Programme

Time / Part	Title	Description and content
Part 1: 9:00 – 12:30	**Sentinel-2 and spatial image analysis**	1 – Sentinel-2 introduction Exercise 1: „*Introduction into Sentinel-2*“ 2 – Spatial image analysis
Part 2: 13:30 – 15:00	**Technologies for big EO image analysis**	3 – Mission planning with the EO-Compass Exercise 2: „*Mission planning with the EO-Compass*“ 4 – Big Earth observation data analytics - overview
Part 3: 15:15 – 17:30	**Concepts for time series analysis for land use / land cover**	5 – Temporal dimension of EO data 6 – Time series analysis of EO data Exercise 3: „*Investigate forest fires in Andalusia, Spain using a time series of Sentinel-2 images*“

1

Sentinel-2 introduction

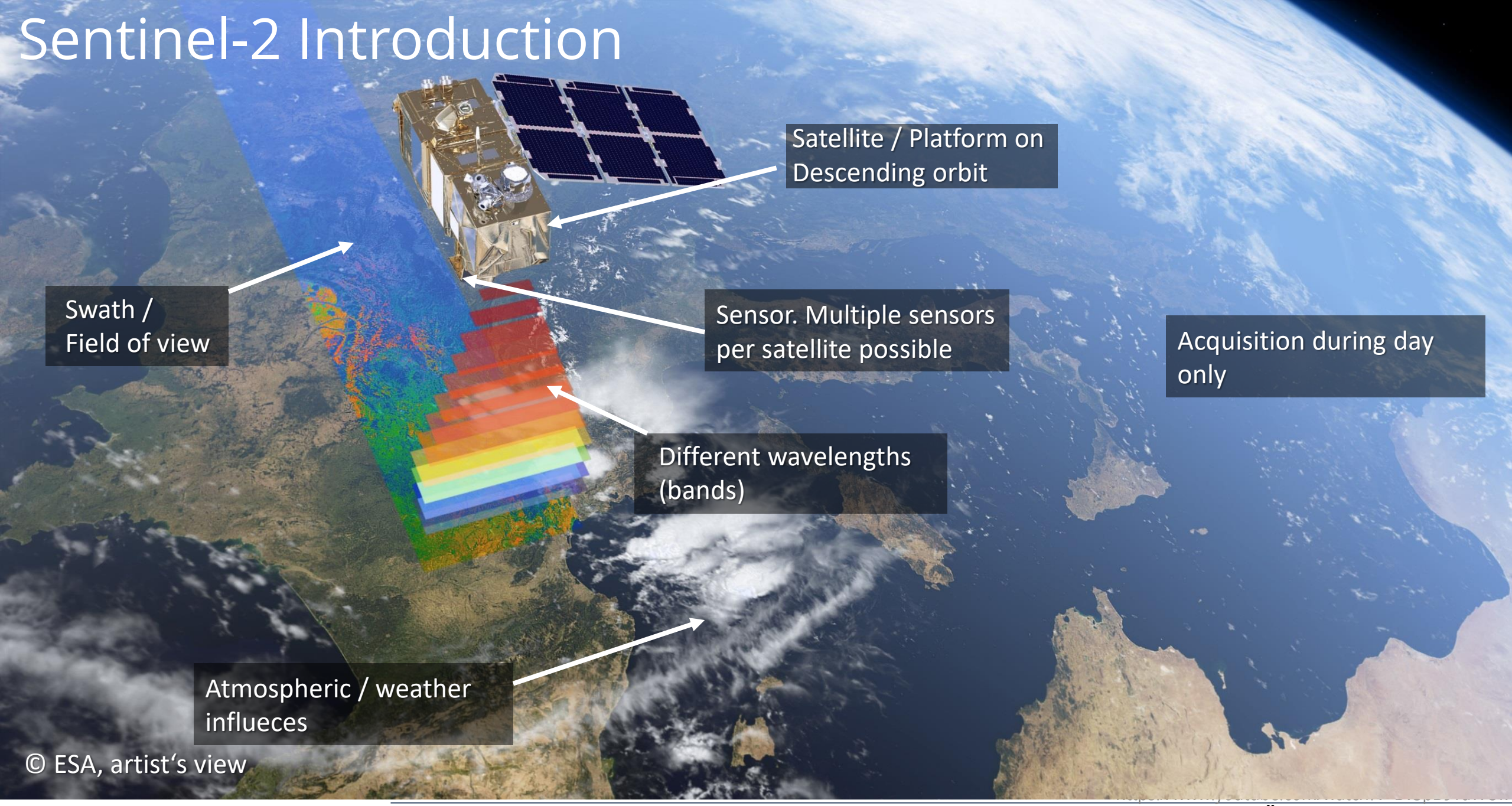
Sentinel-2 and spatial image analysis

TAT-7 | 21.06.2019 | Martin Sudmanns, Dirk Tiede, Stefan Lang, & contrib.
Z_GIS colleagues

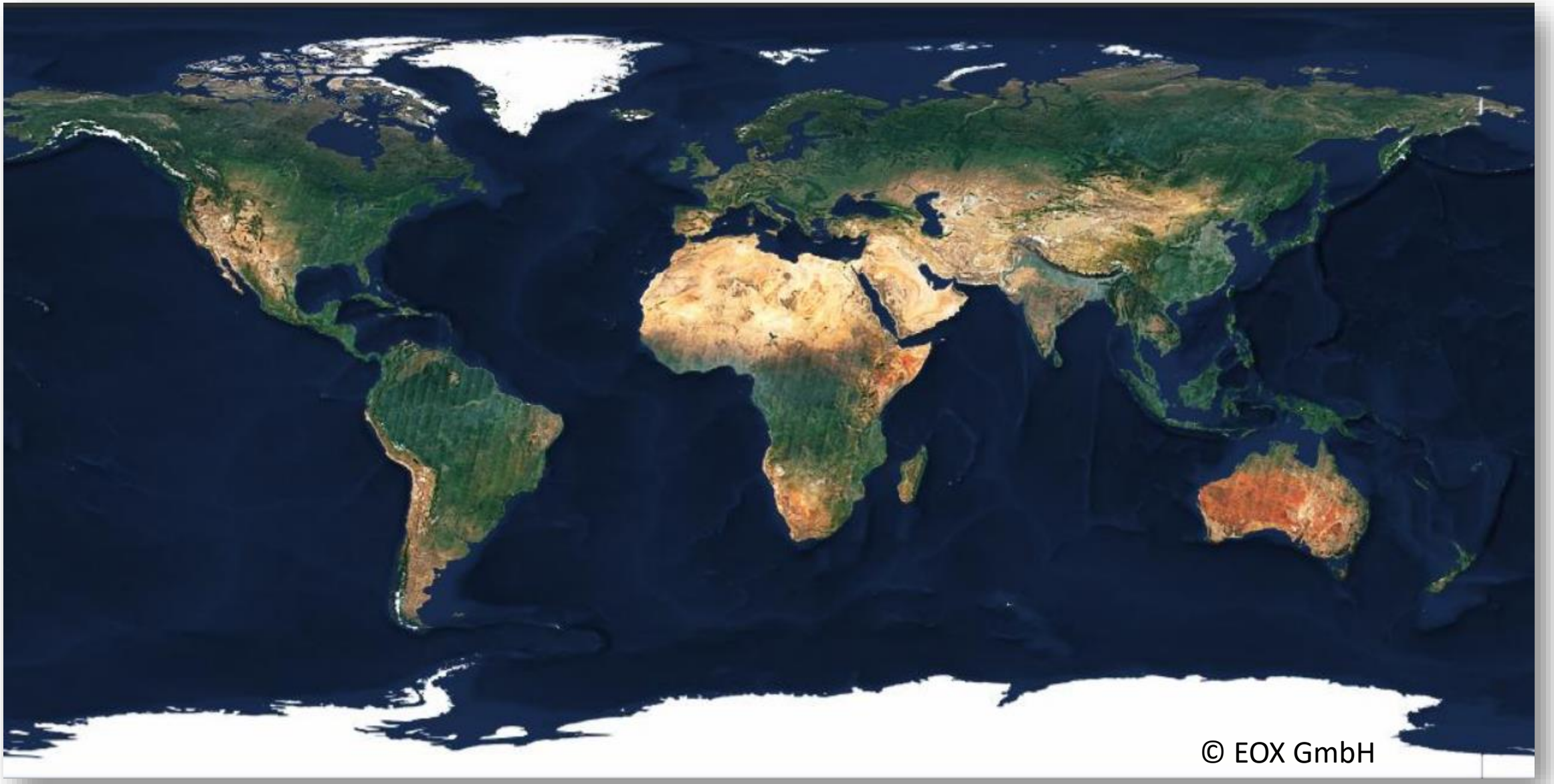
Interfaculty Department of Geoinformatics – Z_GIS, University of Salzburg

