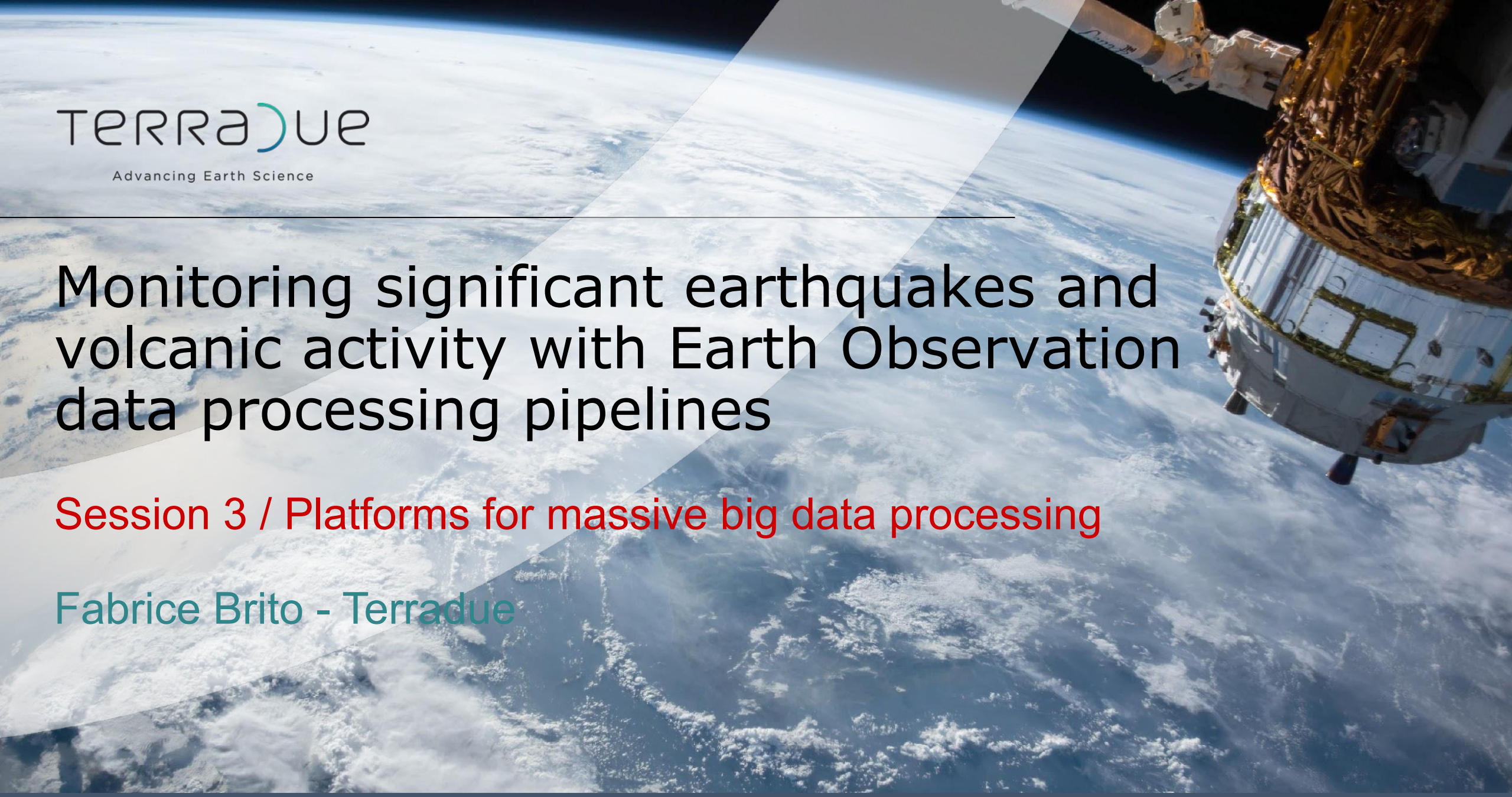

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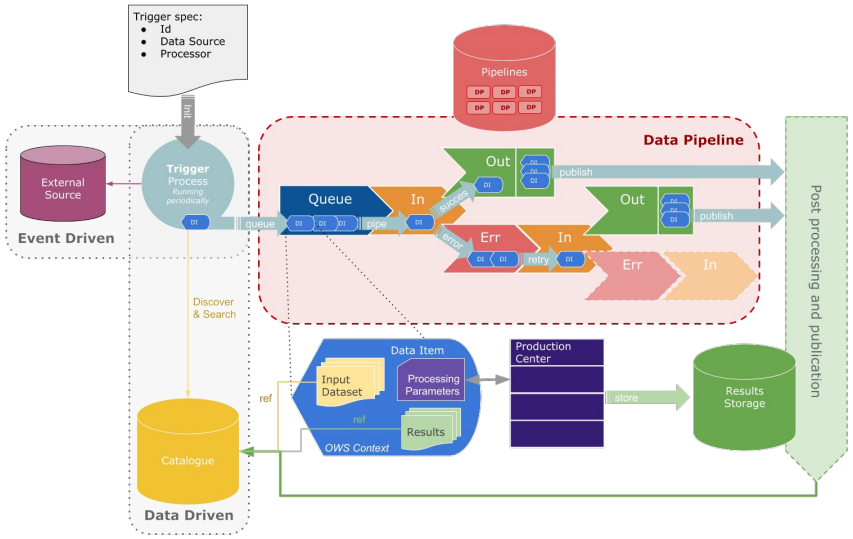
Advancing Earth Science

Monitoring significant earthquakes and volcanic activity with Earth Observation data processing pipelines

Session 3 / Platforms for massive big data processing

Fabrice Brito - Terradue

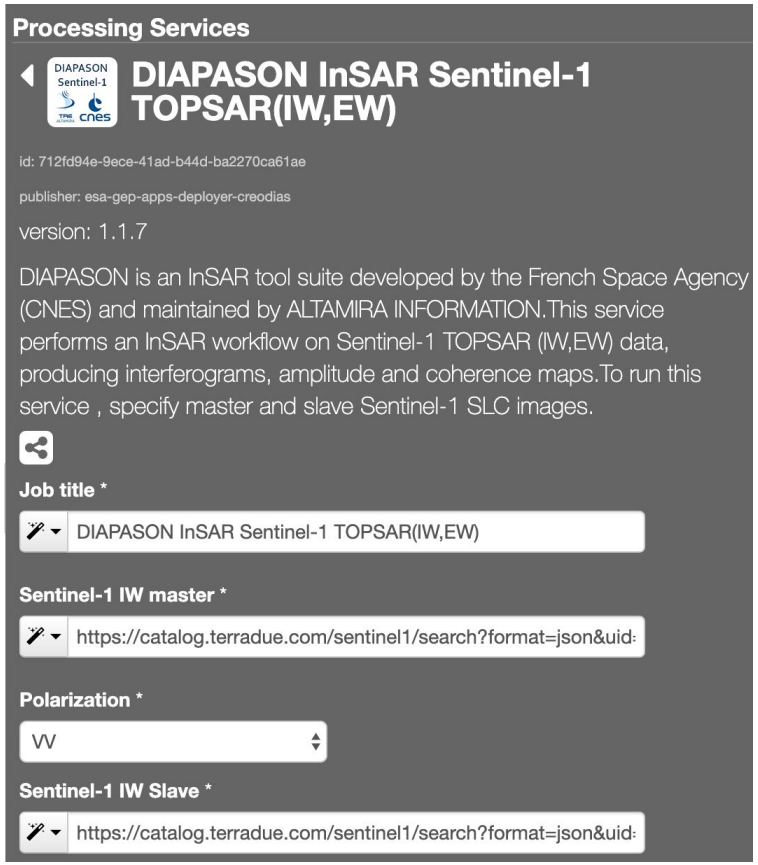
Data processing pipelines



Data processing pipelines rely on the ATC model with:

