CMIX:
Cloud Mask Intercomparison eXercise

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Clouds

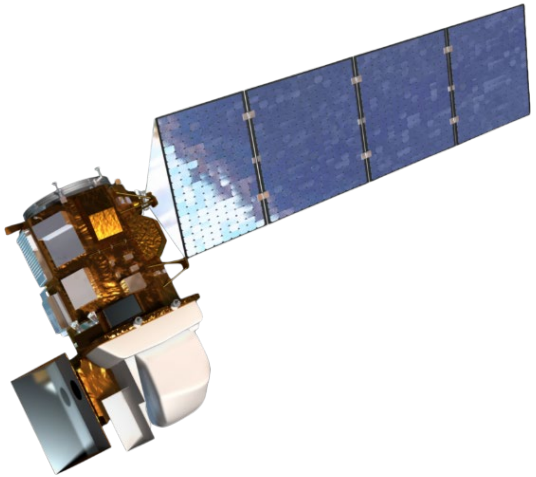
- Limiting factor in optical remote sensing
- Prerequisite for high-quality high-level products
- CEOS **WGCV**: Working Group on Calibration & Validation
  - **ACIX**: Atmospheric Correction Intercomparison eXercise
  - **CMIX**: Cloud Mask Intercomparison eXercise

GOAL

- To **inter-compare** a set of cloud detection algorithms for space-borne high-spatial resolution (10-30 m) optical sensors

- Focus on **Landsat 8** and **Sentinel-2** data

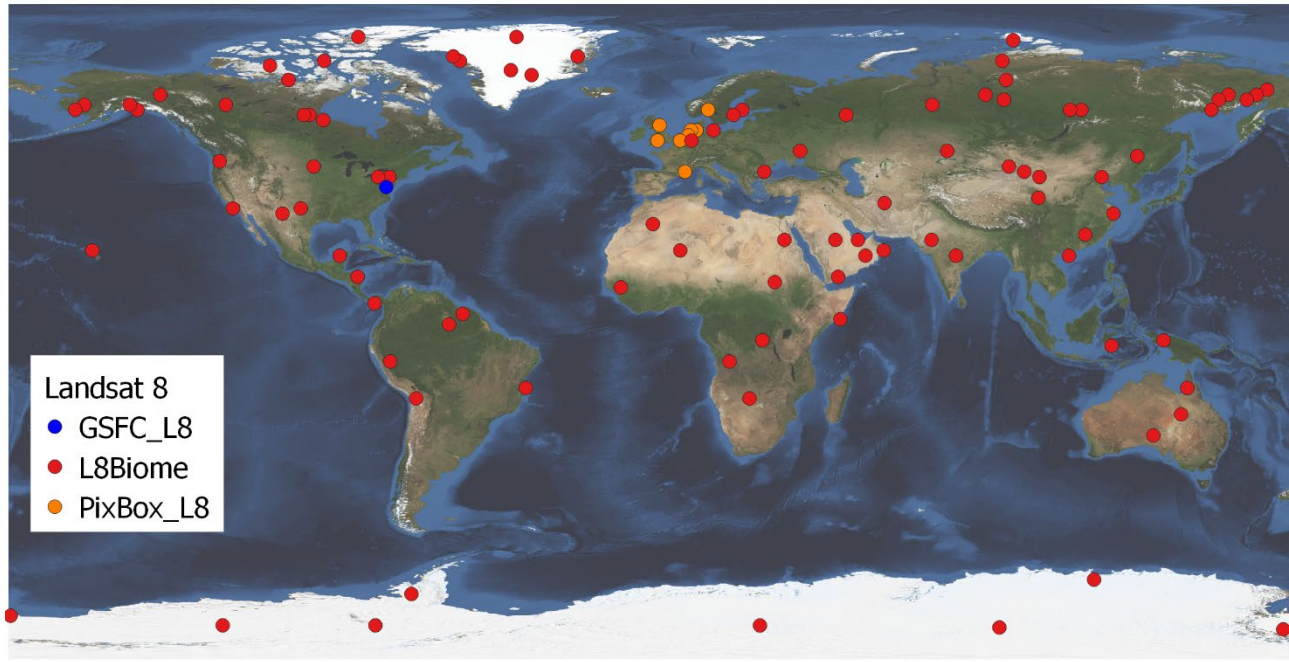
- **Not a competition**, but **inter-comparison**