Sentinel-2 Introduction

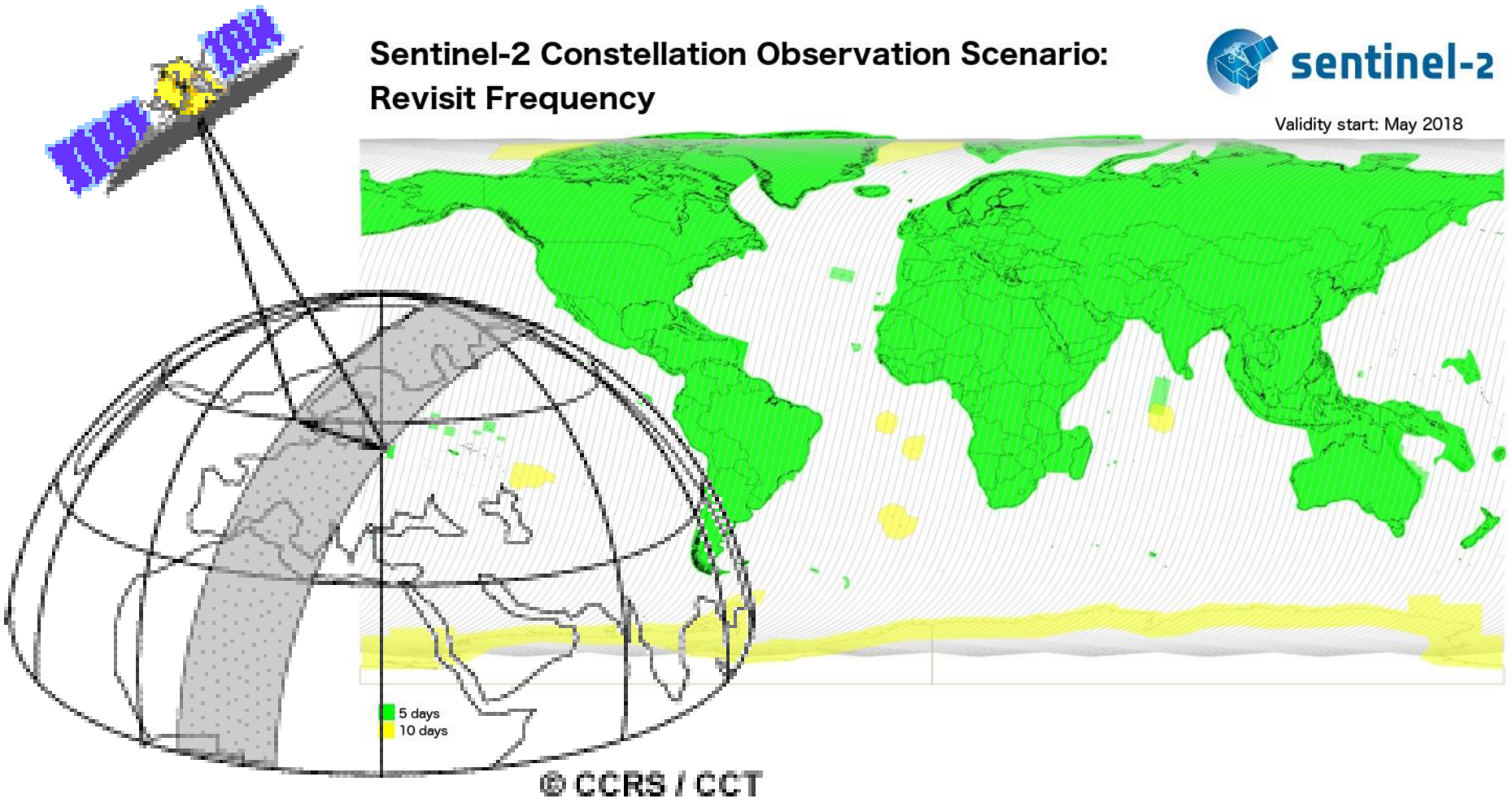
Sentinel-2 Introduction

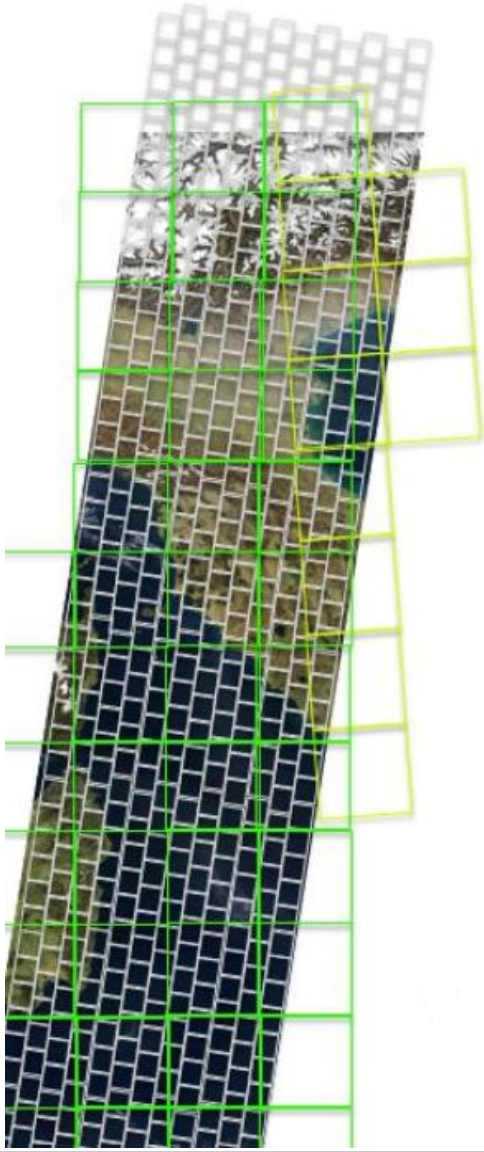


Sentinel-2 Introduction



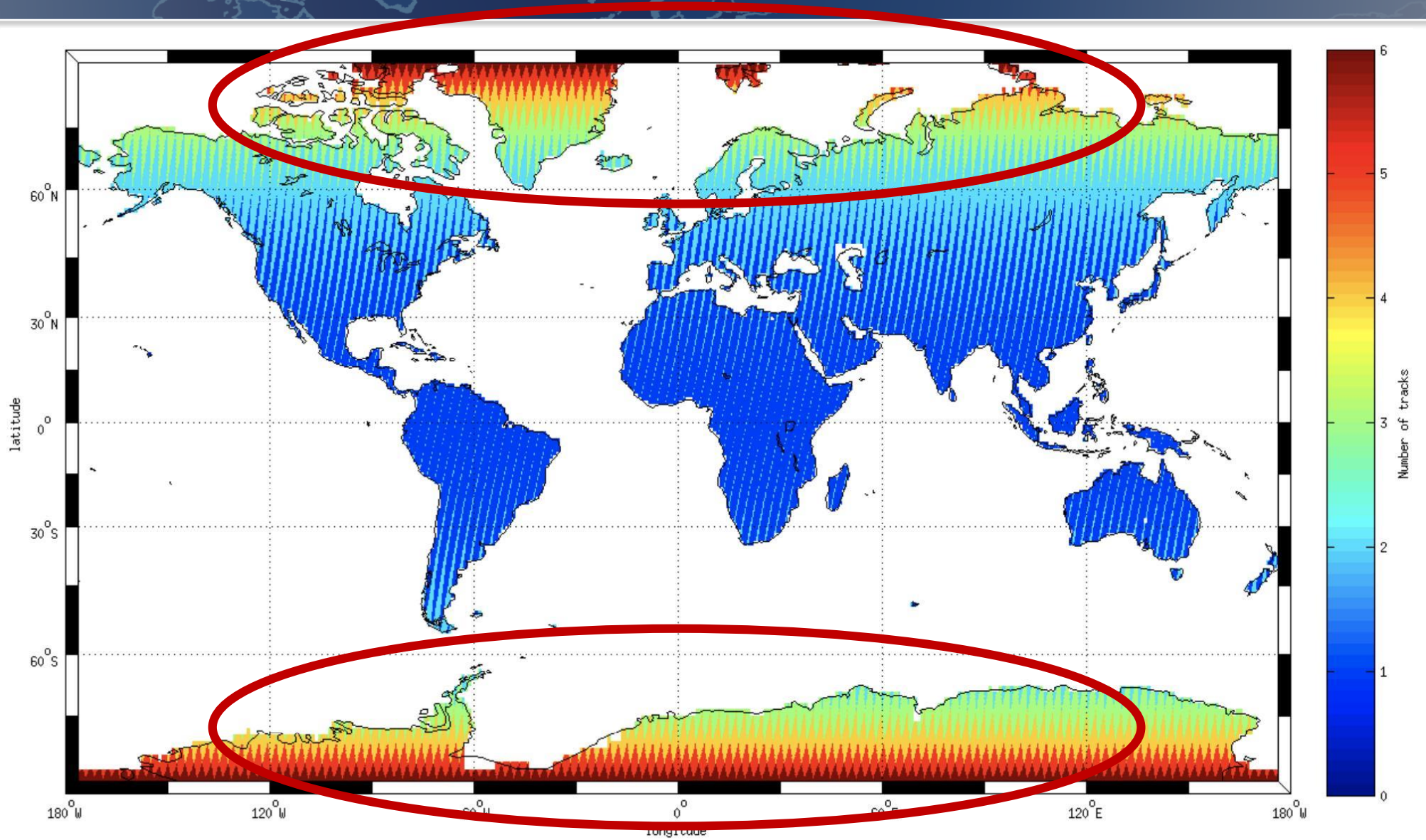
Sentinel-2 Acquisitions





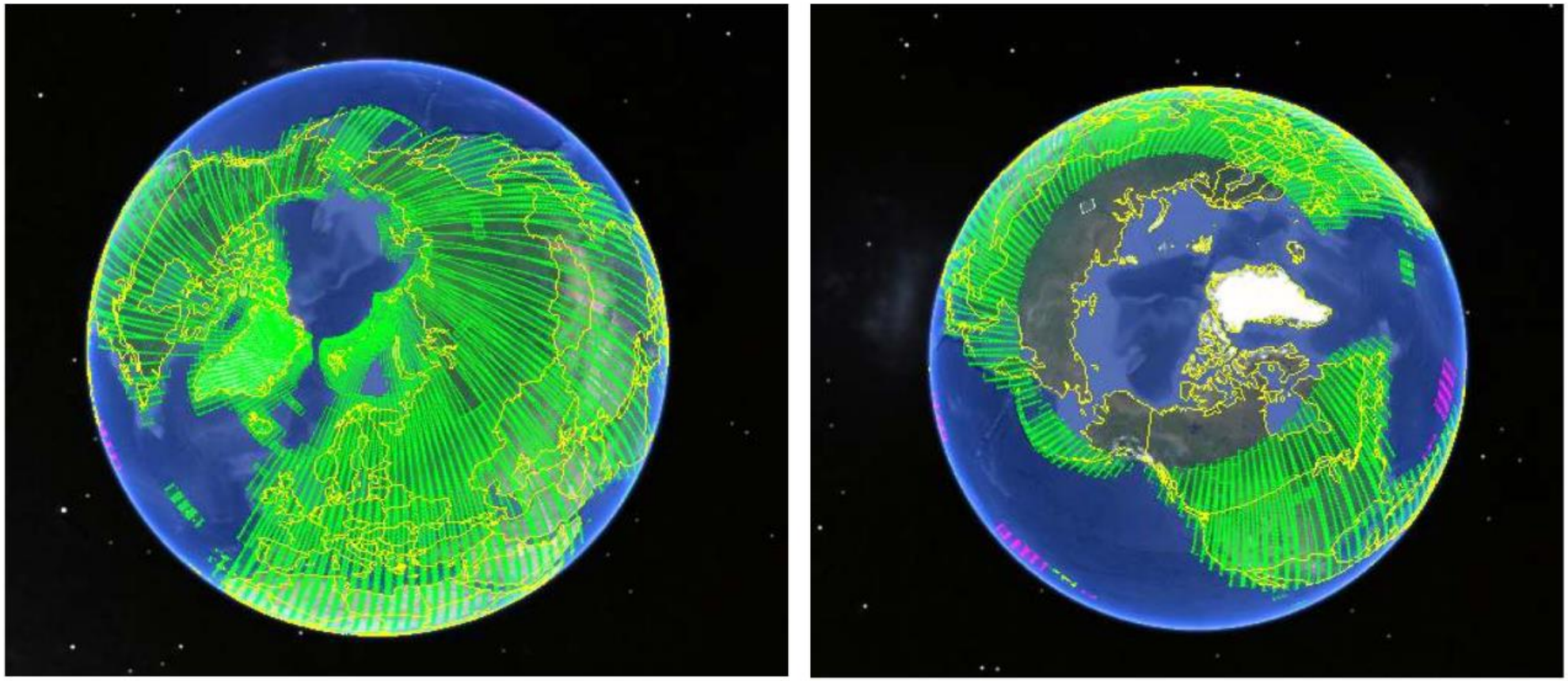
https://sentinel.esa.int/web/sentinel/user-guides/sentinel-2-msi/revisit-coverage

Sentinel-2 Acquisitions



https://sentinel.esa.int/web/sentinel/user-guides/sentinel-2-msi/revisit-coverage

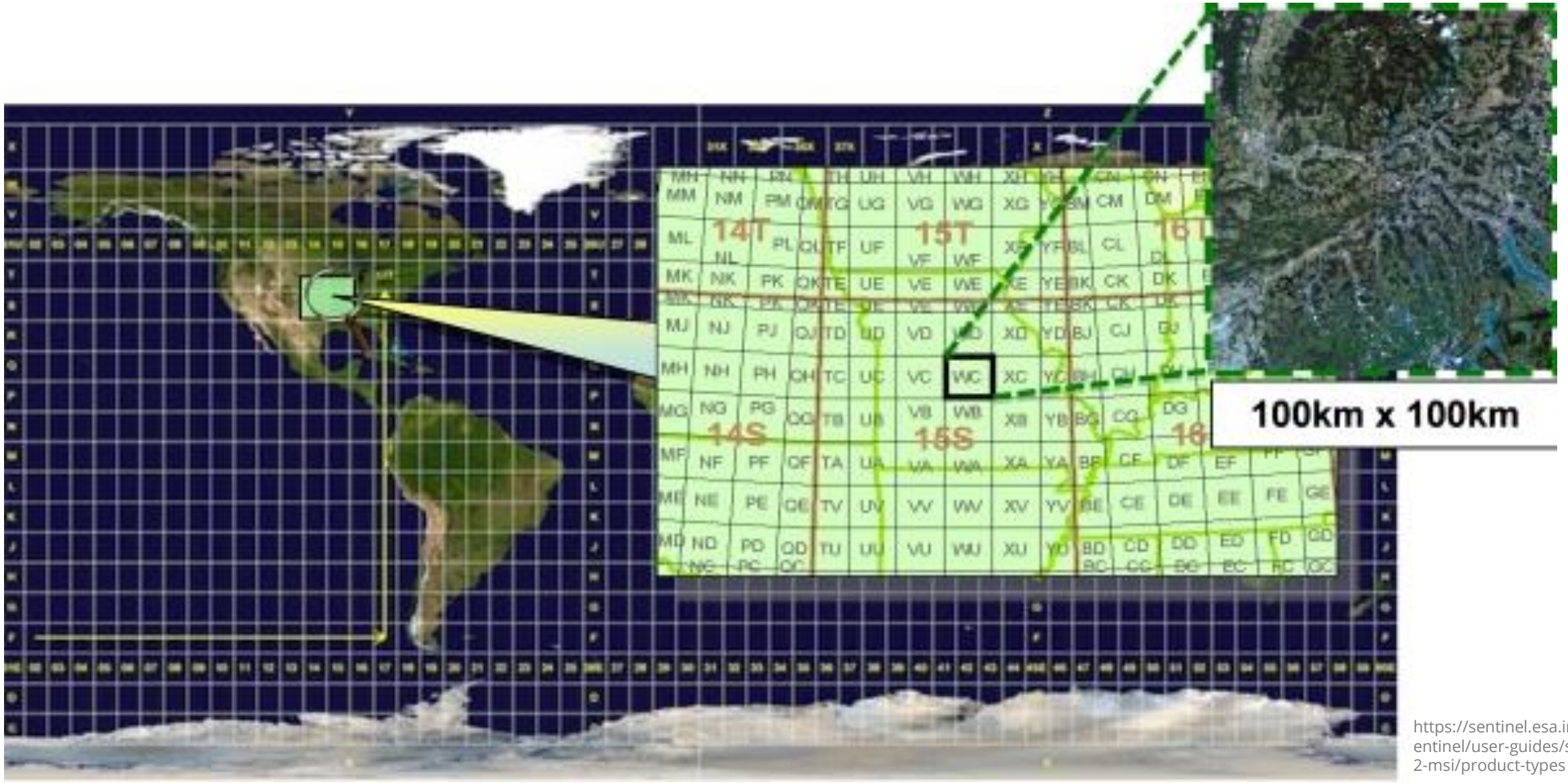
Sentinel-2 Acquisitions



(a) (b)

https://scihub.copernicus.eu/twiki/pub/SciHubWebPortal/AnnualReport2017/COPE-SERCO-RP-17-0186_-_Sentinel_Data_Access_Annual_Report_2017-Final_v1.4.1.pdf

