

# Uncertainty Evaluation of Sentinel-3 OLCI GIFAPAR

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# Sentinel-3 Collection-3 OLCI GIFAPAR

**OLCI Collection-3**, re-processed and released during 2024, is the **last reprocessing** of Sentinel-3, it introduces **two major updates** with respect to Collection-2:

## 1. Updated algorithm for GIFAPAR calculation

All **coefficients** for the calculation of the final GIFAPAR retrieval were **updated** to **reflect** the **new spectral response measurements** of **Sentinel-3A OLCI** (published in 2021)

## 2. Introduction of formally traceable uncertainty propagation

The **uncertainty** is **propagated** step by step through the full retrieval chain: **from** the **Level-1** radiance inputs, through the angular normalization and atmospheric rectification, **to** the **final GIFAPAR value**.



# Sentinel-3 Collection-3

## Sentinel-3 OLCI GI-FAPAR & rectified channels in O10, O11, O12 and O17 bands with uncertainties

**Subtitle:** Algorithm Theoretical Basis Document

**Abstract:** Surface reflectances are important for monitoring land surfaces properties state and their changes. Two rectified channels were already operationally delivered in two bands as side products of Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) using the Sentinel 3 Ocean Land Colour Instrument (OLCI) data. We propose here two additional bands, O11 and O12, but also new coefficients values for O10 and O17 and the FAPAR itself as new spectral responses of OLCI on board Sentinel3A were published (OLCI SR, 2021). The so-called rectified reflectance values are virtual reflectances largely decontaminated from atmospheric and angular effects.

This document summarizes the methodology and presents the results of the new coefficients for the normalization, i.e. angular effects correction, and atmospheric rectification processes over vegetated and bare soil pixels, respectively. We released also the coefficients for the Green Instantaneous FAPAR (GIFAPAR) to have consistency with the spectral response of OLCI on board Sentinel-3A.

**Authors:** [GOBRON Nadine](#) 

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# Research Questions

- **RQ1 Uncertainty Characterization:**

What is the **magnitude**, **temporal** behavior, and **spatial distribution** of uncertainties in Collection-3 at global scale and across surface types?

- **RQ2. Collection comparison**

Are the **differences** introduced by the updated algorithm **between Collection-2 and Collection-3** statistically **significant** with respect to the Collection-3 uncertainty estimates?

- **RQ3. Inter-satellite Consistency**

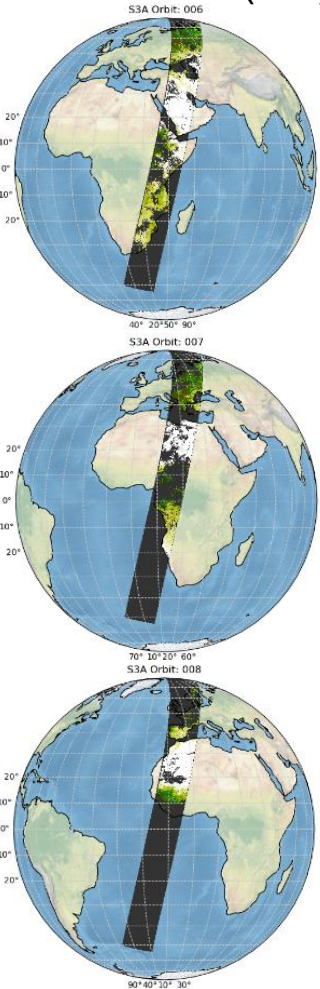
Can the Collection-3 uncertainty estimates support a **quantitative**, uncertainty-aware **assessment** of the **consistency** between **Sentinel-3A** and **Sentinel-3B** retrievals?



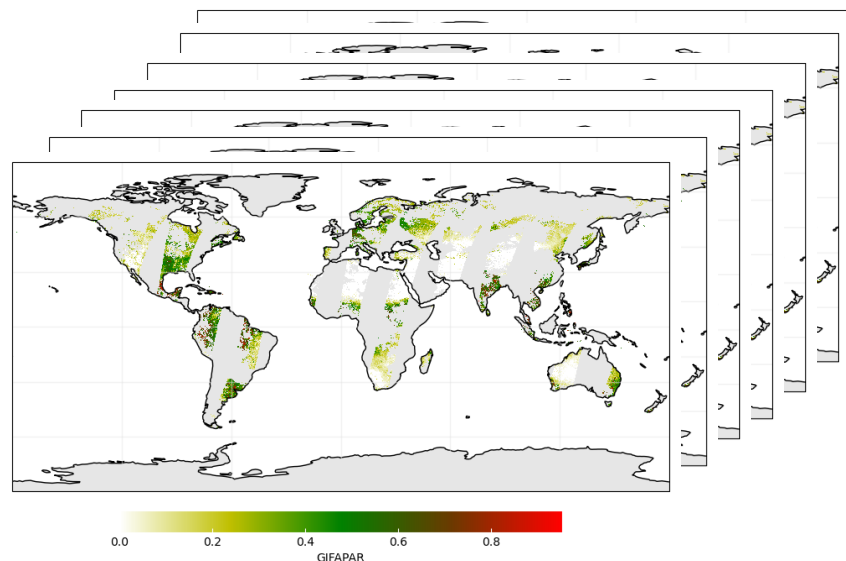
# Data for the Analysis

This analysis uses Sentinel 3A and Sentinel 3B **Reduced Resolution** (RR) datasets, obtained by Level-2 (L2) orbit images through a **re-gridding** and a **temporal compositing** (TC) steps

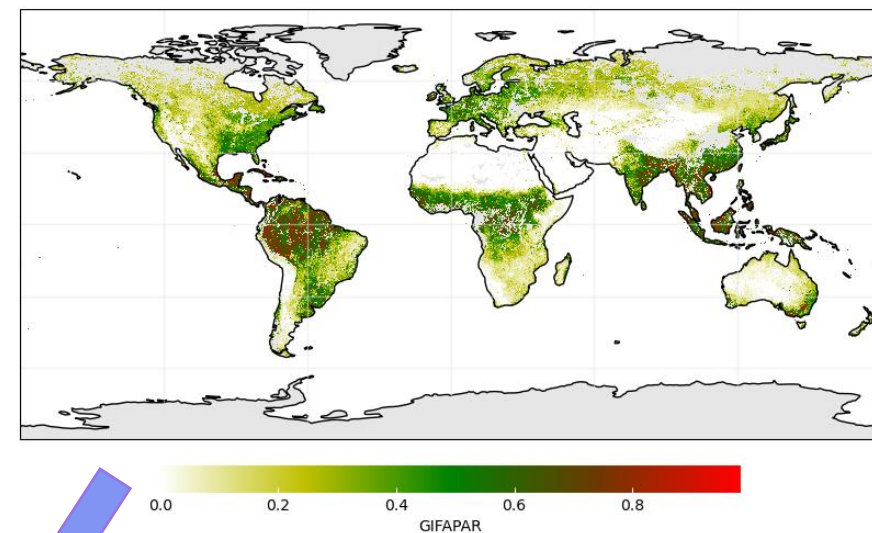
L2 1.2km (RR)



