

URBAN GEO BIG DATA Meeting Rome, 22 January 2018

CNR-IREA Napoli

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PRIN PROJECT: URBAN GEOmatics for Bulk Information Generation, Data Assessment and Technology Awareness



MINISTERO DELL'ISTRUZIONE DELL'UNIVERSITA' E DELLA RICERCA



IREA-CNR (Napoli) Three-Year Activities

- Generation of InSAR products from historical (ERS-ENVISAT) SAR data
- InSAR data and metadata

✤ Generation of InSAR products with new Sentinel-1 SAR data. SBAS analyses require large sets of data. Sentinel-1 archives are being populated.

- Development of new methods for the calibration of SAR images (research activity)
- * Evaluation of SAR backscattering changes in urban areas with Sentinel-1 data (research activity)







Differential interferometric phase

For each interferogram, the phase relevant to a generic point with coordinates x and r, azimuth and range rispectively, can be written as following:

Differential interferometric phase.

Phase component relevant to the deformation occurred in the time period between the two acquisitions.

 $\delta\phi_m(x,r) \approx D\left(t_{IE_m}, x, r\right) - D\left(t_{IS_m}, x, r\right)$

Phase component relevant to the residual topography (DEM Atmospheric errors and position of the phase center respect to the ground). Noise

 $+ \Delta s_{topo}(x,r) + (ATM_m(x,r)) + \Delta n_m(x,r)$





SBAS worflow





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ERS-ENVISAT SAR Data Distribution: the Napoli case study



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Key ideas of the SBAS algorithm

To produce time-series deformation from a SAR data sequence by:

> using DInSAR interferograms characterized by a "*small baseline*" (smaller than the critical one) in order to mitigate noise (decorrelation) phenomena;

> properly "*linking*" interferometric SAR data subset separated by large baselines. This is done by searching for an LS solution with a velocity minimum norm constraint, easily achieved by applying the SVD method.





Mathematical framework of the SBAS algorithm

Following the unwrapping operation we evaluate (for each pixel) the displacement velocity vector \underline{v}

$$\underline{\mathbf{v}}^{T} = \left[v_{1} = \frac{\phi(t_{1}) - \phi(t_{0})}{t_{1} - t_{0}} , \dots , v_{M-1} = \frac{\phi(t_{M-1}) - \phi(t_{M-2})}{t_{M-1} - t_{M-2}} \right]$$

by solving the linear system

$$\mathbf{B}\underline{\mathbf{v}} = \underline{\delta\phi}$$

To solve the linear system, the SVD method is applied.¹

¹ Berardino P. et alii: "A new Algorithm for Surface Deformation Monitoring based on Small Baseline Differential SAR Interferograms", IEEE *Trans. Geosci. Remote Sensing*, Vol. 40, No. 11, pp. 2375-2383, November 2002.



SBAS: a two scale approach





Low resolution SBAS Approach

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SBAS: a two scale approach





Extended SBAS approach: from low to full resolution analysis

Multi-look (low resolution) Interferogram

Single-look

(full resolution)

Interferogram









ERS-ENVISAT SAR Data Distribution: the Napoli case study



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ERS-ENVISAT SAR Data Distribution: the Napoli case study



PRIN PROJECT: URBAN GEOmatics for Bulk Information Generation, Data Assessment and Technology Awareness

ERSENV

Advanced DInSAR technique: the Small BAseline Subset (SBAS)









71 ERS-1/2 and 39 ENVISAT images acquired on ascending orbits (1993-2007)

197 ERS and 115 ENVISAT interferograms







Deformation measurements: the Vomero quarter





> 1.0

LOS Velocity

< -1.0

[cm/year]