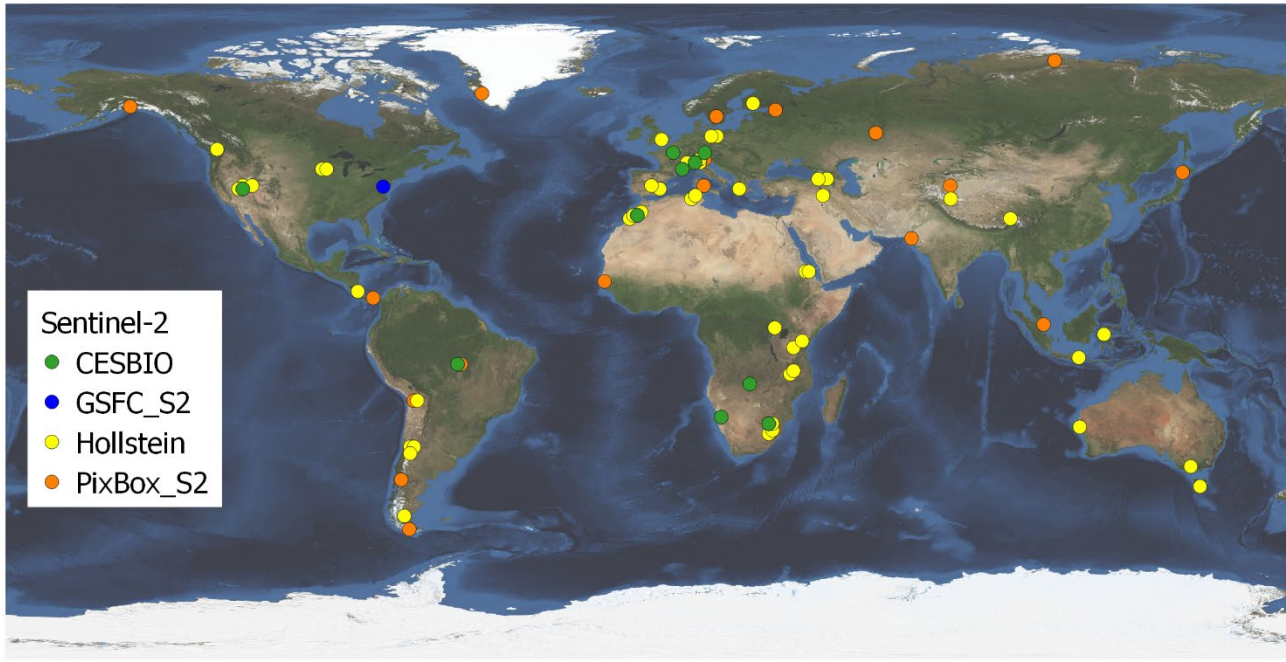
Processor	Organization	Methodology
ATCOR	DLR	Spectral tests (L8, S2)
CD-FCNN	University of Valencia	Machine learning (L8, S2)
Fmask 4.0 CCA	USGS	Spectral tests (L8, S2)
FORCE	Humboldt-Universität zu Berlin / Trier University	Spectral test + parallax (for S2) (L8, S2)
IdePix	Brockmann Consult	Spectral tests (S2)
InterSSIM	Sinergise	Machine learning + spatiotemporal context (S2)
LaSRC	NASA / University of Maryland	Spectral tests (L8, S2)
MAJA	CNES / CESBIO	Multi-temporal and spectral tests (S2)
s2cloudless	Sinergise	Machine learning (S2)
sen2cor	ESA / Telespazio France	Spectral test + auxiliary data (S2)

Dataset	Spatial domain	Spatial resolution	# scenes
CESBIO	Fully classified Sentinel-2 scenes	60 m	S2: 30
GSFC	Sample polygons	Polygons (vector)	L8: 6 S2: 28
Hollstein	Sample polygons	Polygons (at 20 m)	S2: 59
L8Biome	Fully classified Landsat 8 scenes	30 m	L8: 96
PixBox	Sample pixels	S2: 10 m L8: 30 m	S2: 29 L8: 11

