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Calibration of S3-OLCI over Deep Convective Clouds with help of geostationary data

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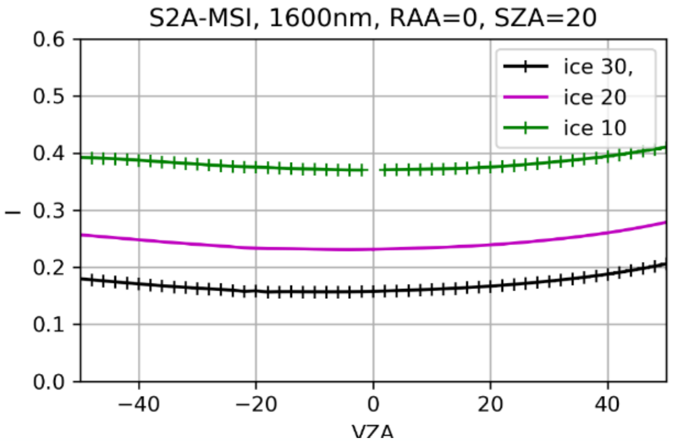
Sensitivity study

	VISIBLE (400 - 700 nm)	
Parameter	**Absolute Calibration**	**Interbands Calibration**
COT	Critical	Negligible
Top ice crystals size	Important	Negligible
Shape of ice crystals	Important	Negligible
Vertical profile	Important	Negligible
Surface	Weak	Negligible
Altitude of DCC	Weak	Negligible

	NEAR INFRARED (700 - 1020 nm)	
Parameter	**Absolute Calibration**	**Interbands Calibration**
COT	Important	Important
Top ice crystals size	Important	Important
Shape of ice crystals	Important	Negligible
Vertical Profile	Important	Weak
Surface	Weak	Negligible
Altitude of DCC	Weak	Negligible

	SHORTWAVE INFRARED	
Parameter	**Absolute Calibration**	**Interbands Calibration**
COT	Negligible for 1600 et 2200 nm, important for 1370 nm	Negligible
Top ice crystals size	Critical	Critical
Shape of ice crystals	Critical	Critical
Vertical Profile	Important	Important
Surface	Negligible	Negligible

Critical error > 2 %,
Important ~1%
Weak < 0.5%.
Negligible ~ 0.1%



Sensitivity on ice particle size in the SWIR

Minimize impact on calibration

- **Minimize impact on calibration**
  - Sensitivity to COT and surface: select brighter DCC
  - Sensitivity to Top ice crystals size and shape and altitude: select the coldest, the more stable and developed DCC (Van Diedenhoven et al., 2014 et 2020)
- **How to select such extreme DCC – coldest, brightest, stable and fully developed**: use of geostationnary sensors (MSG/SEVIRI)* with (i) temporal informations and (ii) thermal infrared bands to create a DCC mask and used it to extract S3-OLCI measurements
- **How to better characterize DCC**: use of active and passive sensors from the A-Train** constellation (Caltrack)*, see especially the DARDAR (liDAR-raDAR) project.
  - cloud properties by combining the CloudSat radar and the CALIPSO lidar measurements and some A-Train collocated measurements
- ** ICARE Data and Services Center (https://www.icare.univ-lille.fr/)*
- *** Afternoon Constellation (https://atrain.nasa.gov/) A-Train which consists of the Aqua, CloudSat, CALIPSO, PARASOL, and Aura satellite missions (1:30 pm solar local time overpass)*

