Land Surface Radiation/Albedo Focus Area

CEOS LPV Plenary 2025

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Outline

- **Status and updates**
  - Follow up from 2023 Action Items and Other Completed Activities
- **2025 – 2027 Action items**
  - House Keeping
  - Action Items
- **Conclusions**

Status and Updates

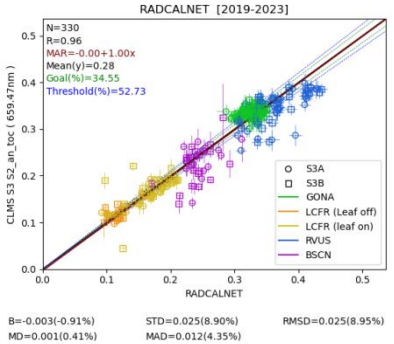
- **Follow up from 2023 Action Items and Other Completed Activities**
  - Sentinel-3/OLCI +SLSR based albedo product validation for the continuity of the Copernicus C3S Climate Data Record.
  - Moderate spatial resolution albedo products (e.g. Landsat, Sentinel-2) validation.
  - MODIS/VIIRS albedo validation efforts.

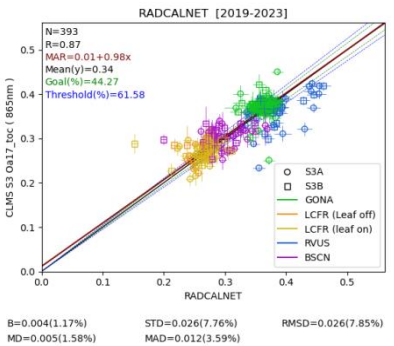
Status and Updates: Sentinel-3 based albedo product validation for the continuity of C3S CDR

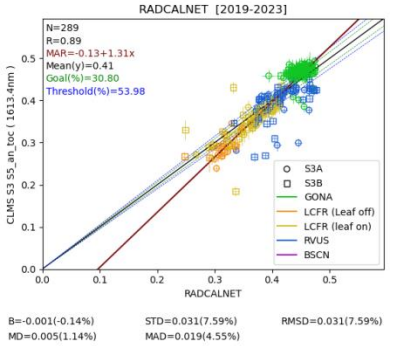
Land Monitoring Service

New version of **Sentinel-3 OLCI+SLSTR TOC-r V2.3**:

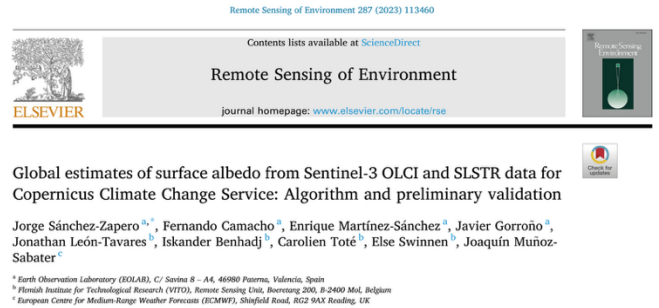
- Improved OLCI & SLSTR co-registration.
- Updated Idepix pre-processing (v2.3.2).
- OLCI & SLSTR calibration coefficients & uncertainties.
- **Direct validation vs. RadCalNet** showed **accuracy < ±2% for most channels**







Climate Change Service



Remote Sensing of Environment 287 (2023) 113460

Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

Global estimates of surface albedo from Sentinel-3 OLCI and SLSTR data for Copernicus Climate Change Service: Algorithm and preliminary validation

Jorge Sánchez-Zapero [a,*], Fernando Camacho [a], Enrique Martínez-Sánchez [a], Javier Gorroño [a], Jonathan León-Tavares [b], Iskander Benhadj [b], Carolien Toté [b], Else Swinnen [b], Joaquín Muñoz-Sabater [c]

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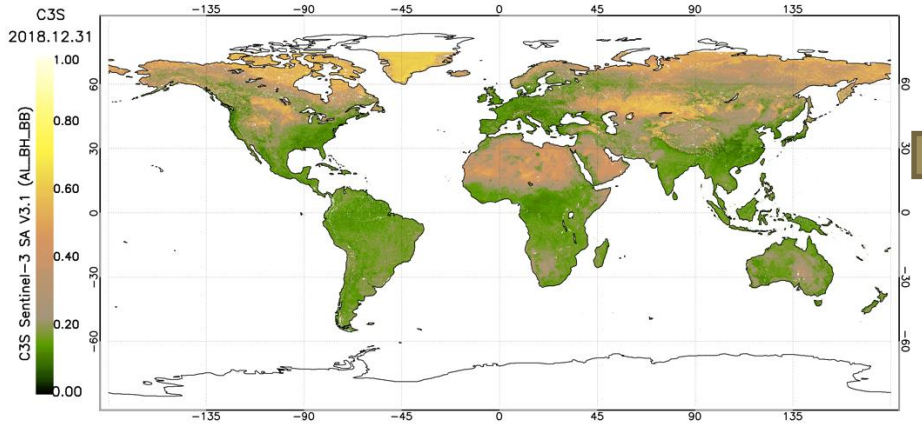
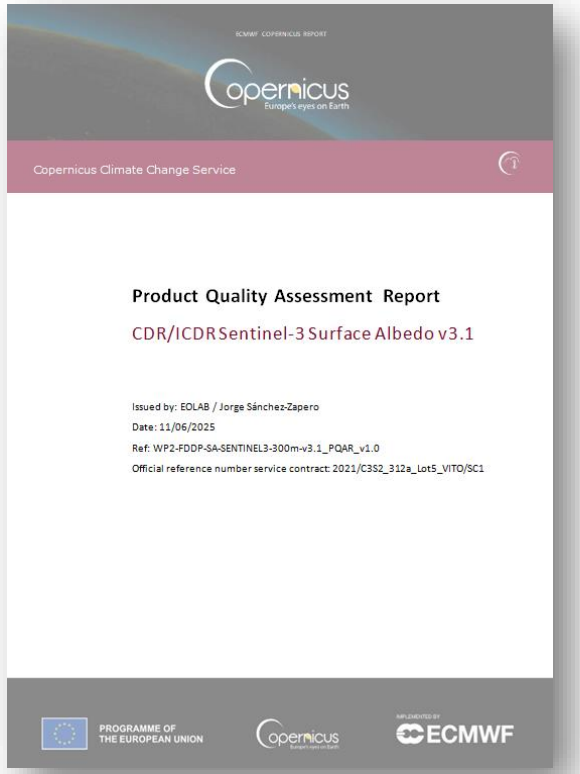
[c] European Centre for Medium-Range Weather Forecasts (ECMWF), Shinfield Road, RG2 9AX Reading, UK

