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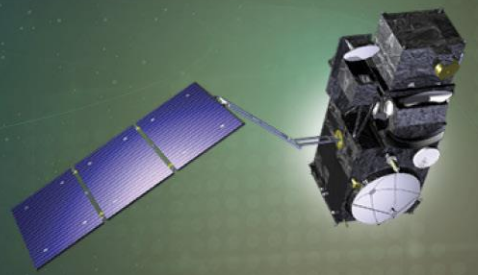

7th Sentinel-3 Validation Team Meeting 2022

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Disclaimer

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Validation of the new SLSTR basic cloud mask prototype

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Overview of the talk

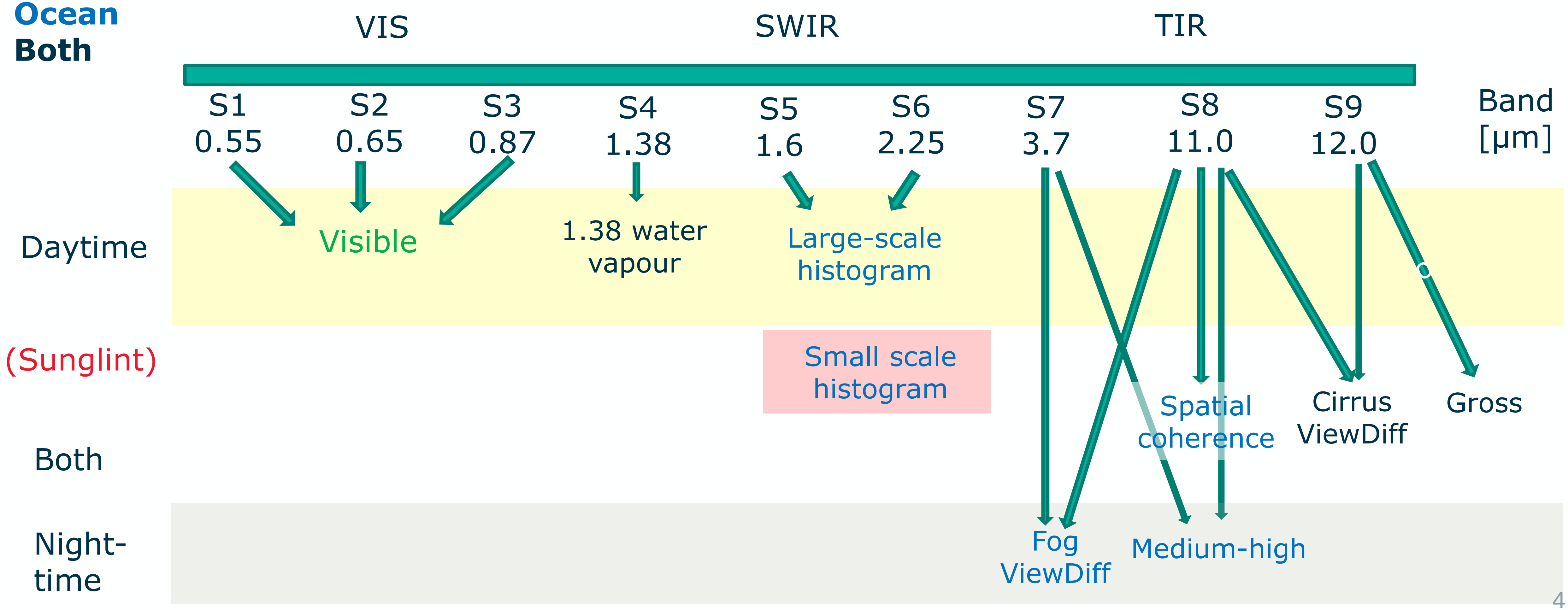
- Objective & scope
- Summary of existing tests
- Validation method/dataset – PixBox expert pixel collection
- Validation results
- Conclusion & Outlook

Objective and scope of the new algorithms

- Update current collection of Level 1 cloud tests, and fully exploit features in SLSTR products that were not available for (A)ATSR
    - S6 (2.25 micron) channel
    - S4 (1.38 micron) channel
    - Meteorological data
    - Land information (biomes or other)
- Retain fast processing, simplify where possible, improve performance
- The proposed work was split into two parts
- The first study, reported here, looked at the following
    - Better sunglint identification, and detection of cloud in glint
    - Implementing a new 2.25 µm threshold test
    - Implementing new test using S3 and S2 channels
    - Reviewing and updating land visible cloud test
    - Switching on fog test over land

Summary of existing cloud tests

Land
Ocean
Both



VIS SWIR TIR

S1	S2	S3	S4	S5	S6	S7	S8	S9	Band
0.55	0.65	0.87	1.38	1.6	2.25	3.7	11.0	12.0	[μm]

Daytime

Visible

1.38 water vapour

Large-scale histogram

(Sunglint)

