Integration of Copernicus Sentinel-1 time series in ML analytics for agricultural practice monitoring

Guido Lemoine, Kostas Anastasakis, Ferdinando Urbano, Wim Devos

Food Security Unit

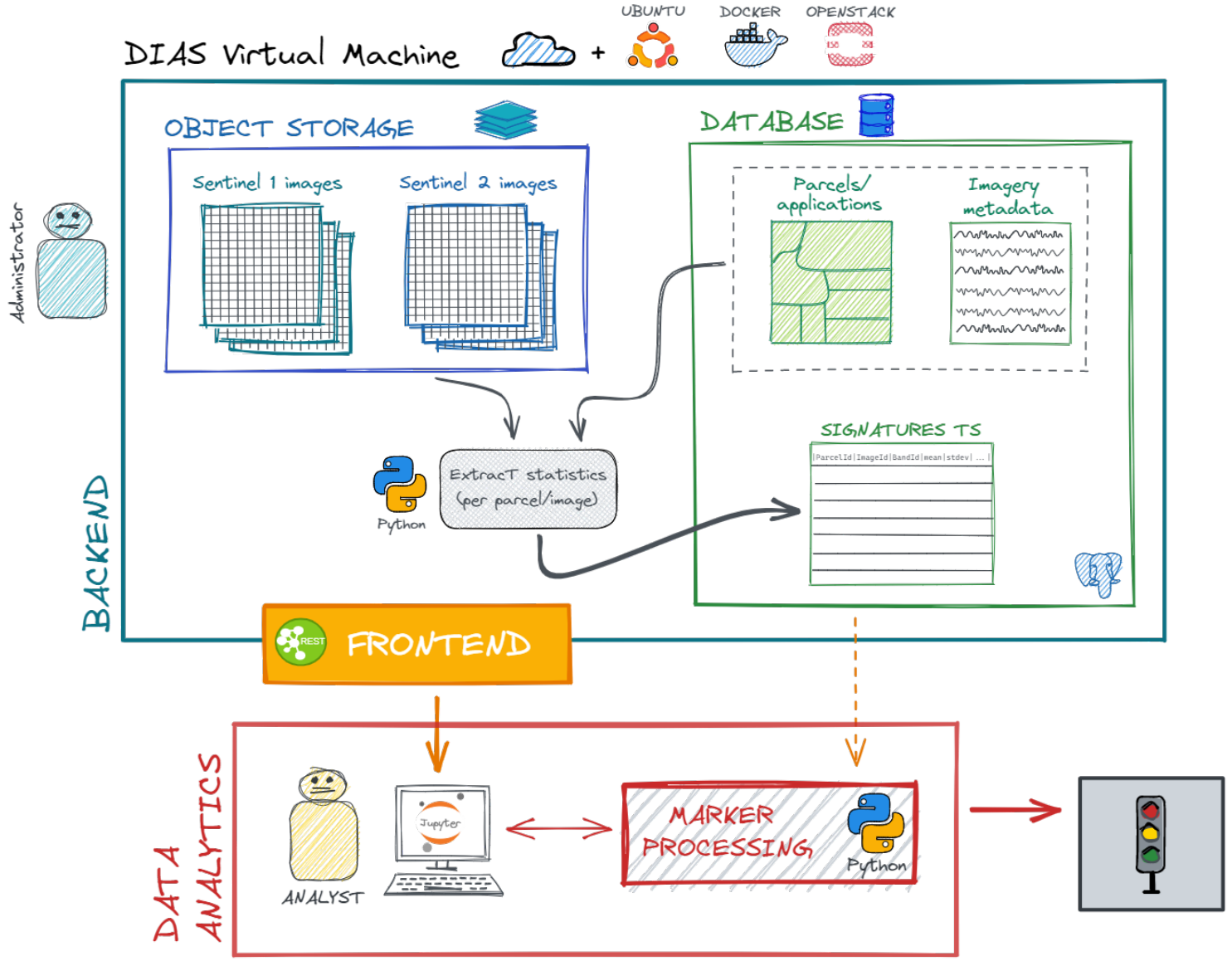
Sustainable Resources Directorate

LPS22 - C01.08
27 May 2022, Bonn (DE)

