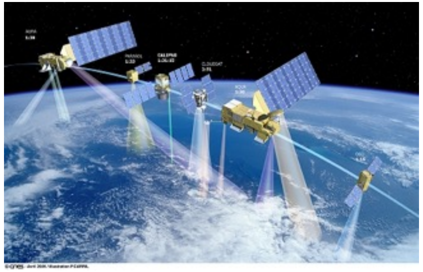
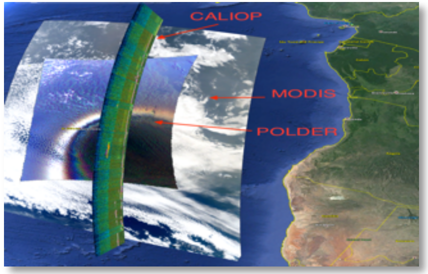




« Retrieval of aerosol properties above clouds from satellite : an overview»

Fabien Waquet

Céline Cornet, Fanny Peers, Lucia T. Deaconu, Nicolas Ferlay, Fabrice Ducos, François Thieuleux and Aurélien Chauvigné

Aerosols above clouds from satellite : an overview

1) Existing retrieval methods
2) Global results with POLDER / comparisons with active retrievals
3) Impacts of 3DRT effects
4) Conclusions/perspectives

Methods (1/3) : aerosols above clouds

ACTIVE

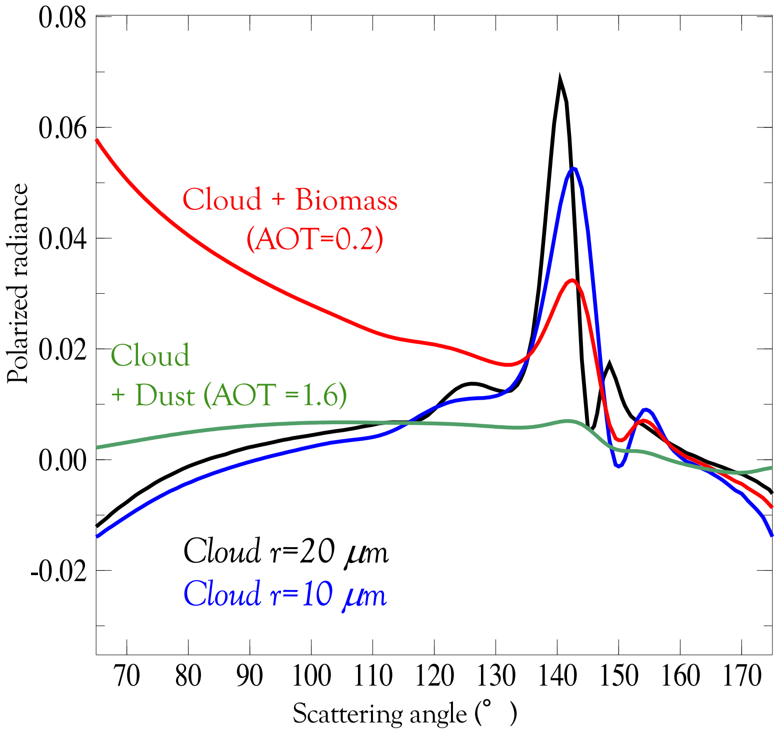
PASSIVE polarized radiance 670/865 nm +total radiance

PASSIVE spectral total radiance (color ratio)

	Retrieved parameters	Main assumption
CALIOP operational method (Winker et al., 2009; Young and Vaughan, 2009)	AOT (Layers' altitudes, extinction profiles)	Lidar ratio is assumed (based on climatology) $\Delta AOT = 0.05 + 0.40 \times AOT$
CALIOP Depolarization DRM (Hu et al., 2007) CALIOP Color Ratio (Chand et al., 2008)	AOT and Angström	Fewer assumptions (Transmission technics)
POLDER polarization (Waquet et al., 2009, 2013) +intensity (Peers et al., 2015)	AOT and Angström + SSA (COT)	Real refractive index is assumed $\Delta AOT/AOT \approx +/-20\%$
OMI (Torres et al., 2012)	AOT (COT)	aerosol model is assumed $-12\% < \Delta AOT/AOT < 46\%$
MODIS color ratio (Jethva et al., 2013)	AOT (COT)	aerosol model is assumed $-23\% < \Delta AOT/AOT < 43\%$
MODIS (Meyer et al., 2015)	AOT (COT, cloud effective radius)	aerosol model is assumed
SEVIRI (Peers et al., 2019)	Temporal AOT (15 min) (COT, cloud effective radius)	aerosol model is assumed
DEEP BLUE (MODIS, VIIRS, SeaWiFs) (Sayer et al., 2019)	AOT (COT)	Aerosol model is assumed (dynamic in function of AOT)

