ACIX-III Land

Atmospheric Correction Inter-comparison eXercise

RAMI WORKSHOP ON RADIATIVE TRANSFER MODELLING
SUPPORT TO EO METROLOGY AND CAL/VAL ACTIVITIES

7-9 JUN 2023 VARESE, ITALY

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WHY?

OPEN
ACCESS

Free and open access policy to Earth Observation imagery has stimulated the development and operational use of Atmospheric Correction (AC) processors for generating Bottom-of-Atmosphere (BOA) products

WHAT?

S	W
C	D

The objective is to point out:

- Strengths & Weaknesses
- Commonalities & Differences

WHEN?

2016 - 2018

ACIX
11 processors
19 AERONET sites
Publication link
Website link

2018 - 2022

CMIX
10 processors
5 validation datasets
Publication link
Website link

ACIX-II Land
12 processors
120 AERONET sites
Publication link
Website link

ACIX-II Aqua
8 processors
20 AERONET OC sites
Publication link
Website link

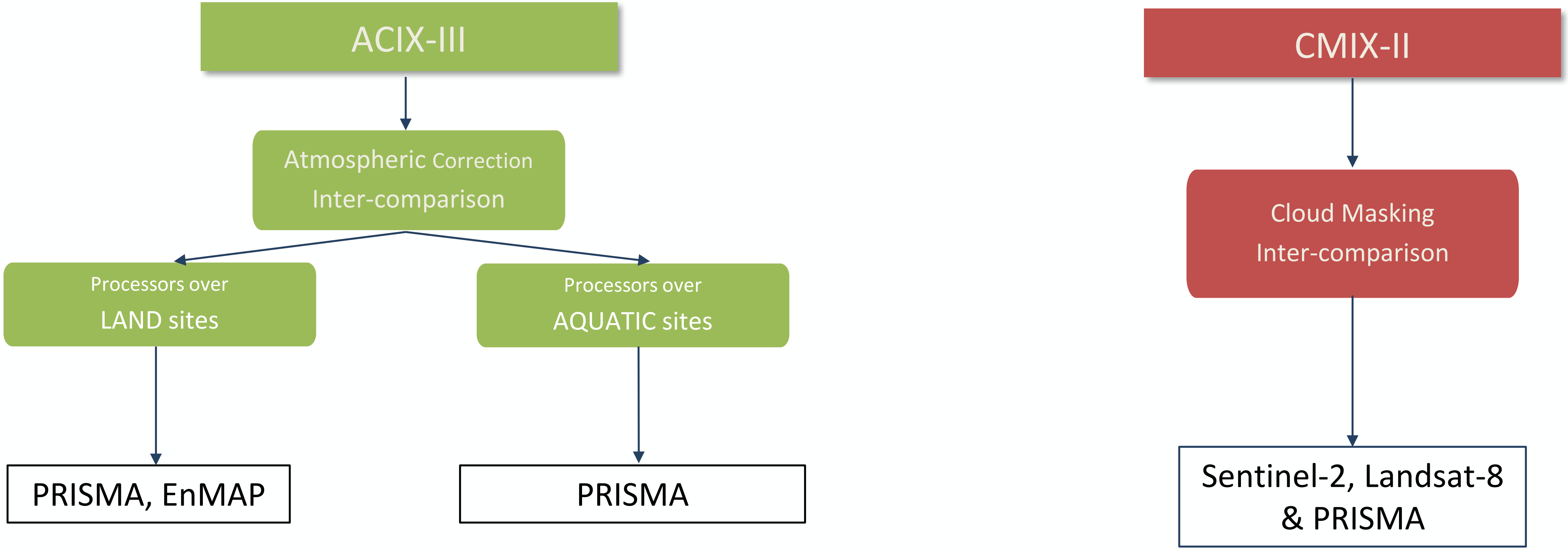
2022 - 2024

CMIX-II
17 processors

ACIX-III Land
14 processors

ACIX-III Aqua
18 processors

How?