L2 daily @ 0.02°



L3 10day @ 0.02°



JRC TC algorithm: each value correspond to the best representative day

Land Cover derived from ESA CCI using FAO LCCS system, 10 vegetation classes

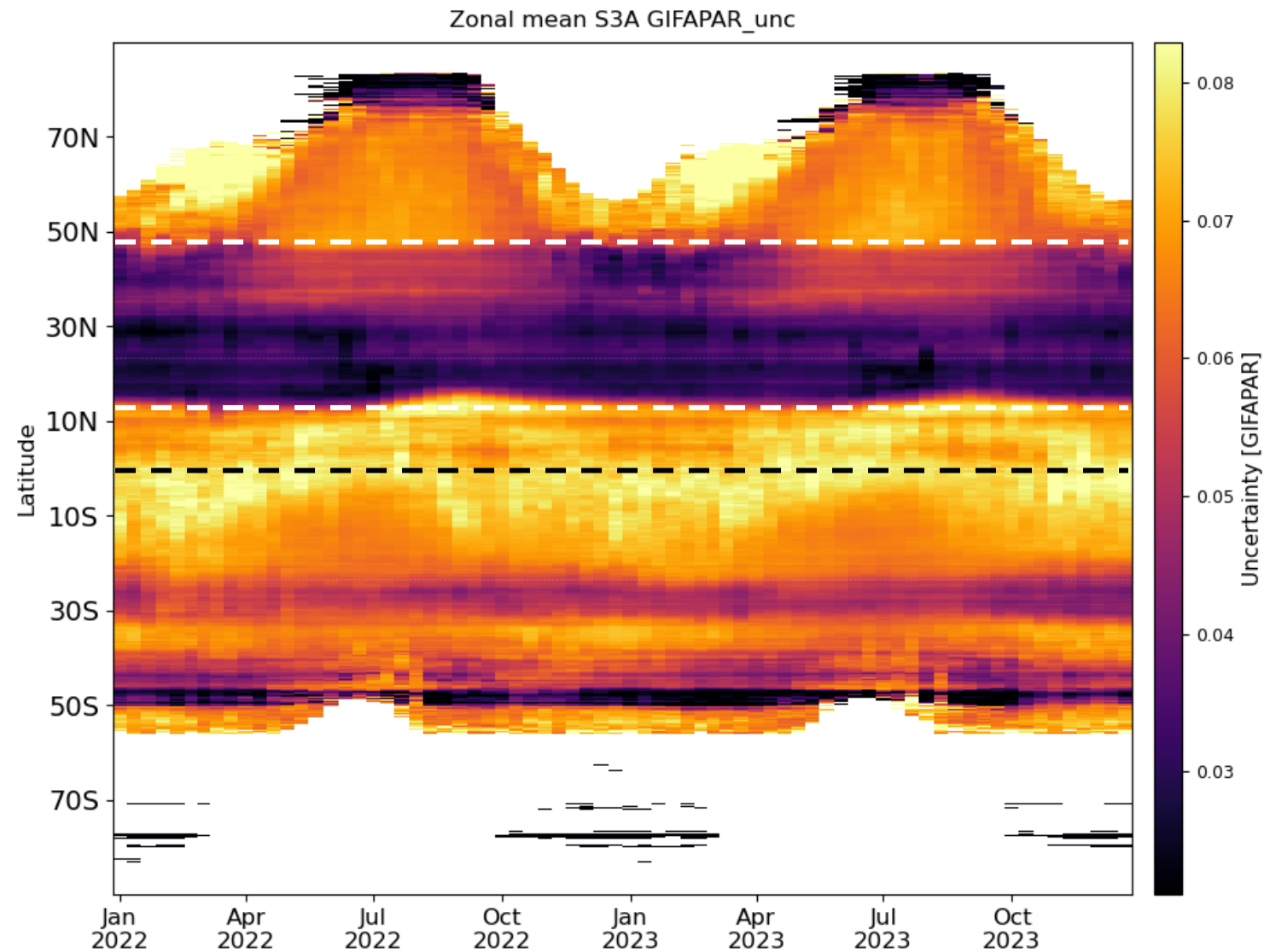
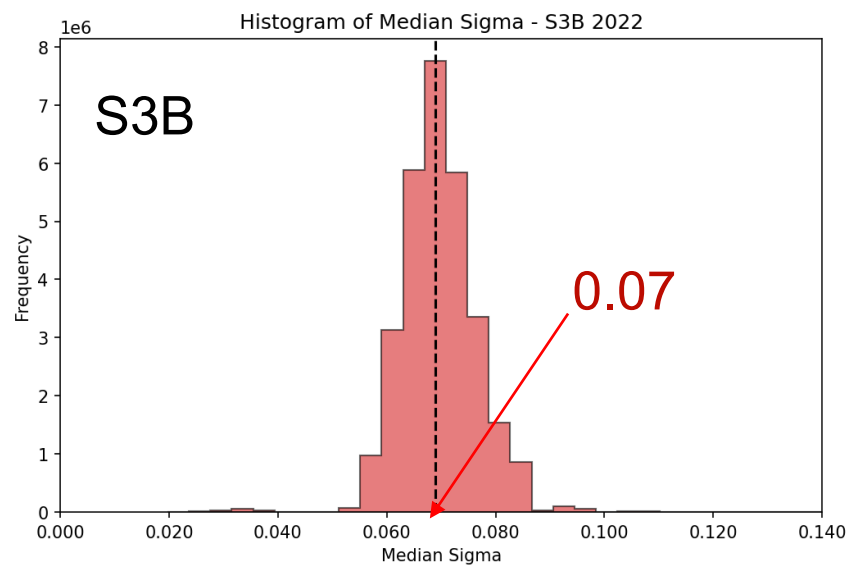
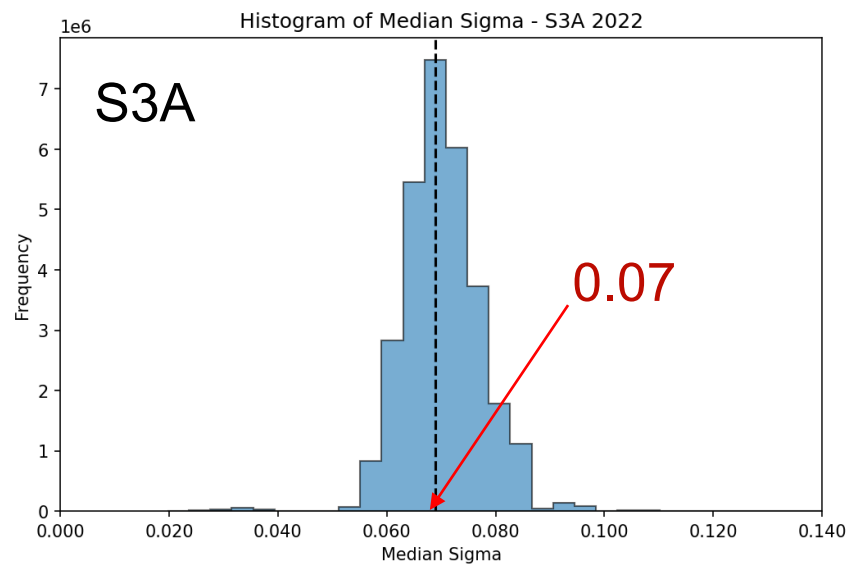


RQ1:

How uncertainties looks like?