Small scale histogram

Spatial coherence

Cirrus ViewDiff

Gross

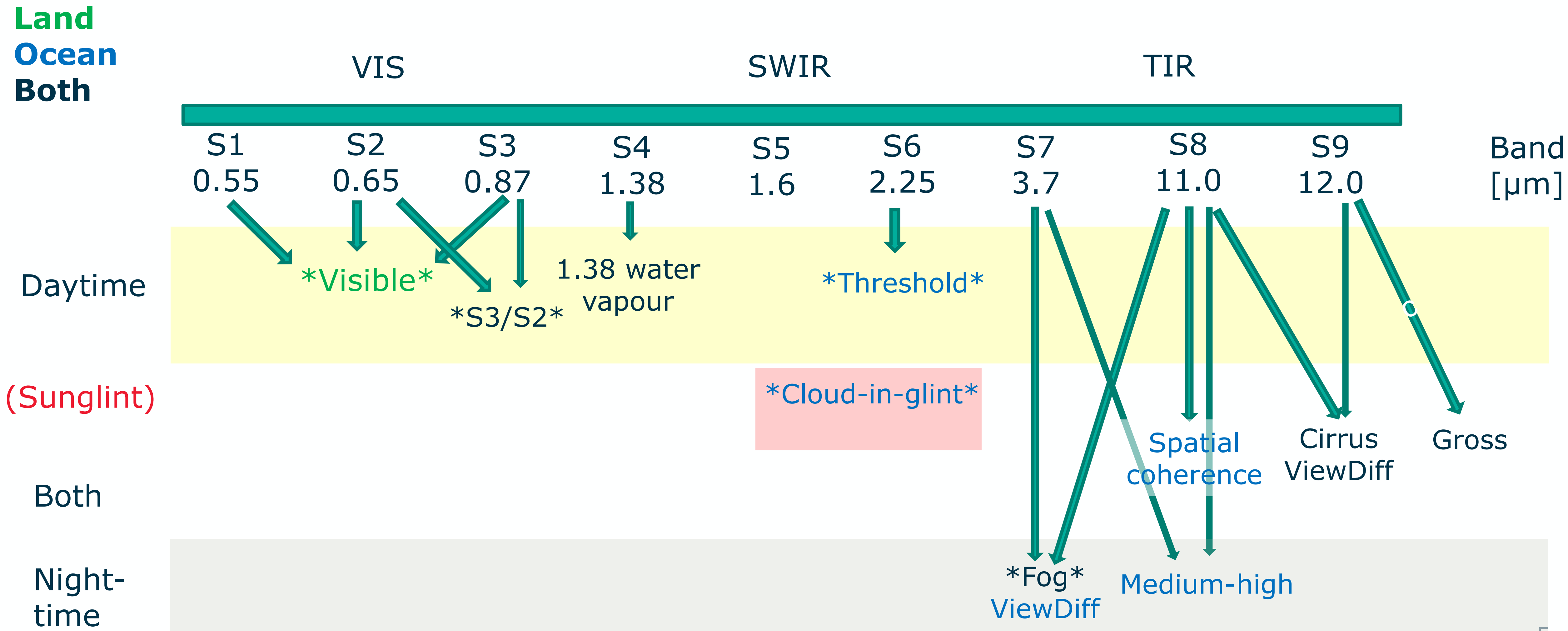
Both

Night-time

Fog ViewDiff

Medium-high

Changes* compared to existing cloud tests



Land
Ocean
Both

VIS SWIR TIR

S1	S2	S3	S4	S5	S6	S7	S8	S9	Band
0.55	0.65	0.87	1.38	1.6	2.25	3.7	11.0	12.0	[μm]

Daytime

Visible

S3/S2

1.38 water vapour

Threshold

(Sunglint)

Cloud-in-glint

Spatial coherence

Cirrus ViewDiff

Gross

Both

Night-time

Fog ViewDiff

Medium-high

Definition of new flags in Prototype Processor (PP) compared to L1: **Ocean**

Sunglint test

- L1 used geometry only
- PP uses geometry **and wind velocity** from met data in Cox and Munk model to predict glint. Impacts new SWIR tests

2.25 test

- L1 used S6 within histogram test (dynamic threshold) and not run on all pixels. Often blocky appearance
- PP applies thresholds to all (non-glinted) ocean pixels based on solar and view geometry, aims for smoother appearance

S3/S2 test

- L1 NA
- PP applies thresholds to all ocean and most land pixels.

Cloud-in-glint

- L1 used 1.6 and 2.25 'small scale histogram test' (uniformity test) when in glint
- PP applies simpler approach, checking non-glinted view to detect warmer clouds missed by TIR

Definition of new flags in Prototype Processor (PP) compared to L1: **Land**

Visible test

- L1 applied to all land pixels, missed light cloud
- PP applied to all land pixels, with an extended LUT used over 'greener' regions

S3/S2 test

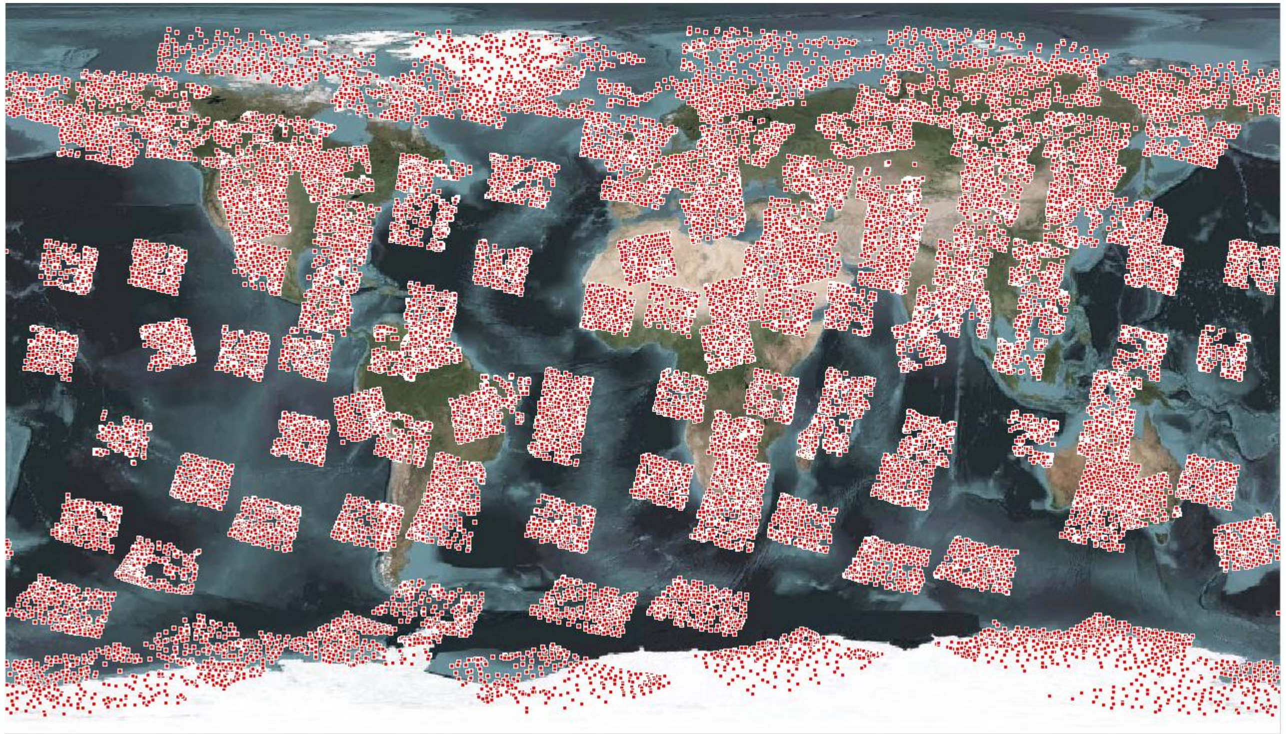
- L1 NA
- PP applies thresholds to all ocean and most land pixels.