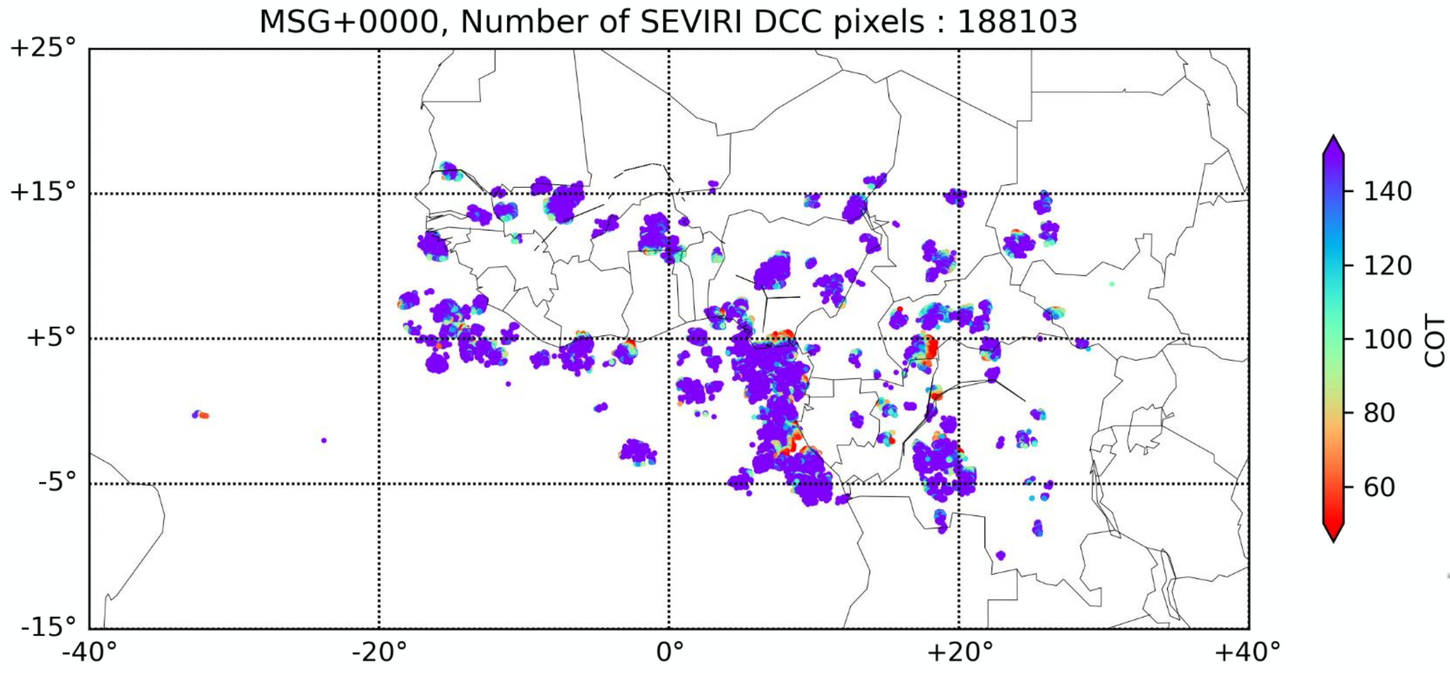
Extrem DCC targets using GEO (MSG/SEVIRI) – GEO DCC database

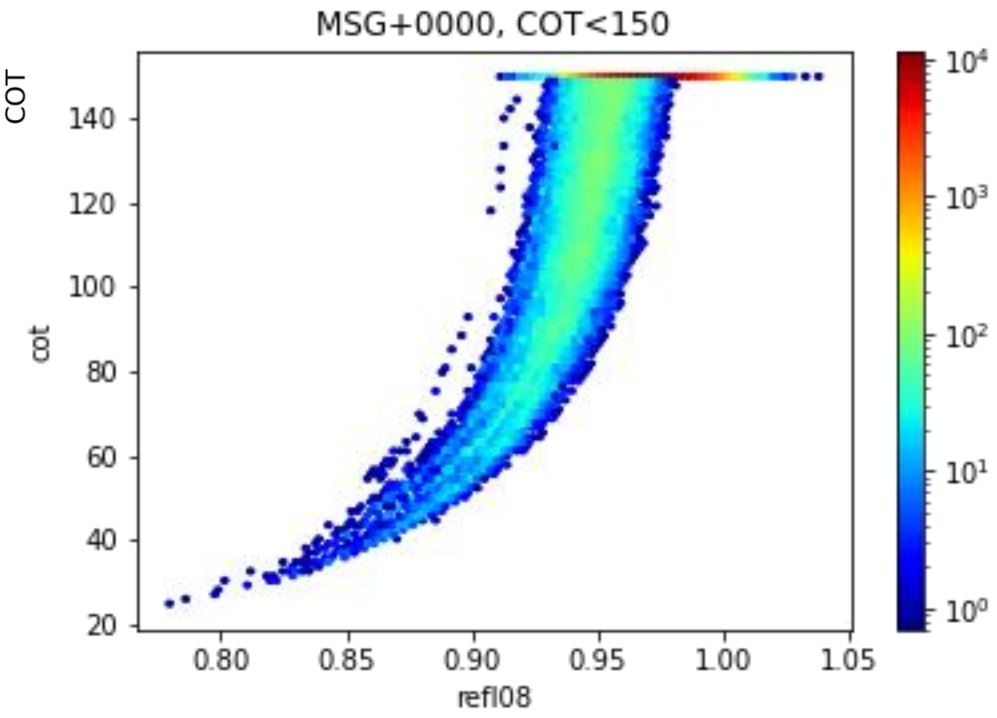
- Local solar time around 10:30 (S3 and S2 overpass)
- Inter-tropical area: -30° < latitude < 30°
- VZA < 40°, scattering angle < 175° and away of 2° from specular direction
- Size of the DCC anvil : D > 25 SEVIRI pixels (~ 75 x 75 km² at nadir)
- Threshold on Brightness Temperature in a square of 9x9 pixels BT108 < 205 K
- Thresholds on $\langle VIS06 \rangle_{9x9} > 0.7$ and $\langle VIS08 \rangle_{9x9} > 0.7$
- Thresholds on horizontal variability – spatial consistency – on VIS06, VIS08 and BT108
  - **σ (TB (10.8)) $_{9x9}$ < 0.5K**
  - **$\sigma(\rho_{VIS06})_{9x9} / \rho_{VIS06} < 3\%$**
  - **$\sigma(\rho_{VIS08})_{9x9} / \rho_{VIS06} < 3\%$**
- **Finally a pixel is flagged DCC if it is classified DCC during ±30 minutes**