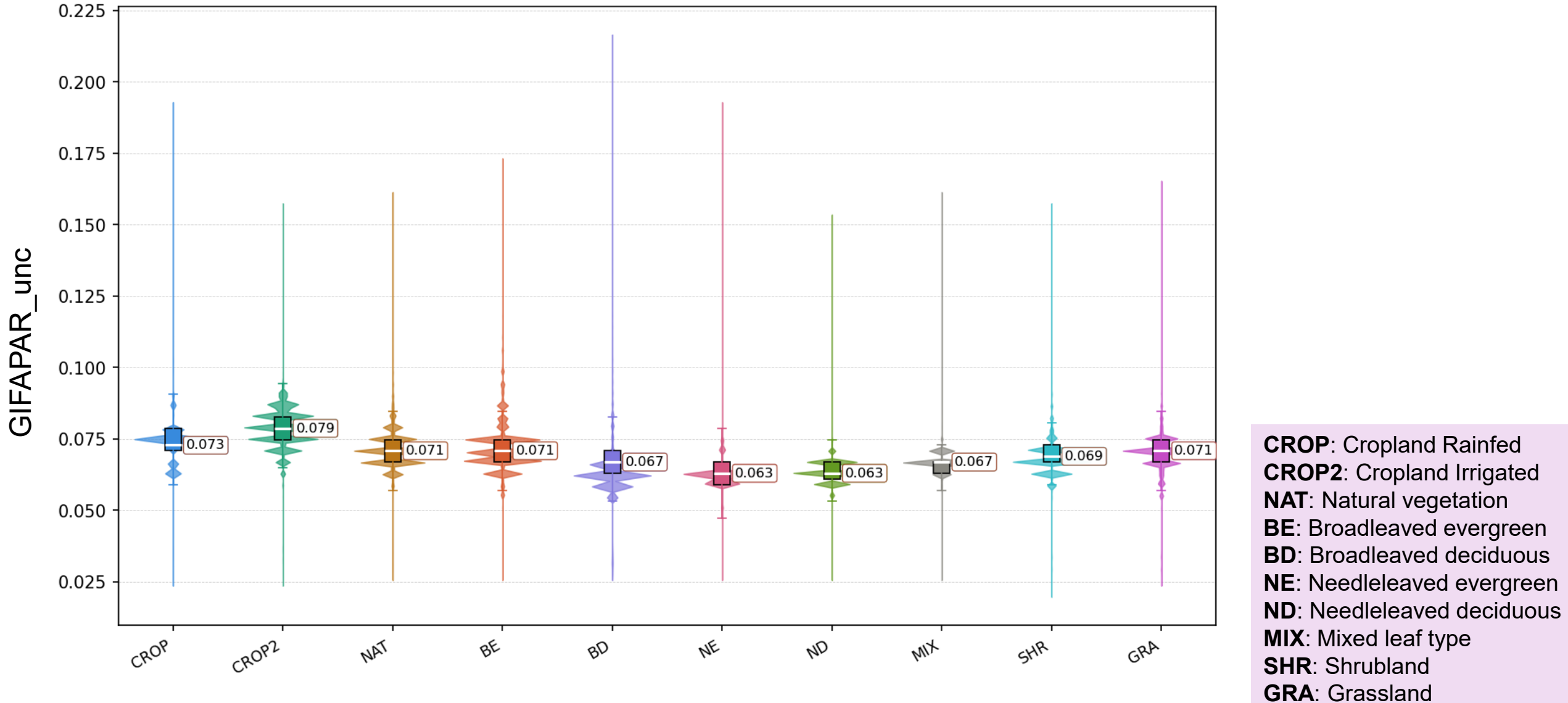


# RQ1 - Uncertainty Characterization



# RQ1 - Uncertainty Characterization

GIFAPAR\_unc by Land Class [LCCS] S3A 2022



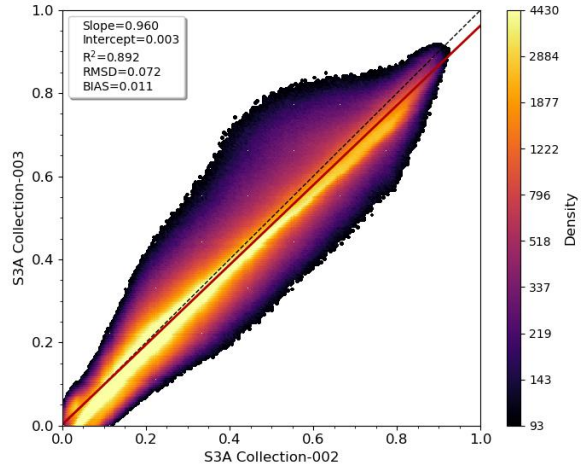
RQ2:

Is the C2-C3 difference statistically significant?

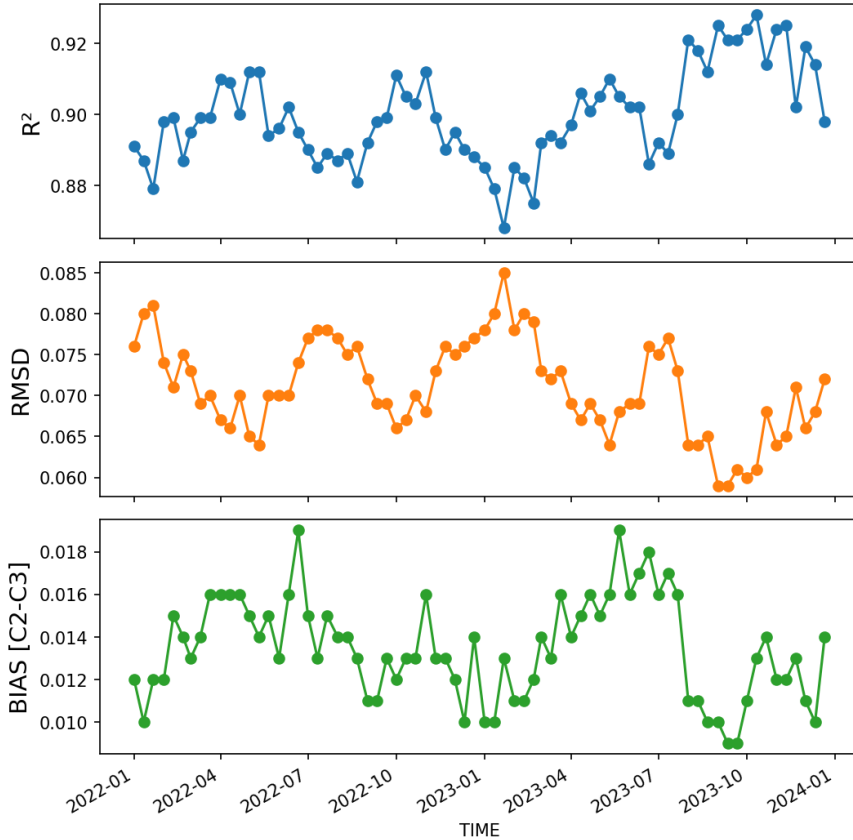


# RQ2 – Collection comparison

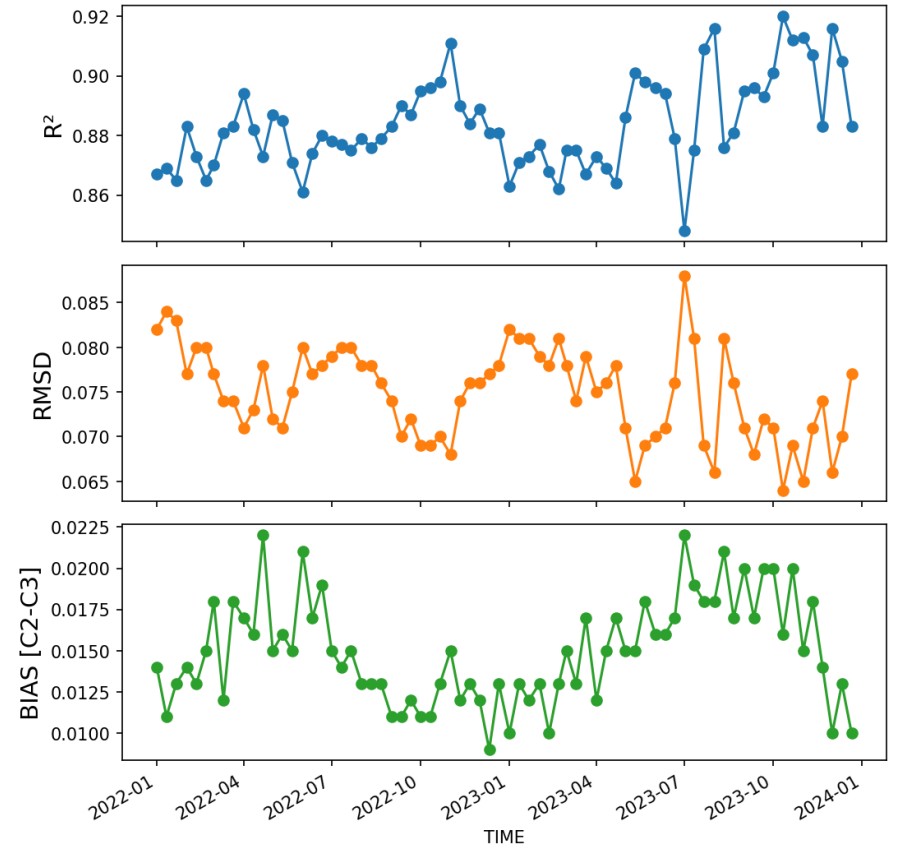
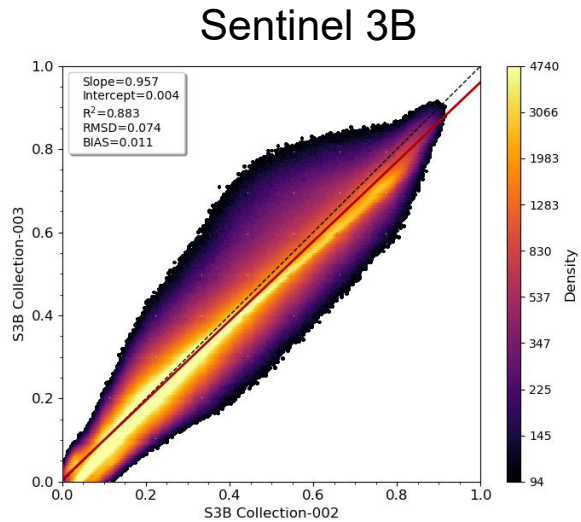
Sentinel 3A