Methods (2/3) : aerosols above clouds

Sensitivity of polarized radiance



- Plane-parallel (1D) transfer radiative code + Mie theory for cloud droplets

- Biomass burning aerosols
(small spherical particles, r_{eff}=0.1 µm)
Mie theory

- Mineral dust particles
(coarse non spherical particles, r_{eff} = 2.5 µm)
Spheroid models (Dubovik et al., 2006)

+ Optimal estimation based retrievals algorithms

(Knobelspiesse et al., 2011, Waquet et al., 2013)

Methods (3/3) : Operational algorithm for POLDER

-1-

AOT, Angström, SSA and COT

LUT : 6 fine modes (0.06->0.16 µm) + 1 non-spherical dust model
(real refractive index, m_r=1.47)

-2-

Selection of cloudy scenes :

- ✓ COT>3
- ✓ Liquid phase
- ✓ Homogenous cloudy pixels (to reduce 3DRT effects…)

-3-

Removal of cirrus above clouds

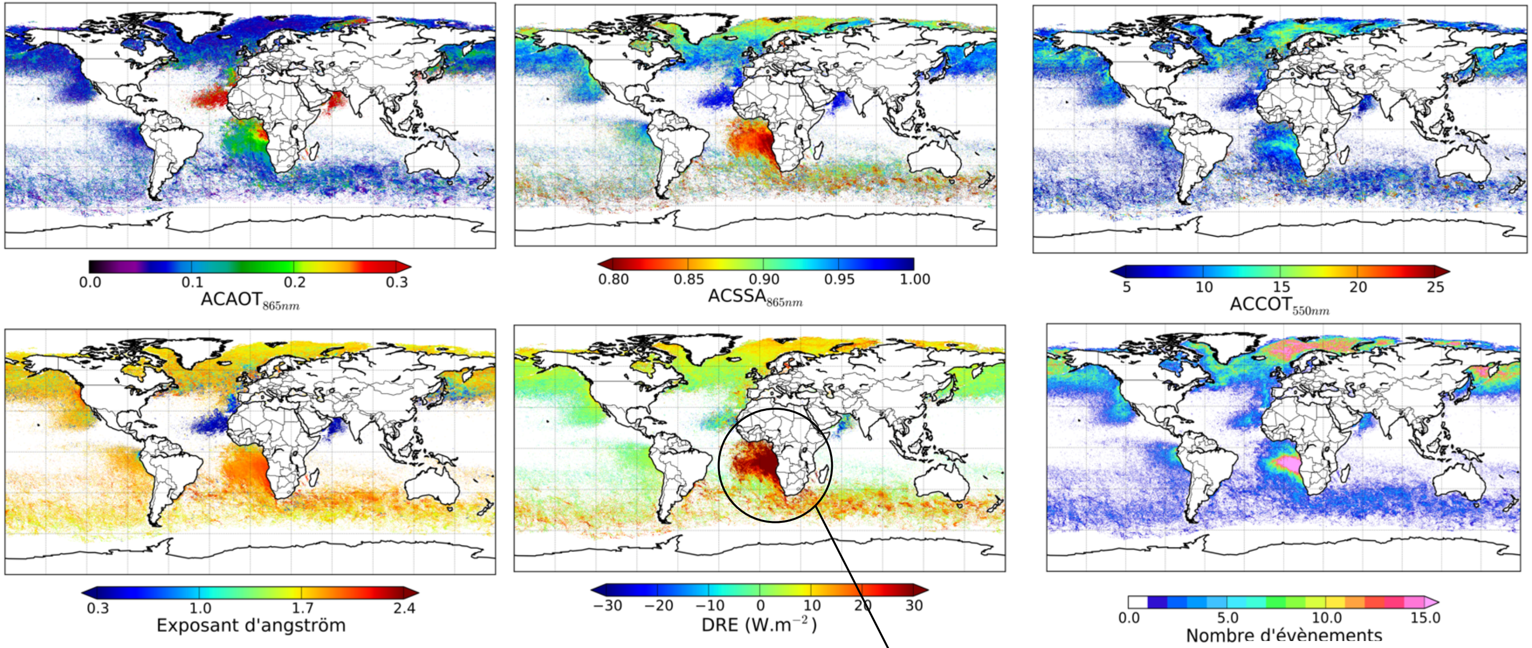
-> Thermal infrared

$BTD_{8mic\text{-}11mic} \leq -1.25$ K

Global results with POLDER/PARASOL

AEROSOL ABOVE CLOUDS (POLDER JJA 2006 + quality filters)

