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Turning Environmental Data Into Knowledge

Challenge and solution for algorithm optimisation for Global Processing of Fire Burned Area at scale and at minimum costs

Hannes Neuschmidt, Brockmann Consult GmbH

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Context

- Project: The ESA Climate Change initiative (CCI), CCIFire+
  - ESA DeepESDL and ESA Network of Resources (NoR)
- Original Algorithm: Ekhi Roteta (formerly University of the Basque Country)
- Scientific Development: University of Alcalá
  - Amin Khairoun
  - Dr. M. Lucrecia Pettinari
  - Prof. Emilio Chuvieco (Scientific Lead)
- Production and QA of the 2023 FireCCIS2.v1 product: Brockmann Consult GmbH
  - Dr. Martin Böttcher
  - Hannes Neuschmidt
  - Thomas Storm
  - Dr. Grit Kirches
  - Mark Hansen
  - Dr. Carsten Brockmann
- First report on performance: Cloudflight GmbH

[1] Roteta, E., A. Bastarrika, M. Padilla, T. Storm, and E. Chuvieco. "Development of a Sentinel-2 Burned Area Algorithm: Generation of a Small Fire Database for Sub-Saharan Africa." Remote Sensing of Environment 222 (March 2019): 1–17. https://doi.org/10.1016/j.rse.2018.12.011.

[2] Chuvieco, Emilio, Ekhi Roteta, Matteo Sali, et al. "Building a Small Fire Database for Sub-Saharan Africa from Sentinel-2 High-Resolution Images." Science of The Total Environment 845 (November 2022): 157139. https://doi.org/10.1016/j.scitotenv.2022.157139.

The Product

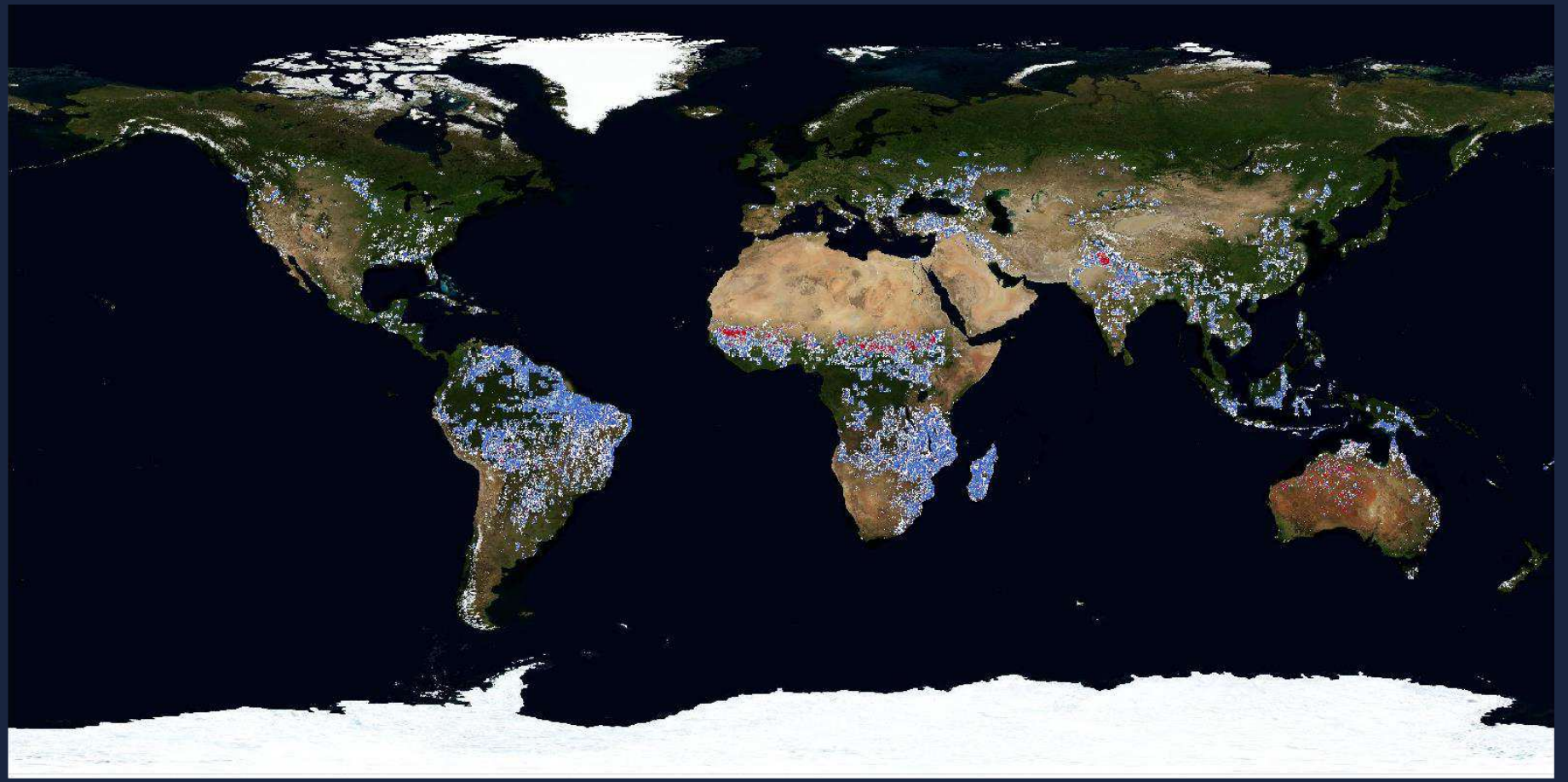
This is a preliminary product, the FireCCIS2.v1 dataset is not yet released!

Product	Scope per file	Grid	Resolution
Grid	Global	Geographical	0.05 degree
Tile	5-by-5 degree tiles	Geographical	Approx. 20 m
Granule	UTM Granule	UTM	20 m

- Total Burned Area
- Day of burn
- Burned Area by land cover class (ESA World Cover)

The Product – Grid

This is a preliminary product, the FireCCIS2.v1 dataset is not yet released!