Fog test

- L1 was switched of over land due to significant over-masking
- PP operational over land, but uses prior knowledge of land emissivity to disable over certain regions

Validation method/dataset

- The SLSTR PixBox validation dataset consists of 30750 manually collected pixels
- The expert pixel collection was conducted on SLSTR L1 products resampled to 1km resolution
- The collection has been limited to SLSTR data of Sentinel-3 A



- SLSTR data from three dates have been selects: 15.03., 15.06. & 15.09.2021
- The following processing baselines are applicable:
    - Products from Mar 2021:
        - SLSTR-A: PB 2.73
    - Products from Jun and Sep 2021:
        - SLSTR-A: PB 2.77

Validation method/dataset

- The collection distinguishes between different cloud types (level of transparency) in the VNIR part of the spectrum
- Additionally, differences in cloud opacities for SWIR and TIR channels are collected if deviating from VNIR
    - *Not used in current analysis*
- Additional features and information are collected with each pixel allowing a very detailed analysis

Distr. of the cloud classification in the VNIR range of the spectrum

Opaque			34.6%
Clear			35.7%
Semi-transparent			29.7%
	Thick	*3.2%*	
	Average	*16.8%*	
	Thin	*6.3%*	
	Haze	*0.8%*	
	Spacially mixed	*2.1%*	
	Fog	*0.2%*	
	Others	*0.4%*	

Distr. of cloud classification in SWIR and TIR range when deviating from VNIR.

SWIR	None	87.6%
	Opaque	8.8%
	Semi-transparent	2.5%
	Haze	0.7%
	Clear	0.5%
TERM	None	82.8%
	Opaque	10.3%
	Semi-transparent	4.5%
	Haze	1.9%
	Clear	0.5%

Day	81.7%
Night	16.2%
Twilight	2.3%

LAND			44.4%
	Land	*29.7%*	
	Mountain	*2.1%*	
	Desert	*0.6%*	
	Urban	*4.0%*	
	Salt/dry lake	*0.6%*	
	Snow/ice Land	*6.6%*	
	Wetland	*0.4%*	
	Atoll	*0.4%*	
WATER			55.6%
	Coastal Waters	*18.4%*	
	Open ocean	*33.7%*	
	River	*1.5%*	
	Lake	*2.1%*	

Floating Ice	6.7%
Oversaturation	2.7%
Glint	5.7%
Aerosoles	1.2%

Validation Results

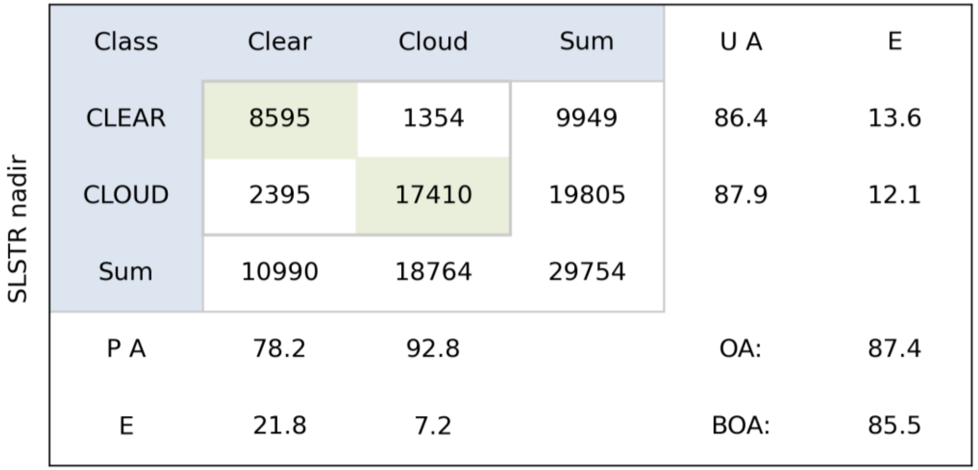
- All surfaces (daytime and nighttime)
- Ocean and coastal water (daytime)
- Ocean and coastal water under glint conditions (daytime)
- Land surfaces (daytime)
- Inland water (daytime)
- Land surfaces (nighttime)

Validation results – all surfaces – daytime and nighttime

- Overall slight decrease in accuracy, but
  - Good improvement in UA clear
  - Cost: Small increase in commissioning error of clear observations as cloud

SLSTR 2022 nadir cloud validation - all surfaces
- Level 1 summary_cloud -

In-Situ Database



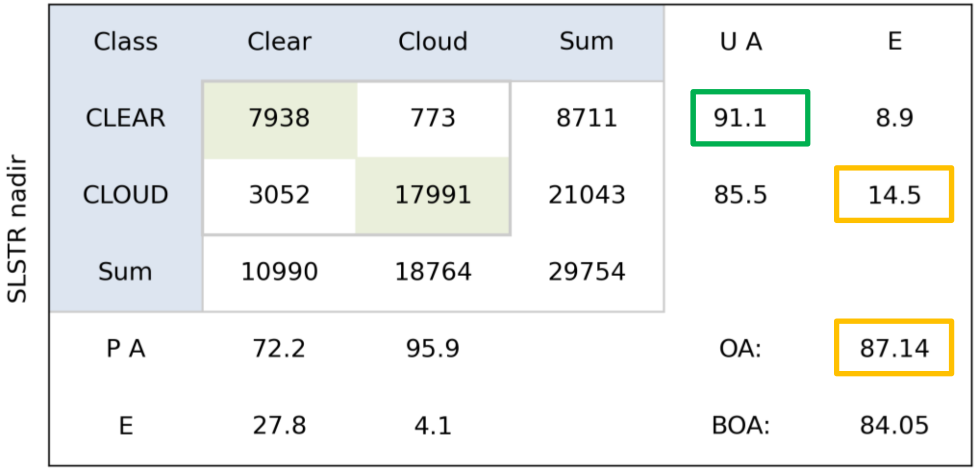
SLSTR nadir

Class	Clear	Cloud	Sum	U A	E
CLEAR	8595	1354	9949	86.4	13.6
CLOUD	2395	17410	19805	87.9	12.1
Sum	10990	18764	29754		
P A	78.2	92.8		OA:	87.4
E	21.8	7.2		BOA:	85.5

