Toward a Fiducial OLCI Green-Instantaneous FAPAR product

Nadine Gobron

Olivier Morgan, Fabrizio Cappucci and Mirko Marioni

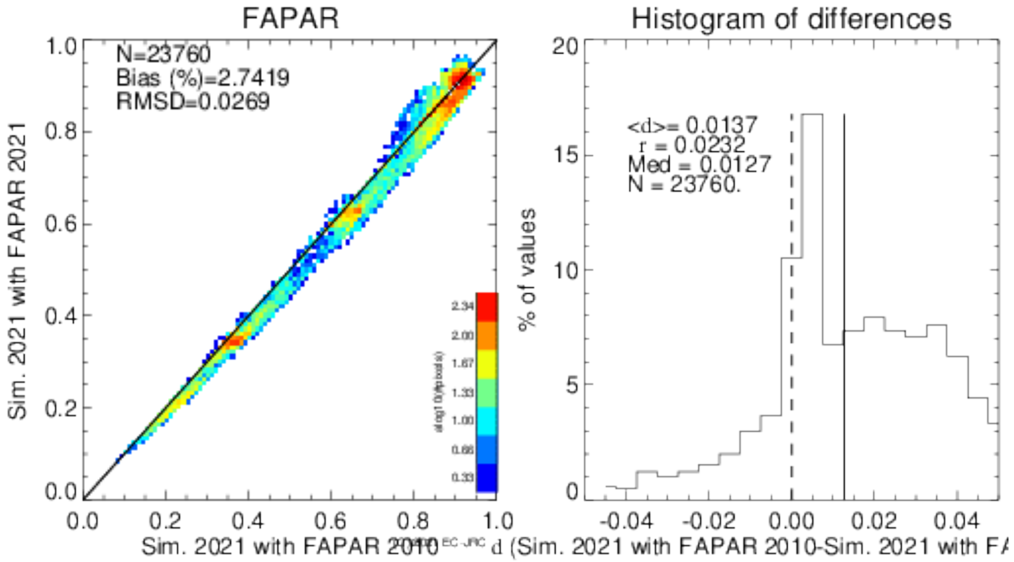
18-20/11/2022 - Sentinel-3 Validation Team Meeting

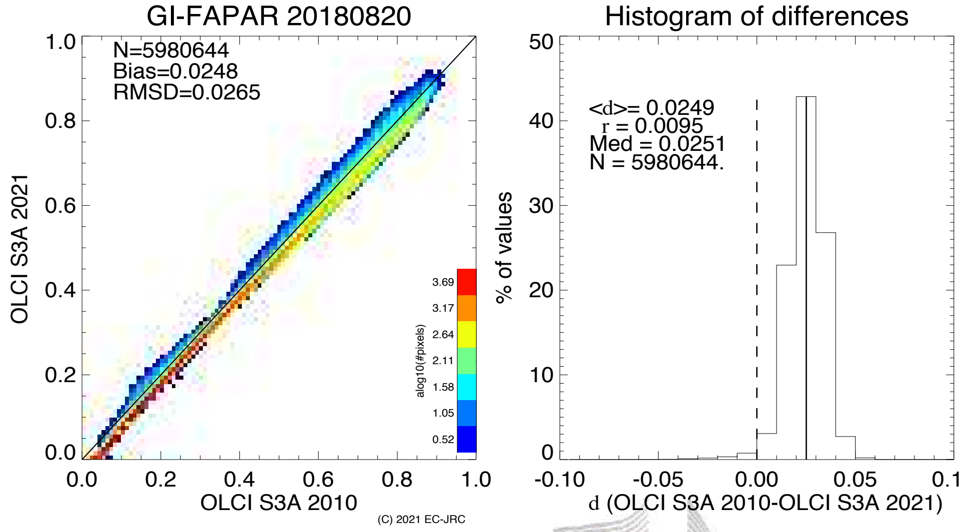
Green Instantaneous (GI)-FAPAR

Impact of spectral response between pre-flight (2010) and mean spectral response OLCIA (2021) is at about **-0.26%**, **-0.74%** and **3.38%** in band O3, O10 and O17, respectively … with RT simulations

=> New coefficients for normalization, rectification and FAPAR were optimized in 2021.

=> Towards GI-FAPAR uncertainties





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Remote Sensing of Environment
Volume 270, 1 March 2022, 112850

Evaluation of Sentinel-3A and Sentinel-3B ocean land colour instrument green instantaneous fraction of absorbed photosynthetically active radiation

Nadine Gobron [a], Olivier Morgan [a], Jennifer Adams [b], Luke A. Brown [c], Fabrizio Cappucci [a], Jadunandan Dash [c], Christian Lanconelli [a], Mirko Marioni [a], Monica Robustelli [a]

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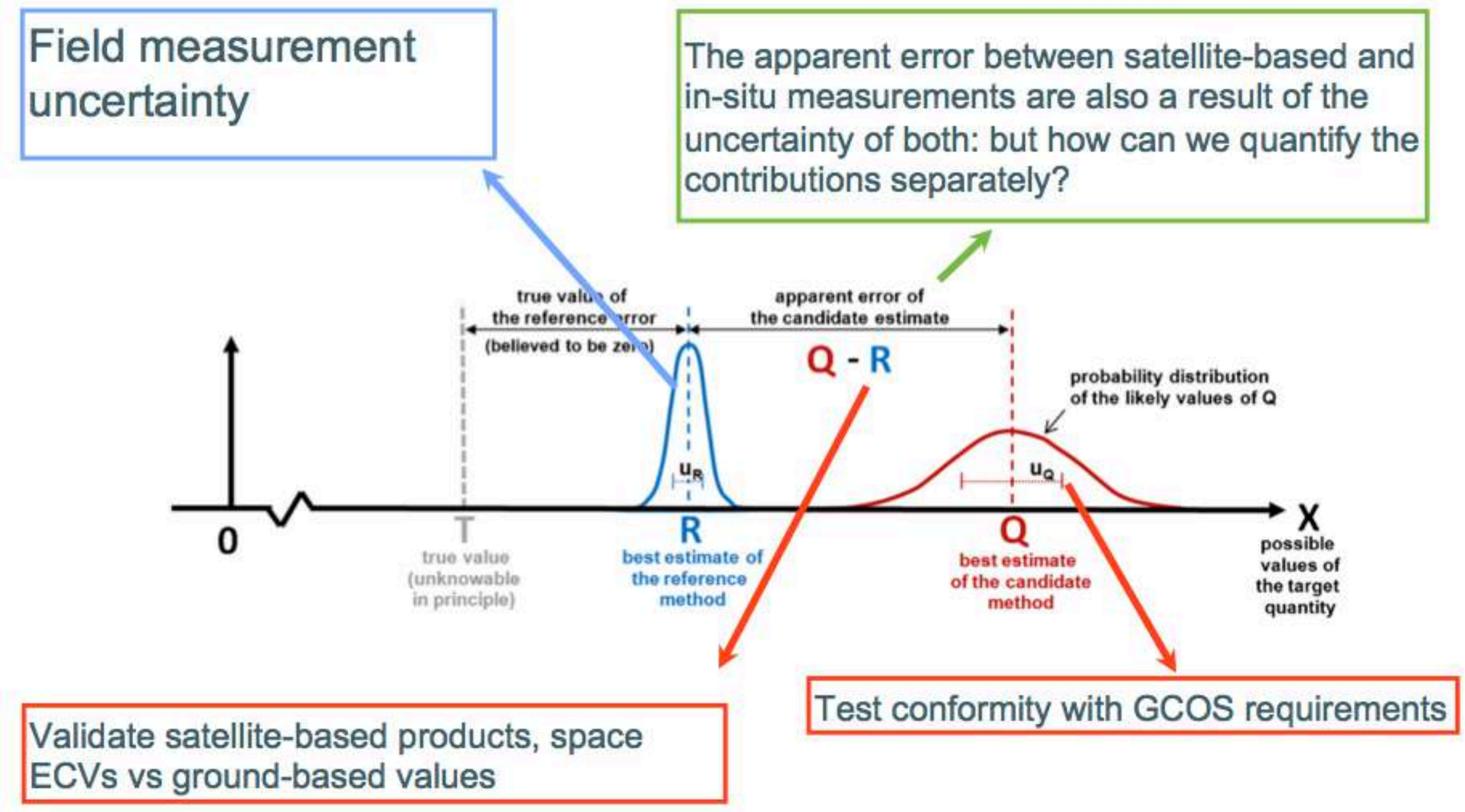
Highlights

- First evaluation of Copernicus S3 OLCI green instantaneous FAPAR products.
- Seasonality with MERIS climatology provide high temporal confidence of products.

