

# CMIX: Cloud Mask Intercomparison eXercise

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SINERGISE



VNIVERSITAT  
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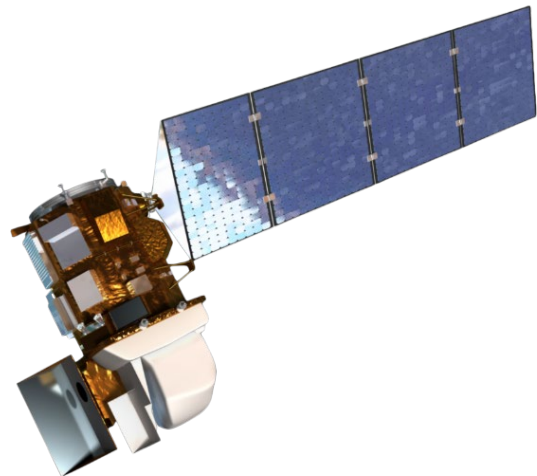
# Clouds

- 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

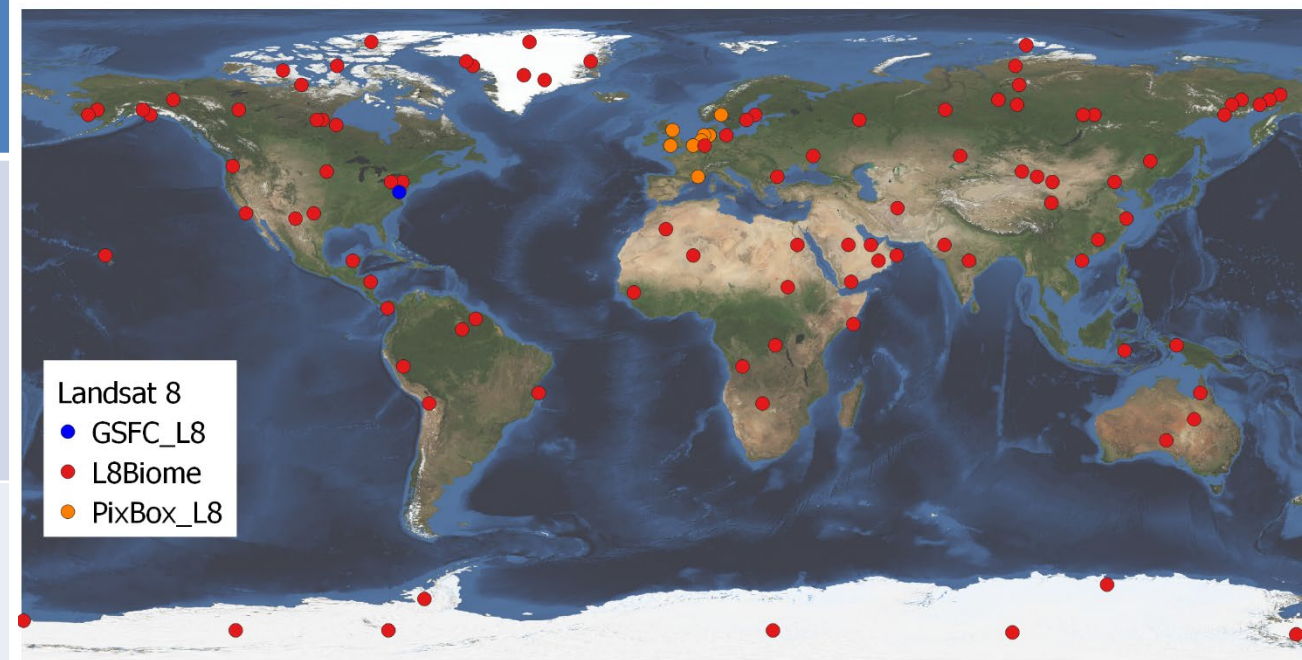
- To **inter-compare** a set of cloud detection algorithms for space-borne high-spatial resolution (10-30 m) optical sensors
- Focus on **Landsat 8** and **Sentinel-2** data
- **Not a competition**, but **inter-comparison**