Sentinel 3A



Sentinel 3B



$BIAS = C2 - C3$



# RQ2 – Collection comparison: gamma-index

Are the Collection-2 to Collection-3 differences statistically significant with respect to the Collection-3 uncertainty estimates?

Let's define this metric:

$$\gamma = \frac{|Coll_2 - Coll_3|}{k\sigma_3} \quad \text{where } k = 1, 2$$

$\gamma = 0$   $Coll_3 \equiv Coll_2$

$0 < \gamma \leq 1$  the difference between  $Coll_3$  and  $Coll_2$  is within  $k\sigma$

$\gamma > 1$  the difference is statistically significant

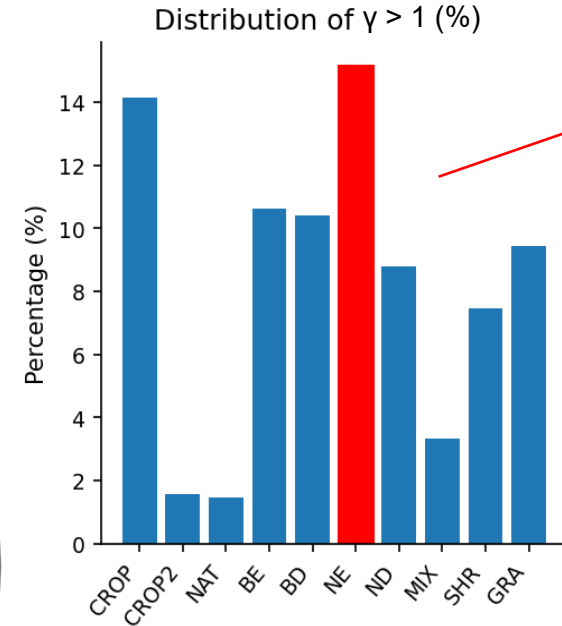
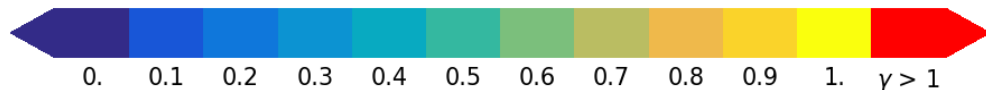
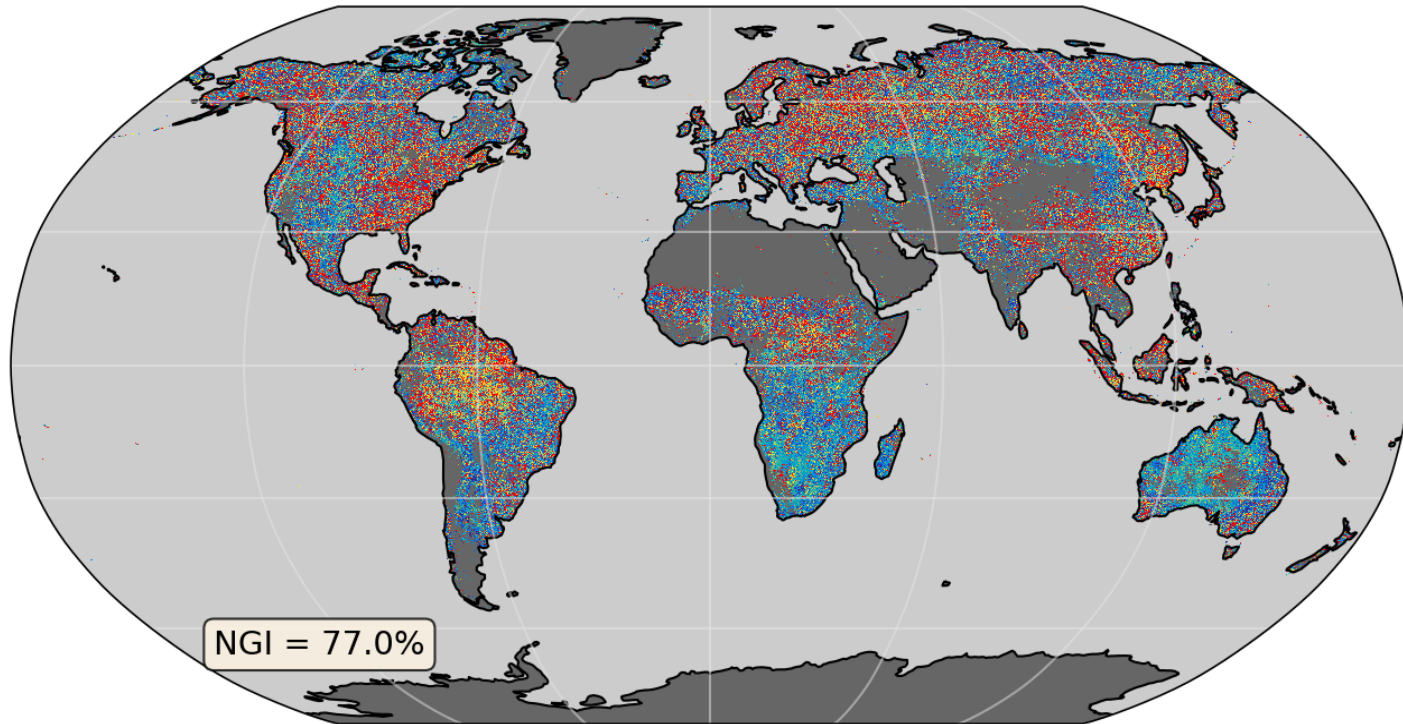
$\gamma$  is calculated at global scale, for each pixel,

The **NGI** (Normalized Gamma Index) factor represents the **percentage** of **pixels** scoring  $\gamma \leq 1$ , normalized over the total number of tested pixels



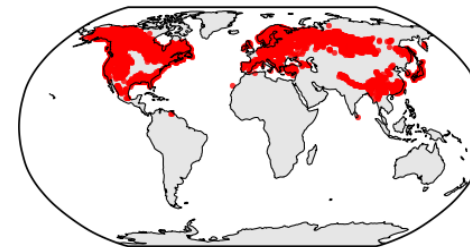
# RQ2 – Collection comparison: gamma-index