Deformation Time Series Data Format

| Data Type: LOS Displacement Time Series | |
|--|--|
| Processing ID: | |
| User ID: CNR-IREA | |
| Software_version: CNR-IREA P-SBAS 24 | |
| Applied_algorithm_description: Parallel SBAS Interferometry Chain | |
| Main_reference: 10.1109/TGRS.2002.803792, 10.1109/JSTARS.2014.2322671 | |
| Date_of_production: 20170906T19:55:03Z | |
| Date_of_publication: 20170906T19:55:03Z | Data Type: LOS Displacement Time Series |
| Service_used_for_generation: CNR-IREA | |
| Geographic_CS_Type_Code: 4326 | Processing_ID: |
| Spatial_Resolution: 10 | User TD: CNR-TREA |
| Sensor: ERS/ENV | Coff and the CAID TREA D CDAC 24 |
| Mode: SIRIP | SOTTWARE_VERSION: UNK-IREA P-SBAS 24 |
| Belative Orbit Number: | Applied algorithm description: Parallel SBAS Interferometry Chain |
| Wavelenght: 0.056564617 | Main reference: 10 1100/TCDS 2002 002702 10 1100/JSTADS 2014 2222671 |
| Number of dates: 164 | Main_Telefence: 10.1109/TGR5.2002.003/92, 10.1109/JSTAR5.2014.25220/1 |
| Time Years: 1992,4397, 1992,6310, 1992,7253, 1992,8224, 1992,9166, 1993, | Date of production: 20170906T19:55:03Z |
| 1995,7648, 1995,8591, 1995,9534, 1995,9561, 1996,0477, 1996,1420, 1996,14 | 4 Date of publication: 20170006T10:55:037 0066. 1997.1009. 1997.2034. 1997.2034. 1997.2977. 1997.3947. 1997.5861. 1997.6787. |
| 1997.7758, 1997.8701, 1997.9671, 1998.1557, 1998.3536, 1998.4479, 1998.54 | 5982, 1999.6924, 1999.7895, 1999.9808, 2000.0751, 2000.1705, 2000.1733, |
| 2000.2676, 2000.3646, 2000.4589, 2000.5559, 2000.6502, 2000.7445, 2000.83 | Service used for generation: CNR-IREA 8536, 2002.9507, 2003.4314, 2003.5285, 2003.6228, 2003.6228, 2003.7170, |
| 2003.8141, 2003.8141, 2003.9084, 2004.0981, 2004.0982, 2004.1979, 2004.29 | Geographic CS Type Code: 4326 3482, 2005.4424, 2005.5394, 2005.6338, 2005.7280, 2005.7281, 2005.8250, |
| 2005.8251, 2005.9205, 2005.9205, 2006.0148, 2006.1091, 2006.2116, 2006.40 | 1705, 2007.3618, 2007.5531, 2007.6475, 2007.8371, 2007.9342, 2008.1228, |
| 2008.2225, 2008.3168, 2008.4138, 2008.4139, 2008.5093, 2008.6036, 2008.69 | Spatial_Resolution: 10 6584, 2009.7538, 2009.8481, 2009.9451, 2010.0394, 2010.1337, 2010.2362, |
| 2010.3305, 2010.4259, 2010.6173, 2010.7116 | Sensor: FRS/FNV |
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| 2002110/103.13.142, 20021212103.47.302, 2003000103.13.122, 2003010103. | NUMBER_OT_GATES: 104 |
| 20050600700.47.557 2005071470.10.107.207020131370.47.537 2005027103. | 19-227 20050022700-47-487 20051027700-10-247 20051027700-47-307 20051201700-10-187 20051201700-47-427 2005010510-10-107 2005020700-10-127 2005020700-10-127 |
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Deformation Time Series Data Format

