A tool for 2+1D phase unwrapping: application examples

O. Monserrat
M. Crosetto
R. Iglesias

G. Rossi
L. Calcagni
B. Crippa
Introduction

- Why “2+1D phase unwrapping”?
  - not fully 3D (not yet)
  - first 2D, then 1D

- What’s its ultimate goal?
  - improve the quality of “deformation time series”

- Original idea presented in 2007:
  - implemented in our PSI processing chain: ERS, Env, TSX
  - implemented in our GBSAR processing chain: C-, S- and Ku-bands

- “Geomatic approach”: least squares (LS) ++
  - framework for interesting extensions
Our approach

- Previous step: 2D phase unwrapping on (redundant) interferograms
- Interferogram to image transformation (int_2_ima):

\[
\Delta \Phi_{\text{DInSAR}} = \Phi_{\text{Slave}} - \Phi_{\text{Master}} = \\
= (\Phi_{\text{defo}} + \Phi_{\text{atmo}} + \Phi_{\text{tlin}})_{\text{S}} - (\Phi_{\text{defo}} + \Phi_{\text{atmo}} + \Phi_{\text{tlin}})_{\text{M}} + 2n \cdot \pi + \text{Res}
\]

- Main goal: detect the unwrapping errors: \(2n \cdot \pi\) \(\rightarrow\) correct/reject
- Procedure: - least squares adjustment + redundant interferograms
  - iterative outlier detection & rejection/correction based on:
    (i) size of residuals (ii) outliers are \(2n \cdot \pi\)
    (iii) carefully managing local redundancy
- Post-processing (optional data analysis)
Example – 1\textsuperscript{st} LS iteration

- 25 Envisat images
- 169 interferograms
- 28% of outliers candidates @ 1\textsuperscript{st} iteration
Example – 8\textsuperscript{th} LS iteration
Example – 16th LS iteration

![Graph showing Iteration 16 with residues in radians against number of observations.](image)

Legend:
- Red circles: Rejected Observations
- Green triangles: New “Good” observations
- Blue circles: “Good” Observations
Performances – 3 datasets

- **Envisat:**
  - 25 images (March 2004 to December 2006)
  - 169 interferograms
  - Number of PS = 96403

- **TerraSAR-X:**
  - 13 images
  - 78 interferograms
  - Number of PS = 32174

- **C-band GBSAR:**
  - 712 images
  - 4678 interferograms
  - Number of pixels = 3125
Performances – 4 cases

A) “Not doing anything”: there are not outliers.
   e.g. Envisat = 77%, TSX = 97% of PS

B) Slight improvement in TS: usually with several outliers in the network.
   e.g. Envisat = 21%, TSX = 2% of PS
Slight improvement
Slight improvement
Perfomances – 4 cases

A) **“Not doing anything”**: there are not outliers.
   e.g. Envisat = 77% of PS, TSX = 97%

B) **Slight improvement in TS**: usually with several outliers in the network.
   e.g. Envisat = 21% of PS, TSX = 2%

**Note**: A+B include 98% (Env) or 99% (TSX) of PS
The remaining is not negligible: usually it contains the **“hot & red PS”**

C) **Global improvement in TS**: with % of outliers candidates up to 30%
   **Condition**: Outliers evenly distributed over the network

D) **“Not working properly”**:
   - High % of outliers
   - **Outliers clustered** in the network.
Not working properly

Deformation mm

Date

Reference
PS estimation

% outliers candidate

Unknown Number

“Alarm”
Not working properly

Not working properly, but “we know it”
(e.g. before - and not after - delivering to end user)
Advanced tools: interactive analysis, etc.

- Exploit information:
  - in space (2D)
  - in time

- Possible extension:
  using external data
  (take advantage of LS)