Scotts Pi: 0.723
Krippendorfs alpha: 0.723
Cohens kappa: 0.724

SLSTR 2022 nadir cloud validation - all surfaces
- Prototype summary_cloud -

In-Situ Database



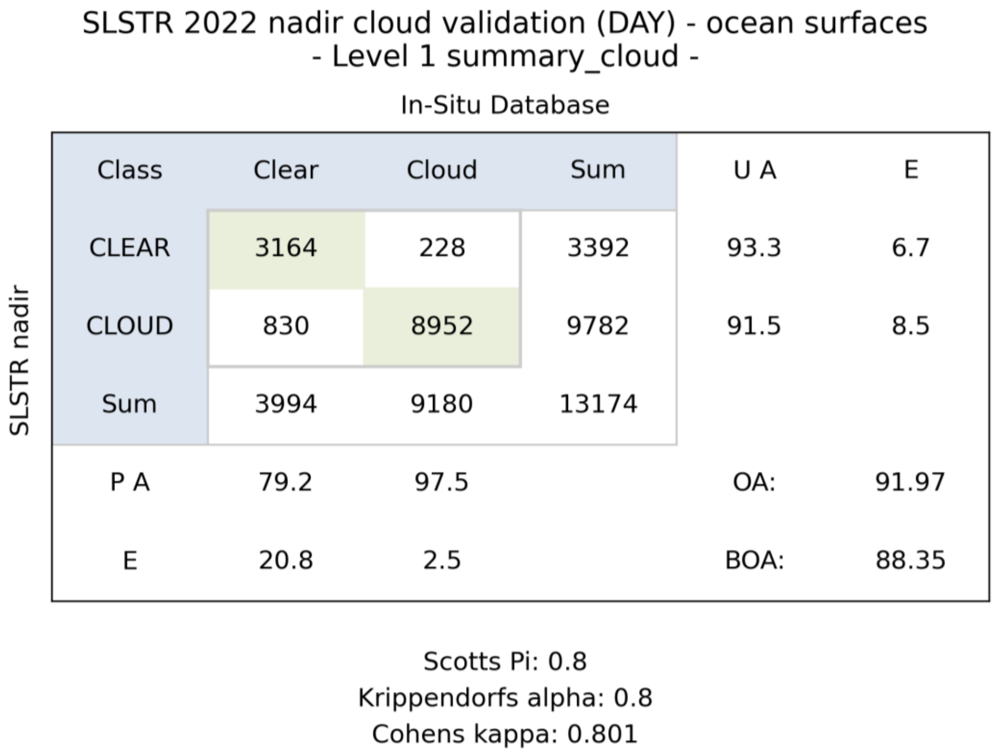
SLSTR nadir

Class	Clear	Cloud	Sum	U A	E
CLEAR	7938	773	8711	91.1	8.9
CLOUD	3052	17991	21043	85.5	14.5
Sum	10990	18764	29754		
P A	72.2	95.9		OA:	87.14
E	27.8	4.1		BOA:	84.05

Scotts Pi: 0.709
Krippendorfs alpha: 0.709
Cohens kappa: 0.711

Validation results – ocean and coast water - daytime

- Overall increase in accuracy
  - Slight improvement in UA clear
  - Reduction of commissioning error of clear as cloud – probably due to glint improvements. Let's have a look!



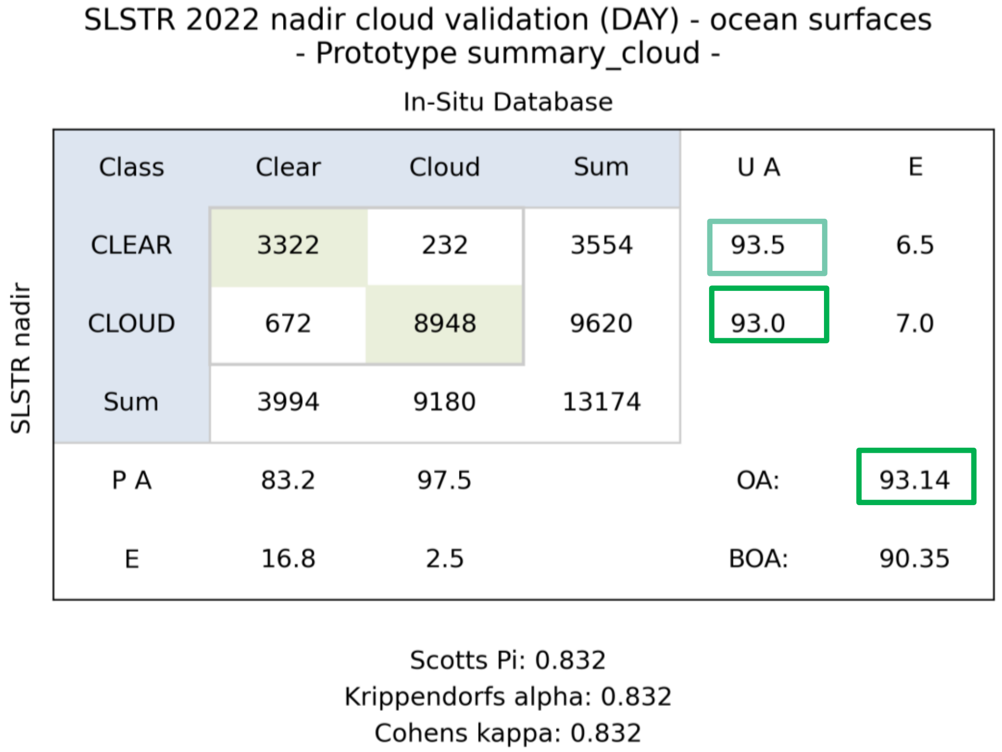
SLSTR 2022 nadir cloud validation (DAY) - ocean surfaces
- Level 1 summary_cloud -

In-Situ Database

SLSTR nadir

Class	Clear	Cloud	Sum	U A	E
CLEAR	3164	228	3392	93.3	6.7
CLOUD	830	8952	9782	91.5	8.5
Sum	3994	9180	13174		
P A	79.2	97.5		OA:	91.97
E	20.8	2.5		BOA:	88.35

Scotts Pi: 0.8
Krippendorfs alpha: 0.8
Cohens kappa: 0.801



SLSTR 2022 nadir cloud validation (DAY) - ocean surfaces
- Prototype summary_cloud -