Distribution of Landsat 8 reference scenes

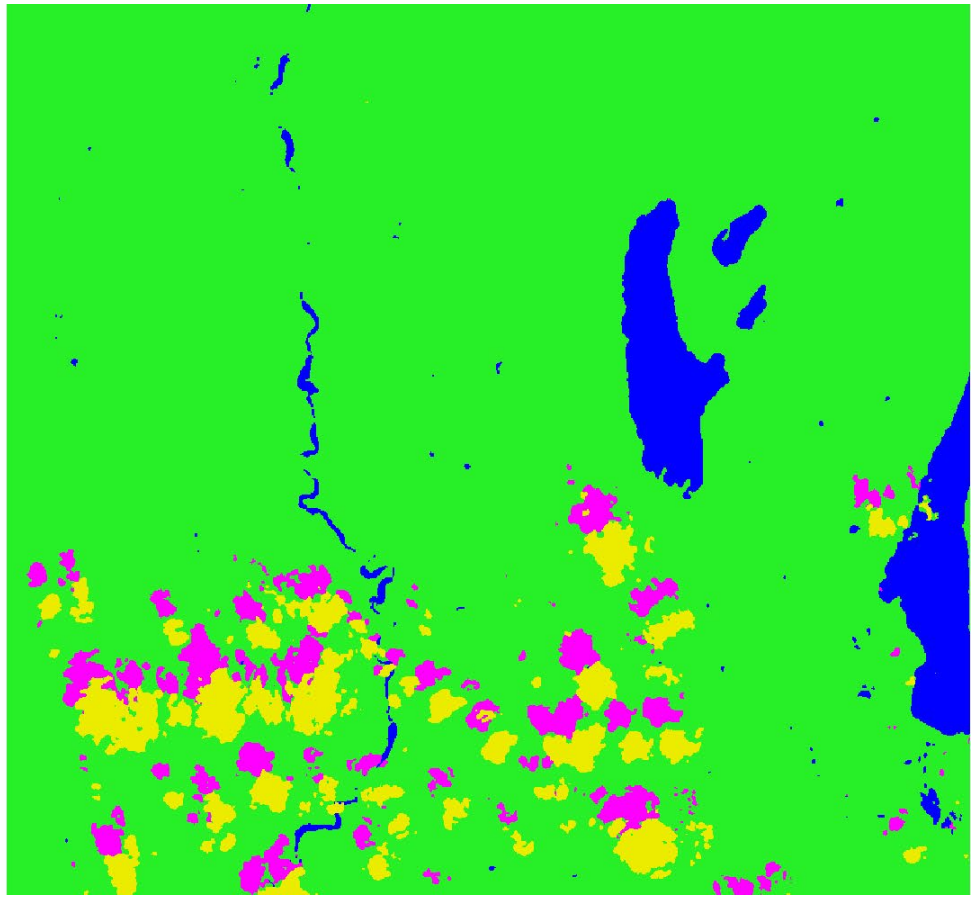


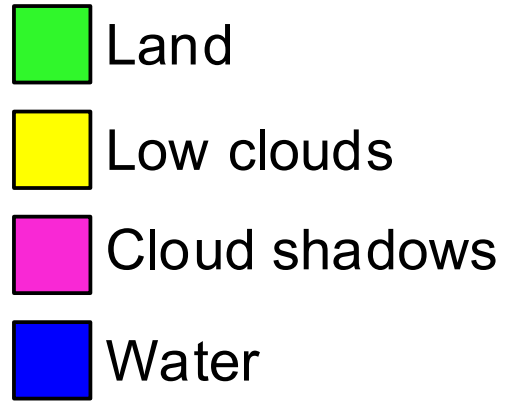
Distribution of Sentinel-2 reference scenes