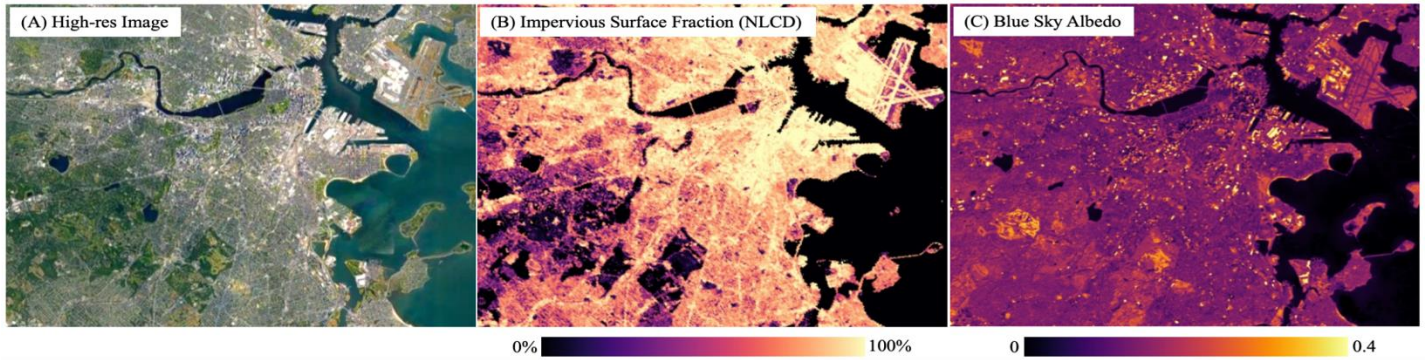




- **2018- 2024**
- Dataset, validation report and product documentation will be available soon in C3S Climate Data Store.
- Validation results in next slides.

Status and Updates: Moderate spatial resolution albedo products (e.g. Landsat, Sentinel-2)

- Product still in progress
  - Developing validation protocols for urban applications of 30m albedo products
  - Currently some funding through LCLUC to develop product and applications for WRF
    - Improving urban climate simulation by integrating remotely sensed high-resolution albedo into the Weather Research and Forecasting (WRF) model



  - Applied to support ET on Landsat Science Team (Funding/Selection TBD)

Status and Updates: Continued MODIS/VIIRS Albedo Validation Efforts

- NASA land product validation paper published.
  - Continuity between NASA MODIS Collection 6.1 and VIIRS Collection 2 land products.
  - Albedo and surface reflectance products show good continuity as we move towards the end of Terra/Aqua/Aura in the next 2 years (or sooner).
  - Sentinel-3 surface reflectance products under development to maintain morning observations.
- SALVAL paper on albedo validation and intercomparison published in Remote Sensing. Validation of 3 existing satellite albedo CDRs (MCD43A3 C6.1, C3S multi-sensor V2, GLASS V4).

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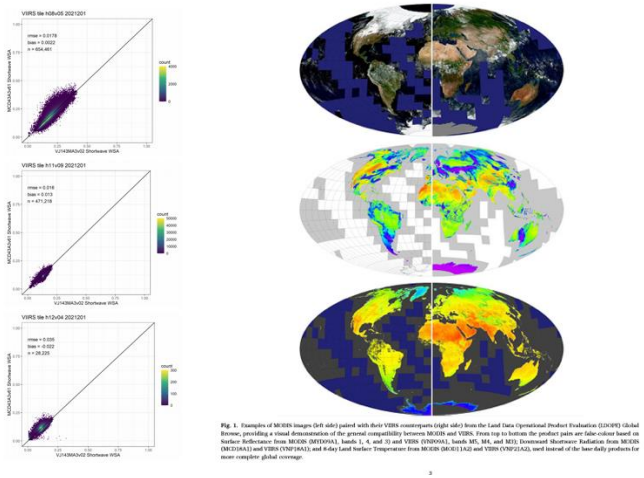
Review

Continuity between NASA MODIS Collection 6.1 and VIIRS Collection 2 land products

Miguel O. Román [a,*], Chris Justice [b], Ian Paynter [a,*], Peter B. Boucher [a], Sadashiva Devadiga [c], Arthur Endsley [e], Angela Erb [f], Mark Friedl [g], Huilin Gao [h], Louis Giglio [b], Josh M. Gray [i,j], Dorothy Hall [k,l], Glynn Hulley [m], John Kimball [e], Yuri Knyazikhin [g], Alexei Lyapustin [n], Ranga B. Myneni [g], Praveen Noojipady [c,d], Jiabin Pu [g], George Riggs [l,d], Sudipta Sarkar [c,d], Crystal Schaaf [f], Deep Shah [h], Khuong H. Tran [o], Eric Vermote [c], Dongdong Wang [b], Zhuosen Wang [c,k], Aisheng Wu [d], Yongchang Ye [o], Yu Shen [o], Shuai Zhang [h], Shuai Zhang [f], Xiaoyang Zhang [o], Maosheng Zhao [c,d], Carol Davidson [c,d], Robert Wolfe [c]