USA_BAR	BarlettExperimentalForest	44.063901	-71.287308	MixedForest
USA_BLA	BlandyExperimentalFarm	39.06026077	-78.07164001	DeciduousBroadleaf
USA_CPE	CentralPlainsExperimentalRange	40.81555	-104.74566	Grassland
USA_DELA	DeadLake	32.54172	-87.80389	DeciduousBroadleaf
USA_DSN	DisneyWildernessPreserve	28.12504005	-81.43625	OpenShrubland
PRI_GUA	GuanicaForest	17.96954918	-66.86869812	EvergreenBroadleaf
USA_HRV	HarvardForest	42.53779984	-72.17150116	MixedForest
USA_JER	JonesEcologicalResearch Center	31.19483948	-84.468777	EvergreenNeedleleaf
USA_JOR	Jornada	32.5907	-106.84261	OpenShrubland
USA_KONA	KonzaPrairieBiologicalStation	39.110446	-96.612935	Cropland
PRI_LAJA	LajasExperimentalStation	18.02125	-67.0769	Grassland
USA_MOA	Moab	38.24836	-109.38831	OpenShrubland
USA_NRF	NiwotRidgeMountainResearchStation	40.03287	-105.5469	EvergreenNeedleleaf
USA_STE	NortSterling	40.461952	-103.02934	Grassland
USA_ORN	OakRidge	35.96411896	-84.2826004	MixedForest
USA_ONA	OnaquiAult	40.17758942	-112.4524384	OpenShrubland
USA_OSB	OrdwaySwisherBiologicalStation	29.67615	-82.00847	EvergreenNeedleleaf
USA_SCB	SmithsonianConservationBiologyInstitute	38.89292145	-78.13950348	MixedForest
USA_SER	SmithsonianEnvironmentalResearchCenter	38.89016	-76.5601	Cropland
USA_SRER	SantaRita	31.91068	-110.83549	ClosedShrubland
USA_SLS	SteigerwaltLandServices	45.50894165	-89.58637238	DeciduousBroadleaf
USA_TAL	TalladegaNationalForest	32.95045853	-87.3932724	EvergreenNeedleleaf
USA_UND	Underc	46.233959	-89.53751	MixedForest
USA_WOO	Woodworth	47.12823105	-99.24136353	Grasslands

How to validate EO products with in-situ?



Level 2 product

Level 3 product

- Satellite products and associated uncertainties
- In-situ measurements only **estimates** actual ECV values

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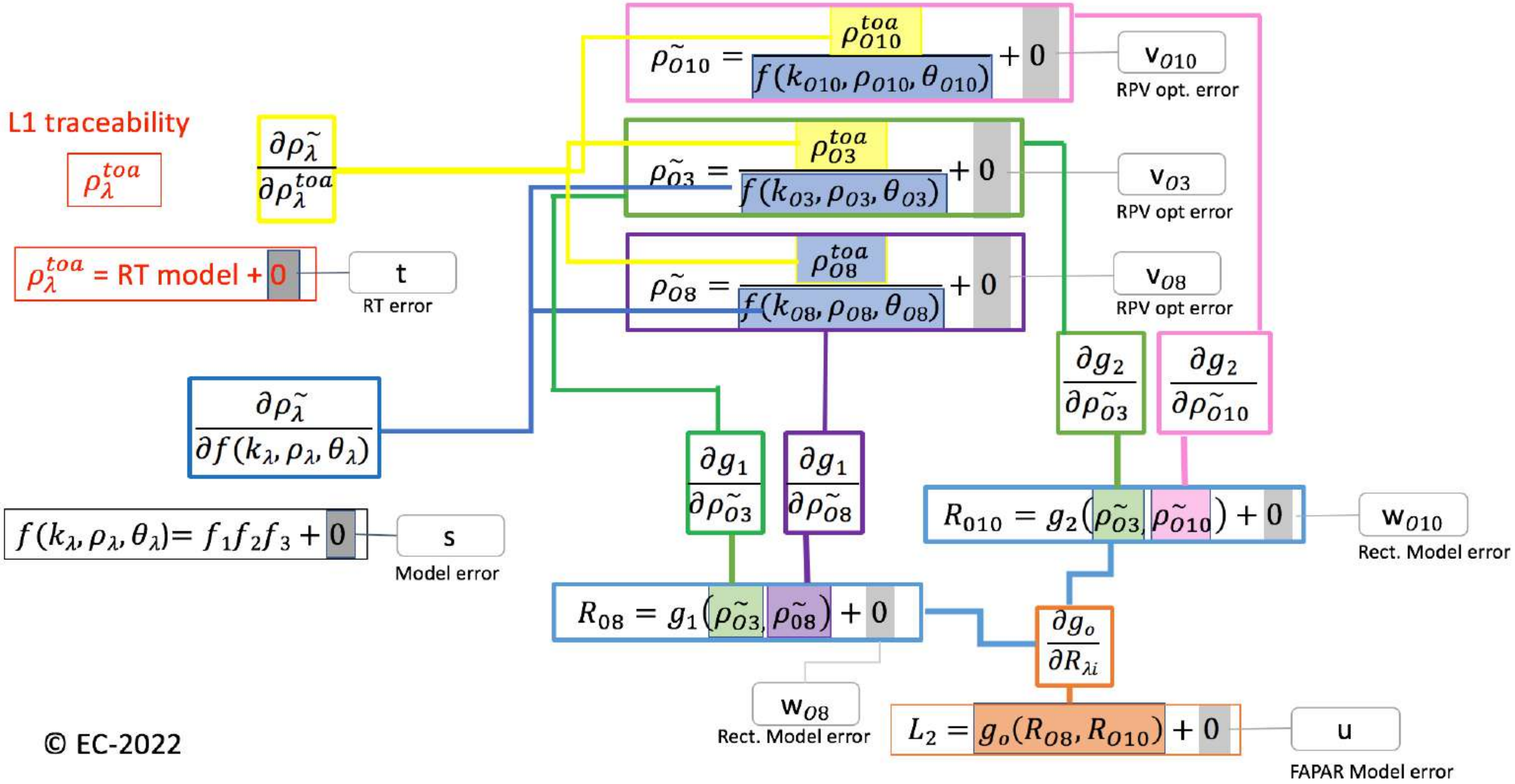
Traceability Uncertainties Chain



Computing the Uncertainties

$$\sigma_{FAPAR}^2 = \sigma_{g0}^2 + u^2$$

$$\sigma_{g0}^2 = \left(\frac{\partial g_0}{\partial x}\right)^2 \sigma_x^2 + \left(\frac{\partial g_0}{\partial y}\right)^2 \sigma_y^2 + 2\left(\frac{\partial g_0}{\partial x}\right)\left(\frac{\partial g_0}{\partial y}\right) \sigma_{xy}$$

$$\frac{\partial f}{\partial \rho_\lambda^{TOA}} = \frac{1}{F(\Omega_i; k_\lambda, \Theta_\lambda^{HG}, \rho_{\lambda c})}$$

$$\frac{\partial f}{\partial F} = \frac{-\rho_\lambda^{TOA}}{F^2}$$

Rectified

$$\sigma_{R\lambda}^2 = \sigma_{g\lambda}^2 + \sigma_{0R\lambda}^2$$

$$\sigma_{g\lambda}^2 = \left(\frac{\partial g}{\partial \rho_{\tilde{O3}}}\right)^2 \sigma_{\rho_{\tilde{O3}}}^2 + \left(\frac{\partial g}{\partial \rho_{\tilde{\lambda}}}\right)^2 \sigma_{\rho_{\tilde{\lambda}}}^2 + 2\left(\frac{\partial g}{\partial \rho_{\tilde{O3}}}\right)\left(\frac{\partial g}{\partial \rho_{\tilde{\lambda}}}\right) \sigma_{\rho_{\tilde{O3}}\rho_{\tilde{\lambda}}}$$

Normalized

$$\sigma_{\rho_{\tilde{\lambda}}}^2 = \left(\frac{\partial f}{\partial \rho_\lambda^{TOA}}\right)^2 \sigma_{\rho_\lambda^{TOA}}^2 + \left(\frac{\partial f}{\partial F}\right)^2 \sigma_F^2 + 2\left(\frac{\partial f}{\partial \rho_\lambda^{TOA}}\right)\left(\frac{\partial f}{\partial F}\right) \sigma_{\rho_\lambda^{TOA} F}$$