ACIX-III
Atmospheric Correction Inter-comparison
Processors over LAND sites
Processors over AQUATIC sites
PRISMA, EnMAP
PRISMA
CMIX-II
Cloud Masking Inter-comparison
Sentinel-2, Landsat-8 & PRISMA

How?

With the support of:

Agenzia Spaziale Italiana

DLR Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

ACIX-III

Atmospheric Correction
Inter-comparison

Processors over
LAND sites

esa


Kevin Alonso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Jet Propulsion Laboratory
California Institute of Technology


Adam Chlus


Philip Brodrick


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Phil Townsend

How?

Definition of the inter-comparison protocol → **Application of the AC processors** → **Analysis of the results**

Coordinators & Participants
discussed all the major points and defined the inter-comparison procedure.

Participants
applied their AC schemes on a set of test sites keeping the processing parameters constant. The results were submitted for analysis to ACIX coordinators.

Coordinators
processed the AC results and assessed the inter-comparison metrics. The results presented and discussed with the participants.

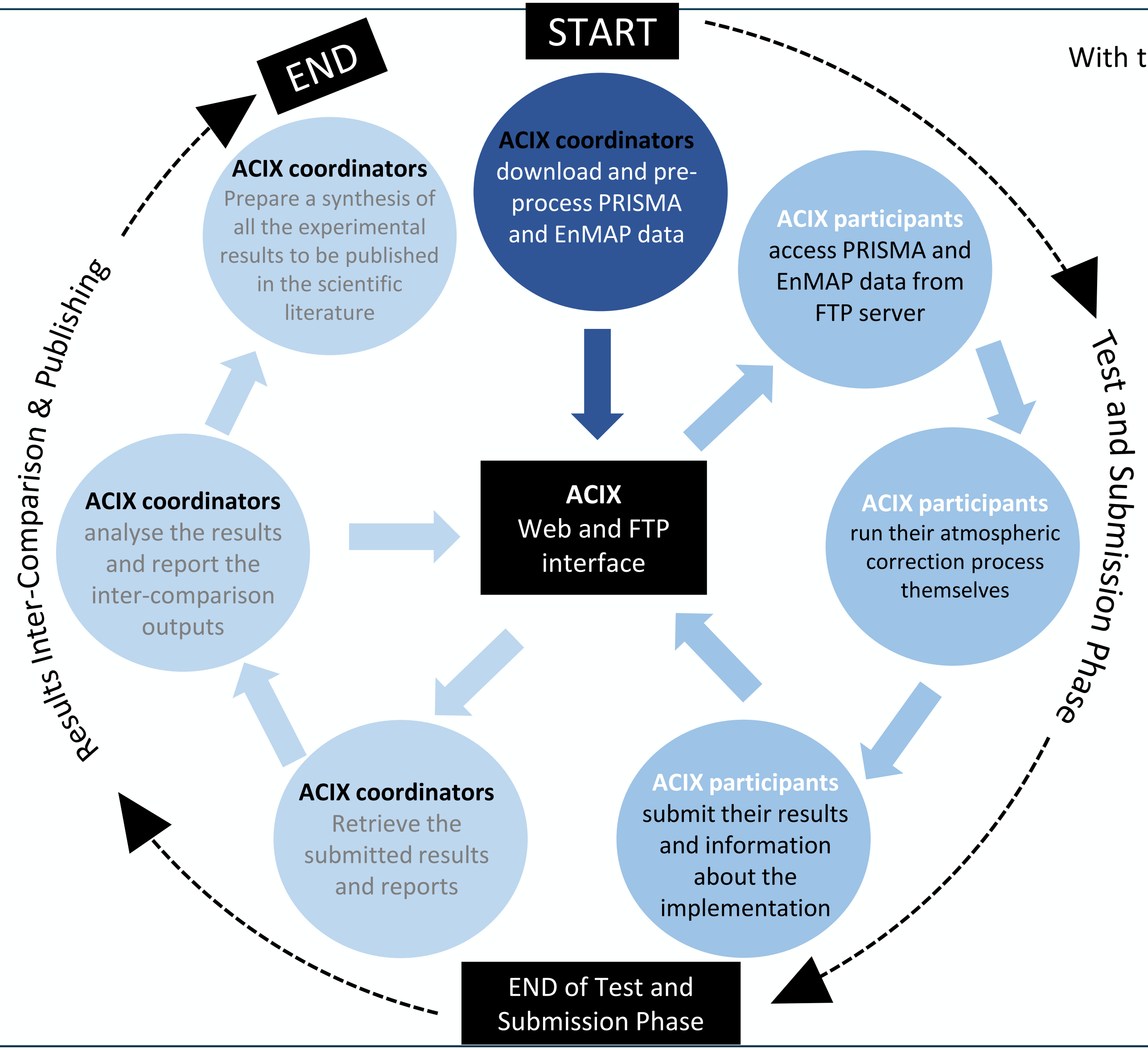
WHO?