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| Applied algorithm description: Paralle | lel SBAS Interferometry Chain | |
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| Map of incidence angle for geotiff: n/ | | |
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| Inputs_ID: inputIDs.txt | 20001201031151052, 200501251031151002, 20050505105125.02, 200505110515.02, 2005001010515.111, 20050725105.151102, 2005027105115.022, 2005027105115102, 2005027105115102, 2005027105115102, 2005027105115.022, 2005027105115.022, 2005027105115102, 2005027105115.022, 2005027105115.022, 2005027105115.022, 2005027105115.022, 2005027105115102, 2005027105115102, 2005027105115102, 2005027105115102, 2005027105115102, 2005027105115102, 2005027105115102, 2005027105115102, 2005027105115102, 2005027105115102, 2005027105115102, 2005027105115102, 2005027105115102, 2005027105115102, 2005027105115102, 20050271051102, 2005027105115, 20050271051102, 2005027105112, 20050271051102, 2005027105115, 2005020, 20050000000000 | |
| | 20100603T09:19:017. 20100812T09:19:037. 20100916T09:19:027 | |
| ID, Lat, Lon, To | Topo, vet, coer, cosw, cose, cosu, is | |
| 0, 40.79619, 14.55528, 23.0 | 3.63, -0.0150, 0.4977162,-0.0708348, 0.3309509, 0.9409856, 0.0000, -0.0447, 0.5588, 0.8460, 0.5617, 0.0314, -0.0337, 0.0580, 0.4956, -0.3504, 0.0918, -0.3526, | 0.0883, -0.2442, |
| 0.1199, -0.9397, -0.0916, -0.5173 | 1/5, 0.1186, -0.5135, -0.7090, -1.4423, -1.0200, -0.74/2, -0.8378, -0.7120, -0.9707, -0.6839, -0.6927, -0.7284, -1.3812, -0.3774, -0.7050, -1.3457, -0.6018 7164, -0.3557, -0.9132, -0.0111, -0.615, -0.2640, -0.4426, -0.219, -0.6554, -0.2156, -0.1075, -0.9652, -0.1240, -0.5240, -0.6574, -0.4657, -0.658 | -0.3687, -0.3964, |
| -0.2000, -0.3521, -0.1357, -0.710 | 7529, 0.4250 , -0.3450 , -0.3490 , 0.0416 , -0.3454 , -0.7278 , -0.7240 , 0.0597 , 0.0210 , 1.0662 , -0.10602 , -0.10203 , -0.4265 , 1.768 , 0.9490 , 0.0731 , -0.4265 , 1.7682 , 0.9623 , -0.2400 , -0.1039 , -0.1019 , -0.1019 , -0.1020 , -0.1019 , -0.1020 , -0.1019 , | 0, -0.8602, -1.1585. |
| 0.0320, -0.2427, -0.2448, -0.689 | 898, -1.2993, -0.8081, -0.2727, -1.5483, -1.6003, -1.6408, -1.1059, -0.7593, -1.00659, -0.1959, 0.0679, -0.0516, 0.0694, -0.8841, -0.8382, -0.5145, -1.4829 | , -0.9601, -0.7658, |
| 0.0430, -0.2961, -0.6888, -0.8383 | 383, -0.7406, -0.4620, -0.3646, -0.2338, -0.1466, -0.5486, -0.8241, -0.6292, -0.9149, -0.7899, 0.2065, -0.3052, -0.9247, -0.8277, -0.4250, -0.1803, 0.4468 | , 0.0352, -0.1421, |