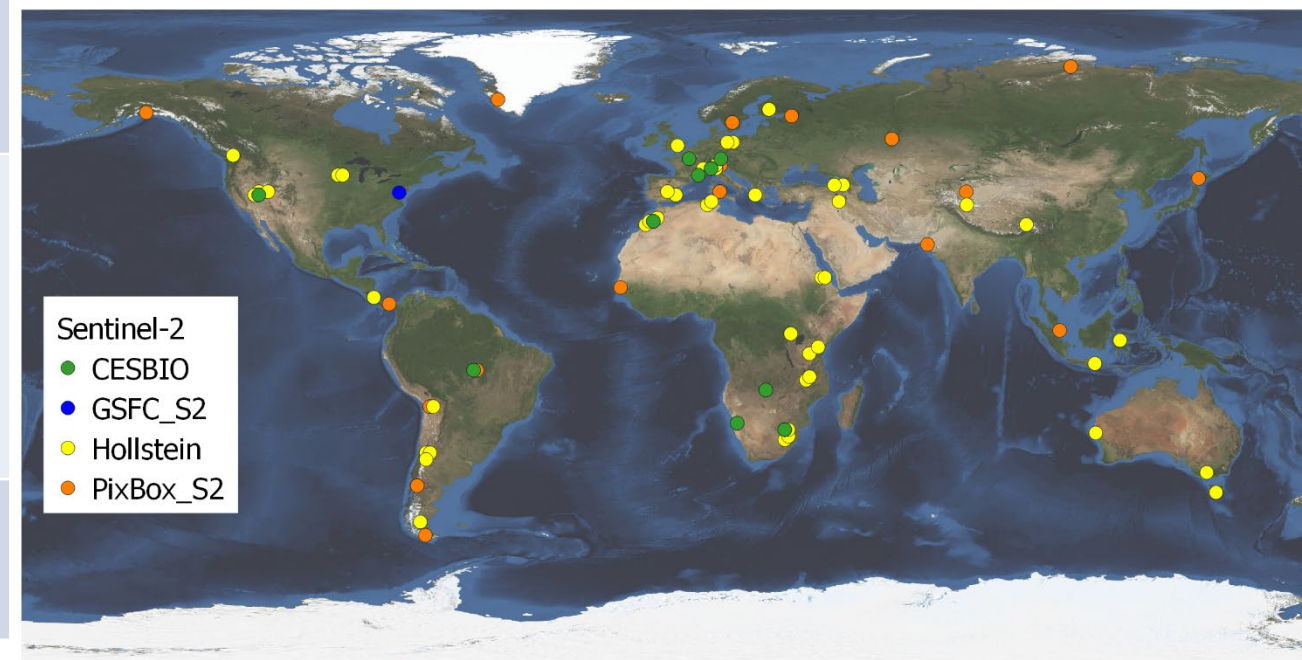
Processor	Organization	Methodology
<b>ATCOR</b>	DLR	Spectral tests (L8, S2)
<b>CD-FCNN</b>	University of Valencia	Machine learning (L8, S2)
<b>Fmask 4.0 CCA</b>	USGS	Spectral tests (L8, S2)
<b>FORCE</b>	Humboldt-Universität zu Berlin / Trier University	Spectral test + parallax (for S2) (L8, S2)
<b>IdePix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