Sentinel 3A 01 August 2022 1 $\sigma$



Forested classes  
~50%

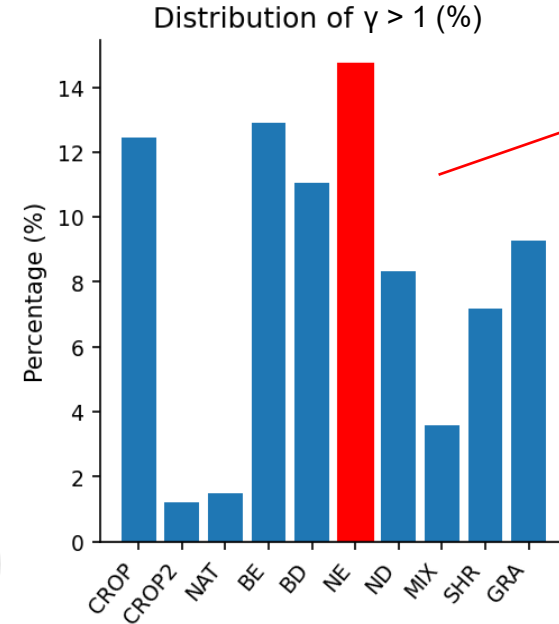
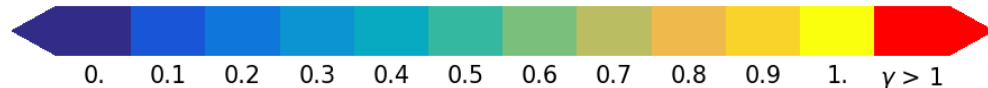
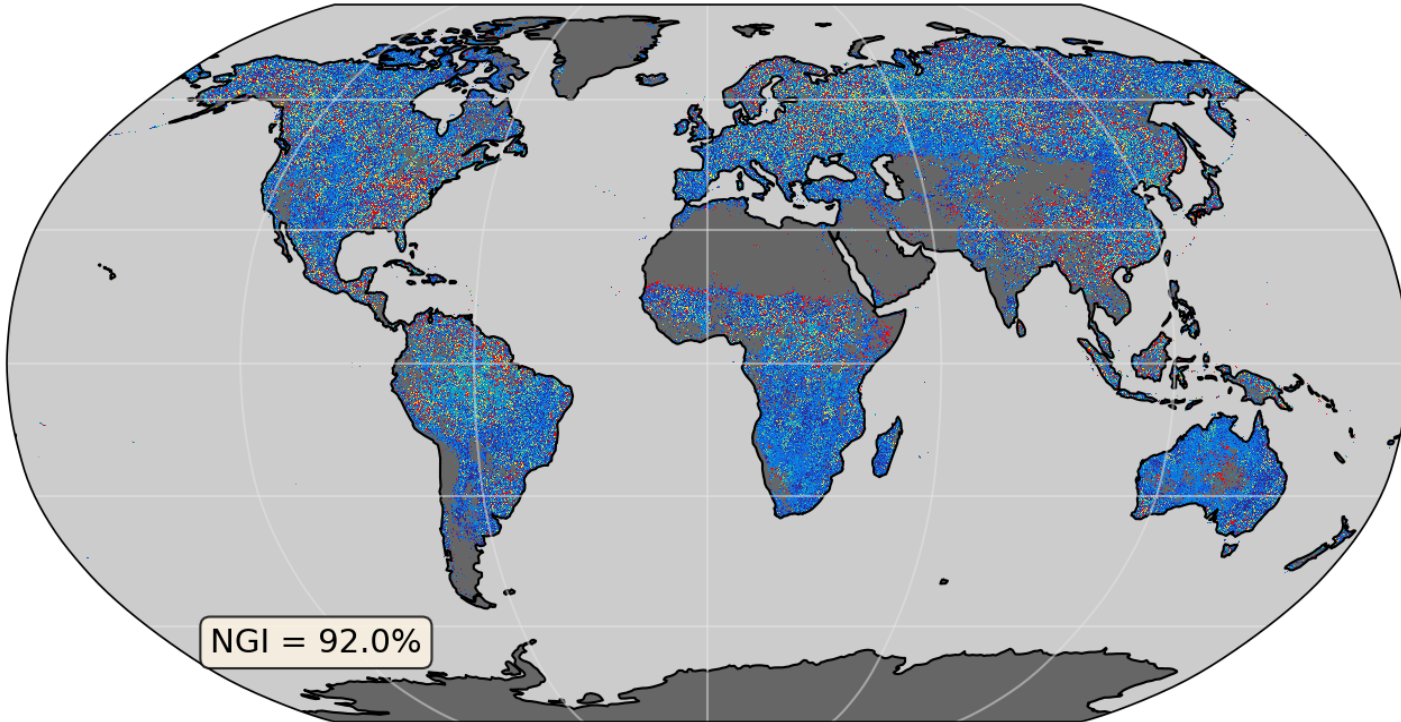
Dominant LC:  
NE



- CROP:** Cropland Rainfed
- CROP2:** Cropland Irrigated
- NAT:** Natural vegetation
- BE:** Broadleaved evergreen
- BD:** Broadleaved deciduous
- NE:** Needleleaved evergreen
- ND:** Needleleaved deciduous
- MIX:** Mixed leaf type
- SHR:** Shrubland
- GRA:** Grassland

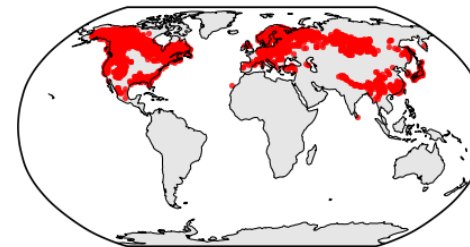
# RQ2 – Collection comparison: gamma-index

