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COPERNICUS SENTINEL-2 GLOBAL REFERENCE IMAGE DATABASE

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SENTINEL 2

OPT-MPC Optical Mission Performance Cluster

What is the Global Reference Image (GRI)?

GRI is composed of about 1000 Level 1B Sentinel-2A & B mono-spectral (B4, red channel, central wavelength ~665nm) images

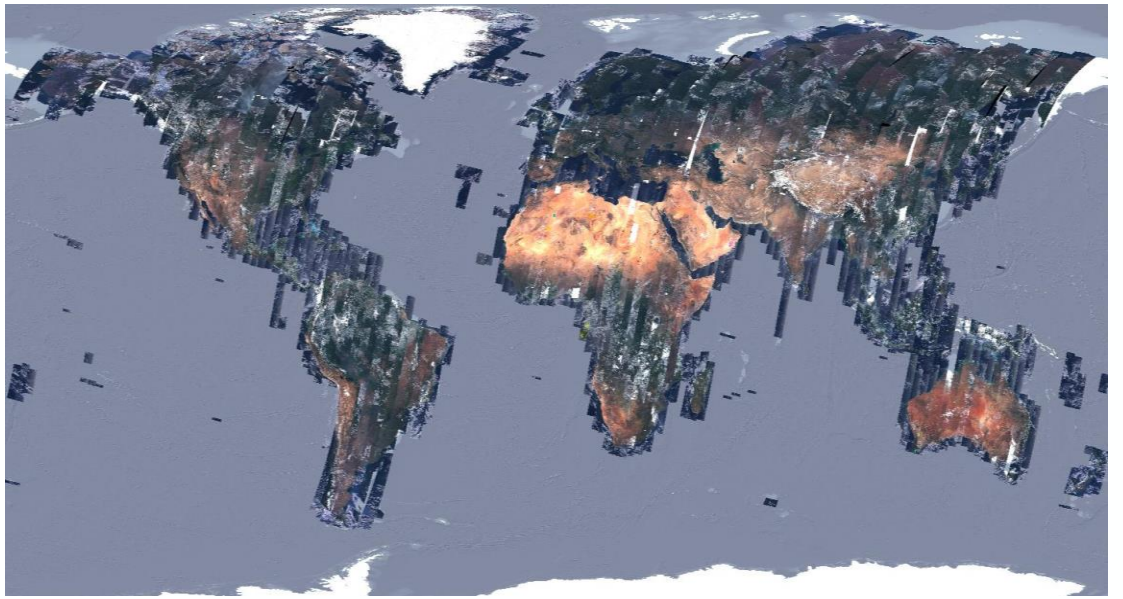
› worldwide coverage including many isolated islands

› stack of images limiting clouds (up to 6 images)

The GRI was introduced in the geometric refinement algorithm since August 2021 worldwide => highly improved the multi-temporal co-registration and the relative geolocation accuracy of Copernicus Sentinel-2 products.

› new products derived from the Sentinel-2 GRI

› developed in a more accessible format.



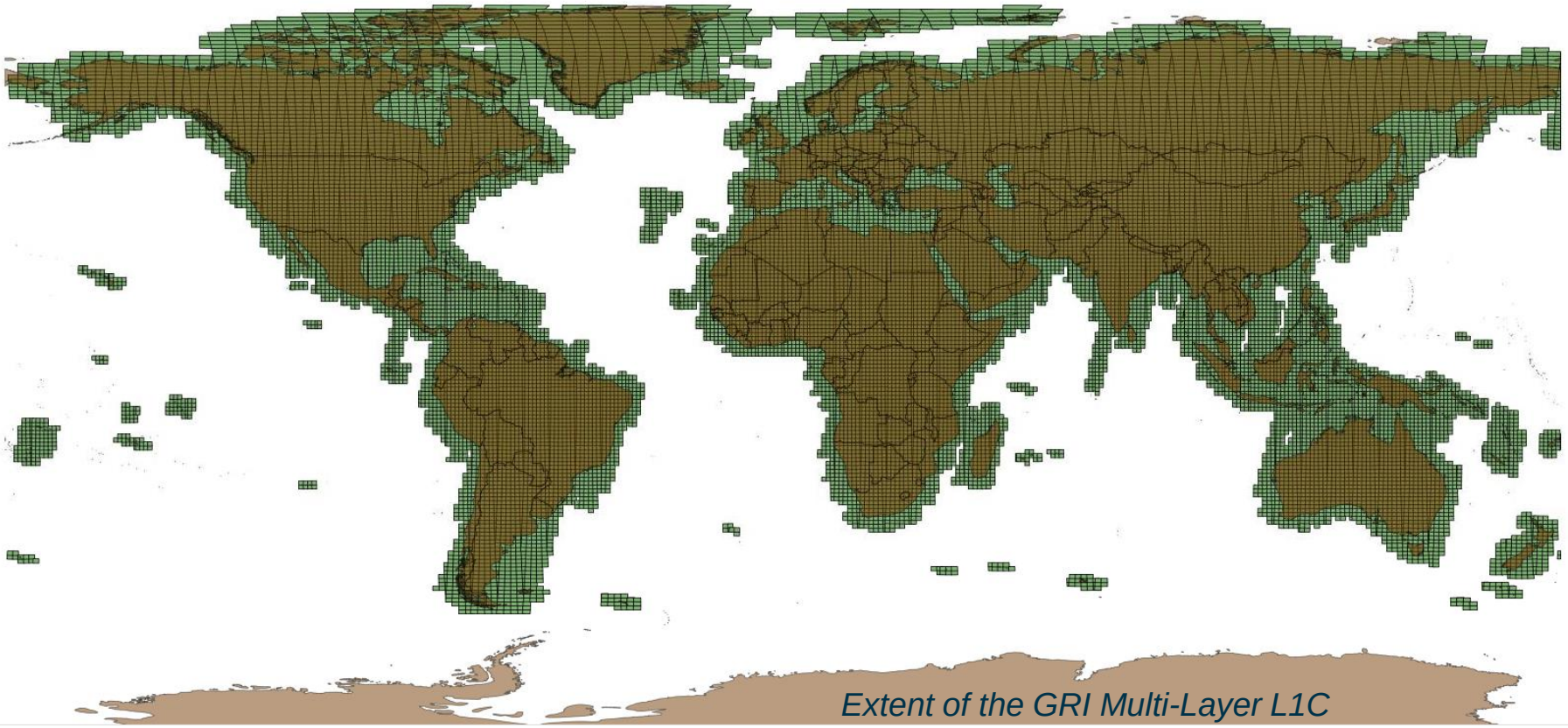
L1C GCPs Database - database of GCPs in L1C geometry	**Multi-layer L1C GRI** - set of L1C images (orthorectified in UTM projection)
L1B GCPs Database - database of GCPs in L1B geometry	**Multi-layer L1B GRI** - set of overlapping Level-1B images (in sensor geometry)

Agenda

- Insight into the new products derived from the Sentinel-2 GRI
- GRI access
- Recommendations of use
- Expected added values