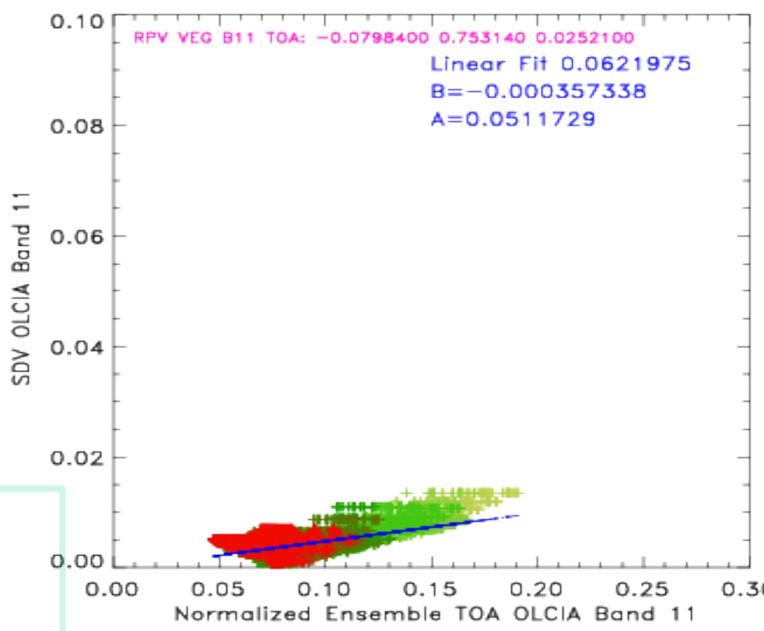
Computing the Uncertainties

$$\sigma^2_{Fi} = \mathcal{F}^2(\tilde{\rho_{\lambda i}}) = (A\,\tilde{\rho_{\lambda i}} + B)^2$$

$$\sigma^2_{FAPAR} = \sigma^2_{g0} + u^2$$

$$\sigma_F \approx \sqrt{\frac{1}{N-1}\sum_{j=0}^{N-1}\left((\rho^E_{\lambda ij} - \rho^U_{\lambda ij}) - \langle (\rho^E_{\lambda ij} - \rho^U_{\lambda ij}) \rangle\right)^2}$$

$$\sigma^2_{g0} = \left(\frac{\partial g_0}{\partial x}\right)^2 \sigma^2_x + \left(\frac{\partial g_0}{\partial y}\right)^2 \sigma^2_y + 2\left(\frac{\partial g_0}{\partial x}\right)\left(\frac{\partial g_0}{\partial y}\right)\sigma_{xy}$$



Rectified

$$\sigma^2_{R\lambda} = \sigma^2_{g\lambda} + \sigma^2_{0R\lambda}$$

Rectified Channel

$$\sigma^2_{g\lambda} = \left(\frac{\partial g}{\partial \tilde{\rho_{O3}}}\right)^2 \sigma^2_{\tilde{\rho_{O3}}} + \left(\frac{\partial g}{\partial \tilde{\rho_\lambda}}\right)^2 \sigma^2_{\tilde{\rho_\lambda}} + 2\left(\frac{\partial g}{\partial \tilde{\rho_{O3}}}\right)\left(\frac{\partial g}{\partial \tilde{\rho_\lambda}}\right)\sigma_{\tilde{\rho_{O3}}\tilde{\rho_\lambda}}$$

Normalized

$$\sigma^2_{\tilde{\rho_\lambda}} = \left(\frac{\partial f}{\partial \rho^{TOA}_\lambda}\right)^2 \sigma^2_{\rho^{TOA}_\lambda} + \left(\frac{\partial f}{\partial F}\right)^2 \sigma^2_F + 2\left(\frac{\partial f}{\partial \rho^{TOA}_\lambda}\right)\left(\frac{\partial f}{\partial F}\right)\sigma_{\rho^{TOA}_\lambda F}$$

à suivre …

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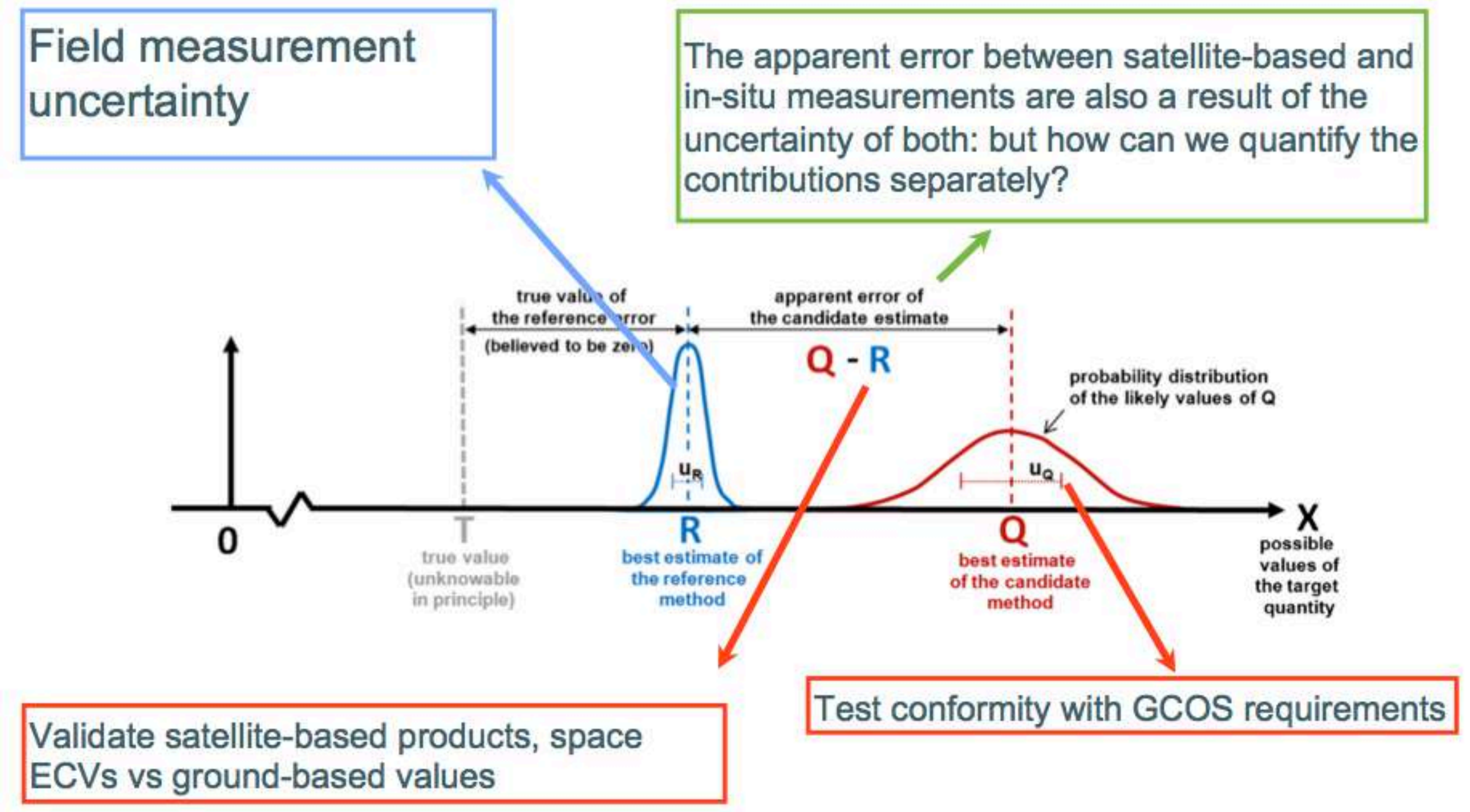
How to validate EO products with in-situ?