In-Situ Database

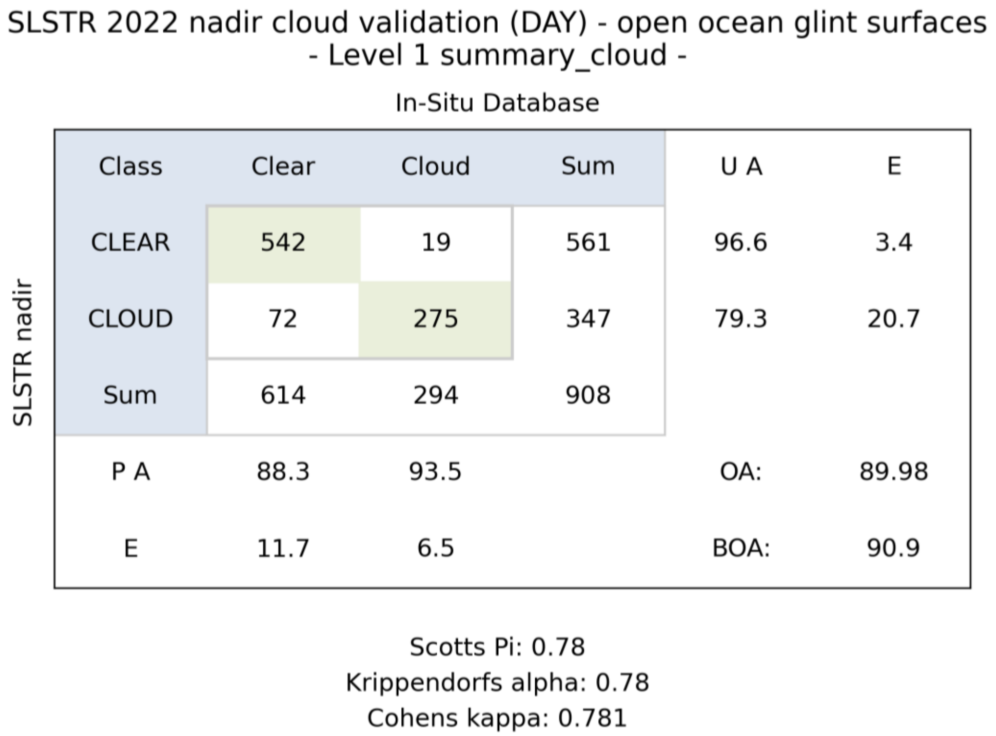
SLSTR nadir

Class	Clear	Cloud	Sum	U A	E
CLEAR	3322	232	3554	93.5	6.5
CLOUD	672	8948	9620	93.0	7.0
Sum	3994	9180	13174		
P A	83.2	97.5		OA:	93.14
E	16.8	2.5		BOA:	90.35

Scotts Pi: 0.832
Krippendorfs alpha: 0.832
Cohens kappa: 0.832

Validation results – ocean and coast water under glint conditions

- Overall slight increase in accuracy
  - Slight improvement in UA clear
  - Reduction of commissioning error of clear surfaces under glint condition as cloud



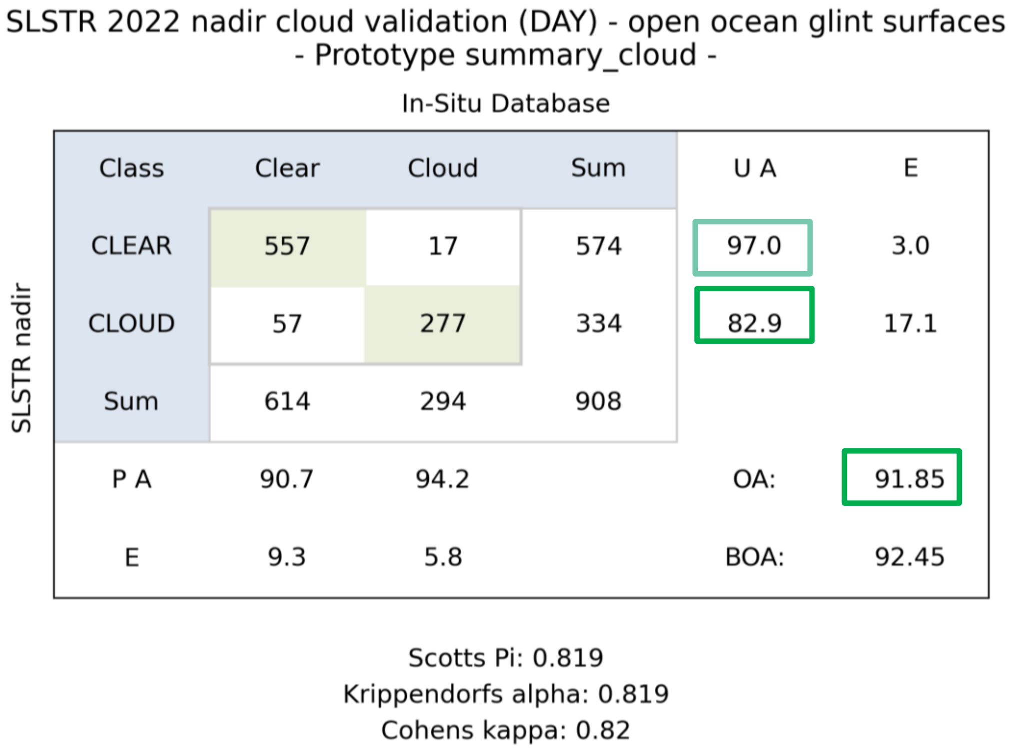
SLSTR 2022 nadir cloud validation (DAY) - open ocean glint surfaces
- Level 1 summary_cloud -

In-Situ Database

SLSTR nadir

Class	Clear	Cloud	Sum	U A	E
CLEAR	542	19	561	96.6	3.4
CLOUD	72	275	347	79.3	20.7
Sum	614	294	908		
P A	88.3	93.5		OA:	89.98
E	11.7	6.5		BOA:	90.9

Scotts Pi: 0.78
Krippendorfs alpha: 0.78
Cohens kappa: 0.781



SLSTR 2022 nadir cloud validation (DAY) - open ocean glint surfaces
- Prototype summary_cloud -