Fully classified scene

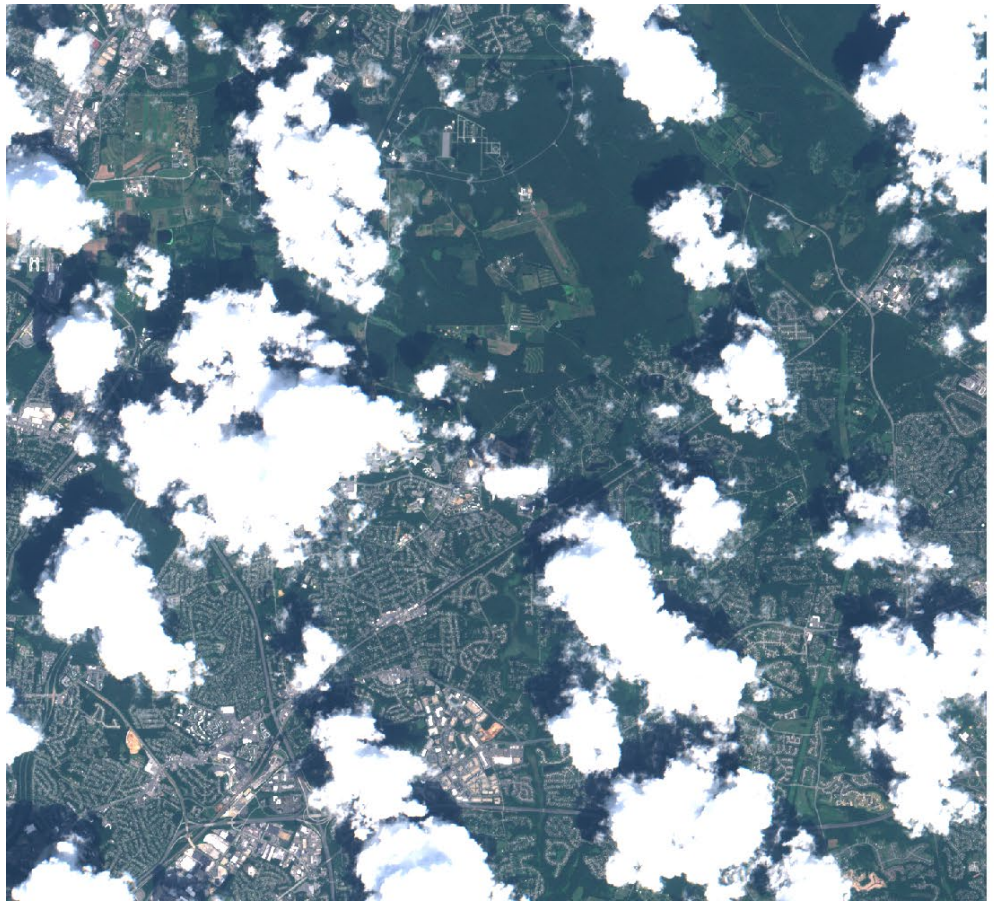
CESBIO Reference Dataset

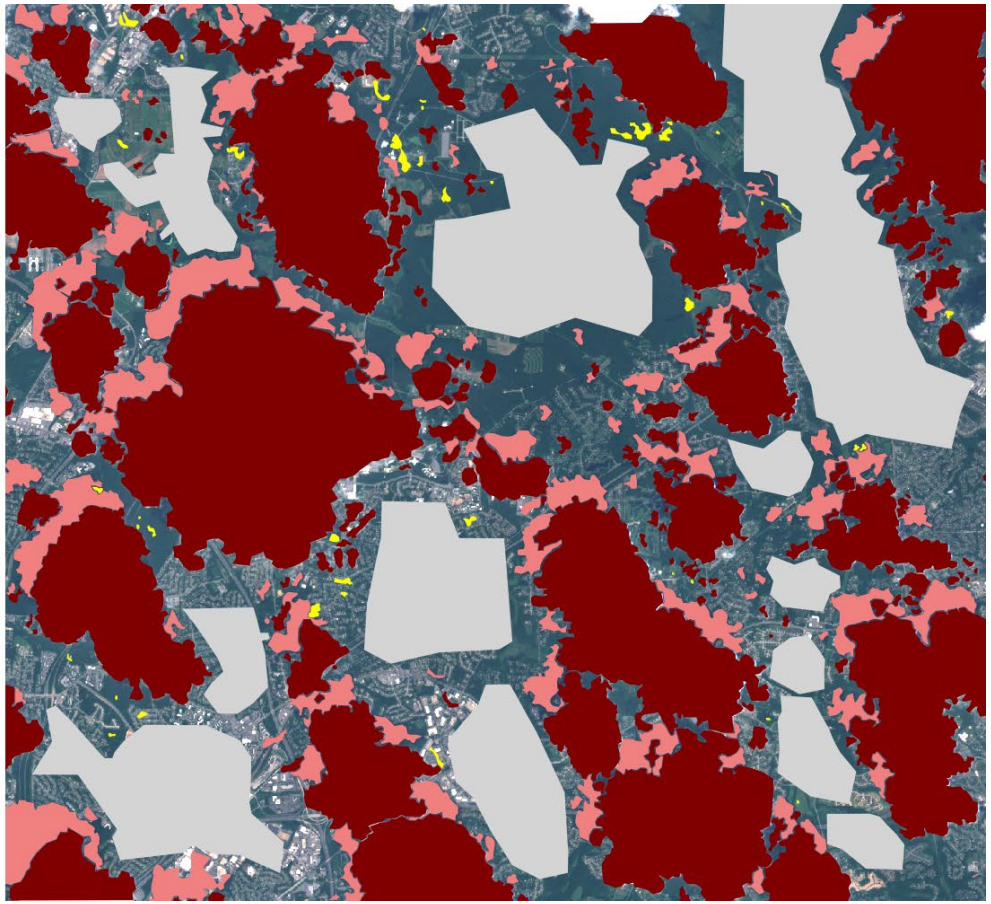




Polygons

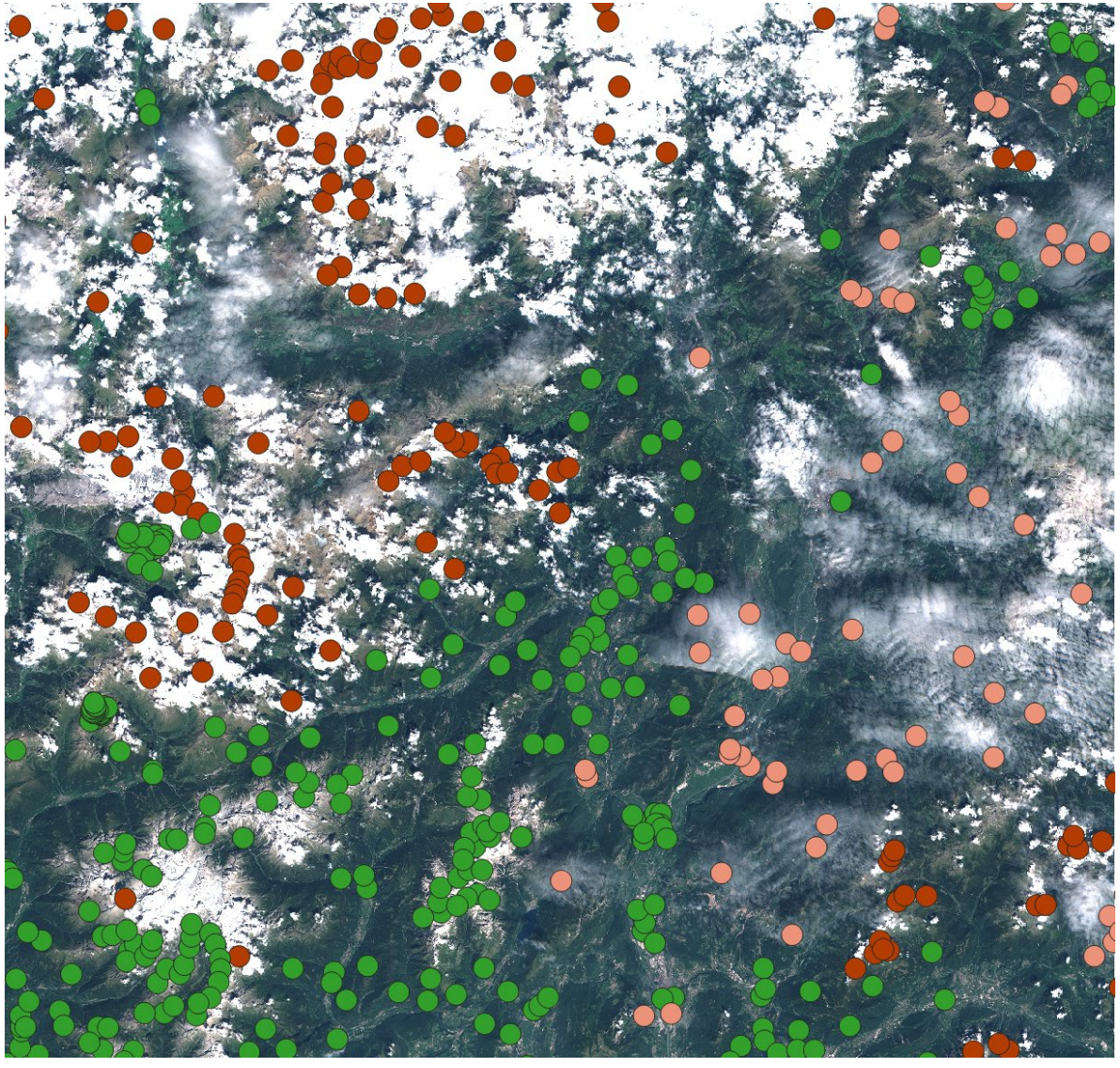
GSFC S2 Reference Dataset





Samples

PixBox S2 Reference Dataset