- **A**pplication - ***data driven*** application
- **T**rigger - ***date*** or ***event driven*** application
- **C**oordinator - ***schedule*** the execution of the Trigger instances periodically at fixed times, dates, or intervals

A(pplication)TC



It starts with a ***data driven*** application taking as inputs one or more references to EO catalogue entries:

- A single input reference
- A pair of input references (e.g. interferometry)
- A stack of input references

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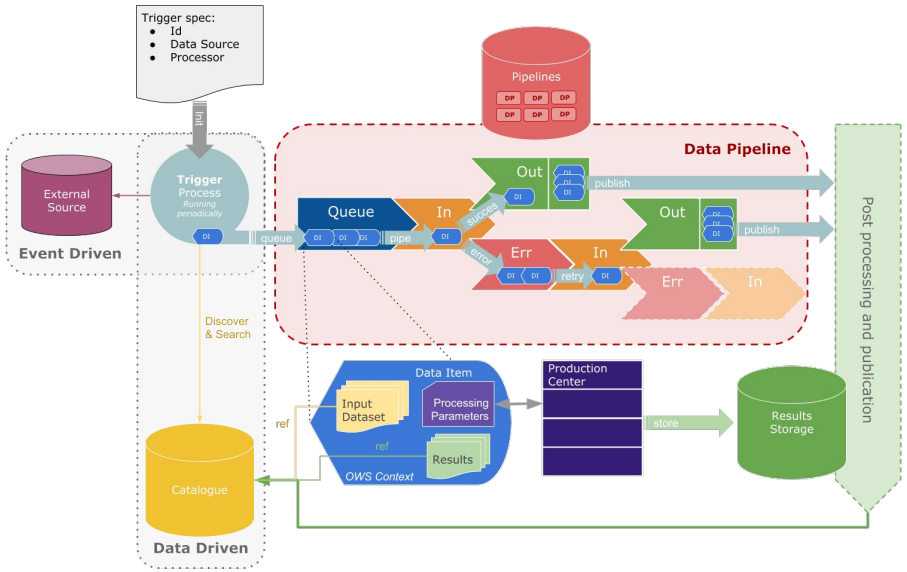
AT(rigger)C

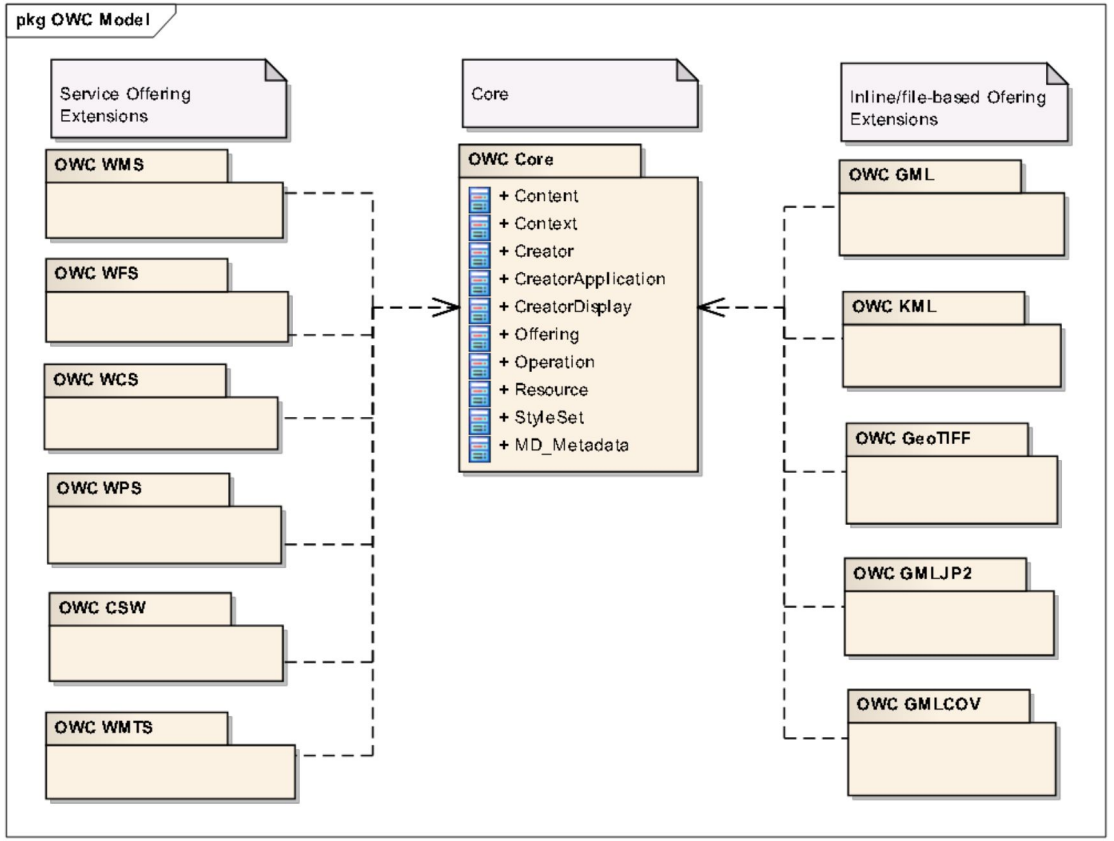


The Trigger is a ***date*** and/or ***event driven*** application that, when there's new data available or an event:

- Creates ***Data Items***
- Queues ***Data Items***
- Pipes ***Data Items***

AT(rigger)C - Data items

OWS Context (*) documents encapsulating all the information for processing the application



(*) https://www.opengeospatial.org/standards/owc

AT(rigger)C - Data items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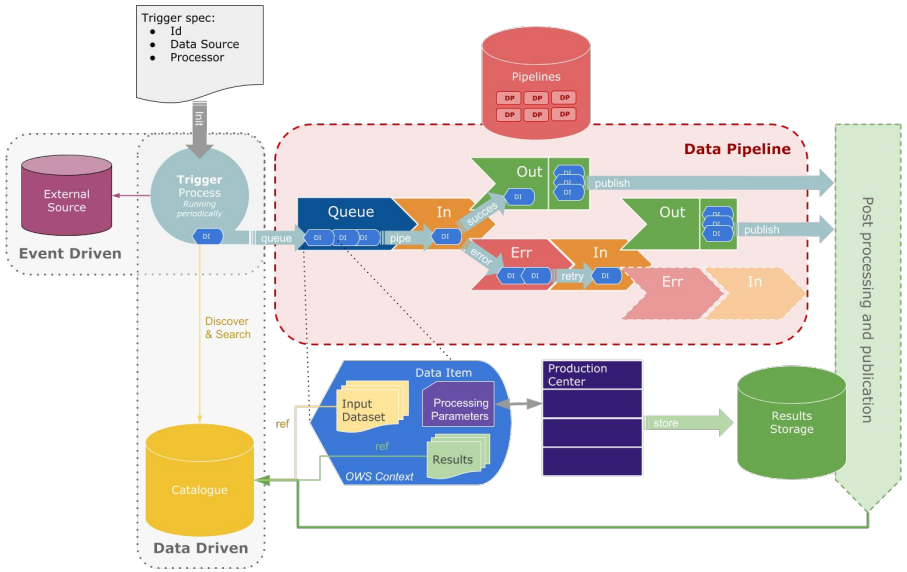
ATC(oordinator)



