MAPPING THE SURFACE DEFORMATION AT NATIONAL SCALE THROUGH THE AWS CLOUD IMPLEMENTATION OF THE S1 P-SBAS PROCESSING CHAIN

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BiDS' 2019, Munich, Germany

IREA-CNR, Napoli, Italy

Consiglio Nazionale delle Ricerche

Outline

- ✓ the Small Baseline Subset (SBAS) DInSAR technique
- ✓ objective: full exploitation of the available big SAR data archives

  Parallel SBAS (P-SBAS) processing chain

  Cloud Computing P-SBAS solution within Amazon Web Services
- ✓ mapping the ground displacement at large scale

  the South California case study (ENVISAT data)
- ✓ Sentinel-1: the new SAR data paradigm

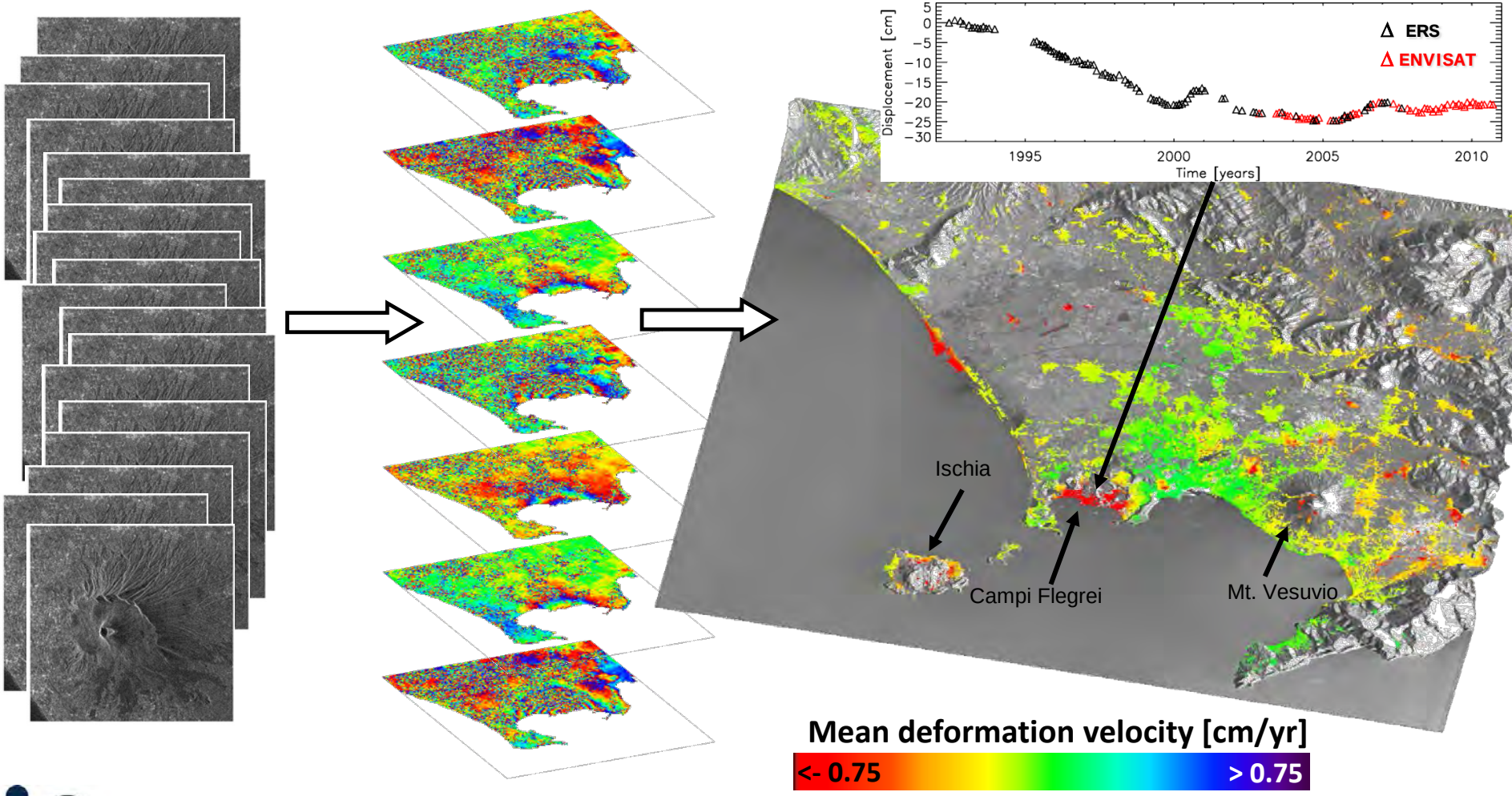
  the National Scale DInSAR analysis over Italy
- ✓ future perspective

Advanced DInSAR technique: Small BAseline Subset (SBAS)

SAR Images

SB Interferograms

ERS/ENVISAT images (1992 – 2010)



Berardino et al., 2002, IEEE Trans. Geosci. Remote Sens.; Pepe et al., 2005, IEEE Trans. Geosci. Remote Sens.

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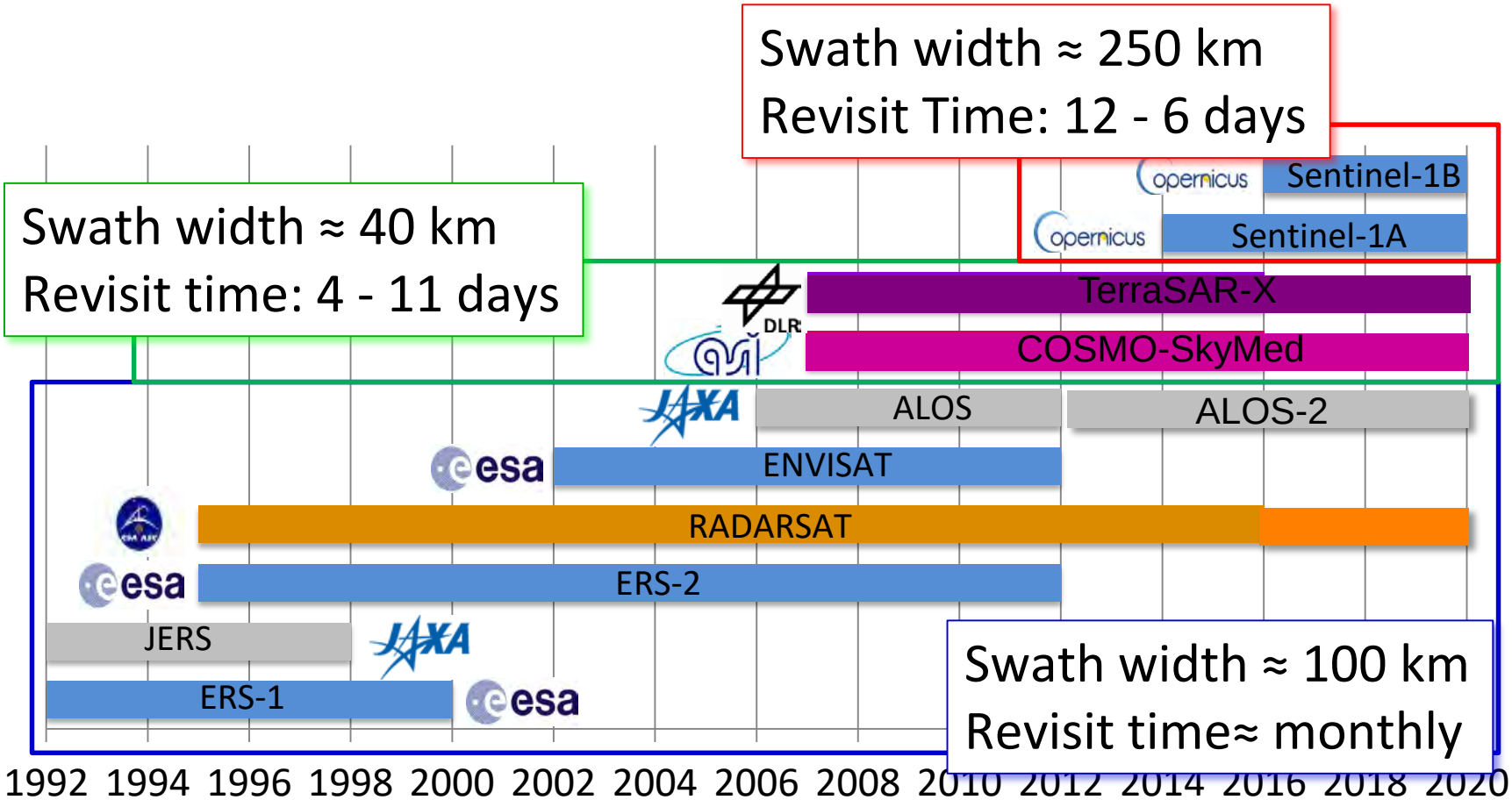
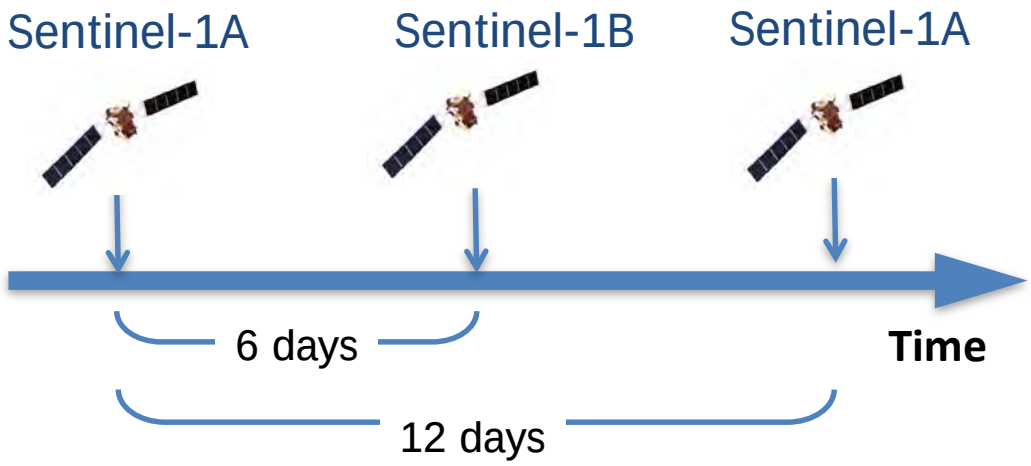
SAR data scenario: satellites