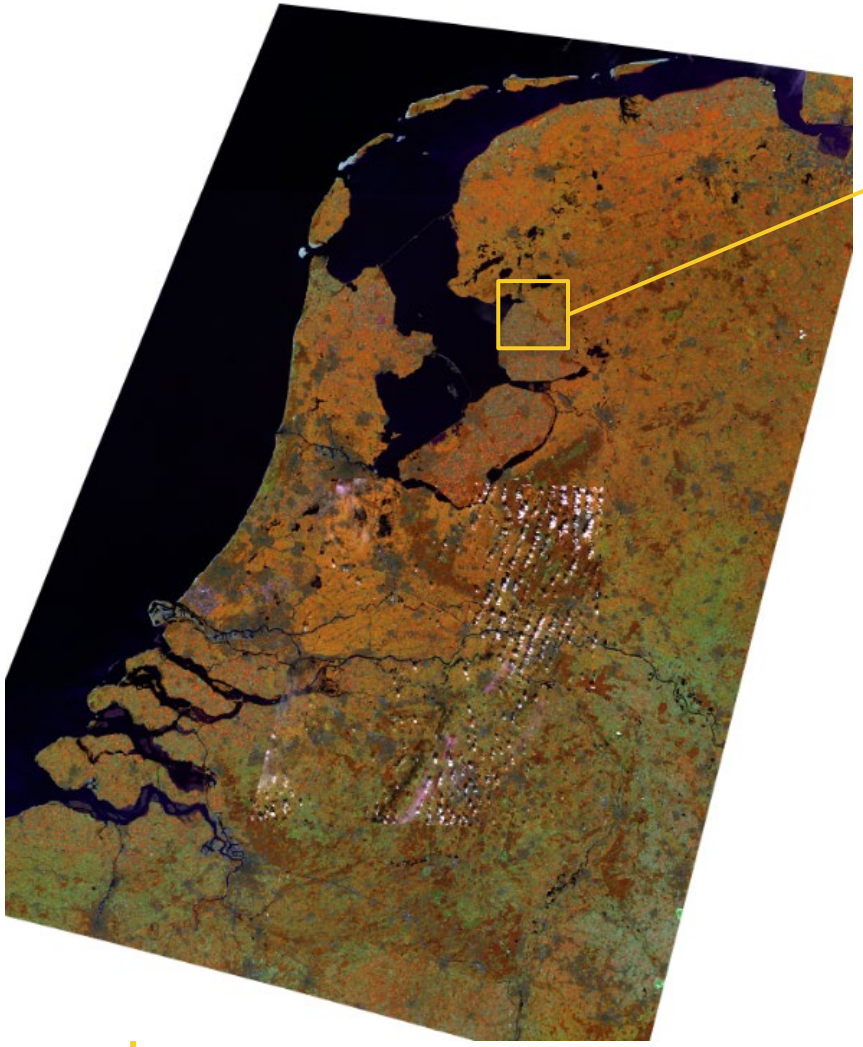
Agricultural practice monitoring

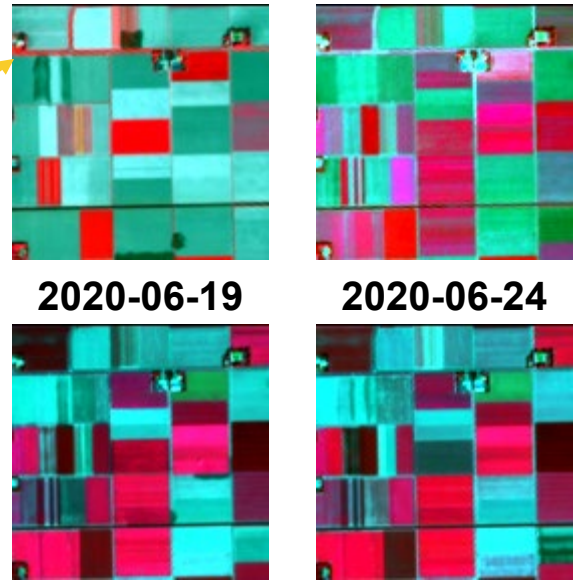
- **CAP area based support** can be specific to cropping practices
- For instance, mowing regime of grassland, post harvest catch crops, etc.
- EU Monitoring systems have introduced the use of Sentinel 1 & 2
- For 100% of the territory, full annual cycle (“always on”)
- Data handling requires cloud capacities
- JRC has implemented an open source backend/frontend reference
- Extensively tested on (multiply) DIAS platforms, ready for DAS

Backend in the JRC CbM architecture



CbM on DIAS





Winter wheat harvest ?

Detected
Inconclusive
Not detected

n parcels
m Sentinel-2 @ DIAS (14 bands)
p Sentinel-1 @ DIAS (2x2 bands)

~ 100,000,000,000 records per year for all Europe

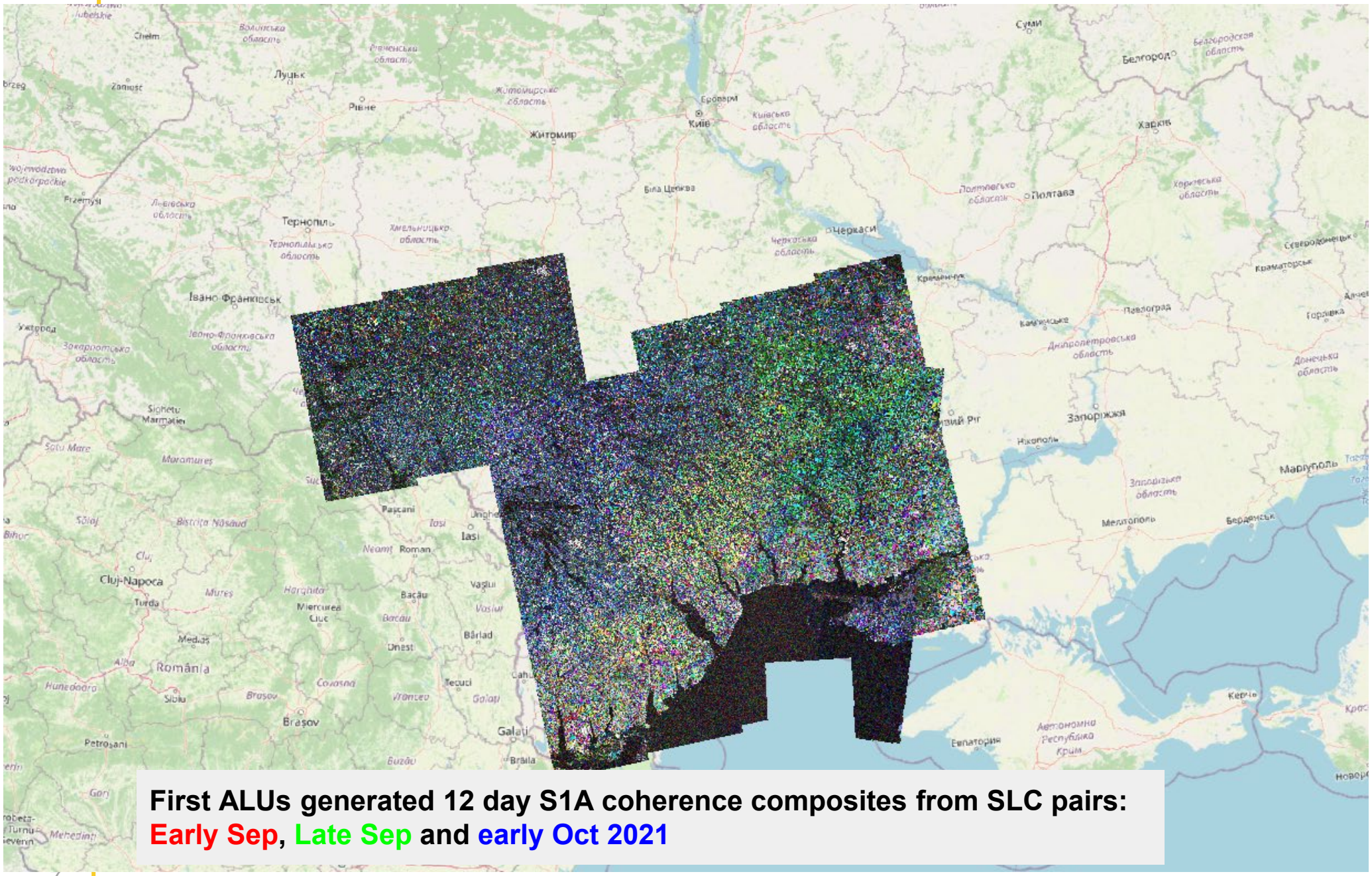
Need for Analysis Ready Data

- Essential role for Sentinel-1: the only consistent, calibrated time series
- Core concept is time series reduction for parcel objects
- This requires input imagery as Analysis Ready Data

- For Sentinel-1:
  - No standard production of ARD (on Copernicus infrastructure)
  - But open source code to process standard recipes (SNAP)
  - Both geocoded backscattering, geocoded coherence, [H-A-α]
  - So DIY is matter of resources
  - PaaS on (CREO)DIAS

SAR On The Fly

- Coherence ARD is data heavy (~ 16 GB SLC input) and slow on CPU
- CGI Estonia open source ALUs GPU accelerated **superfast**
- Benchmark project awarded by the C-SCALE H2020 project
- Implemented on a CREODIAS RTXA6000.4 instance (56 GB on board)
- **11 sec per subswath**
- Cloud data (S3) transfer, CPU postprocessing latencies
- For systematic generation of **S1A COH12** over Ukraine (shared data!)
- Check the CloudFerro EO4UA initiative