The Coordinator submits Trigger instances **periodically** at fixed times, dates, or intervals

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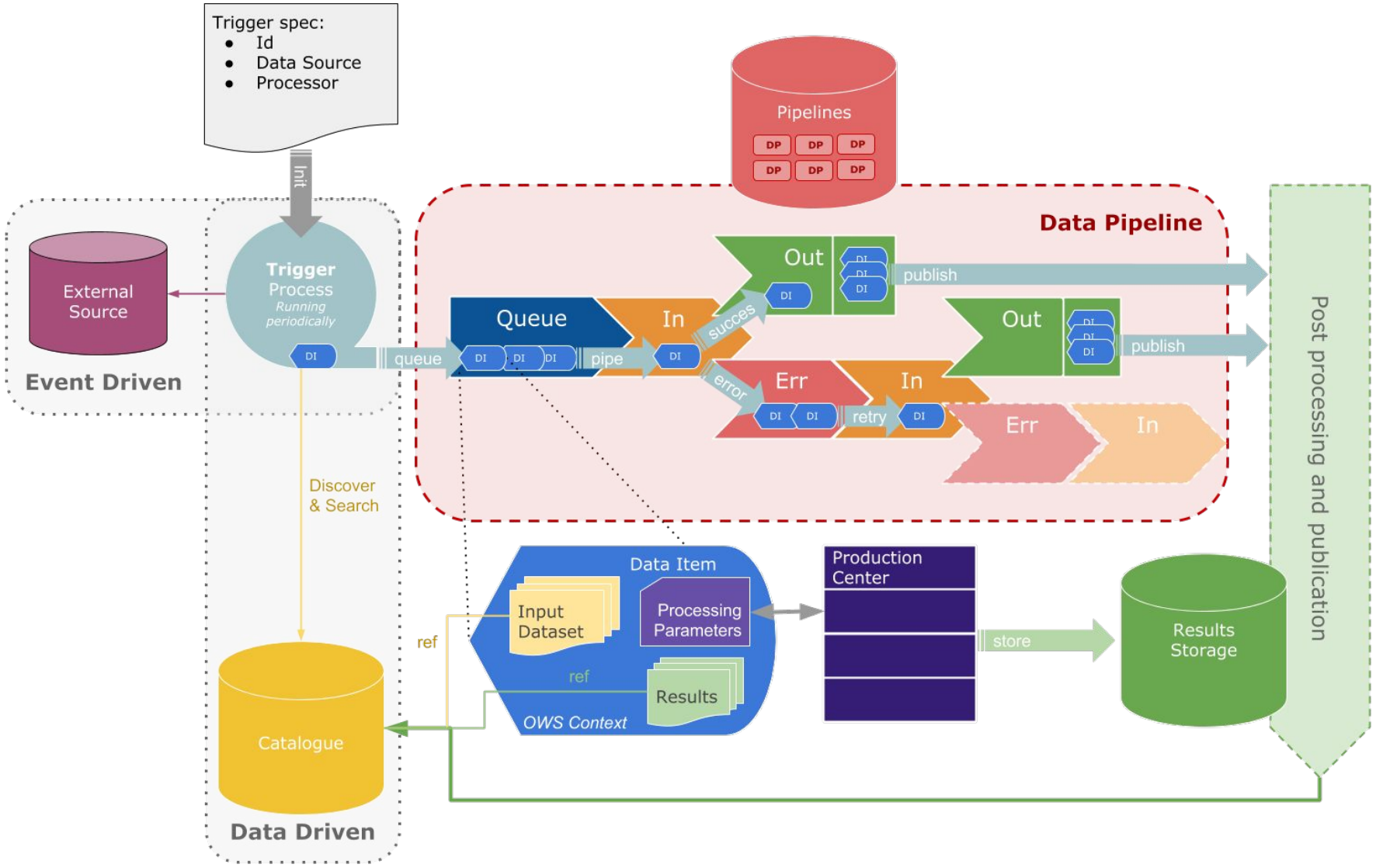
Data processing pipelines



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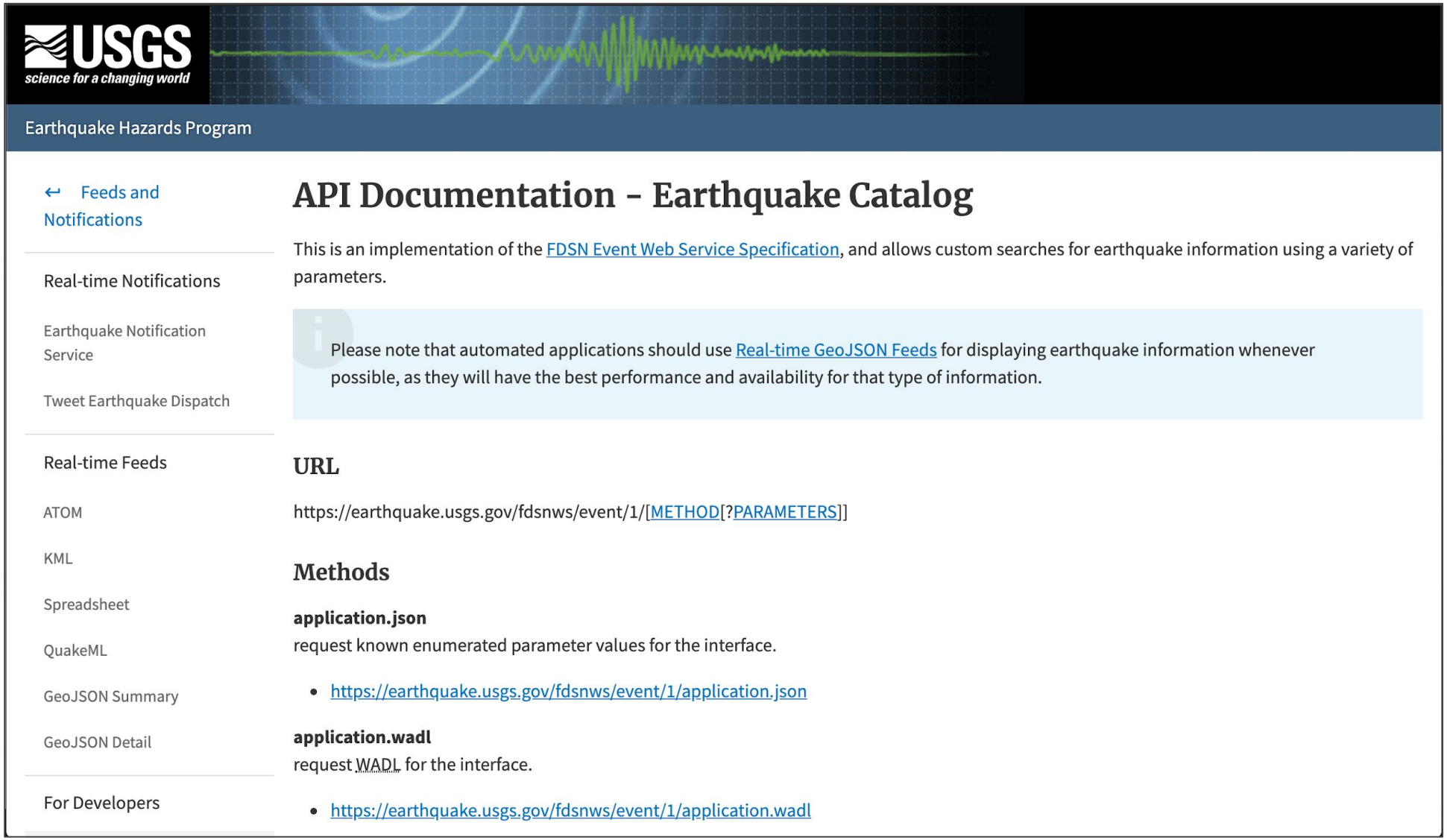
Earthquake source