Remark (1) : part of these tests are from Fougnie and Bach (2009) and Rayference (2019)

Remark (2) : SEV06_CLD product are saved

Localisation of DCC targets (2019): GEO DCC mask

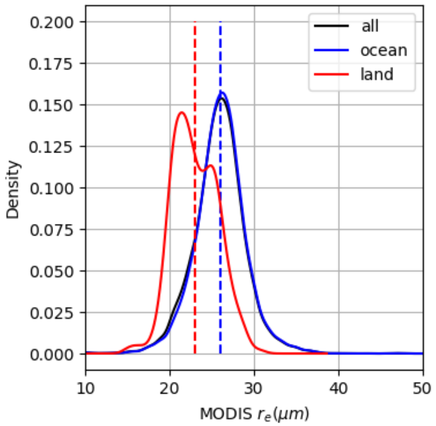


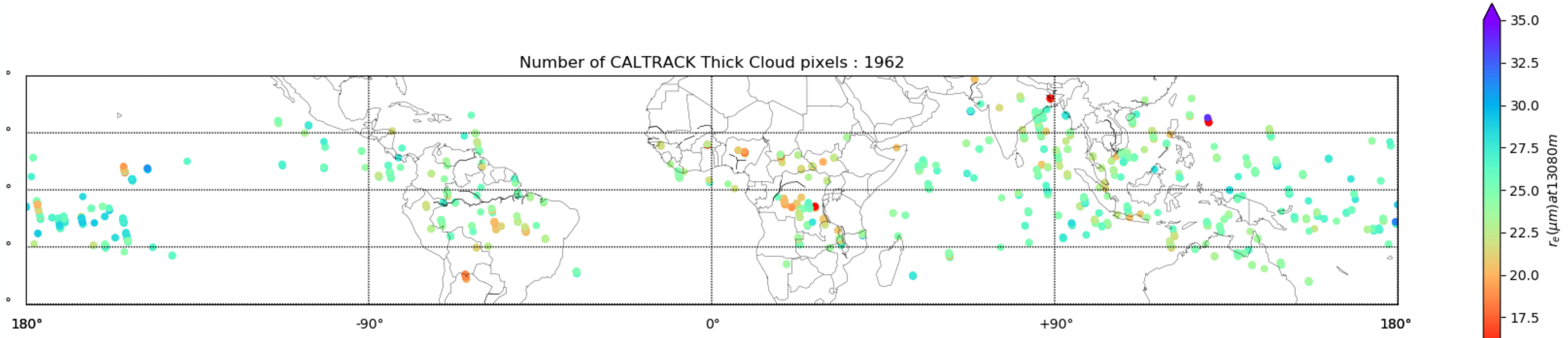


Aim: search for OLCI match-ups with these GEO DCC targets

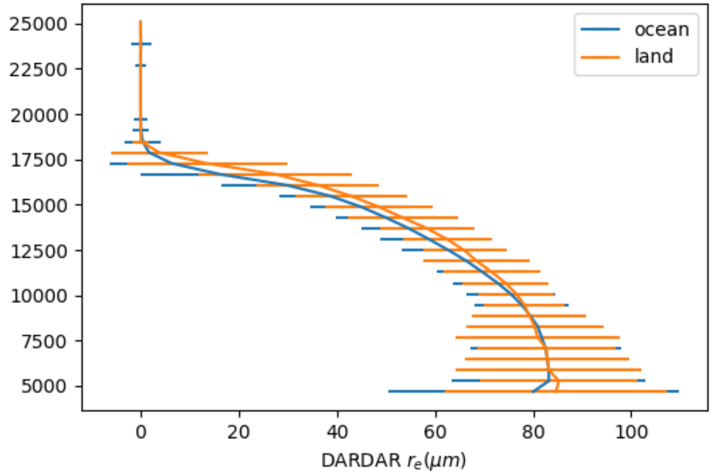
Create a **OLCI DCC database** with average values at different scale (9x9 km^2, 27x27)