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

Distribution of Landsat 8 reference scenes

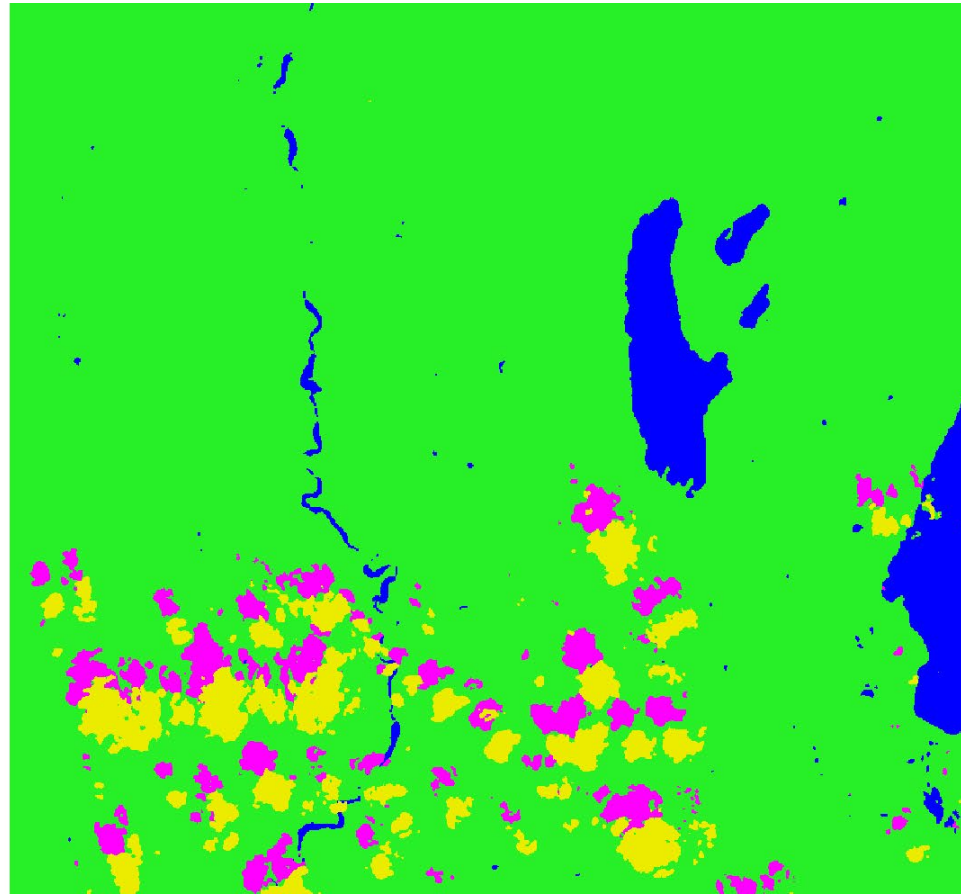