- Satellite products and associated uncertainties
- In-situ measurements only **estimates** actual ECV values

Copernicus Ground-Based Observations for Validation (GBOV) VERSION 2

https://land.copernicus.eu/global/gbov

USA_BAR	BarlettExperimentalForest	44.063901	-71.287308	MixedForest
USA_BLA	BlandyExperimentalFarm	39.06026077	-78.07164001	DeciduousBroadleaf
USA_CPE	CentralPlainsExperimentalRange	40.81555	-104.74566	Grassland
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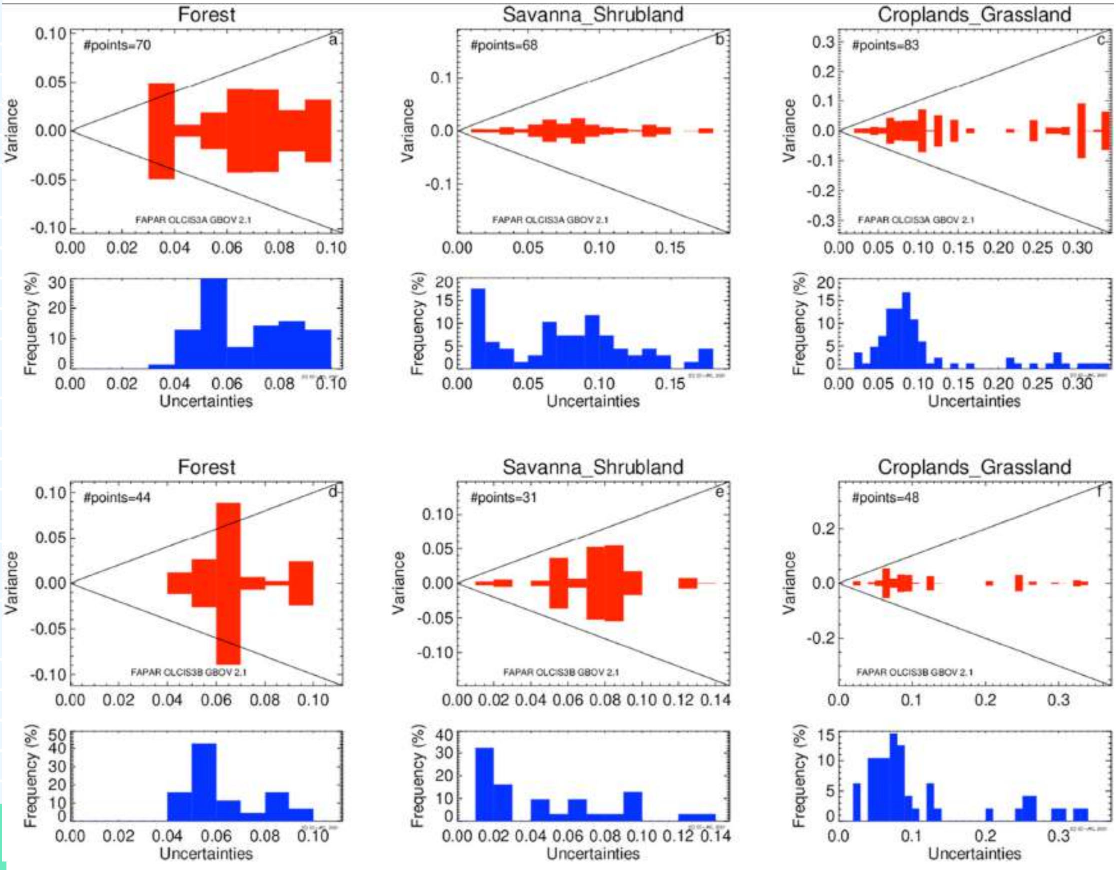
USA_WOO	Woodworth	47.12823105	-99.24136353	Grasslands
GER_HAIN	**Hainich**	**51.07920074**	**10.4522**	**MixedForest**
AUS_WOMB	**WombatStringbarkEucalypt**	**-37.4222**	**144.0944**	**EvergreenBroadleaf**
AUS_LITC	**Litchfield**	**-13.18**	**130.79**	**WoodySavanna**
AUS_TUMB	**Tumbarumba**	**-35.65652**	**148.15163**	**EvergreenBroadleaf**
ESP_VASN	**ValenciaAnchorStation**	**39.57072067**	**-1.288220048**	**Cropland**

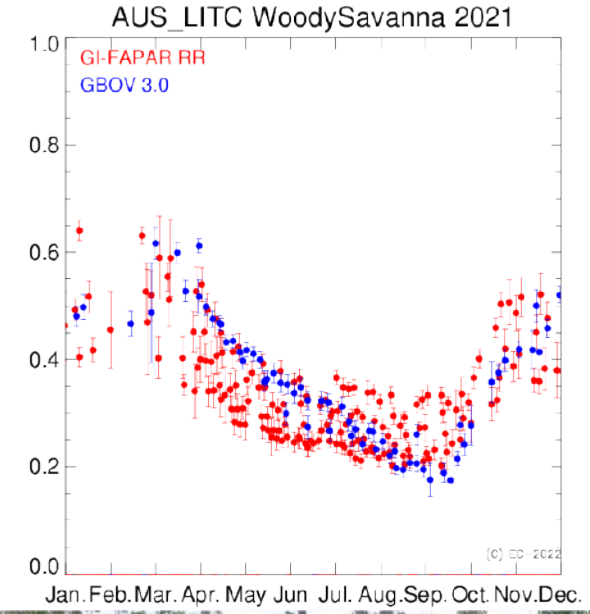


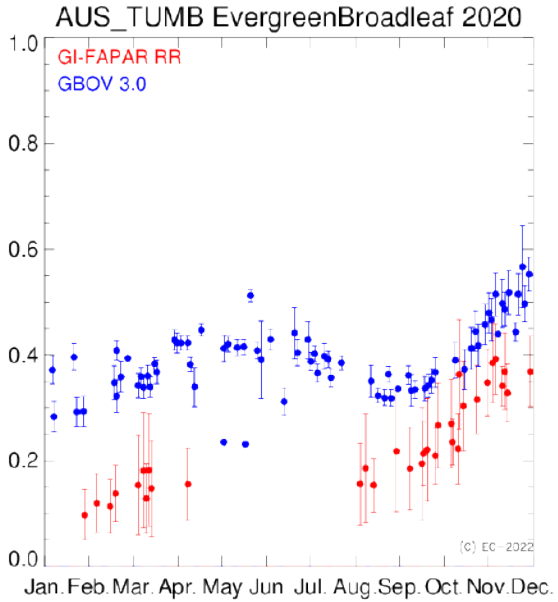
Gobron, N. et al, Evaluation of Sentinel-3A and Sentinel-3B ocean land colour instrument green instantaneous fraction of absorbed photosynthetically active radiation, Remote Sensing of Environment, Volume 270, 2022,12850, SSN 0034-4257, https://doi.org/10.1016/j.rse.2021.112850.

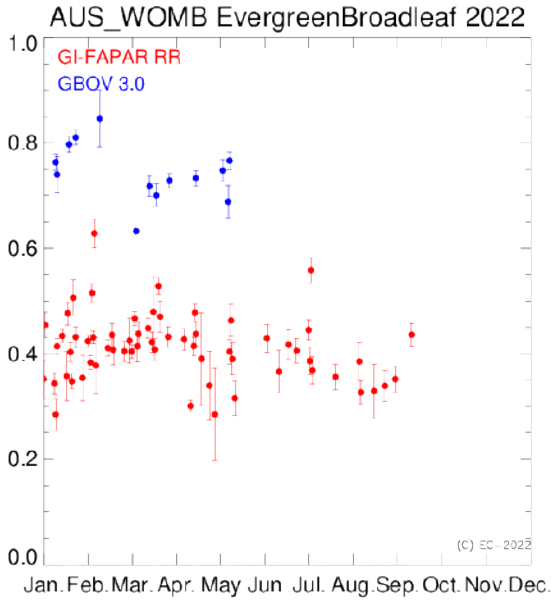
https://land.copernicus.eu/global/gbov/news/

Copernicus -GBOV – Version 3 2020-2022 New Sites

AUS_WOMB	Wombat Stringbark Eucalypt	-37.4222	144.0944	Evergreen Broadleaf
AUS_LITC	Litchfield	-13.18	130.79	Woody Savanna
AUS_TUMB	Tumbarumba	-35.6565	148.1516	Evergreen Broadleaf