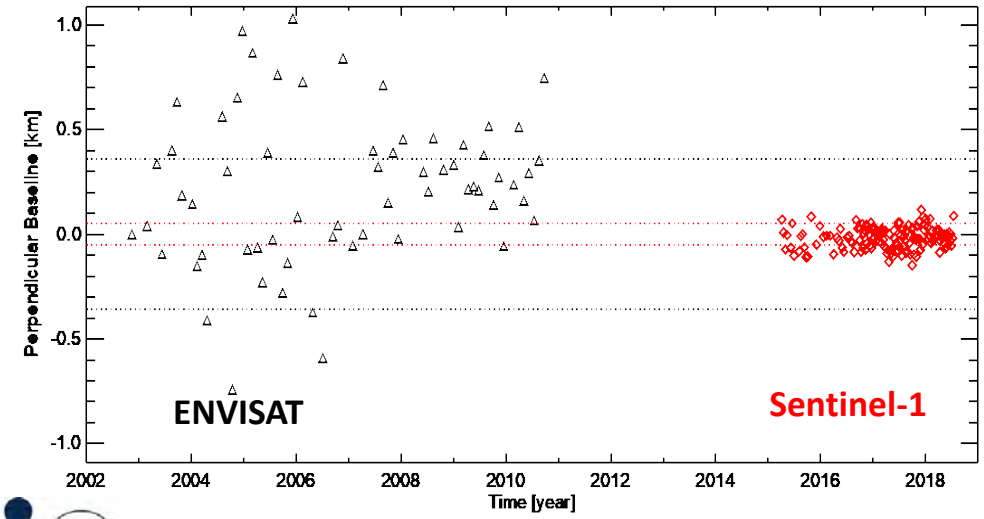


Sentinel-1 Constellation

- Revisit time: **12/6 days**
- Spatial resolution: **15 x 4 m**
- Spatial coverage: ~ **250 x 250 km**
- **Small Baseline System**
- **C-band**
- **Global coverage**
- **FREE AND OPEN DATA ACCESS**



Perpendicular baseline distribution



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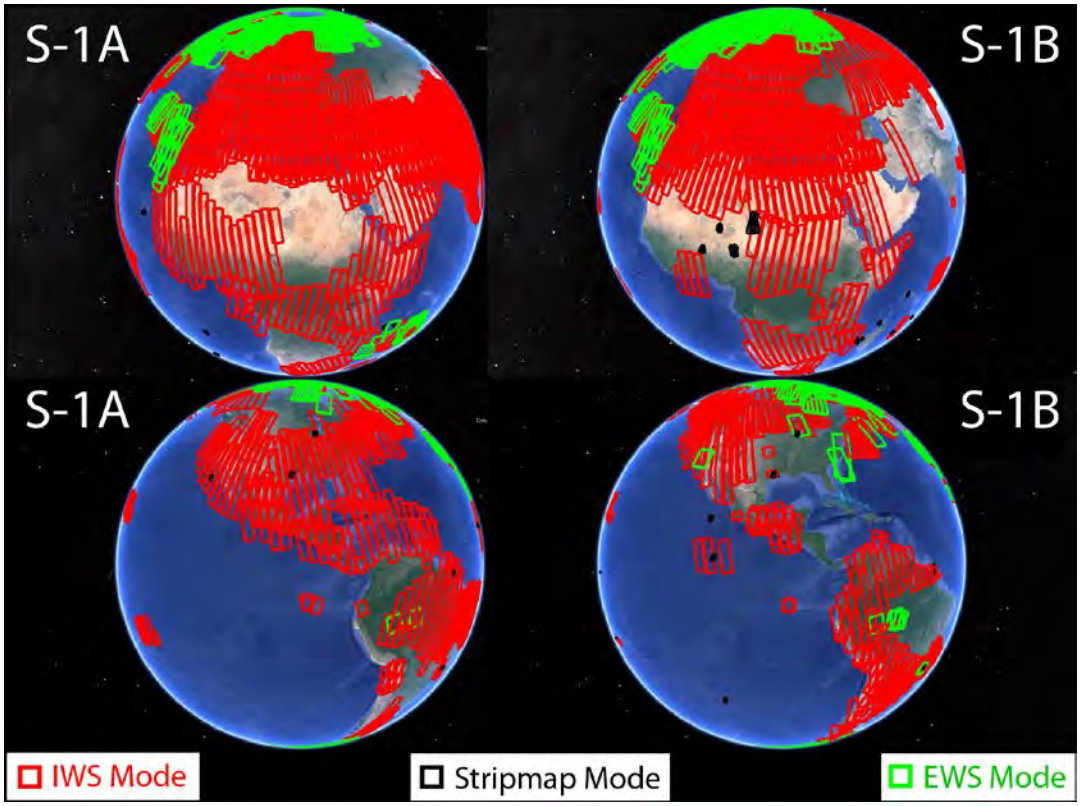
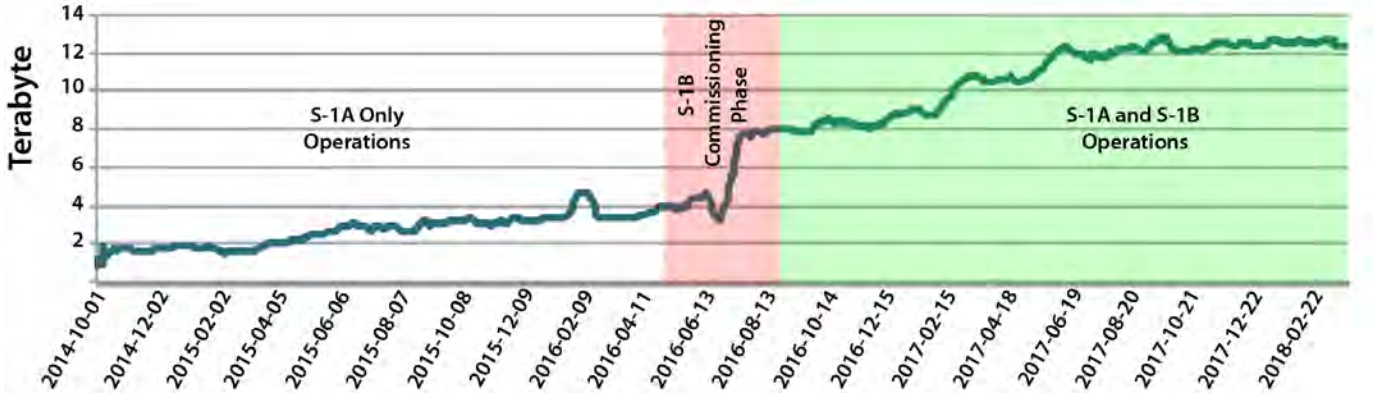
Sentinel-1A and Sentinel-1B spatial coverage

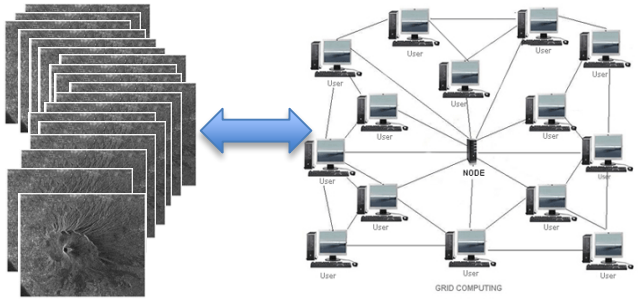




Fully exploiting SAR data archives

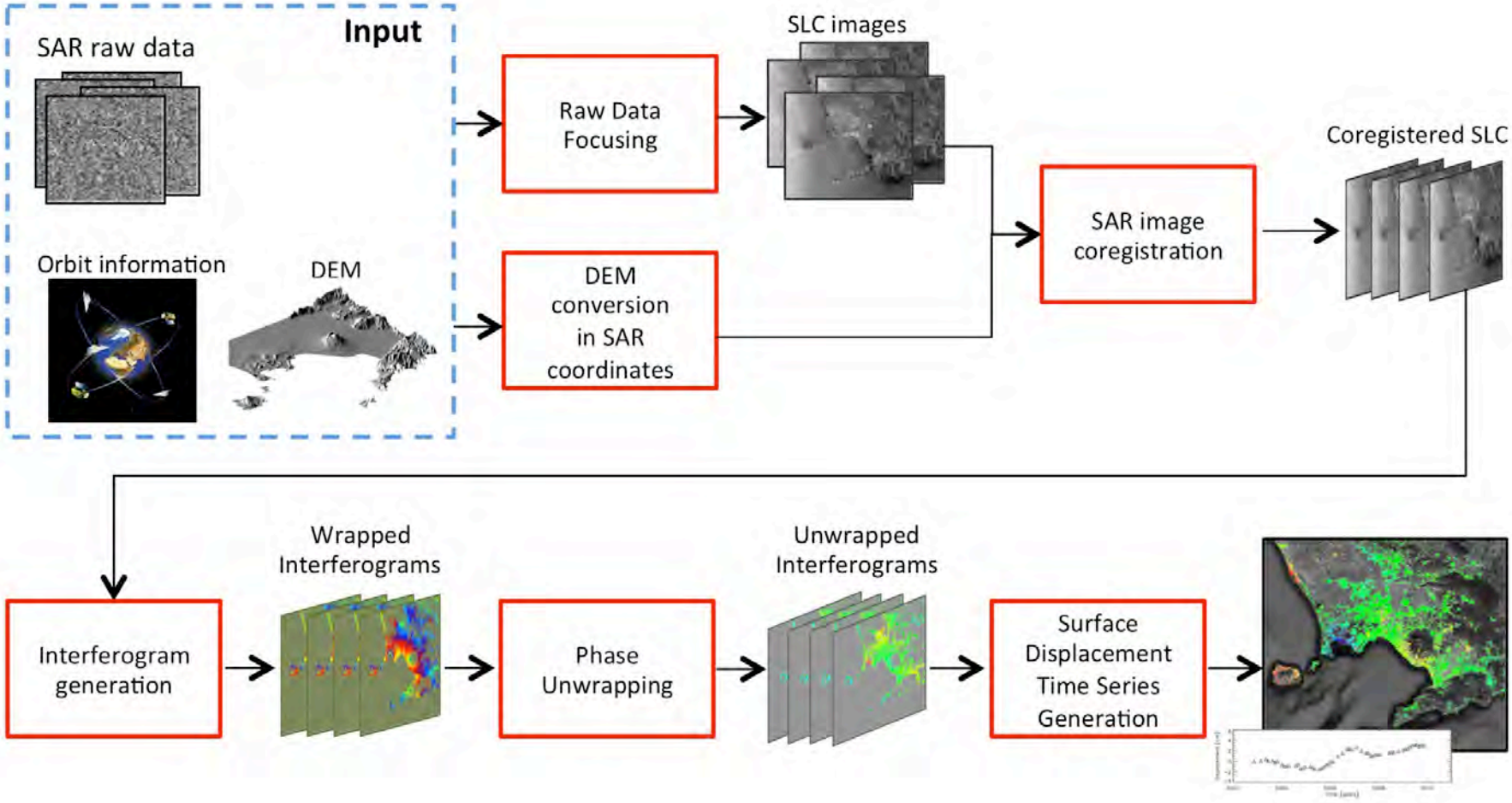
- ✓ Efficient Processing Tools:
  parallel algorithms for distributed HPC platforms to cut down the processing times

- ✓ Computing Resources:
  large (distributed computing infrastructures) and in proximity to data!