#	Organization/Entity	Processor's Name
1	DLR	PACO
2	University College London	SIAC
3	VITO	iCOR
4	MAGELLIUM	MAGAC
5	Spectral Sciences, Inc.	QUAC
6		FLAASH
7	NASA Ames Research Center	HECC
8	JPL	isofit
9	NASA Ames Research Center	GeoNEX-AC
10	ONERA	COCHISE
11	CAS.CHINA	Hikerliu
12	RBINS	ACOLITE/DSF
13	CNR Institute of Methodologies for Environmental Analysis (IMAA)	ImaACor
14	Naval Research Lab, Washington DC USA	ATREM

Reported RTMs

MODTRAN 4/5/6
LibRadTran
6S
SHARM
IPOL

How?



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Agenzia Spaziale Italiana

Modified PRISMA L1 Geocorrected (L1G)

- **Altered datasets:**
  1. Data fields
     - Projection to WGS84/**UTM at 30m** spatial resolution using Nearest Neighbor
  2. Geolocation fields
     - Because VNIR and SWIR datasets are **co-registered**, separate latitude and longitude datasets are not needed and instead have been replaced with single **datasets adjusted using an image matching algorithm**.
     - The original time dataset contained per line time in MJD2000, this has been replaced with **per-pixel UTC decimal hour**.

- **New datasets/attributes:**
  1. Solar geometry in degrees calculated at mean scene acquisition time
     - **Solar_Azimuth_Angle**
     - **Solar_Zenith_Angle**
  2. Sensor geometry in degrees calculated using satellite positional data provided with the L1 dataset
     - **Sensor_Azimuth_Angle**
     - **Sensor_Zenith_Angle**

Orbit Altitude Reference	615 km
Swath / FOV	30 km / 2.77°
GSD	Hyperspectral: 30 m PAN: 5 m
Spatial Pixels	Hyperspectral: 1000 PAN: 6000
Pixel Size	Hyperspectral: 30x30 µm PAN: 6.5x6.5 µm
Spectral Range	VNIR: 400 – 1010 nm (66 bands) SWIR: 920 – 2500 nm (173 bands) PAN: 400 – 700 nm
Spectral Sampling Interval (SSI)	≤ 12 nm
Spectral Width	≤ 12 nm
Cross-Track Variation of Centre Wavelength (Smile)	< +/- 0.1 SSI
Spatial registration of spectral sampling (incl. Keystone)	≤ 0.1 pixel
Spectral Calibration Accuracy	+/-0.1 nm
Radiometric Quantization	12 bit
VNIR SNR	>200:1
SWIR SNR	>100:1
PAN SNR	> 240:1
Absolute Radiometric Accuracy	Better than 5%
Aperture Diameter	210 mm
MTF@ Nyquist Frequency	VNIR/SWIR along track >0.18 VNIR/SWIR across track > 0.34 PAN along track >0.1 PAN across track >0.2
Cooling System	Passive Radiator
Lifetime	5 years

Modified PRISMA L1 Geocorrected (L1G)