| 1.0865, 0.6091, 0.0481, 0.0020 | 0200, -0.3539, -0.1126, -0.0401, -0.5522, -0.3287, 0.0109, -0.3076, -0.3731, -0.0354, -0.1942, -0.3878, 0.6312, -0.2698, -0.0822, -0.4152, -0.6513, -0.5007 | , –1.0707, –0.9416, |
| | 0142, -0//3/8, -1/0238, -1/0359, -1/0021, -0/3540, -0/3580, -1/0534, -0/3529 3.G0.0811 0.5550467 _0.0708348 0.3306111 0.040856 0.04000 _0.6490 0.6713 0.4650 0.3871 _0.3206 _0.2056 _0.3410 0.3408 _0.0633 _0.1700 _0.6772 | -0 2120 -0 3700 |
| -0.6062, -1.3241, -1.0061, -1.20 | (-1, -1) = (-1, -1) | 9, -0.5611, -0.9347. |
| -0.8108, -1.3637, -0.6868, -0.68 | 6813, -0.6416, -0.7490, -0.4043, -0.4973, -0.3890, -0.3513, -0.0088, -1.1278, -0.4046, -0.3960, -0.4018, -0.0544, -0.9219, -1.0493, -1.1079, -0.7512, -1.059 | 6, -1.3980, -0.9368, |
| -1.0472, -1.0496, -0.8935, -0.50 | 5025, -0.3689, -0.8782, -0.6977, -1.1389, -1.2191, -1.8293, -0.8277, -1.2254, -0.9360, 0.2584, 0.0701, 0.3300, -0.3589, -0.4467, 0.4078, -0.9137, -1.276, 0.0001, 0. | 9, -2.1279, -1.9331, |
| -1.0/2/, -1.1611 , -1.4169 , -1.88 | 8877, -2.2804 , -1.9155 , -1.7955 , -1.8981 , -2.3272 , -2.3595 , -2.1115 , -1.8899 , -2.5229 , -0.88995 , -0.9552 , -1.3094 , -1.1083 , -1.5866 , -2.1248 , -1.9394 , -1.917 , -1.917 , -1.917 , -1.918 , -1.918 , -1.918 , -1.919 , -1.918 , -1.919 , | -1.8677, -1.8677 , -1.0134 |
| -1.29041.71941.20281.34 | 5.64, -2.929, -0.6730, -1.1994, -1.7375, -1.2930, -1.8644, -0.3964, -0.7911, -1.5760, -1.2899, -1.2970, -1.2159, -1.4817, -0.9655, -1.8565, -1.5177, -1.3864, -0.7911, -1.5760, -1.2899, -1.2570, -1.2159, -1.4817, -0.9655, -1.8565, -1.5177, -1.3864, -1.3864, -1.3864, -1.3864, -1.3864, -1.5970, -1.2159, -1.4817, -0.9655, -1.8565, -1.5177, -1.3864, -1.5177, -1.5864, -1.5977, -1.5977, -1.2159, -1.2159, -1.5867, -1.5867, -1.5177, -1.5864, -1.5867, -1.58 | 2, -2.3523, -2.1114. |
| -1.5432, -1.8544, -1.9770, -1.88 | 8833, -2.2069, -1.9684, -2.6540, -1.9523, -2.2804, -1.9461, -2.4001, -1.9420 | |
| 2, 40.79610, 14.55526, 23. | 3,39, -0.1246, 0.5990841, -0.0708348, 0.3309514, 0.9409854, 0.0000, 0.7673, 1.3539, 1.5718, 1.4283, 0.8956, 0.9227, 0.4100, 1.2002, -0.0099, 0.8860, 0.5134, | 0.8030, 0.7781, |
| 0.4034, -0.0901 , -0.2394 , -0.434 | 342, 0.4551, 0.3762, -0.1230, -0.5861, -0.2110, 0.0237, -0.0258, -0.1176, -0.0072, -0.5681, -0.4695, 0.0238, 0.2228, -0.6481, 0.2543, 0.1261, -0.0197 504, 0.2022, 0.2776, 0.2007, 0.2701, 0.5040, 0.2600, 0.2519, 0.2529, 0.1004, 0.4701, 1.6522, 1.0207, 0.202 | , 0.2637, -0.1321, |
| -0.1825, -0.0385, 0.4358, 0.33 | -0.4128, 0.4276 , -0.7135 , 0.1259 , -0.2733 , -0.2736 , 0.2247 , 0.4232 , 1.61632 , 0.4701 , 1.0227 , 1.0257 , 0.1262 , 0.2027 , 0.2023 , 0.2427 , -0.2135 , 0.1259 , 0.2136 , -0.2136 , | 8, -0.0434, -0.3375, |