- ✓ Operational Services:
  widening the fruition of SAR data and the dissemination of value added products

Parallel SBAS (P-SBAS) processing chain worflow



DUAL LEVEL PARALLELISM FOR MULTI-NODE AND MULTI-CORE ARCHITECTURES

Casu et al., 2014, IEEE JSTARS
Zinno et al., 2015, IEEE JSTARS
Zinno et al., 2015, IEEE Transaction Cloud Computing

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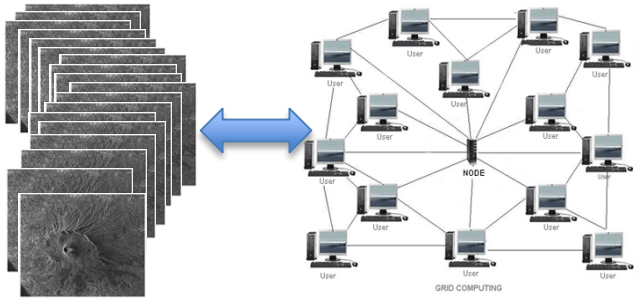

- ✓ Operational Services:
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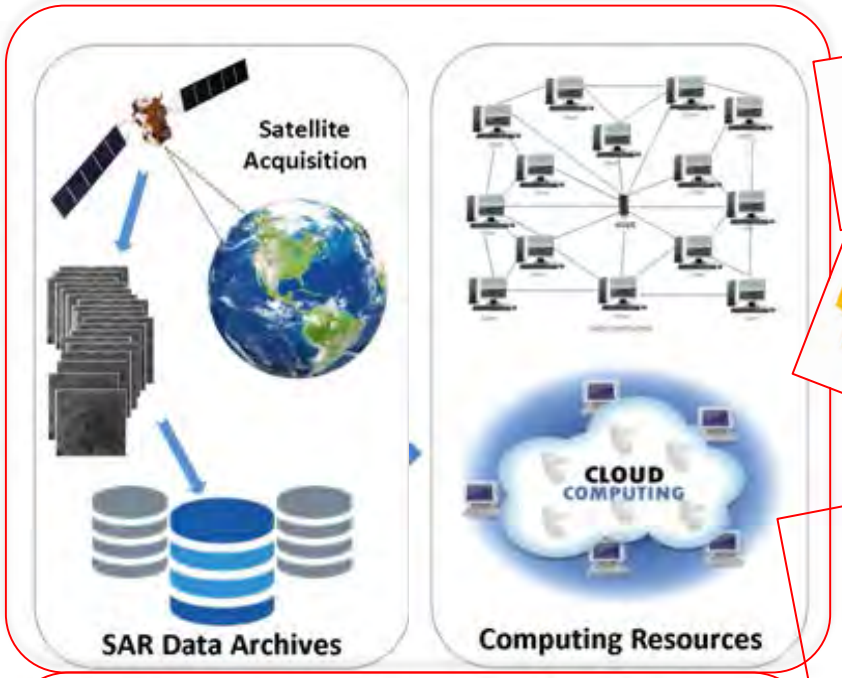
Huge SAR data: a full exploitation scenario

Cloud Computing Environments

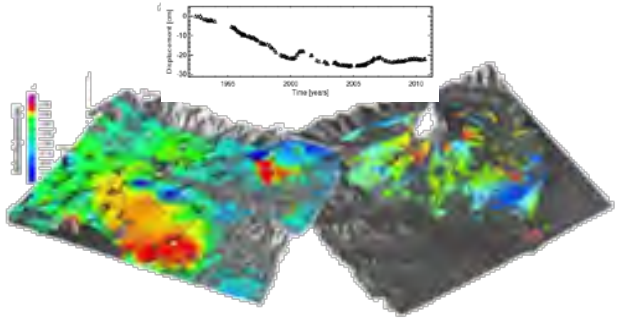


Google Cloud

amazon web services™

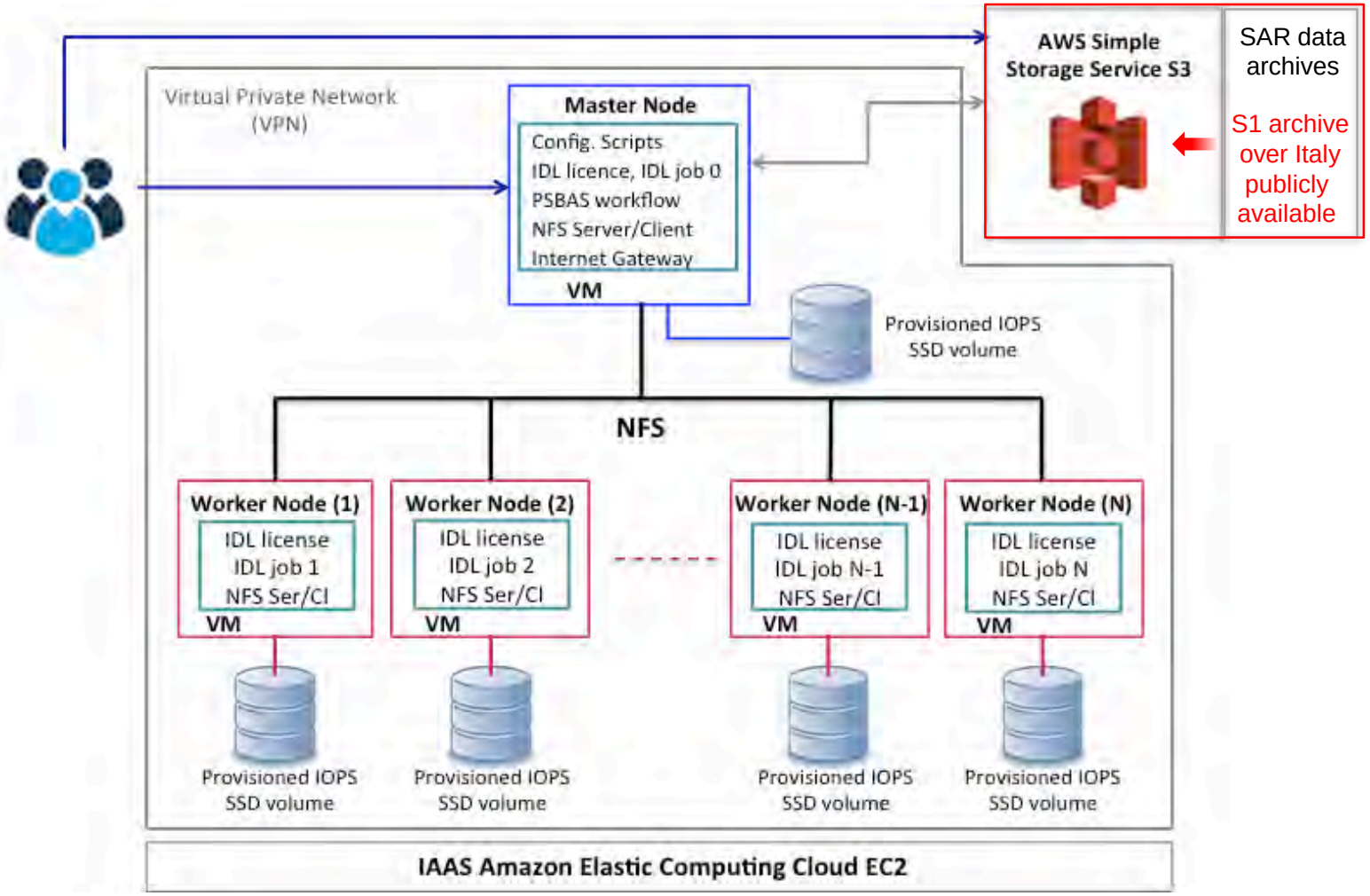
IBM Cloud

Microsoft Azure



Earth surface monitoring products and results

P-SBAS Cloud solution: multi-node/distributed computing architecture implemented within Amazon Web Services



Zinno et al., in *IEEE* Transaction on Cloud Computing 2015
Zinno et al., in *IEEE* JSTARS 2015
Zinno et al., in *IEEE* JSTARS 2016

