PACE Polarimetric Cloud Retrievals:

PACE_HARP2_CLOUD_GPC product

GSFC-OEL: Chamara Rajapakshe*, Kirk Knobelspiesses, Andrew M. Sayer, Brian Cairns, Alexandr V. Semenov, …

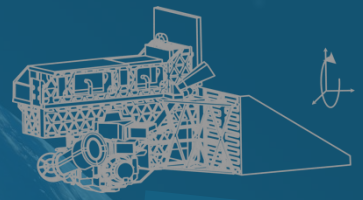
GISS: Bastiaan van Diedenhoven (SRON), Andrzej Wasilewski, Mikhail Alexandrov

UMBC HARP2: Xiaoguang(Richard) Xu, Brent McBride, Anin Puthukkudy, Rachel Smith, Vanderlei Martins

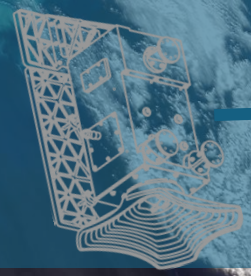
SAT/PVST: Daniel J. Miller, Zhibo Zhang , Igor Geogdzhayev, Kenneth A. Sinclair

Picture: PACE / Carina Poulin

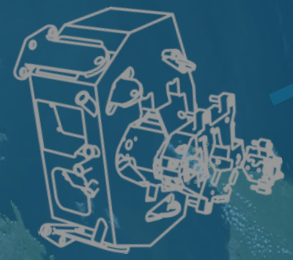
OCI
340-890 nm in 2.5 nm steps, 7 discrete SWIR: 940-2260 nm
1-2 day coverage; ±20° tilt; 1.2km resolution
NASA Goddard Space Flight Center
Primary instrument is a wide swath imaging spectrometer with high accuracy

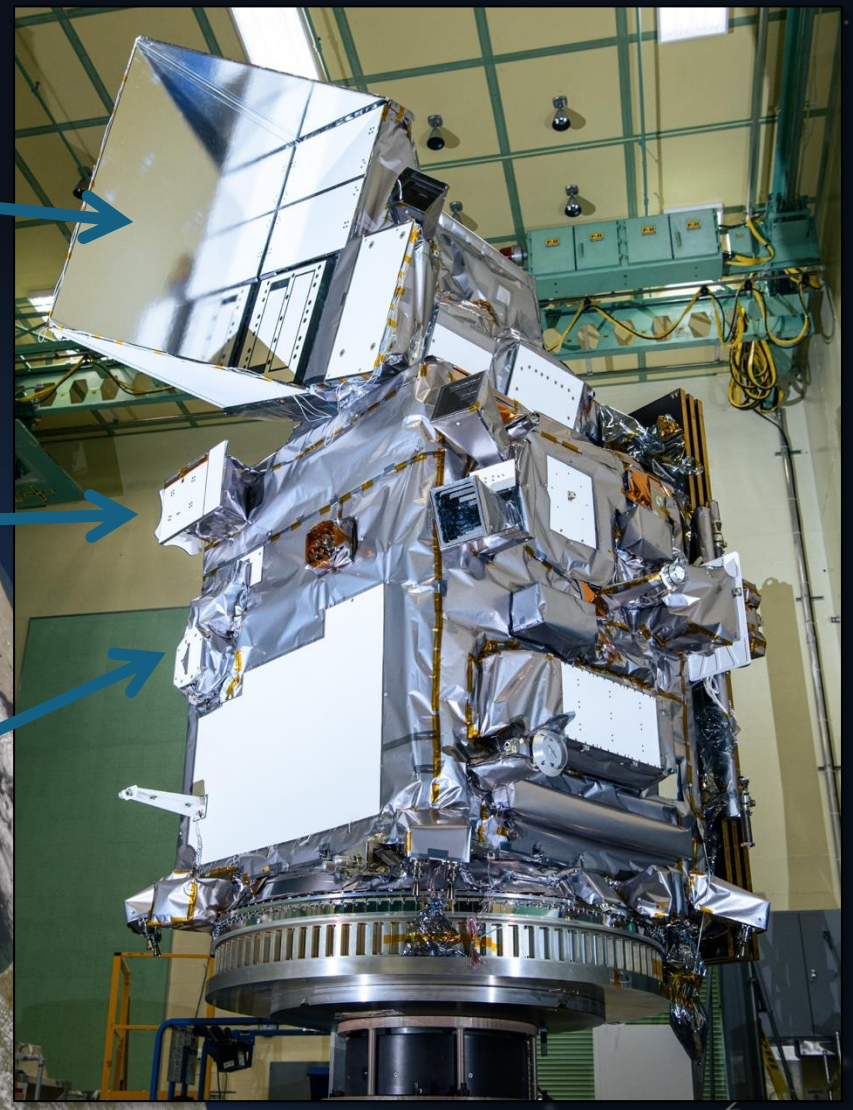


HARP2
440, 550, 670, 870 nm, 10-60 viewing angles
2-3 day coverage; ~3 km resolution, gridded to 5.2km
University of Maryland, Baltimore County
Contributed wide swath hyperangular imaging polarimeter



SPEXone
380-770 nm in 2-4 nm steps, 5 viewing angles
~30 day coverage; 2.5 km, gridded to 5.2km
SRON, Airbus NL
Contributed narrow swath multi-angular spectrometer