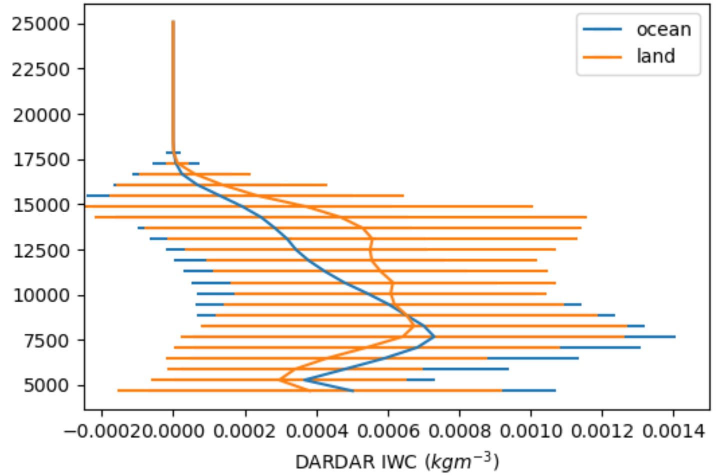
Characterization of DCC: examples





A-Train: 1:30 pm local solar time

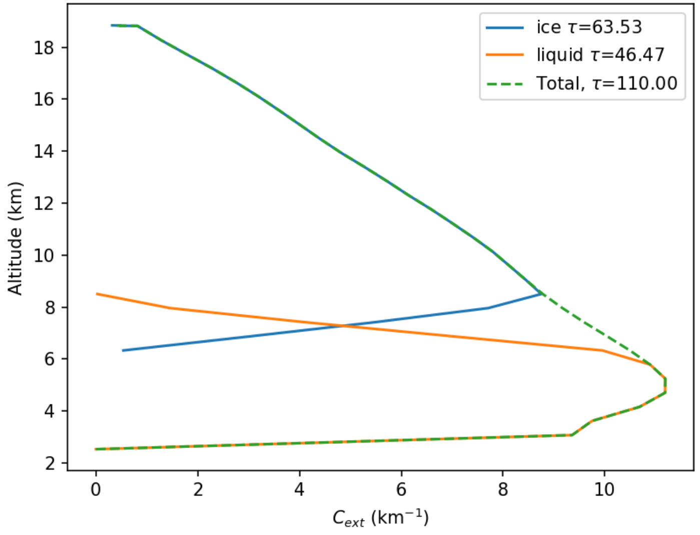




DCC Look-Ups Tables designed from A-train informations

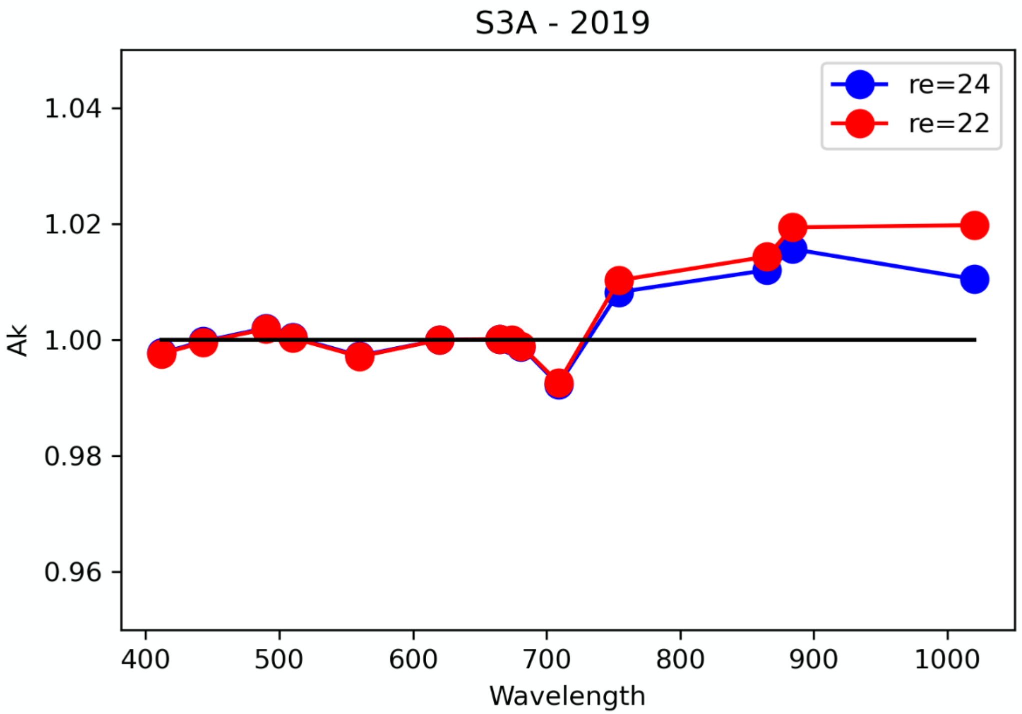
DCCproperties in LUTs	
Effective radius of top ice crystals	24 μm (over ocean) 22 μm (over land)
Vertical variation of ice crystals size	dR_{eff}/dz = - 8 μm /km (ice crystals effective radius increases when altitude is decreasing)