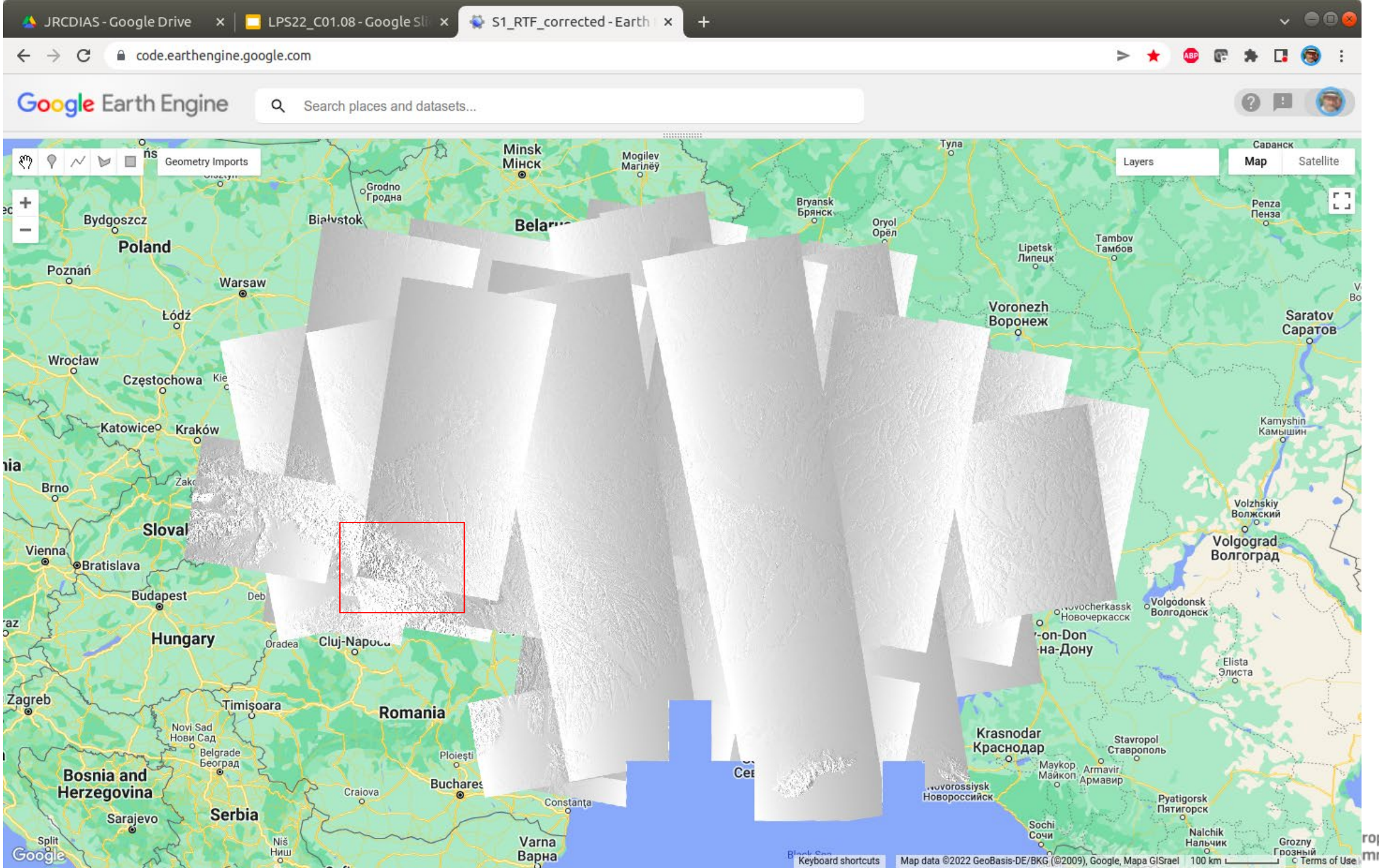
First ALUs generated 12 day S1A coherence composites from SLC pairs: Early Sep, Late Sep and early Oct 2021

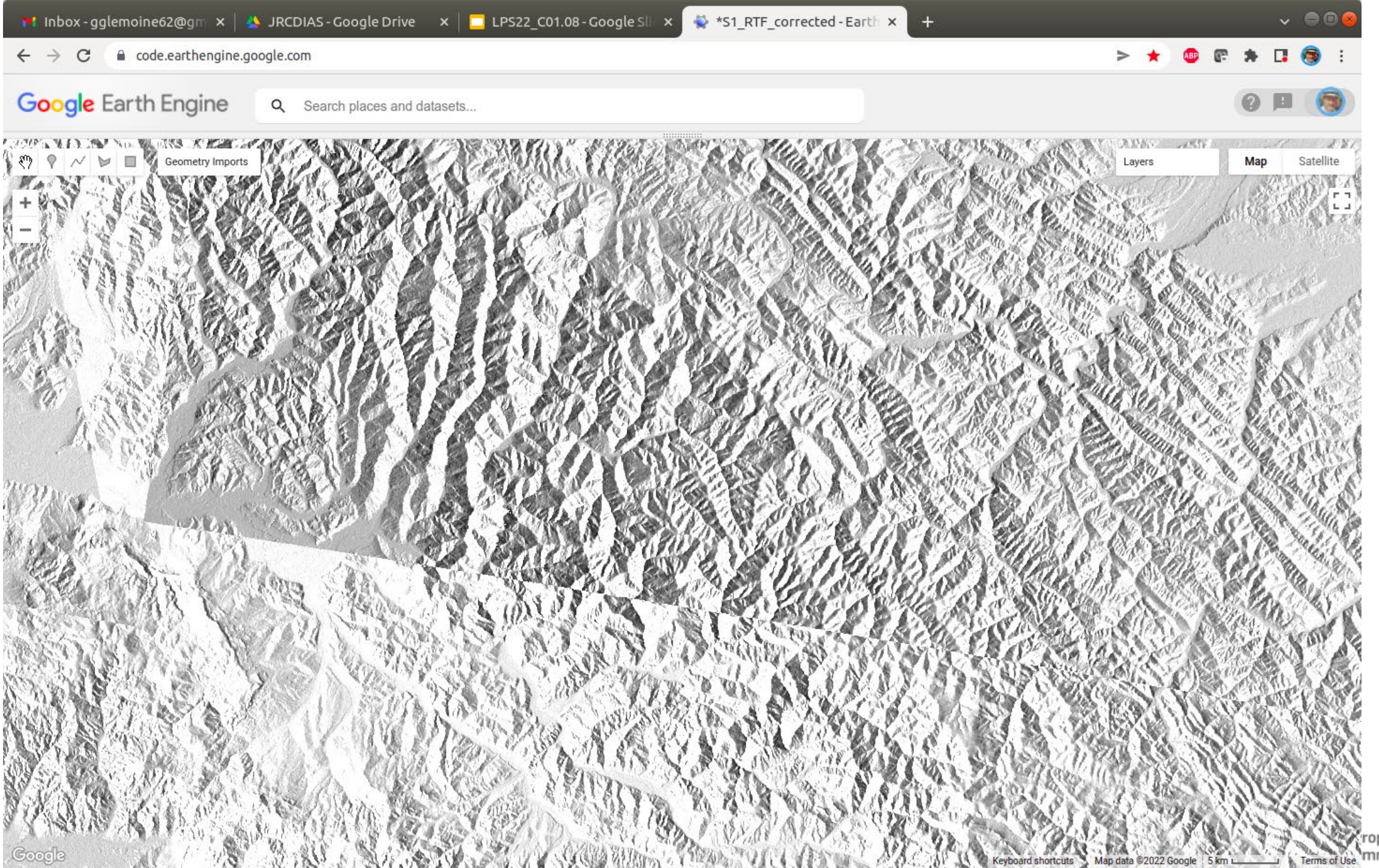
- 6 full SLC frames
- 18-20 12 day pairs
- 130 COH12 total
- ~ 4 hours
- (incl. transfer)
- 1 Sep - 1 May 22