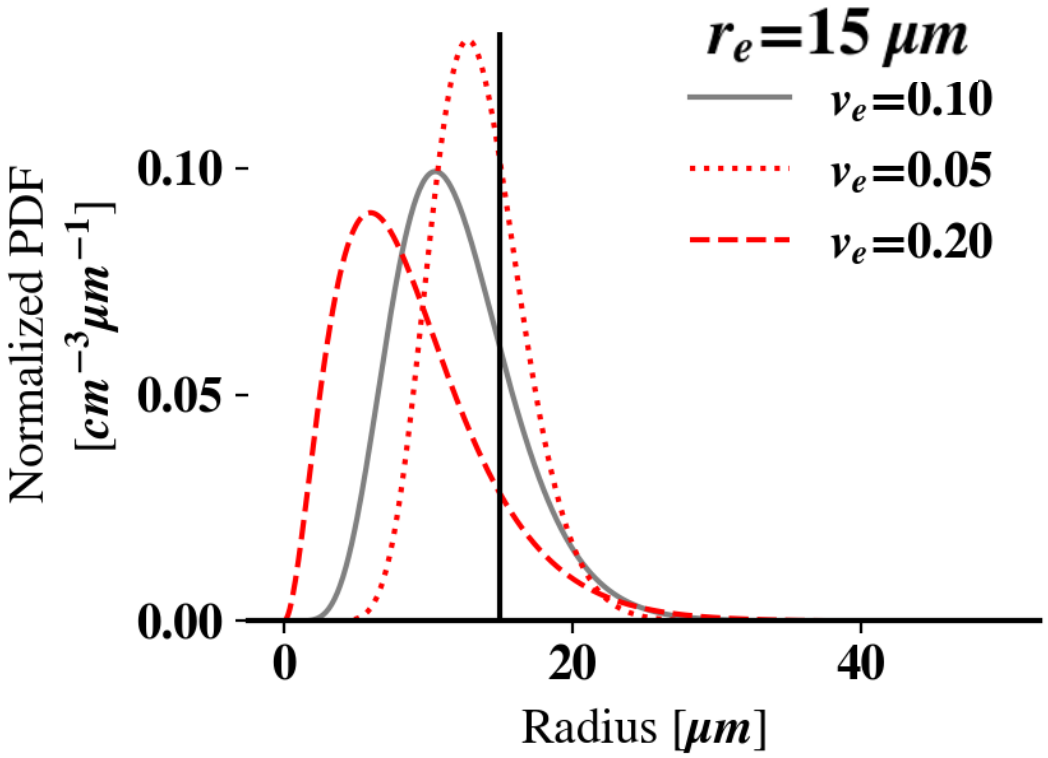




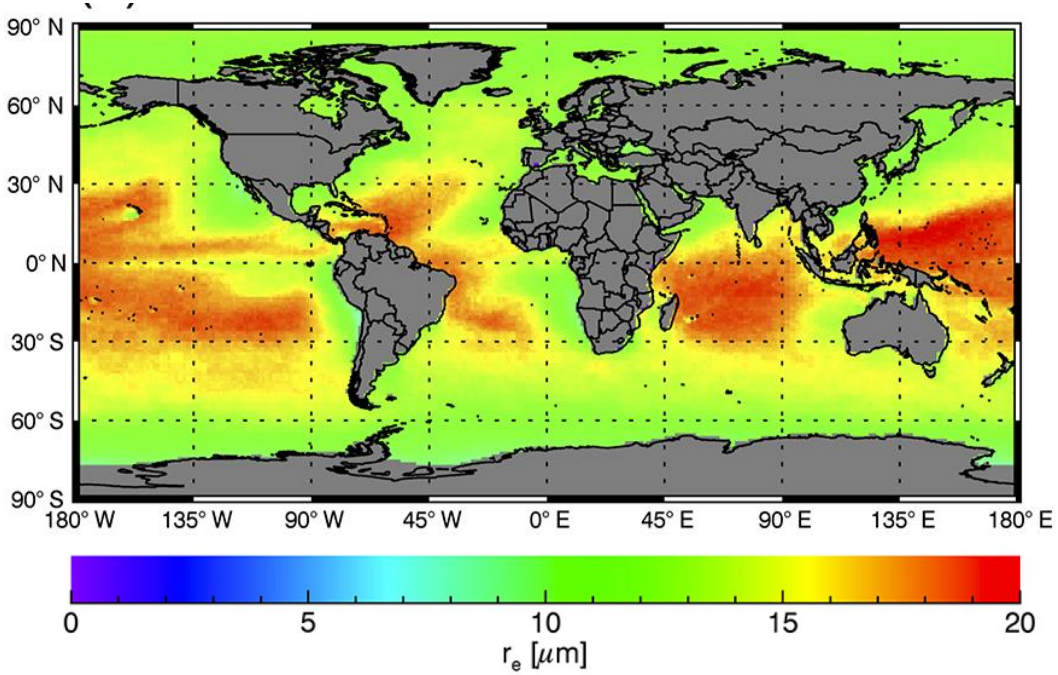
Modified Gamma Distribution

$$n(r) = \frac{dN(r)}{dr} = N_0 r^{(1-3v_e)/v_e} e^{\frac{-r}{r_e v_e}}$$

r_e : Cloud Effective Radius (CER)
v_e: Cloud Effective Variance (CEV)