Shape of ice crystals	3 shapes: • General habit mixture (**GHM**, Cole et al, 2013) * • Aggregate stratified columns (asc) • Stratified columns (Sc)
Top altitude of DCC	18 km
Ice-water transition altitude	Between 6 et 8 km
Liquid water layer	R_{eff}= 30 μm (vertically homogeneous)

* GHM selected from Diedenhoven et al (2020).



Vertical profile of ice and liquid water extinction

Interband calibration

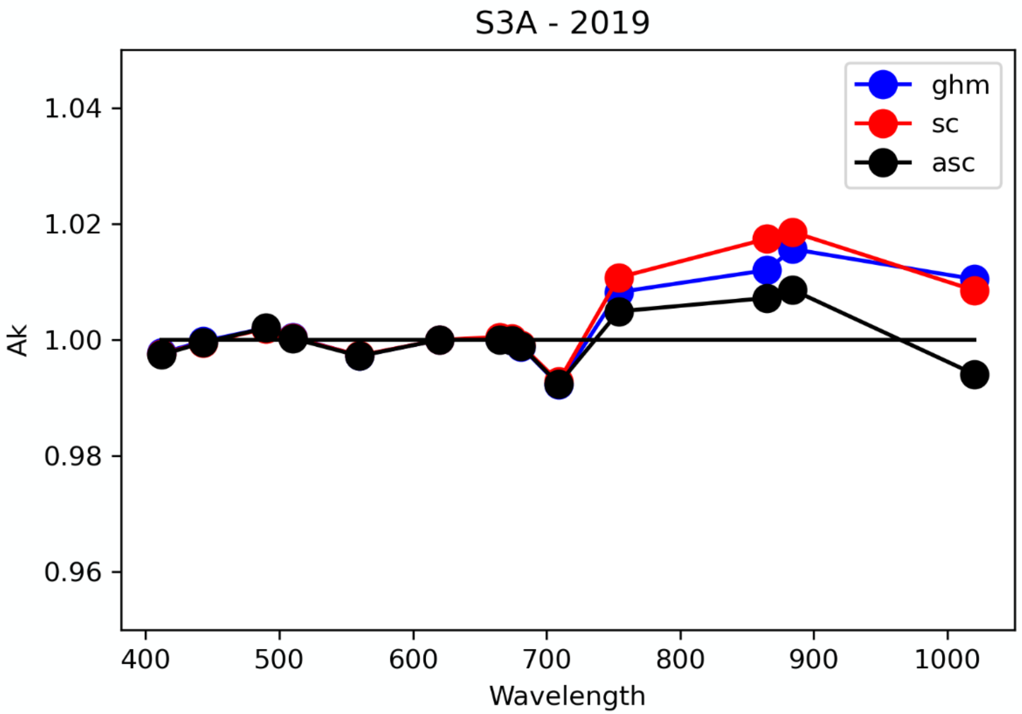


More than 8000 S3A-OLCI measurements (at 9x9 km^2)
Filtered on :