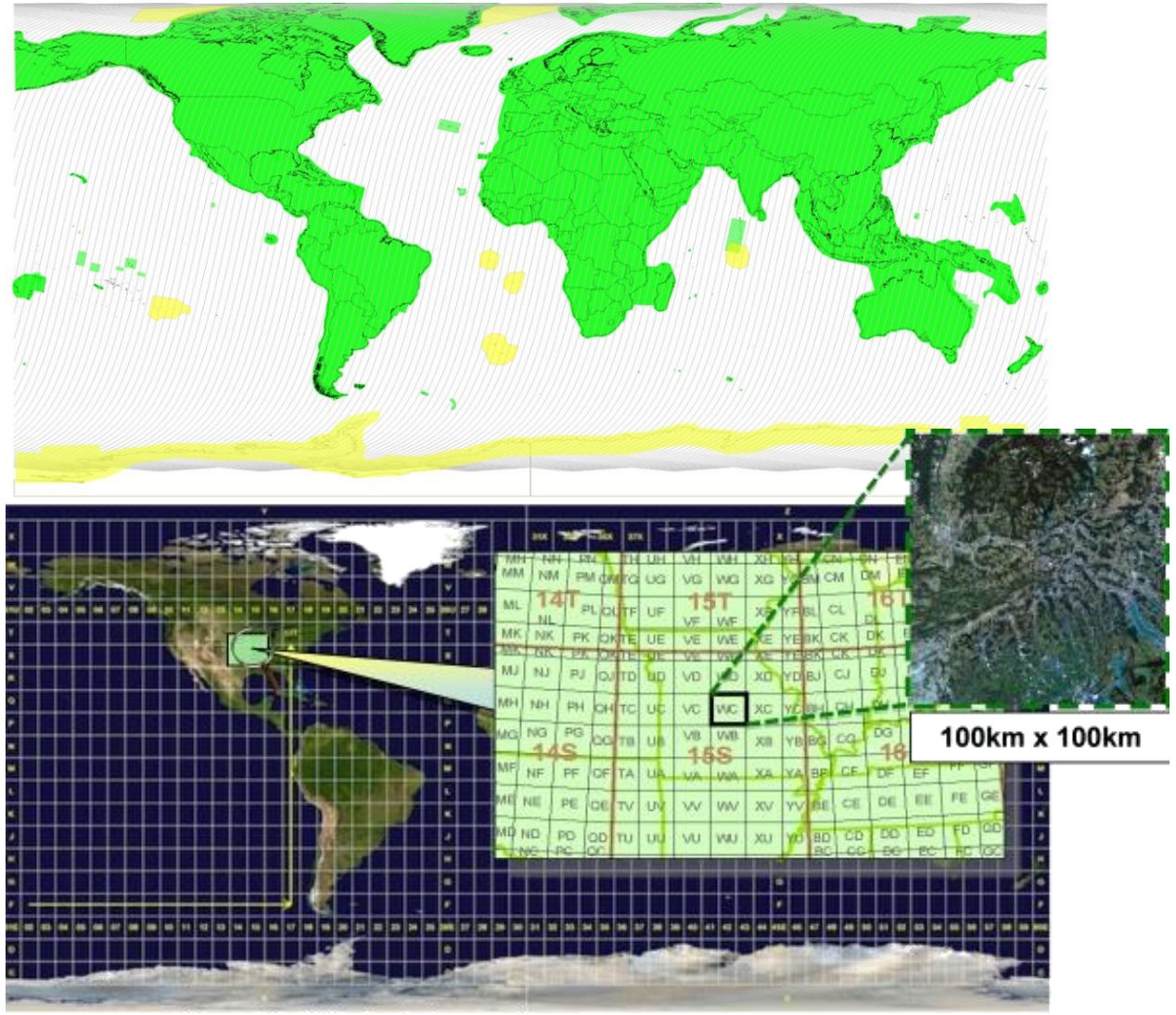
Sentinel-2 Acquisitions



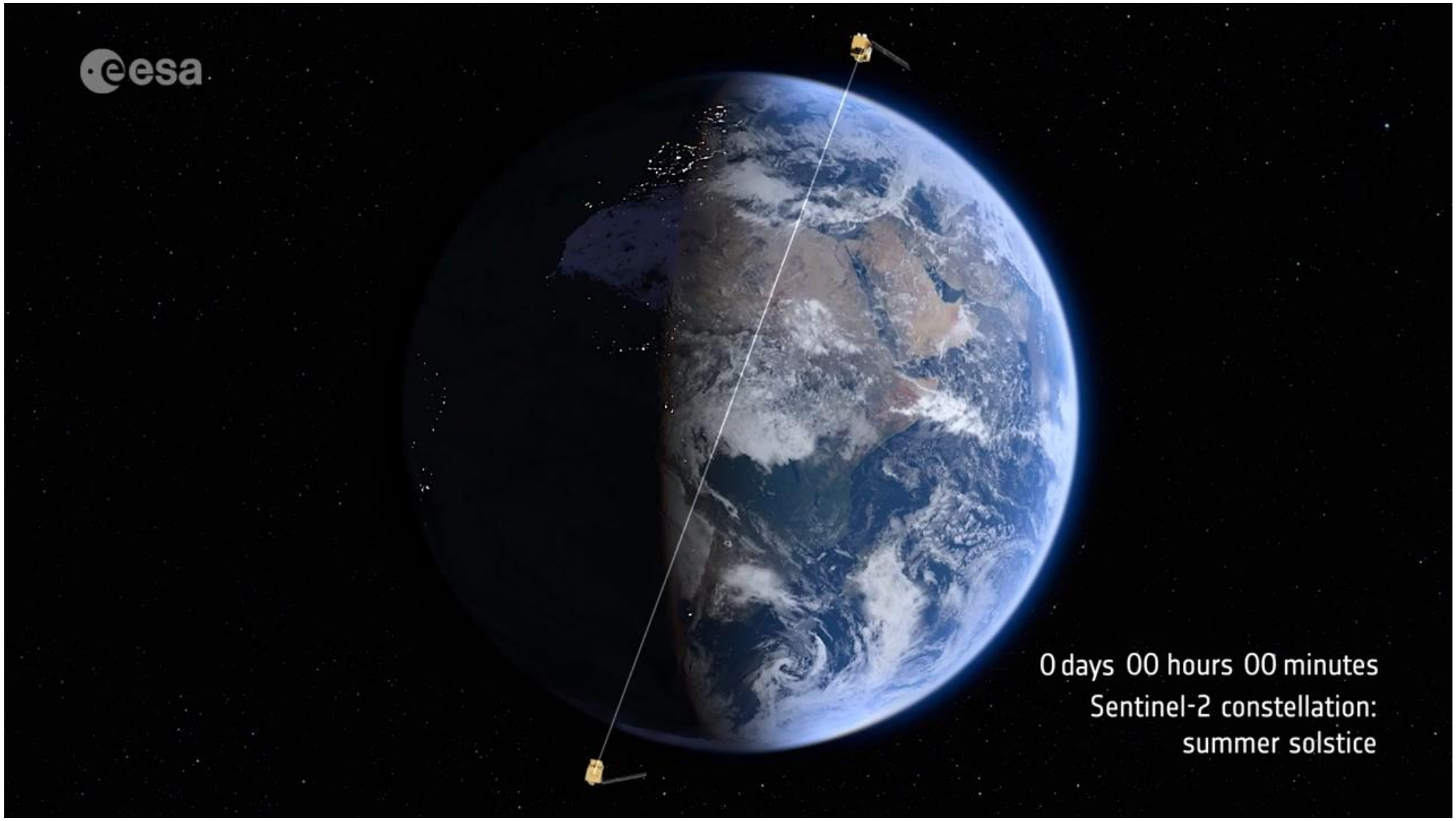
https://sentinel.esa.int/web/sentinel/user-guides/sentinel-2-msi/product-types

Sentinel-2 Acquisitions

- **Datatake**: The continuous acquisition of an image from one SENTINEL-2 satellite in a given MSI imaging mode is called a "datatake". The maximum length of an imaging datatake is 15,000 km (continuous observation from northern Russia to southern Africa).
- **Granule / Tile**: For Level-1C and Level-2A, the granules, also called tiles, are 10,000 km^2 ortho-images in UTM/WGS84 projection. It is a part of the datatake and has a metadata file.

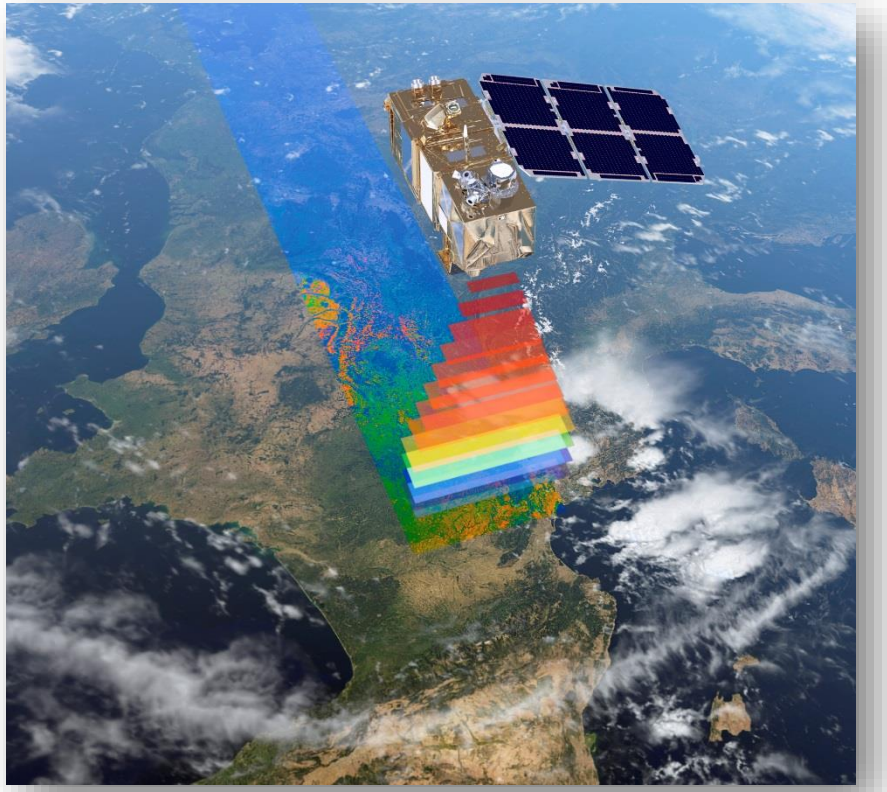


Sentinel-2 Acquisitions



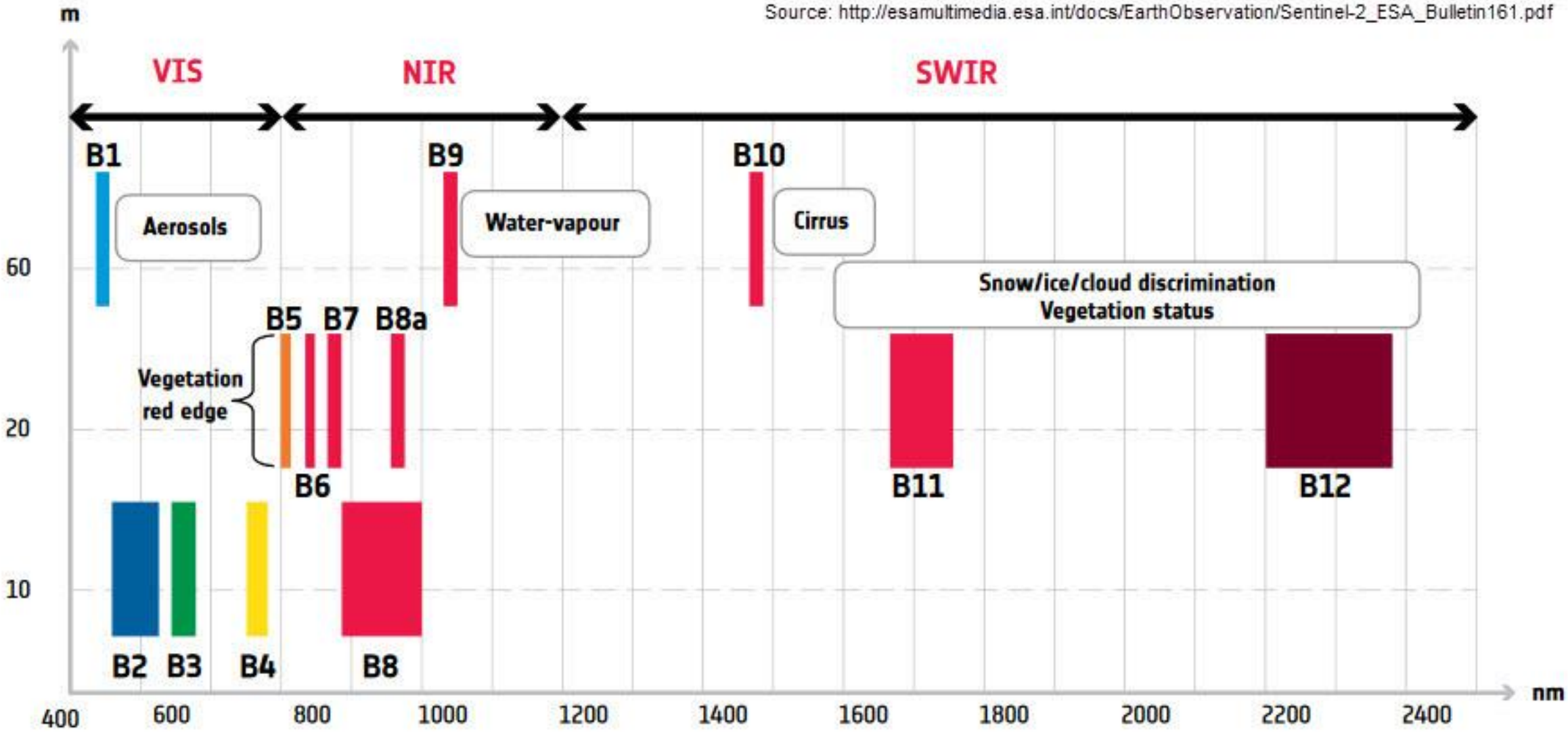
Sentinel-2 Facts

- **Optical instrument MSI (Multi-Spectral Imager)**
  - 290 km swath
  - 13 spectral channels (443 nm - 2190 nm)
  - Spatial resolution: 10, 20 and 60 m
- Sentinel 2 **A + B in orbit**
- Acquisition frequency: **5 days** at least
- Main application areas:
  - Agriculture, forestry
  - Land-use (change)
  - Water bodies
  - Emergency mapping / monitoring