Generation of a multi-layer GRI product in L1C - Multi-layer L1C GRI -

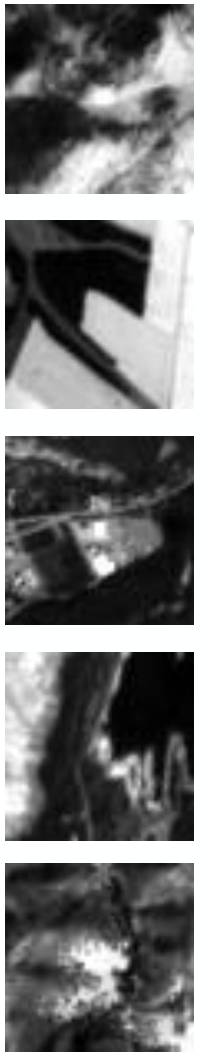
- generated by converting the Multi-Layer L1B GRI to L1C tiles (same coverage)
- compliant to the last Sentinel 2 L1C format evolutions (PSD 14.9, PB 05.00)
- generated with the Copernicus DEM at 30m resolution
- composed by multiple layers
- cloud mask regenerated



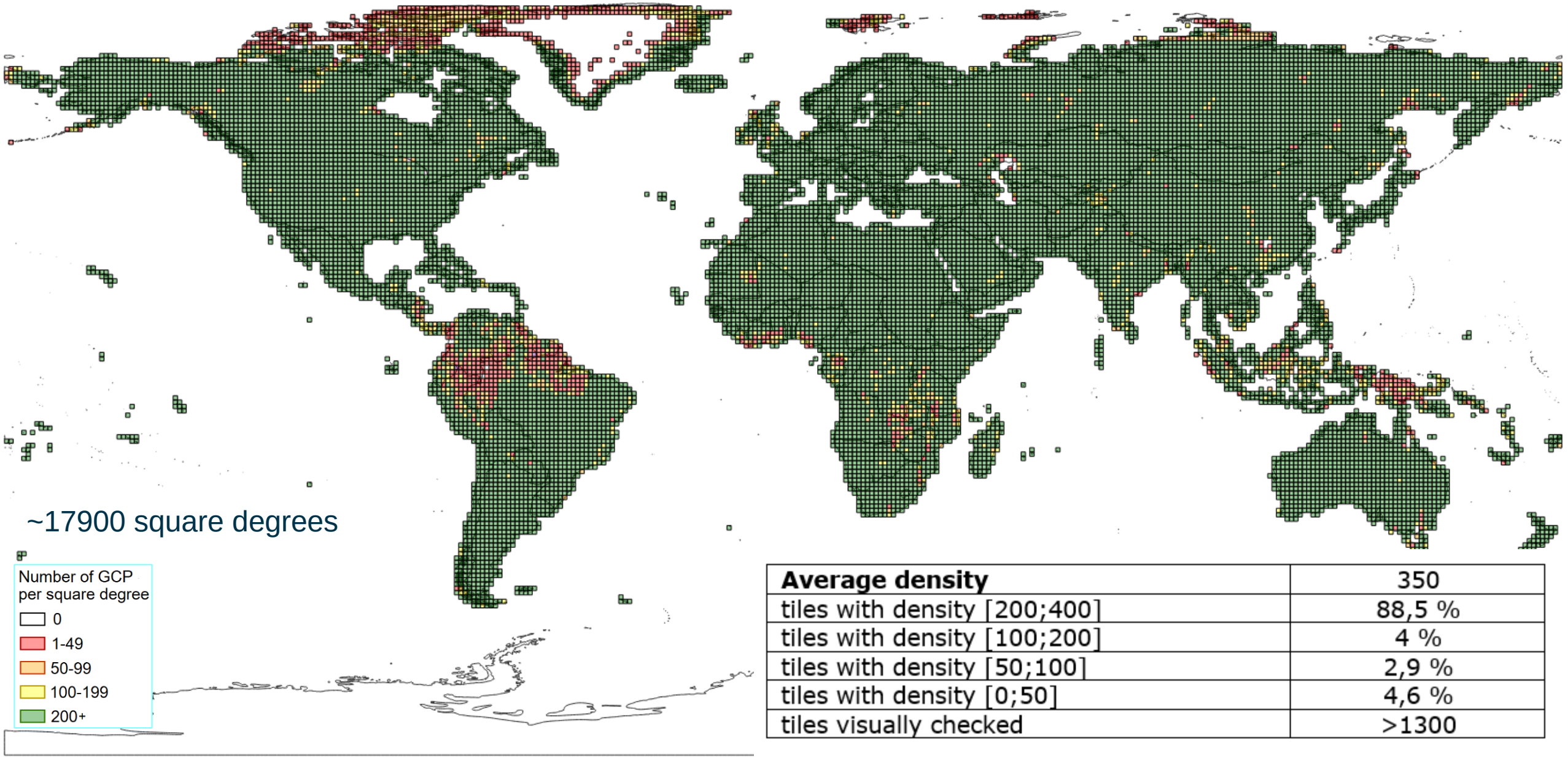
Extent of the GRI Multi-Layer L1C

Conversion of the GRI in a Database of GCPs in L1C

- What is the GRI GCP DB?
  - A set of textured points of interest extracted from GRI images
    - Same coverage as the Multi-layer L1B GRI
    - Relevant features of the landscape automatically detected
    - Same geometric quality as GRI
    - Qualified
- Data are delivered by tiles of 1° x 1°. For each square degree:
  - the L1C chips are in the ./L1C_chips folder.
  - a single .json file gathering all the GCPs.
- Chip size: 57*57 pixels at 10m of resolution, B04 red band
- GeoTIFF format, 16 bits and rectified in UTM projection (constant altitude).



Map of GCPs density per square degree for the GRI GCP (land cover considered)



Average density	350
tiles with density [200;400]	88,5 %
tiles with density [100;200]	4 %
tiles with density [50;100]	2,9 %
tiles with density [0;50]	4,6 %
tiles visually checked	>1300

