Advanced Cloud Retrievals

PACE Science Team 3

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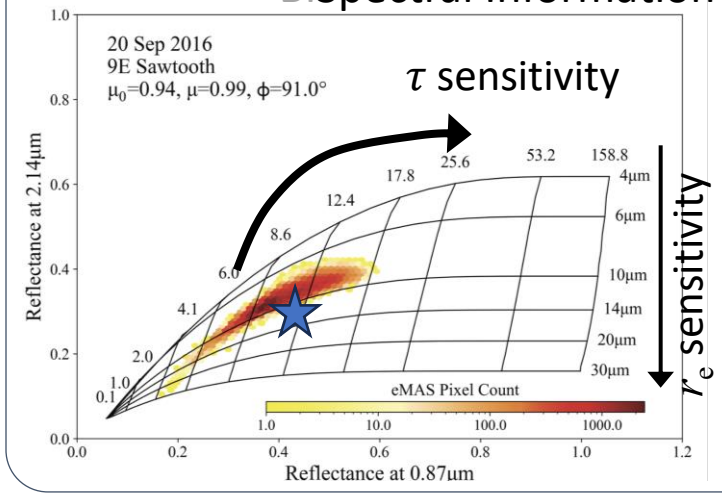
Core Cloud Algorithms

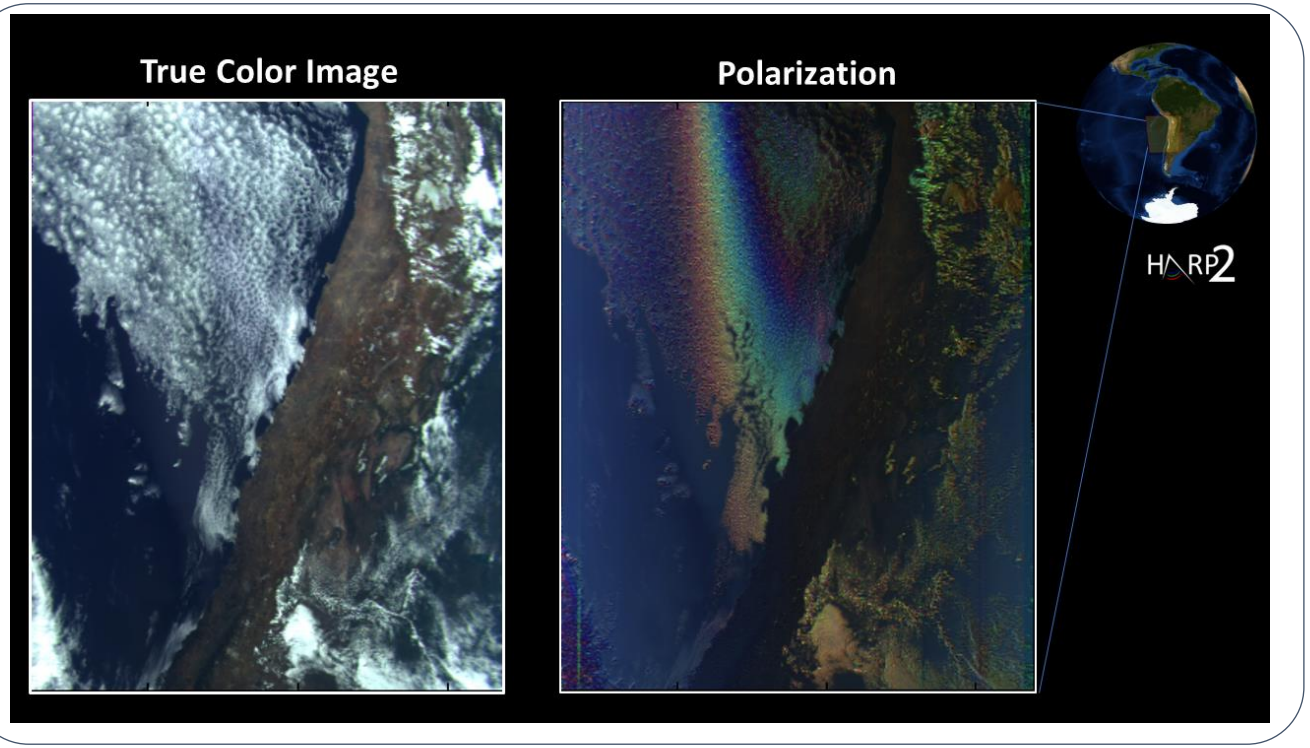
Clouds look very different in total and polarized light. Where total reflectances in the visible are dominated by multiple scattering the polarized scattered light is almost exclusively sensitive to single scattering. This is because linearly polarized light scattering can quickly become depolarized after a few subsequent multiple scattering events. As a consequence retrievals exhibit very different sensitivities and can help us constrain different cloud aspects.