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Volcanic activity source

Smithsonian Institution
National Museum of Natural History
Global Volcanism Program

Home | Reports | Database | Learn | Questions | Info & Contacts

Current Eruptions

Although detailed statistics are not kept on daily activity, **generally there are around 20 volcanoes actively erupting at any particular time**. The Smithsonian / USGS Weekly Volcanic Activity Report (WVAR) for the week ending on 8 October 2019 includes the 19 volcanoes bolded and shown below in the WVAR column (rollover for report).

Overall there are 46 volcanoes with ongoing eruptions as of the Stop Dates indicated, and as reported through the last data update (13 September 2019), sorted with the most recently started eruption at the top. Information about more recently started eruptions can be found in the Weekly Report linked above.

An eruption marked as "continuing" does not always mean that the activity is continuous or happening today, but that there have been at least some intermittent eruptive events at that volcano without a break of at least 3 months since it started. An eruption listed here also might have ended since the last public data update, or at the update time a firm end date had not yet been determined due to potential renewed activity.

Volcano	Country	Eruption Start Date	Eruption Stop Date	Max VEI	WVAR
Tangkubanparahu	Indonesia	2019 Jul 26	2019 Sep 13 (continuing)	–	Yes

Earthquakes S1 Interferometry

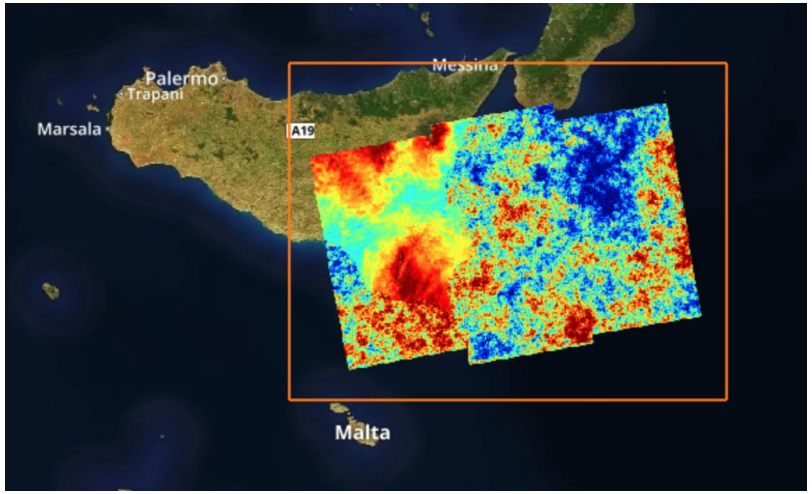
- Production triggered for events with a magnitude (Mw) of the EQ > 5 and depth < 30km
- For DIAPASON and DLR's InSAR Browse, produce:
  - **Pre-seismic** interferograms of AT LEAST two ascending passes
  - **Pre-seismic** interferograms of AT LEAST two descending passes
  - **Co-seismic** interferograms of AT LEAST two ascending passes
  - **Co-seismic** interferograms of AT LEAST two descending passes
  - **Post-seismic** interferograms of AT LEAST two ascending passes for AT LEAST two cycles after the event (post-ascending)
  - **Post-seismic** interferograms of AT LEAST two descending passes for AT LEAST two cycles after the event (post-descending)

Earthquakes S2 offset tracking

Use CNRS-EOST MPIC-OPT to produce a diachronic offset tracking Sentinel-2 product

- For events with magnitude (Mw) of the EQ is > 5 AND Focal Mechanism is Strike-Slip OR Moment Tensor abs(rake) = 0 or 180 +/-20 (if FM not available)
- Triggered production is:
  - **1a** + **2a** (as soon as the fist image post-event is available)
  - **2a** + **2b** (as soon as the second image post-event is available)
- Scenario 1a: 1 pre / 1 post image, the closest to the date of the EQ
- Scenario 1b: 2 pre / 2 post images, the closest to the date of the EQ
- Scenario 2a: 1 pre / 1 post image, the pre being in the same season (same month of previous year) than the post
- Scenario 2b: 2 pre / 2 post, the pre being in the same season (same month of previous year) than the post

Volcanoes S1 Interferometry



- For DIAPASON and DLR's InSAR Browse, produce:
  - For ***NEW*** volcano activity in a given WVAR report:
    - All ascending and descending passes for the last 3 weeks
  - For ***ON-GOING*** volcano activity in a given WVAR report:
    - All ascending and descending passes for the current week