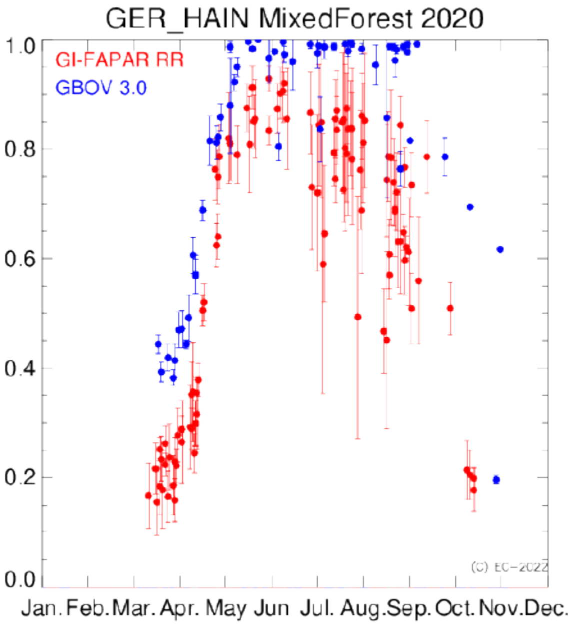


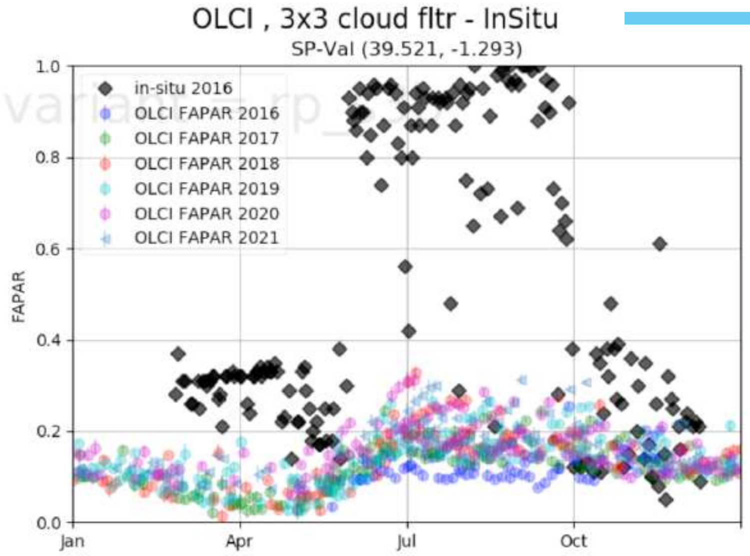


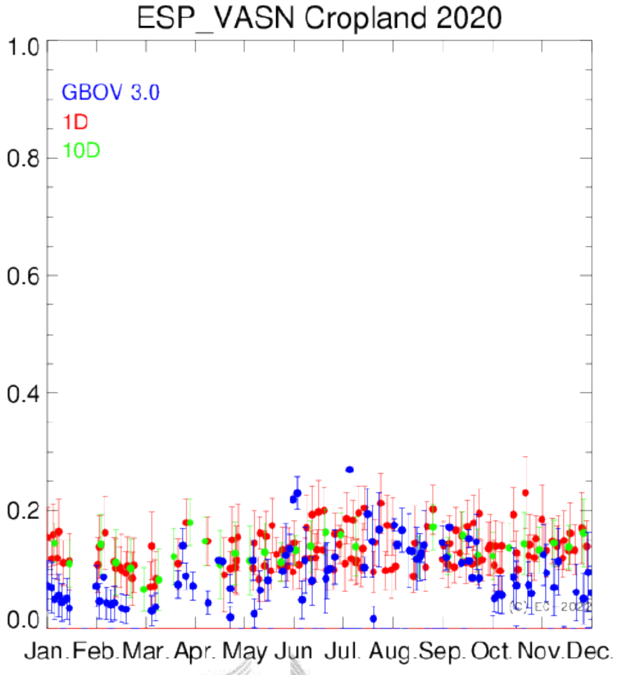


Copernicus -GBOV – Version 3
2020-2022 New Sites

GER_HAIN	Hainich	51.0792	10.4522	Mixed Forest
ESP_VASN	Valencia Anchor Station	39.5707	-1.2882	Cropland

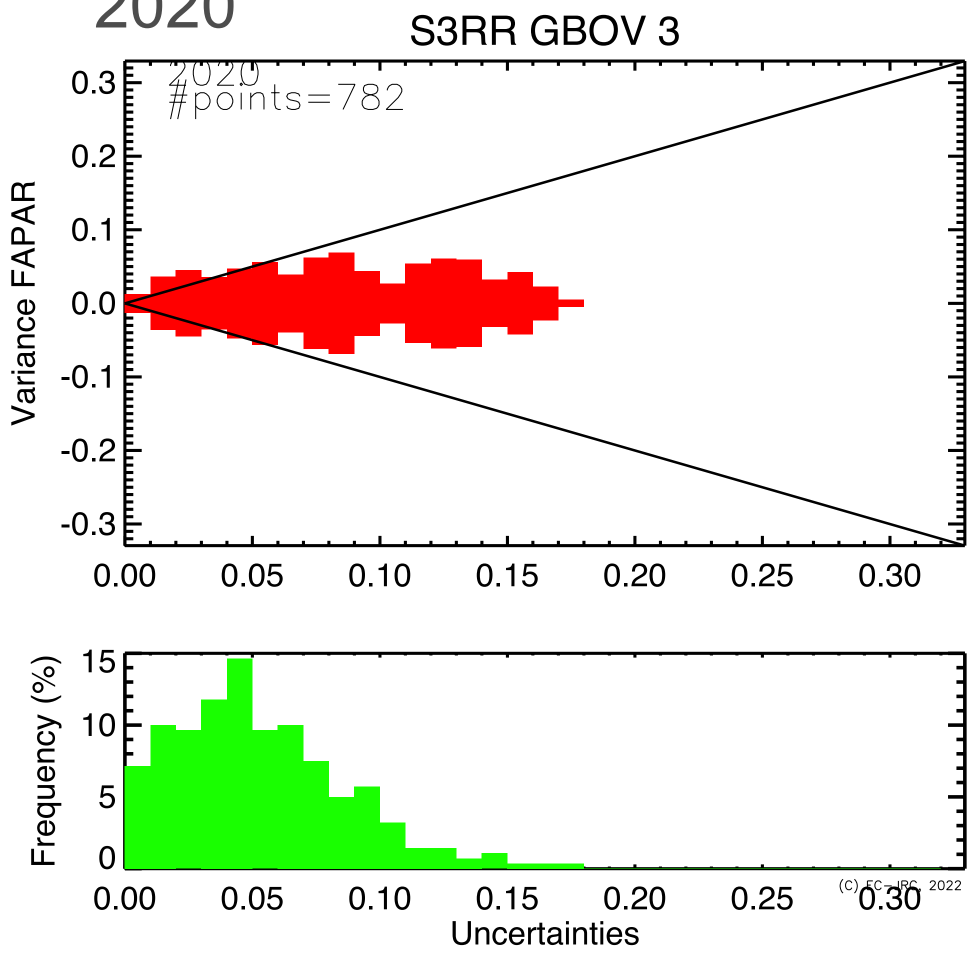




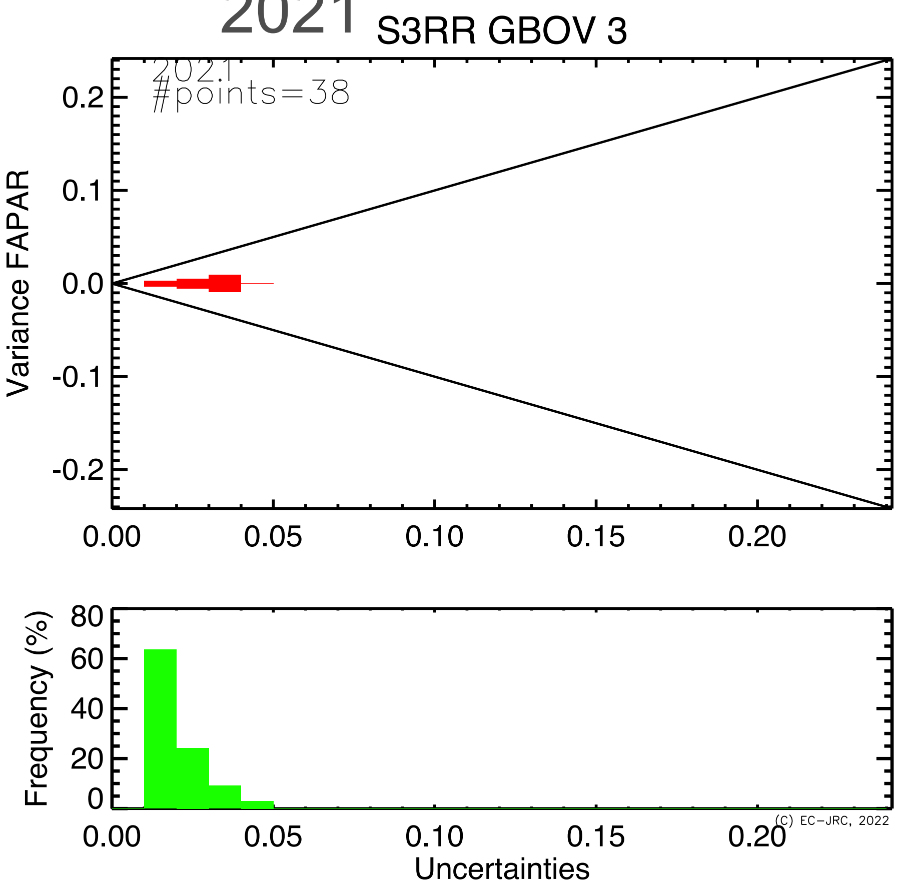


Results for 2020 & 2021 – GBOV 3.0(3.1)

2020



2021



IN>80 %

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https://ccvs.eu/

Background: Level 3

Mittaz et al. (2019) [46] highlighted the actual issues with historical Earth Observation (EO) time series to analyse environmental or climatic change, given the complex forms of uncertainty that could contribute in time series of Level-3 and Level-4. In this paper, Level-4 is defined as "Spatio-temporally complete fields on a regular grid" rather than model output.