- PRS_L1G_STD_OFFL_20190710091734_20190710091738_0001.h...
  - HDFEOS
    - ADDITIONAL
      - FILE_ATTRIBUTES
    - SWATHS
      - PRS_L1_HCO
        - Data Fields
          - SWIR_Cube
          - VNIR_Cube
        - Geolocation Fields
          - Latitude
          - Longitude
        - Geometric Fields
          - Sensor_Azimuth_Angle
          - Sensor_Zenith_Angle
          - Solar_Azimuth_Angle
          - Solar_Zenith_Angle
        - Terrain Fields
          - DEM
  - HDFEOS INFORMATION
  - Info
  - KDP_AUX

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Input Data EnMAP

Deutsches Zentrum
für Luft- und Raumfahrt
German Aerospace Center

EnMAP Products are distributed as a ***.zip* file** with several ***.tif*** files and a set of **.xml** (including one for the metadata).

EnMAP L1C data: **Top-of-Atmosphere Radiance** radiometrically corrected, orthorectified and calibrated in physical units (incl. Cloud layer; Cirrus layer; Haze layer; Snow layer; Cloud shadow Layer; Classes layer Pixel mask; Calibration and characterization data)

EnMAP HSI Instrument Specification

Spectral range:	420 nm - 2450 nm
Spectral sampling distance:	6.5 nm (420 nm - 1000 nm; VNIR) 10 nm (900 nm - 2450 nm; SWIR)
Spectral accuracy / stability:	0.5 nm / 0.5 nm (VNIR) 1.0 nm / 0.5 nm (SWIR)
Signal-to-Noise ratio*:	> 500 (at 495 nm; VNIR) > 150 (at 2200 nm; SWIR)
Smile and keystone:	< 0.2 pixel
Polarization sensitivity:	< 5%
Radiometric resolution:	≥ 14 bits
Radiometric accuracy / stability:	5% / 2.5% (between two consecutive calibrations)
On-board calibration:	Full aperture diffuser Integrated sphere with various calibration lamps Shutter for dark measurements
Telescope:	Three-mirror anastigmat Focal length: 522.4 mm Aperture: 174 mm in diameter F-number: 3.0
Geometric resolution:	30 m × 30 m (swath width: 30 km) (IFOV 9.5 arcsec × integration time 4.4 ms (FOV 2.63 deg)) swath length of 5000 km per day with 512 Gbit on-board mass memory
Modulation Transfer Function:	> 0.25 @ 60m across track > 0.16 @ 60m along track > 0.64 @ 240m across track > 0.62 @ 240m along track
Geometric co-registration:	< 0.2 pixel (at Level 1C)
Pointing:	Accuracy: < 500 m Knowledge: < 100m Stability: < 1.5 m in 4 ms Agility: 30° in 5 min with pointing stabilization

*reference radiance level represents 30% surface albedo, 30° Sun zenith angle, ground at sea level, and 40 km visibility with rural atmosphere

How?

Aerosol Optical Depth

Water Vapour

AERONET

Estimated AOD (/WV) & compared to Level 1.5 (cloud screened) AERONET data

1. Interpolate AERONET values @ λ=550 nm using Angstrom Exponent
2. Average AERONET values over time period within ±15 min from AOD retrieved values (PRISMA/EnMAP overpass)
3. Average estimated AOD values over an image subset of 9 km x 9 km centred on the AERONET sun-photometer station

Statistics

No. of samples

R^2 (Coefficient of determination)

RMSE

bias

APU analysis

$$\textit{Accuracy (A)}: A = \frac{1}{n}\left(\sum_{i=1}^{n} \Delta_{AOD}\right)$$

$$\textit{Precision (P)}: P = \sqrt{\frac{1}{(n-1)}\sum_{i=1}^{n}(\Delta_{AOD} - A)^2}$$

$$\textit{Uncertainty (U)}: U = \sqrt{\frac{1}{n}\sum_{i=1}^{n} \Delta_{AOD})^2}$$

AERONET sites with PRISMA/EnMAP acquisitions

35 AERONET sites with valid measurements have been selected for PRISMA

49 AERONET sites with valid measurements have been selected for EnMAP

Final selection pending!