Number of chips per GCP

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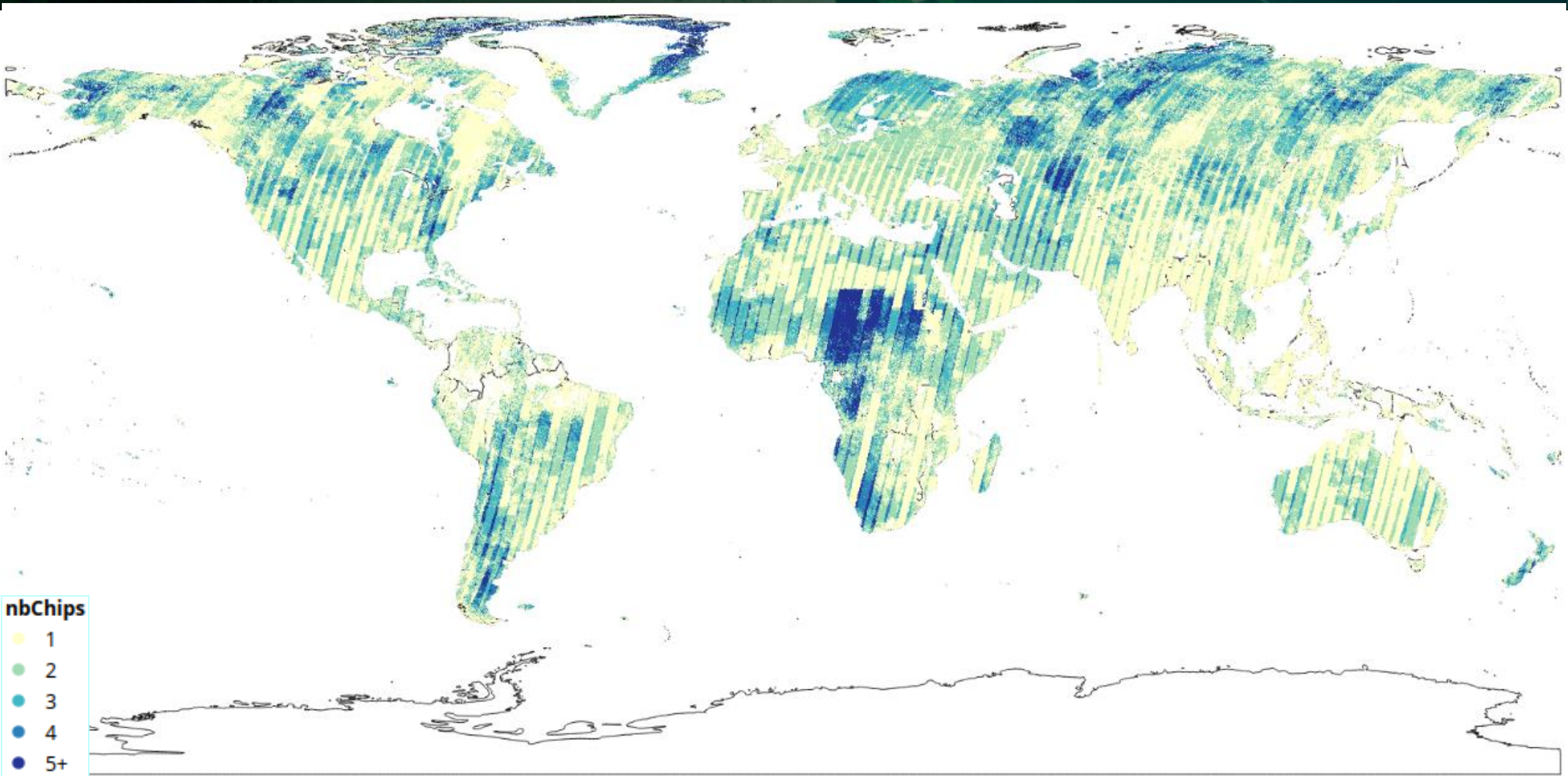

Quality scores provided for each GCP

- Anisotropy & Entropy & gradient
- Percentage of clouds, snow and water bodies
- Seasonal curvature & correlation scores

} per chip

  - Multi-Layer L1B GRI acquired mainly between 2015 and 2017 => the surface may have changed.
    - correlation tool (bi-bicubic optimized correlator) to provide sub-pixel estimates of the spatial shifts between the GCPs and the selected images (S2 acquisitions: Sep. 2021 to Sep. 2022)
    - curvature: around the maximum shift found with bicubic interpolation, the curvature is computed using a quadratic fit

      1. Summer: from April to September
      2. Winter: from October to March.

- Final score between 1 to 5 (per GCP)