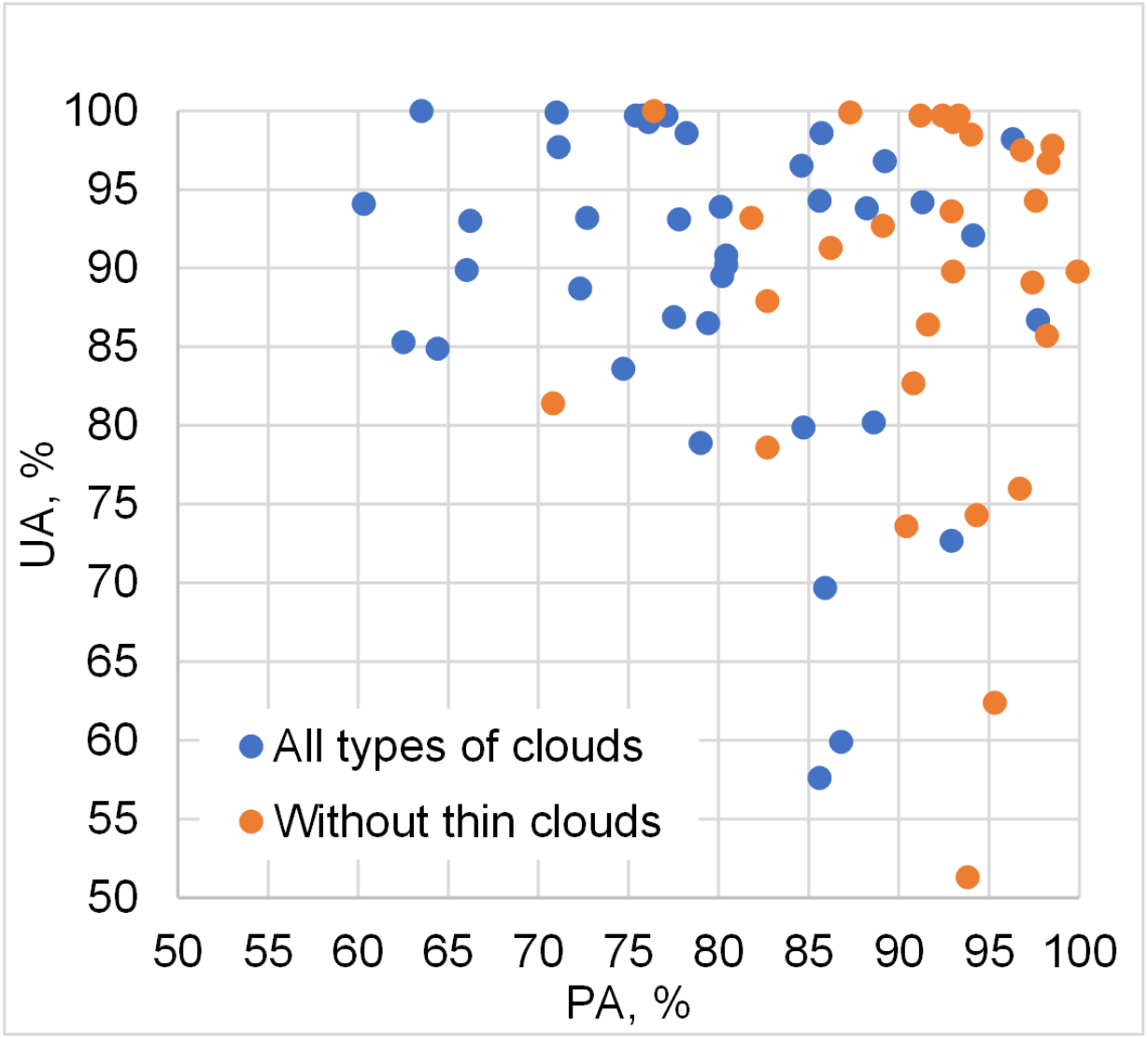


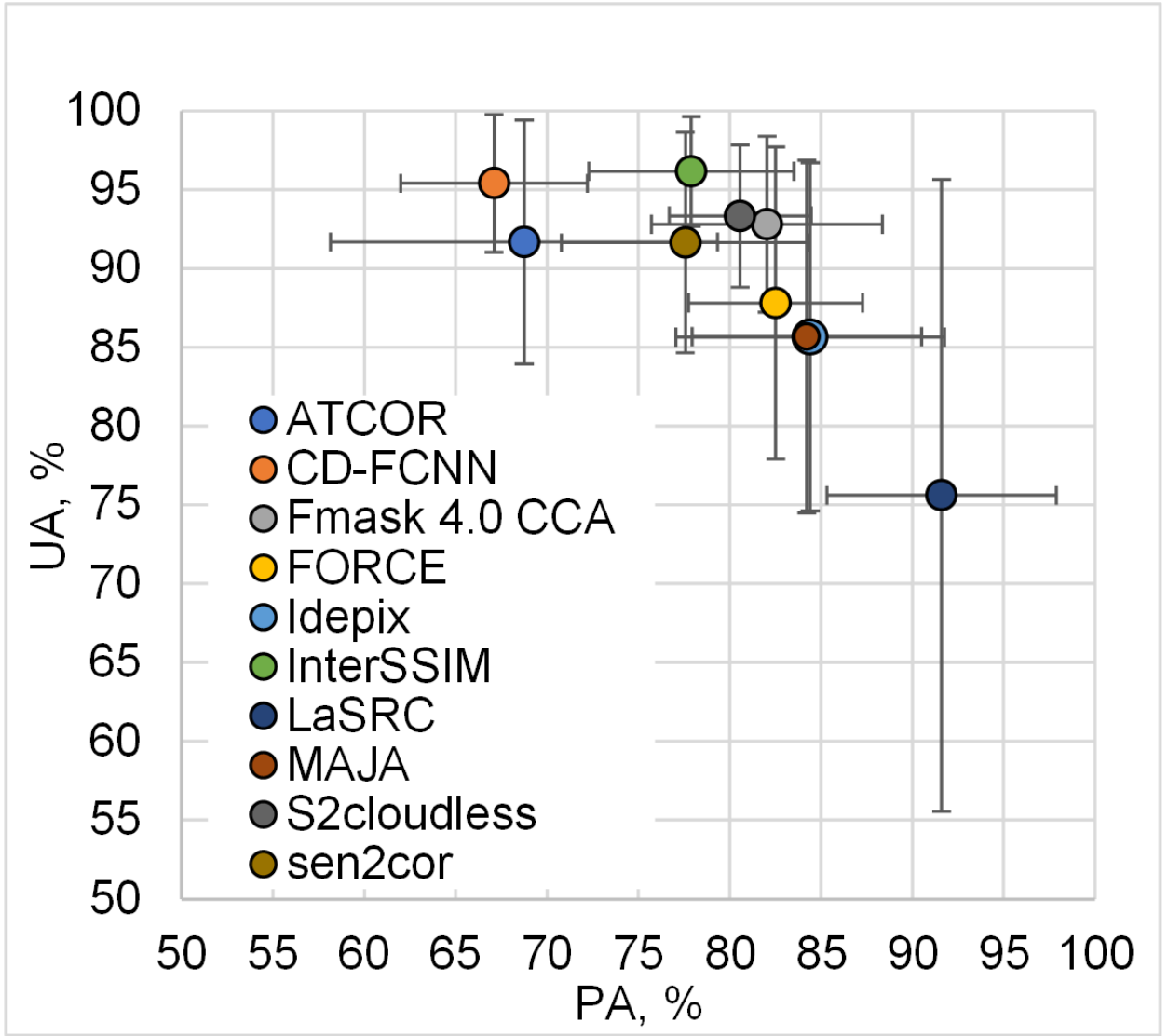
Opaque clouds

Semi-transparent clouds

Clear

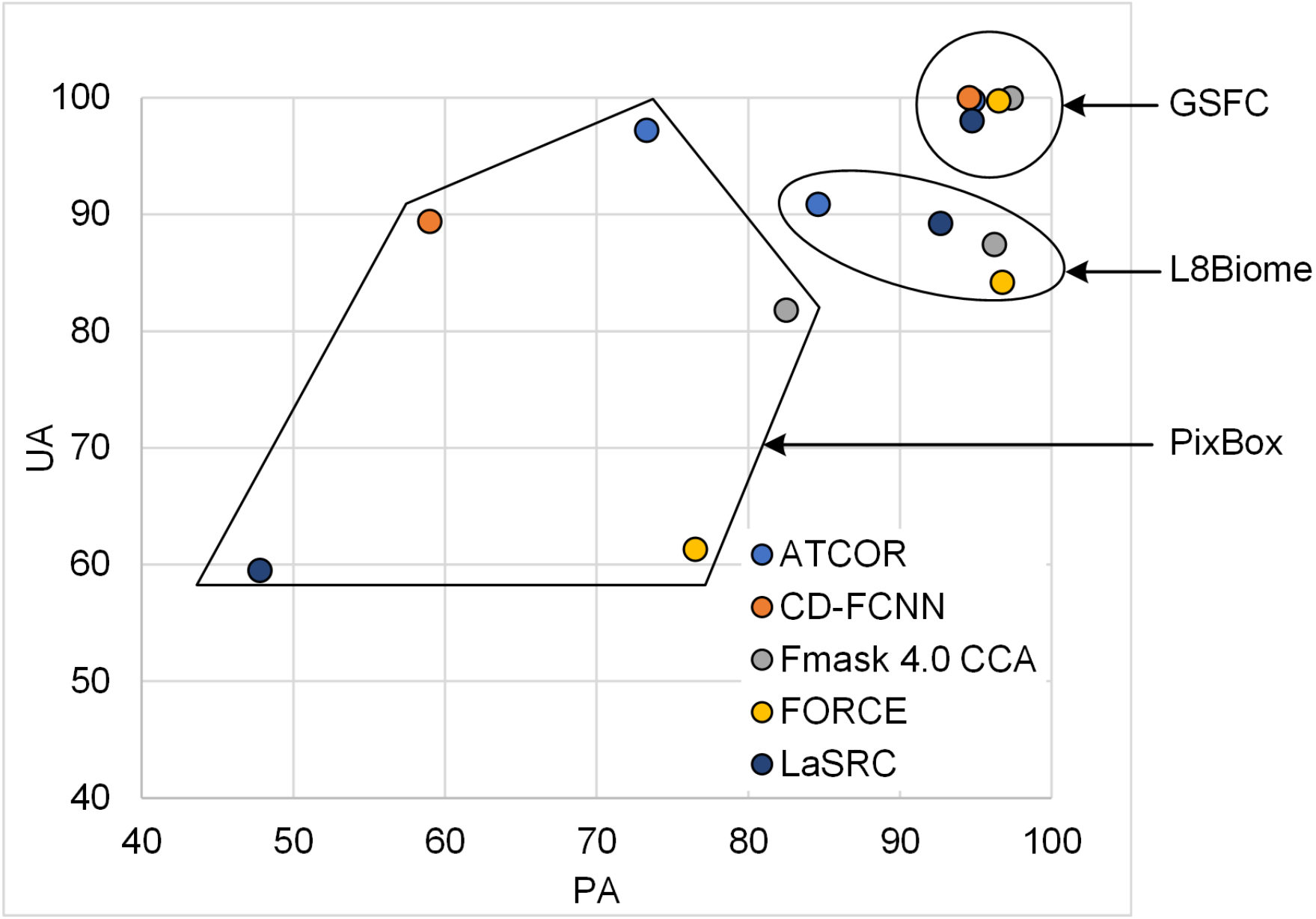
Results: Sentinel-2





PA = producer's accuracy (recall); UA = user's