Overlap of stations/regions for both sensors has been considered

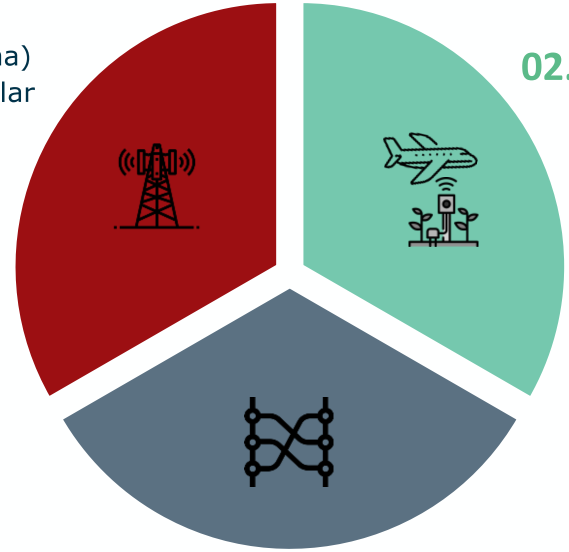
How?

How?

01. Ground based validation

RadCalNet [La Crau] (France), [Gobabeb] (Namibia), [Railroad Valley Playa] (USA), [Baotou] (China)
If possible, SR at same angular conditions that the satellite.

HYPERNET



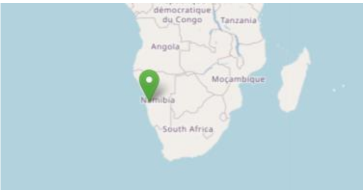
02. Campaign Data

ESA CHIME & SBG 2021 campaign and NEON Airborne Observation Platform (AOP).
Reference BOA retrieved by in-situ measurements.

03. Relative SR inter-comparison

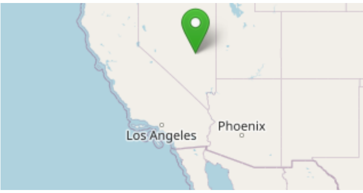
Plotting the spectral profiles per AC approach.

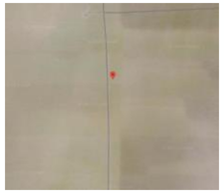
Gobabeb [Namibia]: 22 PRISMA
10 EnMAP scenes with overpass [CC<30%]



La Crau [France]: 5 PRISMA
0 EnMAP scenes with overpass [CC<30%]

Railroad Valley Playa [USA]: 14 PRISMA
11 EnMAP scenes with overpass [CC<30%]





Baotou [China]: 0 PRISMA
0 EnMAP scenes with overpass [CC<30%]

The measurements will be processed to PRISMA/EnMAP observation geometry when possible