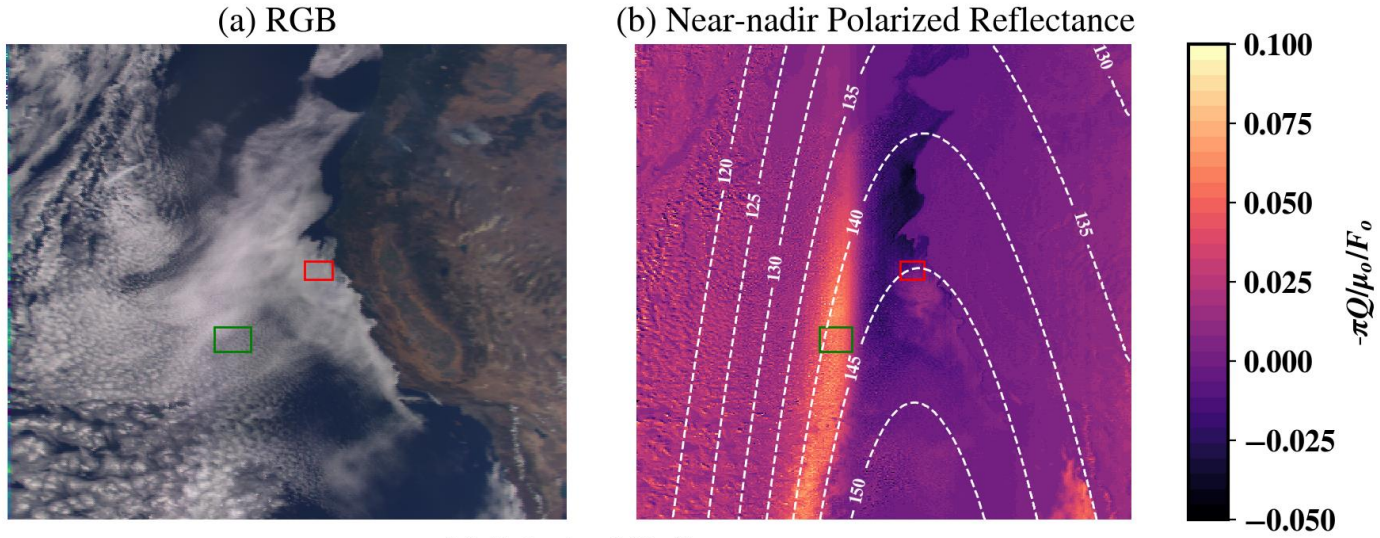


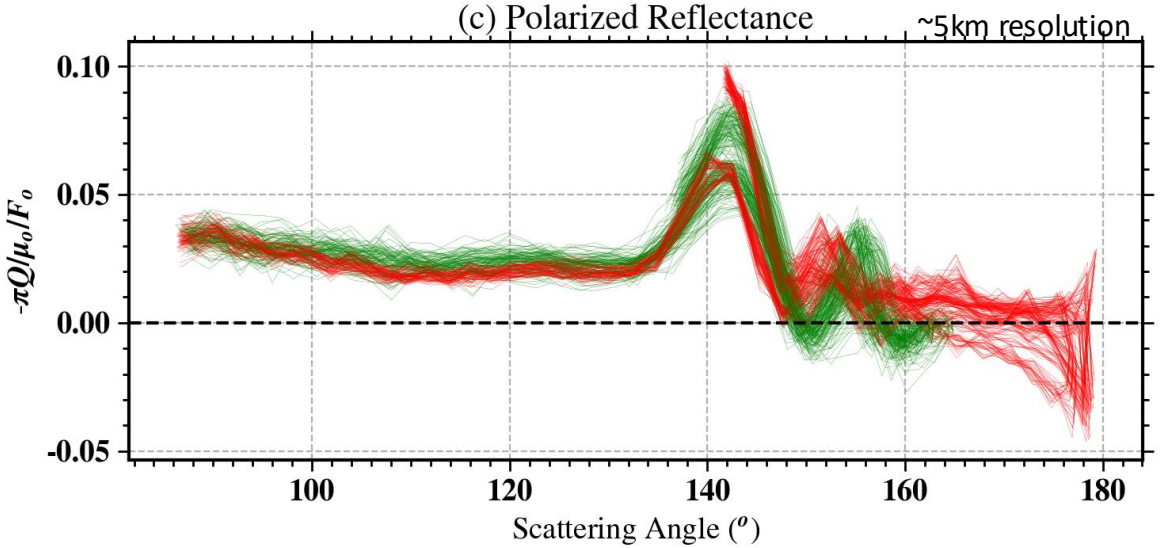
Mean annual Cloud Effective Radius in 2008 from MODIS[1]