accuracy (precision); for cloud class

Results: Landsat 8



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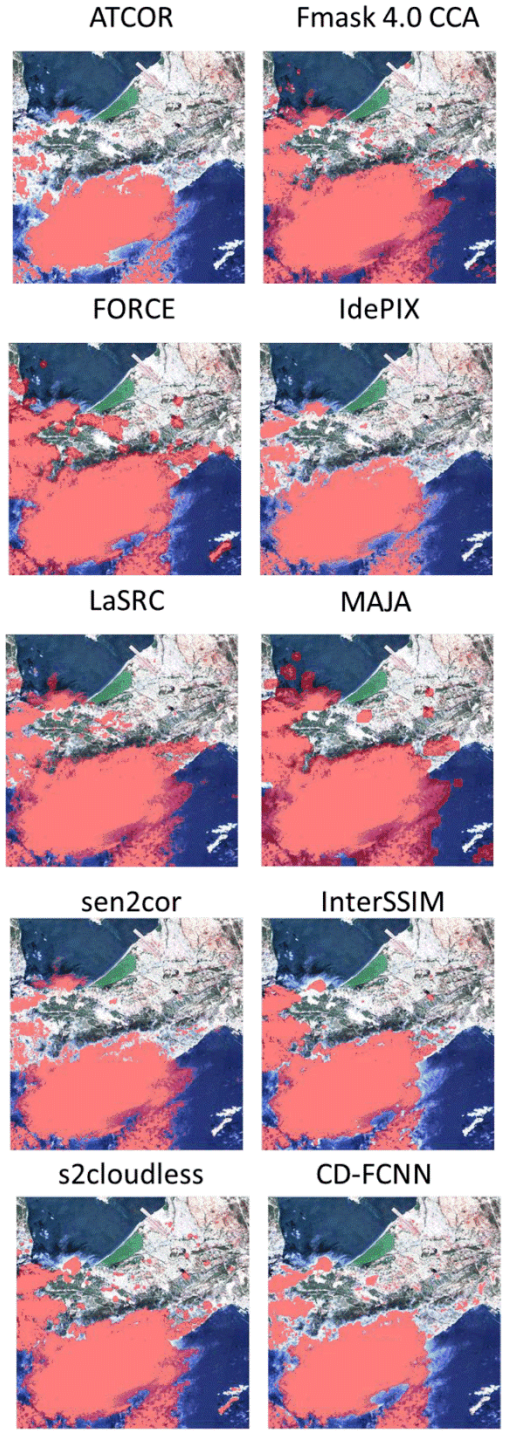
Cloud Mask Intercomparison eXercise (CMIX): An evaluation of cloud masking algorithms for Landsat 8 and Sentinel-2

- Major findings
  - Performance varied depending on the reference data
  - Average OA for Sentinel-2: 80% to 89%
  - Average OA for Landsat 8: 80% to 98%
  - Performance improved when thin/semi-transparent clouds not considered