Distribution of Sentinel-2 reference scenes



# Fully classified scene

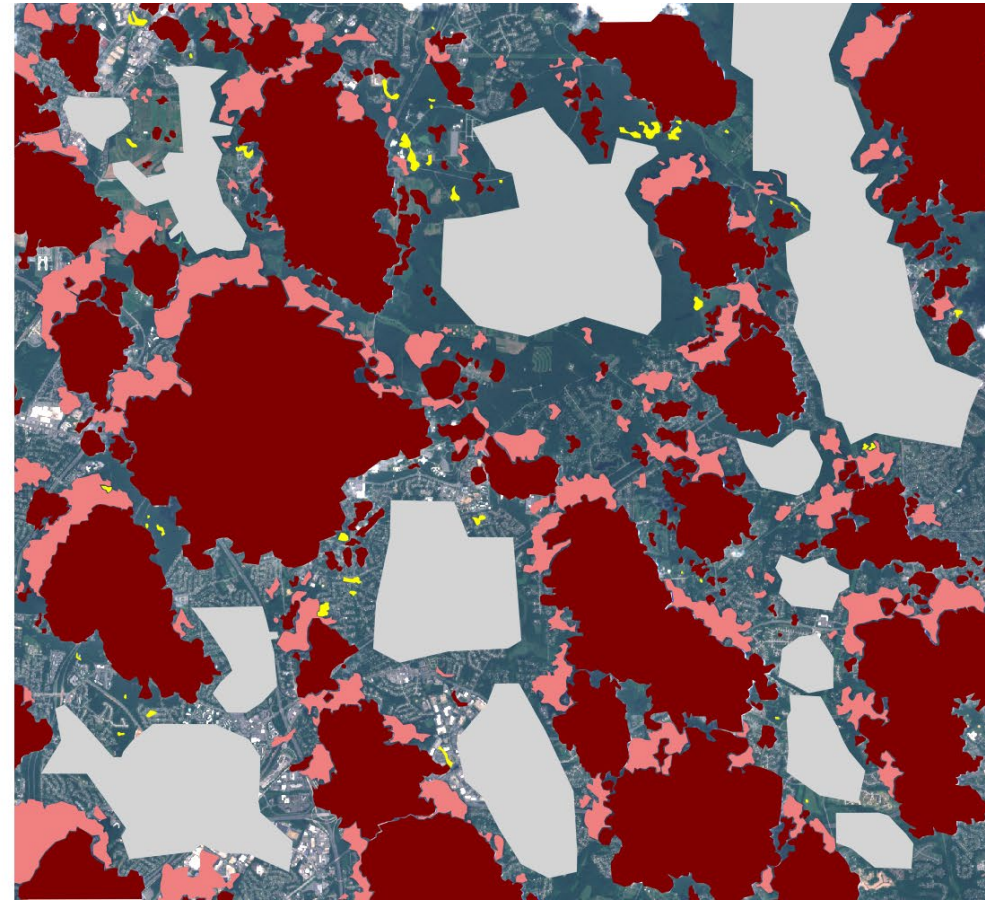
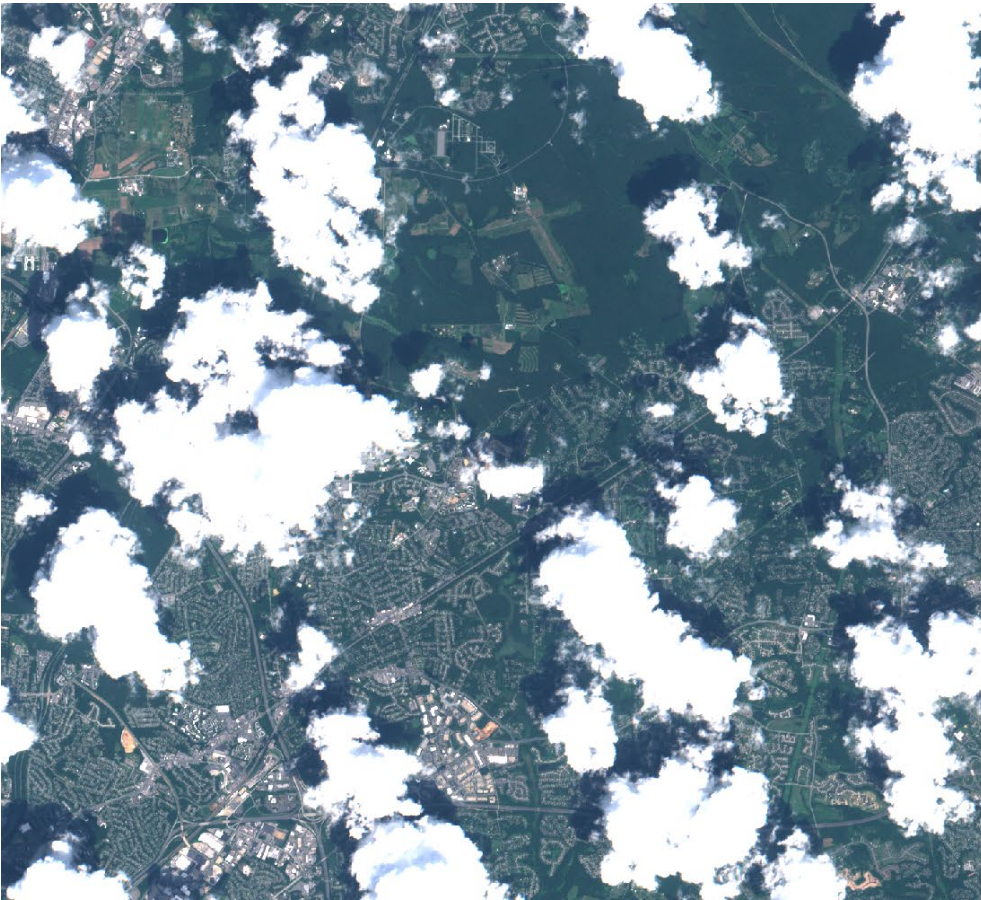
CESBIO Reference Dataset