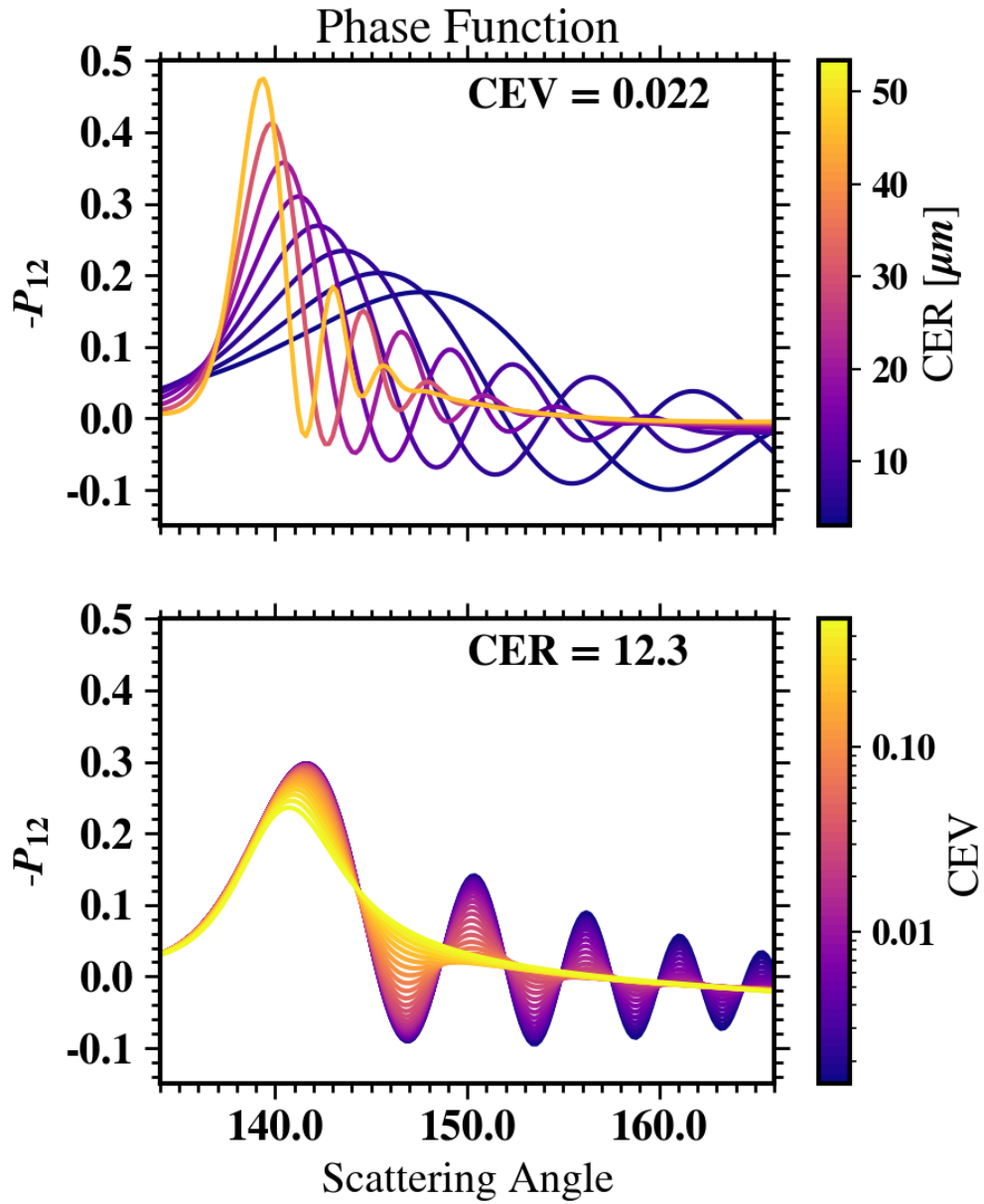


[1]Rausch et. al. (2017)

2024/09/04


(a) RGB
(b) Near-nadir Polarized Reflectance
120
125
130
135
140
145
150
0.100
0.075
0.050
0.025
0.000
−0.025
−0.050
$-\pi Q/\mu_0/F_0$

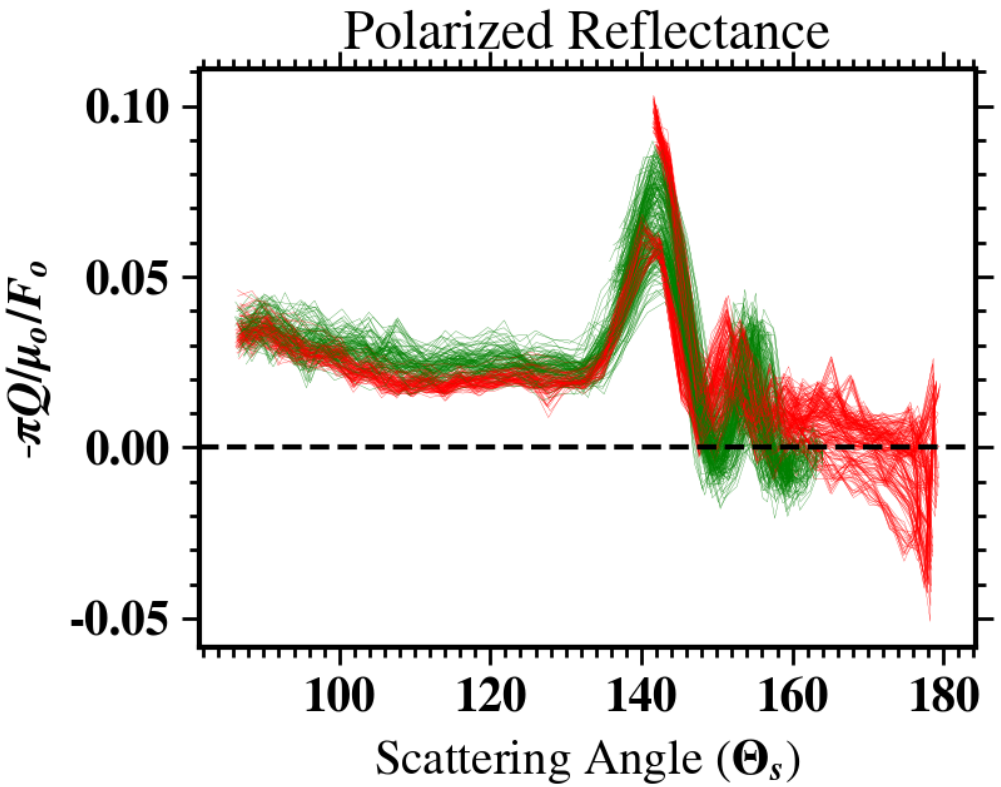

(c) Polarized Reflectance
~5km resolution
0.10
0.05
0.00
-0.05
$-\pi Q/\mu_0/F_0$
100
120
140
160
180
Scattering Angle (^{o})


Phase Function
CEV = 0.022
CER = 12.3
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
$-P_{12}$
50
40
30
20
10
CER [μm]
0.10
0.01
CEV
140.0
150.0
160.0
Scattering Angle

Cloud Liquid Index

(Van Diedenhoven, et. al. 2012)

$$\mathrm{CLI} = \frac{\sum_{i=1}^{N^{\Theta_S}} \left[\frac{\pi Q(\Theta_{S_i})}{\mu_0 F_0} - (a\Theta_{S_i} + b) \right]}{N_{\Theta_S}(a\Theta_{S_0} + b)}$$