World map of seasonal correlation scores: summer correlation scores

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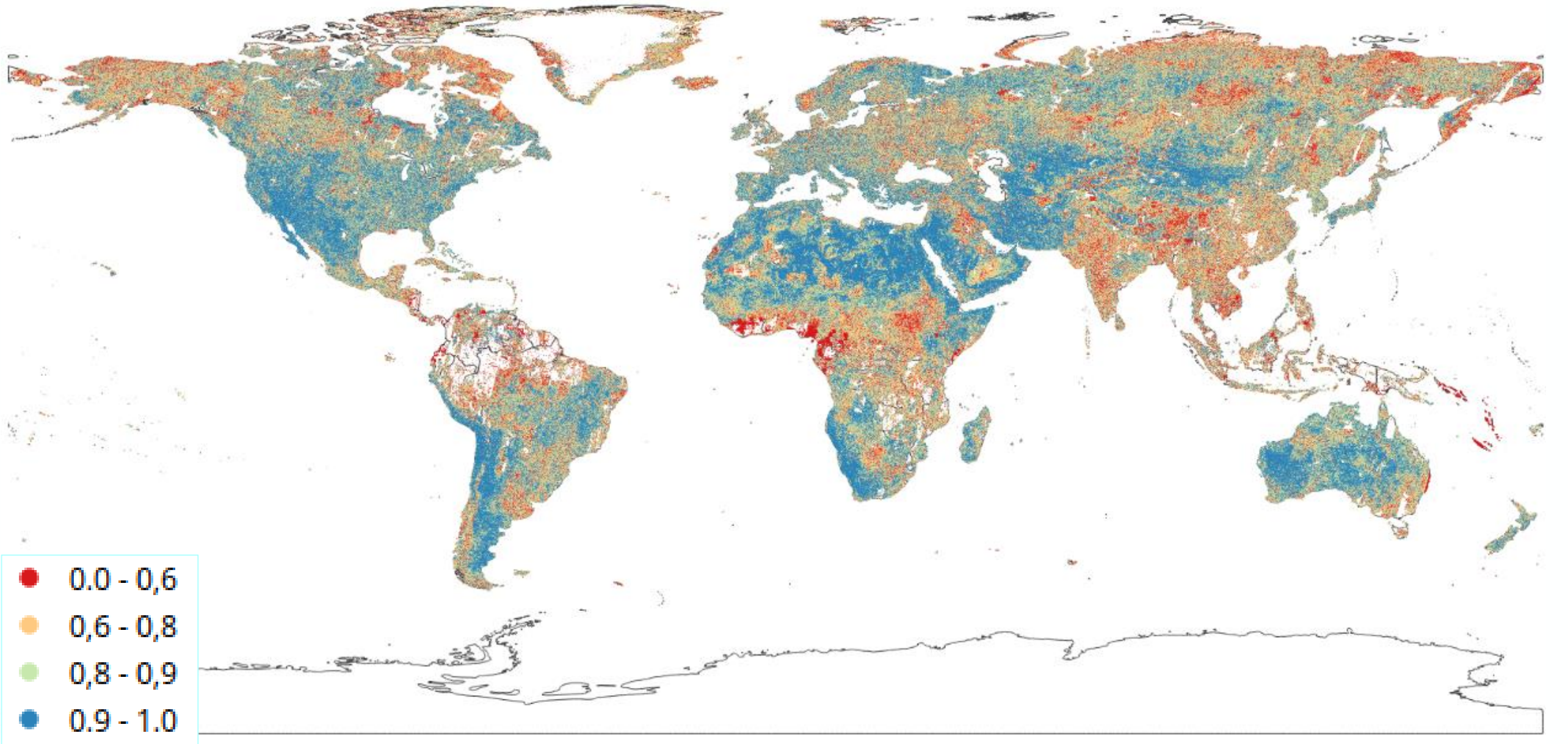
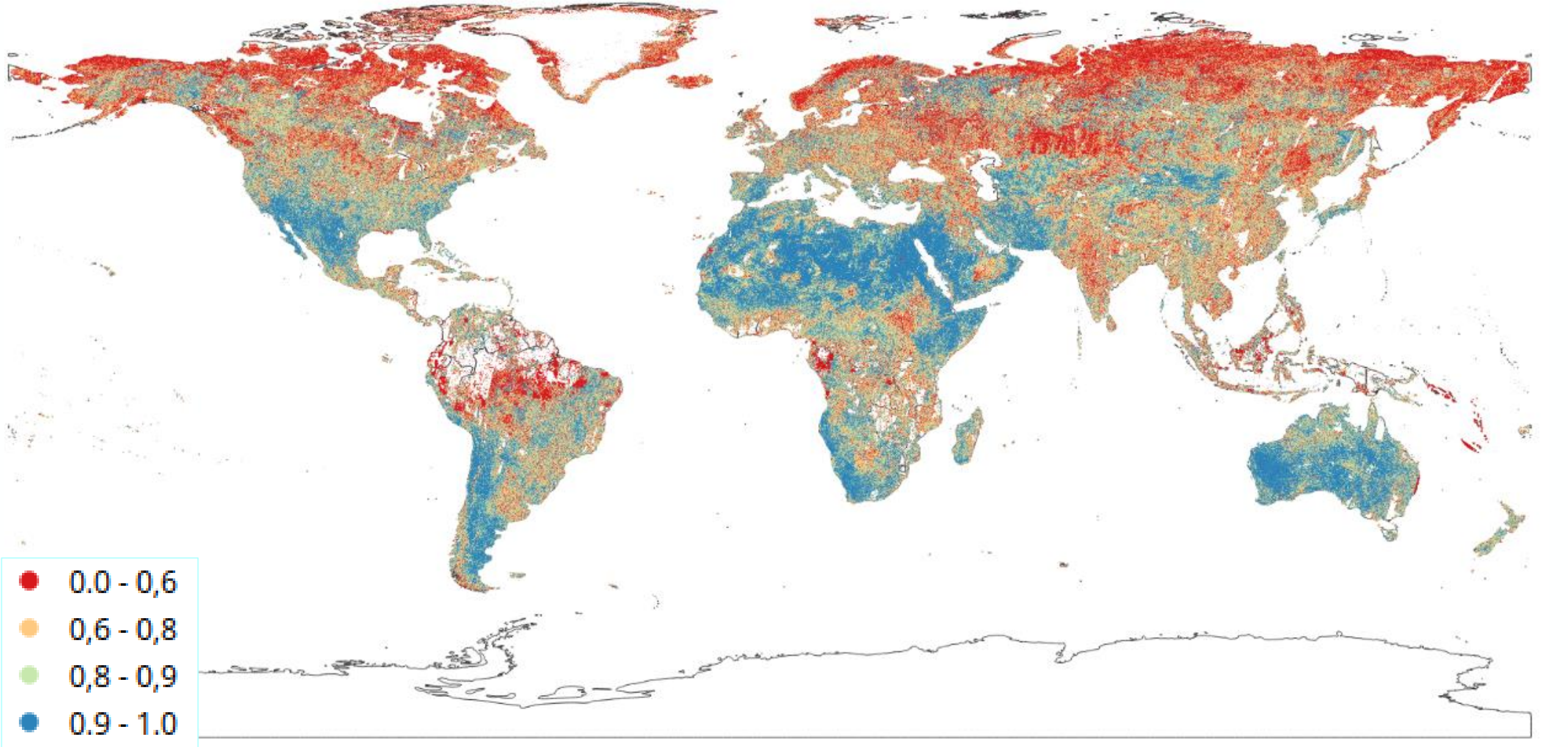


World map of seasonal correlation scores: winter correlation scores



World map of the GCP final scores

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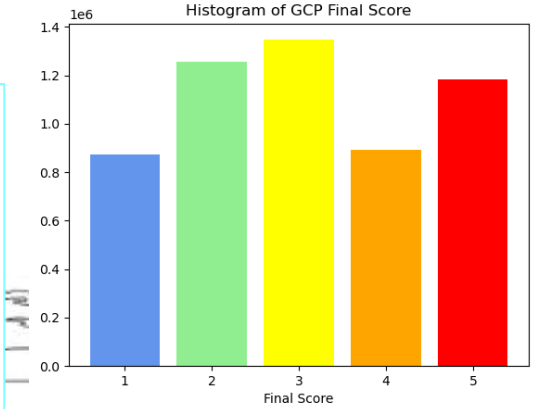
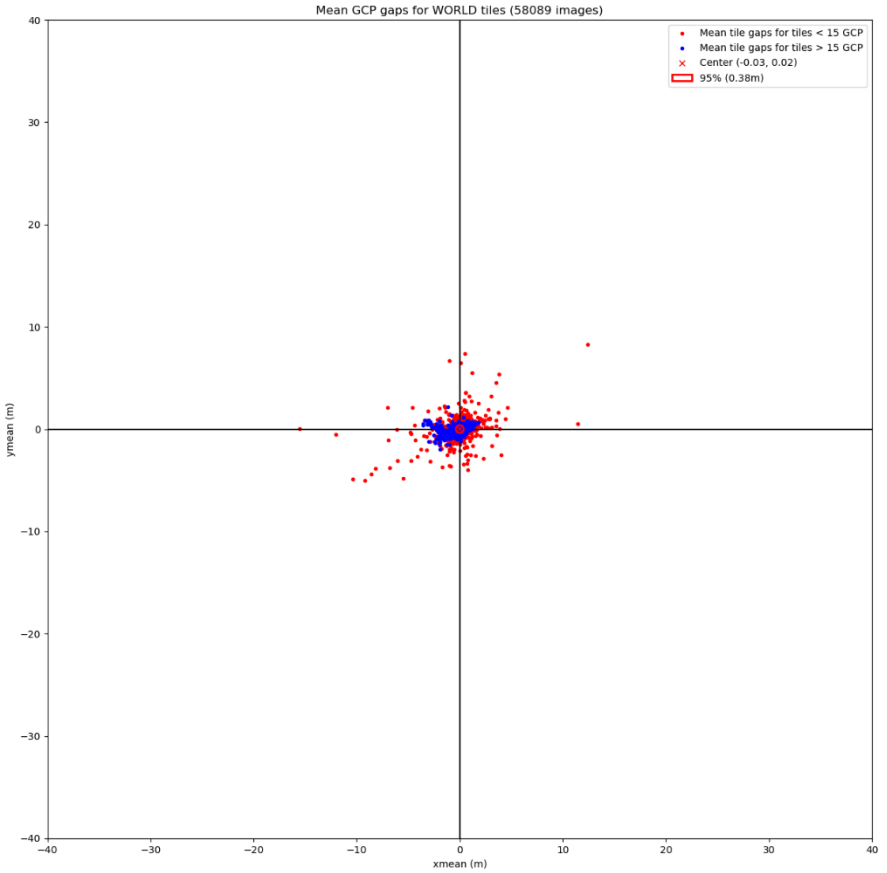