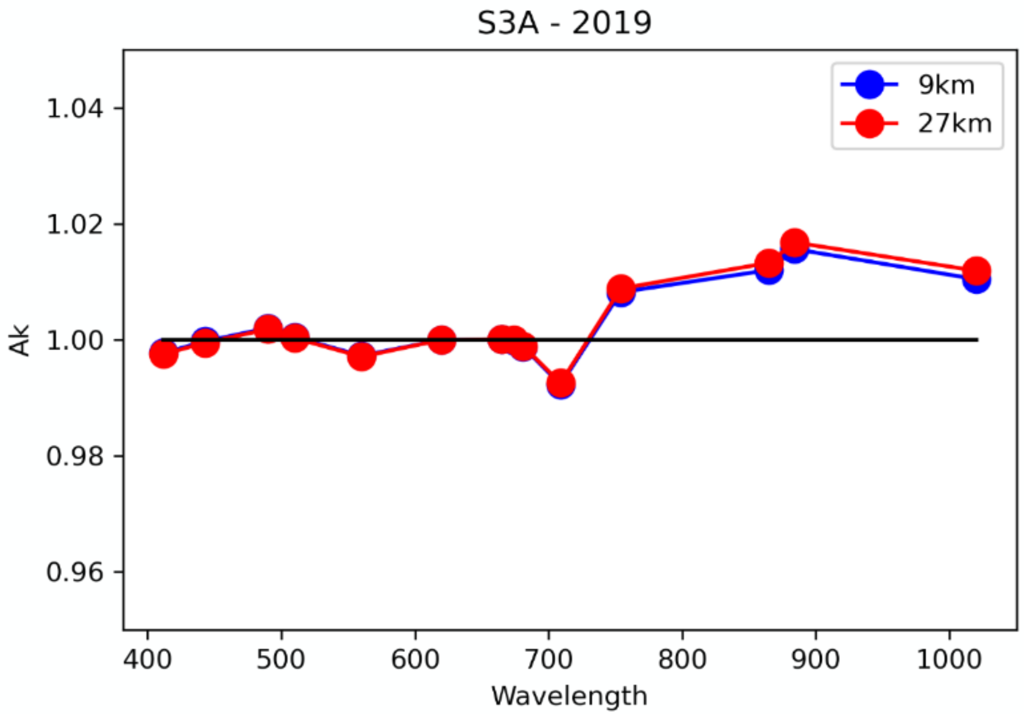
- *Saturated pixels*
- *Spatial consistency at 9 km and 27 km*
- *Mean value of the reflectance at 865 nm*
- *Angular conditions*
- *Number of available measurements in the box of 9x9 km^2*