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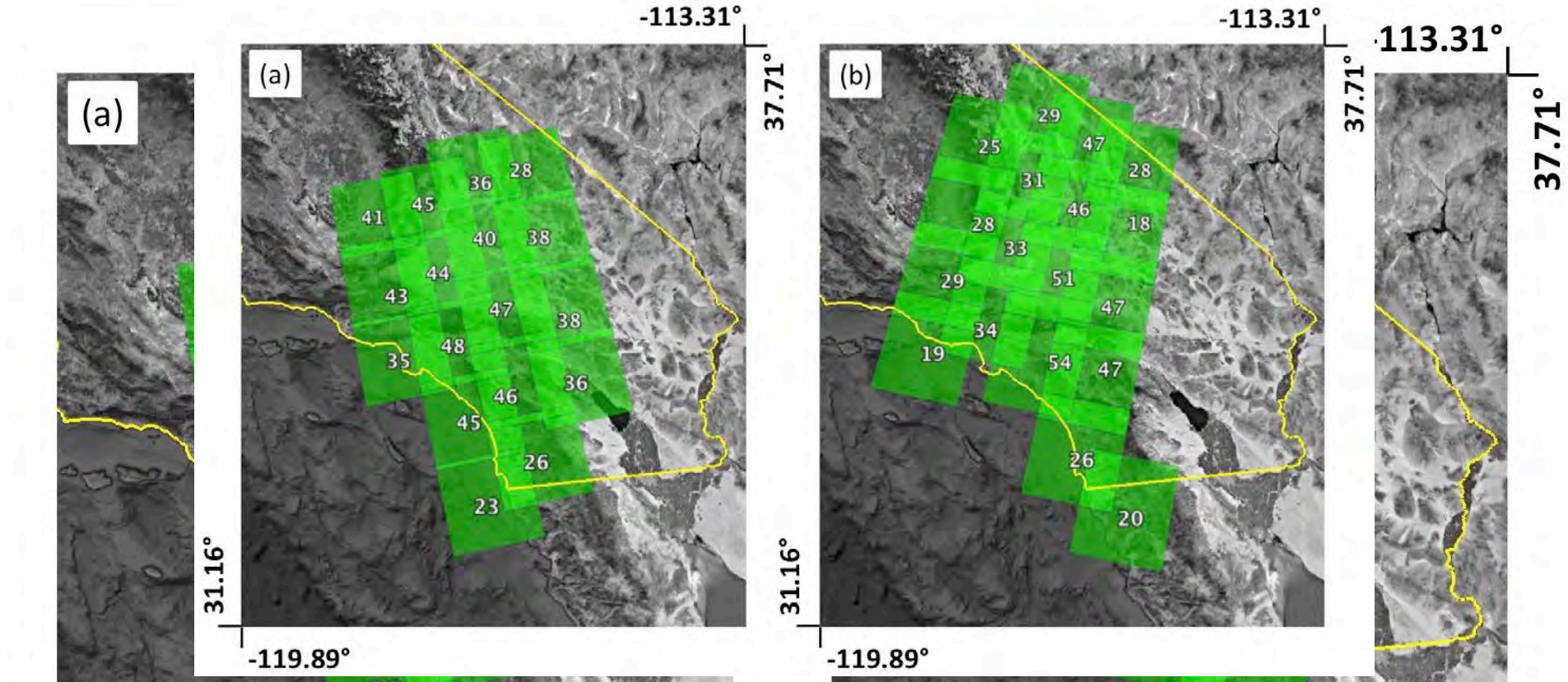
Large scale processing in the AWS Cloud: the California case-study



Time Span	2005-2010
Covered area	90,000 km²
#processed frames (asc & desc orb)	35 (1270 images!)
# AWS computing nodes	280
Overall employed storage	33.6 TB

entire ENVISAT archive over Southern California!

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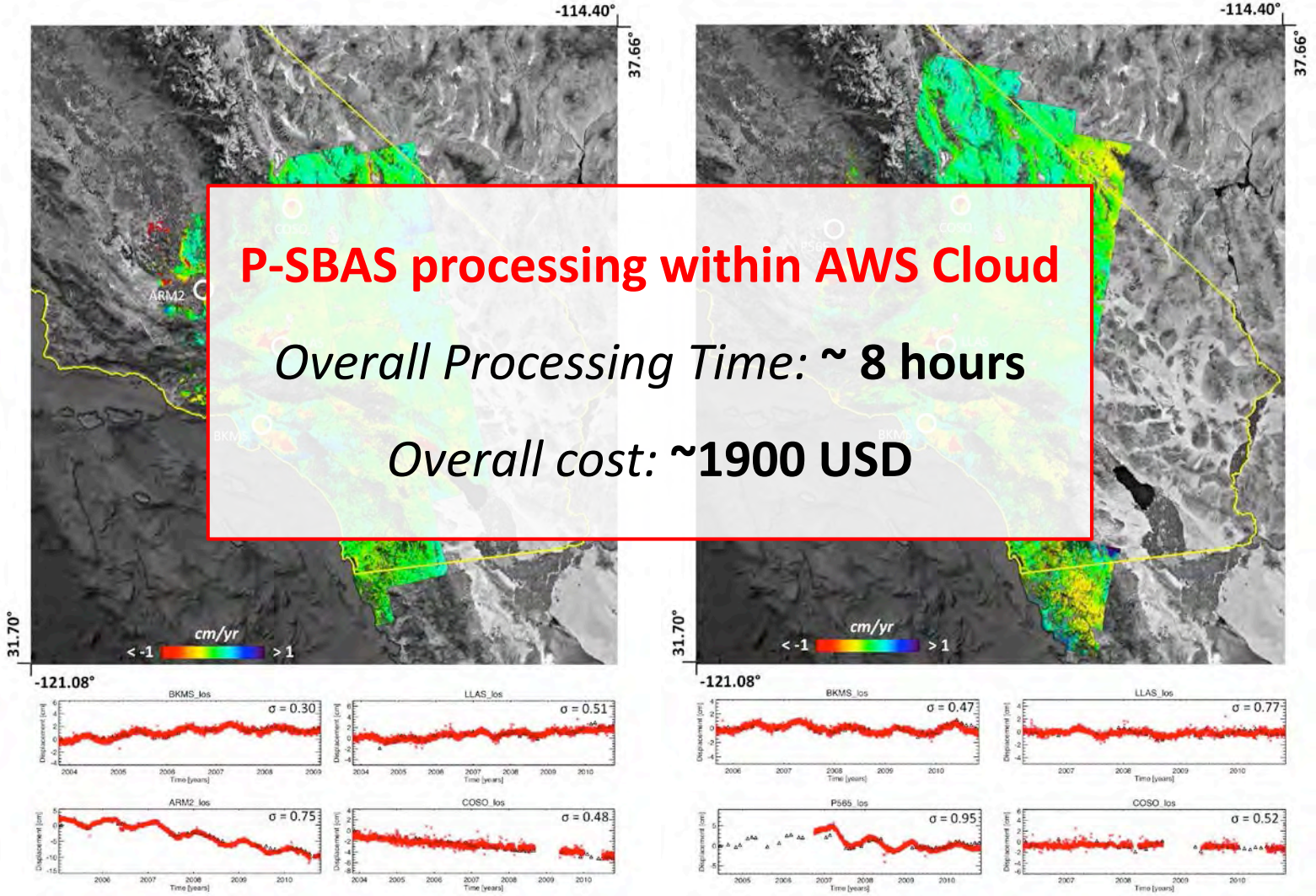
Large scale processing in the AWS Cloud: the California case-study