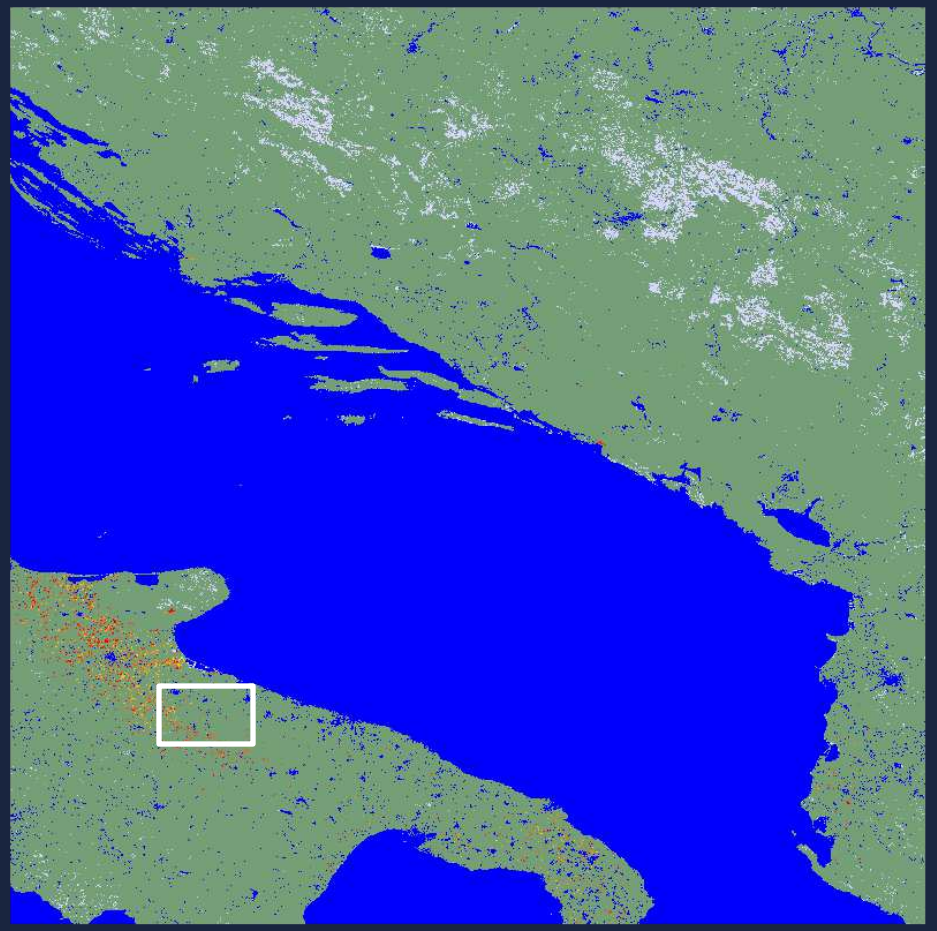
Grid
Global
Geographical
0.05 degree

20231101-ESACCI-L4_FIRE-BA-MSI-fv1.0.5 : Global (0.05°) burned area for **November 2023**

The Product – Tile

This is a preliminary product, the FireCCIS2.v1 dataset is not yet released!

- Green: unburned
- Blue: not burnable
- Yellow: fire early in month
- Red: Fire late in month



Tile
5-by-5 degree tiles
Geographical
Approx. 20 m

5°x5° tile product, tile h39v09, **July 2023**: Day of burn.

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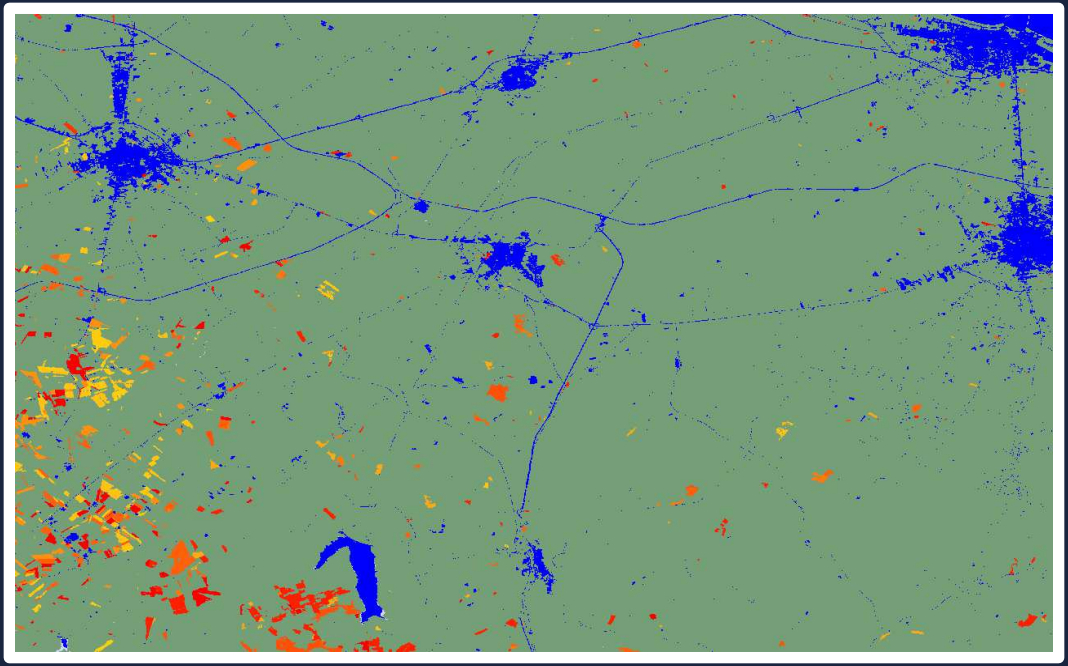