In-Situ Database

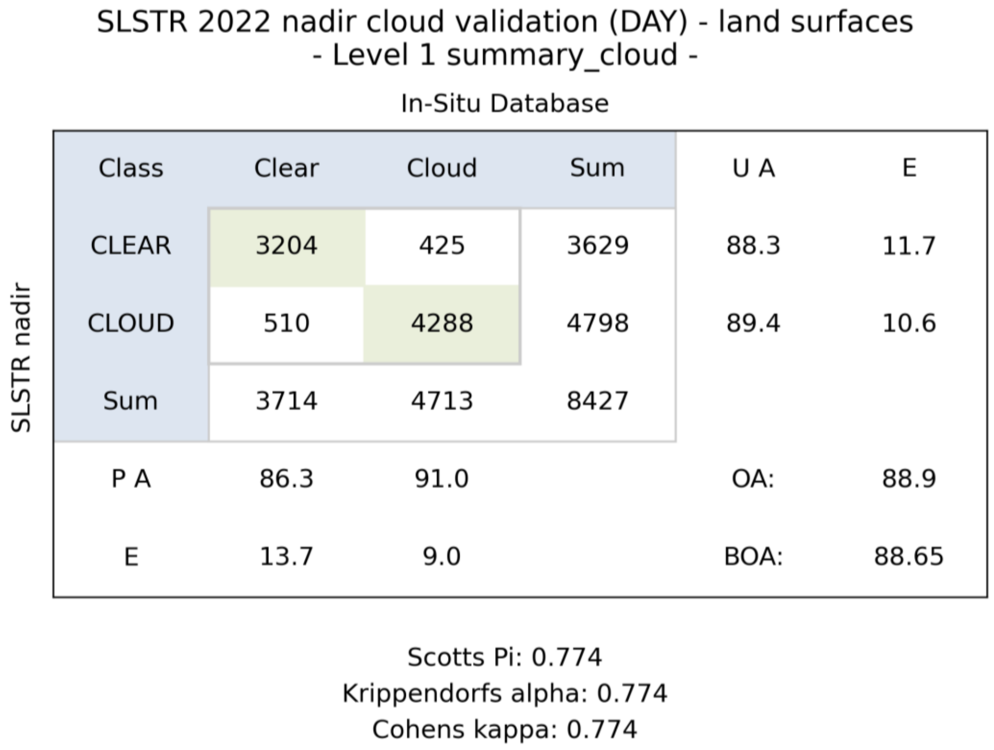
SLSTR nadir

Class	Clear	Cloud	Sum	U A	E
CLEAR	557	17	574	97.0	3.0
CLOUD	57	277	334	82.9	17.1
Sum	614	294	908		
P A	90.7	94.2		OA:	91.85
E	9.3	5.8		BOA:	92.45

Scotts Pi: 0.819
Krippendorfs alpha: 0.819
Cohens kappa: 0.82

Validation results – land surfaces during daytime

- Overall slight decrease in accuracy
  - Good improvement in UA clear
  - Cost: increase in commissioning error of clear surfaces as cloud



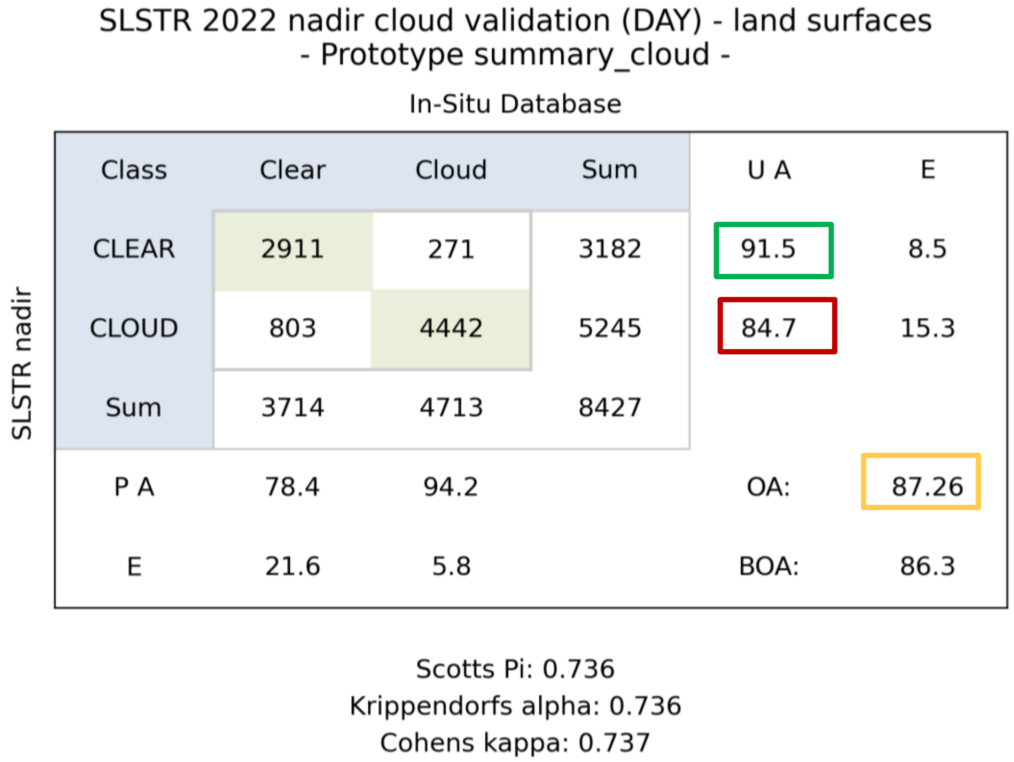
SLSTR 2022 nadir cloud validation (DAY) - land surfaces
- Level 1 summary_cloud -

In-Situ Database

SLSTR nadir

Class	Clear	Cloud	Sum	U A	E
CLEAR	3204	425	3629	88.3	11.7
CLOUD	510	4288	4798	89.4	10.6
Sum	3714	4713	8427		
P A	86.3	91.0		OA:	88.9
E	13.7	9.0		BOA:	88.65

Scotts Pi: 0.774
Krippendorfs alpha: 0.774
Cohens kappa: 0.774



SLSTR 2022 nadir cloud validation (DAY) - land surfaces
- Prototype summary_cloud -