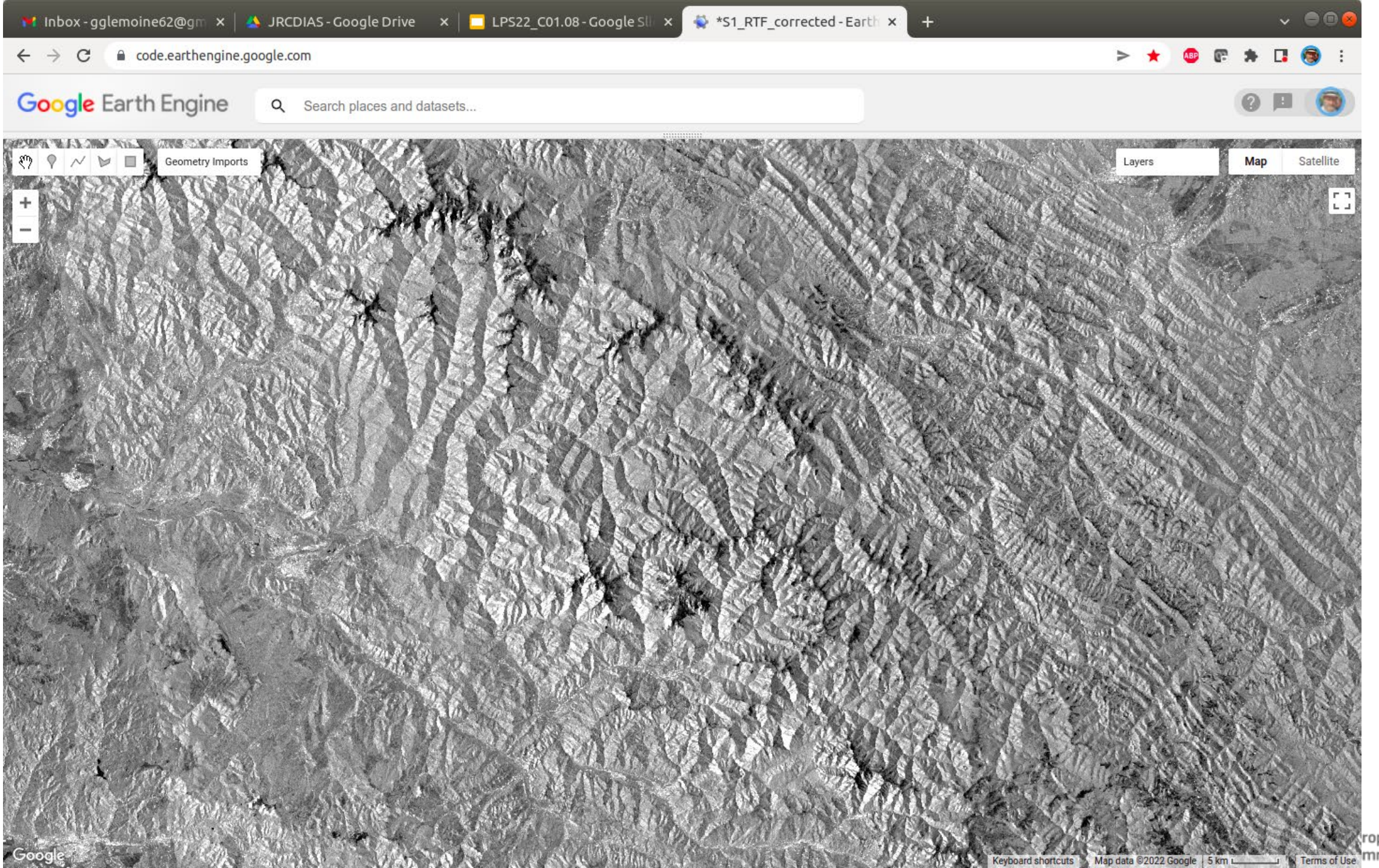
First ALUs generated 12 day S1A coherence composites from SLC pairs: Early Sep, Late Sep and early Oct 2021

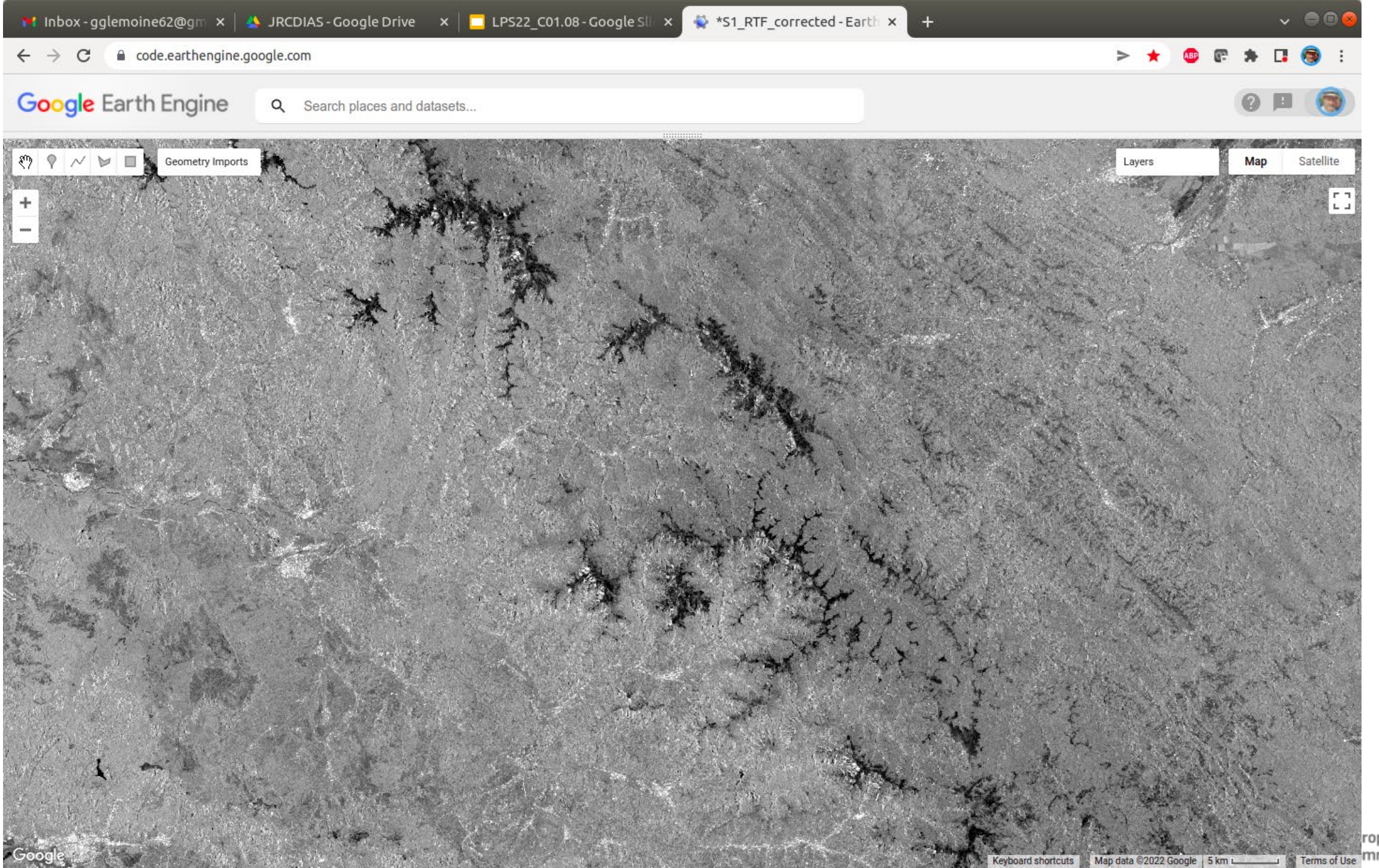
So, do we need σ, γ or β?