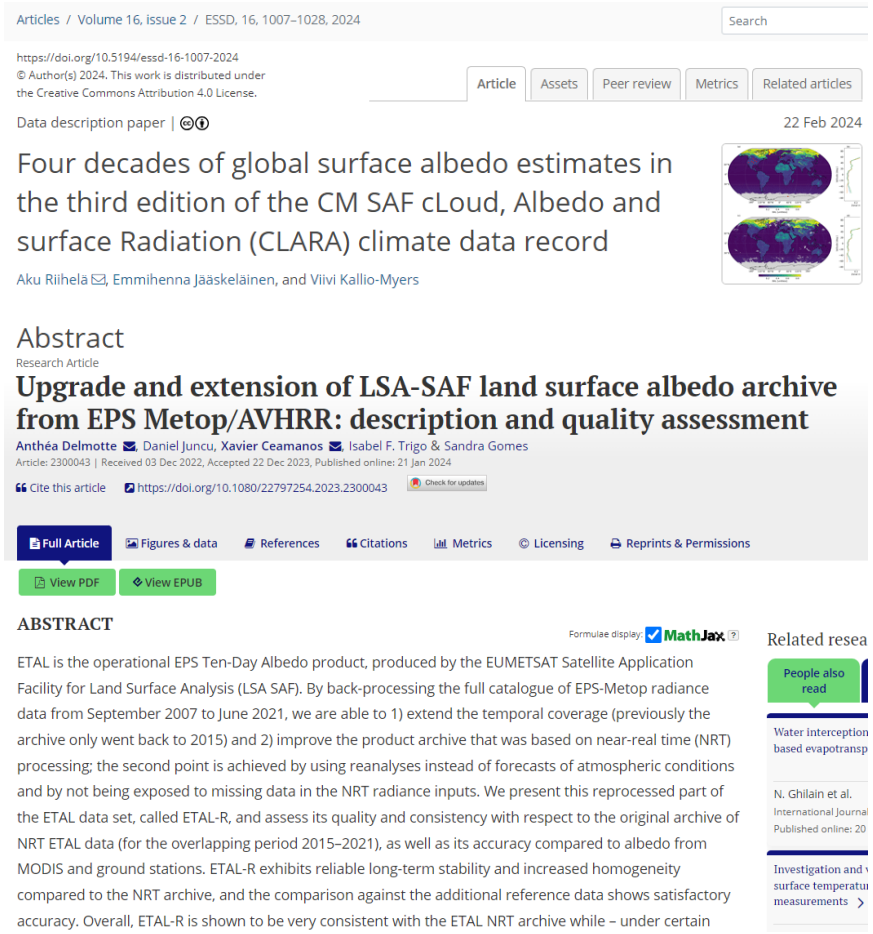
2025-2027 Action Items

- **House Keeping**
  - New/updates to product tables / references.
  - Newsletter / communication / outreach.
  - Global Surface Albedo Product Validation Best Practices Protocol.
  - Annual updates of SALVAL.
- **Action Items**
  - Update Global Surface Albedo Product Validation Best Practices Protocol to reflect current GCOS standards and goals:
    - Review albedo protocol and update, if needed, in response to the latest GCOS requirements.
  - Highlight gaps in albedo validation protocols and practices Promoting new validation and intercomparison exercises (VNP43, VJ143, VJ243, C3S Sentinel-3, EUMETSAT, …).
  - Final draft and distribute Global Downward Radiation Product Validation Best Practices Protocol.
  - SALVAL improvements (LANDVAL V2 global sampling, REALS V1.2 in situ database).
  - Paper on C3S Sentinel-3 (+other SA products) using REALS V1.2.

2025-2027 Action Items: CEOS-LPV Housekeeping

- New/updates to product tables and references
  - Product tables updated in Oct 2024
    - Includes new and updated products like ->
  - References update is currently ongoing.

- Newsletter / communication / outreach
  - Newsletter sent in early 2024 – will work on 2025
  - Website Reviewed in 2024
- Global Surface Albedo Product Validation Best Practices Protocol
  - Not yet been reviewed and updated – tasked for next term
- Annual updates of SALVAL (*conditioned to additional funds*)



Action Items 2025-2027: update surface albedo validation protocol

- Update Global Surface Albedo Product Validation Best Practices Protocol to reflect current GCOS standards and goals
  - Review albedo protocol and update, if needed, in response to the latest GCOS requirements.

Name	Spectral and Broadband (visible, near infrared and shortwave) DHR & BHR with Associated Spectral Bidirectional Reflectance Distribution Function (BRDF) parameters (required to derive albedo from reflectance)				
Definition	The land surface albedo is the ratio of the radiant flux reflected from Earth's surface to the incident flux. Each spectral/broadband value depends on natural variations and is highly variable in space and time as a result of terrestrial properties changes, and with illumination conditions.				
Unit	Dimensionless				
Note	Length of record: Threshold: 20 years; Target: > 40 years				
Requirements					
Item needed	Unit	Metric	[1]	Value	Notes
Horizontal Resolution	m		G	10	Due to the heterogeneous nature of terrestrial surfaces, having surface albedo at such scale will increase accuracy for further assimilation of local/regional climate model.
			B		
			T	250	Enable assimilation in earth/climate model.
Vertical Resolution			G	-	N/A
			B	-	
			T	-	
Temporal Resolution	day		G	1	For climate change services. Multi-angular instruments (including geostationary) and/or accumulation of daily data for BRDF parameters retrieval.
			B		
			T	10	For assimilation in earth/climate model. Same as above as mono-angular
Timeliness	day		G	1	For climate change services.
			B		
			T	5	For NRT reanalysis.
Required Measurement Uncertainty	%	1 standard deviation or error covariance matrix, with associated PDF shape (functional form of estimated error distribution for the term)	G	3% for values ≥0.05; 0.0015 (absolute value) for smaller values	"A change of 1% to the Earth's albedo has a radiative effect of 3.4 W/m²" Over snow-free and snow-covered land, climate, biogeochemical, hydrological, and weather forecast models require this uncertainty.
			B		
			T	5% for values ≥0.05; 0.0025 for smaller values	See Ohring, et al. 2005
Stability	% / decade	A factor of uncertainties to demonstrate that the 'error' of the product remains constant over the period, typically a decade or more	G	< 1 %	Rate of change of surface albedo over the available time period (per decade). The required stability is some fraction of the expected signal' (see Ohring, et al. 2005)
			B		
			T	< 1.5 %	