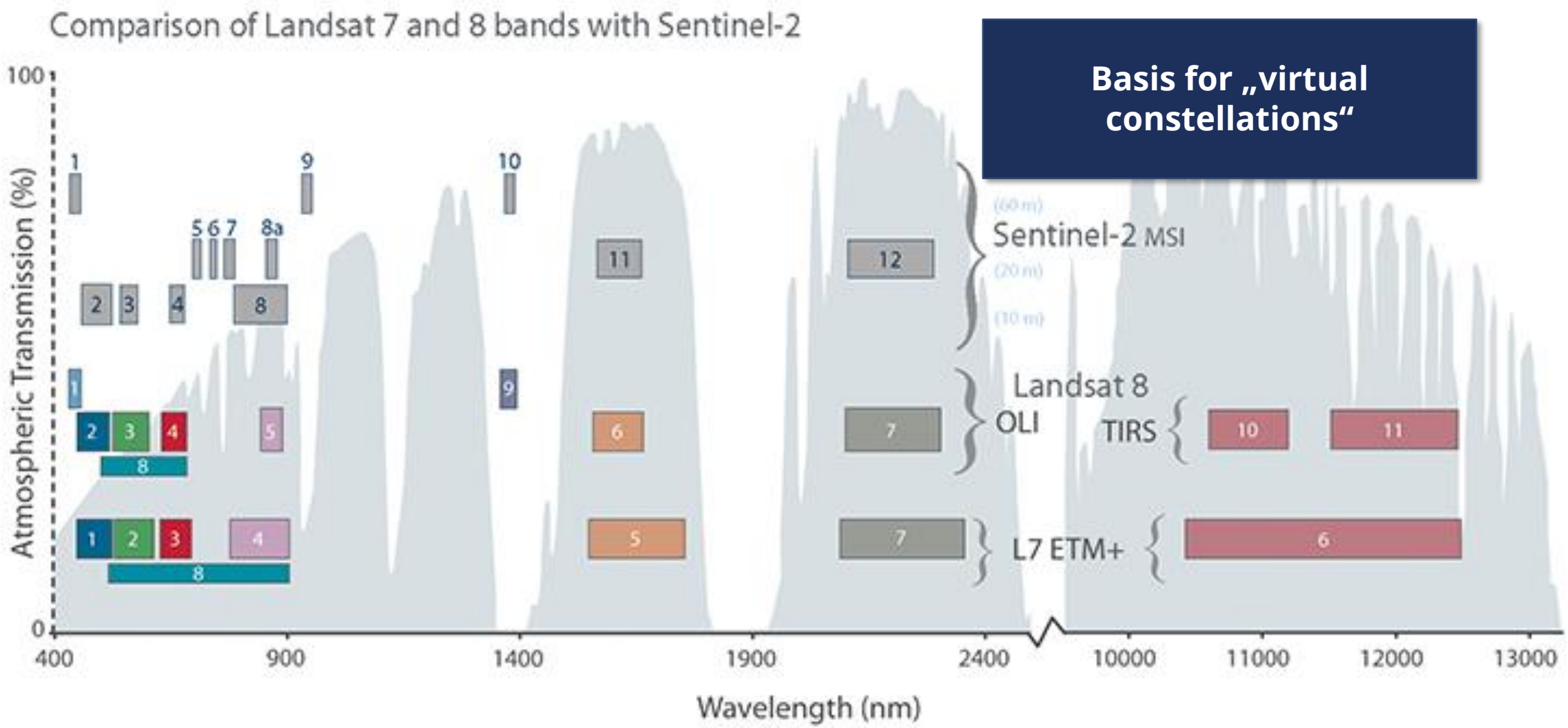


Sentinel-2 Website
http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-2/

Sentinel-2 Facts



Sentinel-2 Facts



ESA Level-2A data

Level 2A for optical EO data according ESA definition[1] consists of:

1. **Image corrected** for atmospheric, adjacency and topographic effects
2. **Scene classification map** (pre-requisite for atmospheric correction)
3. **Quality indicators** (e.g. also as masks)

Top of Atmosphere (TOA) Level 1C

Bottom of Atmosphere (BOA) Level 2A

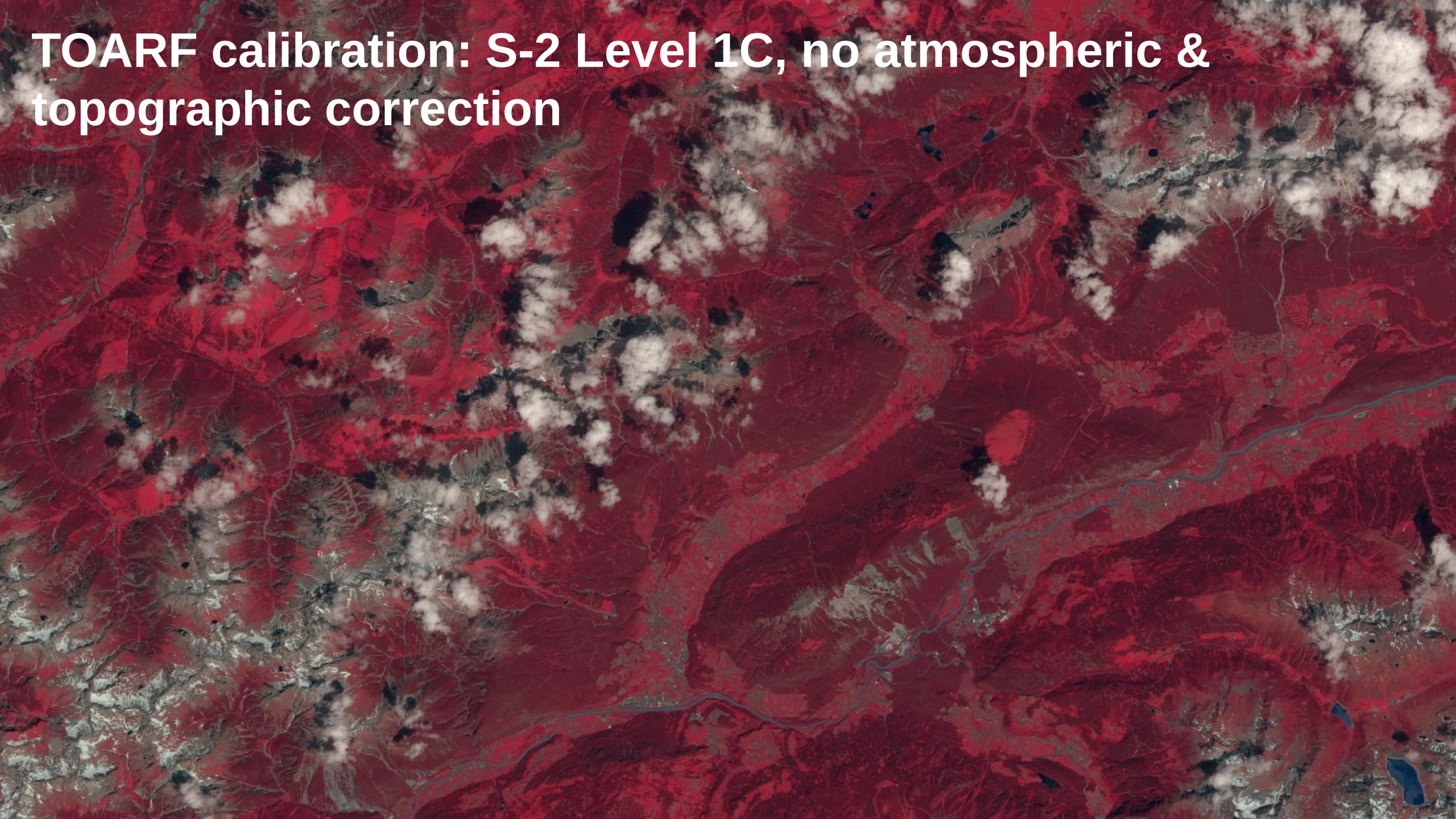
Scene classification map and quality indicators

https://sentinel.esa.int/documents/247904/3681608/Sentinel-2-Level-1C-2A-TOA-processing-full.png

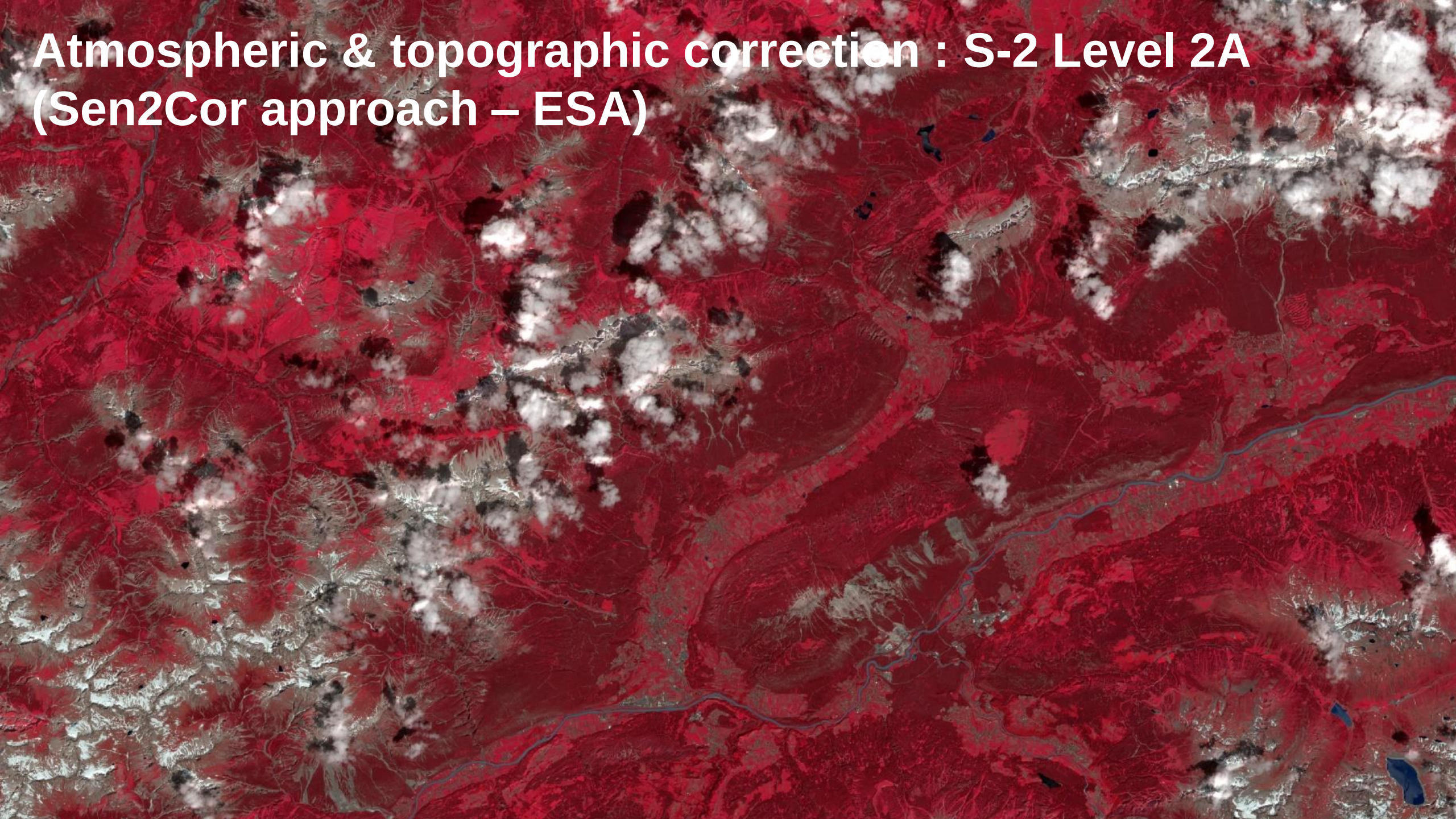
It is not possible to remove clouds completely

[1] Level 2A Products Algorithm Theoretical Basis Document (https://earth.esa.int/c/document_library/get_file?folderId=349490&name=DLFE-4518.pdf)