-  Land
-  Low clouds
-  Cloud shadows
-  Water

# Polygons

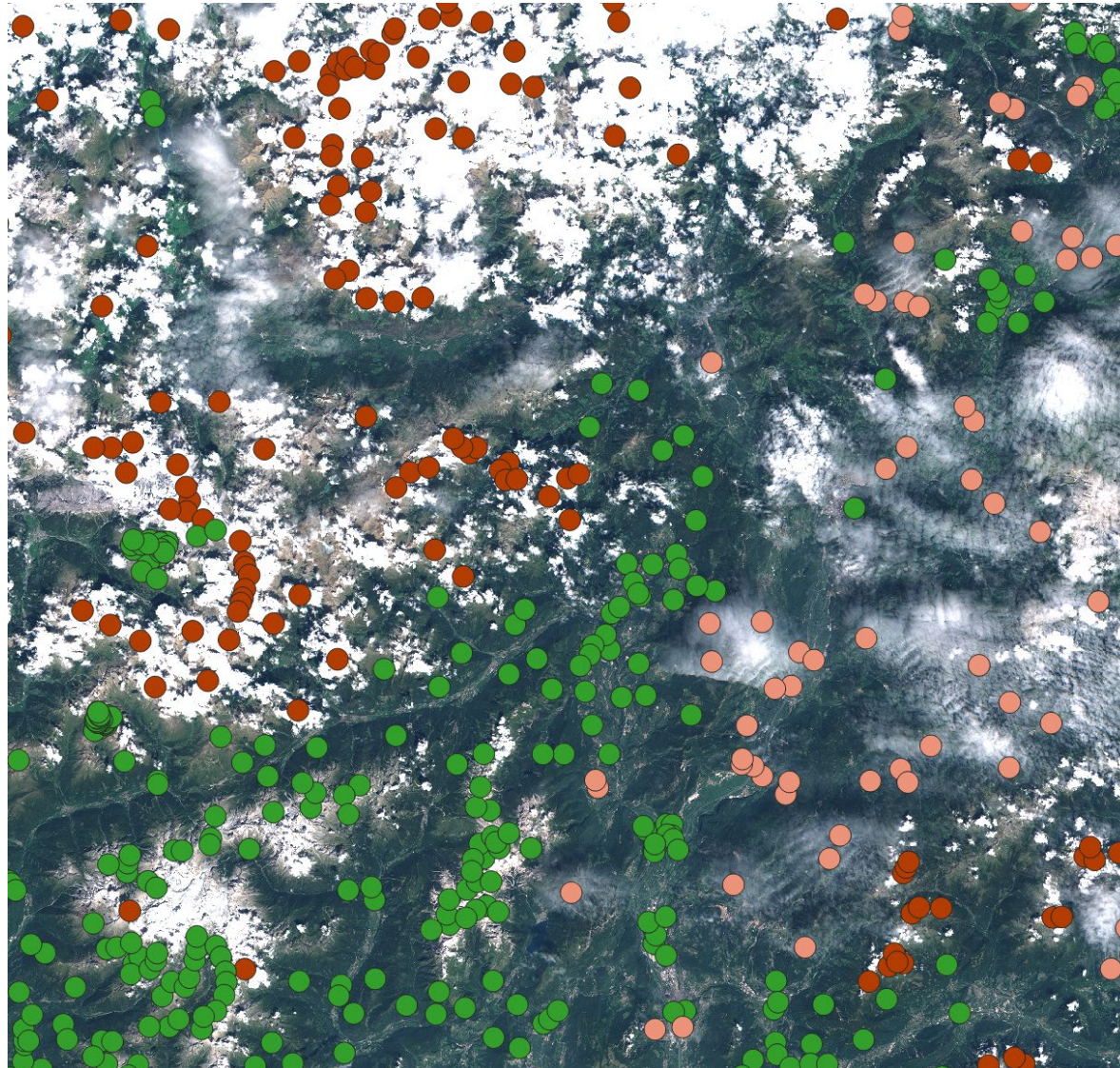
GSFC S2 Reference Dataset






-  Clouds
-  Thin clouds