The requirements are expressed in terms of five criteria:

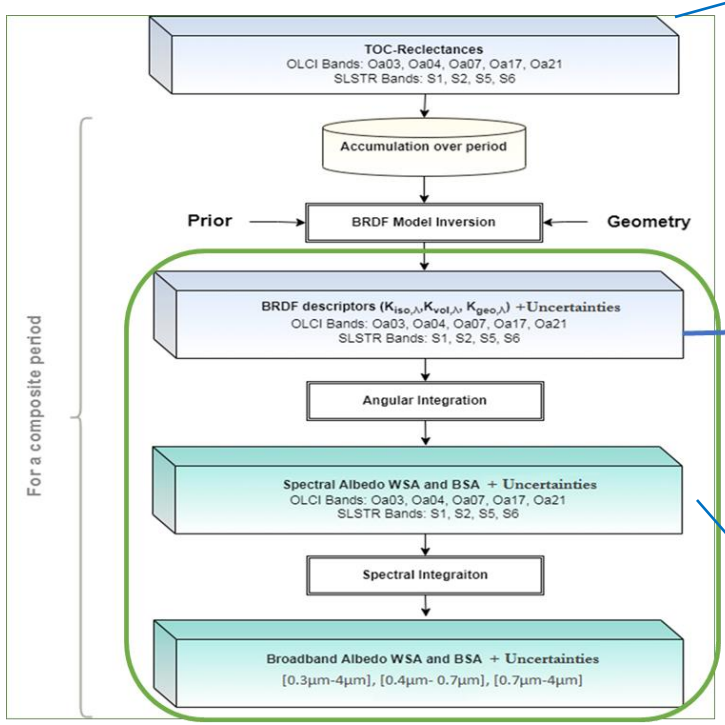
1. Spatial Resolution - horizontal and vertical (if needed).
2. Temporal resolution (or frequency) – the frequency of observations e.g. hourly, daily or annual.
3. Measurement Uncertainty – the parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand (GUM)1. It includes all contributions to the uncertainty, expressed in units of 2 standard deviations, unless stated otherwise.
4. Stability – The change in bias over time. Stability is quoted per decade.
5. Timeliness - The time expectation for accessibility and availability of data. In this

Implementation Plan, for each of these criteria, a goal, breakthrough and threshold value are presented. These are defined as:

- Goal (G): an ideal requirement above which further improvements are not necessary.
- Breakthrough (B): an intermediate level between threshold and goal which, if achieved, would result in a significant improvement for the targeted application.
- Threshold (T): the minimum requirement to be met to ensure that data are useful. For each ECV product, a definition and units are provided together with the requirements.

Action Items 2025-2027: gaps in albedo validation and promoting new intercomparison exercises

- Highlight gaps in albedo validation protocols and practices Promoting new validation and intercomparison exercises (VNP43, VJ143, VJ243, C3S Sentinel-3, EUMETSAT, …)



GCOS ECV definition: BRDF param. + spectral albedo + broadband albedo

Validation of Sentinel-3 TOC reflectance was performed in the context of Copernicus services, mainly based on comparison with RadCalNet → next publication is expected

Surface albedo validation is commonly focused on broadband albedos, but spectral albedos and BRDF parameters should be validated in response to CGOS, as they are included in the ECV definition

BRDF validation can be based on:

- satellite product intercomparison
- new approaches based on ground data: **Eric Vermote et al., LPVE23**
- New approaches such as Synergetic retrieval of AERONET and satellite measurements: **Pavlo Lytvynov et al., LPVE23**

Spectral albedo validation:

- Should be based in similar approach than broadband albedos: direct validation with tower-based in situ data and product intercomparison

Action Items 2025-2027: Global Downward Radiation Product Validation Best Practices Protocol

- Final draft and distribute Global Downward Radiation Product Validation Best Practices Protocol

- Global Downward Radiation Product Validation Best Practices Protocol *-First draft*

