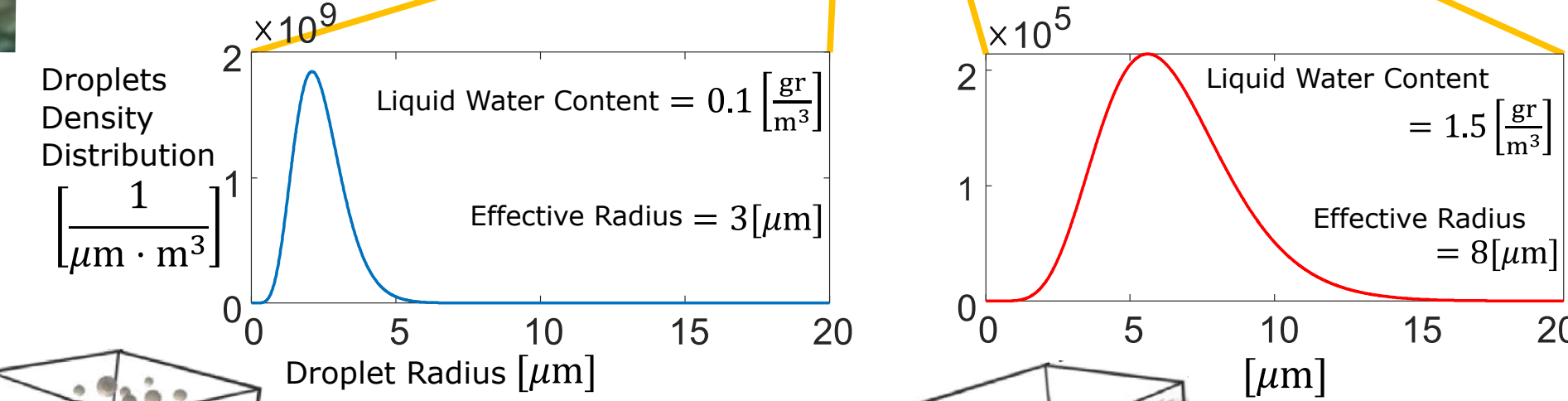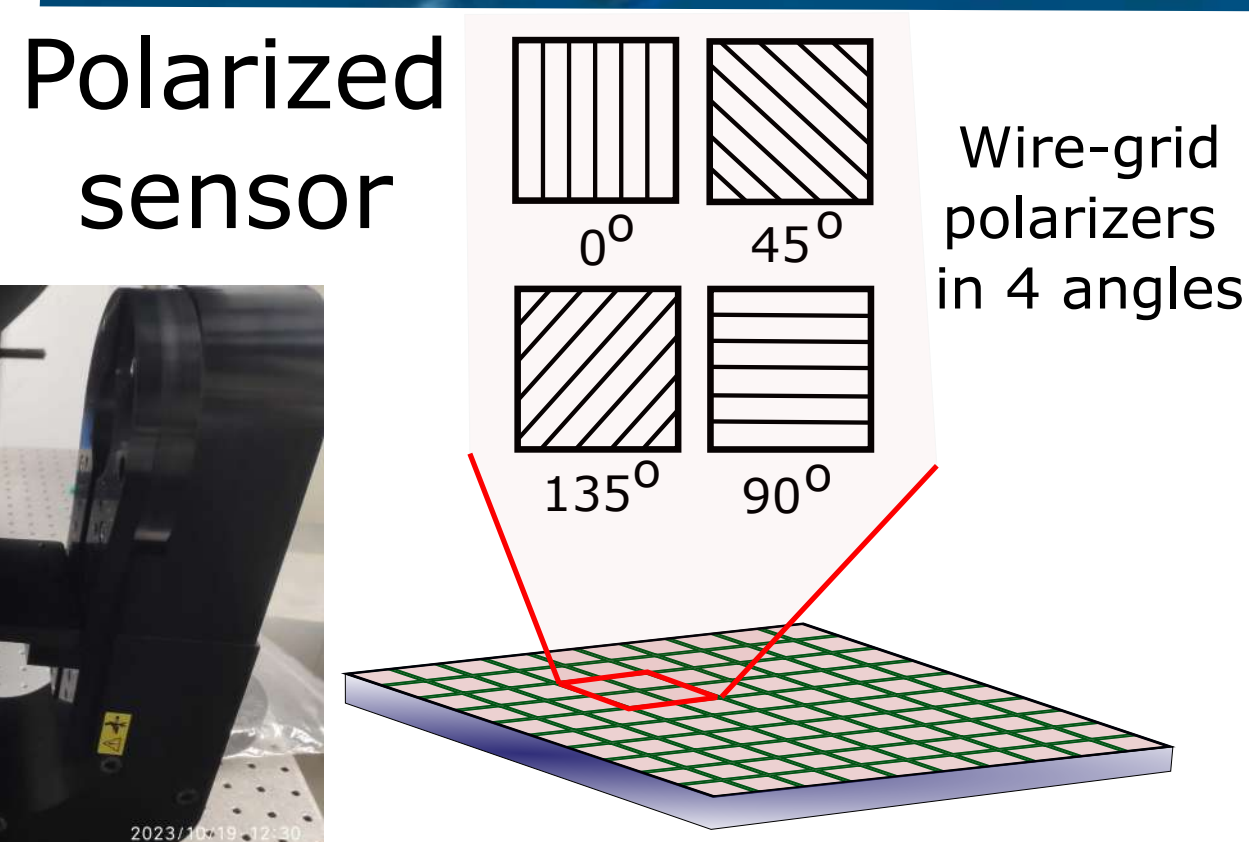**Inbal Kom Betzer, Roi Ronen, Vadim Holodovsky, Klaus Schilling, Ilan Koren, Yoav Y. Schechner**