Corr. / Curv.	>= 0,9	0,9-0,8	0,8-0,6	< 0,6
>= 0,1	1	2	3	5
0,1-0,05	2	3	4	5
< 0,05	3	4	5	5

L1C GCP GRI and Multi-Layer L1C GRI cross-validation

› Mean shifts per L1C Tile versus all L1C GCP chips coming from the same L1B datastrip

Area	shift (CE95)
WORLD	0.38 m
AFRICA	0.41 m
ANTARTICA	0.23 m
ASIA	0.32 m
AUSTRALIA	0.21 m
EUROPE	0.31 m
NORTH_AMERICA	0.38 m
SOUTH_AMERICA	0.28 m



Sentinel 2 Level 1 processor prototype using the L1C GCPs GRI

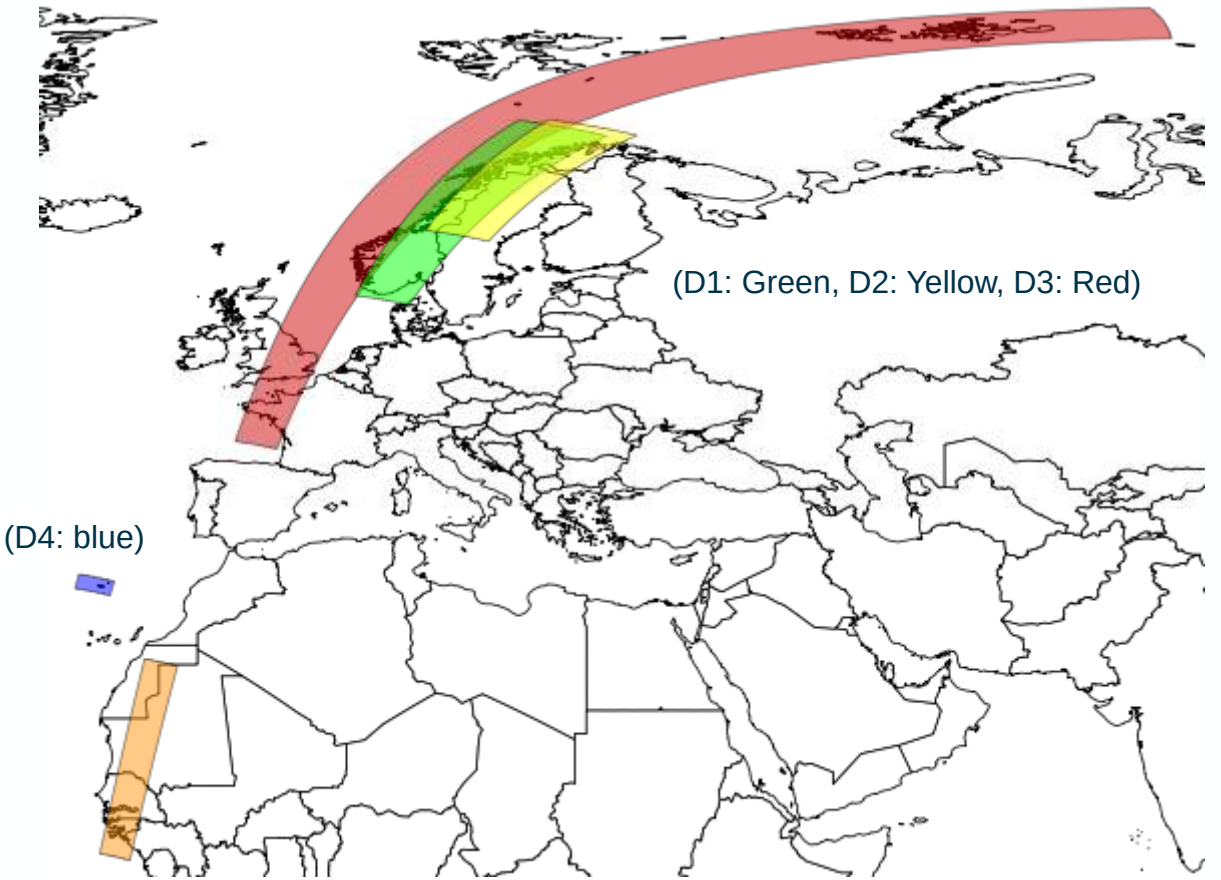
› Distances to GCP (Mean in metres):

TDS	Caracteristics	Mean distance GCP vs L1C tiles over the DS	
		Nominal processing	ProtoGCP Processing
D1	Mountains	0.58	0.47
D2	Mountains	1.10	0.63
D3	Mountains/Water/High Latitude	1.32	1.01
D4	Island (Water)	1.71	0.74
D5	Desert	1.48	0.13