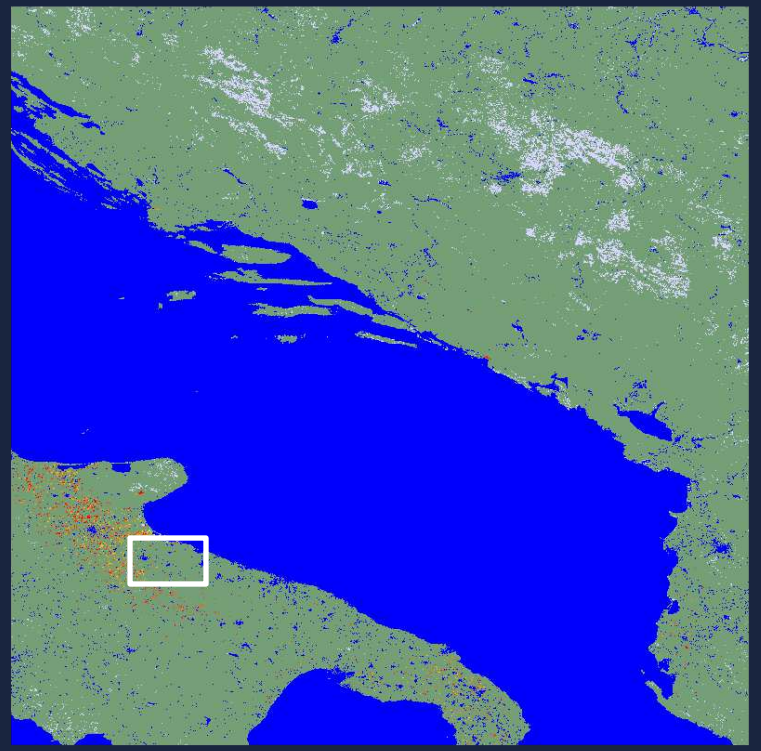

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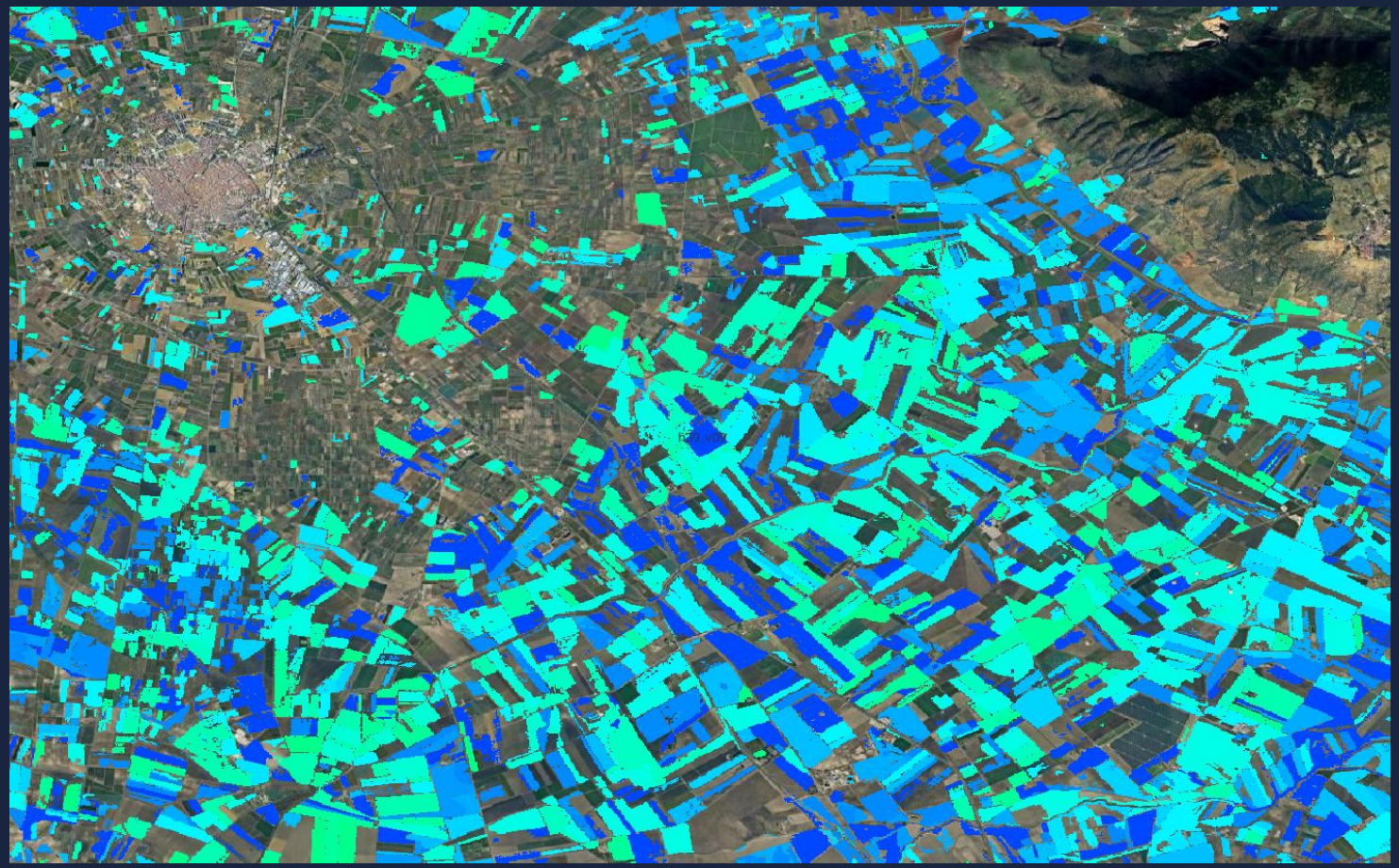

Burned Area from June (Green) to August (Blue)

Image credit: M. Lucrecia Pettinari, Amin Khairoun, Emilio Chuvieco (UAH)

Generated from 5°x5° tile product, tile h39v09, **June/July/August 2023**: Day of burn.