Earthquake timeline - S1

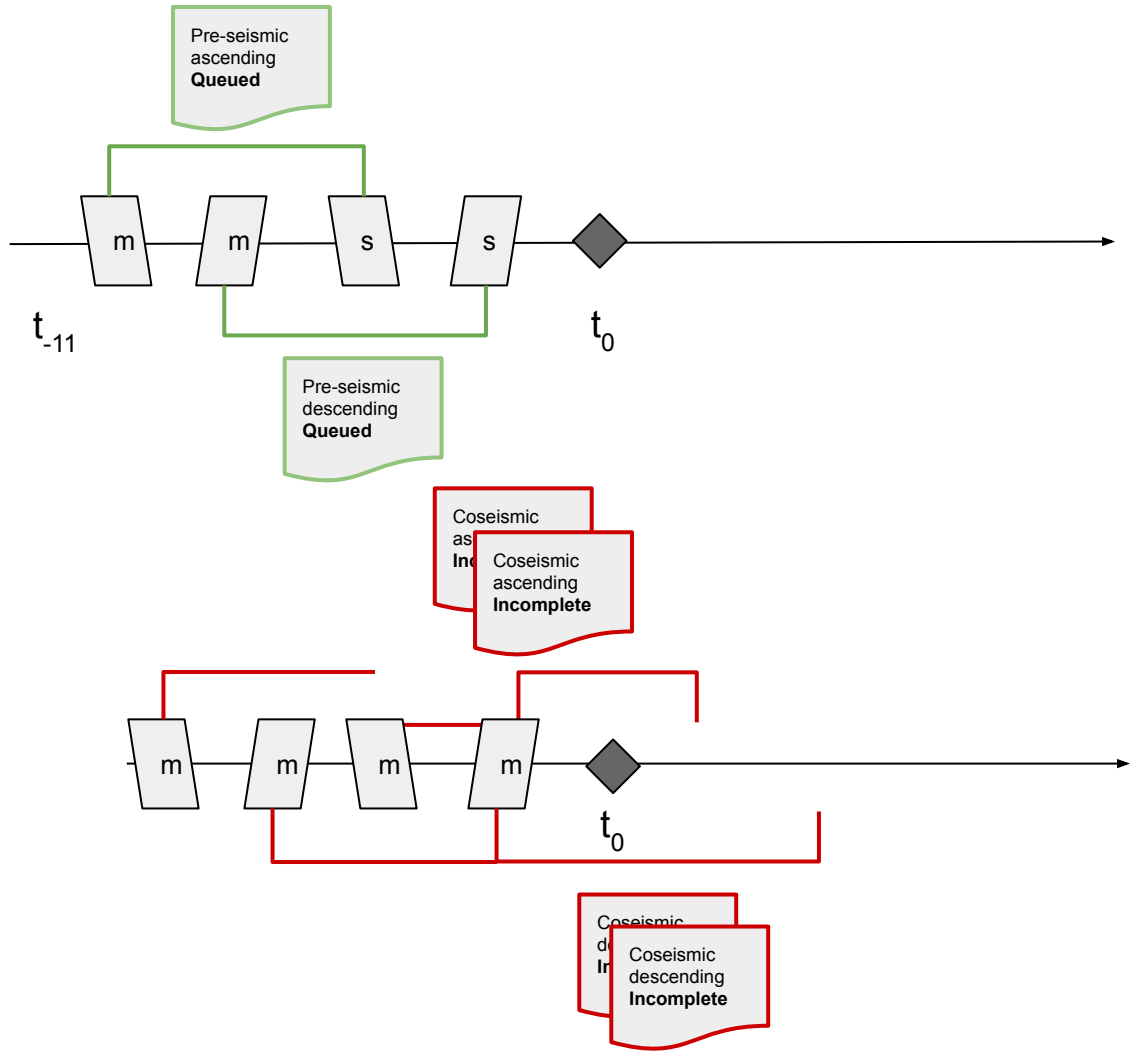
t_0 event day

A new event is recorded.

Identify the ascending and descending orbits that cover the area of interest defined as the bounding box of a buffer around the epicentre in the range $[t_{-11}, t_0]$.

Any pair identified in this interval yields a data item immediately queued as pre-seismic data items.

These products will yield incomplete data items. Masters closer to t_{-11} will yield coseismic ifg very soon after the event.



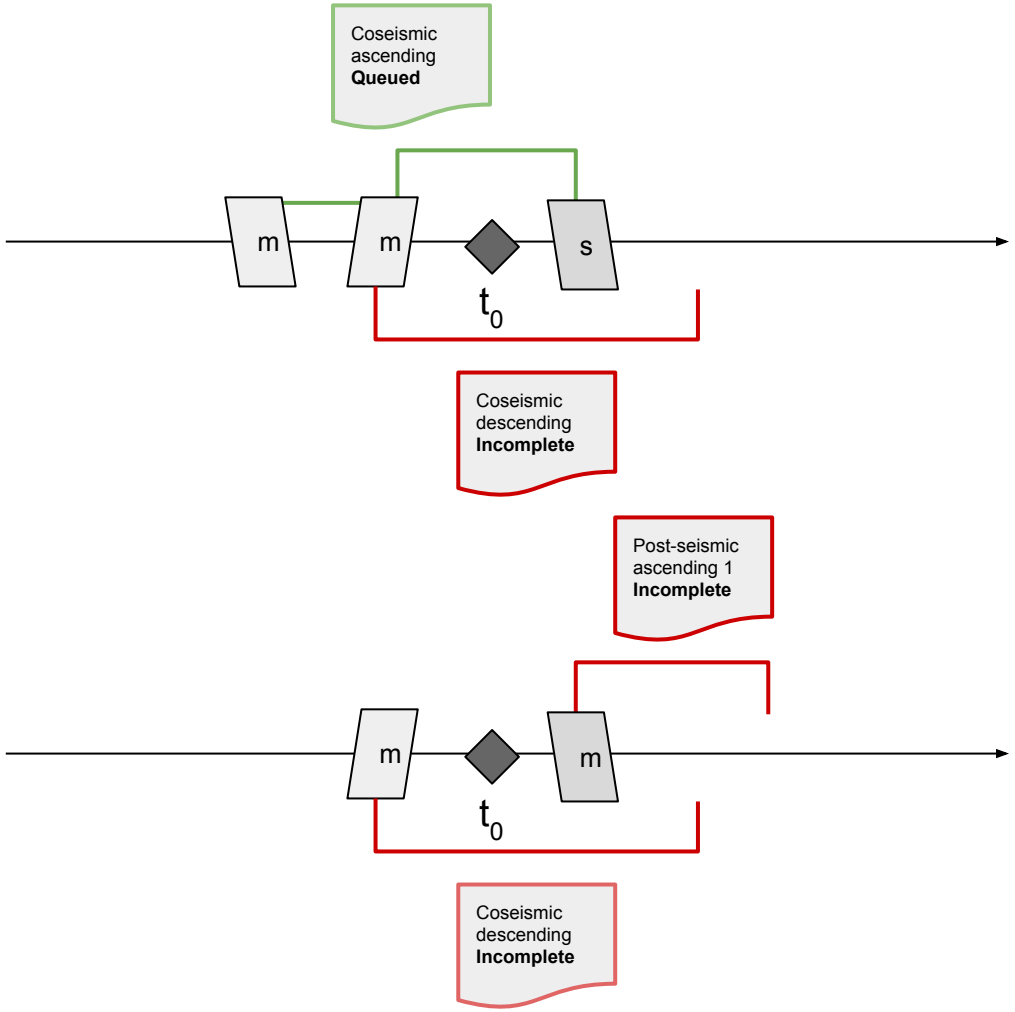
Earthquake timeline - S1

t_0 + few days

As time passes, new satellite scenes acquired are the slave needed to complete the coseismic data items marked *incomplete*.

