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

Zinno Ivana, Bonano Manuela, Casu Francesco, De Luca Claudio, Manunta Michele, Manzo Mariarosaria, Onorato Giovanni, and Lanari Riccardo

BiDS’ 2019, Munich, Germany

IREA-CNR, Napoli, Italy
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)


Mean deformation velocity [cm/yr]

SAR data scenario: satellites

Swath width ≈ 250 km
Revisit Time: 12 - 6 days

Swath width ≈ 40 km
Revisit time: 4 - 11 days

Swath width ≈ 100 km
Revisit time: ≈ monthly
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**

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Sentinel-1A and Sentinel-1B spatial coverage

S-1A

IWS Mode

Stripmap Mode

EWS Mode

S-1B

Terabyte

S-1A Only Operations

S-1B Commissioning Phase

S-1A and S-1B Operations
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 workflow

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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Fully exploiting SAR data archives

- Efficient Processing Tools:
  parallel algorithms for HPC 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
Huge SAR data: a full exploitation scenario

Cloud Computing Environments

Satellite Acquisition

Google Cloud

Earth surface monitoring products and results

SAR Data Archives

amazon web services

Earth Observation Algorithms & Tools

IBM Cloud

Microsoft Azure

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zinno.i@irea.cnr.it
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
Large scale processing in the AWS Cloud: the California case-study

entire ENVISAT archive over Southern California

<table>
<thead>
<tr>
<th>Time Span</th>
<th>2005-2010</th>
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</thead>
<tbody>
<tr>
<td>Covered area</td>
<td>90,000 km²</td>
</tr>
<tr>
<td># processed frames (asc &amp; desc orb)</td>
<td>35 (1270 images!)</td>
</tr>
<tr>
<td># AWS computing nodes</td>
<td>280</td>
</tr>
<tr>
<td>Overall employed storage</td>
<td>33.6 TB</td>
</tr>
</tbody>
</table>
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

* GPS – △ P-SBAS measurements

Overall Processing Time: ~ 8 hours

Overall cost: ~1900 USD
## Sentinel-1 national scale DInSAR analyses over Descending orbit

<table>
<thead>
<tr>
<th>Frame</th>
<th>Number of S-1 slices</th>
</tr>
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<tbody>
<tr>
<td>T66_N1</td>
<td>292</td>
</tr>
<tr>
<td>T66_N2</td>
<td>391</td>
</tr>
<tr>
<td>T168_N1</td>
<td>286</td>
</tr>
<tr>
<td>T168_N2</td>
<td>303</td>
</tr>
<tr>
<td>T168_N3</td>
<td>319</td>
</tr>
<tr>
<td>T168_N4</td>
<td>279</td>
</tr>
<tr>
<td>T168_N5</td>
<td>290</td>
</tr>
<tr>
<td>T168_N6</td>
<td>308</td>
</tr>
<tr>
<td>T95_N1</td>
<td>295</td>
</tr>
<tr>
<td>T95_N2</td>
<td>289</td>
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<tr>
<td>T95_N3</td>
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<td>T95_N4</td>
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<td>T22_N1</td>
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</table>
### Sentinel-1 national scale DInSAR analyses over Ascending orbit

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<tr>
<td>T88_N2</td>
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<td><strong>19</strong></td>
<td><strong>6952</strong></td>
</tr>
</tbody>
</table>
Sentinel-1 P-SBAS processing for national scale DInSAR analyses

Time span: March 2015 – September 2018

Descending Orbit

- 38 frames to be processed
- Analyzed area 300,000 km²

升空轨道

- 38 帧需处理
- 分析区域 300,000 km²

AWS Cloud: 13.16xlarge instances

<table>
<thead>
<tr>
<th>CPUs</th>
<th>RAM</th>
<th>Storage (SSD)</th>
<th>Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>500 GB</td>
<td>15.2 TB</td>
<td>20 Gb/s</td>
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</tbody>
</table>

Operational scenario
(for each orbit)

Processing time: \(~16\) weeks
Time Series update: 3 times/year
Total cost per year: \(~20,000\) USD

Rapid mapping scenario

Processing time: \(<3\) days
Total cost: \(~16,500\) USD

Mean Deformation Velocity LOS [cm/yr]
Large Scale Analysis Results: Seismic events

Central Italy Seismic Sequence
Large Scale Analysis Results: Natural and Anthropogenic Hazards

Napoli Bay Area

Mean Deformation Velocity LOS [cm/yr]

<-3

>3

Mean Deformation Velocity LOS [cm/yr]
Large Scale Analysis Results: Aquifer and Gas Reservoir

Pistoia, Toscana

Minerbio, Emilia Romagna

Mean Deformation Velocity LOS [cm/yr]
Large Scale Analysis Results: Landslides

Plataci, Calabria

Mean Deformation Velocity LOS [cm/yr]
Fully exploiting SAR data archives

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Huge SAR data: a full exploitation scenario

Cloud Computing Environments

Web Portal

ESA GEP platform

Earth Observation Algorithms & Tools

Earth Surface Monitoring

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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)

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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
Thank You!
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

Time [year]

Perpendicular Baseline [km]

ENVISAT

Sentinel-1
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.