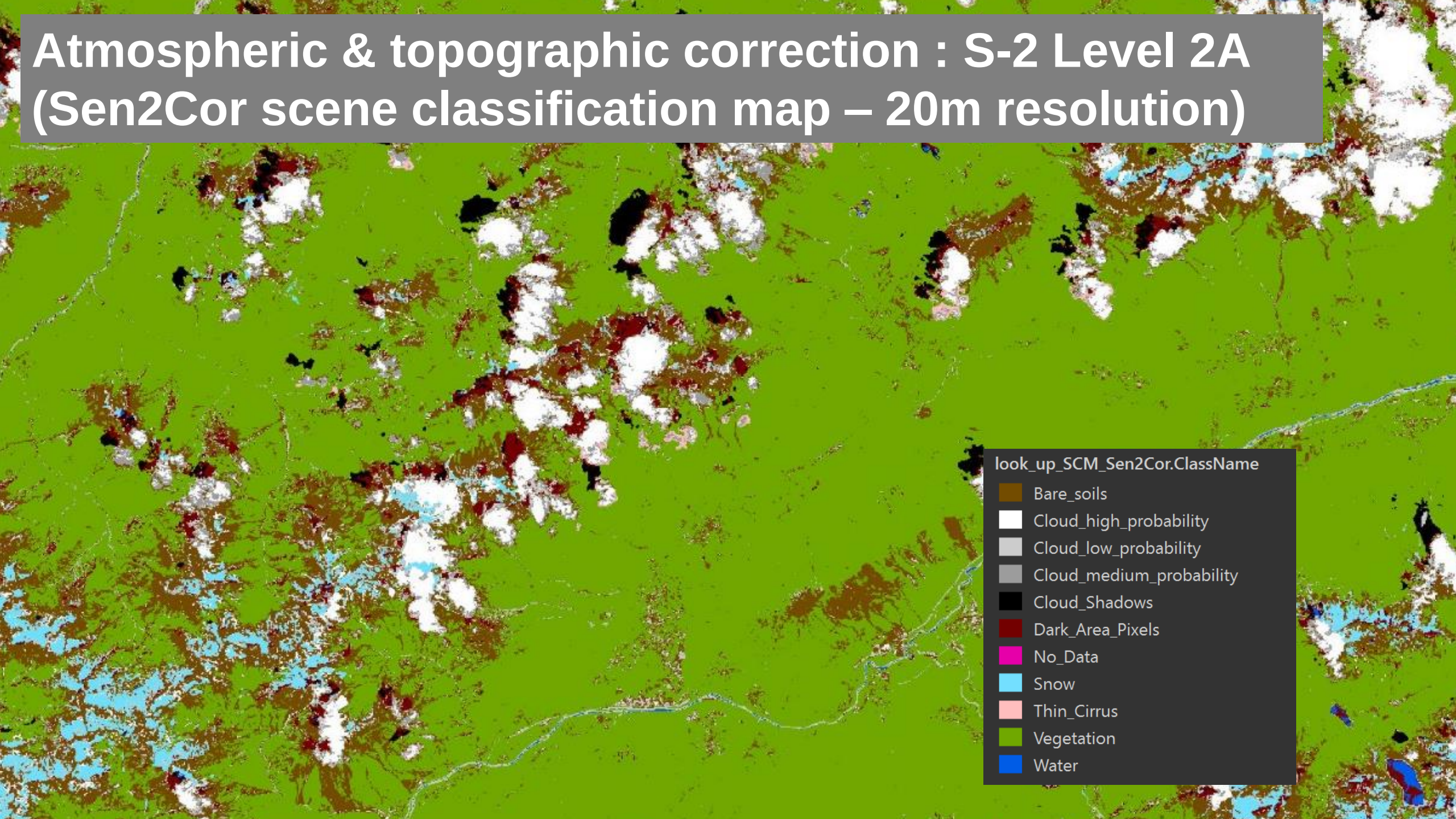
TOARF calibration: S-2 Level 1C, no atmospheric & topographic correction



Atmospheric & topographic correction : S-2 Level 2A (Sen2Cor approach – ESA)



Atmospheric & topographic correction : S-2 Level 2A (Sen2Cor scene classification map – 20m resolution)



Sentinel-2 processing levels

- Processing levels of satellite data are not standardised and depend on the organisation (e.g. ESA, NASA other satellite providers) and the different satellites

Definition by ESA and CNES, compliant with the norms of the Committee on Earth Observation Satellites (CEOS):

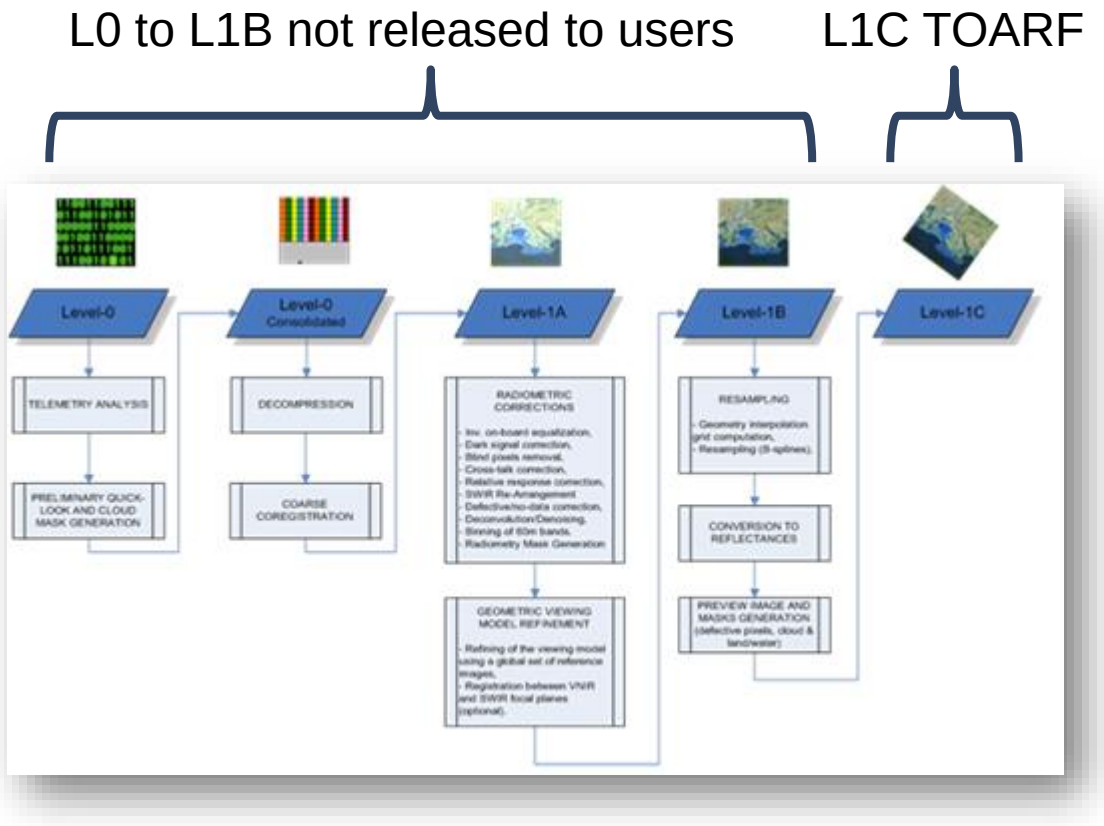
- Level 1C is a monodate ortho-rectified image expressed in TOA reflectance
- Level 2A is a monodate ortho-rectified image expressed in surface reflectance, provided with a cloud/cloud shadow/snow/water mask
- Level 3A is a monthly composite of Level2A Cloud/Cloud-shadow-free pixels

Data Level	NASA-EOSDIS Definition http://science.nasa.gov/earth-science/earth-science-data/data-processing-levels-for-eosdis-data-products/
Level 0	Reconstructed, unprocessed instrument and payload data at full resolution, with any and all communications artifacts (e.g., synchronization frames, communications headers, duplicate data) removed.
Level 1A	Reconstructed, unprocessed instrument data at full resolution, time-referenced, and annotated with ancillary information, including radiometric and geometric calibration coefficients and georeferencing parameters (e.g., platform ephemeris) computed and appended but not applied to Level 0 data.
Level 1B	Level 1A data that have been processed to sensor units (not all instruments have Level 1B source data).
Level 2	Derived geophysical variables at the same resolution and location as Level 1 source data.
Level 3	Variables mapped on uniform space-time grid scales, usually with some completeness and consistency.
Level 4	Model output or results from analyses of lower-level data (e.g., variables derived from multiple measurements).

Sentinel-2 processing levels

ESA Sentinel-2 processing chain:

- All data acquired by the MSI instrument are systematically processed to Level-1C by the Payload Data Ground Segment (PDGS).
- Only the Level-1C and Level-2A products are released to Users.
- Level-2A products are generated either by the PDGS using the Sen2Cor processor, or on the User side through the Sen2Cor Toolbox (standalone or within SNAP)



Exercise 1:

Introduction into Sentinel-2

2

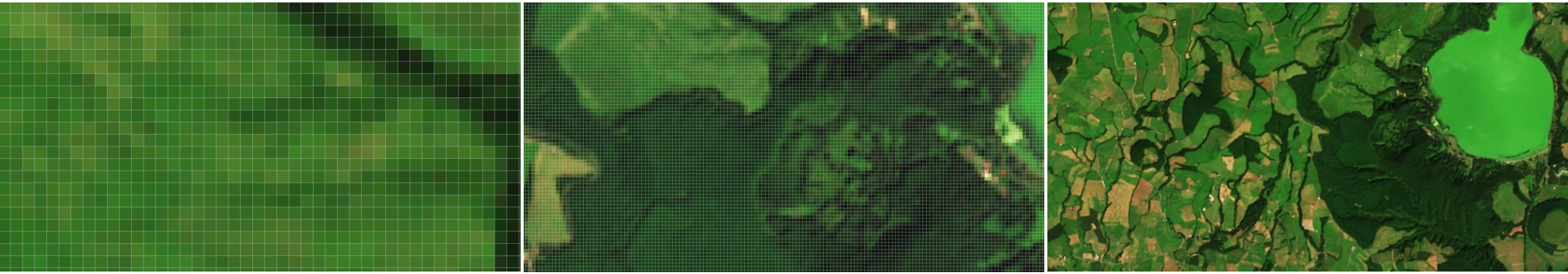
Spatial image analysis

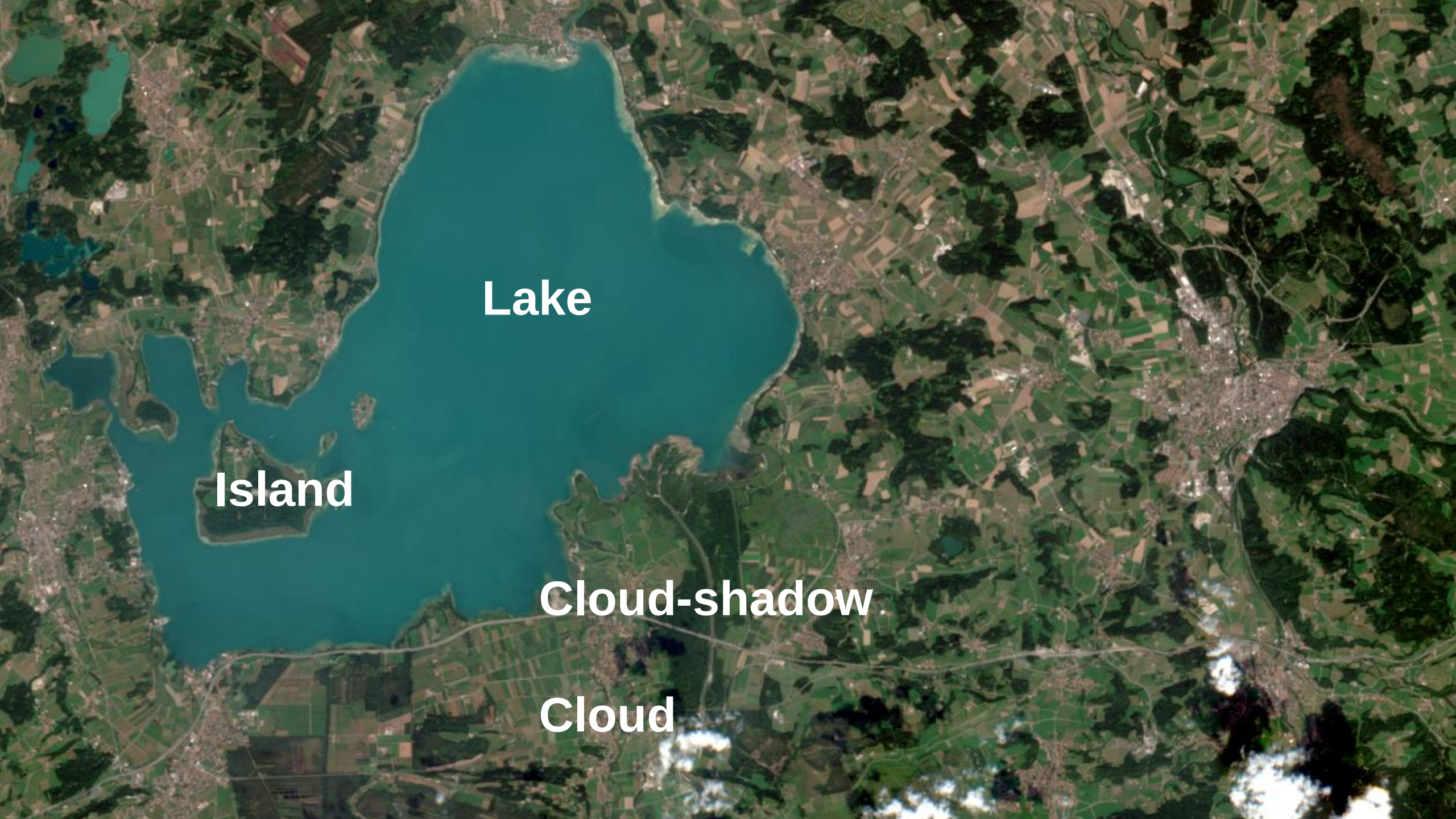
Sentinel-2 and spatial image analysis

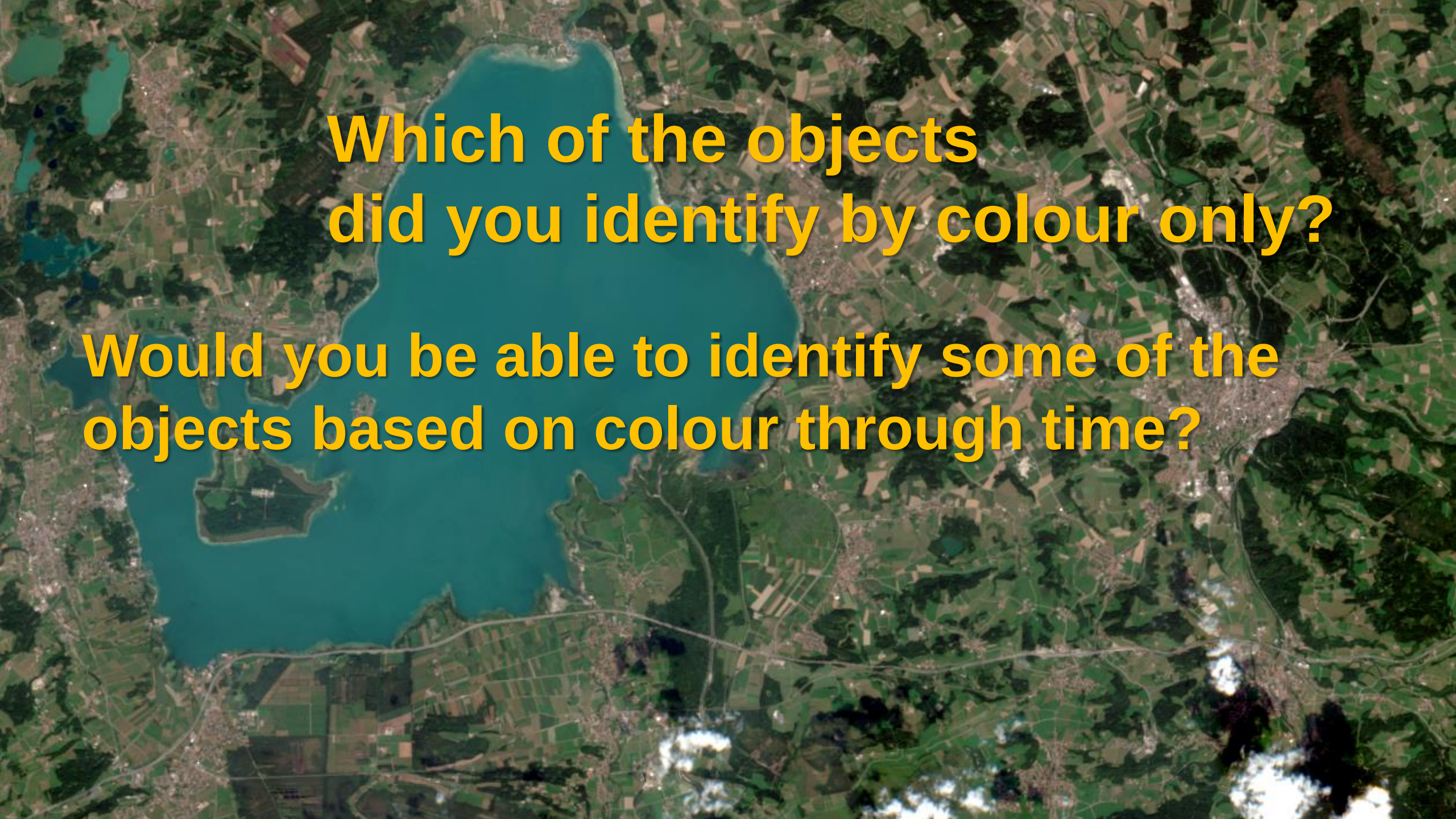
TAT-7 | 21.06.2019 | Martin Sudmanns, Dirk Tiede, Stefan Lang, & contrib.
Z_GIS colleagues

Interfaculty Department of Geoinformatics – Z_GIS, University of Salzburg

Where is the ***space*** in spatial analysis?




Lake
Island
Cloud-shadow
Cloud


Which of the objects
did you identify by colour only?
Would you be able to identify some of the objects based on colour through time?

Object-based image analysis (OBIA)

ObjectID=27
Mixed arable land

Object representation
Vector model

Clear boundaries, unique and unambiguous content

Interpretations

(GE-)**OBIA**

a mediating strategy

Imaged representation
Raster data model

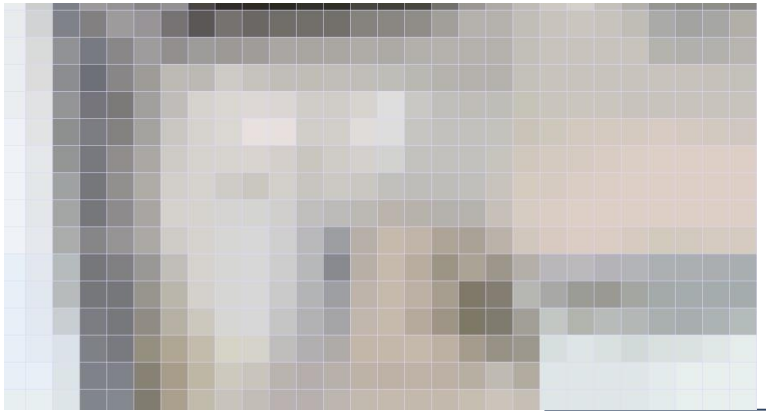
No boundaries, no semantic content, spectral values

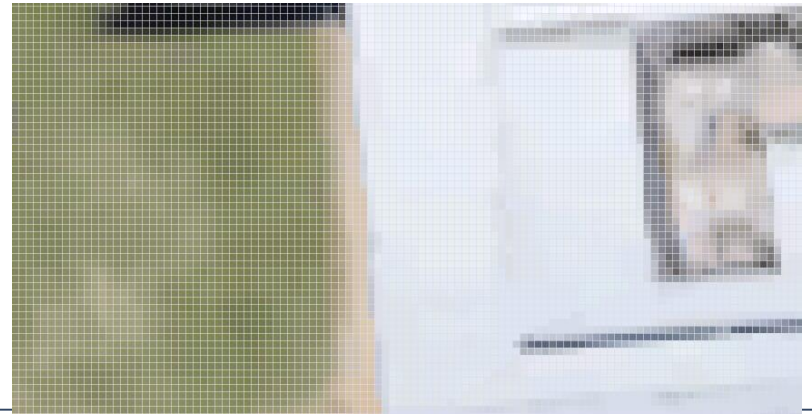
(pseudo-continuous) measurements

Stefan Lang et al 2018

Object-based image analysis (OBIA)

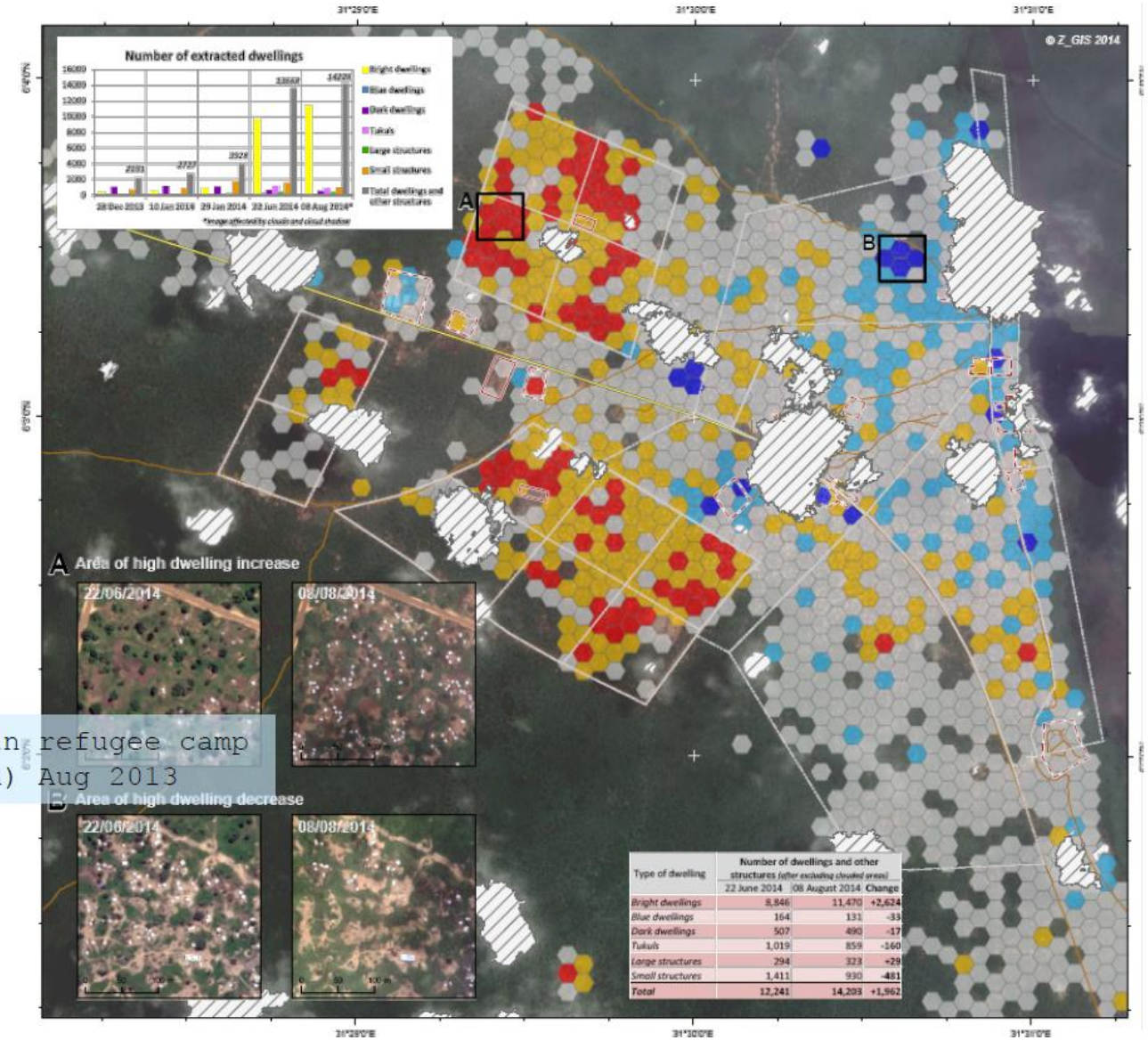
- **Spatial**, temporal and semantic relationships
- Prior **knowledge** about the scene
- Change in **vocabulary** (semantic gap):
  - Pixel values → Semantic concepts
  - Location, amount, size, … of objects





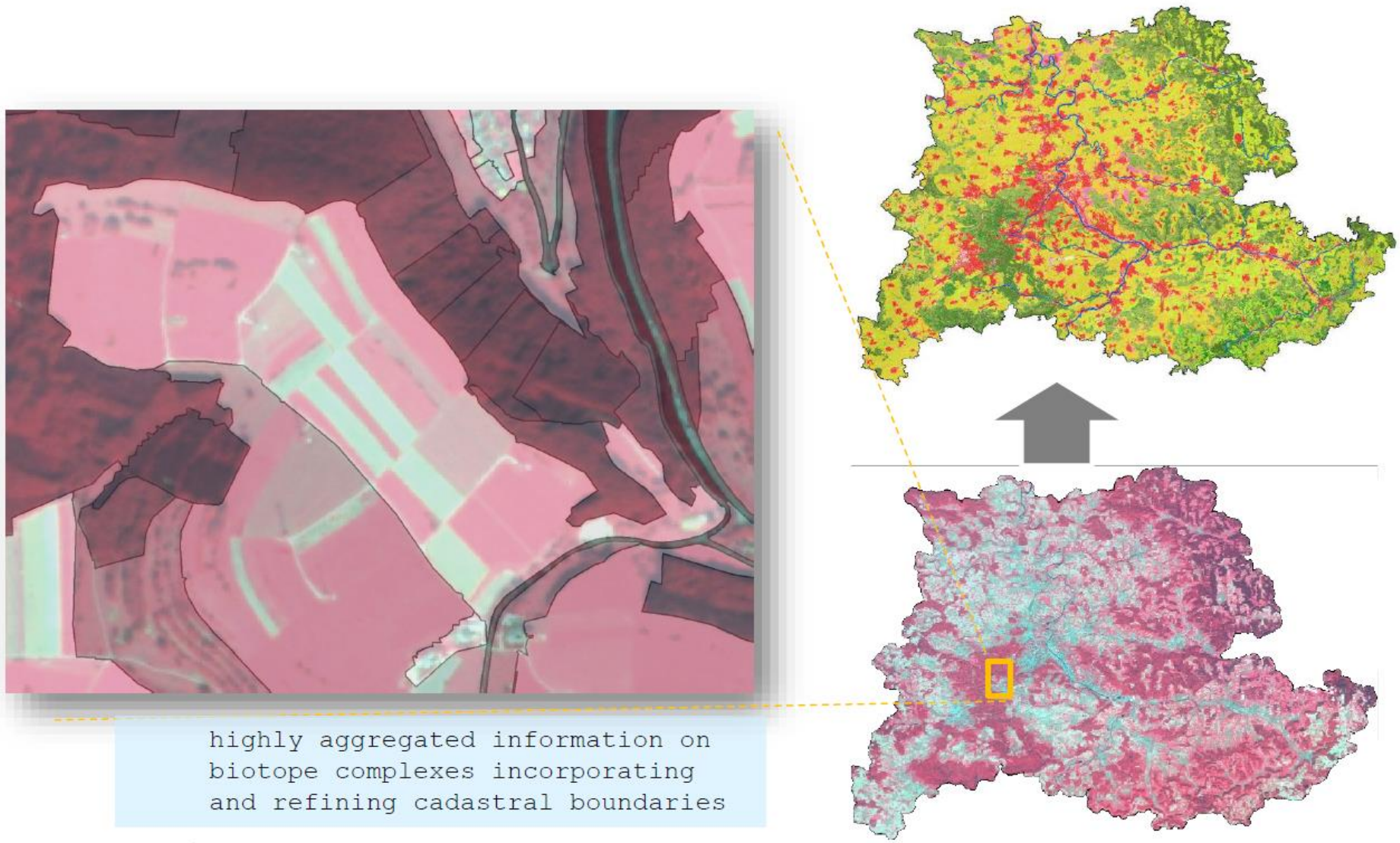
Object-based image analysis (OBIA)