BiSpectral Information

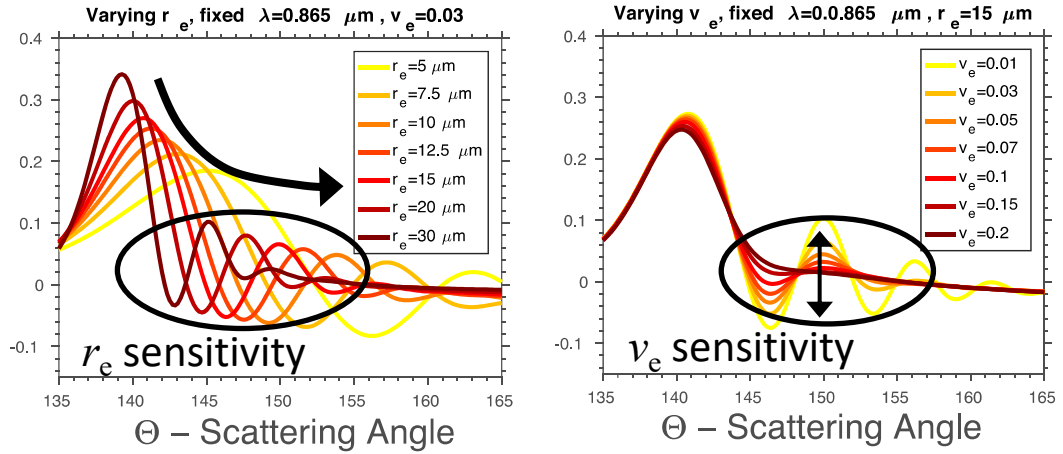


Bispectral

- Sensitive to r_e, τ
- Less sensitive to v_e*
- vertical/horizontal inhomogeneity weighted tp top (~100's m)



Polarization Information



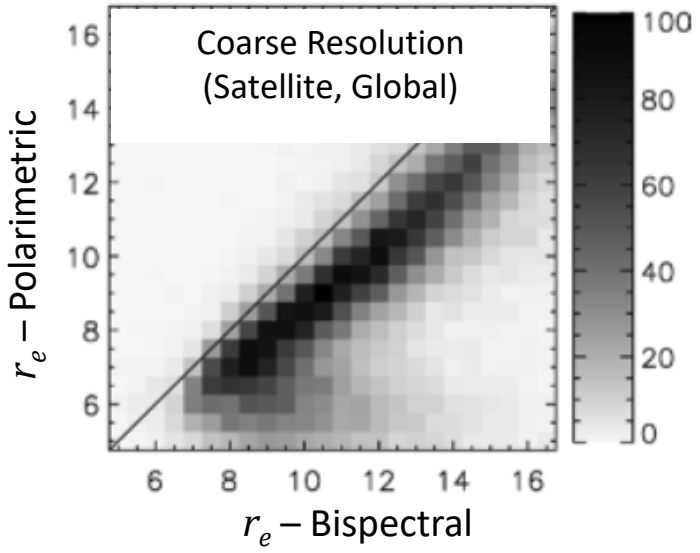
Polarimetric

- Sensitive to full DSD shape: r_e & v_e
- Less sensitive to τ
- Depolarization: insensitive vertical profile
- Cloud top weighted (~10's m)