AOT | SSA | Cloud Optical Thickness



(F. Peers thesis, LOA 2015)

Angström

Direct aerosol forcing (solar spectrum)
August 2006 : 33W.m^{-2}

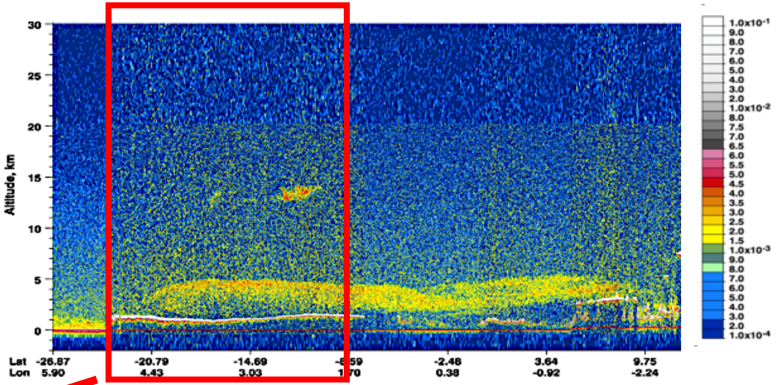
Number of events

Aerosol above cloud : comparison with active retrievals (1/2)

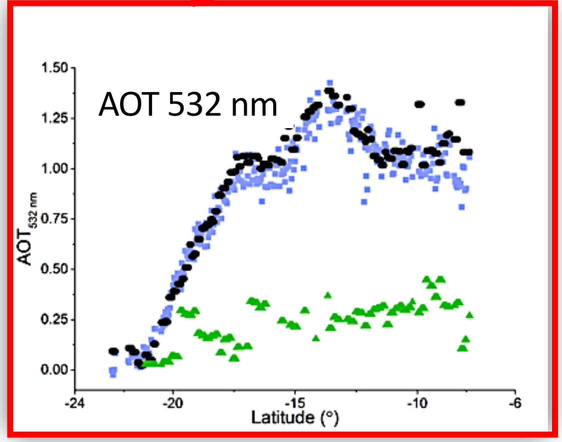
A case study (13/08/2006) - South-East Atlantic Ocean-

CALIPSO/CALIOP
Backscatter Profile
at 532 nm

South Atlantic Ocean
- off coast of Namibia-



km^{-1}sr^{-1}



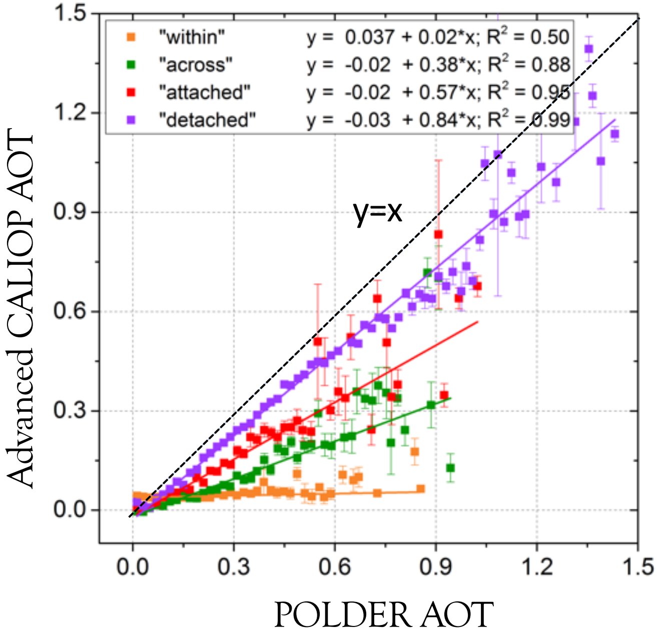
- POLDER AOT
- CALIOP AOT is under-estimated (Jethva et al., 2013)
- Advanced CALIOP AOT
  A calibrated version of the depolarization method

(coll. D. Josset NASA / SODA product available at AERIS/ICARE)