The Burned Area Detection Algorithm

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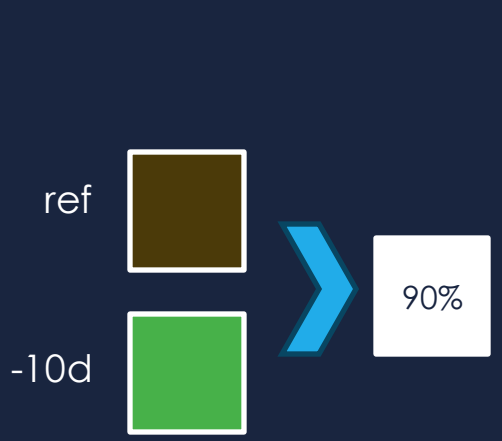
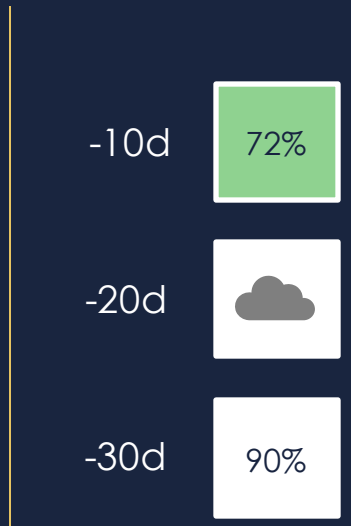
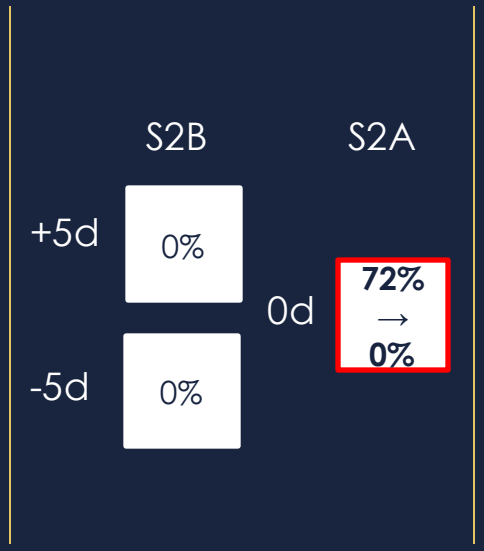
Pre	Post	Fuse	Tile	Formatting
Per-pixel probability of burn based on a pair of observations	**Select probability** of burn from closest-in-time pair	**Filter burned pixels** by confirmation with the other platform S2A/B	**Temporal aggregation** by month	**Spatial aggregation**
Per reference-predecessor pair (up to 40 days before)	Reduce reference-predecessor pairs to S2 observation time series	Per S2 observation	Per month	Per Month, on a larger grid







Global Production

- Global Production on 20 m resolution
- 3 mio Sentinel-2 L2A input images processed (> 2 PB)
- Approach used sub-Saharan Africa (2016 and 2019) not cost effective for global scale

Our Approach

- Production with Calvalus: Our Big Data Processing system based on Apache Hadoop
- Deployment on Creodias
  - Highly parallel processing with on-demand cloud resources
  - Input data available on-site
  - Commodity hardware
- Suitable intermediate results make the production robust against job failures
- Optimisation of the algorithm

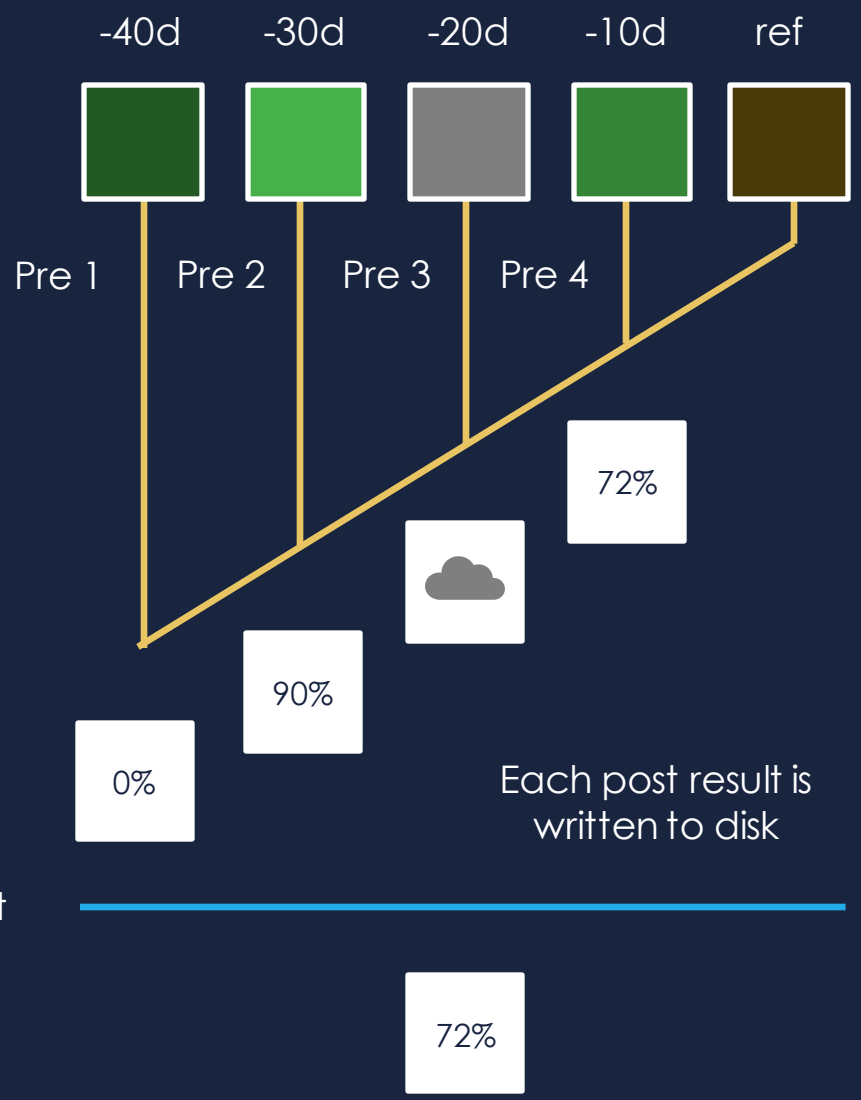
Optimization

- Pre-processing
  - Active Fire (VIIRS) indexing by UTM granule
  - Pre-processing World Cover to match Sentinel-2 in extend, projection, resolution