› Multi-temporal analysis

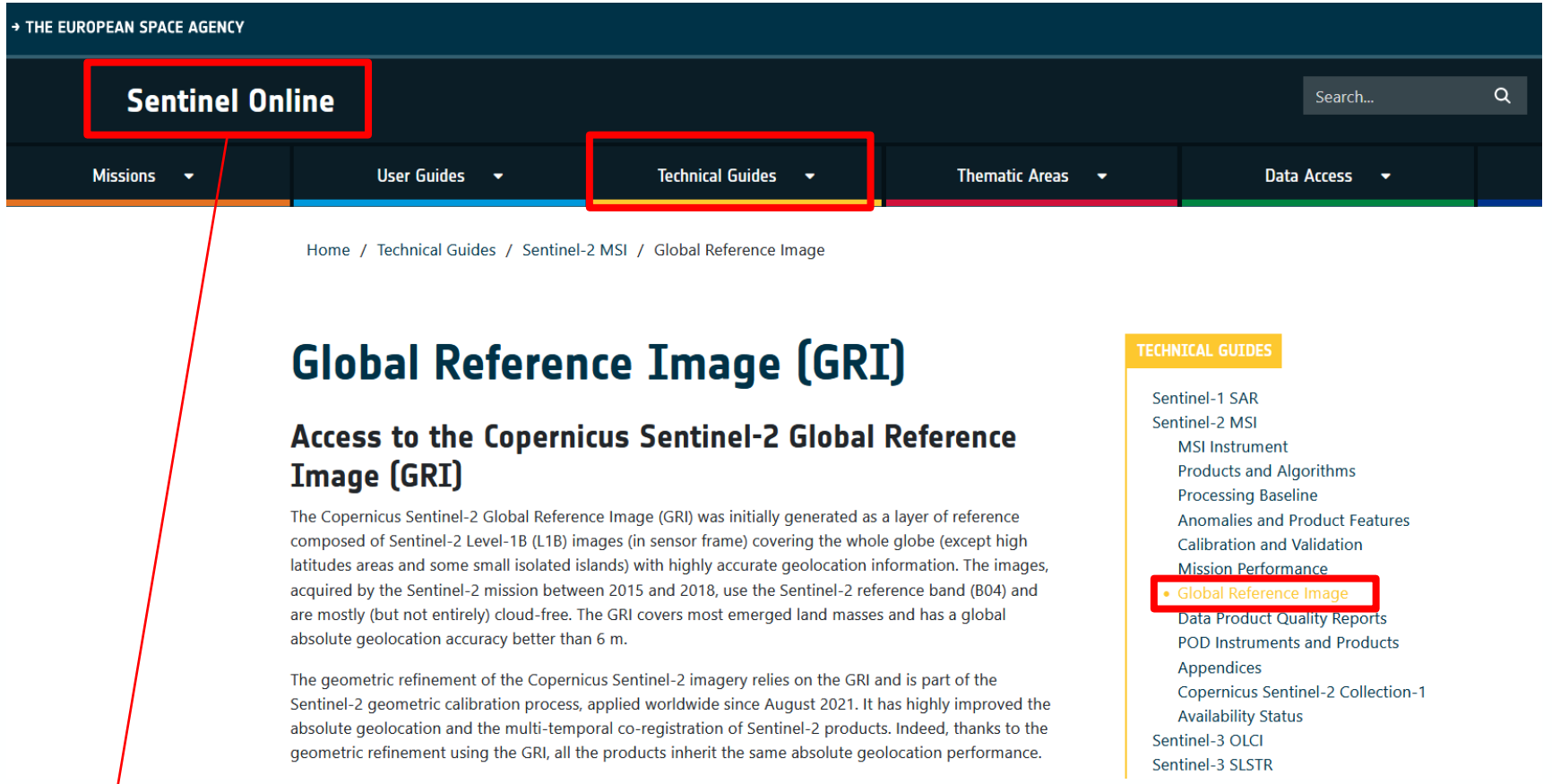
(Dense correlation on Tile 33WWS)

CE95 coregistration intra-tile (in meters)	Nominal	ProtoGCP
D2/D1	1.88	1.61
D2/D3	7.97	5.94
D3/D1	5.78	5.32



=> Equivalent refining with ProtoGCP but with larger possibilities (Fallback triggering, refining on difficult area, monitoring of the GRI)

Sentinel-2 Global Reference Image webpage



https://sentinels.copernicus.eu/web/sentinel/home

Sentinel-2 Global Reference Image webpage

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→ THE EUROPEAN SPACE AGENCY

Copernicus Sentinel-2 GRI as Database of GCPs in L1C

Source | Share | Language: English

in Copernicus Sentinel-2 Global Reference Image (S2 GRI) Up | Browse

Description

Copernicus Sentinel-2 GRI as Database of GCPs in Level-1C

copernicus esa eu sentinel S2 GCP L1C

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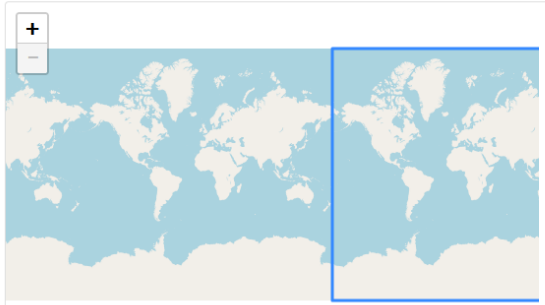


Catalogs 139

Tiles | List | Ascending | Descending

Filter catalogs by title

GCP_L1C N00

L1C GCPs for N00 latitude.

GCP_L1C N70

L1C GCPs for N70 latitude.

GCP_L1C N42E012

in Copernicus Sentinel-2 Global Reference Image (S2 GRI) Up | Collection | Browse

Description

L1C Ground Control Points (GCP) for N42E012 square degree.

Collection

Copernicus Sentinel-2 GRI as Database of GCPs in L1C

Copernicus Sentinel-2 GRI as Database of GCPs in Level-1C

Metadata

General

Platform	1. Sentinel-2A 2. Sentinel-2B

General

Version	1.1
GCP Count	399

Assets

- Square Degree GCPs GeoTIFF images + json description (.tar.gz) — DATA GEOTIFF
- Square degree GCPs description (.json) — DATA JSON

Recommendations of use

- Points have to be considered as cluster (statistical set)
- L1C Tiles + GCPs => composed of several layers. Each layer cannot be considered as absolute reference with perfect geolocation.

  => use of all the overlaps, to improve the quality of the estimated correlation and the accuracy of the n measured spatial offsets.
- Single spectral band with single resolution: i.e. 10 m, central wavelength ~665 nm.

  => use spectral length close to it.
- GRI in GCPs:

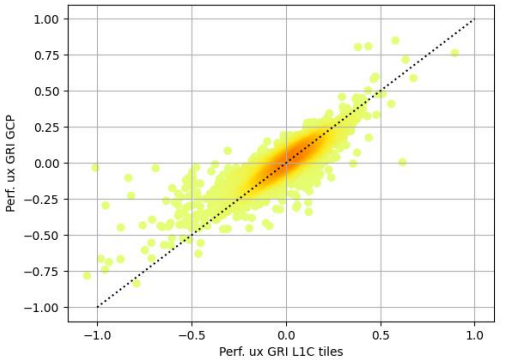
  => up to 50 m resolution.

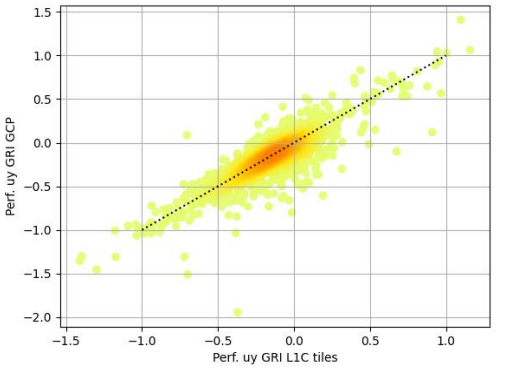
Copernicus Sentinel-2 GRI as Database of GCPs added values