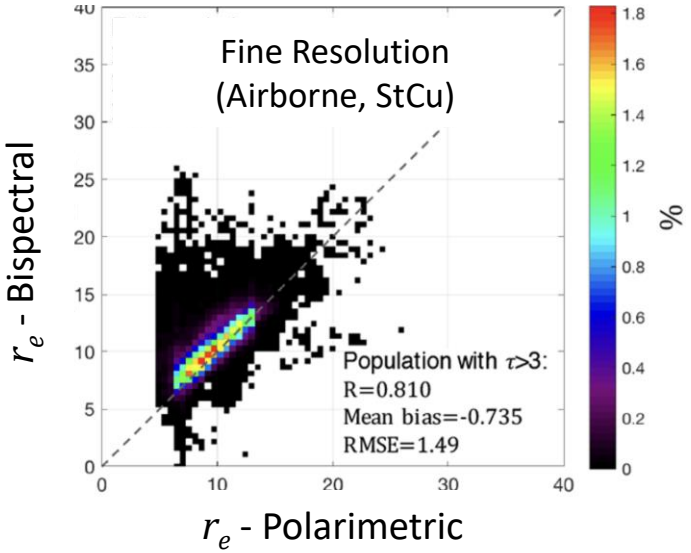
PACE can disentangle longstanding sensitivities of passive cloud retrieval to cloud inhomogeneity (vertical, horizontal, and 3D effects)

Inhomogeneity Sensitivity

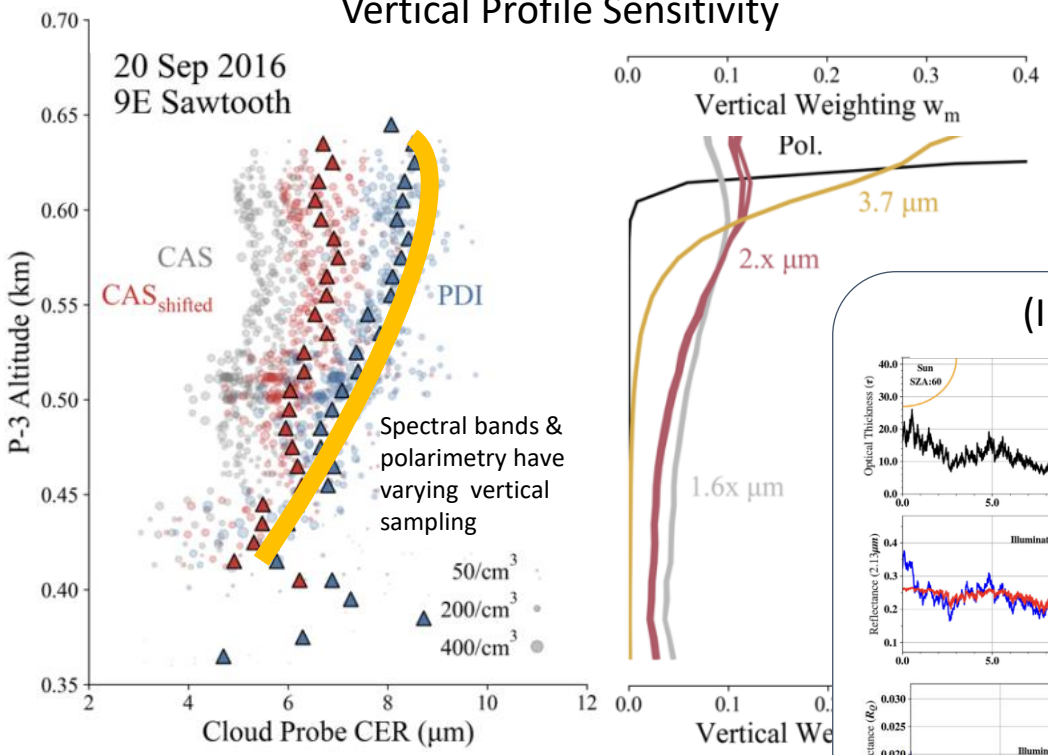
[Brèon et al., 2005]