-  Cloud shadows
-  Clear

# Samples

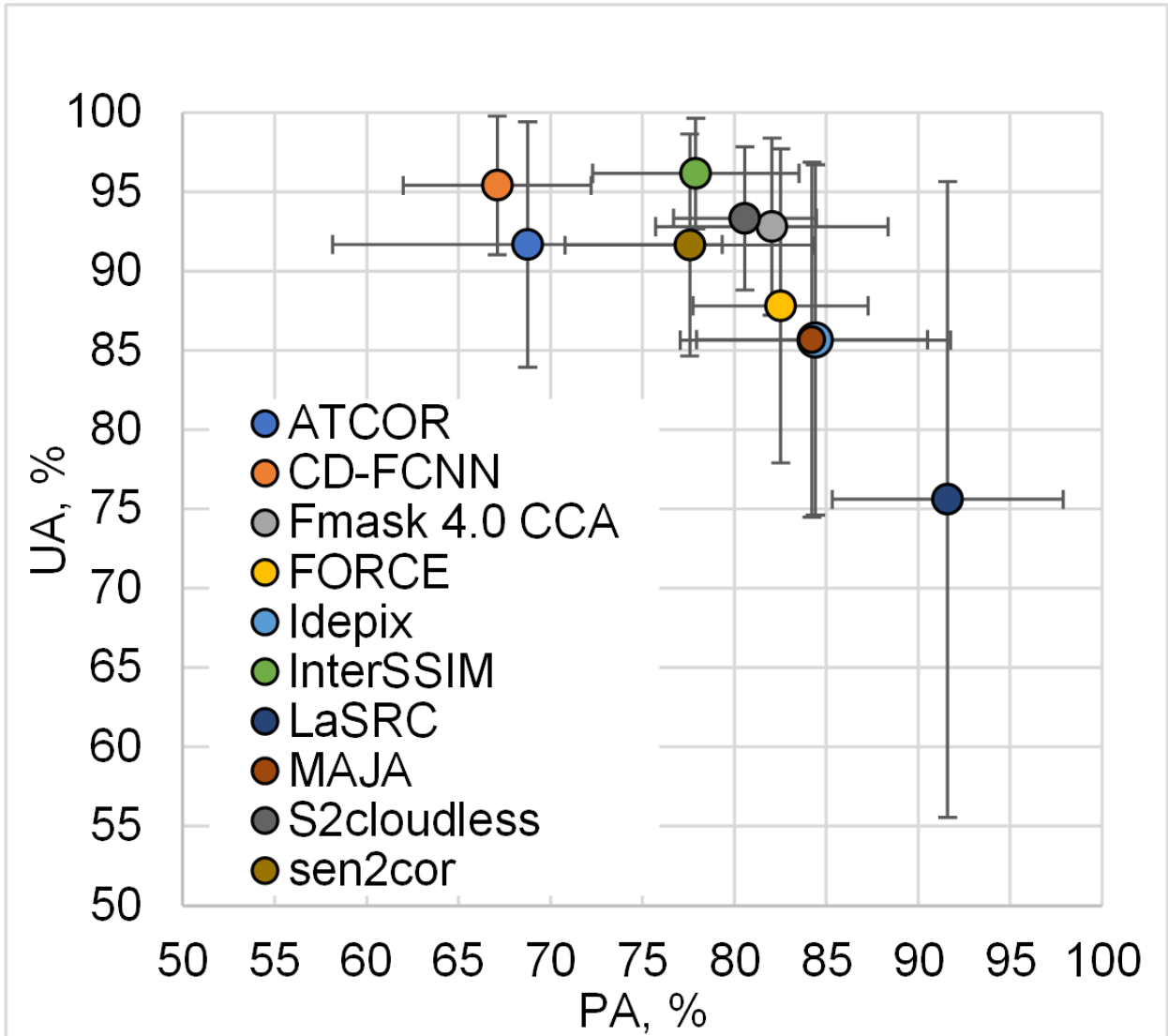
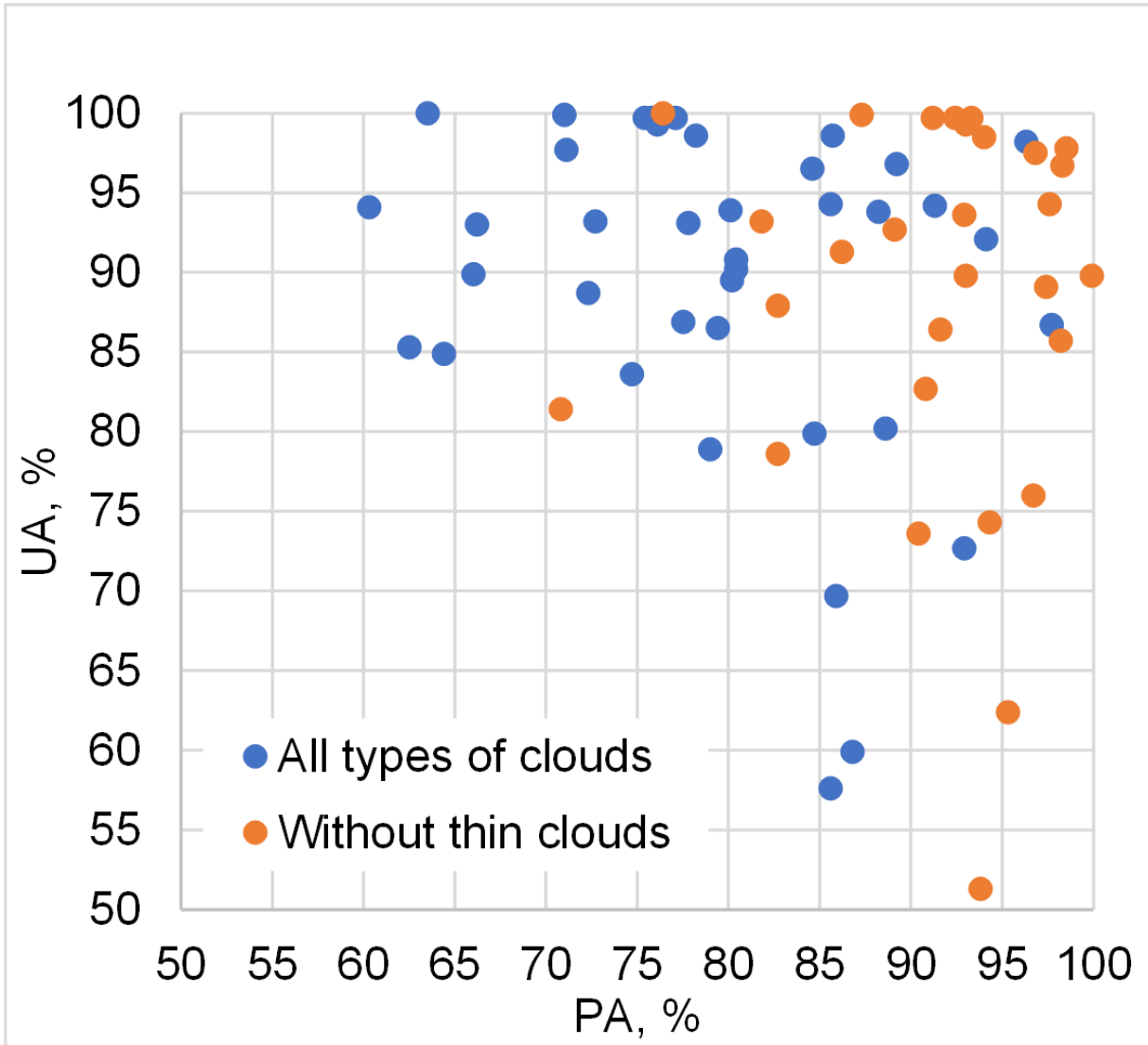
PixBox S2 Reference Dataset