Mean deformation velocity maps relevant to ascending and descending orbits



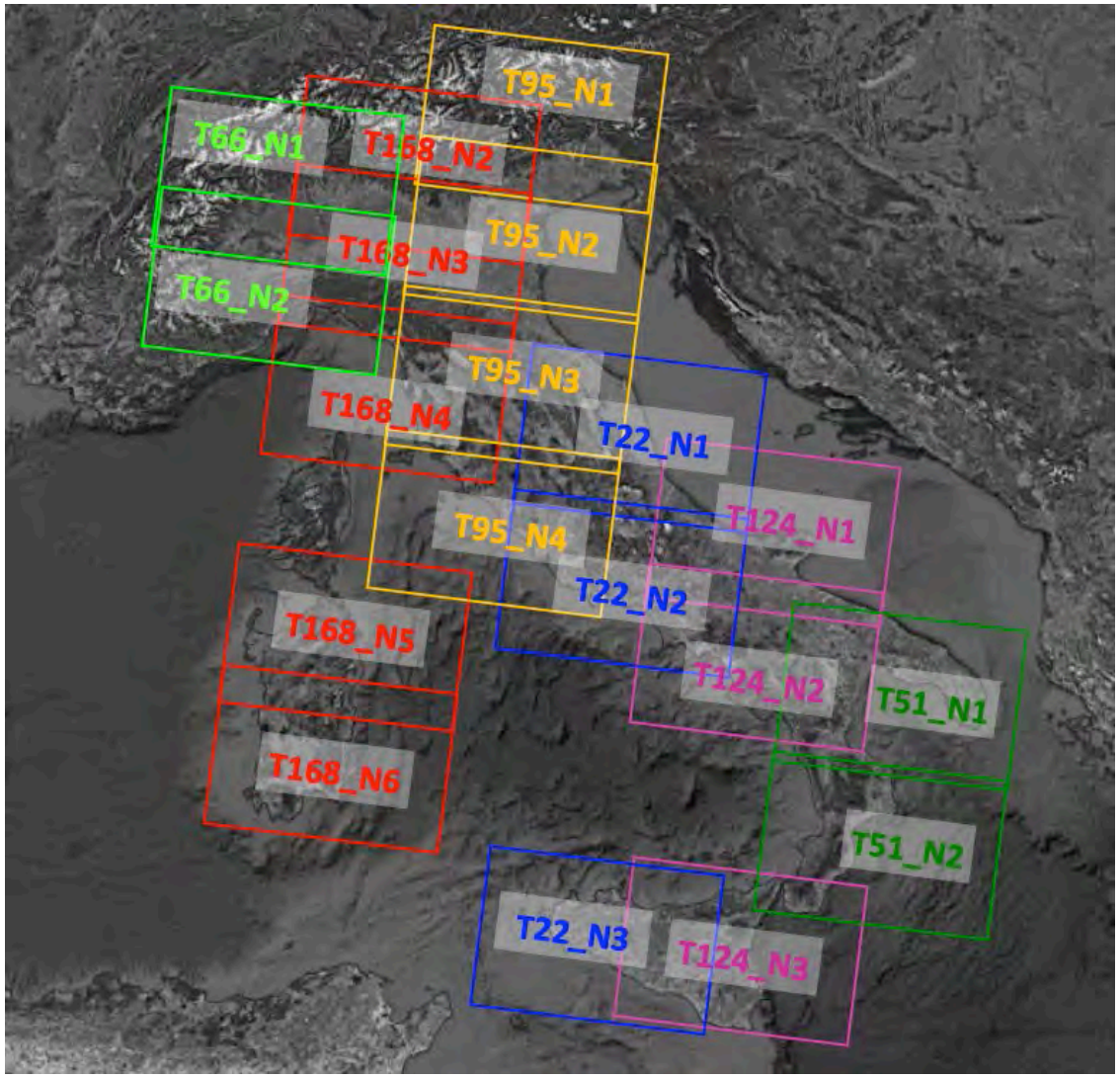
P-SBAS processing within AWS Cloud

Overall Processing Time: **~ 8 hours**

Overall cost: **~1900 USD**

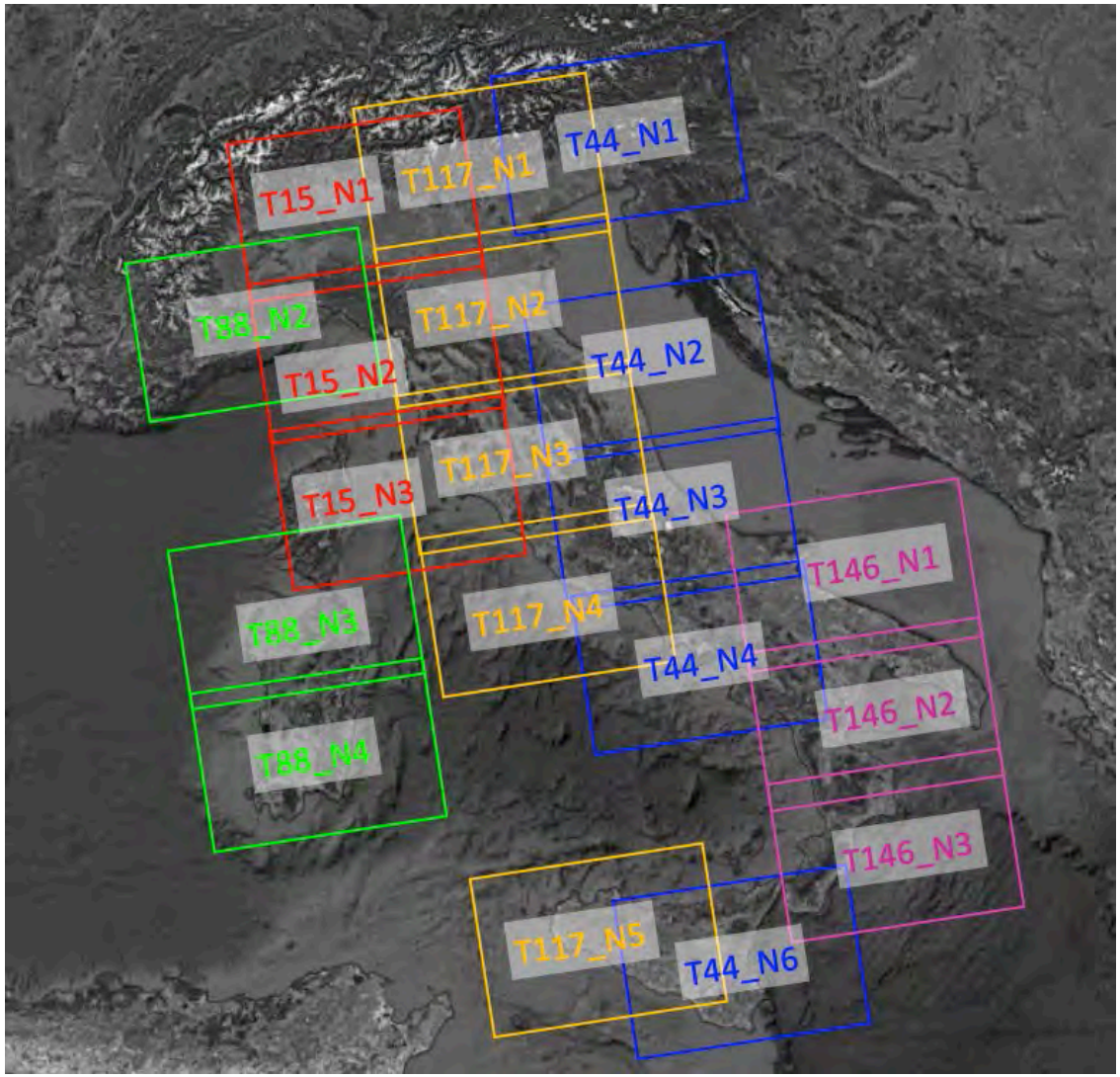
* GPS – ∆ P-SBAS measurements

Sentinel-1 national scale DInSAR analyses over Descending orbit



Frame	Number of S-1 slices
T66_N1	292
T66_N2	391
T168_N2	286
T168_N3	286
T168_N4	303
T168_N5	319
T168_N6	279
T95_N1	290
T95_N2	308
T95_N3	295
T95_N4	289
T22_N1	327
T22_N2	330
T22_N3	288
T124_N1	300
T124_N2	359
T124_N3	353
T51_N1	361
T51_N2	375
19	**6031**

Sentinel-1 national scale DInSAR analyses over Ascending orbit



Frame	Number of S-1 slices
T88_N2	353
T88_N3	312
T88_N4	308
T15_N1	355
T15_N2	370
T15_N3	387
T117_N1	435
T117_N2	321
T117_N3	402
T117_N4	344
T117_N5	384
T44_N1	422
T44_N2	457
T44_N3	410
T44_N4	315
T44_N6	348
T146_N1	324
T146_N2	361
T146_N3	344
19	**6952**

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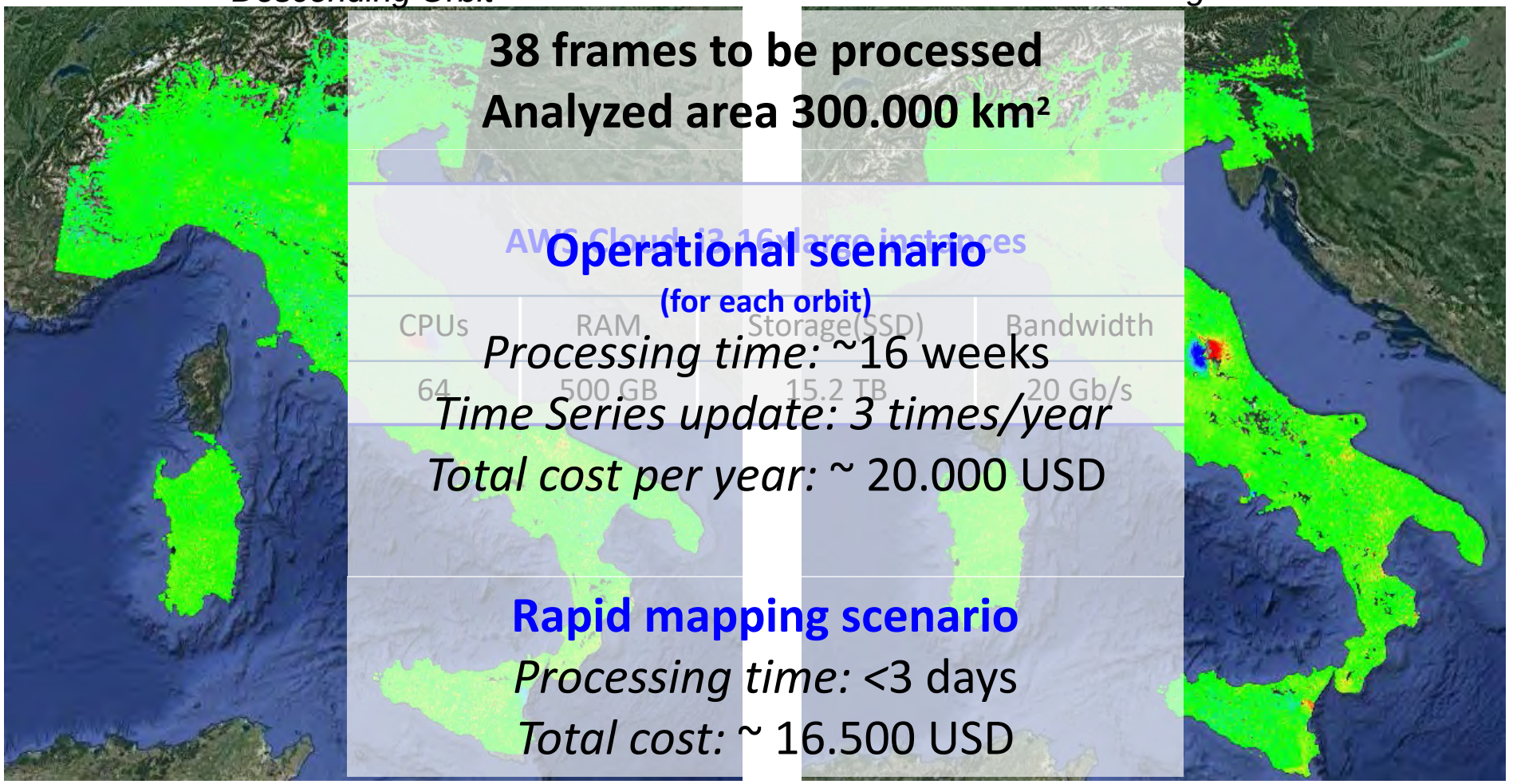
Sentinel-1 P-SBAS processing for national scale DInSAR analyses

Time span: March 2015 – September 2018

Descending Orbit

Ascending Orbit



38 frames to be processed

Analyzed area 300.000 km²

Operational scenario

(for each orbit)

Processing time: ~16 weeks

Time Series update: 3 times/year

Total cost per year: ~ 20.000 USD

AWS Cloud: i3.16xlarge instances

CPUs	RAM	Storage(SSD)	Bandwidth
64	500 GB	15.2 TB	20 Gb/s

Rapid mapping scenario

Processing time: <3 days

Total cost: ~ 16.500 USD

<-3 **>3**

Mean Deformation Velocity LOS [cm/yr]