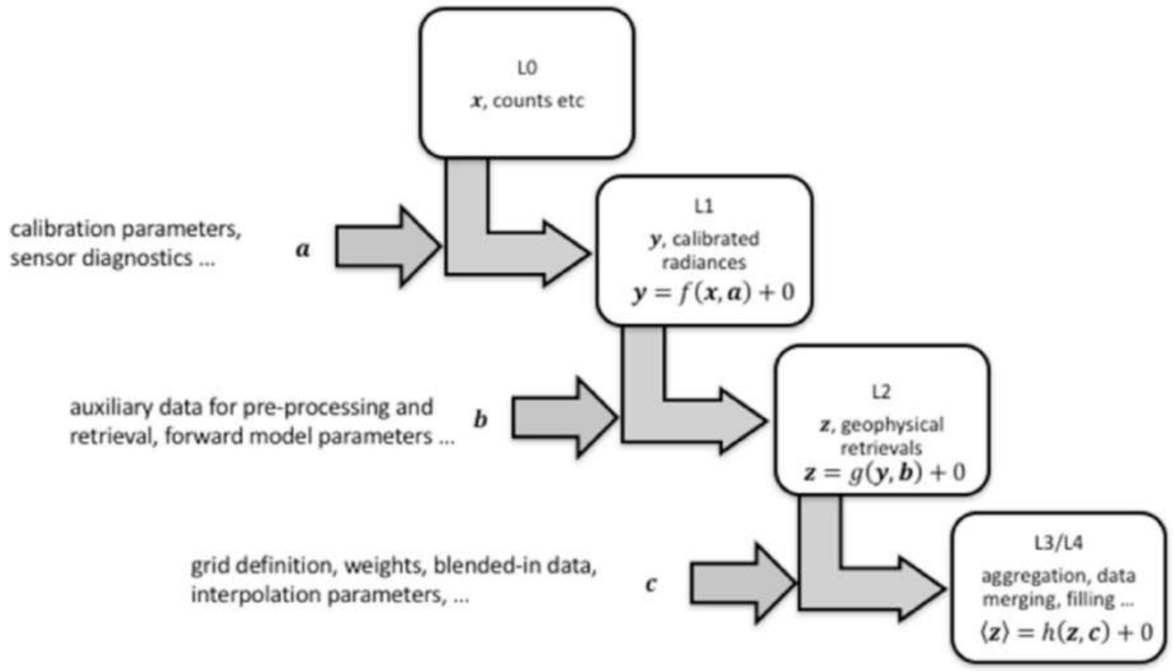

Figure 1 Relationship of satellite data processing levels from level 0 to 3+. Source: Mittaz et al. (2019) [1]

According to the Committee on Earth Observation Satellites (CEOS) and ISO/TS 19159-1 [31] definition, Level 3 refers to the "data or retrieved environmental variables which have been spatially and/or temporally re-sampled (i.e., derived from Level-1 or 2 products), usually with some completeness and consistency. Such re-sampling