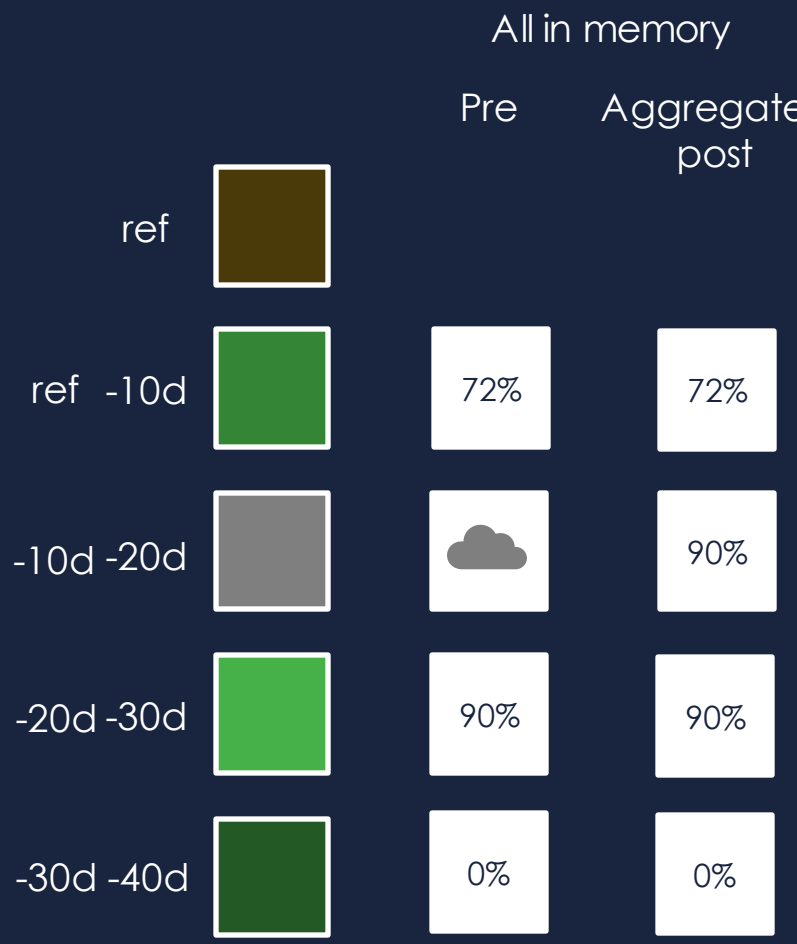
- Single pass algorithm
  - Drastically reduce the number of intermediate products read and written
  - Minimal information kept in memory

Optimisation – Pre/Post

Original



Optimized



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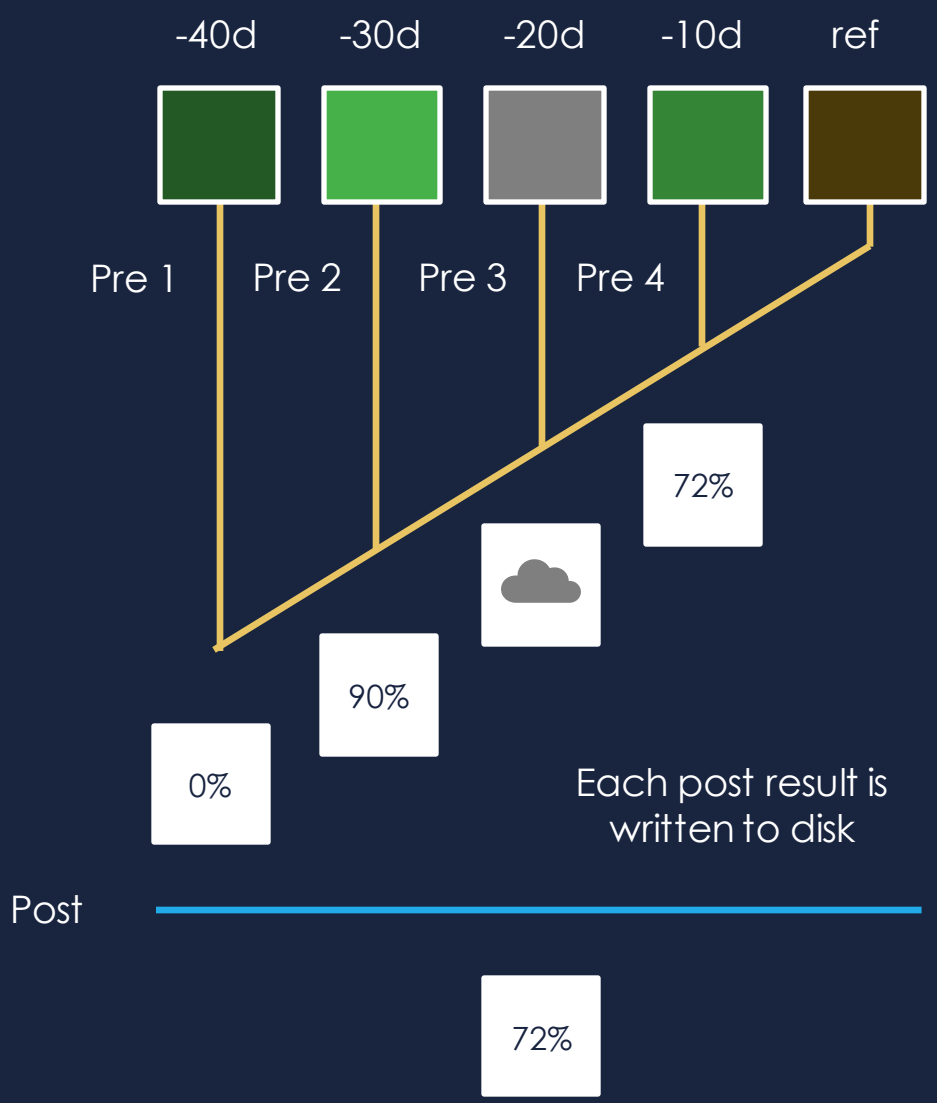