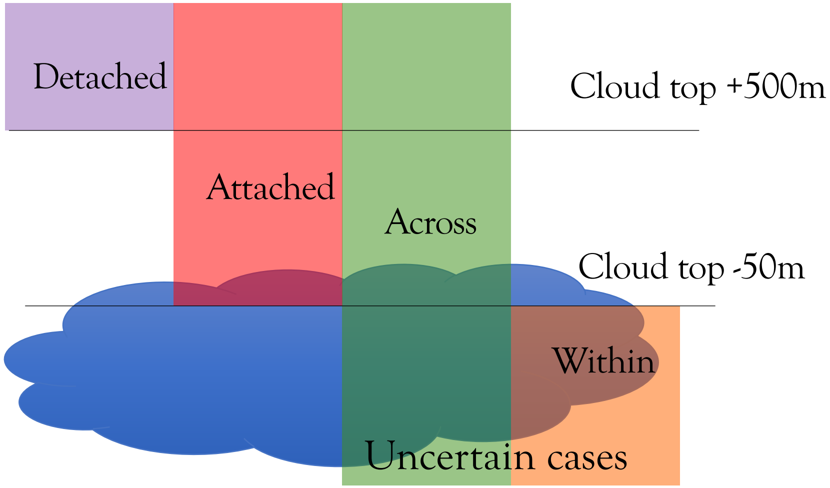
(Deaconu et al., AMT 2017)

Aerosol above cloud : comparison with active retrievals (2/2)

GLOBAL AOT comparison (from 2006 to 2010)



Vertical positions of the aerosol and cloud layers

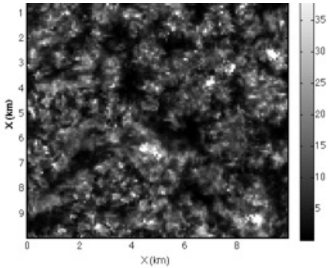


Aerosols within clouds might impact the retrievals (Deaconu et al., AMT 2017 / CaPPA thesis 2017)

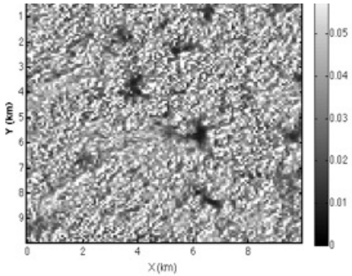
- Aerosols located at cloud top polarize light
- Soot within droplets modify the abilities of droplets to backscatter light

Evaluate 1D retrieval algorithm with 3DRT simulations (1/2)

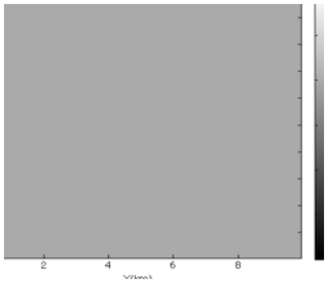
Field of optical thickness
Resolution : 80mx80m



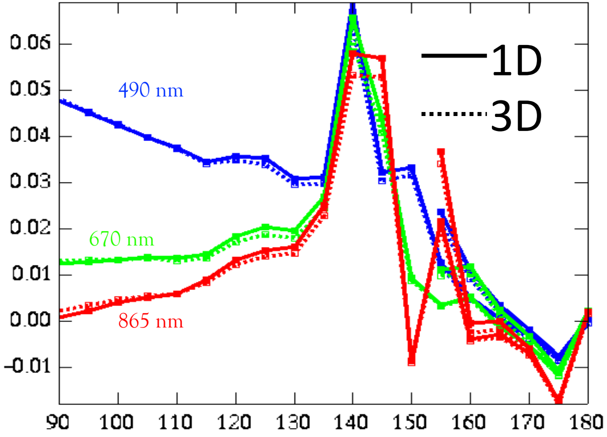
Rp : Polarized reflectance (3D)
scattering angle of 140°



Rp as seen by POLDER
Resolution : 10kmx10km



Polarized reflectance, Rp : 1D vs 3D



Scattering angle (°)

A rather homogenous cloud field (100% cloudy)

Plane-parallel RT codes overestimate by 4-8% the cloud bow magnitude => errors on above cloud dust AOT of 6% *(Waquet et al., 2013)*

3D MCPOL : 3D Monte-Carlo radiative transfer code with polarization *(Cornet et al., 2010)*

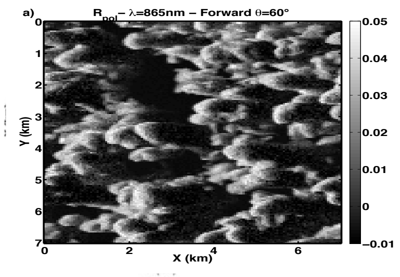
Evaluate 1D retrieval algorithm with 3DRT simulations (2/2)