AVIRIS NG for ESA CHIME & SBG 2021

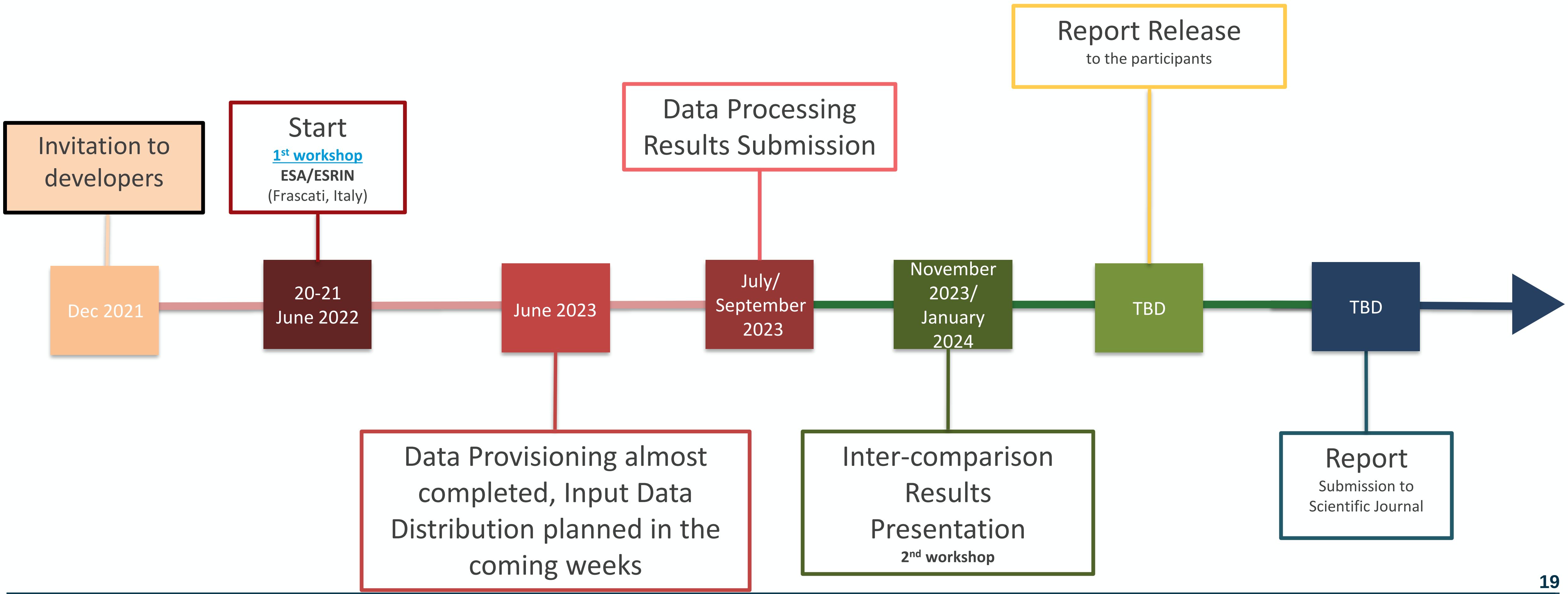
Country	Site	Latitude	Longitude	PRISMA date	AVIRIS-NG date(s)	PRISMA scene
Germany	Demmin	53.7723	13.089	20210518	20210530	20210518102102_20210518102107_0001
Spain	**Camarena**	**39.9703**	**-4.1459**	**20210630**	**20210630**	**20210630110522_20210630110526_0001**
Italy	**Braccagni**	**42.8374**	**11.0709**	**20210604**	**20210604**	**20210604101721_20210604101725_0001**
	Rio Tinto	**37.7791**	**-6.5747**	**20210625**	**20210625**	**20210625111917_20210625111921_0001**
	Jolanda	44.8905	11.957	20210621	20210625	20210621101020_20210621101024_0001
Great Britain	FlowCountry	58.3652	-3.9573	20210603	20210615	20210603113329_20210603113333_0001

3 campaign sites with PRISMA overpasses

NEON Airborne Observation Platform (AOP)

Site	Latitude	Longitude	PRISMA date	NEON AOP date(s)	PRISMA scene
MOAB	38.248283	-109.38827	20200702	20200705	20200702181741_20200702181745_0001
WREF	45.82049	-121.95191	20210729	20210718	20210729190927_20210729190932_0001
SRER	31.91068	-110.83549	20210829	20210823-20210902	20210829180958_20210829181002_0001
NIWO	40.05425	-105.58237	20200822	20200801 - 20200807	20200822175652_20200822175657_0001

Timeline


Invitation to developers
Dec 2021
Start
1st workshop
ESA/ESRIN
(Frascati, Italy)
20-21 June 2022
June 2023
Data Provisioning almost completed, Input Data Distribution planned in the coming weeks
Data Processing Results Submission
July/ September 2023
November 2023/ January 2024
Inter-comparison Results Presentation
2nd workshop
Report Release
to the participants
TBD
TBD
Report
Submission to Scientific Journal

Thank you for your attention!

1st WS of ACIX-III Land, -Aqua and CMIX-II:
https://earth.esa.int/eogateway/events/1st-workshop-of-acix-iii-land-aqua-and-cmix-ii/agenda