TECHNION Israel Institute of Technology | WEIZMANN INSTITUTE OF SCIENCE | ZfT ZENTRUM FÜR TELEMATIK E.V. | ISRAEL SCIENCE FOUNDATION | erc

Polarized multiview imaging

3U

CloudCT satellite design by Zentrum fuer Telematik

https://dragonflyaerospace.com/

String of pearls formation — 46° ... 40°

At Nadir view, FOV ~100km x 70km, pixel ~25m on the ground

Polarized sensor — Wire-grid polarizers in 4 angles: 0°, 45°, 135°, 90°

Stokes vector image

Droplets Density Distribution $\frac{1}{[\mu m \cdot m^3]}$

$\times 10^9$ — Liquid Water Content = 0.1 $[\frac{gr}{m^3}]$, Effective Radius = 3 $[\mu m]$

Droplet Radius $[\mu m]$

$\times 10^5$ — Liquid Water Content = 1.5 $[\frac{gr}{m^3}]$, Effective Radius = 8 $[\mu m]$

$[\mu m]$

Microphysics

S. H. Salter, Solar Radiation Management, Cloud Albedo Enhancement, 2013.

Neural Microphysics Field (NeMF)

Stokes vector images y — Encoder — Feature encoder — NeMF Deep Neural Network — Decoder — head 1 — head 2 — head 3 — Effective Radius — Effective Variance — Liquid Water Content