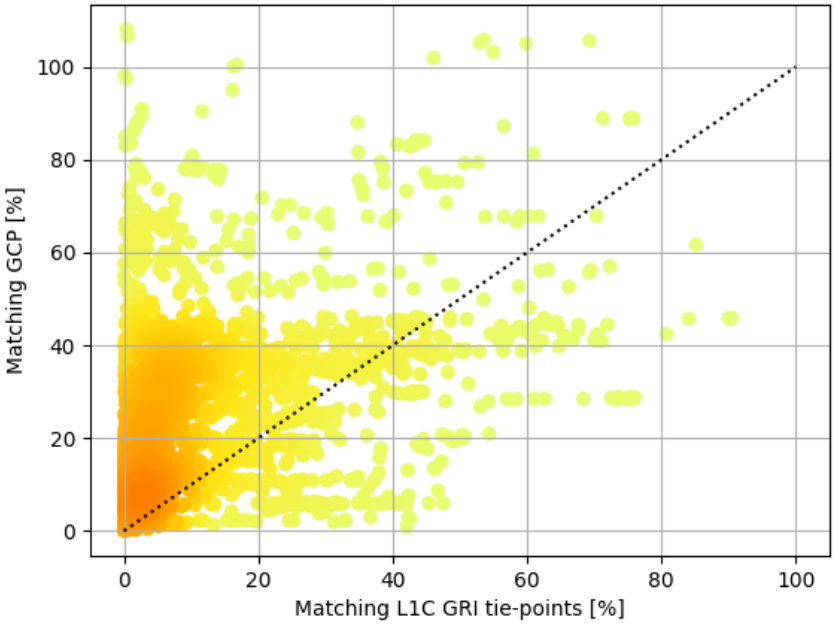
- Optimised performances:
  - easy to handle by the Sentinel-2 Level 1 processor and for users: relevant, preselected and validated points/multi-temporal registration improvement
- Accessibility:
  - freely distributed to users for their own geometric applications up to 50 m resolution
  - easy to support spatial query: distributed in square degrees, include spatial information about points and MGRS tile
  - parameters accessible for query defined on priorities of the end-user: include quality indicators
- Easy to update and improve density locally (by other S2 refined products or external products)

Copernicus Sentinel-2 GRI as Database of GCPs added values

- Example of use for S2 refinement perfo. monitoring
  - Comparison between extraction of 5000 random points from L1C GRI images and GCP approach
  - Shift estimates are very consistent
  - But use of GCP is much more efficient: percentage of useful point is almost always better and I/Os are much faster
- Feedback from use case
  - Download of many small zip files is very long and error-prone
  - 2 "black" chips found (only) among all tested
  - Multiple chips per GCP not easy to use
  - Chips belonging to two UTM zones should be provided in both projections







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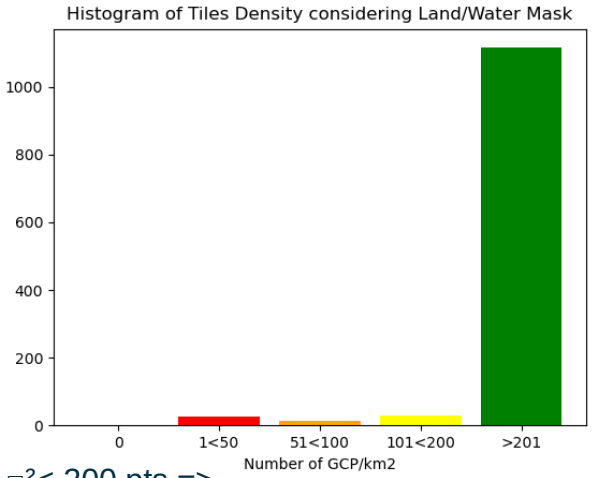
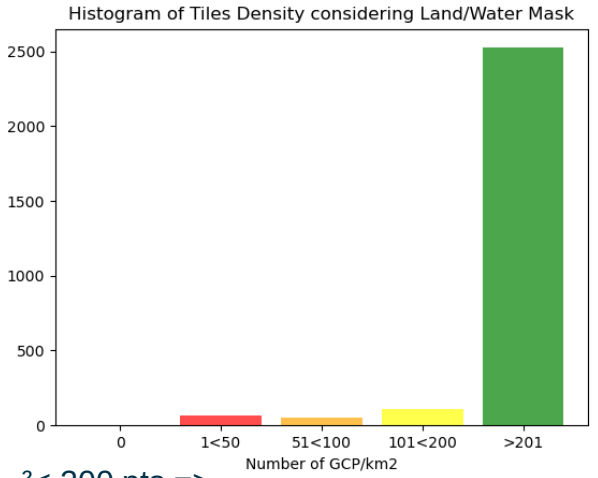


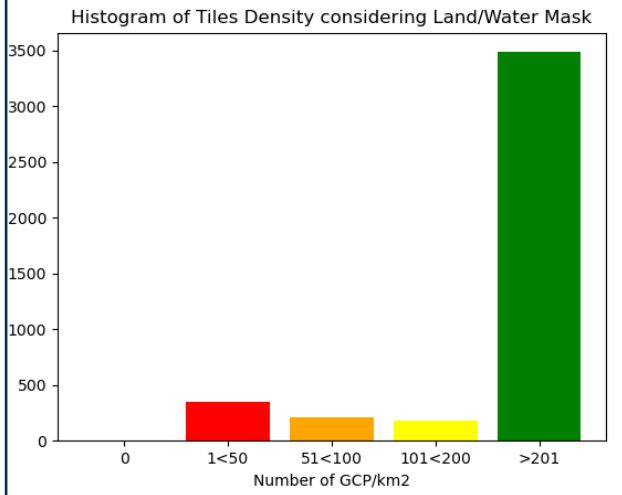
□²< 200 pts =>
- over icy or cloudy areas where it was not possible to find images of visible land

Africa



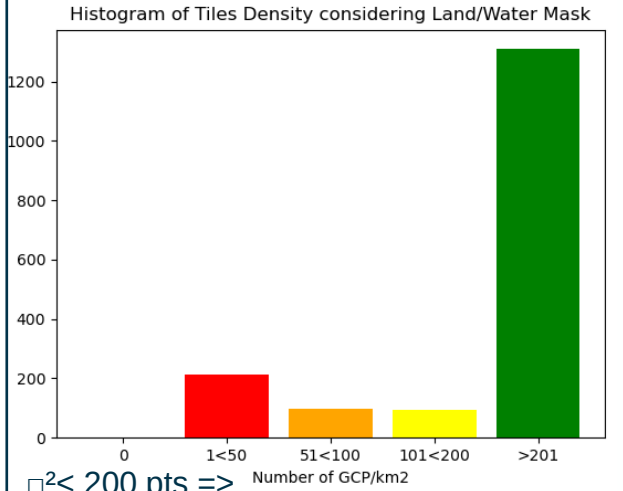
□²< 200 pts =>
- heavy cloud cover

North America



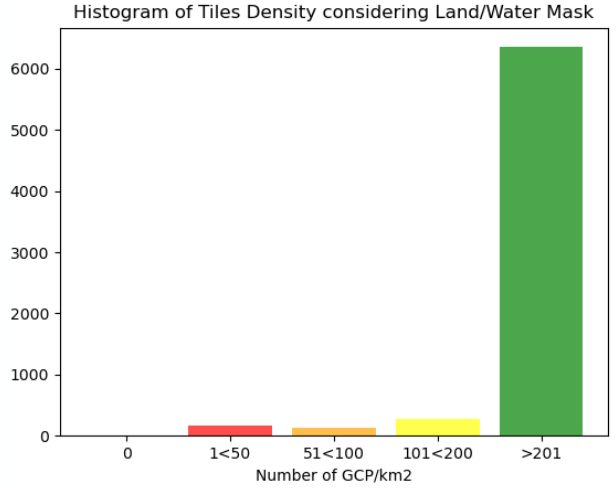
□²< 200 pts =>
- over northern latitudes, i.e. Greenland, Nunavut and Yukon territories
- mostly due to the presence of the lakes