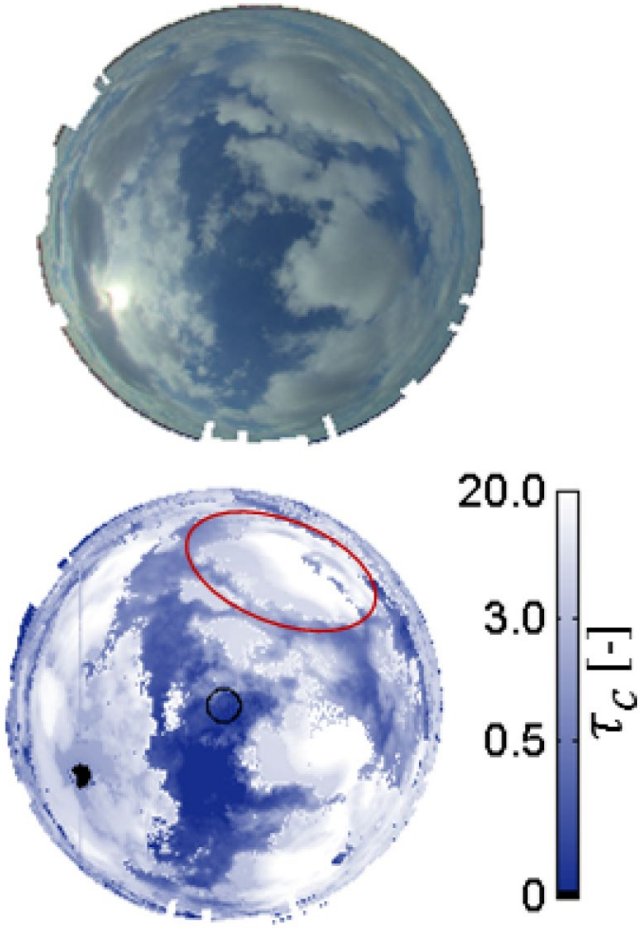


Recommendations

- Definition of clouds
  - Cloud optical depth
- New validation/reference data
  - Consistent cloud definition
  - Cloud boundary
  - Time series
- Analysis framework
  - Sample-based vs area-based
  - Temporal analysis
  - Application-based

Network of sky imagery:

- NASA GSFC, **Greenbelt, MD, USA**
- Sapienza University, **Rome, Italy**
- Valencia University, **Valencia, Spain**
- Sao Paulo University, **Sao Paulo, Brazil**
- Princess Elisabeth Station, **Antarctica**
- WLEF, **Park Falls, WI, USA**

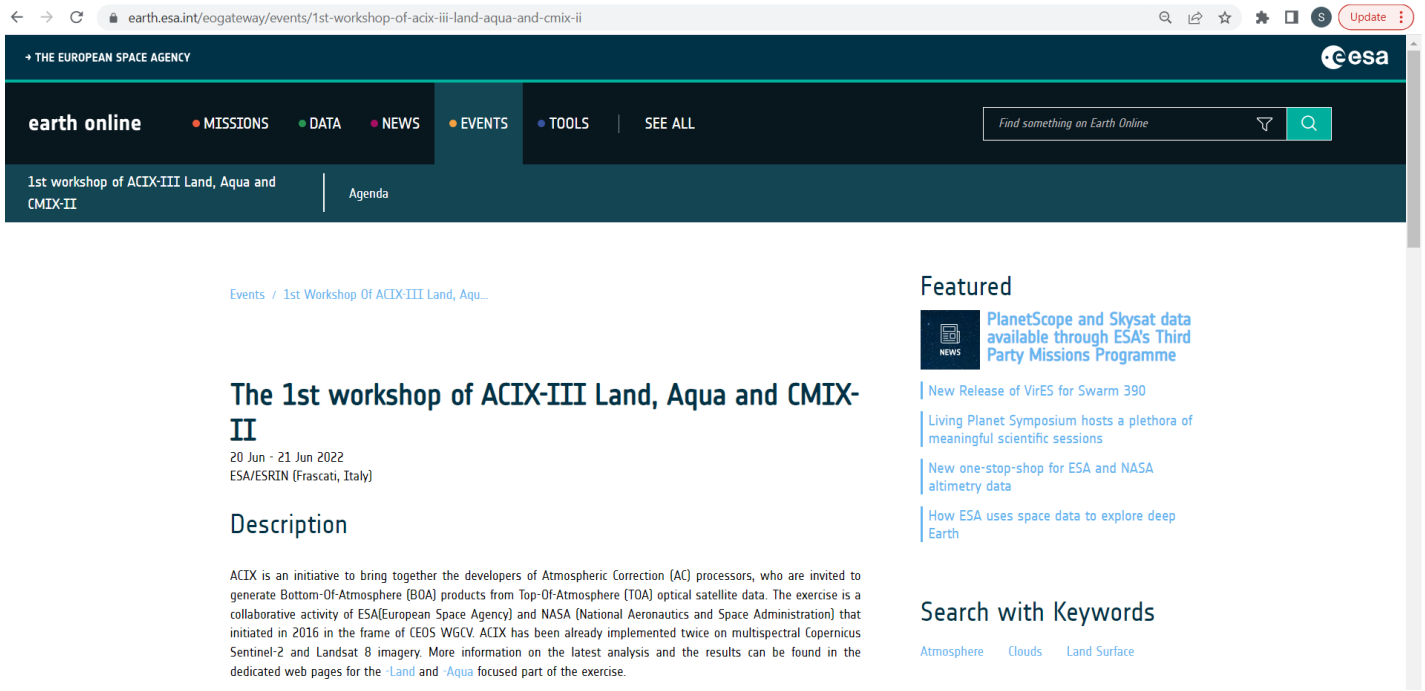


Cloud optical depth retrieval from ground-based cloud imager (Mejia et al., 2016)

Way Forward

1st Workshop **ACIX-III Land**, **Aqua** and **CMIX-II**

-- 20-21 June 2022, ESA/ESRIN, Frascati (Italy) --



https://earth.esa.int/eogateway/events/1st-workshop-of-acix-iii-land-aqua-and-cmix-ii