- Well, depends…
- The simple view: agriculture mostly in flattish terrain
- The complex view: generate and store all
- The pragmatic view: Radiometric Terrain Flattening is a constant correction, due to very stable orbit configurations
- So, generate once for a full orbit cycle, use the correction often


JRCDIAS - Google Drive
LPS22_C01.08 - Google Sli
S1_RTF_corrected - Earth
code.earthengine.google.com
Google Earth Engine
Search places and datasets...
Geometry Imports
Layers
Map
Satellite
Minsk
Мінск
Mogilev
Магілёў
Grodno
Гродна
Białystok
Bydgoszcz
Poland
Poznań
Warsaw
Łódź
Wrocław
Częstochowa
Katowice
Kraków
Brno
Vienna
Bratislava
Budapest
Hungary
Oradea
Cluj-Napoca
Zagreb
Timişoara
Romania
Novi Sad
Нови Сад
Belgrade
Београд
Bosnia and
Herzegovina
Sarajevo
Serbia
Craiova
Ploieşti
Constanţa
Varna
Варна
Split
Niš
Ниш
Bryansk
Брянск
Oryol
Орёл
Tula
Тула
Lipetsk
Липецк
Tambov
Тамбов
Penza
Пенза
Voronezh
Воронеж
Saratov
Саратов
Kamyshin
Камышин
Volzhskiy
Волжский
Volgograd
Волгоград
Volgodonsk
Волгодонск
Novocherkassk
Новочеркасск
Elista
Элиста
Krasnodar
Краснодар
Stavropol
Ставрополь
Maykop
Майкоп
Armavir
Армавир
Novorossiysk
Новороссийск
Pyatigorsk
Пятигорск
Sochi
Сочи
Nalchik
Нальчик
Grozny
Грозный
Keyboard shortcuts
Map data ©2022 GeoBasis-DE/BKG (©2009), Google, Mapa GISrael
100 km
Terms of Use
Google


Inbox - gglemoine62@gm
JRCDIAS - Google Drive
LPS22_C01.08 - Google Sli
*S1_RTF_corrected - Earth
code.earthengine.google.com
Google Earth Engine
Search places and datasets...
Geometry Imports
Layers
Map
Satellite
Google
Keyboard shortcuts
Map data ©2022 Google
5 km
Terms of Use

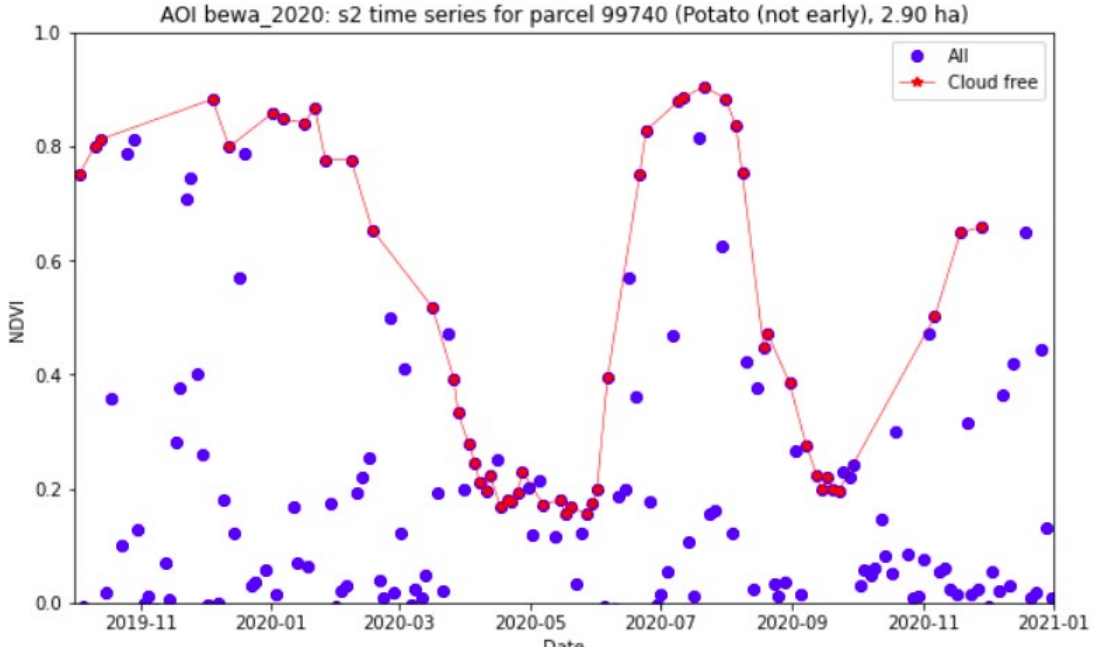

Inbox - gglemoine62@gm
JRCDIAS - Google Drive
LPS22_C01.08 - Google Sli
*S1_RTF_corrected - Earth
code.earthengine.google.com
Google Earth Engine
Search places and datasets...
Geometry Imports
Layers
Map
Satellite
Google
Keyboard shortcuts
Map data ©2022 Google
5 km
Terms of Use

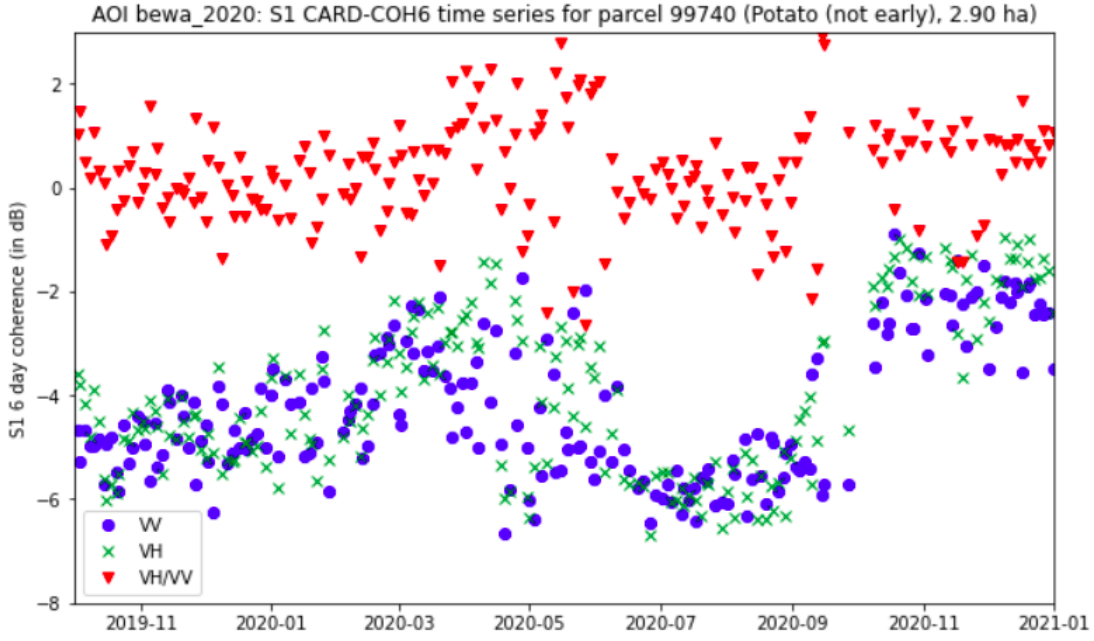

Inbox - gglemoine62@gm
JRCDIAS - Google Drive
LPS22_C01.08 - Google Sli
*S1_RTF_corrected - Earth
code.earthengine.google.com
Google Earth Engine
Search places and datasets...
Geometry Imports
Layers
Map
Satellite
Google
Keyboard shortcuts
Map data ©2022 Google
5 km
Terms of Use