Reference band: 620 nm (Oa07)
Ak is measured over estimated

Interband calibration – Variation of DCC parameters

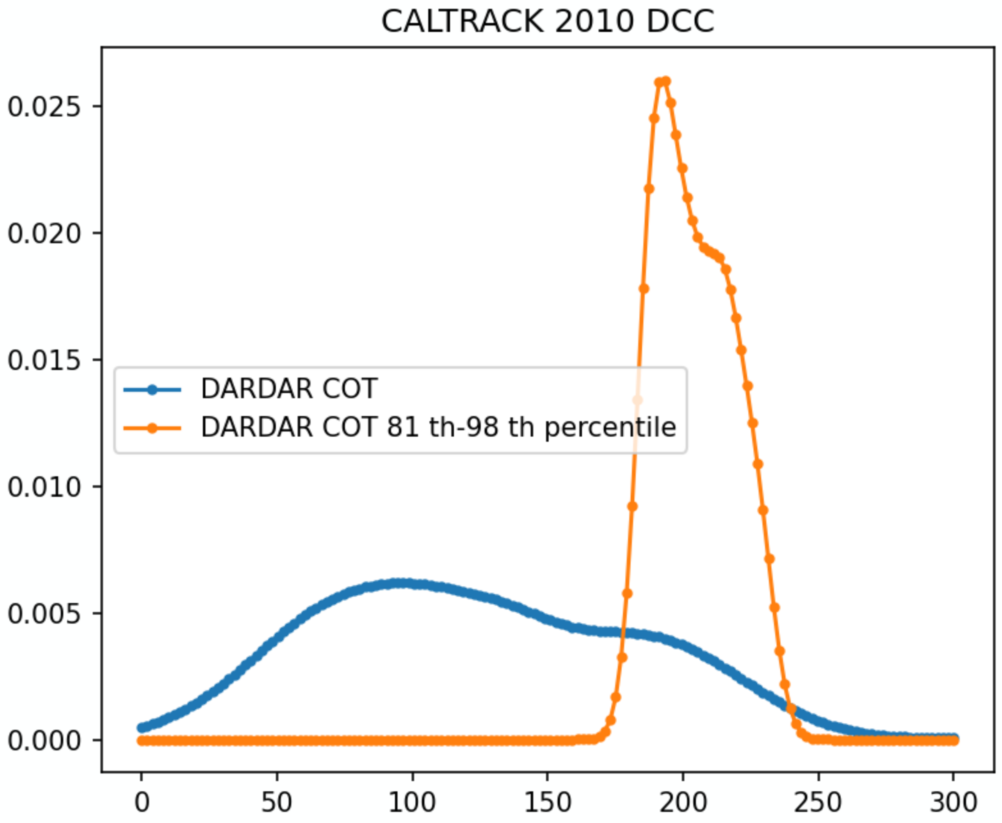


Impact of ice crystals shape on interband calibration results
No impact in the visible



Impact of the sampling size (average on 9x9 and 27x27 km^2 give similar results)

Absolute Calibration - Method



DARDAR COTs for the area of interest of GEO DCC mask (around 0° longitude)

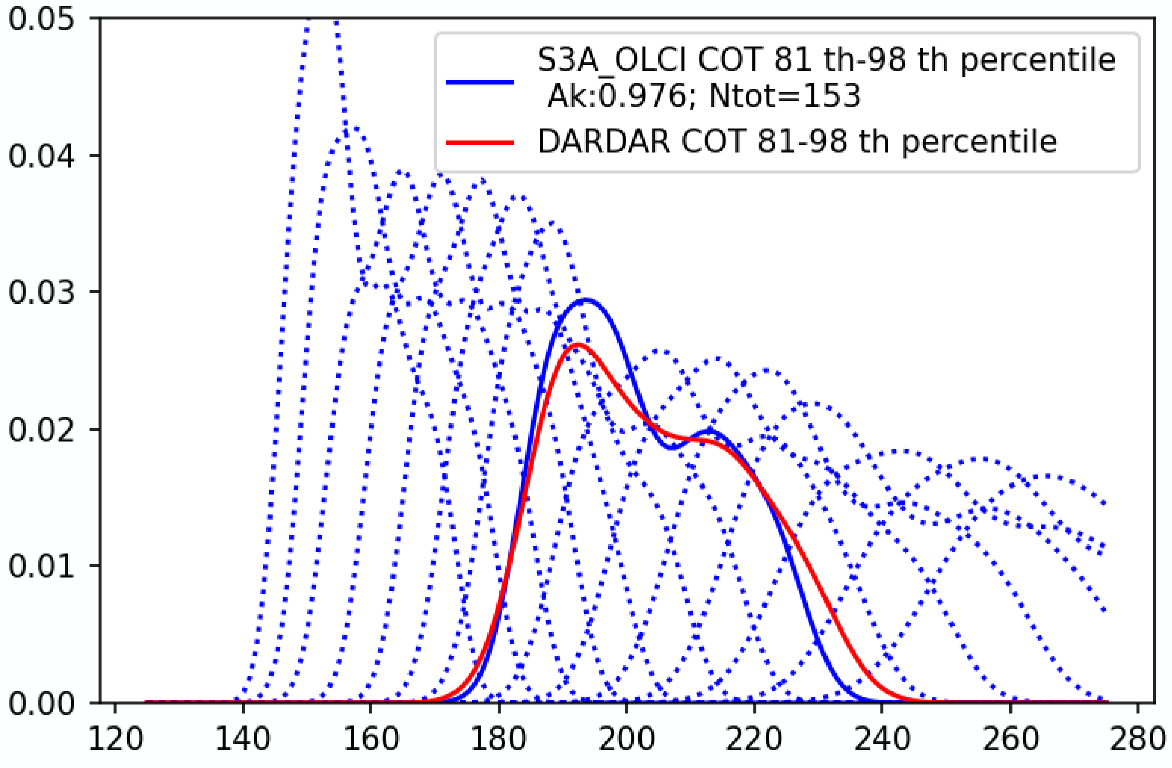
Principles: similarity of histograms

Match DARDAR COT histogram with S3A-OLCI histogram obtained from match-ups with the GEO DCC database with the common metrics, i.e., COT.
Focus on high reflectances (high COT) to reach asymptotic regime.