Sentinel 3A 01 August 2022 2 $\sigma$



Forested classes  
~50%

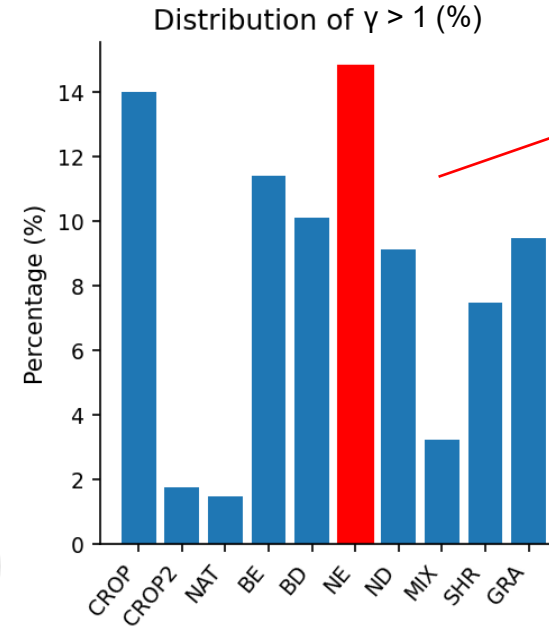
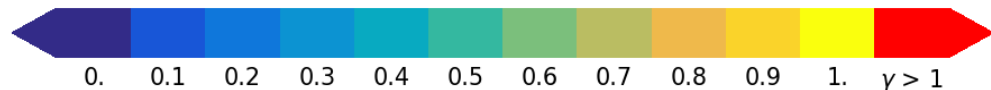
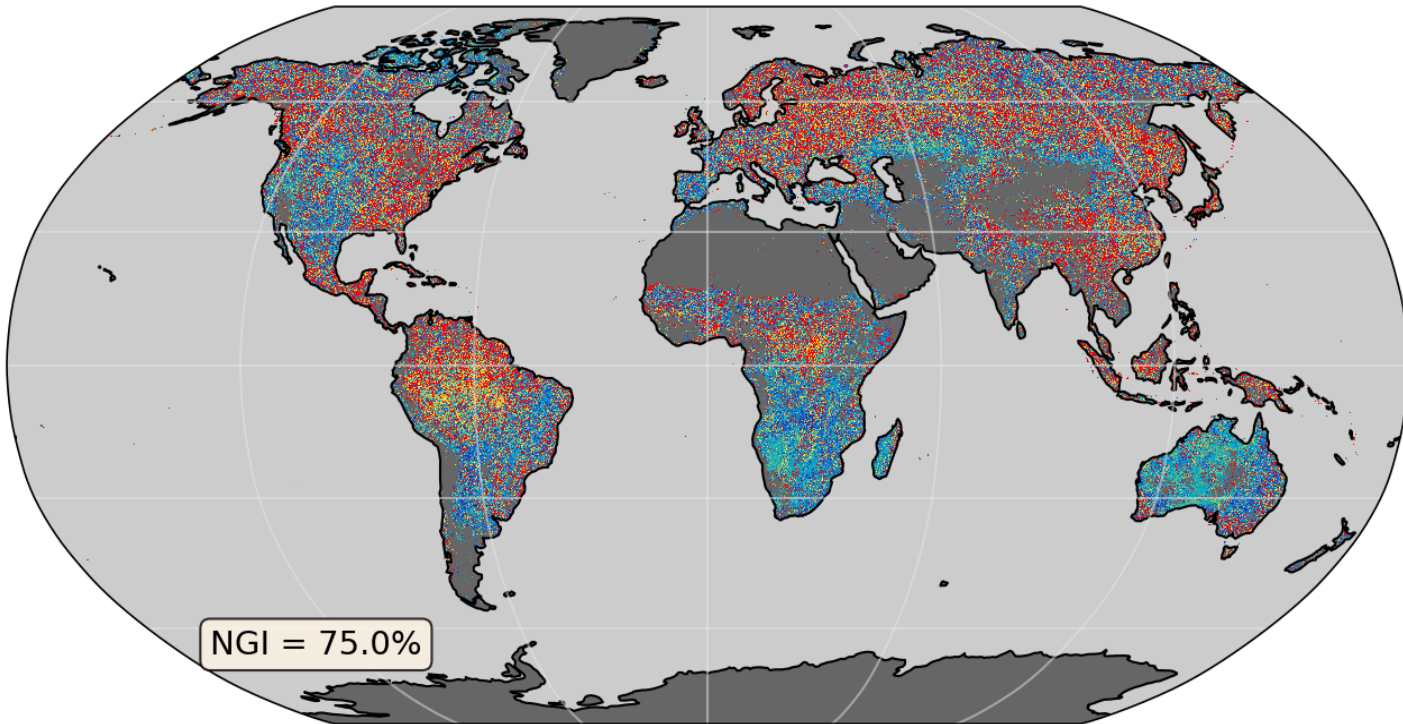
Dominant LC:  
NE



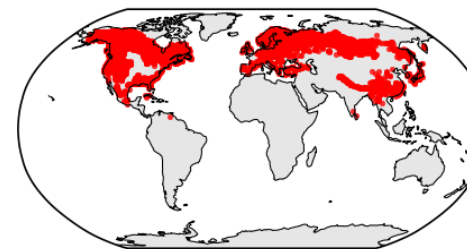
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# RQ2 – Collection comparison: gamma-index

Sentinel 3B 01 August 2022 1 $\sigma$



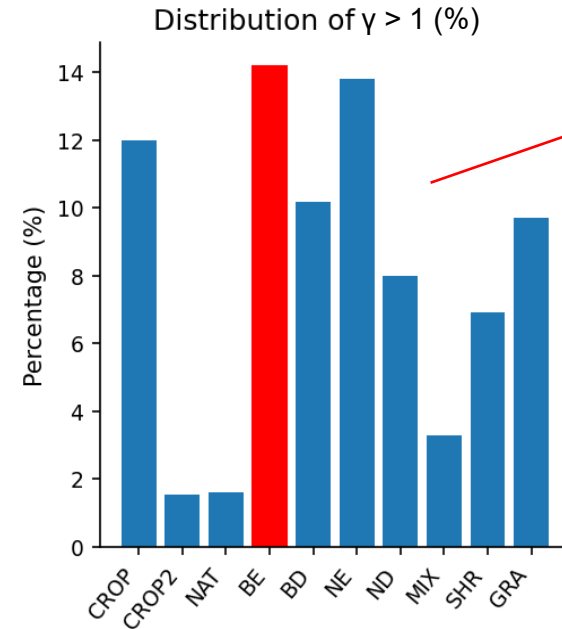
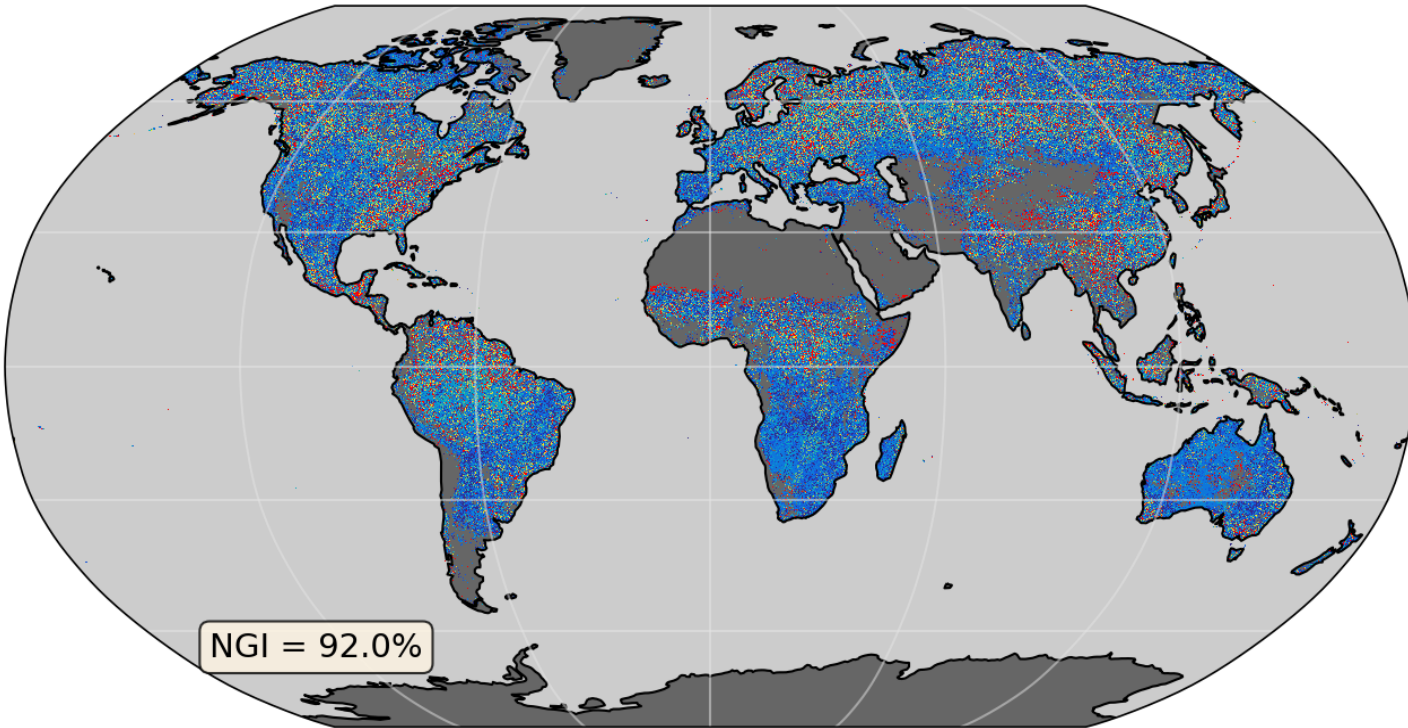
Dominant LC:  
NE



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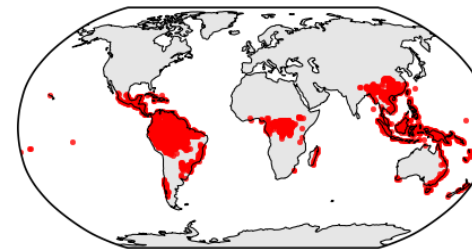
# RQ2 – Collection comparison: gamma-index

Sentinel 3B 01 August 2022  $2\sigma$



Forested classes  
~50%

Dominant LC:  
BE



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- GRA:** Grassland

RQ3:

Are S3A and S3B consistent  
within C3 uncertainties?