Parametric Cloud Bow Retrievals

(Breon & Goloub, 1998, Alexandrov et al. 2012)

$$\frac{\pi Q}{\mu_0 F_0} = AP_{12}(\Theta_S, n(r)) + Bcos^2(\Theta_S) + C$$

Rainbow Fourier Transform (RFT) retrievals (Non-parametric)

(Alexandrov, et. al. 2012)

$$n_a(r) = \int_0^{\xi_{max}} \hat{n_a}(\xi) F(r,\xi)\xi^2 d\xi$$

$$F(r,\xi) = P_{12}(r, \theta_0 + \xi)$$

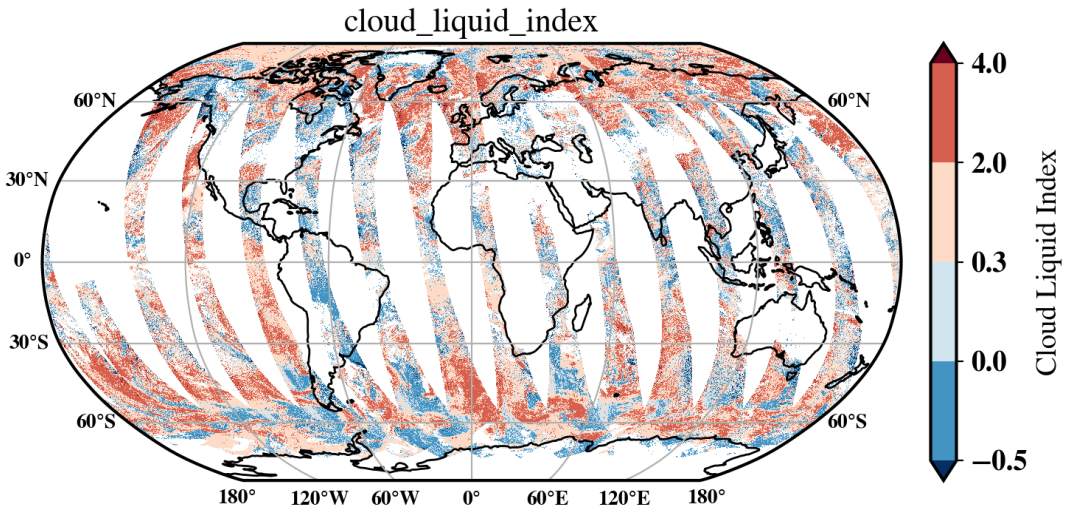
+ More variables combining with OCI L2 products

ATBD: https://oceandata.sci.gsfc.nasa.gov/files/atbd/atbd-obdaac-cloud-GPC.pdf

RETRIEVALS FROM GPC ALGORITHM(S)	
cloud_bow_droplet_effective_radius	μm
cloud_bow_droplet_effective_variance	-
cloud_liquid_index	-
cloud_rft_droplet_effective_radius_mode0/1	μm
cloud_rft_droplet_effective_variance_mode0/1	-
cloud_rft_mode_fraction_0/1	-
cloud_bow_extinction_cross_section_355/532 nm	μm^2
cloud_bow_lidar_ratio_355/532 nm	sr

DERIVED COMBINING WITH OCI L2.CLD PRODUCTS	
cloud_bow_liquid_water_path	g/m^2
cloud_bow_droplet_number_concentration_adiabatic	$/cm^3$

FROM OCI L2.CLD PRODUCTS	
cloud_top_altitude	m
cloud_top_temperature	K
cloud_top_pressure	Pa
cloud_optical_thickness	-