  1. INTRODUCTION

  2. DEFINITIONS

  3. GENERAL CONSIDERATIONS FOR SATELLITE SURFACE DOWNWARD RADIATION PRODUCTS

  4. GENERAL CONSIDERATIONS FOR DOWNWARD RADIATION REFERENCES (Leading author: Christian Lanconelli)

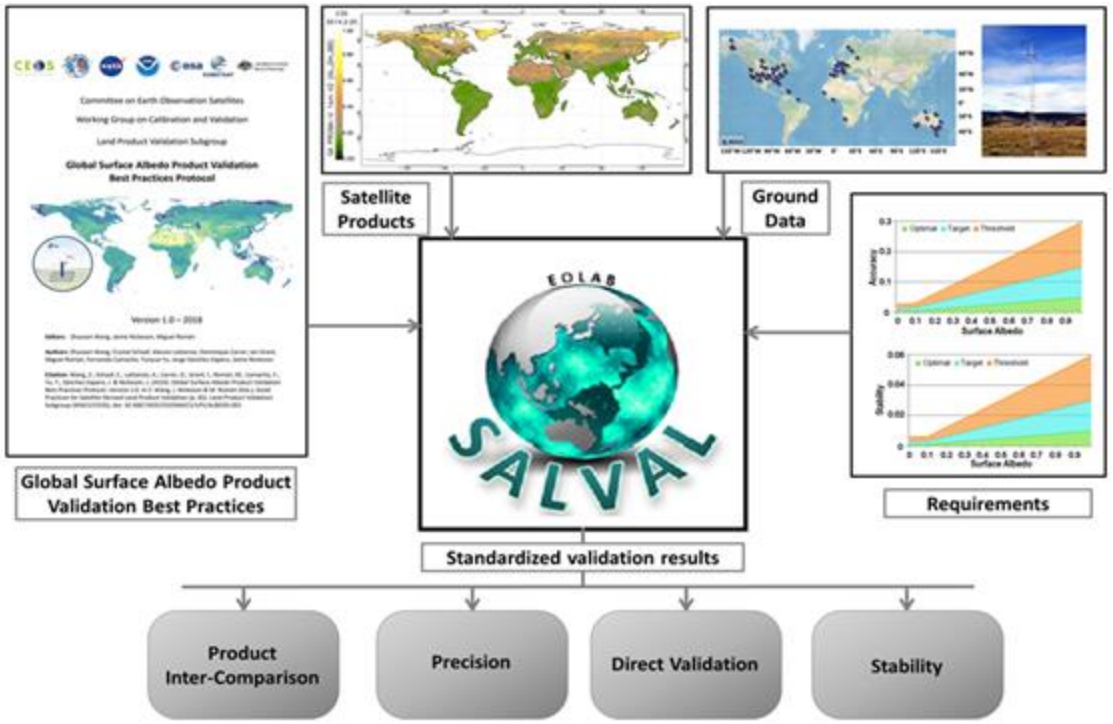
  5. GENERAL STRATEGY FOR THE VALIDATION OF SURFACE DOWNWARD RADIATION PRODUCTS (Leading author: Dongdong Wang)

  6. CONCLUSIONS

  Green: completed Red: under development

Action Items 2025-2027: SALVAL improvements

SALVAL achievements: new satellite datasets



Existing SATELLITE datasets:

Product	Start period	End period
CGLS VGT V1	2000-01-01	2014-05-31
C3S VGT V1	2000-01-01	2014-05-31
C3S VGT V2	2000-01-01	2014-05-31
C3S PBV V1	2013-12-23	2020-06-30
C3S PBV V2	2013-10-31	2020-06-30
C3S S3 V3.1	2018-06-01	2021-12-31
GlobAlbedo	2000-01-01	2011-12-31
GLASS V4	2000-01-01	2019-12-31
MCD43A3 C61	2000-02-24	2022-12-31
VNP43MA3 V1	2012-01-20	2022-12-31
VNP43MA3 V2	2018-01-01	2024-12-31
LSASAF AVHRR	2018-01-01	2024-12-31

New datasets were incorporated:

VIIRS VNP43 C2 (new C2 replaces previous C1)

EUMETSAT LSA SAF AVHRR (new incorporation)

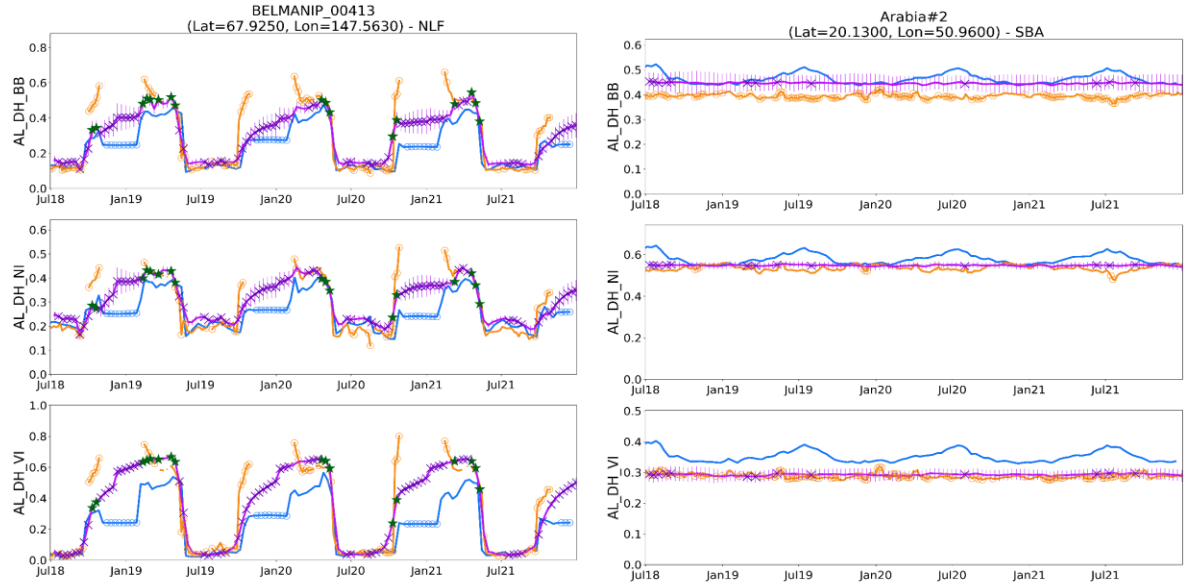
C3S Sentinel-3/OLCI+SLSTR v3.1 (recently produced)