# RQ3 – Collection-3 Inter-satellite consistency

Is the difference between OLCI-A and OLCI-B statistically significant with respect to the **(combined) uncertainties**?

Proficiency Index:

$$E_n = \frac{|S3A - S3B|}{k\sqrt{\sigma_{S3A}^2 + \sigma_{S3B}^2}} \quad \text{where } k = 2$$

$E_n = 0$   $S3A \equiv S3B$

$0 < E_n \leq 1$  the difference between S3A and S3B is within the combined uncertainties

$E_n > 1$  the difference is statistically significant

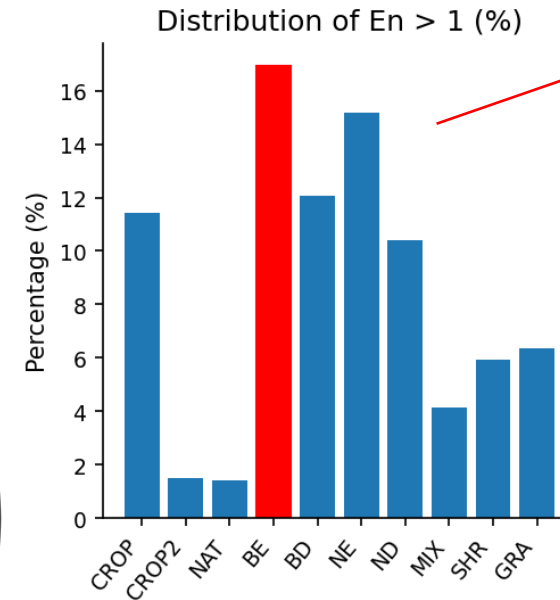
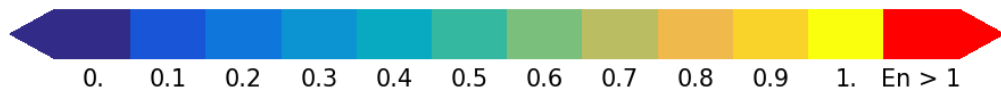
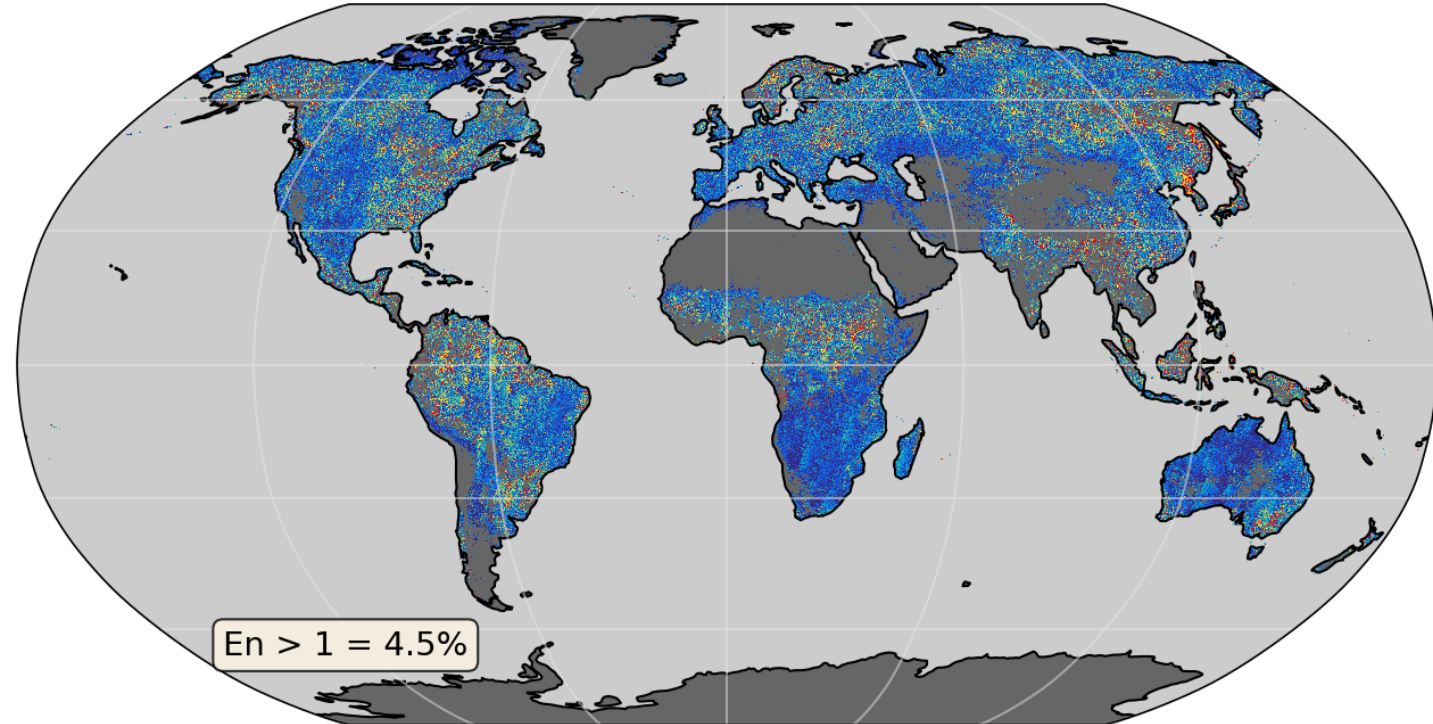
$E_n$  is calculated at global scale, for each pixel.