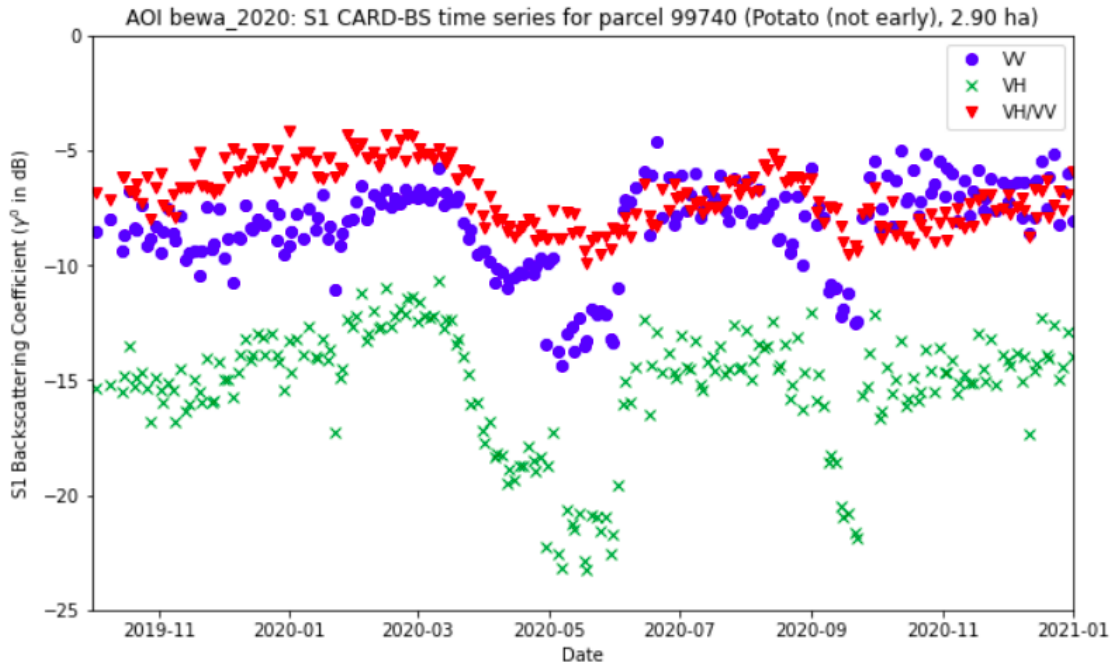
Time series in ML Analytics

- Comprehensive S1 and S2 time series for all monitored parcels
- Typically several 100 million records per 1 million parcels
- Used in marker analysis, ML, peer review
- ML in our context:
  - For outlier detection (we know the declared parcel practice!)
  - Transfer learning for early season classification
  - Full territory crop maps (e.g. EU2018, SAR only with LUCAS)
  - [parcel delineation, multi-scale landscape metrics]

Signature basics







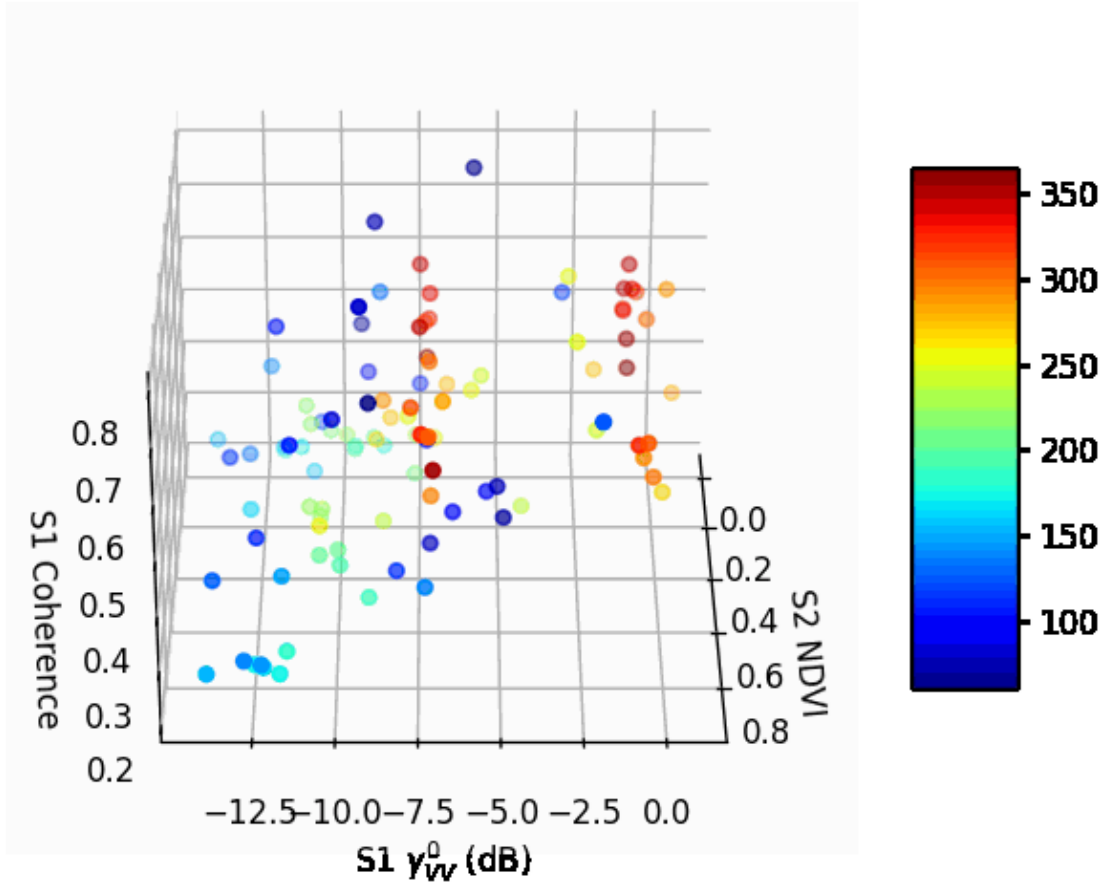
Sentinel-1 CARD-BS

- Sensitive to vegetation removal and emergence
- Sensitive to soil surface preparation
- Revisit matches agricultural practice dynamics (!)