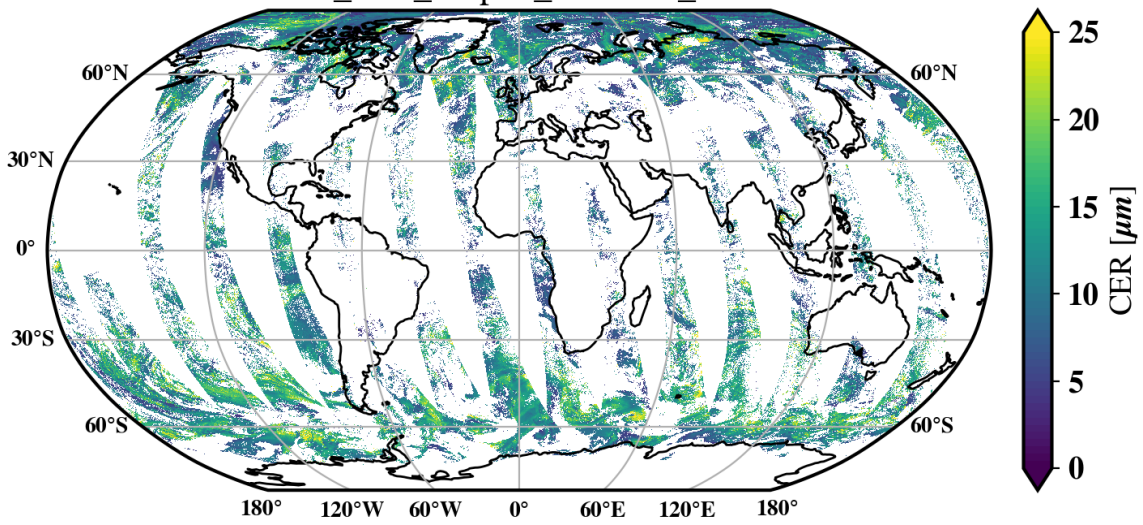


ATBD: https://oceandata.sci.gsfc.nasa.gov/files/atbd/atbd-obdaac-cloud-GPC.pdf

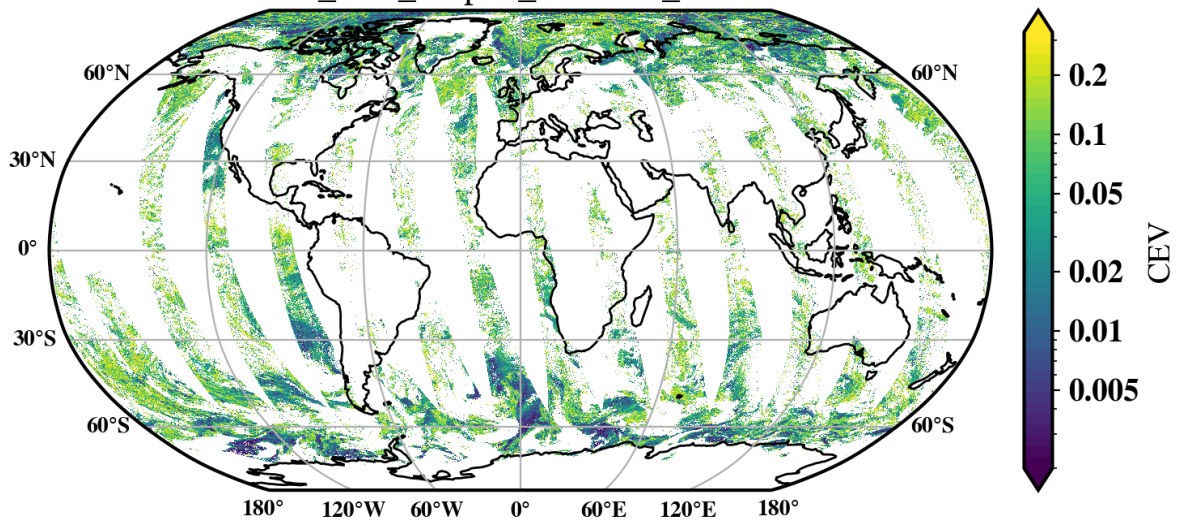
L2 (~5.2km)