If a shake map is made available via the USGS, the AOI may be refined to better cover the area of the deformation using a range of peak ground velocity

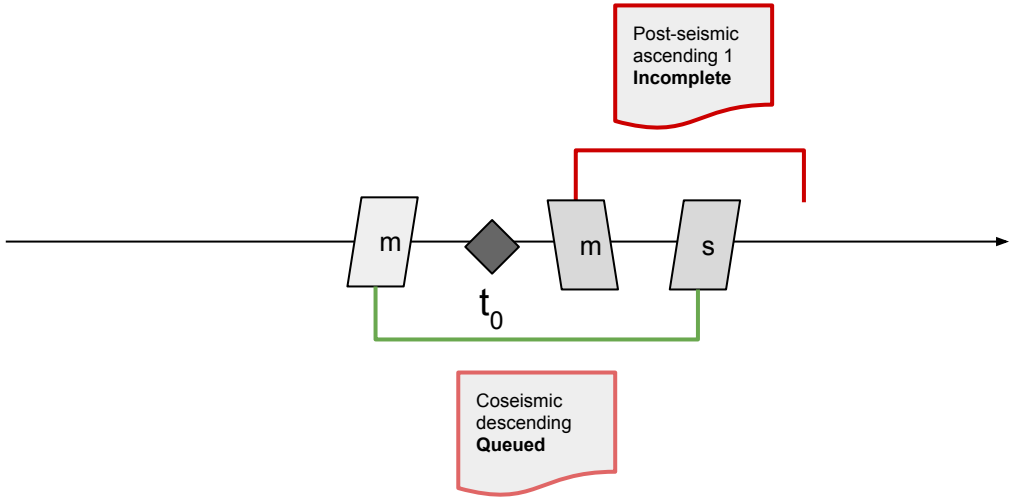
In turn, these slaves become the masters of the first post-seismic incomplete data items.



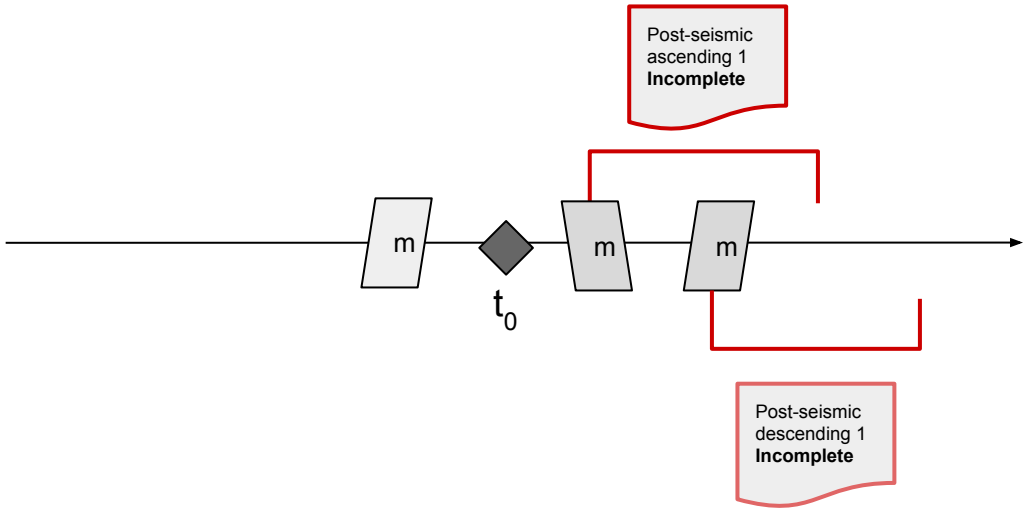
Earthquake timeline - S1

t_0 + few more days

As time passes, new satellite scenes acquired are the slave needed to complete the post-seismic data items marked *incomplete*.

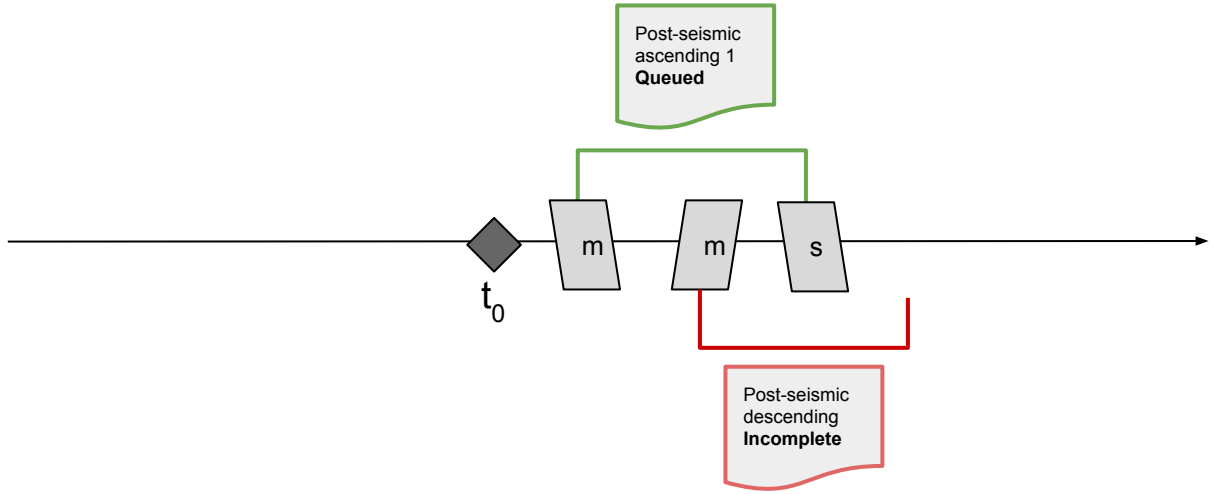


In turn, these slaves become the masters of the next post-seismic incomplete data items.

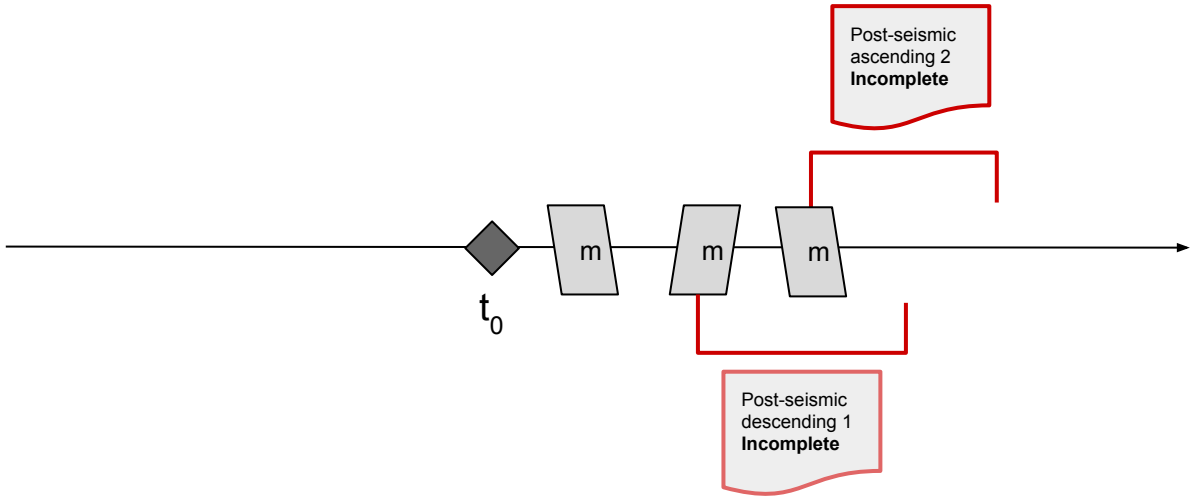


Earthquake timeline - S1

t_0 event + more more days



This process stops as soon as the event is rekon well covered, i.e. at least two cycles of data have been used to generate interferograms.