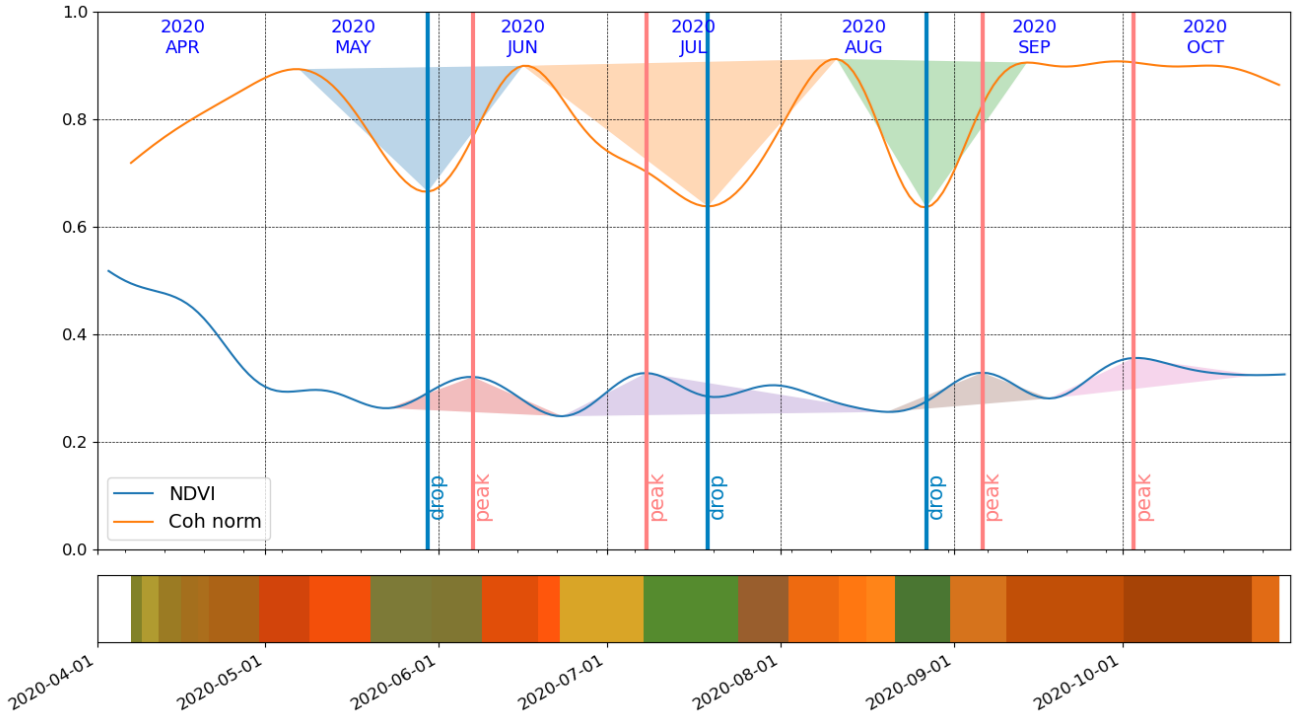
Sentinel-1 CARD-COH6

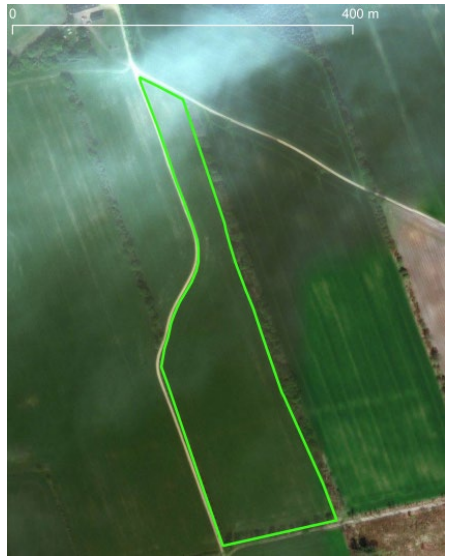
- Sensitive to stable bare soil vs. canopies
- Sensitive to change in bare soil conditions

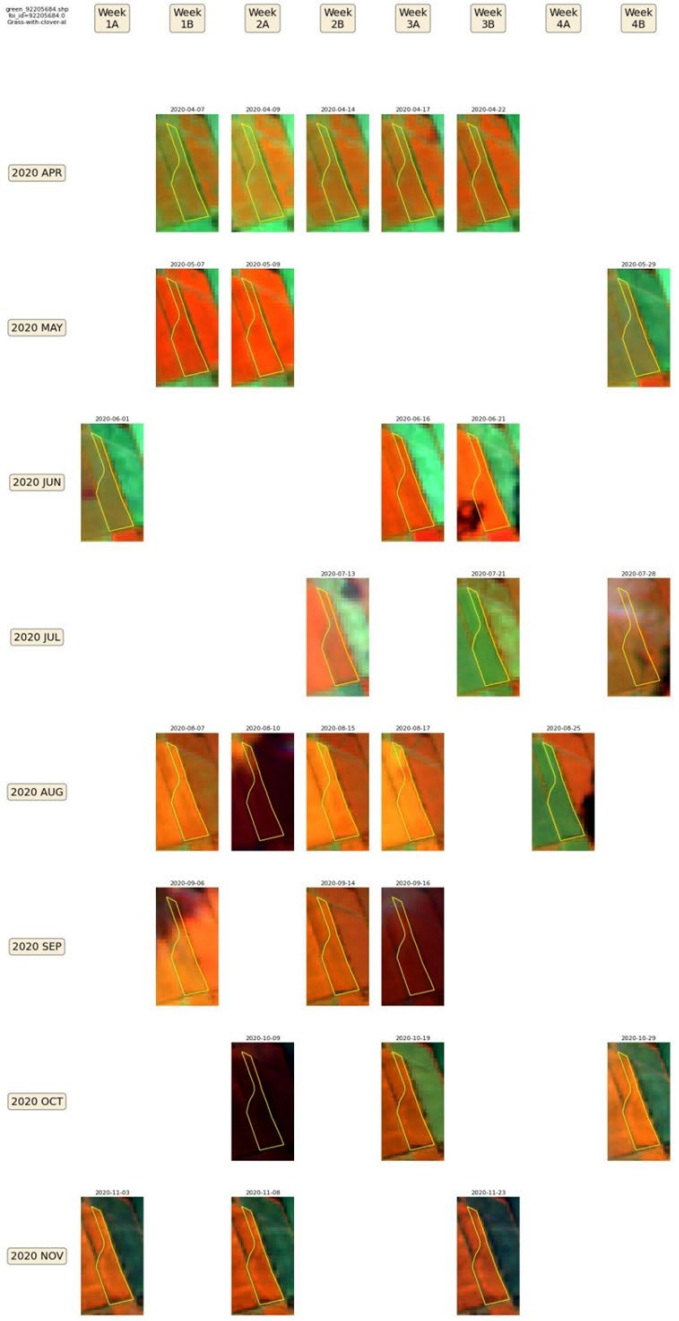
:inel time series for parcel 92883817 (Broad bean, fava bea, 21.04 ha)



“How does your FOI perform [with regards to heterogeneity] in it's temporal trajectory in hybrid HR Sentinel radiometric feature space?”