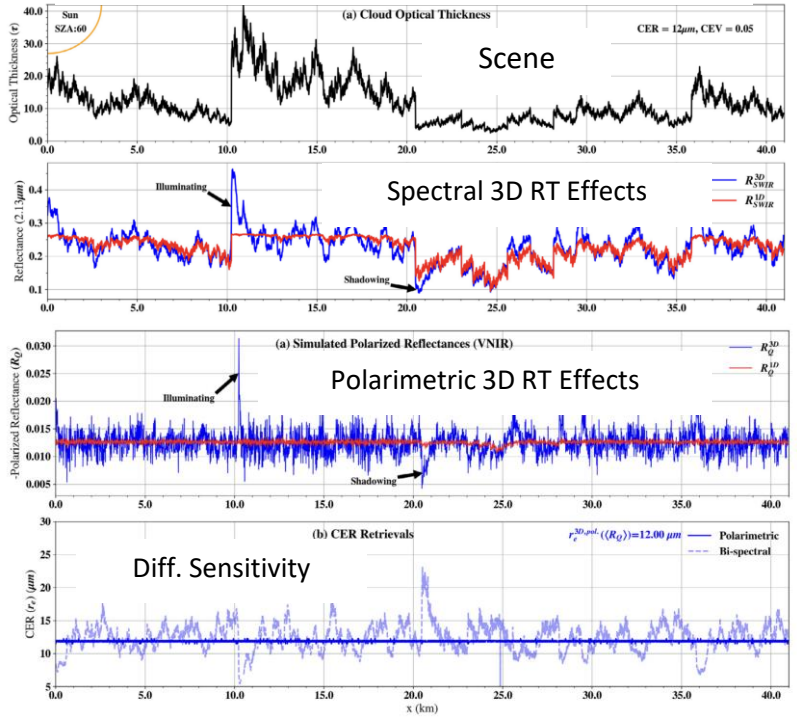
Miller et al., 2020]



Vertical Profile Sensitivity



(In)sensitive to "3D Effects"



Refined Products	Ret.	Phase	Input	ΔX (km)	Method	References
r_e	λ	liq	OCI L1B	1 km	Polarimetric Ancillary (CEV, CER)	Miller et al. 2016
r_e	λ	liq	OCI L1C	5 km	bispectral retrieval using sub-grid OCI	Werner et al. 2016
τ	λ/ϕ	both	HARP2	5 km	Multi-angle VNIR LUT with CER (λ/ϕ) a priori	Liang et al., 2014 Werner et al. 2016
Detect 3D effect	λ(ϕ)	liq	OCI L1C	1 km	Polarimetric Ancillary (threshold CER)	Rajapakshe & Zhang, 2020
Droplet Size Distribution Shape	ϕ	liq	HARP2 L1C	5 km	Rainbow Fourier Transform	Alexandrov et al. 2012b
Ice crystal shape	ϕ	ice	HARP2 L1C	5 km	Polarimetric, parallax corr.	Van Diedenhoven, 2012b, 2020
r_e **(λ, ice)**	λ	ice	OCI L2C	1 km	Bispectral, informed by polarimetric particle model	
r_e **(λ,ice)**	λ	ice	OCI L2C	1 km	Bispectral, informed by polarimetric particle model	
Cloud Top Height	λ/ϕ	both	both	5 km	Variety of methods, parallax	
Retrieval Performance Metrics (RPM)	λ/ϕ	both	OCI	-	Variety of methods, informed by polarimetric ancillary	MODIS Cloud User Guide RFM

Advanced Products	Ret.	Phase	Input	ΔX (km)	Method	References
Multi-layer Cloud Detection	λ/ϕ	liq/ice	HARP2 L1C	5km	Variety of methods	Described here
Cloud Top Phase and Multi-phase Detection	λ/ϕ	liq/ice	HARP2 L1C	5 km	Variety of methods	Described here
Cloud Geometrical Shape	ϕ	-	HARP2 L1C	Granule	Granule scale cloud cut-out from multi-angle views	Alexandrov et al. 2017
Cloud Shadow Aspect Ratio	λ	-	OCI L1B	Granule	Granule scale cloud shadow for cloud geometry (base height)	Described here
Adjustment of τ due to 3D effect	λ	-	OCI L2B	Granule	Dependent on cloud base and aspect ratio from cloud shadow	Described here