Earthquake timeline - S2

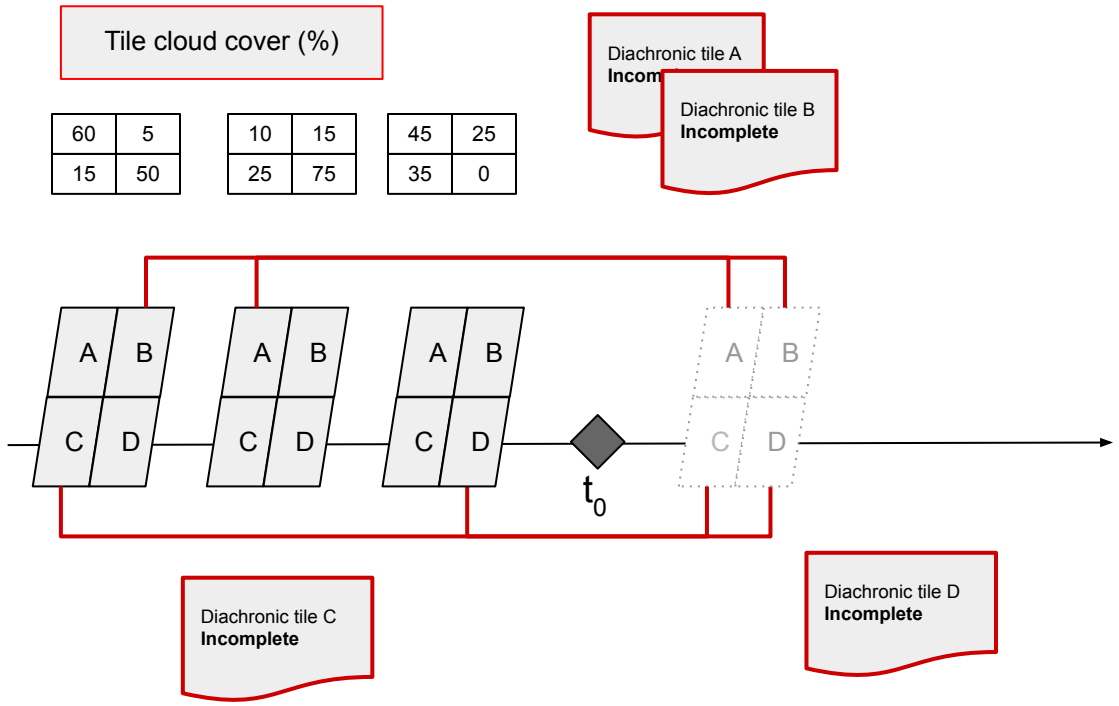
t_0 event day

A new event is recorded.

Identify the Sentinel-2 tiles covering the AOI defined as the bounding box of a buffer around the epicentre.

For each tile identified, search for a pre-seismic acquisition with the lowest cloud coverage.

Add the diachronic offset tracking incomplete data item



These products will yield incomplete data items. Masters closer to t_{-9} will yield coseismic offset tracking product very soon after the event.

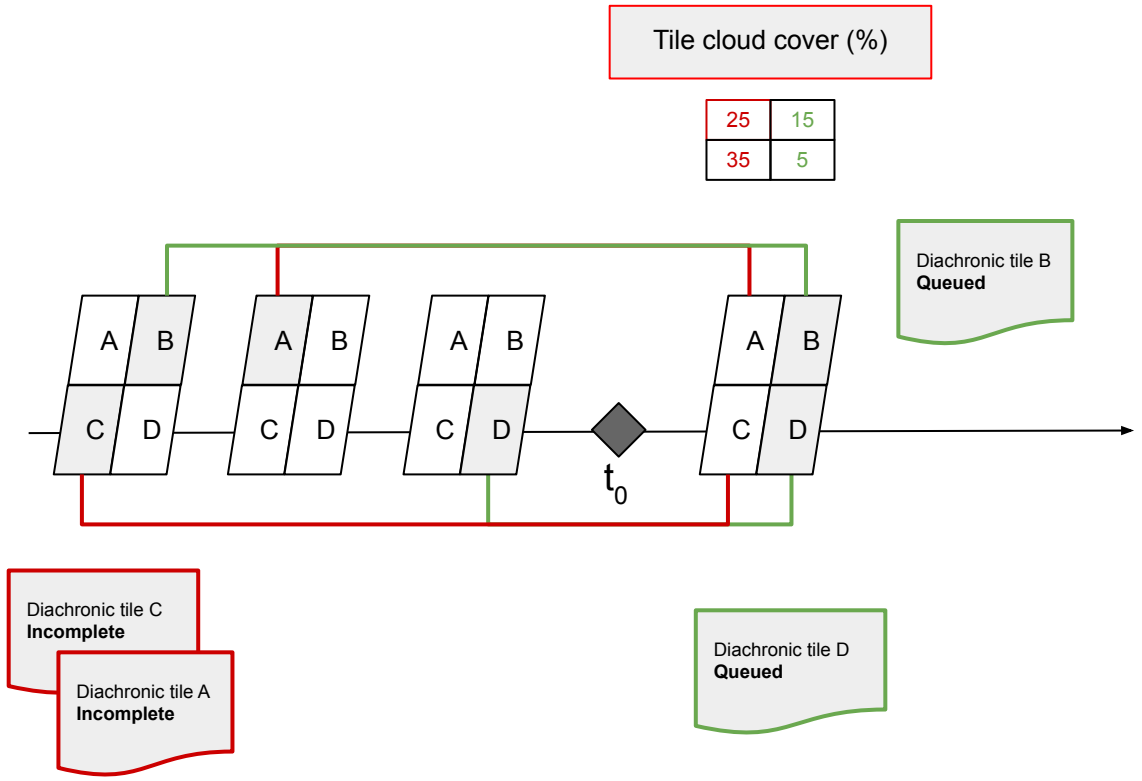
Earthquake timeline - S2

t_0 + a few days

New Sentinel-2 acquisitions

For each tile, check if cloud cover is below threshold (e.g. 20%), if so, complete the Diachronic tile data item and queue it