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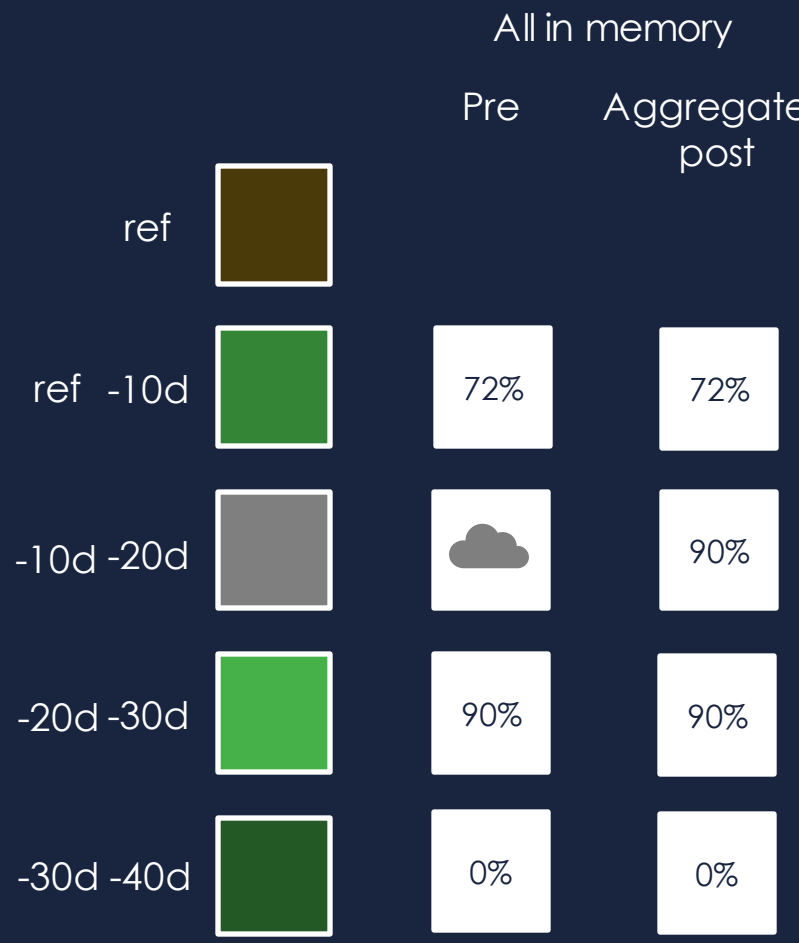
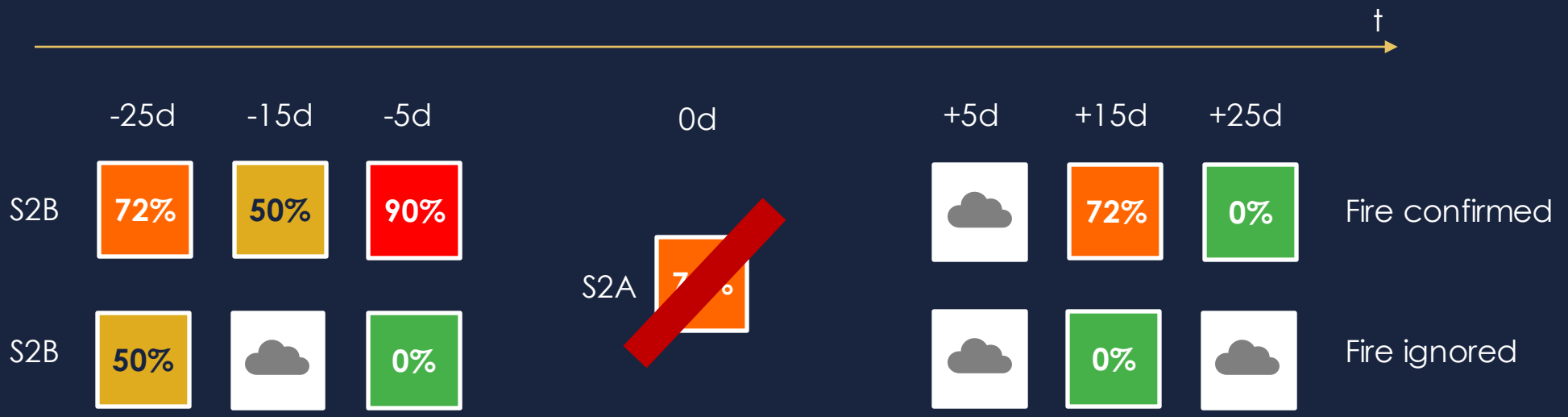


Optimization – Fuse



- Fuse: Confirms fire by comparing with observations from the other platform
- 40 days in future and past (relative to the current) observation are considered

- Do we need to store 80 days of products, for both platforms?