1 day

cloud_bow_droplet_effective_radius



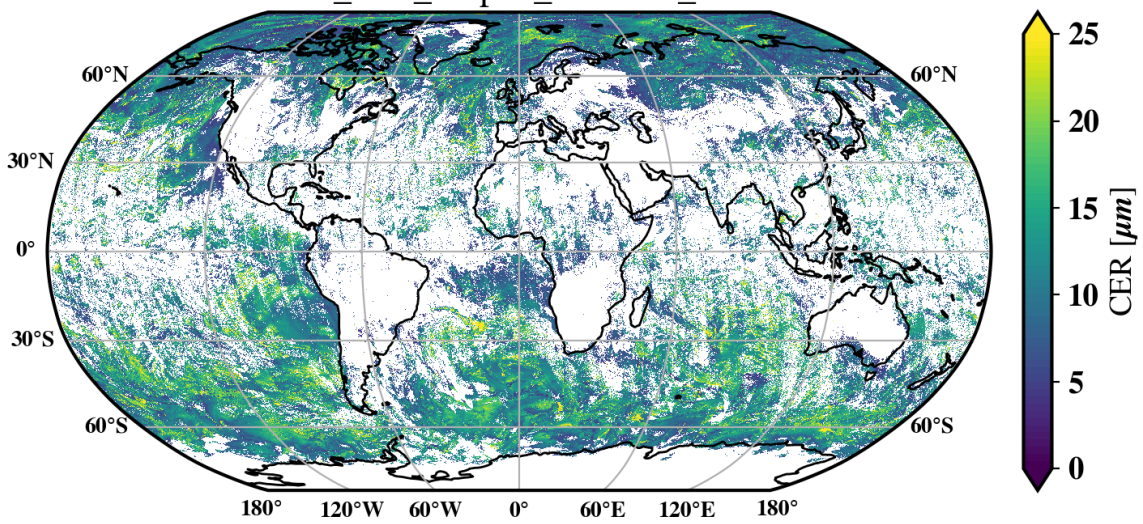
cloud_bow_droplet_effective_variance



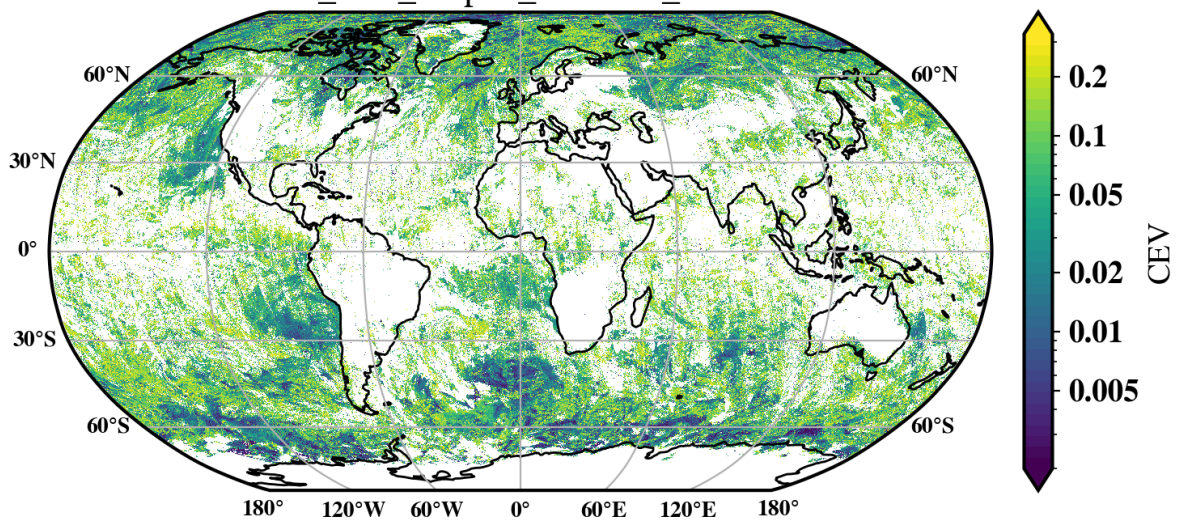
20209/09/04

Global coverage ~ 3 days

cloud_bow_droplet_effective_radius



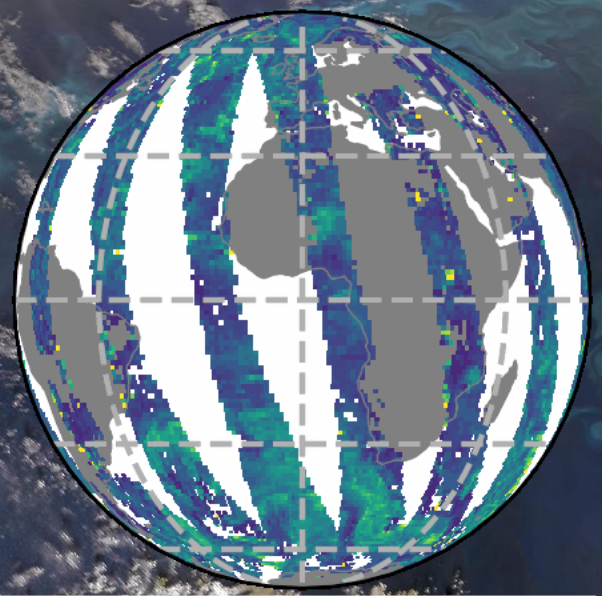
cloud_bow_droplet_effective_variance

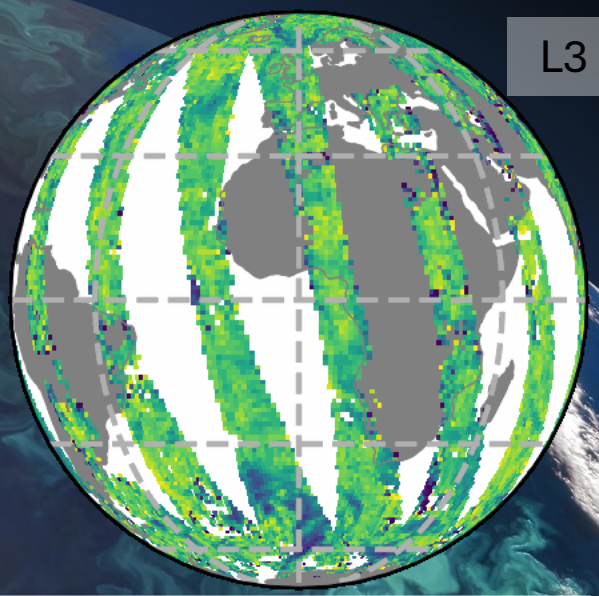


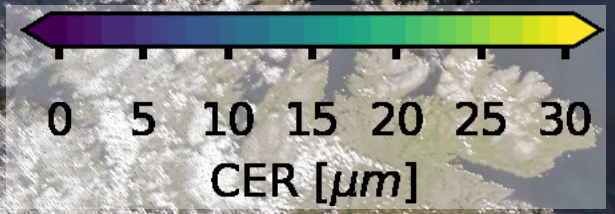
20209/09/04-06

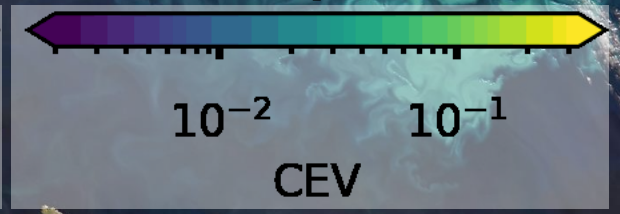
L3 (1x1°)

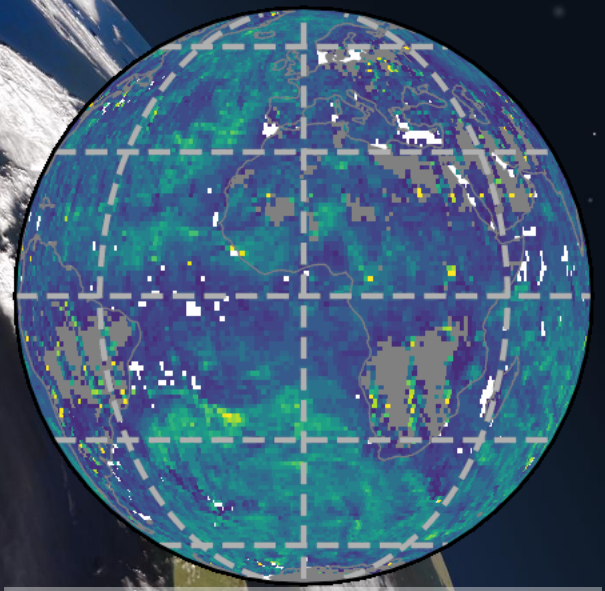
- 3 days (2024/09/04-06
- Global coverage within 2.76 days