Fractionnal cloud cover

Sun zenithal angle of 60°

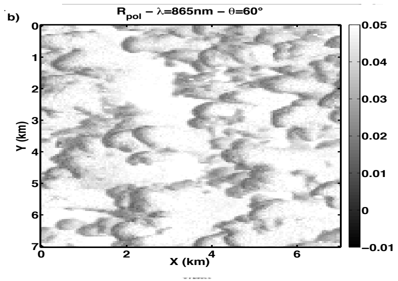
without aerosol

Rp : Polarized reflectance (3D)
scattering angle of 60°

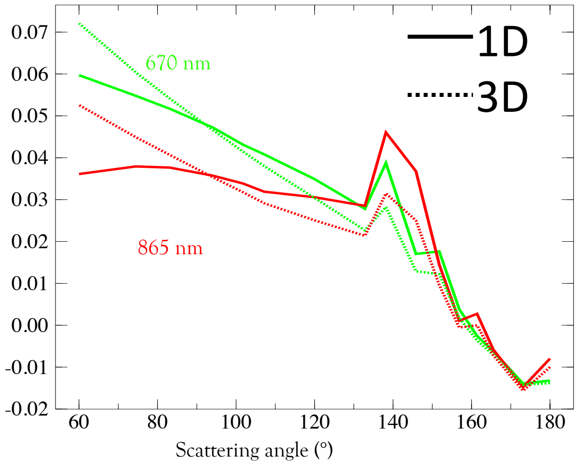


with aerosol

Rp : Polarized reflectance
scattering angle of 60°



Polarized reflectance, Rp : 1D vs 3D



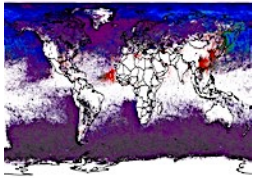
Aerosol over a fractionnal cloud cover (70% cloudy)

Relative errors on above cloud AOT ranges between 0% and 60% depending on sun zenital angle and/or scattering angle range used for the retrieval.

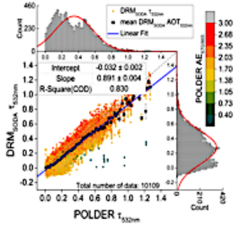
(Cornet et al., AMT, 2018)

Conclusions/perspectives

1) AOT, SSA & Angström above clouds with POLDER / 5 years of global data available at AERIS/ICARE (Waquet et al., AMT, 2013, Peers et al., ACP, 2015)

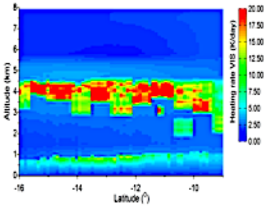


2) Overall agreement between POLDER and CALIOP advanced AOT when the aerosol layer is detached from the cloud (Deaconu et al., AMT, 2017)



3) Preparation of 3MI : POLDER instrument extended to MIR (0.41-2.2 µm) on post-EPS for 2022 (ESA) / preparation with airborne OSIRIS (Chauvigné et al. in prep)

4) Preparation of passive/active synergies : e.g. computation of heating rates with CALIOP/POLDER for the study of the semi-direct effect (Deaconu et al., ACP, 2019)



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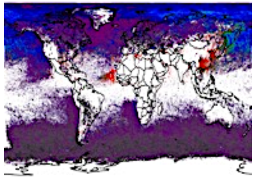

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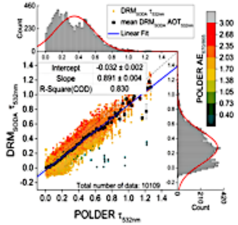

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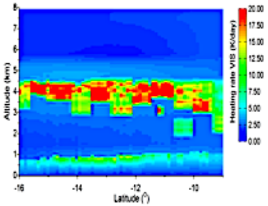

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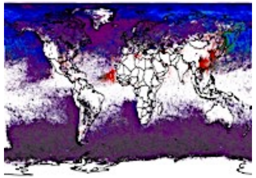

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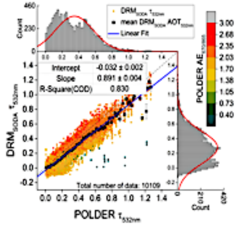

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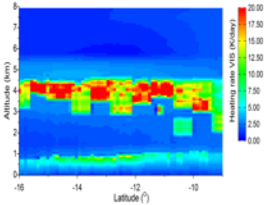

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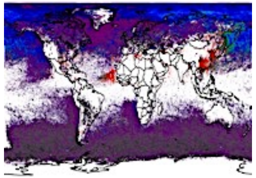

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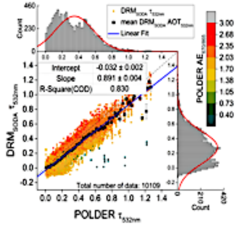

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