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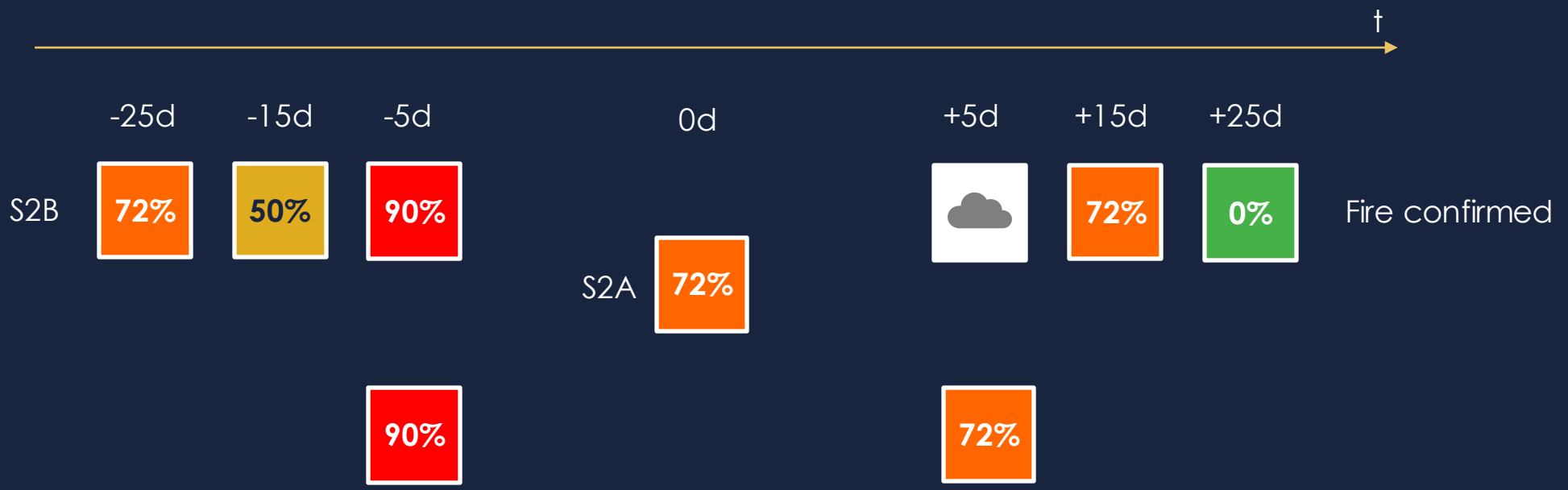

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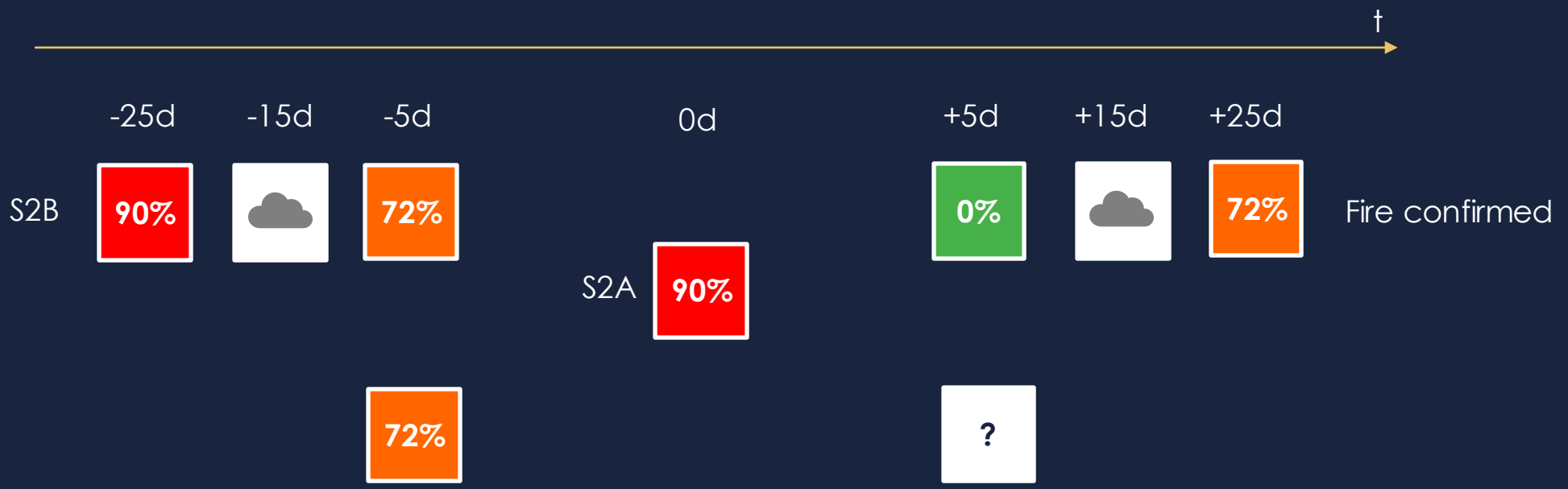