SALVAL allows to incorporate new developed products

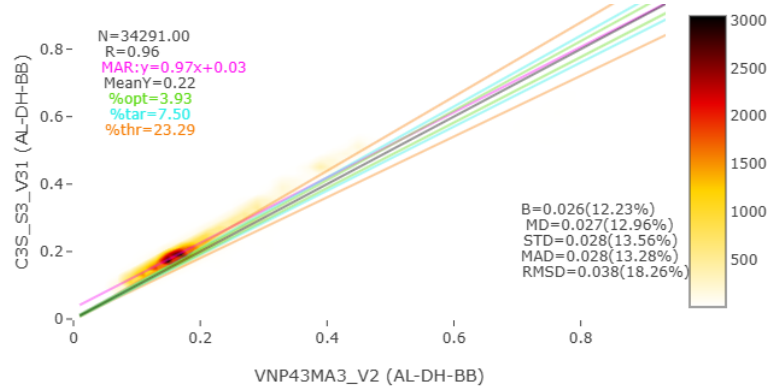
Action Items 2025-2027: SALVAL improvements

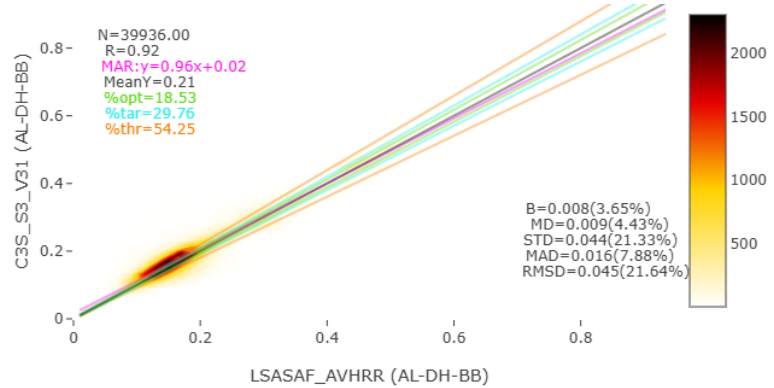
SALVAL achievements: intercomparison new satellite datasets

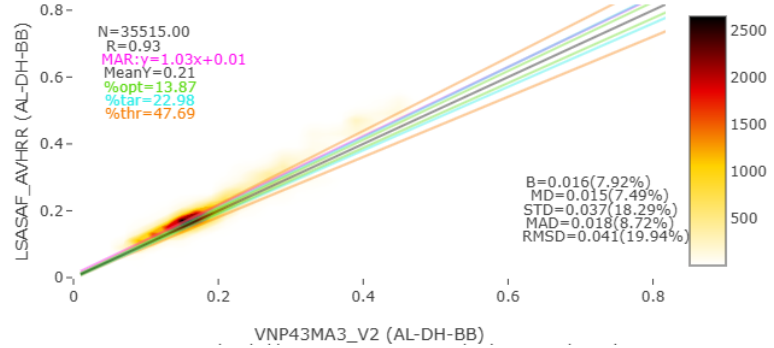
	AL-DH-BB	
	Intra-annual precision (Median δ)	**Inter-annual precision** (median absolute deviation)
Climate Change Service **C3S Sentinel-3/OLCI+SLSTR v3.1**	0.0024	**0.002 (0.47%)**
NASA **VIIRS VNP43 C2**	**0.0014**	0.004 (1.03%)
EUMETSAT LSA SAF **EUMETSAT LSA SAF AVHRR**	0.0025	0.004 (0.96%)



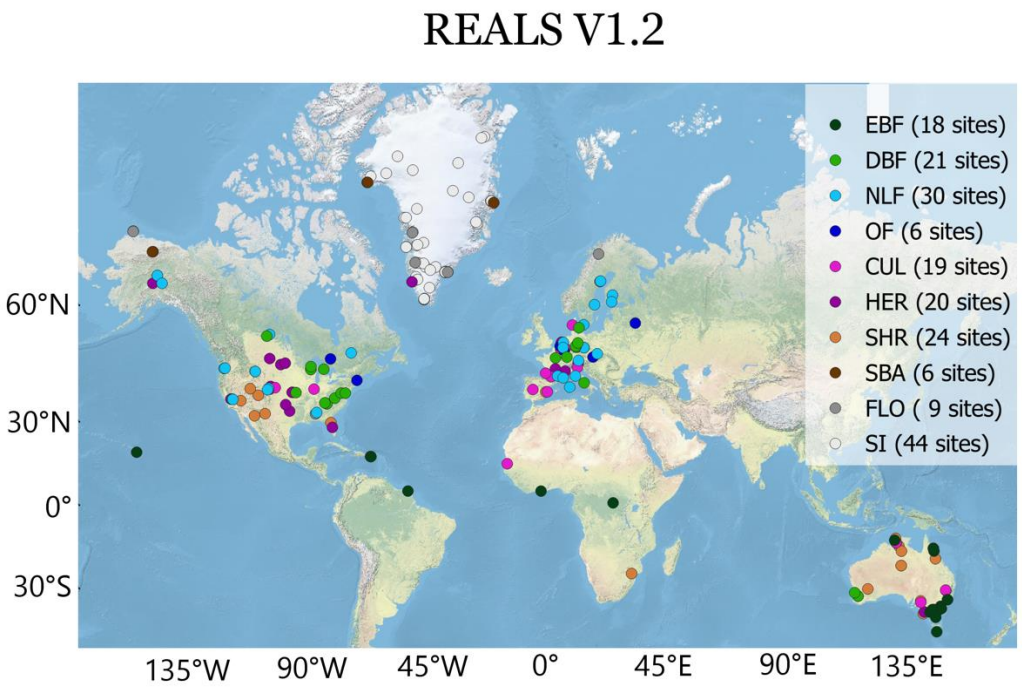
C3S S3 V31 X No data ★ Snow - NASA VIIRS V2 - LSA SAF AVHRR ○ low quality







SALVAL achievements: development new in situ database



Ground data: Representativeness-Evaluated ALbedo Stations (REALS) v1.2

A unique high quality-controlled sub-set of **in situ measurements** selected from tower-based stations that meet the CEOS LPV validation standards (including spatial representativeness)

- **Update from 99 to 197 stations.**
- A review of previous version was performed, removing some stations over heterogeneous landscapes.
- 44 PROMICE stations **over permanent Snow and Ice** (SI) in Greenland were included.