South America

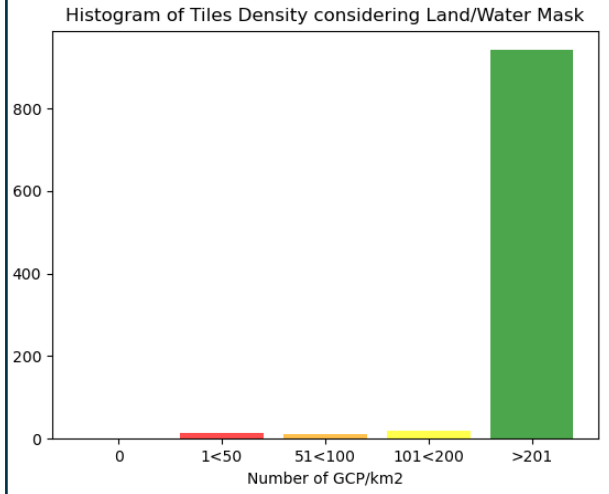


□²< 200 pts =>
- consistent with the known weakness of the Multi-Layer L1B GRI on equatorial areas.

Asia

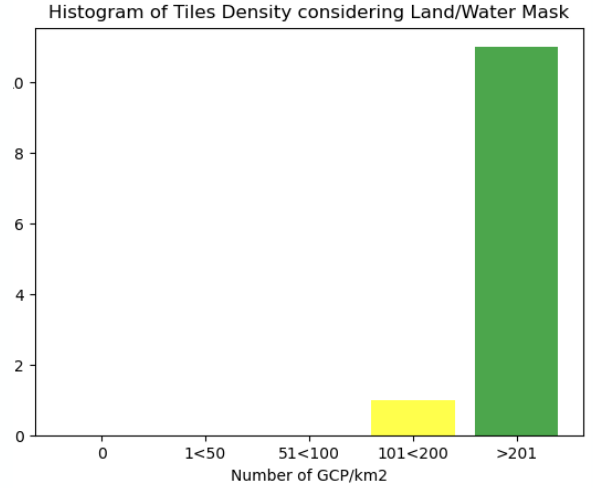


Australia

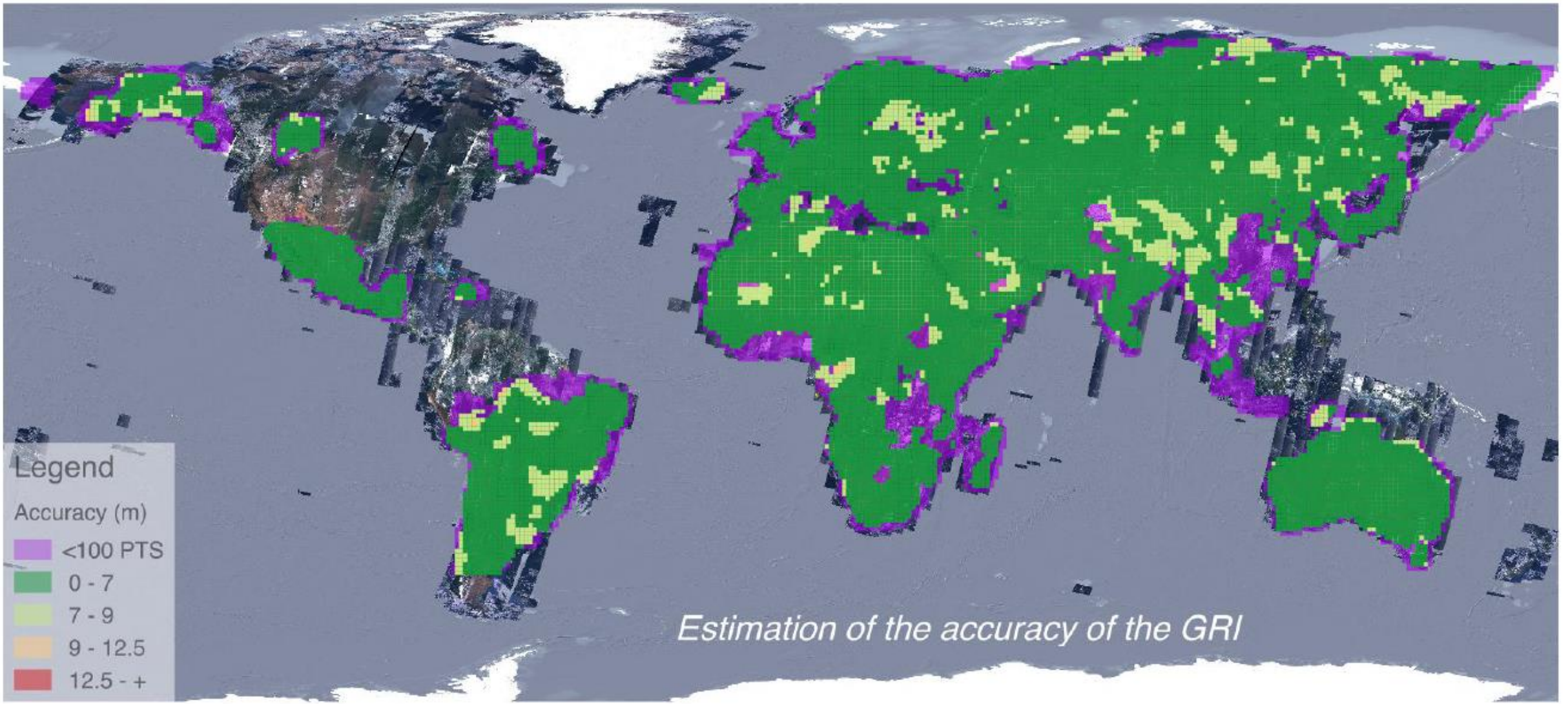


□²< 200 pts =>
- heavy cloud cover

Antarctica



Map of accuracy of the GRI



Potential improvements

- To propose a multi scale DB of GCPs
  - ✓ Adapted to different resolutions of use

- To improve the coverage

  👎 coverage issues inherited from the Multi-Layer L1B GRI => no available data to supplement this initial GRI

  - ✓ To analyse the current state of the GRI
  - ✓ To list all the missing parts: islands, gaps, clouds, snow, bugs …
  - ✓ To add products from different dates
    - ➢ Add chips that the potential users use the closest ones to the analysed data mainly in the areas with a high level of changes (deforestation, new buildings…)
    - ➢ Summer/winter