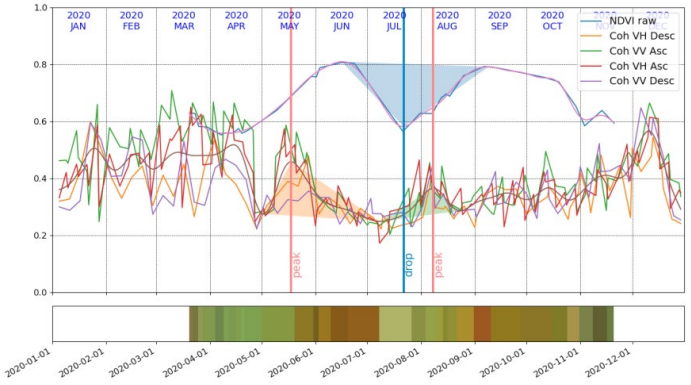


Grassland mowing

European Commission

From markers to traffic light classification

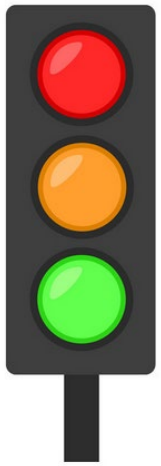
Markers detection



markers_id [PK] integer	foi_id integer	marker character	marker_type character	date_start date	date_main date	date_end date	duration_days integer	value_1 numeric	value_2 numeric	value_3 numeric	pid integer	practice character
2	92769440	coh_norm	peak	2020-07-30	2020-08-18	2020-08-30	31	0.26	0.34	0.27	15	mowing
3	92769440	coh_norm	peak	2020-08-30	2020-09-13	2020-10-18	49	0.27	0.36	0.28	15	mowing
4	92769440	ndvi	drop	2020-05-22	2020-06-18	2020-07-29	68	0.85	0.56	0.89	15	mowing
5	92769440	band_class	state_change	2020-04-07	2020-04-18	2020-04-29	21	4.00	4.00	7.00	15	mowing
6	92769440	band_class	state_change	2020-06-10	2020-06-21	2020-07-02	21	7.00	4.00	7.00	15	mowing
7	92769440	band_class	state_change	2020-08-12	2020-08-22	2020-09-01	19	7.00	4.00	4.00	15	mowing
8	92788301	ndvi_raw	gap	2020-09-24	2020-10-05	2020-10-16	21	0.87	[null]	0.88	21	mowing
9	92788301	coh_norm	peak	2020-09-30	2020-10-15	2020-10-27	27	0.24	0.35	0.30	21	mowing
10	92788301	ndvi	drop	2020-05-16	2020-06-02	2020-06-15	30	0.89	0.63	0.85	21	mowing

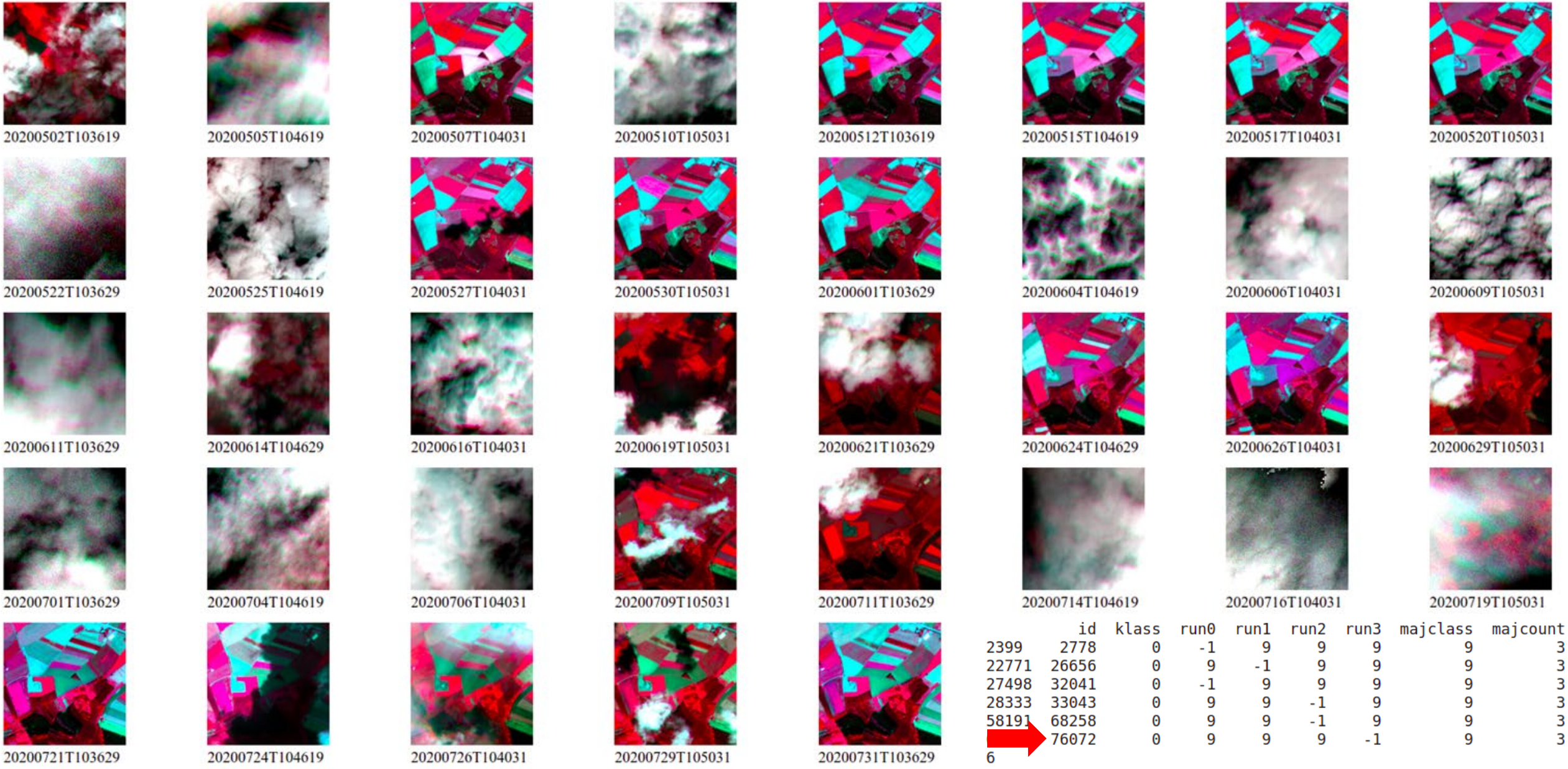
Markers table

Decision



```
▾ marker-aggregator: [] 3 items
  ▾ 0:
      action: "merge"
    ▾ signals: [] 2 items
        0: "ndvi"
        1: "ndvi_raw"
  ▾ 1:
      action: "confirm"
    ▾ signals: [] 1 item
        0: "band_classes"
  ▾ 2:
      action: "aggregate"
    ▾ signals: [] 1 item
        0: "coh_norm"
      overlap: 7
```

Markers aggregation and classification (agricultural practice)



	id	klass	run0	run1	run2	run3	majclass	majcount
2399	2778	0	-1	9	9	9	9	3
22771	26656	0	9	-1	9	9	9	3
27498	32041	0	-1	9	9	9	9	3
28333	33043	0	9	9	-1	9	9	3
58191	68258	0	9	9	-1	9	9	3
6	76072	0	9	9	9	-1	9	3

Outlier review with S2 chips

temporary meadow found as oil seed rape (4.1 ha)

What's next?

- DIAS transition to "data ecosystem" foreseen **for Q3 2022**
- Will provide a 6+ year service availability outlook
- Backend likely to migrate into a standard service ("post your parcels")
- Loss of Sentinel-1B halves "continuous data flow" basis
- Bigger information loss due to less-than-optimal coherence window (6 to 12)
- Not restored until end of 2023 (assuming continuity of S1A)
- Toward "On the fly" ARD generation for BOTH S1 and S2?
- "Don't store what you can compute" (a GEE motto…)

JRC CbM dissemination

- All code is released as Open source on Github: github.com/ec-jrc/cbm
- The system is fully documented in all its elements: jrc-cbm.readthedocs.io
- A step-by-step backend configuration manual is available

Thank you

European Commission