Repeat until all the Diachronic tile incomplete data items are completed

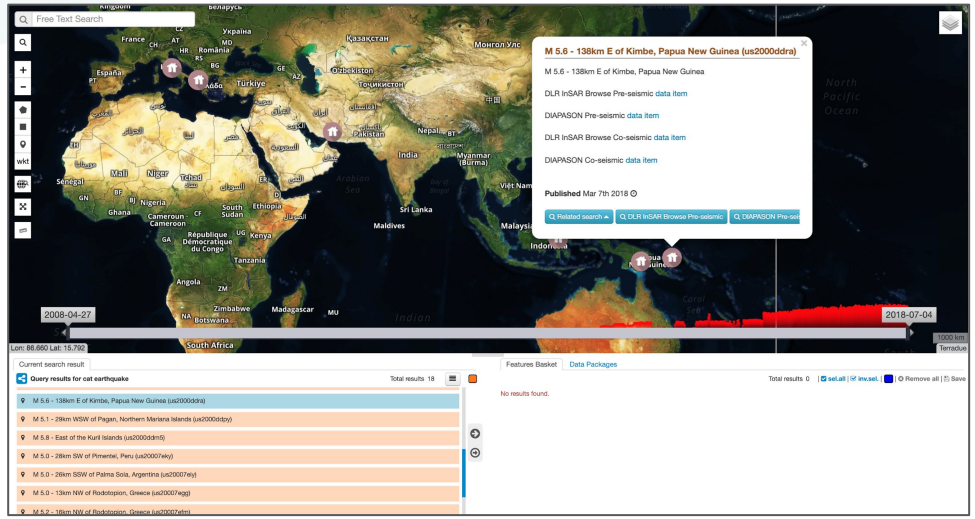


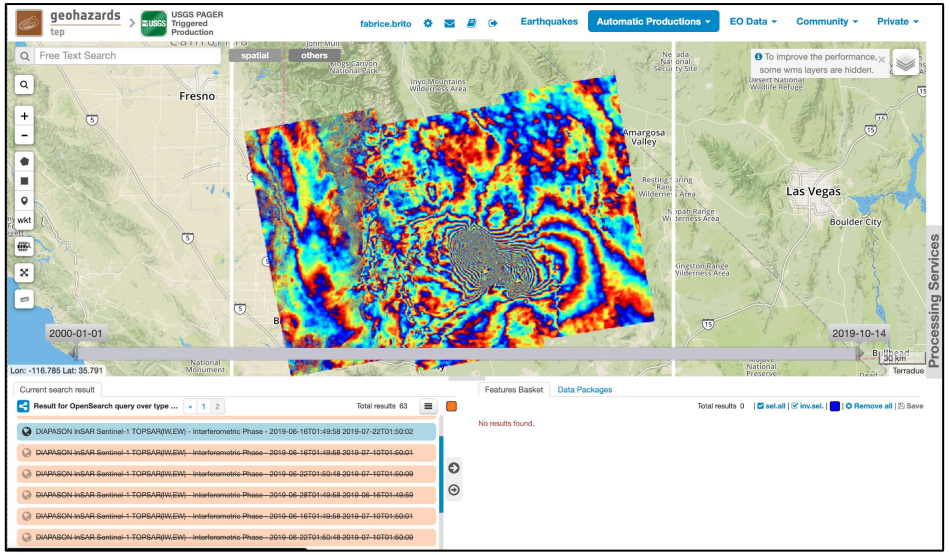
Volcano activity

Volcano	Country	Eruption Start Date	Eruption Stop Date	Max VEI	WVAR
Tangkubanparahu	Indonesia	2019 Jul 26	2019 Sep 13 (continuing)	–	
Shishaldin	United States	2019 Jul 23	2019 Sep 10 (continuing)	–	
Ubinas	Peru	2019 Jun 24	2019 Sep 9 (continuing)	–	
Asosan	**Japan**	**2019 Apr 16**	**2019 Sep 13 (continuing)**	**–**	**Yes**
Sangay	Ecuador	2019 Mar 26	2019 Sep 13 (continuing)	–	
Karymsky	Russia	2019 Feb 16	2019 Sep 13 (continuing)	–	
Poas	Costa Rica	2019 Feb 7	2019 Sep 13 (continuing)	–	
Tinakula	Solomon Islands	2018 Dec 8 (in or before)	2019 Sep 10 (continuing)	2	
Karangetang	**Indonesia**	**2018 Nov 25**	**2019 Sep 13 (continuing)**	**2**	**Yes**
Barren Island	India	2018 Sep 25	2019 Sep 9 (continuing)	1	
Krakatau	**Indonesia**	**2018 Jun 18**	**2019 Sep 13 (continuing)**	**3**	**Yes**
Merapi	**Indonesia**	**2018 May 11**	**2019 Sep 13 (continuing)**	**3**	**Yes**
Kerinci	Indonesia	2018 Apr 21	2019 Sep 2 (continuing)	1	
Nyamuragira	DR Congo	2018 Apr 18	2019 Sep 13 (continuing)	0	
Mayon	Philippines	2018 Jan 13	2019 Sep 7 (continuing)	2	
Kadovar	Papua New Guinea	2018 Jan 5	2019 Sep 13 (continuing)	2	
Sangeang Api	Indonesia	2017 Jul 15	2019 Sep 13 (continuing)	2	
Ol Doinyo Lengai	Tanzania	2017 Apr 9	2019 Sep 13 (continuing)	0	
Aira	**Japan**	**2017 Mar 25**	**2019 Sep 13 (continuing)**	**1**	**Yes**

- For each ***NEW*** volcano activity in a given WVAR report:
  - A coordinator is instantiated to trigger all ascending and descending passes for the 3 previous weeks
- For ***ON-GOING*** volcano activity in a given WVAR report:
  - A coordinator is instantiated to trigger all ascending and descending passes for that week

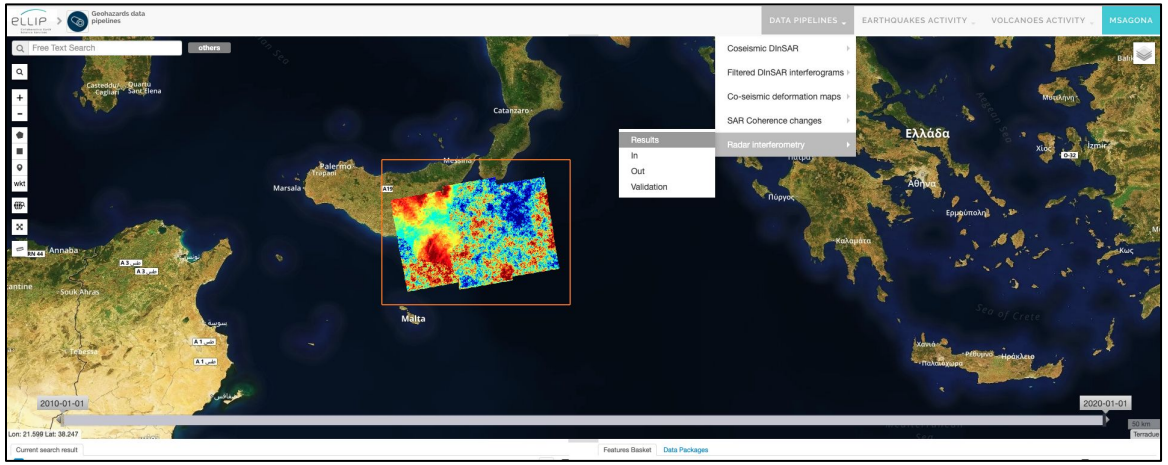
Where we are - USGS EQ





- Service in operations since mid-June 2019
- Produces pre-seismic and co-seismic interferograms with Sentinel-1 (ascending and descending passes) with two InSAR services
- Produces diachronic offset tracking Sentinel-2 products with pre- and post-event acquisitions (ascending and descending passes) in a period of 120 days around the event
- Thematic app on GEP available to Early Adopters: https://geohazards-tep.eu/geobrowser/?id=usgs-pager-trigprod-app

Where we are - WVAR



- A validation WVAR report chosen for validating the data processing pipeline
- Feedback from Dr. Andrea Manconi from ETH-Z expected in the coming weeks
- After acceptance, trigger the data pipeline from February 2019 onwards

Way forward

- Data processing pipelines
  - Potentially extend the earthquake data processing pipelines to process PSI with StAMPS
  - Extend the volcanic activity data processing pipelines to process the hot spot detection

Thank you!

- Fabrice Brito

  fabrice.brito@terradue.com