-  Opaque clouds
-  Semi-transparent clouds
-  Clear

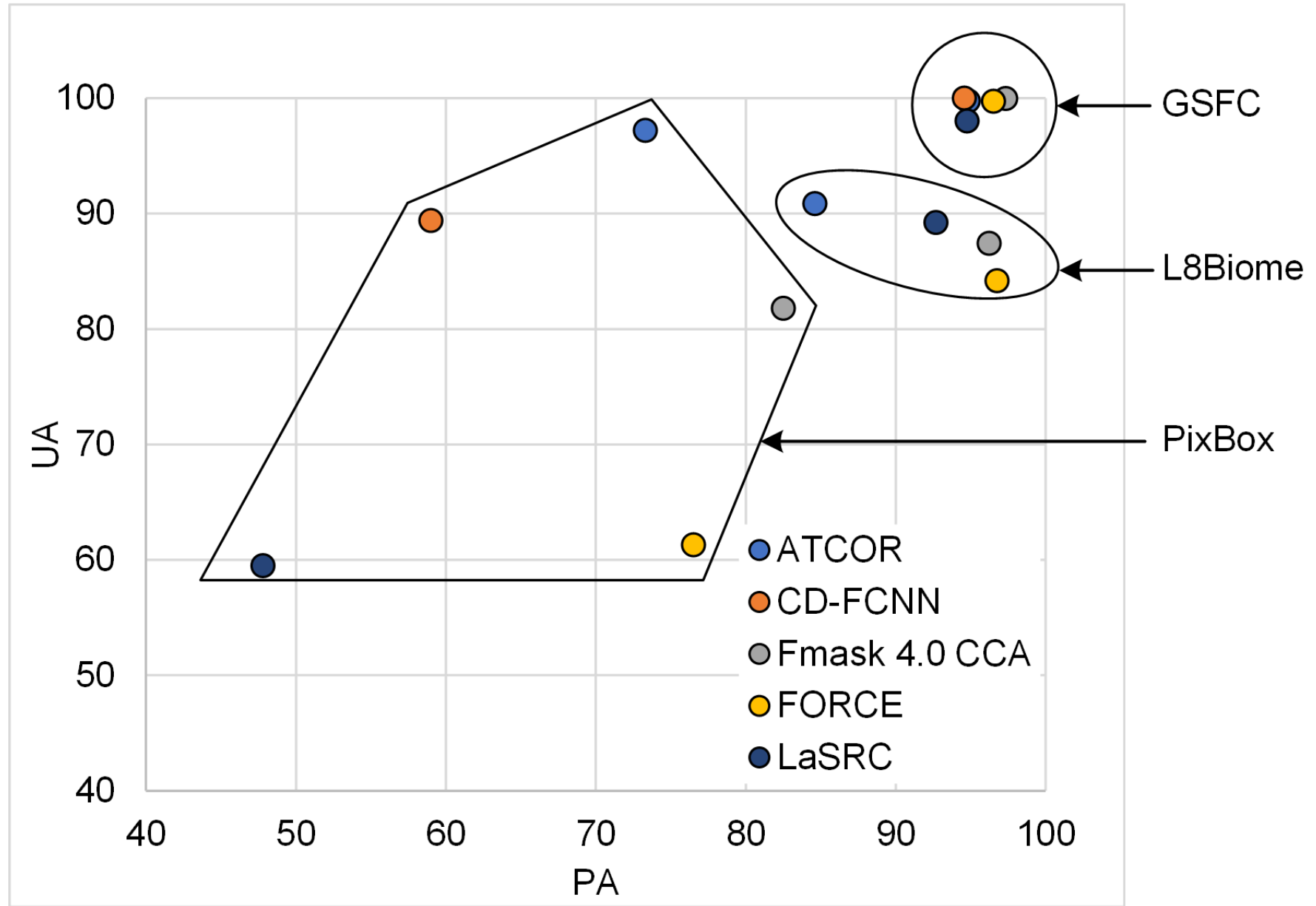


# Results: Sentinel-2



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

# Results: Landsat 8





Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

## Remote Sensing of Environment

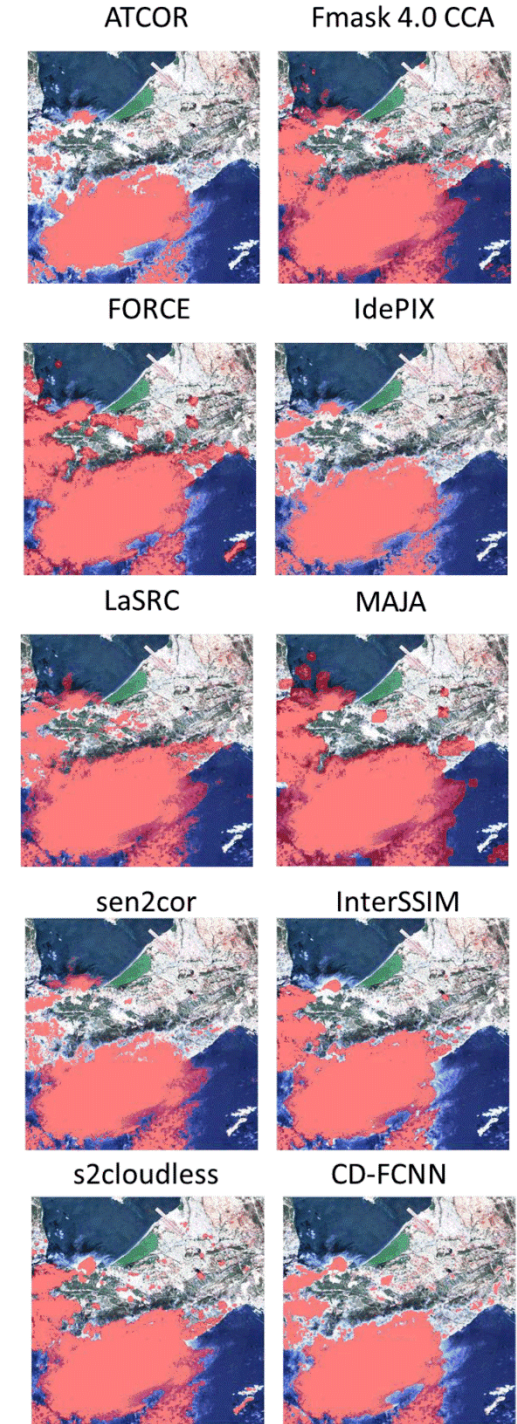
journal homepage: [www.elsevier.com/locate/rse](http://www.elsevier.com/locate/rse)



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

### ■ Major findings

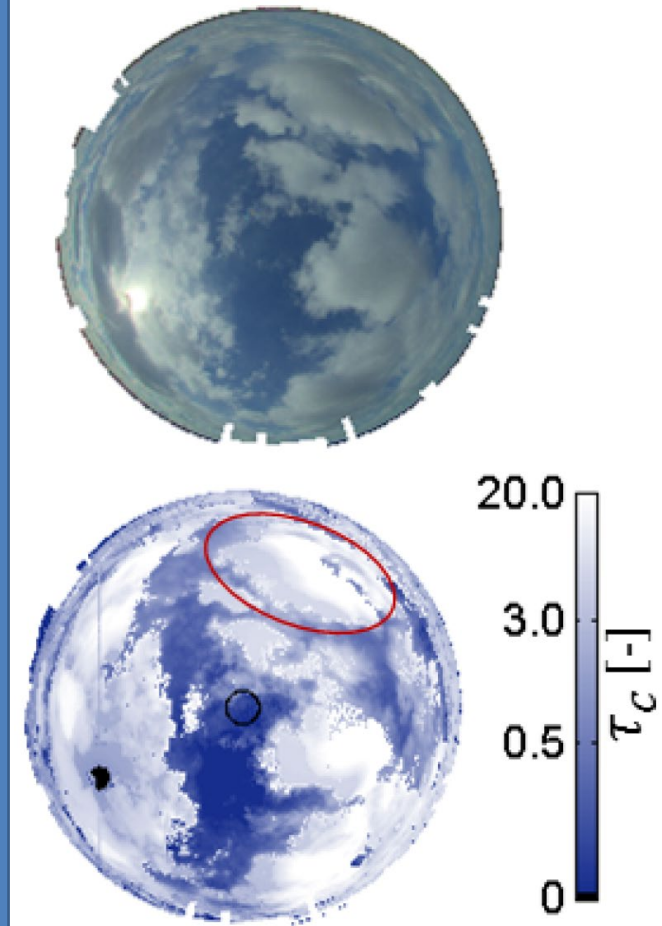
- Performance varied depending on the reference data
- Average OA for Sentinel-2: 80% to 89%
- Average OA for Landsat 8: 80% to 98%
- Performance improved when thin/semi-transparent clouds not considered