- Some of the **benefits** leading to a greater expressivity of analyses
  - Location
  - Count
  - Area / size
  - Composition
  - Begin / end
  - …



Population density in refugee camp Minkaman(South Sudan) Aug 2013

Delineating image objects

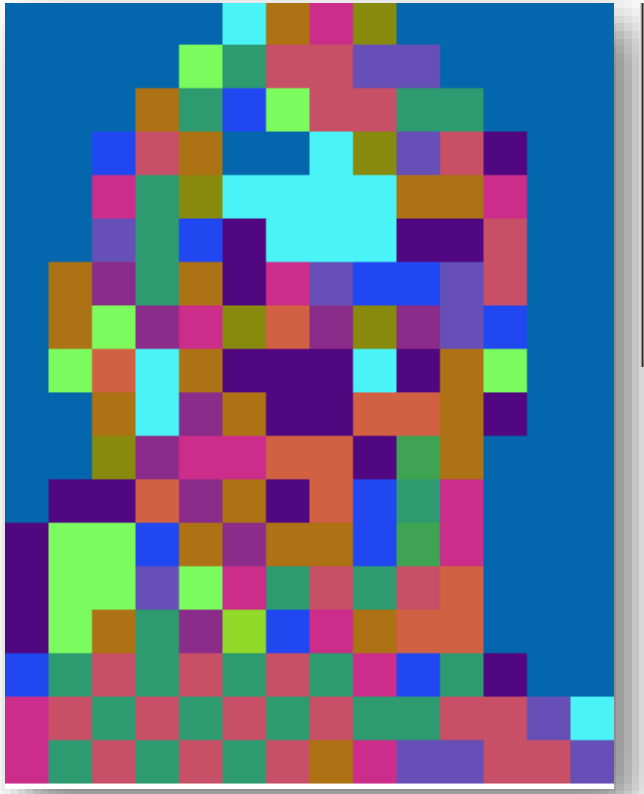


highly aggregated information on biotope complexes incorporating and refining cadastral boundaries

Lang, 2013
Lang & Tiede, 2018

Delineating image objects

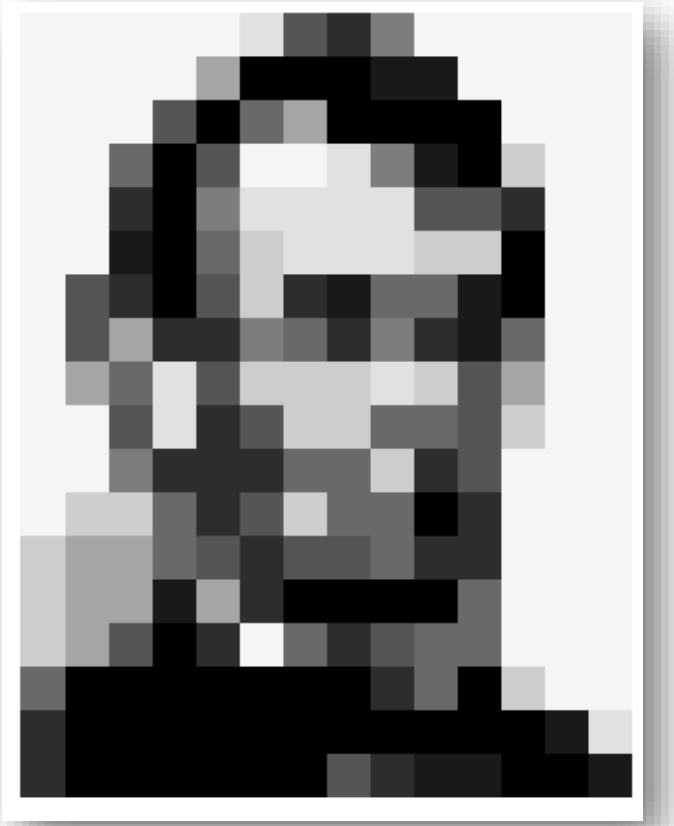
- Luckily, there is **spatial auto-correlation ***…



```
ncols 14
nrows 18
xllcorner 1000
yllcorner 1000
cellsize 10
nodata_value -9999
240 240 240 240 240 210 90 80 140 240 240 240 240 240
240 240 240 240 160 20 10 10 40 40 240 240 240 240
240 240 240 90 20 110 160 10 10 20 20 240 240 240
240 240 110 10 90 240 240 210 140 40 10 190 240 240
240 240 80 20 140 210 210 210 210 90 90 80 240 240
240 240 40 20 110 190 210 210 210 190 190 10 240 240
240 90 70 20 90 190 80 40 110 110 40 10 240 240
240 90 160 70 80 140 130 70 140 70 40 110 240 240
240 160 130 210 90 190 190 190 210 190 90 160 240 240
240 240 90 210 70 90 190 190 130 130 90 190 240 240
240 240 140 70 80 80 130 130 190 60 90 240 240 240
240 190 190 130 70 90 190 130 110 20 80 240 240 240
190 160 160 110 90 70 90 90 110 60 80 240 240 240
190 160 160 40 160 80 20 10 20 10 130 240 240 240
190 160 90 20 70 255 110 80 90 130 130 240 240 240
110 20 10 20 10 20 10 20 80 110 20 190 240 240
80 10 20 10 20 10 20 10 20 20 10 10 40 210
80 20 10 20 10 20 10 90 80 40 40 10 10 40
```

It's not just about grouping the **same** values

It's about grouping **similar** values!

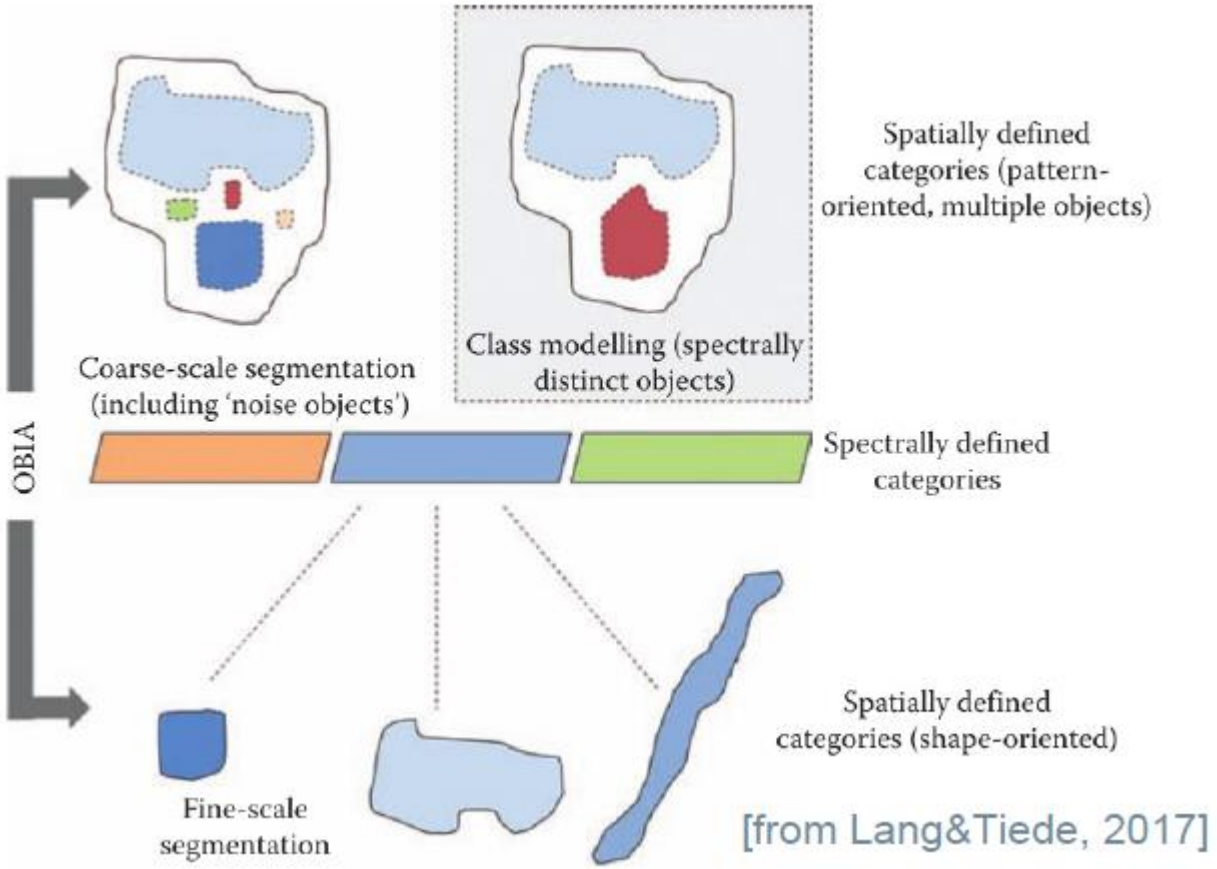


** The so-called 1st Law of Geography that closer things tend to be more similar than distant ones*

Stefan Lang et al 2018

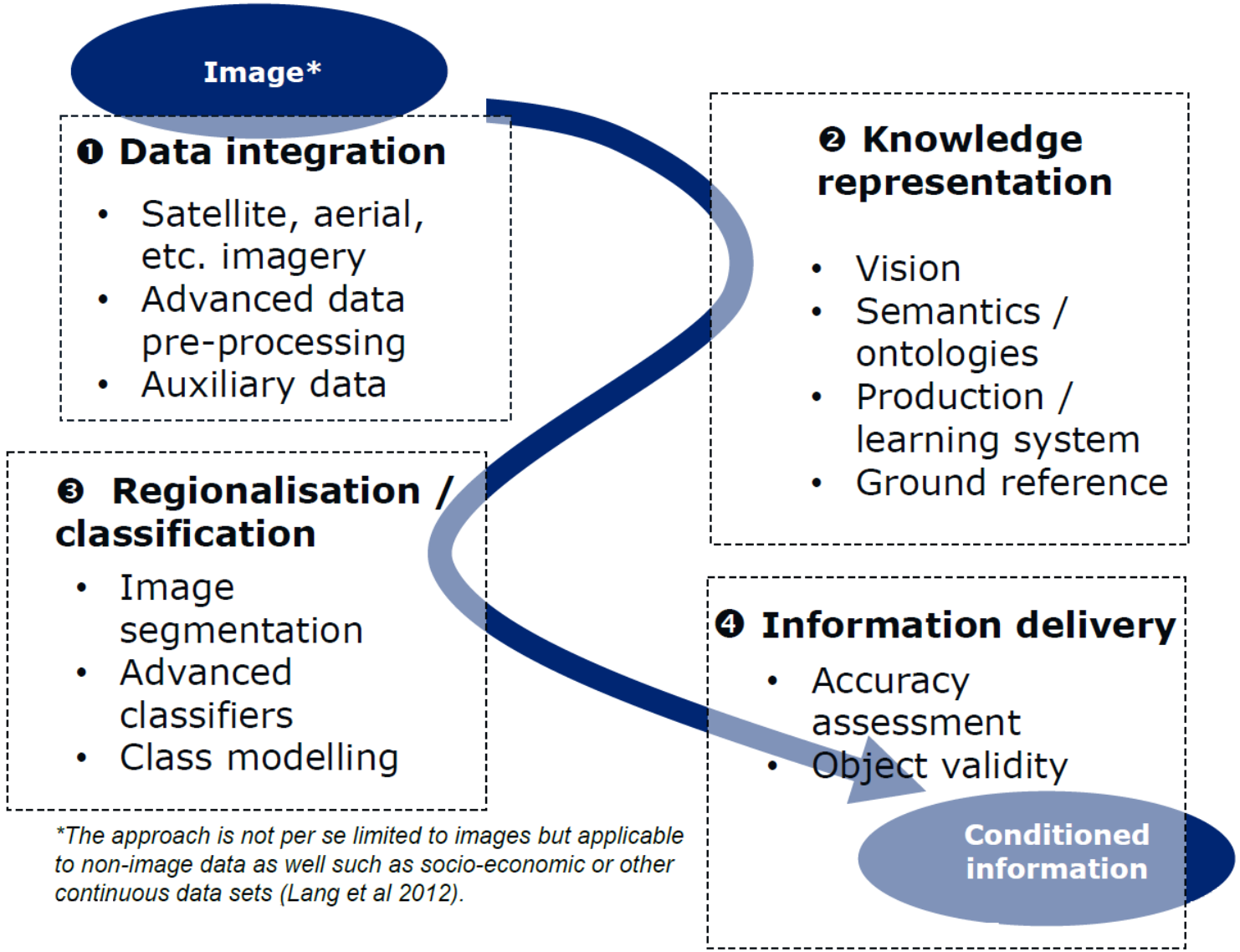
General approach

- regionalization techniques for **image segmentation**
  - "a trade-off" between spectral and spatial similarities
  - (scalable) generalization
  - reduction of the so-called salt-and-pepper effect
- explicit **focus on objects and their relationships**
  - address and model new dimensions of target classes
- offers the possibility to **include expert knowledge** in rule-sets or semantic networks