# RQ3 – Collection-3 Inter-satellite consistency

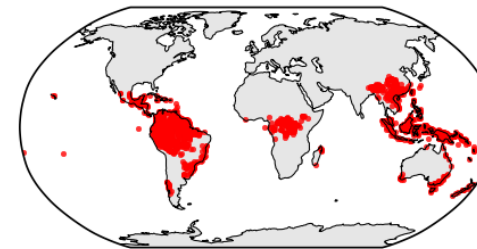
Proficiency test S3A-3B Coll-3

01-August-2022



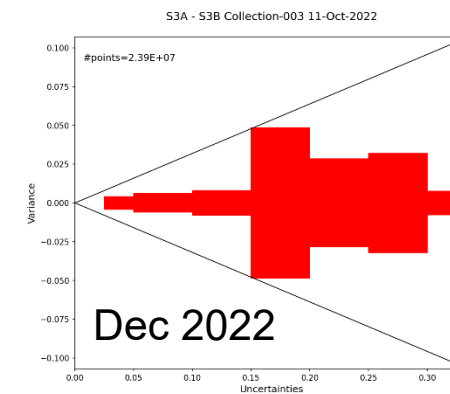
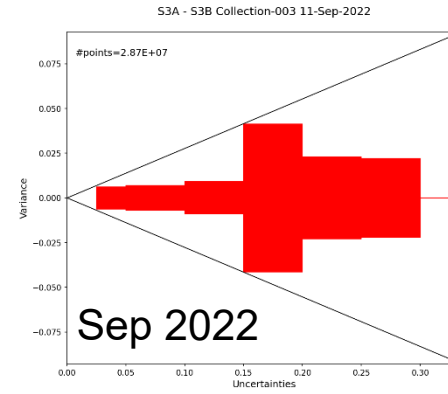
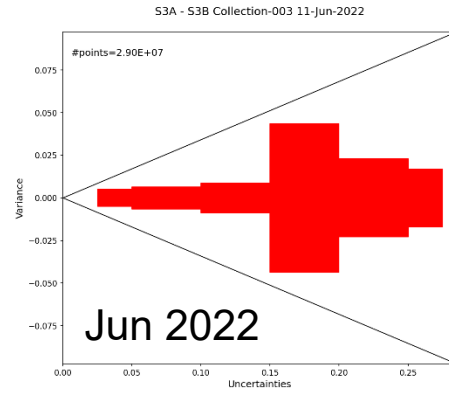
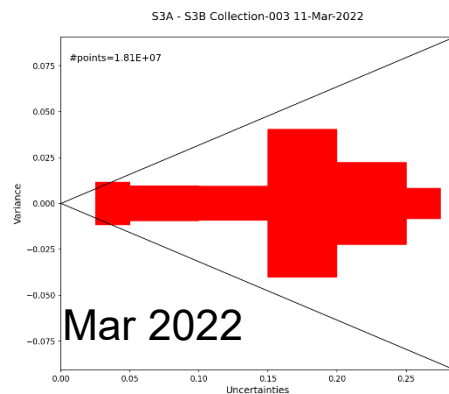
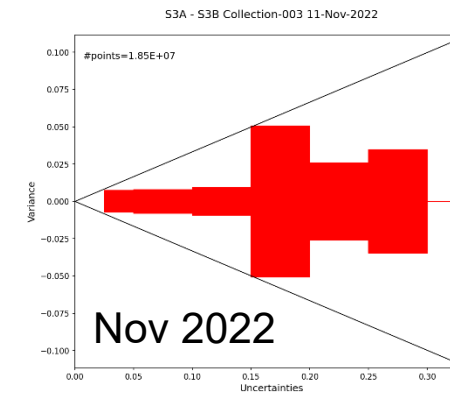
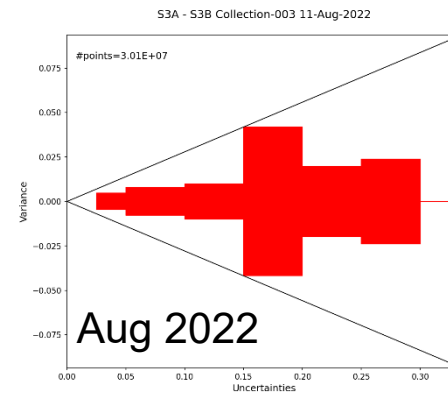
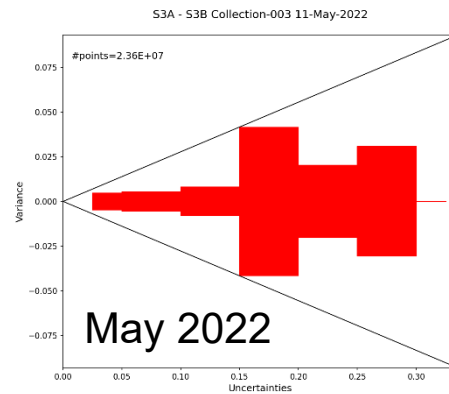
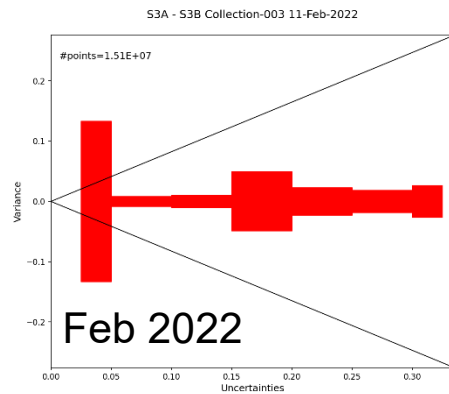
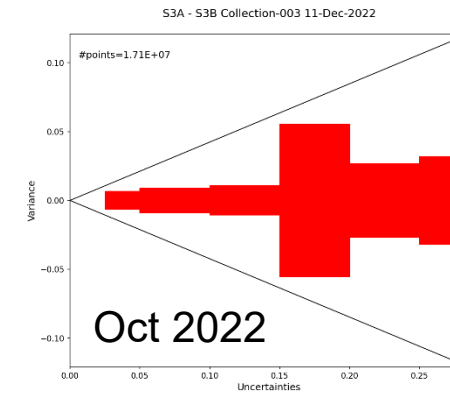
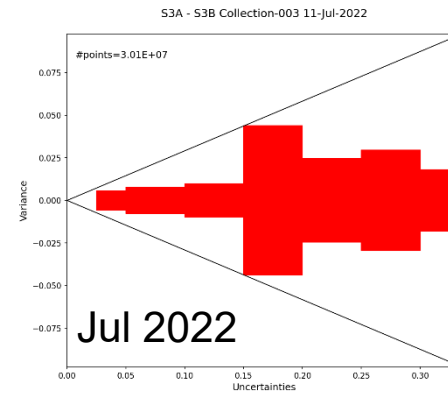
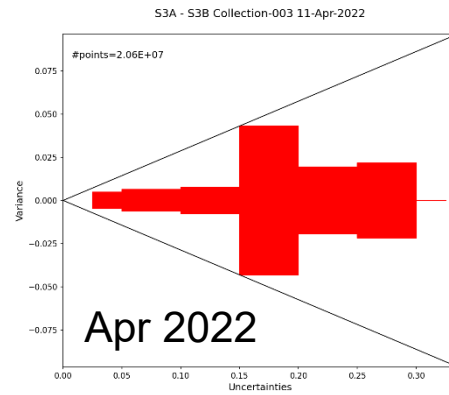
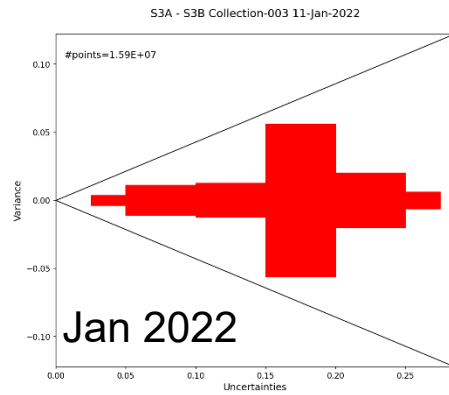
Forested classes  
~50%

Dominant LC:  
BE



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# RQ3 – Immler Diagram



# Conclusion

## RQ1 — Uncertainty Characterization

- Are **consistent** between S3A and S3B
- Shows a clear **latitudinal** and **seasonal pattern**, as revealed by the Hovmöller diagram
- Varies across land cover types: **croplands** show the **highest** values, **forests-classes** the **lowest**

## RQ2 — Collection Comparison

- The **bias** is **small** ( $\sim 0.01$ ) but **systematic**, consistent between S3A and S3B
- Using **gamma**, the **BIAS** are largely **within  $2\sigma$**  (NGI $>90\%$ ), with **marginal discrepancies** over **forested** surfaces, mostly linked to low uncertainty values

## RQ3 — Inter-satellite Consistency

- S3A and S3B are **largely consistent** within C3 **combined uncertainties**
- Residual **inconsistencies** are concentrated over **forested surfaces**
- The **Immler** diagram confirms that C3 **uncertainties** are **realistic** and **well-scaled** with respect to the observed S3A-S3B **variance** across all seasons



# Next Steps:

- Investigate the **sources** of **residual** inter-satellite **inconsistency**, with particular **focus** on the role of **quality flags**, **cloud** contamination and **angular** geometry
- **Extend** the uncertainty-aware analysis to the **rectified reflectance** channels (RC685 and RC861)
- **Extend** the **temporal coverage** of the analysis and assess potential long-term **trends** in uncertainty and inter-satellite consistency



# Thank you

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