Assumption: representative set on each side

How: applying a absolute coefficient of calibration on band at 665 nm to find similar histograms of COT

Absolute Calibration – Application (1)



Ak = measured / estimated

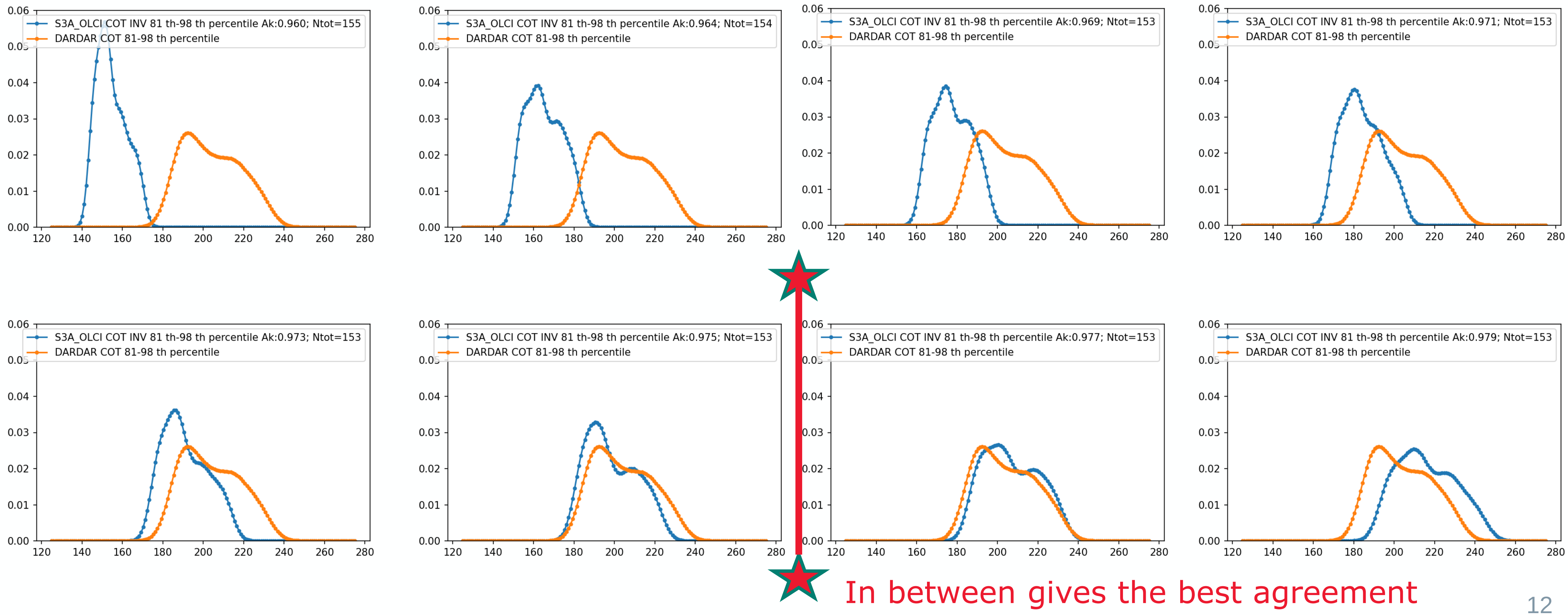
Dashed blue lines : histogram of COT (81 – 98th percentile) retrieved with S3A-OLCI for different calibration factor (by step of 0.01)

Red line : DARDAR COT

Solid blue line : histogram of COT (81 – 98th percentile) retrieved with S3A-OLCI for the calibration factor that gives the better agreement with DARDAR

Overestimation of 2.4 % at 665 nm (Oa08) for S3A-OLCI

Absolute Calibration – Application (2)



In between gives the best agreement

Perspectives

- Work/study is still in progress
- Consolidation :
  - Similarity of histograms:
    - Test on another area (MSG/SEVIRI at 41.5° for example). Check if results are the same (longitudinal variation of DCC properties from East Atlantic-Africa to Indien Ocean, Sohn et al., 2019)
    - Run the GEO DCC mask at the local solar time of A-Train overpass.
  - Use temporal information from GEO (+2 hours after OLCI acquisition) to test, filter and classify OLCI measurements stability
  - Add error bars (due to natural variability, assumption, etc …)
- Applications: SWIR (very challenging) with S2-MSI and S3-SLSTR. Do we constraint enough the DCC targets to minimize effect of microphysics at the top of the DCC ?
- Thanks to **CNES** for the financial support
- Thanks to **CGTD ICARE** for GEO and A-Train data and for facilities