Space carving — Spatial location — Voxel encoder — Cameras locations — Formation encoder — $\hat{\tau}$ — 3D Mask — ×
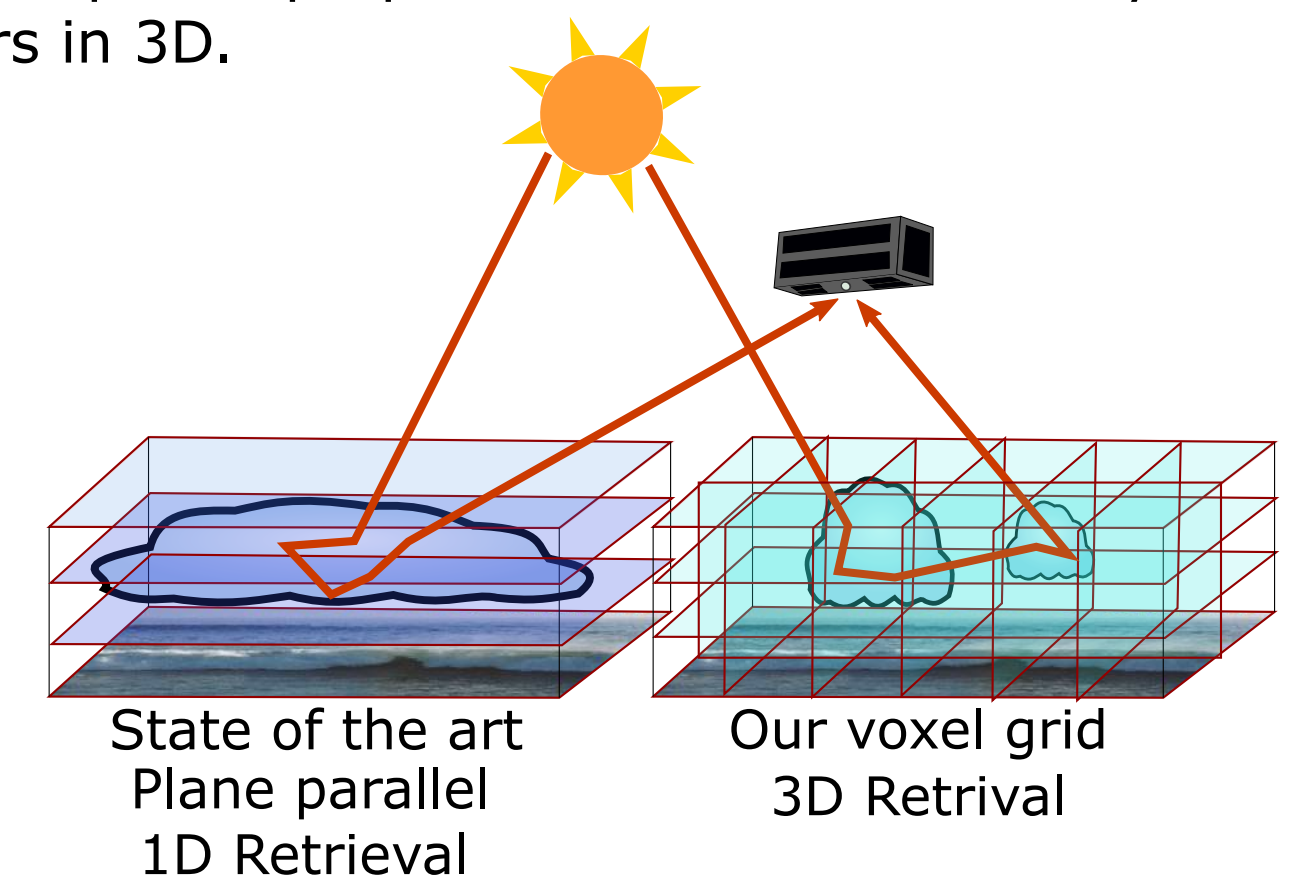
Abstract:

Computational photography from spaceborne multi-views and 3D scattering tomography of cloud microphysics.