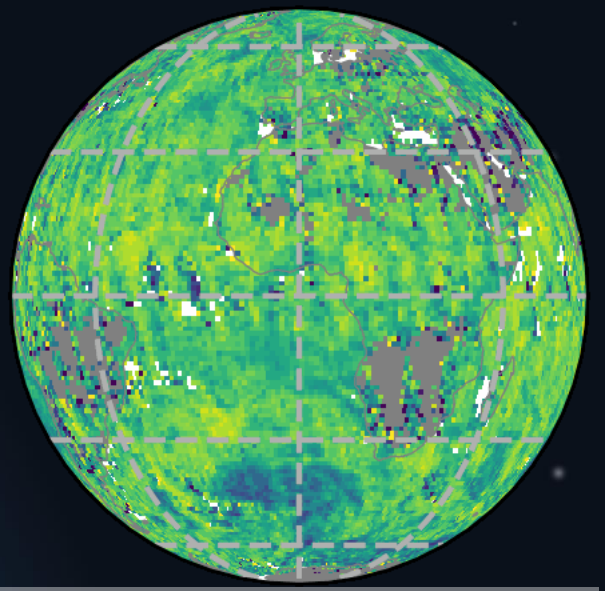


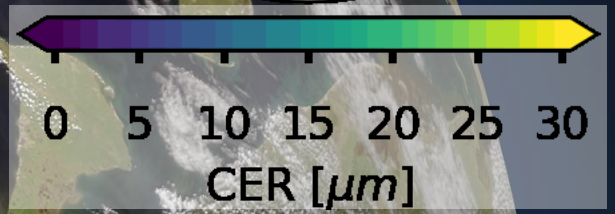


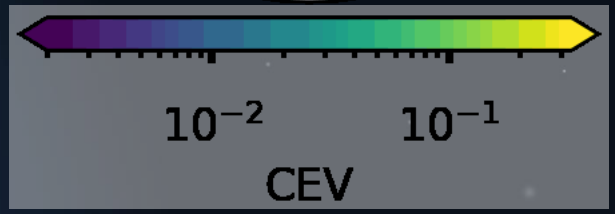








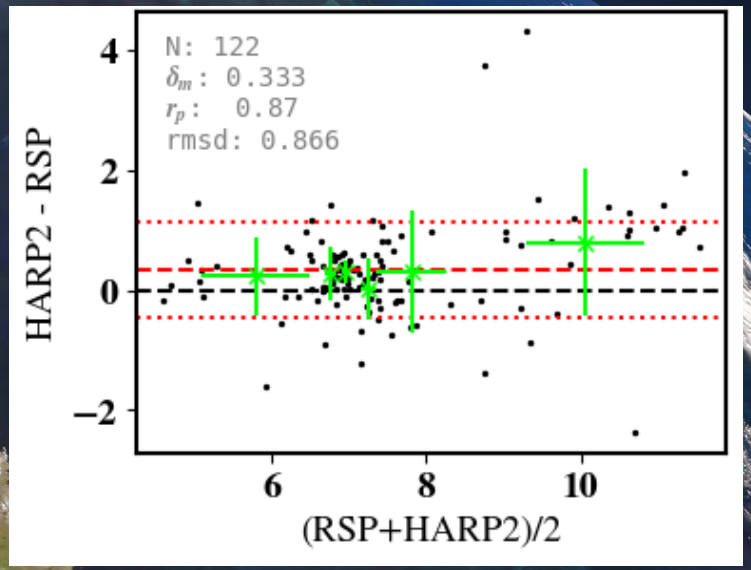




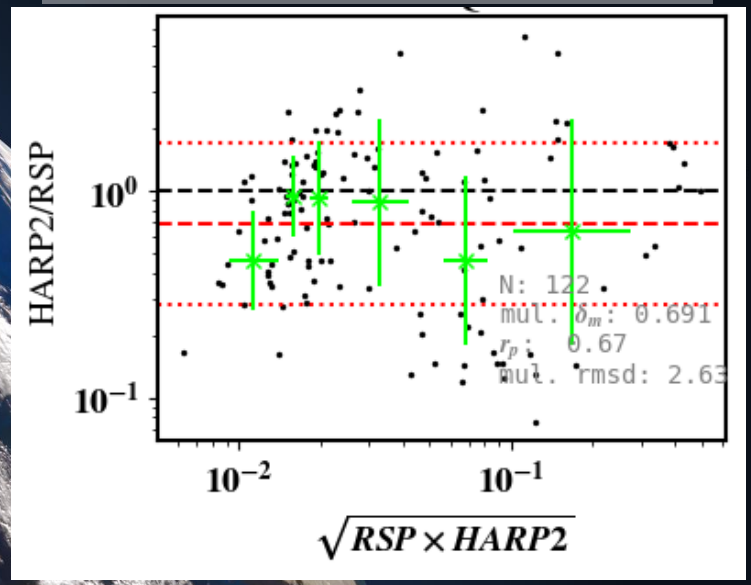
- One day (2024/09/04)
- ~992km swath width near equator

Compared with Research Scanning Polarimeter (RSP) observations from PACE-PAX

Cloud effective radius (CER)



Cloud effective variance (CEV)



Product	Cloud Type	Pearson Correlation	Bland-Altman				Linear Regression
			Mean Difference [um]	Mean multiplicative difference	Root-mean-squared-difference (rmsd) [um]	Multiplicative Root-mean-squared-difference	
CER	StCu	0.87	0.333		0.866		1.00*RSP+0.37
CEV	StCu	0.67		0.691		2.63	0.23*RSP^0.66

PACE-PAX: https://pace.oceansciences.org/pace-pax.htm

THANK YOU !

- ATBD: https://oceandata.sci.gsfc.nasa.gov/files/atbd/atbd-obdaac-cloud-GPC.pdf
- PACE-PAX: PACE-PAX: https://pace.oceansciences.org/pace-pax.htm
- Earthdata: https://www.earthdata.nasa.gov/
- Help Hub: https://nasa.github.io/oceandata-notebooks/
- PACE-EarthCare matchup tool: https://github.com/seanremy/pace-earthcare-matchups