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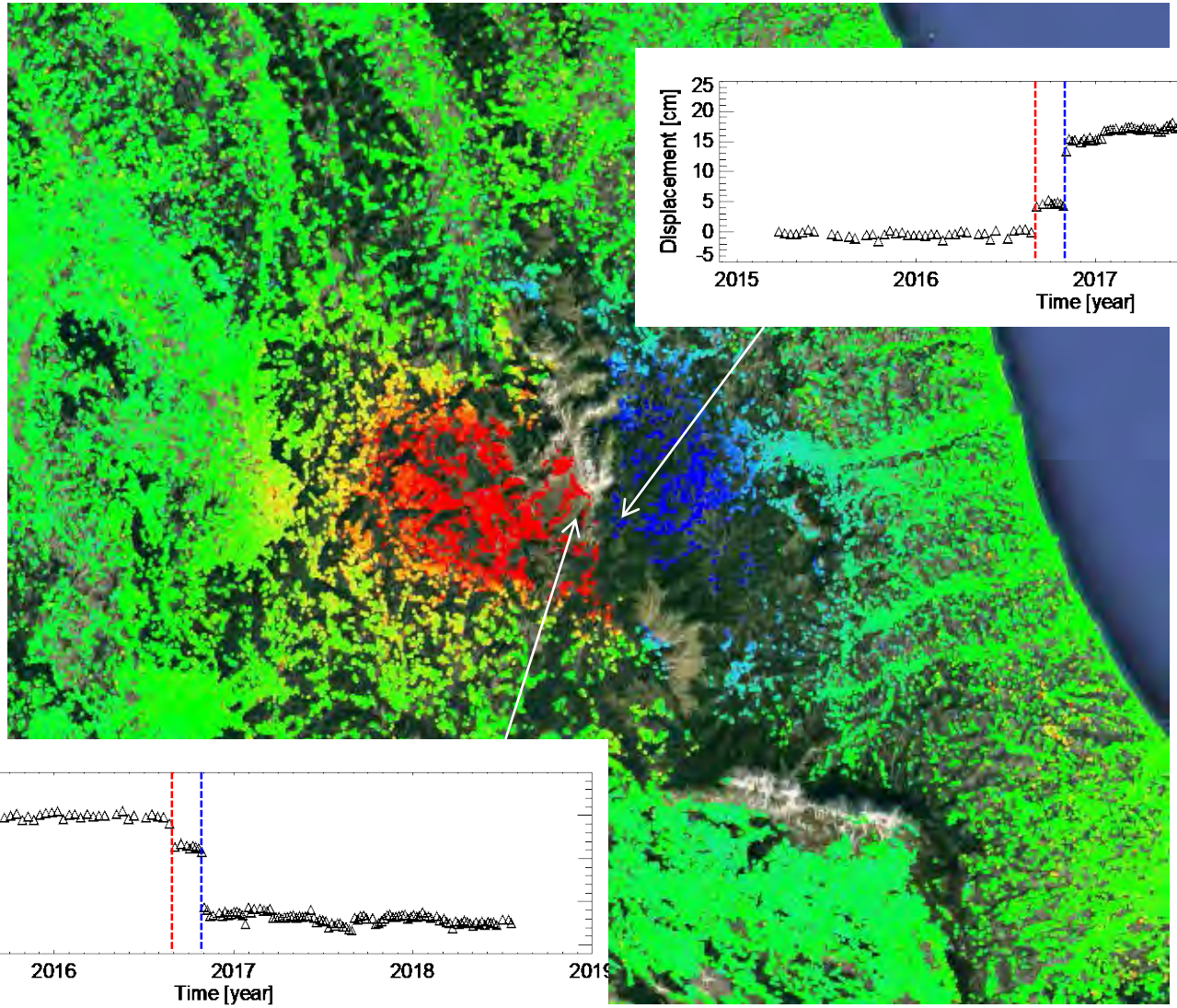
Large Scale Analysis Results: Seismic events

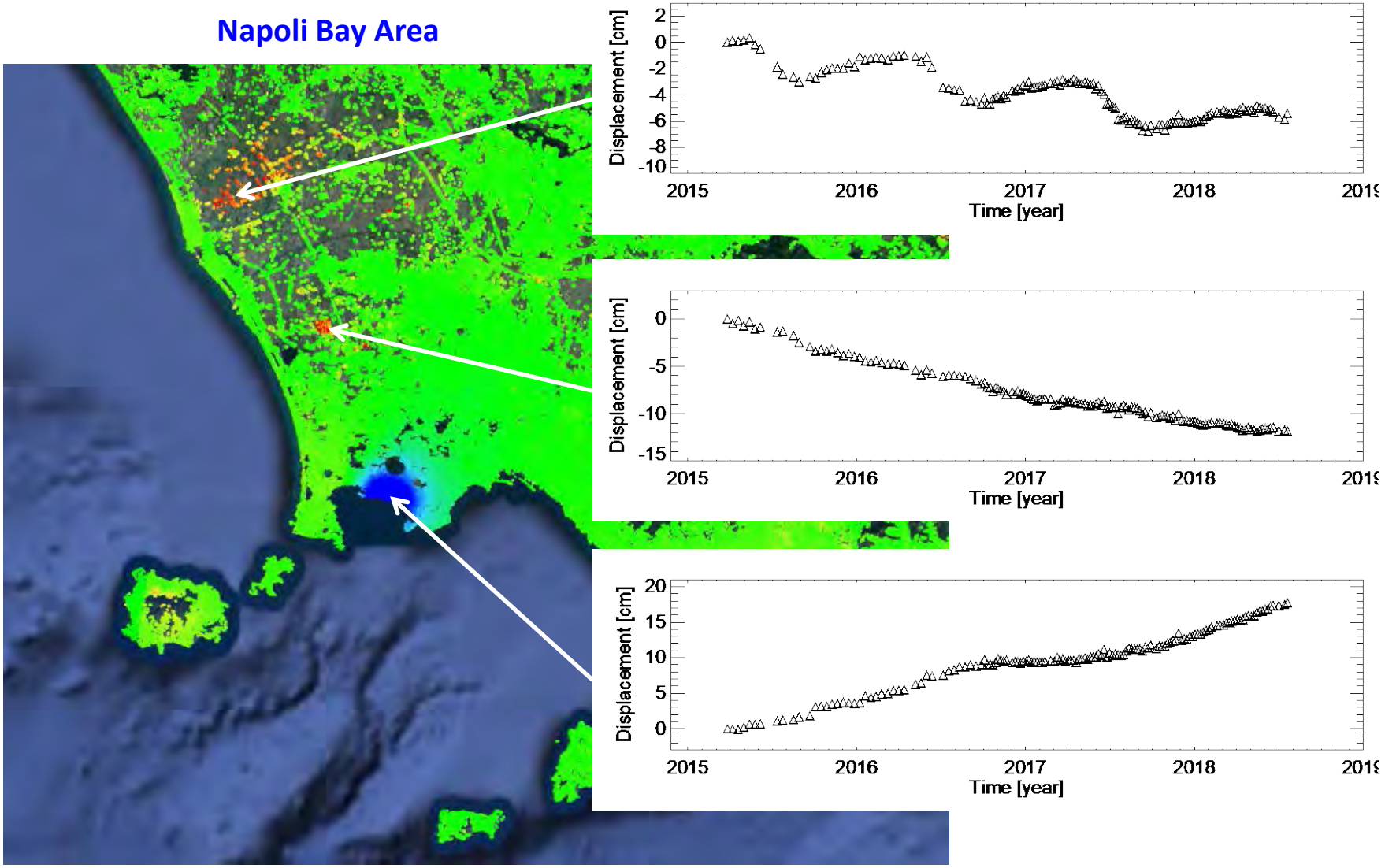
Central Italy Seismic Sequence



<-3 >3

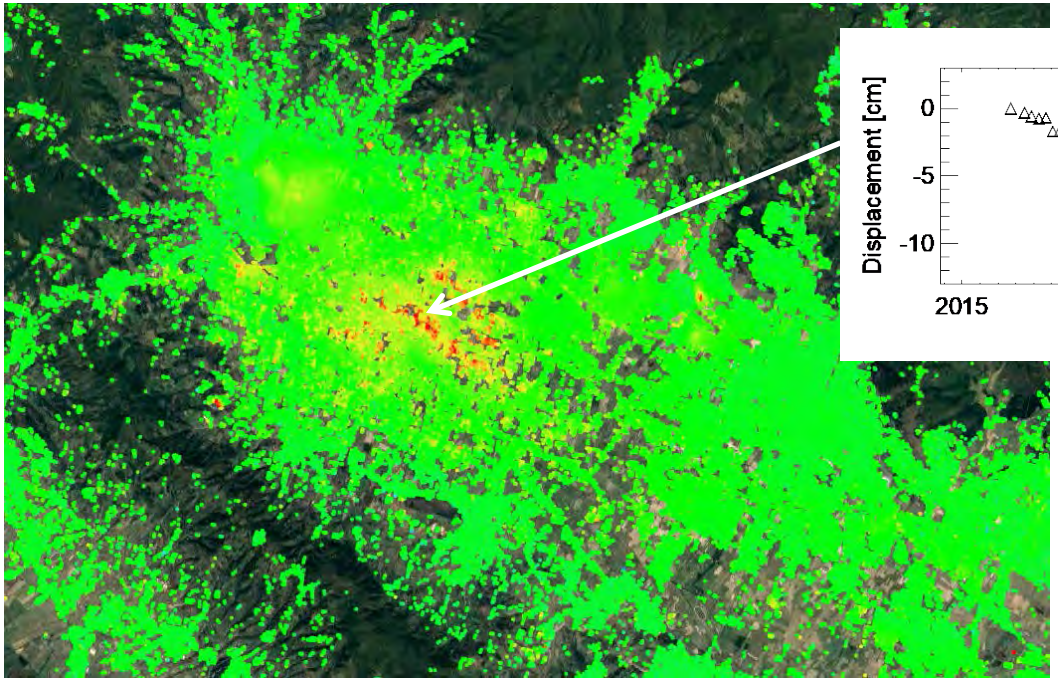
Mean Deformation Velocity LOS [cm/yr]

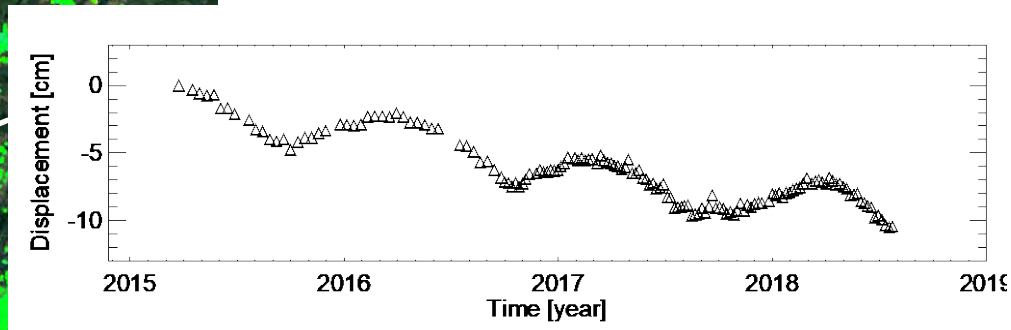
Large Scale Analysis Results: Natural and Anthropogenic Hazards