Lang, 2013
Lang & Tiede, 2018

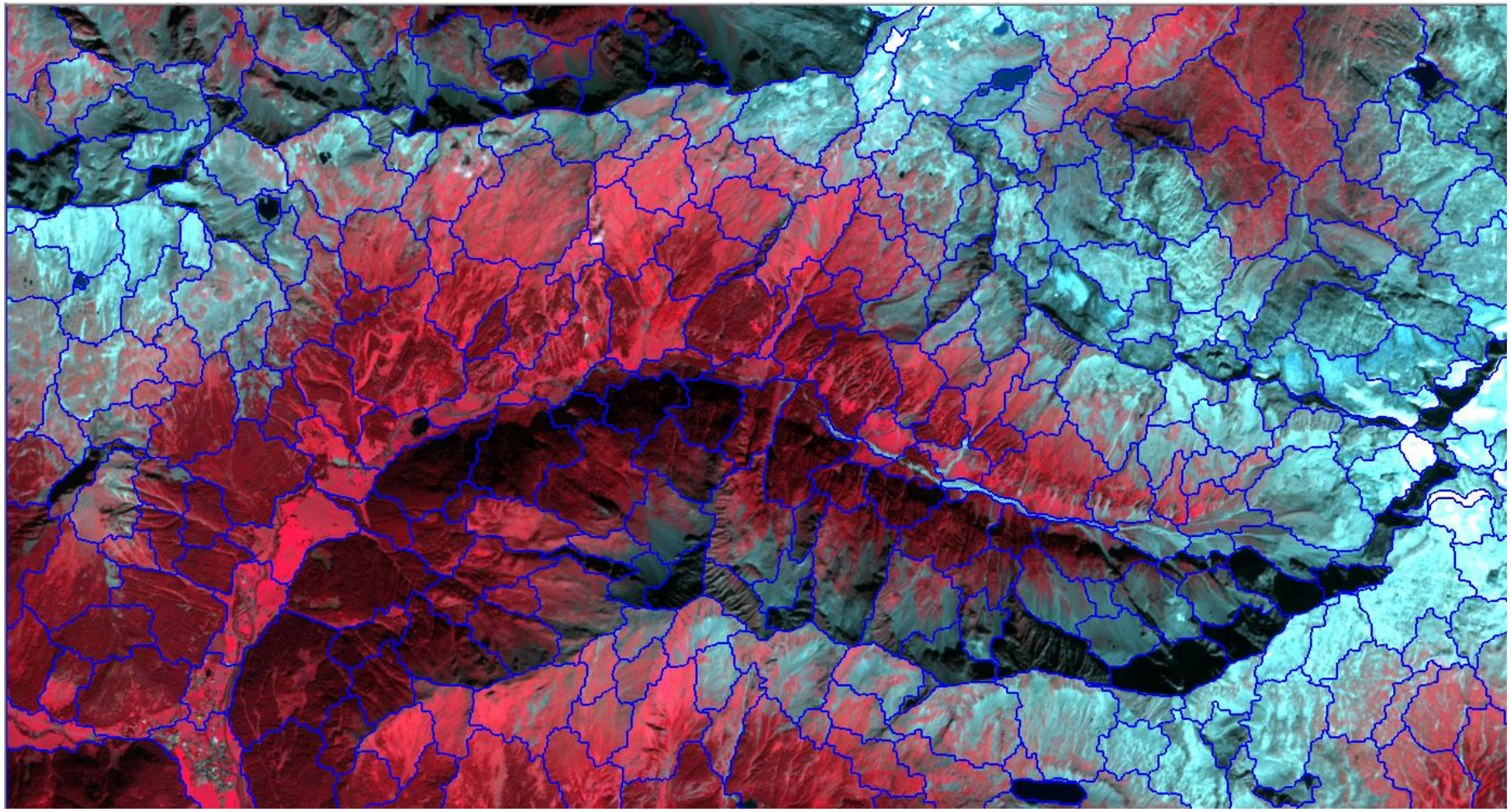
Typical workflow



*The approach is not per se limited to images but applicable to non-image data as well such as socio-economic or other continuous data sets (Lang et al 2012).

Lang, 2013
Lang & Tiede, 2018

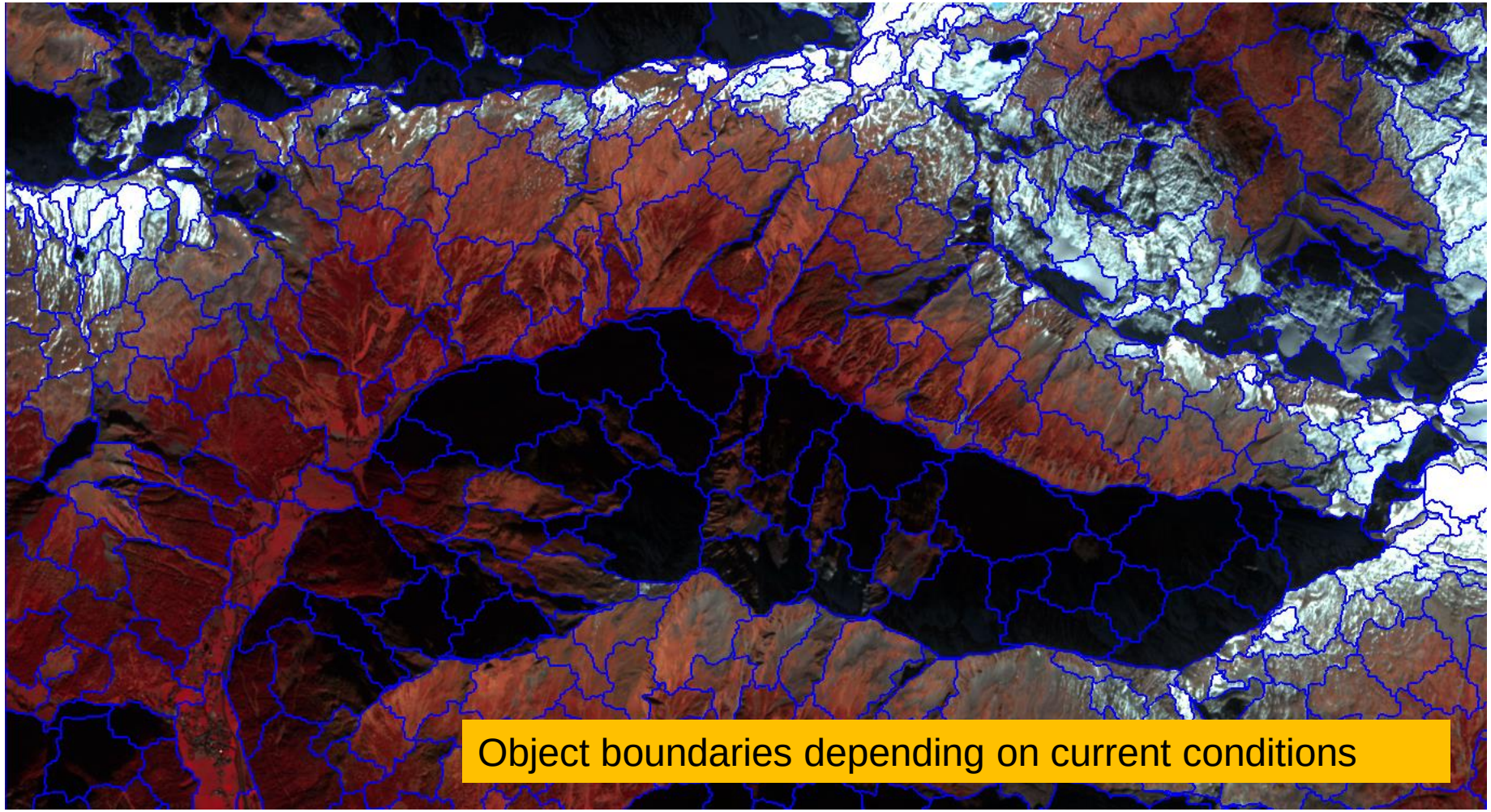
Object delineation problems



Aug 2017

Stefan Lang et al 2018

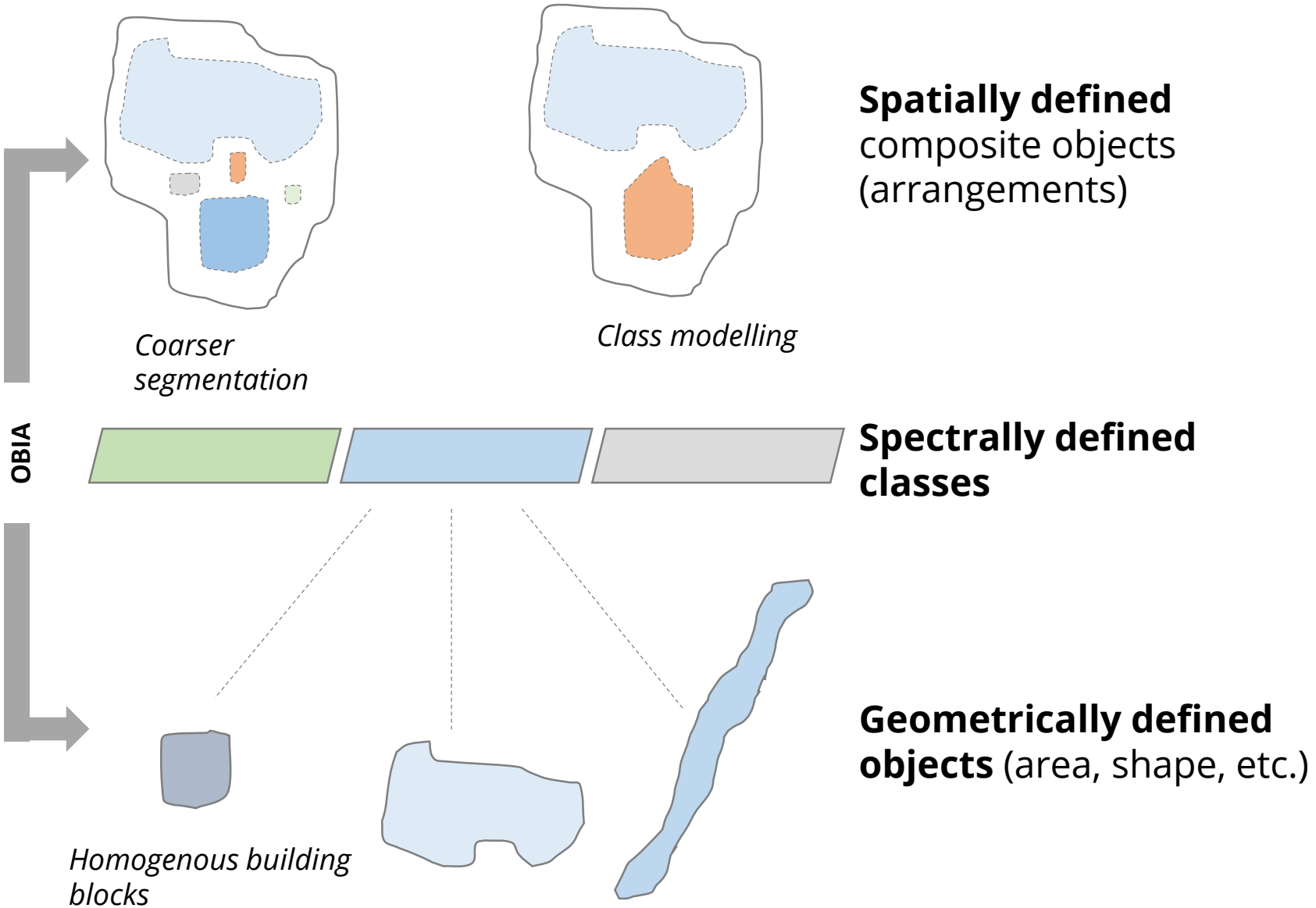
Object delineation problems



Oct 2017

Stefan Lang et al 2018

Object delineation problems



Spatially defined composite objects (arrangements)

Spectrally defined classes

Geometrically defined objects (area, shape, etc.)

Stefan Lang et al 2018