In-Situ Database

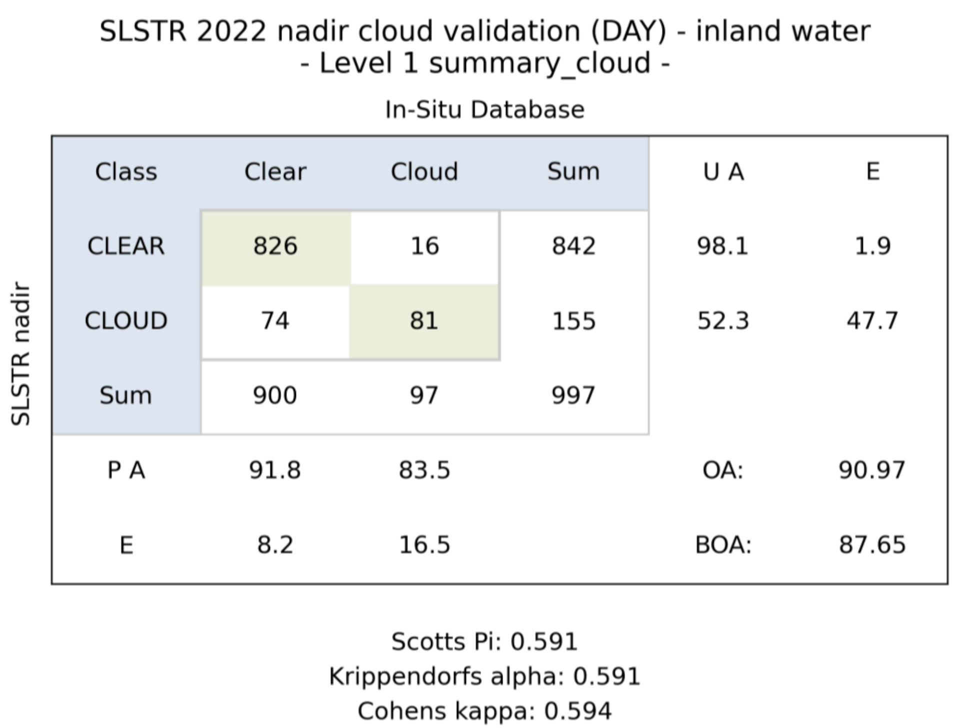
SLSTR nadir

Class	Clear	Cloud	Sum	U A	E
CLEAR	2911	271	3182	91.5	8.5
CLOUD	803	4442	5245	84.7	15.3
Sum	3714	4713	8427		
P A	78.4	94.2		OA:	87.26
E	21.6	5.8		BOA:	86.3

Scotts Pi: 0.736
Krippendorfs alpha: 0.736
Cohens kappa: 0.737

Validation results – inland water during daytime

- Overall high decrease in accuracy
    - Minimal improvement in UA clear
    - High increase in commissioning error of clear as cloud



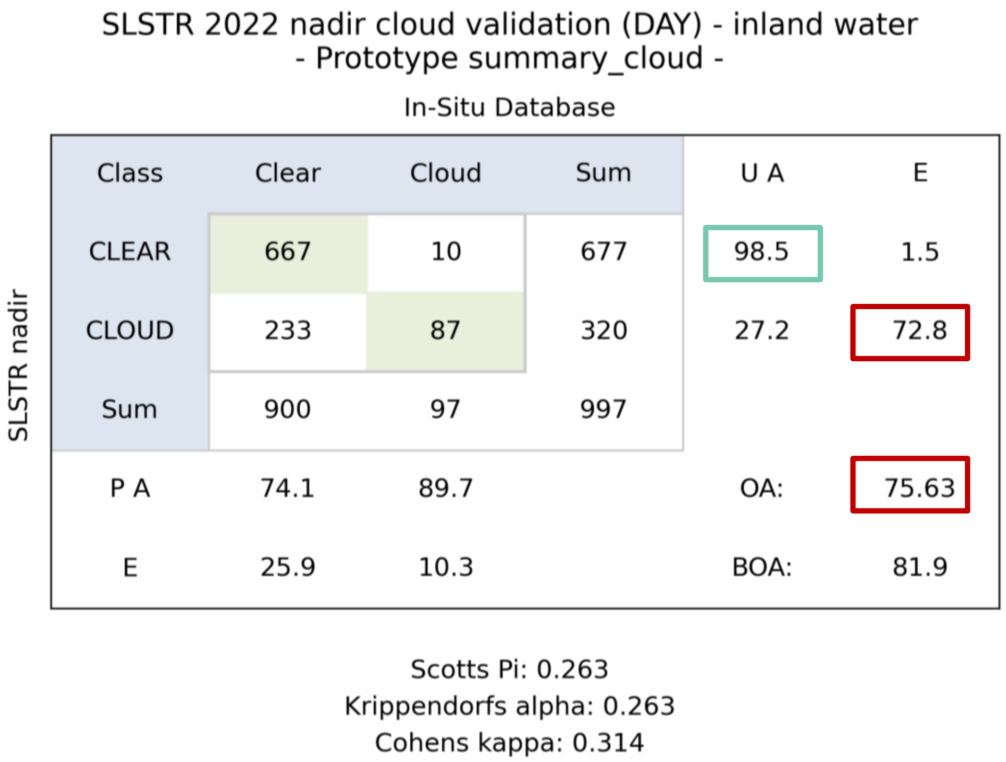
SLSTR 2022 nadir cloud validation (DAY) - inland water
- Level 1 summary_cloud -

In-Situ Database

SLSTR nadir

Class	Clear	Cloud	Sum	U A	E
CLEAR	826	16	842	98.1	1.9
CLOUD	74	81	155	52.3	47.7
Sum	900	97	997		
P A	91.8	83.5		OA:	90.97
E	8.2	16.5		BOA:	87.65

Scotts Pi: 0.591
Krippendorfs alpha: 0.591
Cohens kappa: 0.594



SLSTR 2022 nadir cloud validation (DAY) - inland water
- Prototype summary_cloud -