Deep neural network trained by supervised learning.
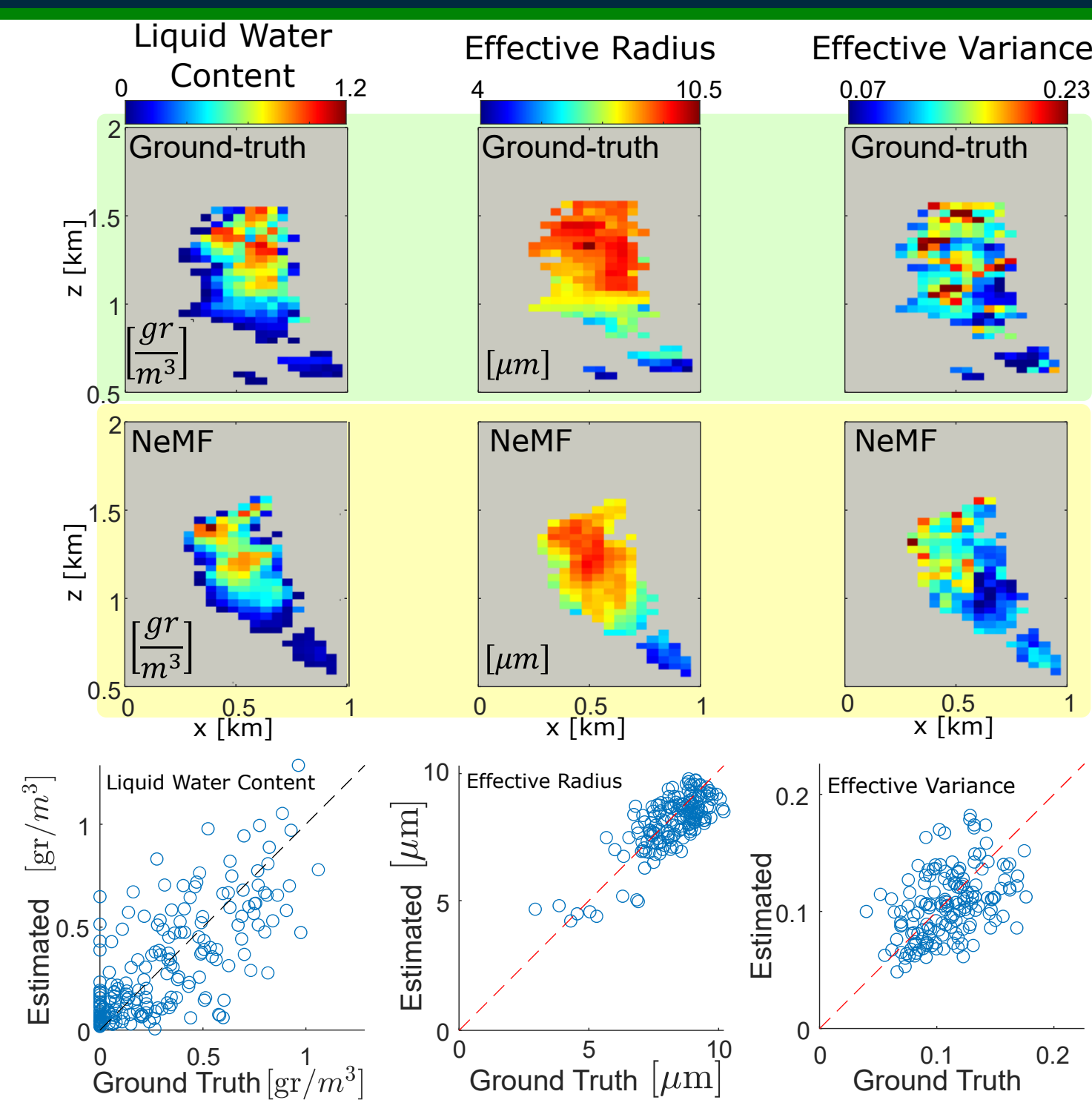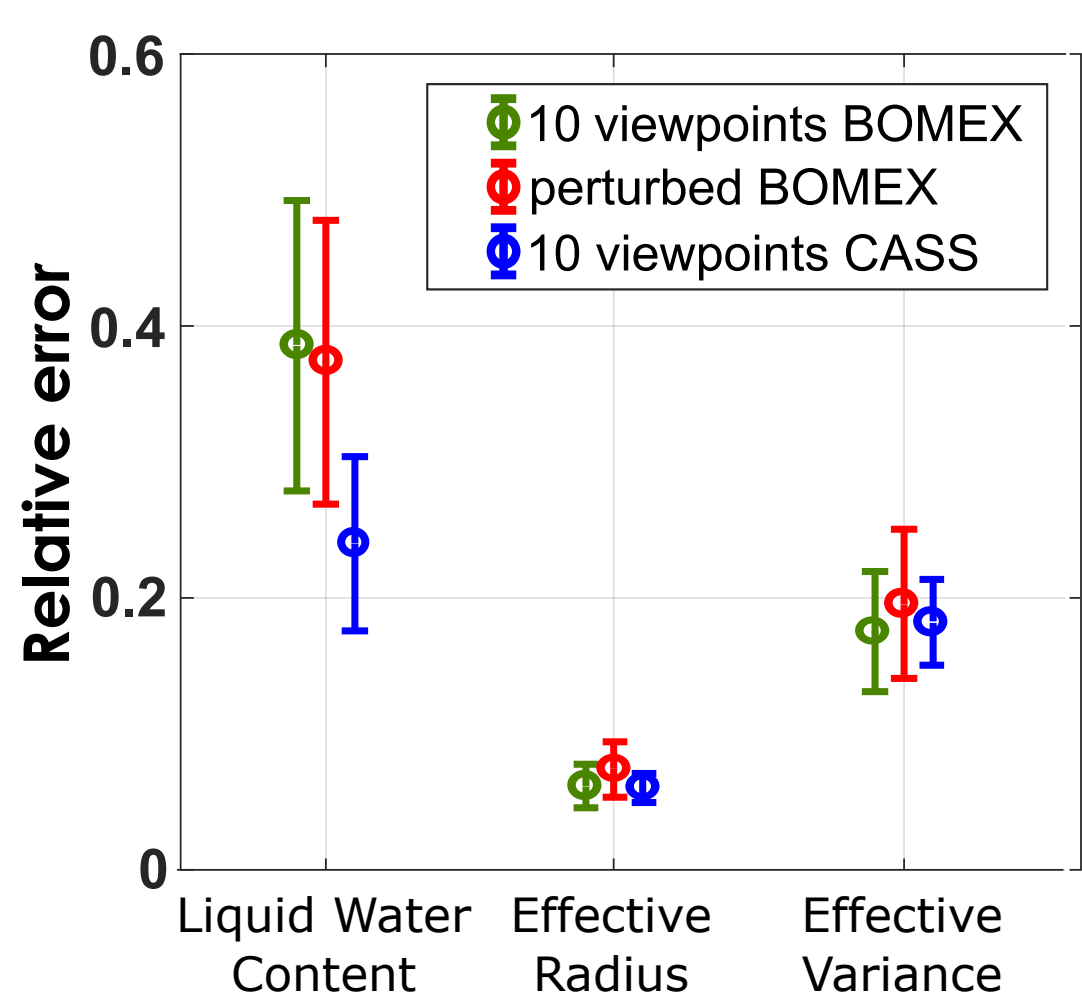
Satellites are being integrated.