may include averaging and compositing" whereas **Level 4 corresponds to "model output or results from analyses of lower-Level data (i.e., variables that are not directly measured by the instruments, but are derived from these measurements)".**

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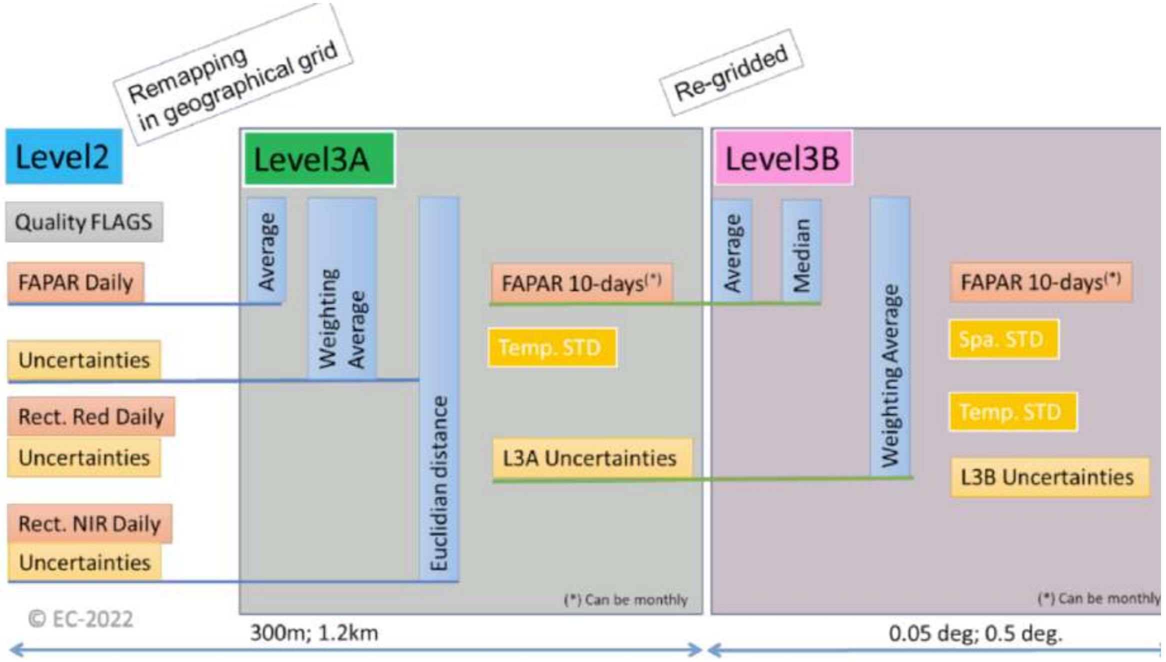
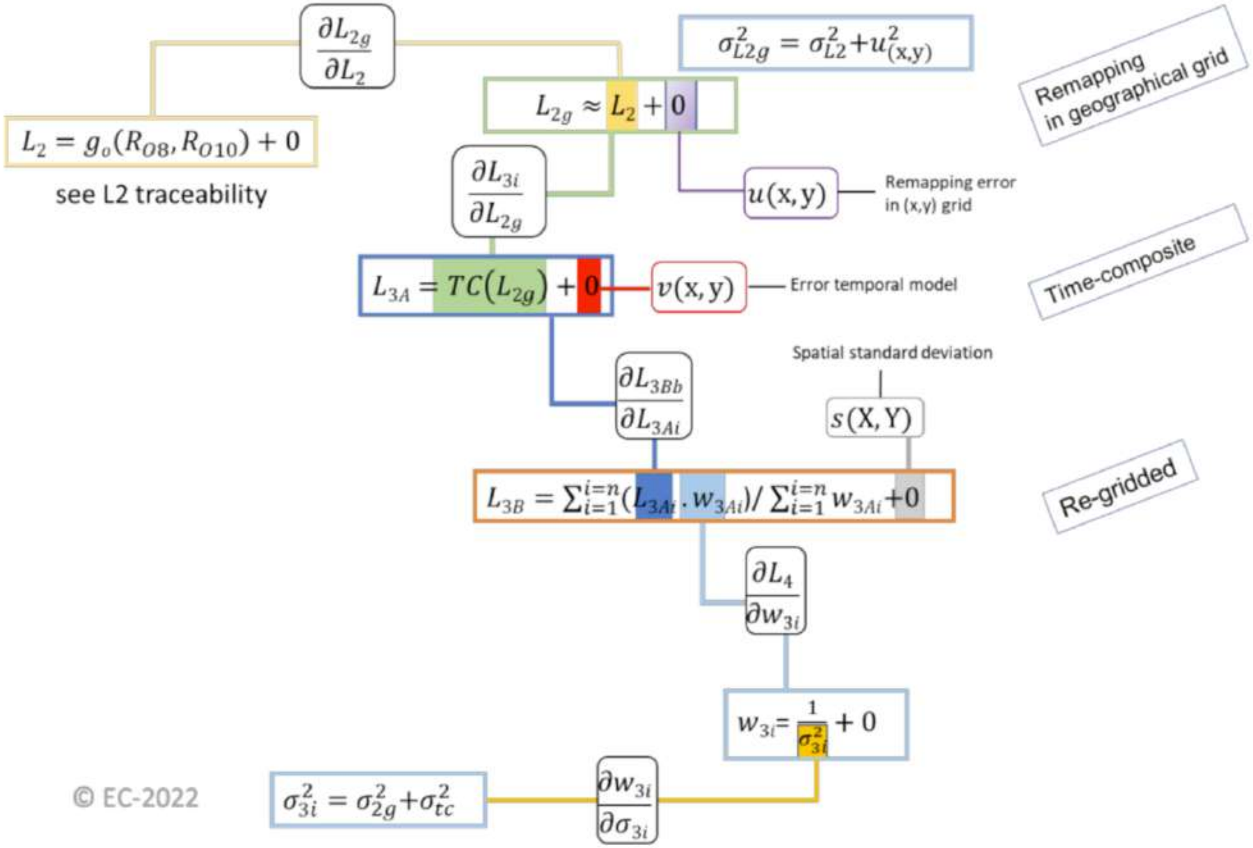
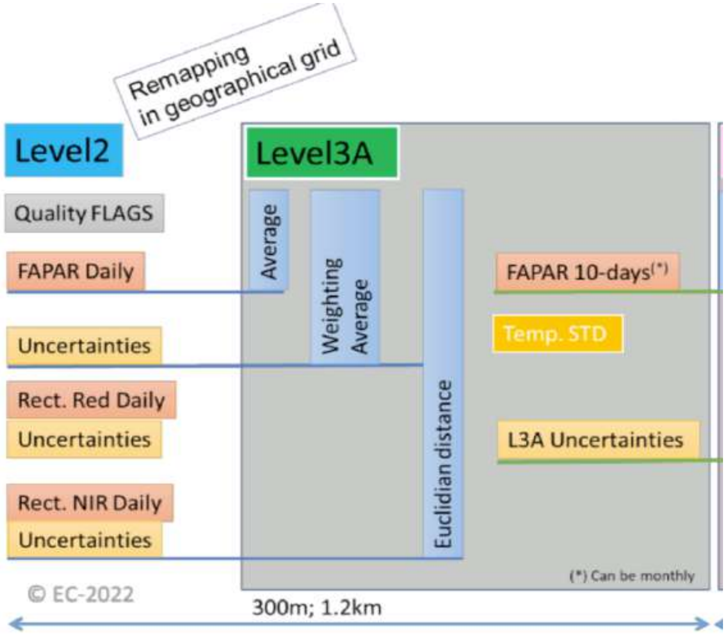
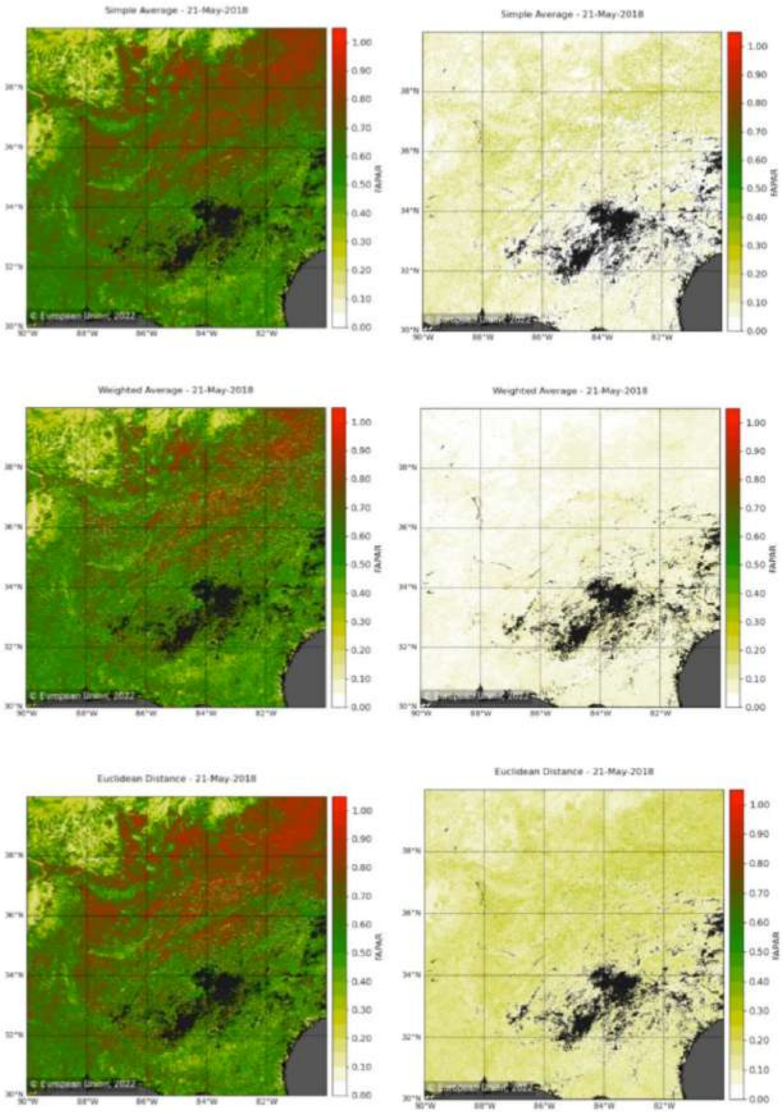
Level 3 GI-FAPAR