In-Situ Database

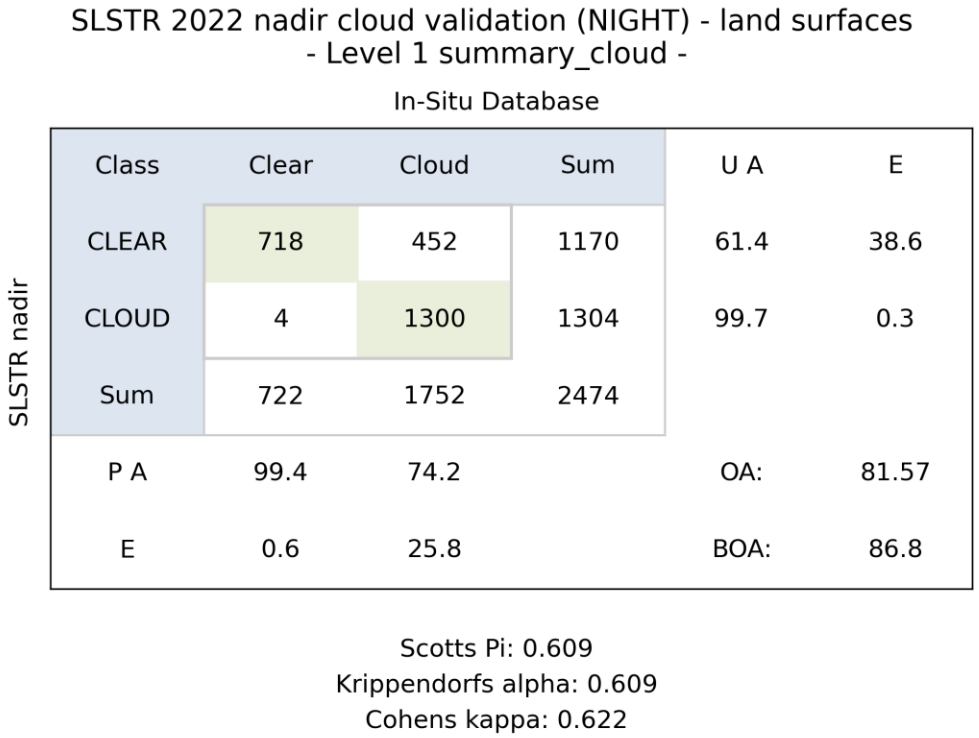
SLSTR nadir

Class	Clear	Cloud	Sum	U A	E
CLEAR	667	10	677	98.5	1.5
CLOUD	233	87	320	27.2	72.8
Sum	900	97	997		
P A	74.1	89.7		OA:	75.63
E	25.9	10.3		BOA:	81.9

Scotts Pi: 0.263
Krippendorfs alpha: 0.263
Cohens kappa: 0.314

Validation results – land surfaces during nighttime

- Overall improvement in accuracy – due to new fog test
  - Good improvement in UA clear
  - Cost: increase in commissioning error of clear surfaces as cloud



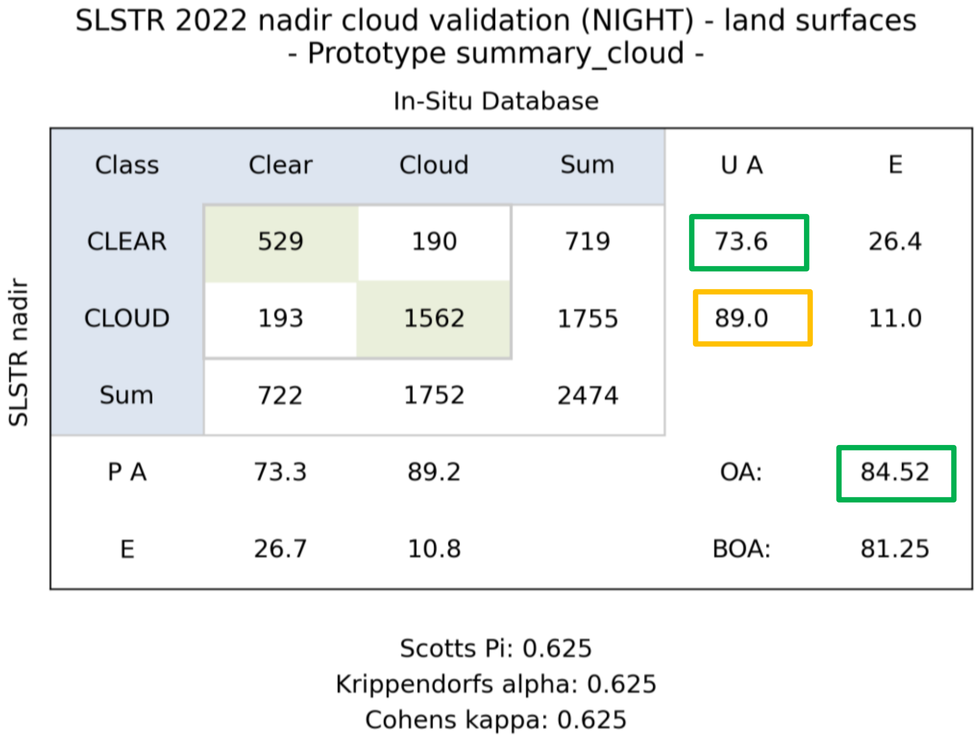
SLSTR 2022 nadir cloud validation (NIGHT) - land surfaces
- Level 1 summary_cloud -

In-Situ Database

SLSTR nadir

Class	Clear	Cloud	Sum	U A	E
CLEAR	718	452	1170	61.4	38.6
CLOUD	4	1300	1304	99.7	0.3
Sum	722	1752	2474		
P A	99.4	74.2		OA:	81.57
E	0.6	25.8		BOA:	86.8

Scotts Pi: 0.609
Krippendorfs alpha: 0.609
Cohens kappa: 0.622



SLSTR 2022 nadir cloud validation (NIGHT) - land surfaces
- Prototype summary_cloud -

In-Situ Database

SLSTR nadir

Class	Clear	Cloud	Sum	U A	E
CLEAR	529	190	719	73.6	26.4
CLOUD	193	1562	1755	89.0	11.0
Sum	722	1752	2474		
P A	73.3	89.2		OA:	84.52
E	26.7	10.8		BOA:	81.25

Scotts Pi: 0.625
Krippendorfs alpha: 0.625
Cohens kappa: 0.625

Conclusion

- Very good improvements for ocean and glint.
  - Ocean: Simpler threshold-based tests (S3S2R and 2.25) achieve better results and improve performance
  - Glint: Simpler cloud-in-glint test achieves better results compared to complex tests (L1) and improves performance
- Improvement over land (UA clear) on the expanse of commission error.
  - Daytime: S3S2R test over land causes high commission error of clear as cloud -> lower OA
  - Nighttime: New fog test leads to overall improvement
- Lower performance over inland water, with slight increase on UA clear

Outlook

- Cause of issues (land & inland water) currently under investigation -> most likely S3S2R test
- Improvements to the S3S2R will be investigation.

Thank you for the attention!