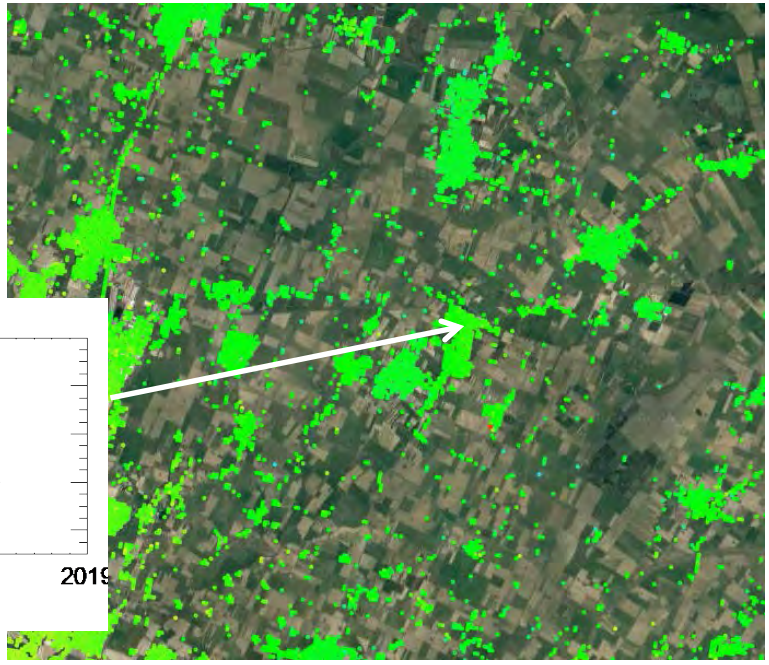
Large Scale Analysis Results: Aquifer and Gas Reservoir

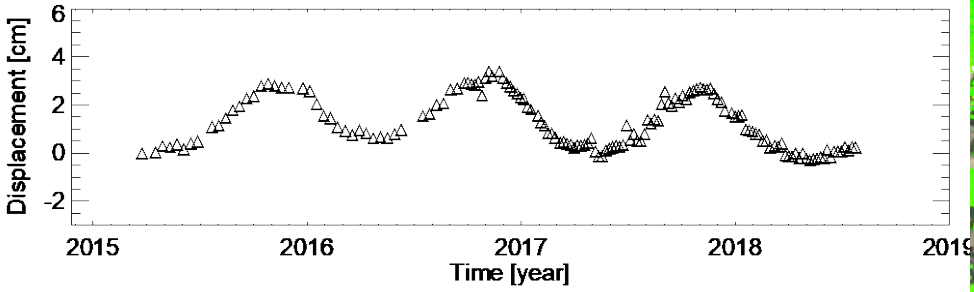
Pistoia, Toscana





Minerbio, Emilia Romagna





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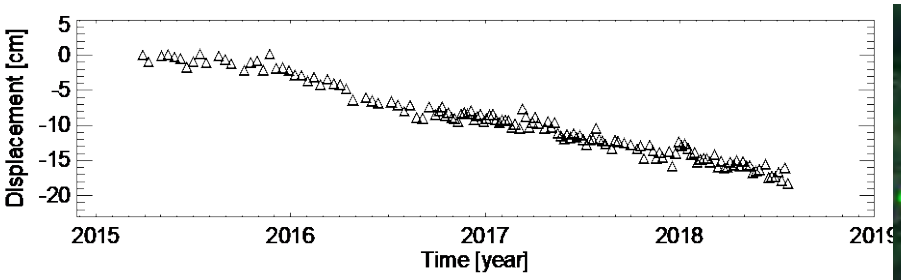
Large Scale Analysis Results: Landslides

Plataci, Calabria



Mean Deformation Velocity LOS [cm/yr]

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Fully exploiting SAR data archives

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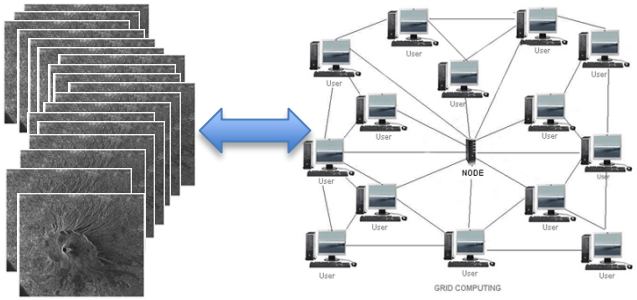

- ✓ Operational Services:
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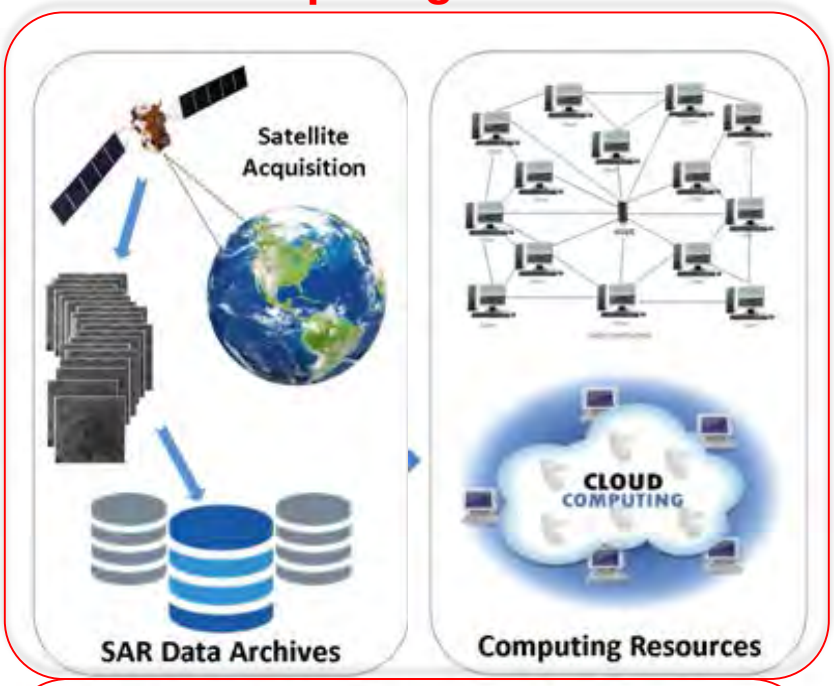
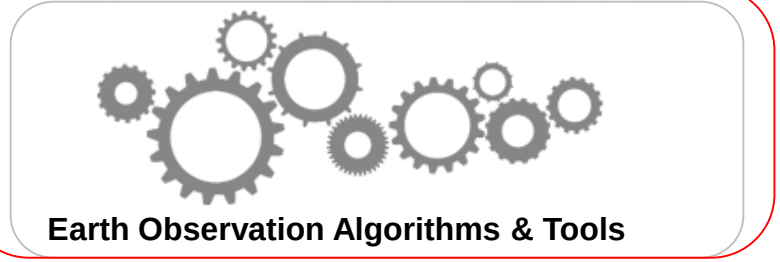
Huge SAR data: a full exploitation scenario

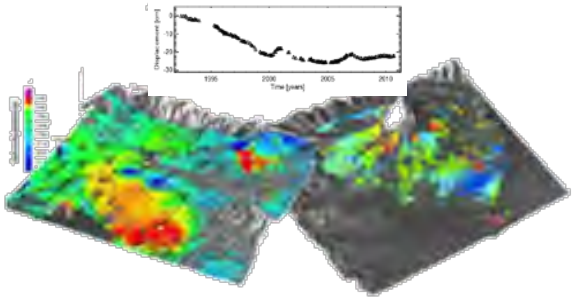
Cloud Computing Environments





Web Portal

ESA GEP platform



Earth Surface Monitoring

Future Perspective

✓ **Enlarge the capacity of performing DInSAR analyses at continental/global scale**

Exploitation of the Copernicus Data Information and Access Services (DIAS) launched by the European commission

✓ **Make the results easily and freely available**

e.g. through the EPOS Research Infrastructure

(standard ISO 19115 and interoperability)

EPOS
EUROPEANPLATEOBSERVINGSYSTEM

Sentinel-1 continental scale DInSAR analyses over Descending orbit

~190 frames to be processed

5 computing nodes each one equipped with:

CPU's: 64

RAM: 512 GB RAM

Storage: 20 TB

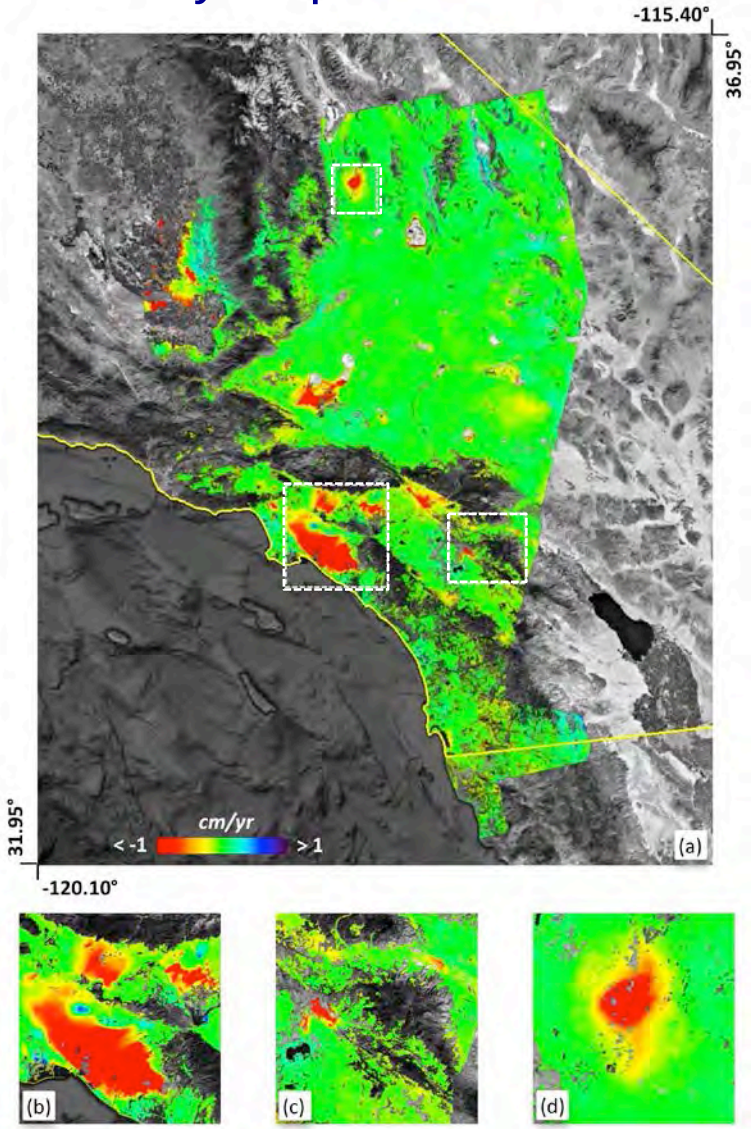
Task's Start Date: 01/2019

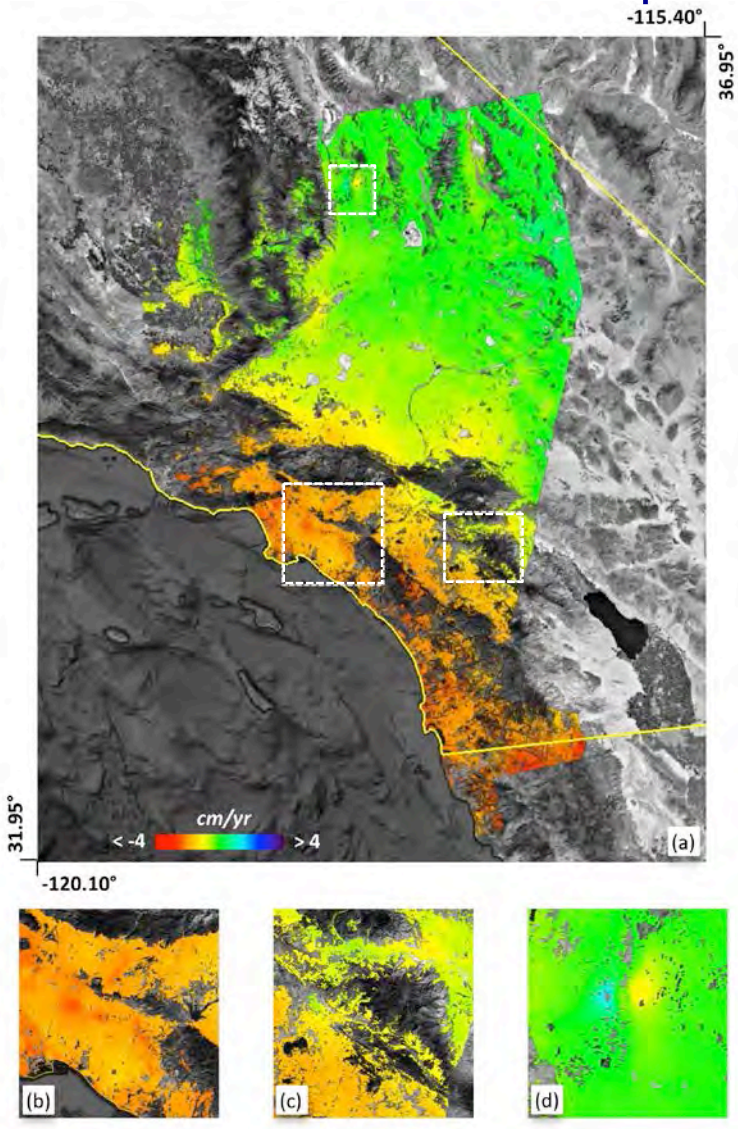
Time Needed: ~6 months

BiDS' 2019, Munich, Germany

Large scale processing in the AWS Cloud: the California case-study

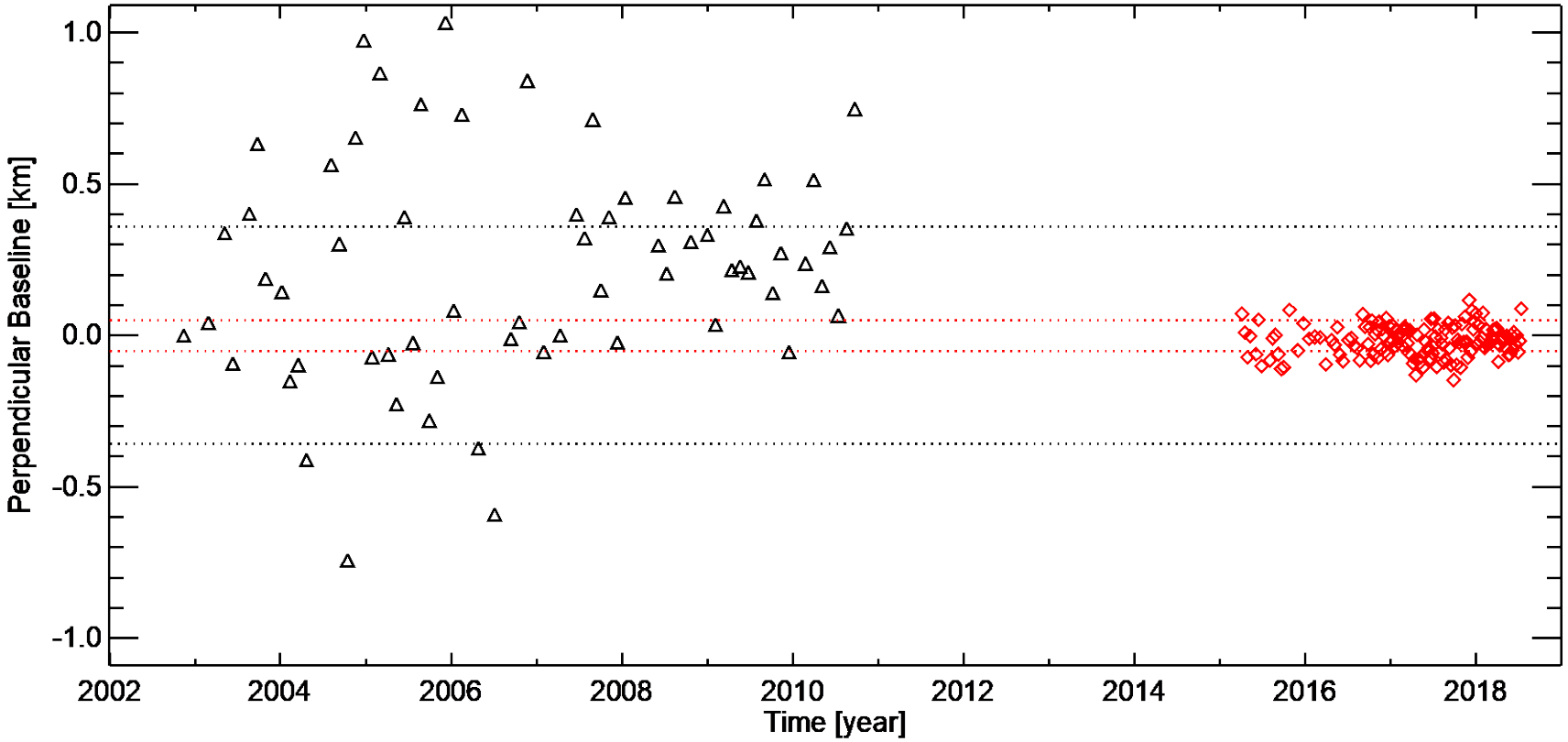
Mean velocity maps of the Deformation vertical and East-West components





Sentinel-1: a Small Baseline system

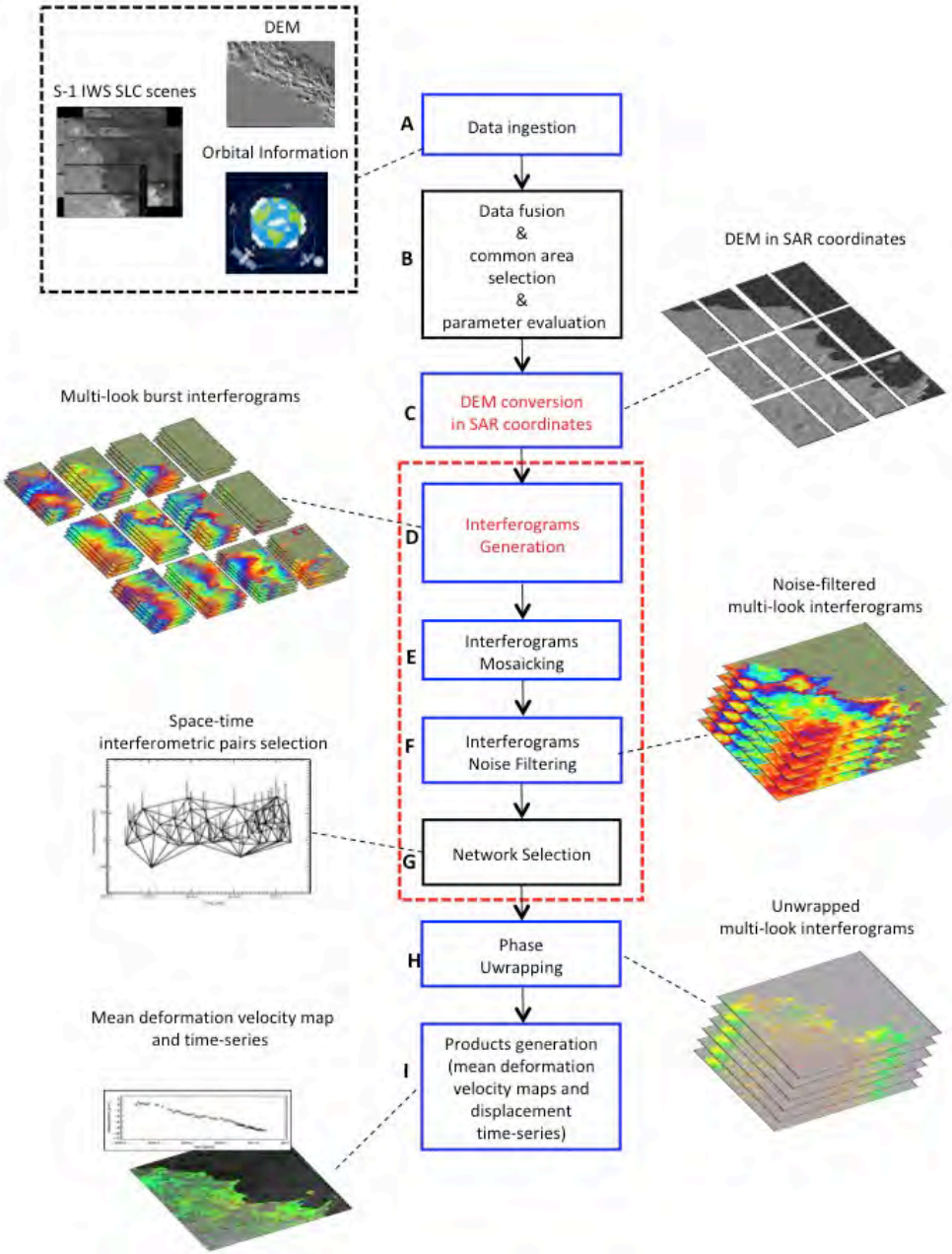
Perpendicular baseline distribution



ENVISAT

Sentinel-1

Sentinel-1 P-SBAS processing chain workflow



The burst partitioning of the S1 data is exploited to increase the granularity of the "embarrassingly parallel" tasks of the processing:

- Burst level
- Interferogram level

Both multi-node and multi-core parallelization strategies are implemented.