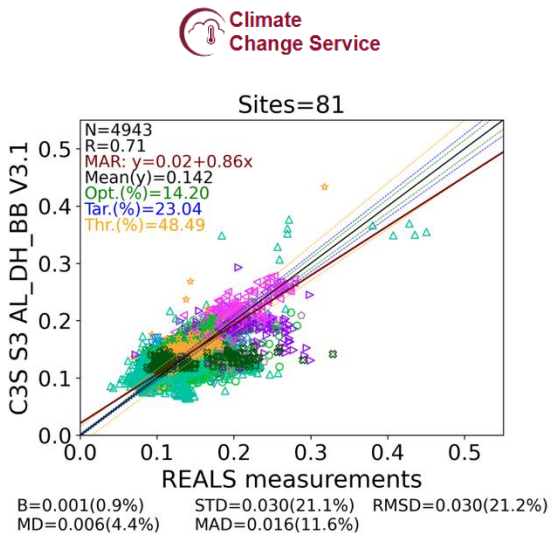
→ the main limitation is the gap in under-sampled areas (South America, Africa, Asia)

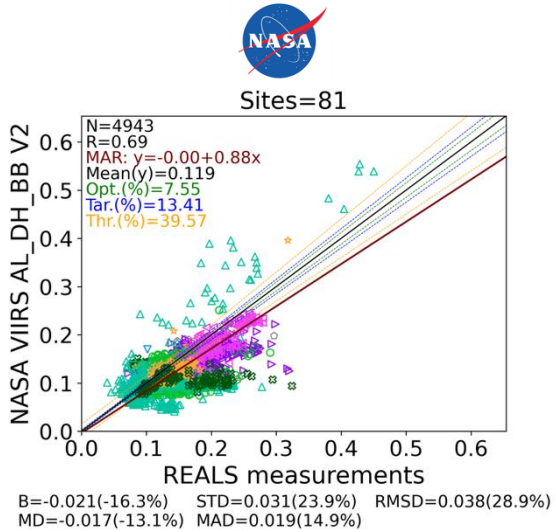
SALVAL achievements: development new in situ database

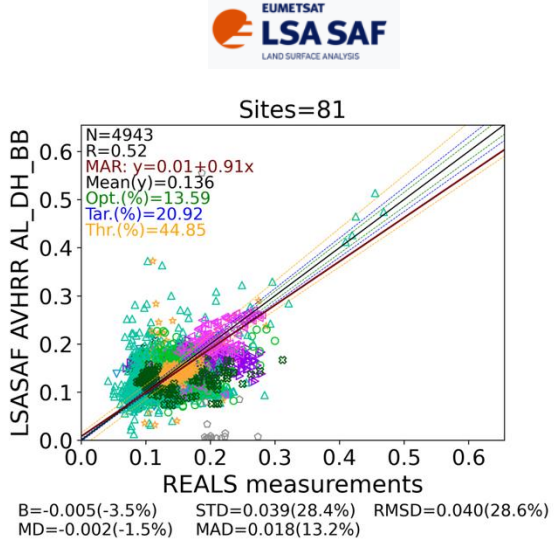
Direct validation of new satellite datasets:

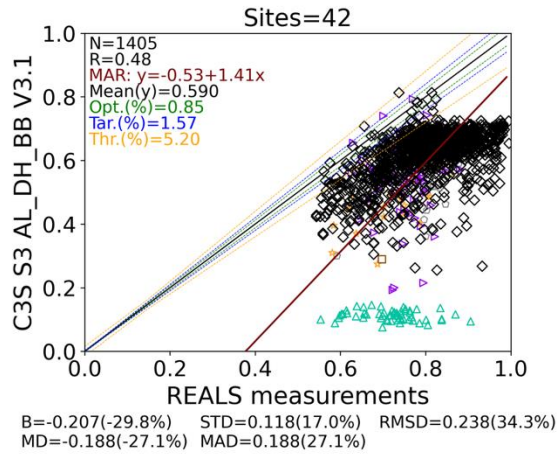
Snow-free pixels

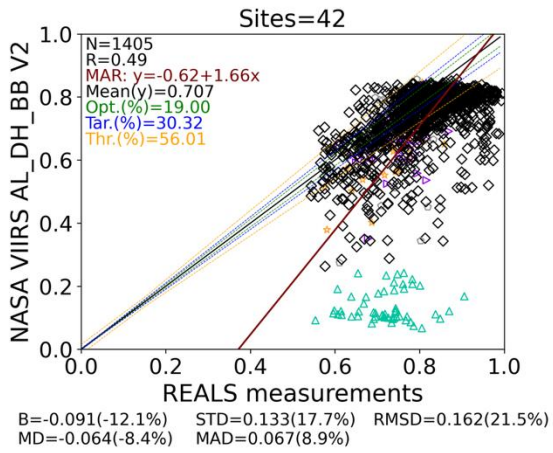
Snow pixels

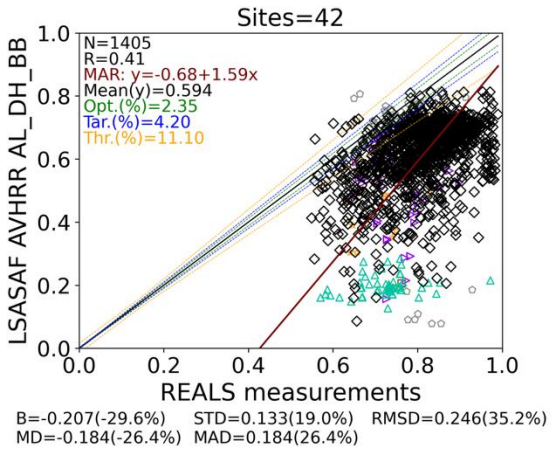












SALVAL – new achievements

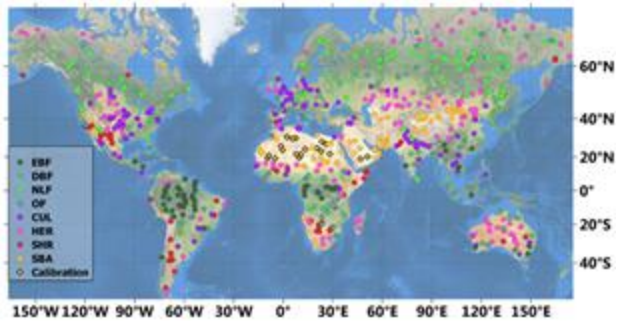
- Incorporation new datasets for a limited period: C3S Sentinel-3, NASA VIIRS VNP43 V2, EUMETSAT LSA SAF AVHRR
- Intercomparison of new datasets
- Development of new in situ database (REALS V1.2)

SALVAL – plan and needs (to be implemented)

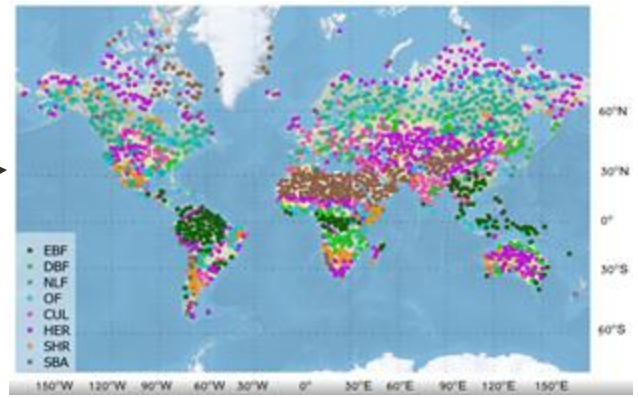
- **Needs for maintenance (annual update).**
- **Needs for two main improvements based on new developments**:
  - Incorporation new REALS V1.2 database for direct validation → **From 99 to 197 stations** (developed and tested but no incorporated)
  - Improve sampling scheme by using LANDVAL V2 global sampling for product intercomparison → **from 720 to 2000 sites**
  - Needs to update product database based on new sampling schemes.

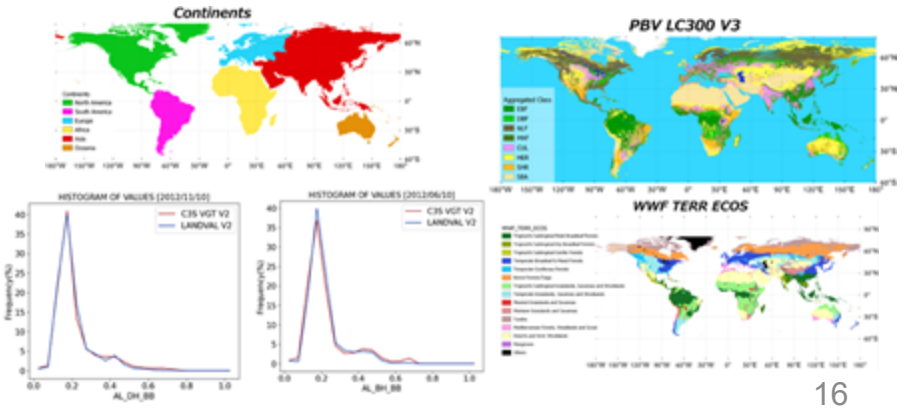
For this funding is required (QA4EO ??)

720 Sites LANDVAL V1



2000 Sites LANDVAL V2





Paper on validation of C3S Sentinel-3/OLCI+SLSTR (+ other surface albedo products: NASA VIIRS V2, EUMETSAT LSA SAF AVHRR)

- Product intercomparison based on existing results.
- Direct validation using REALS V1.2, with attention to snow albedo

Conclusions

- **Status and updates:**
  - new C3S Sentinel-3/OLCISLSTR was produced albedo, moderate resolution, Continued MODIS/VIIRS Albedo Validation Efforts.
- **2023-2027 Action items**:
  - CEOS-LPV Housekeeping.
  - Review and update (if needed) surface albedo validation protocol based on GCOS requirements.
  - Identify albedo validation gaps and promote new intercomparison exercises.
  - Global Downward Radiation Product Validation Best Practices Protocol → final stages.
  - SALVAL ACHIEVEMENTS:
    - Incorporation and intercomparison new satellite datasets (C3S S3/OLCI+SLSTR V3.1, NASA VIIRS V2, EUMETSAT LSA SAF AVHRR).
    - Development of new in situ database REALS V1.2 with stations over permanent snow/ice.
  - SALVAL NEEDS (for this *funding is required*):
    - Improve global sampling scheme by using LANVAL V2.
    - Incorporation new in situ database REALV V1.2.
    - Adapt and Update satellite database based on new sampling.
  - New paper: Validation of C3S S3/OLCI+SLSTR V3.1, NASA VIIRS V2, EUMETSAT LSA SAF AVHRR.