Current State of the Art:

Atmospheric properties reconstruction only in 1D. Ours in 3D.

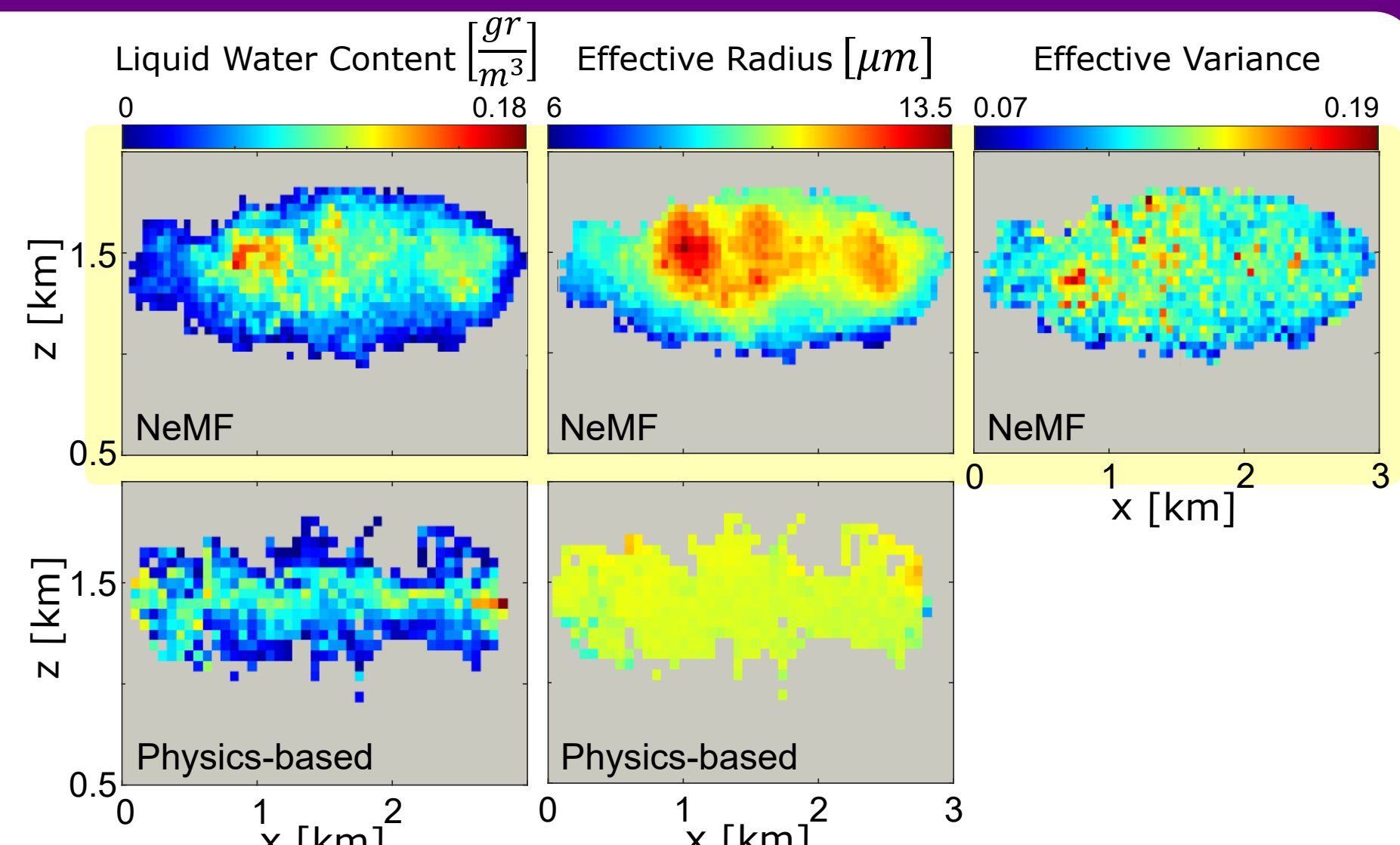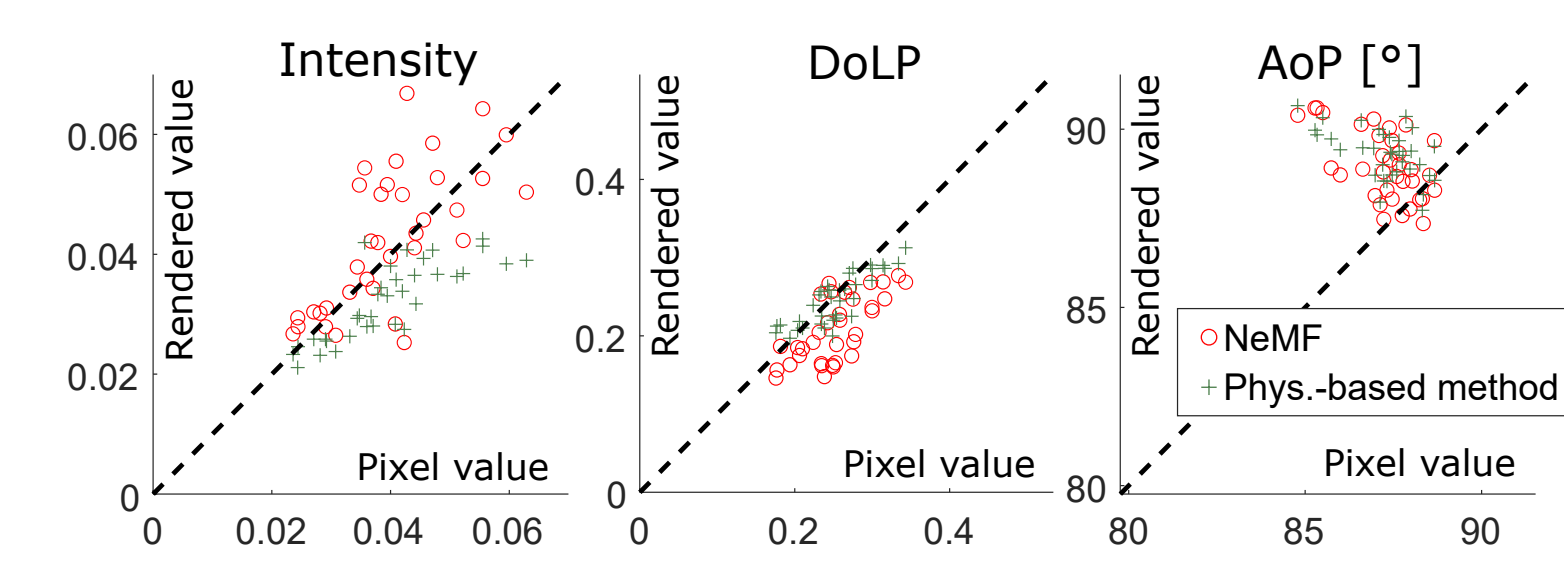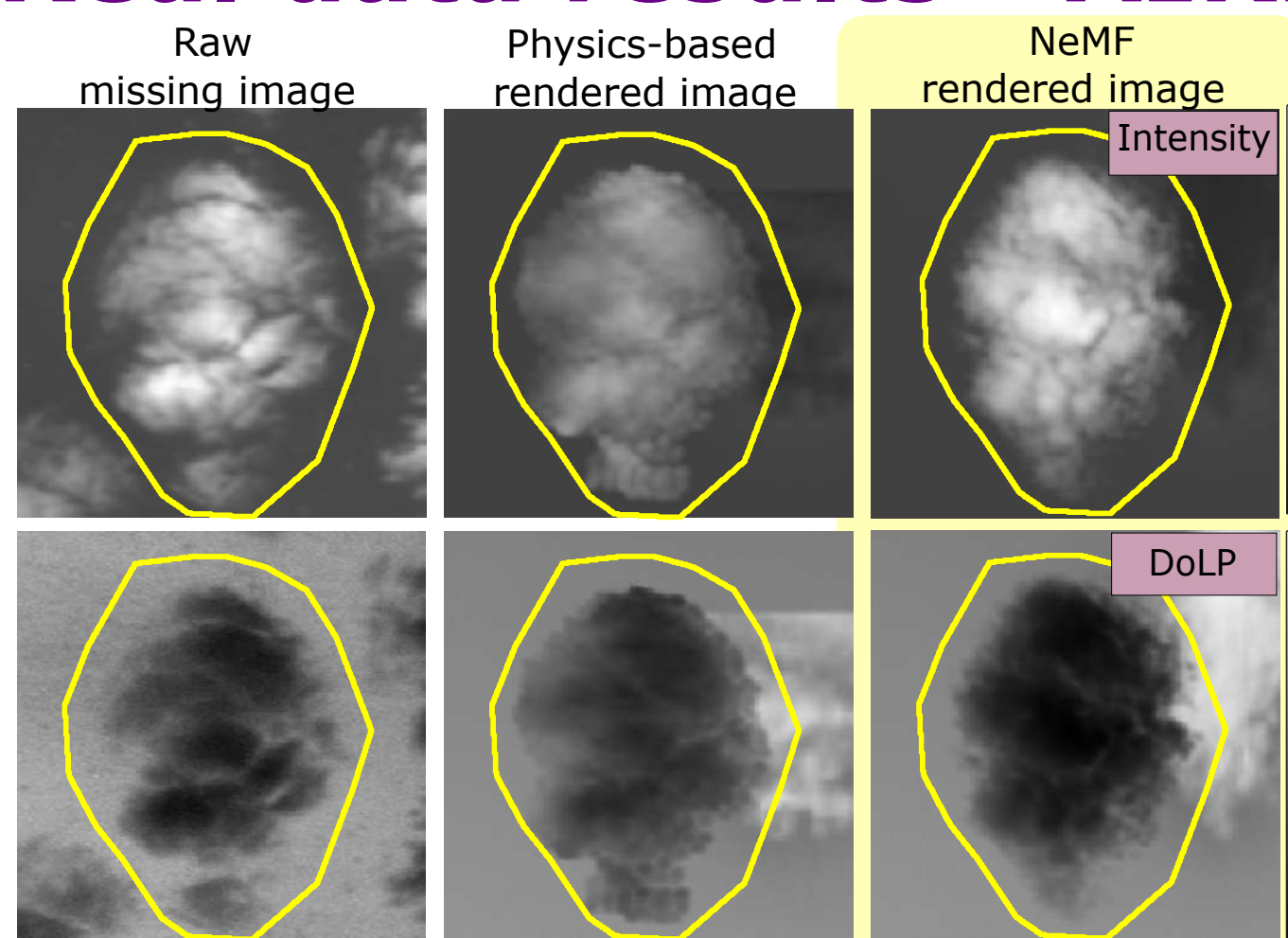State of the art Plane parallel 1D Retrieval | Our voxel grid 3D Retrival

No existing spaceborne setups for simultaneous multi-view imaging with high spatial resolution. Ours: ~10 nano-satellites capable of simultaneous high resolution polarimetric imaging.

CloudCT Spaceborne Cloud Tomography — www.cloudct.space

Simulations results

Relative error — Liquid Water Content, Effective Radius, Effective Variance

- 10 viewpoints BOMEX
- perturbed BOMEX
- 10 viewpoints CASS

Liquid Water Content — Effective Radius — Effective Variance

Ground-truth — NeMF

Estimated vs Ground Truth

Real data results - AIRMSPI (NASA)

Raw missing image — Physics-based rendered image — NeMF rendered image (Intensity, DoLP)

Intensity — DoLP — AoP [°]: Rendered value vs Pixel value

- NeMF
- Phys.-based method

Liquid Water Content $[\frac{gr}{m^3}]$ — Effective Radius $[\mu m]$ — Effective Variance

NeMF — Physics-based