# 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

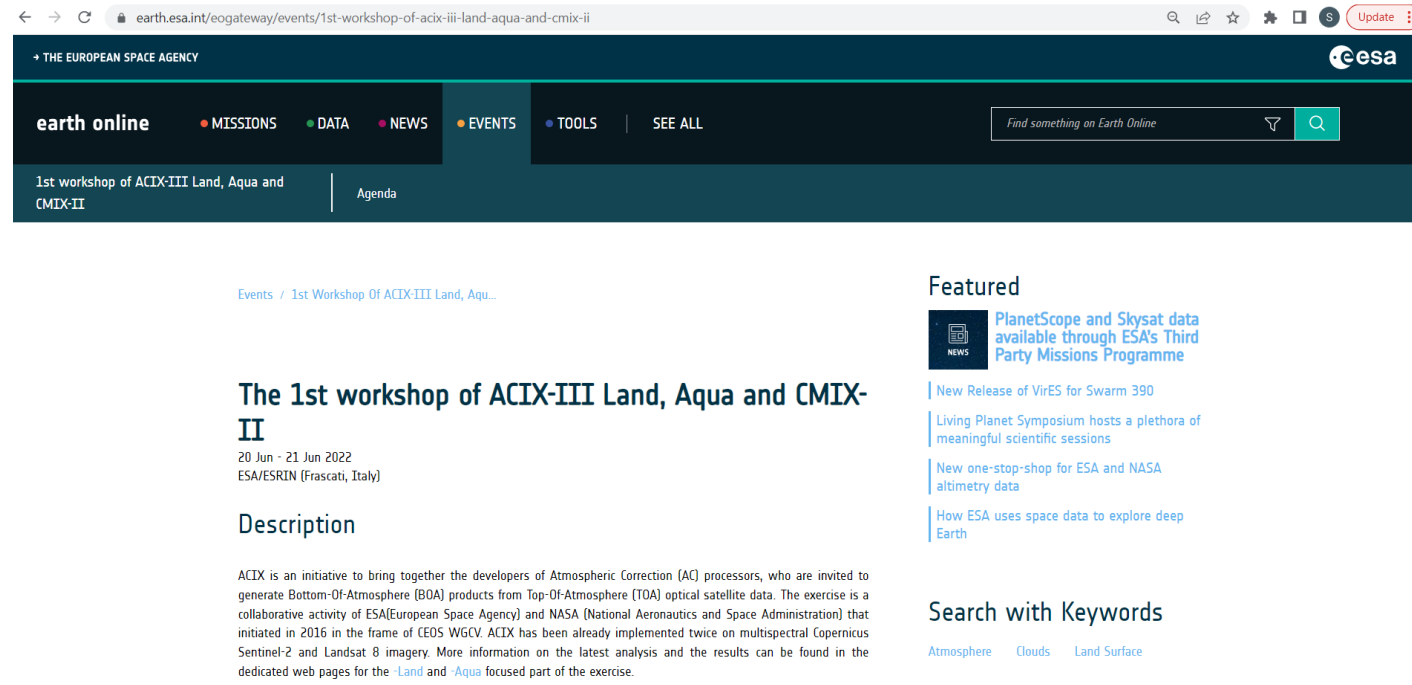
- Network of sky imagery:
- NASA GSFC, **Greenbelt, MD, USA**
  - Sapienza University, **Rome, Italy**
  - Valencia University, **Valencia, Spain**
  - Sao Paulo University, **Sao Paulo, Brazil**
  - Princess Elisabeth Station, **Antarctica**
  - WLEF, **Park Falls, WI, USA**



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)** --



The screenshot shows a web browser displaying the ESA Earth Online website. The URL in the address bar is [earth.esa.int/eogateway/events/1st-workshop-of-acix-iii-land-aqua-and-cmix-ii](https://earth.esa.int/eogateway/events/1st-workshop-of-acix-iii-land-aqua-and-cmix-ii). The page features a dark blue header with the ESA logo and navigation tabs for 'earth online', 'MISSIONS', 'DATA', 'NEWS', 'EVENTS', 'TOOLS', and 'SEE ALL'. A search bar is located on the right side of the header. Below the header, the main content area is divided into two columns. The left column contains the event title 'The 1st workshop of ACIX-III Land, Aqua and CMIX-II', the dates '20 Jun - 21 Jun 2022', and the location 'ESA/ESRIN (Frascati, Italy)'. Below this is a 'Description' section with text about the ACIX initiative. The right column is titled 'Featured' and lists several news items, including 'PlanetScope and Skysat data available through ESA's Third Party Missions Programme', 'New Release of VirES for Swarm 390', 'Living Planet Symposium hosts a plethora of meaningful scientific sessions', 'New one-stop-shop for ESA and NASA altimetry data', and 'How ESA uses space data to explore deep Earth'. At the bottom of the right column is a 'Search with Keywords' section with tags for 'Atmosphere', 'Clouds', and 'Land Surface'.

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