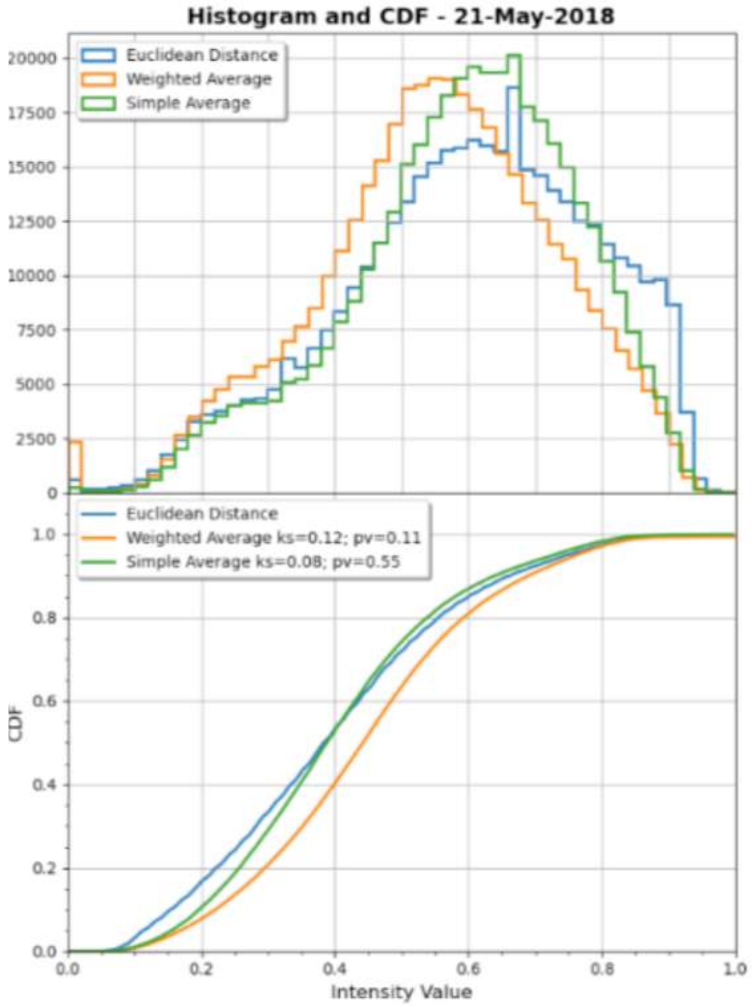




Level 3 GI-FAPAR



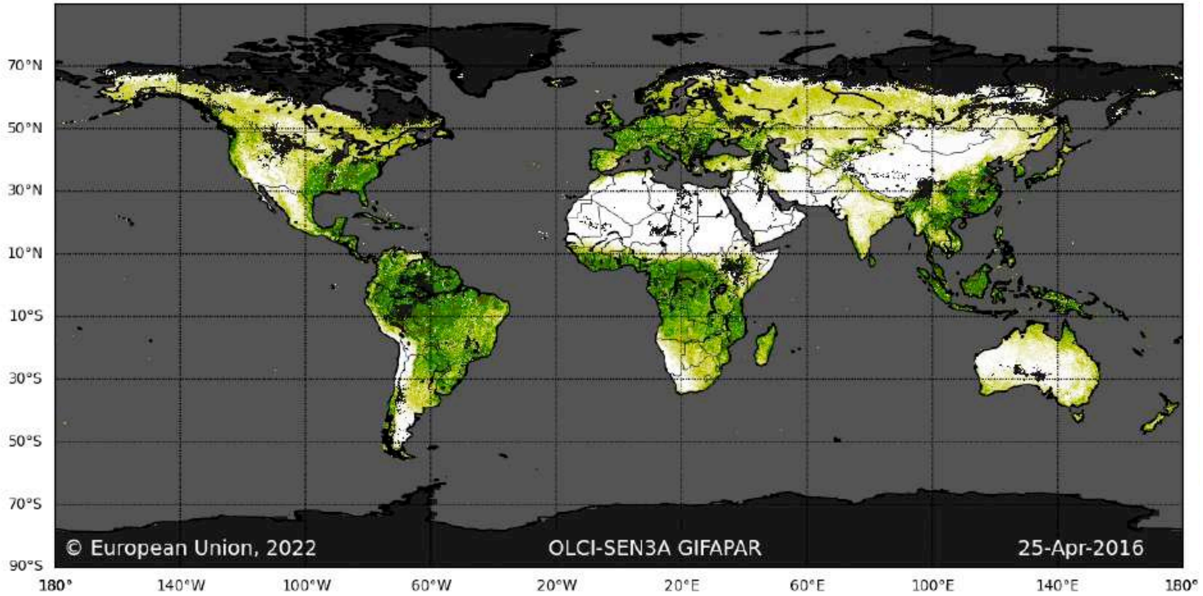


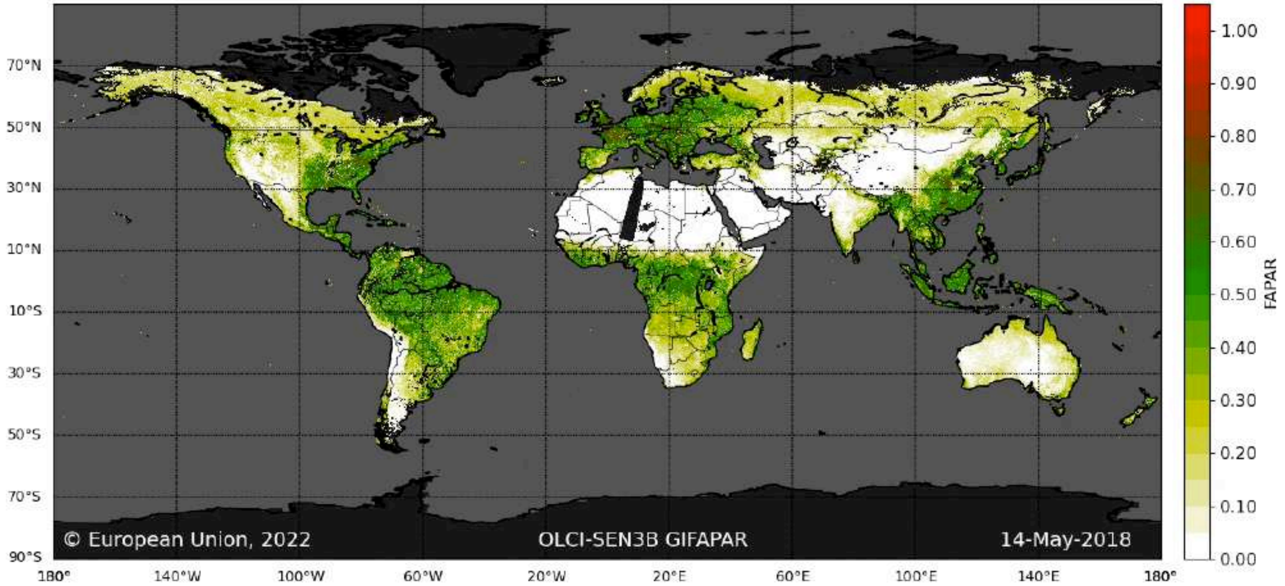


Level 4 GI-FAPAR OLCI

Sentinel3A

Sentinel3B





View @0.05 deg.

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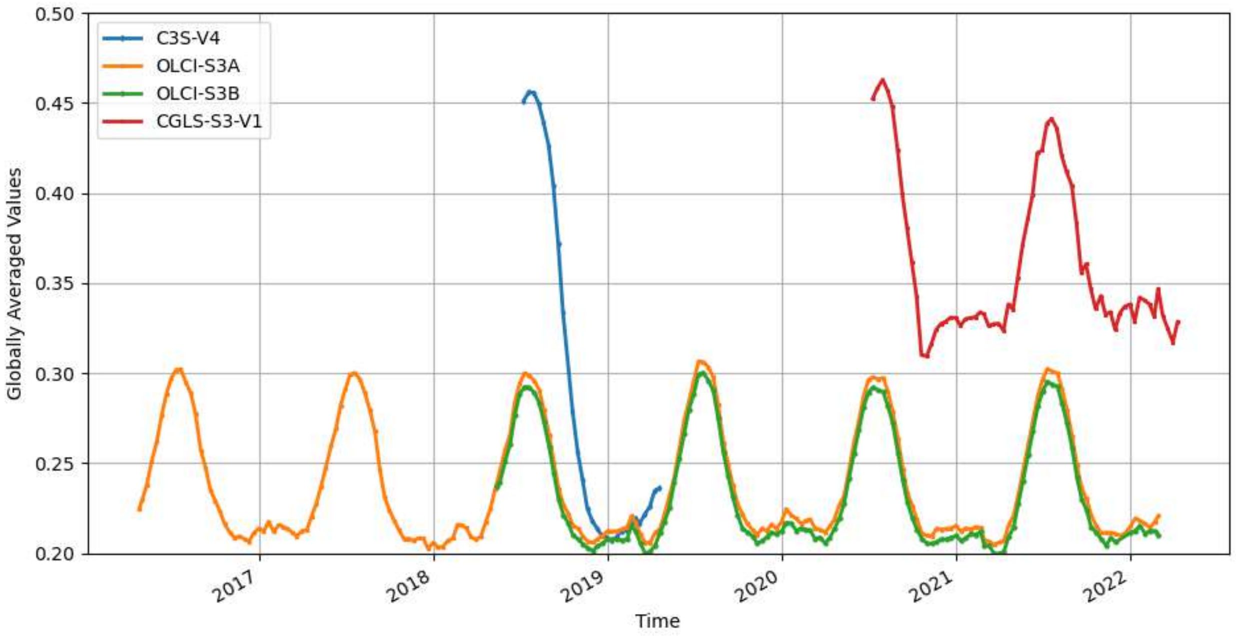
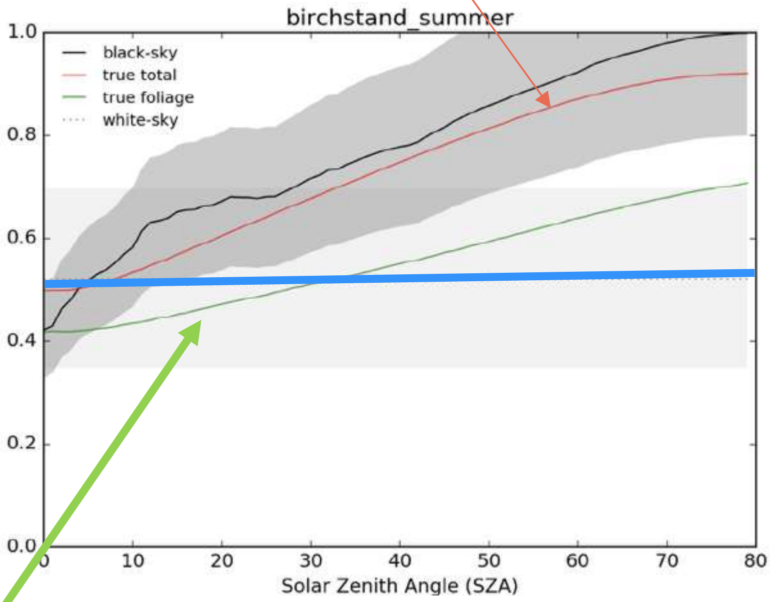
Global OLCI Copernicus Products



Standard Leaf Diffuse FAPAR

Leaf Instantaneous FAPAR



Green Instantaneous FAPAR

Summary

- Uncertainties G-FAPAR budget chain was designed using FIDUCEO concept at level 2 and level 3. Some information is still missing … need R&D and … spare times.

- In-situ data: New data (**new sites and new up-scaling**) from GBOV based on DHP images.

- **Next**: **Use GBOV reference data from Fapar network**, not yet up-scaled, that can be used as better fit the definition on OLCI products.

Tumbarumba FAPAR network in operation

Published on 2019-10-10 17:12

4 fluxes PAR network (19 nodes) is now in operation on TERN Tumbarumba site to support EO data validation. Congrats to Darius Culvenor (http://sensingsystems.com.au) & William Woodgates (https://csiro.au) for the great job!

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Thank you

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