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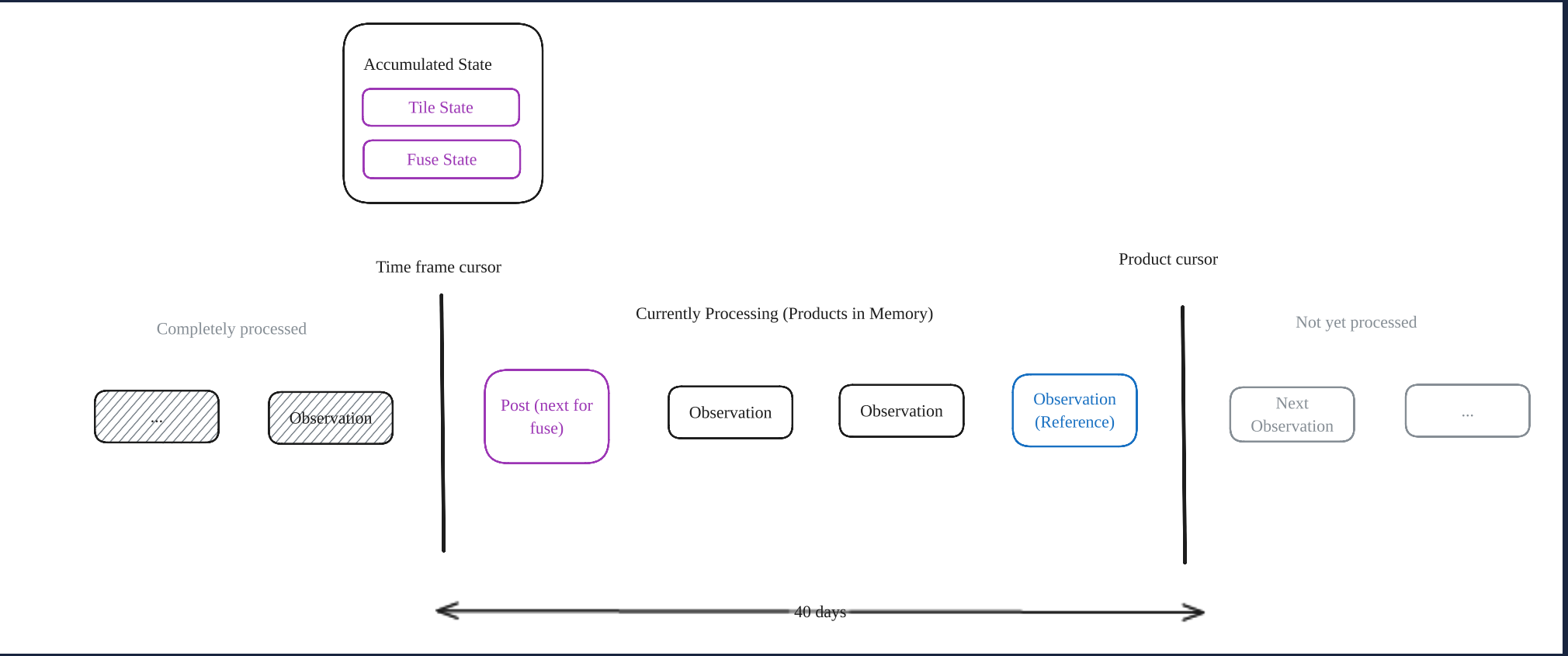
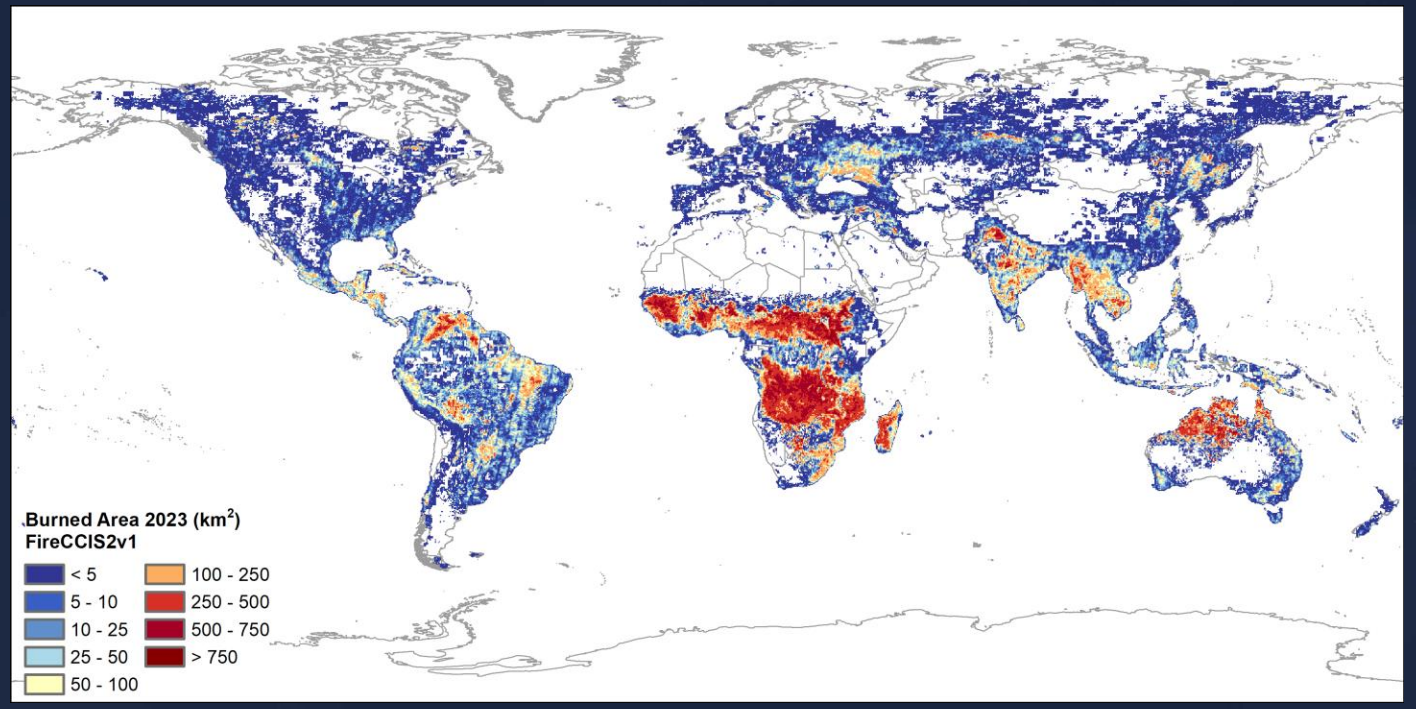


- Time frame cursor: advances when full 40 days of forward times series are available
  - Fuse state represents the backward-looking time series
- Product cursor: advances, when all pre/post/fuse operations are complete
  - Product cursor advance triggers new pre/post computations
- For each open observation, the post result is kept for fuse

We need only 40 days of time series in memory (inputs + post result)

Conclusion

- Production of a global high-resolution product is possible at limited cost
- Cloud platforms with data access like Creodias enable efficient custom data processing solutions
- The optimisation requires significant algorithmic work, beyond purely technical improvements
- “Optimization” is highly dependent on the target platform
- Stay tuned for the release of the product



Yearly aggregation of 2023 burned area (0.05°)
Image credit: M. Lucrecia Pettinari, Amin Khairoun, Emilio Chuvieco (UAH)

Thank you for listening!
Questions?

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