Deformation Time Series Data Format

| Data_Type: LOS_Displacement_Time_Series | 5 | | | | | | | | | | | | | | |
|---|--------------|--------------|----------------|-----------------|------------|--------------|-------------|----------------|--------------|---------------------------------------|--------------|--------------|-------------|-----------------------|--------------|
| Processing_ID: | | | | | | | | | | | | | | | |
| Software_version: CNR-IREA P-SBAS 24 | | | | | | | | | | | | | | _ | |
| Applied_algorithm_description: Paralle | #### | 0.53 | 10055 | | | | | | | | | | | 1 | |
| Main_reference: 10.1109/TGRS.2002.80379 | TD | Lat | Lon | Topo | Ve1 | Coer | COSN | COSE | cosli | TS | | | | | |
| Date_of_production: 20170906T19:55:03Z | 10, | 40 70610 | 14 55529 | 22 63 | -0 0150 | 4077162 -1 | 0709349 | 0 3300500 | 0 0100956 | 0 0000 | 0 0117 | 0 5500 | 0 9460 | | |
| Date_ot_publication: 201/0906/19:55:034 | 0 5617 | 40.79019, | 14.33320 | 0 0500 | 0.0150, | 0.49//102,-1 | 0.0010 | 0.3309309, | 0.9409030, | 0.0000, | -0.0447, | 0.0307 | 0.0400, | | |
| Geographic CS Type Code: 4326 | 0.3017, | 0.0314, | -0.0337, | 0.0580, | 0.4950, | -0.3504, | 0.0918, | -0.3520, | 0.0883, | -0.2442, | 0.1199, | -0.9397, | -0.0910, | | |
| Spatial Resolution: 10 | -0.51/5, | 0.1186, | -0.5135, | -0.7090, | -1.4423, | -1.0200, | -0.7472 | , -0.8378, | -0.7120, | -0.9/0/, | -0.6839, | -0.6927, | -0.7284, | | |
| Sensor: ERS/ENV | -1.3812, | -0.3774, | -0.7050, | -1.3457, | -0.0618, | -0.3687, | -0.3964, | , -0.2656, | -0.3921, | -0.1357, | -0.7164, | -0.3537, | -0.8132, | | |
| Mode: STRIP | -0.0111, | -0.6115, | -0.2649, | -0.4436, | -0.2018, | -0.6554, | -0.2136, | , 0.1075, | -0.0862, | -0.1700, | -0.2309, | 0.5714, | -0.4668, | | |
| Antenna_Side: Right | -0.6589, | -0.6371, | -0.8101, | 0.0341, | -0.2904, | -0.4609, | -0.6353, | , -0.5529, | 0.4250, | -0.3450, | -0.3409, | 0.0416, | -0.3454, | | |
| Relative_Orbit_Number: | -0.7578, | -0.2740, | 0.0507, | 0.0210, | 1.0166, | 0.5949, | 0.0731, | , -0.4265, | 1.2682, | 0.9623, | -0.2040, | -0.1390, | -0.8602, | | |
| Number of dates: 164 | -1.1585, | 0.0320, | -0.2427, | -0.2448, | -0.6898, | -1.2993, | -0.8081 | , -0.2727, | -1.5483, | -1.6003, | -1.6408, | -1.1059, | -0.7593, | | |
| Time Years: 1992.4397. 1992.6310. 1992 | -1.0069. | -0.1959. | 0.0679. | -0.0516. | 0.0694. | -0.8841. | -0.8382 | -0.5145. | -1,4829. | -0.9601. | -0.7658. | 0.0430. | -0.2961. | 4. 1995.5751. 1995.66 | 66. 1995.669 |
| 1995.7648, 1995.8591, 1995.9534, 1995.9 | -0.6888. | -0.8383. | -0.7406. | -0.4620. | -0.3646. | -0.2338. | -0.1466 | -0.5486. | -0.8241. | -0.6292. | -0.9149. | -0.7899. | 0.2065. | 1997.3947, 1997.5861 | , 1997.6787, |
| 1997.7758, 1997.8701, 1997.9671, 1998.1 | -0.3052 | -0.9247 | -0.8277 | -0.4250 | -0.1803 | 0.4468 | 0.0352 | -0.1421 | 1.0865 | 0.6091 | 0.0481 | 0,0020 | -0.3539 | 2000.0751, 2000.1705 | , 2000.1733, |
| 2000.2676, 2000.3646, 2000.4589, 2000.5 | -0 1126 | -0 0401 | -0 5522 | -0 3287 | 0 0100 | -0 3076 | -0 3731 | _0 0354 | -0 1042 | -0 3878 | 0 6312 | -0 2608 | -0 0822 | 2003.6228, 2003.6228 | , 2003.7170, |
| 2003.8141, 2003.8141, 2003.9084, 2004. | 0 4152 | 0.6512 | 0.5007 | 1 0707 | 0.01105, | 0.1001 | 0. 7012 | 0.7301 | 0 6142, | 0.3070, | 1 0220 | 1 0556 | 1 0022, | 2005.7280, 2005.7281, | , 2005.8250, |
| 2005.8251, 2005.9205, 2005.9205, 2006.0 | -0.4152, | -0.0513, | -0.5007, | -1.0/0/, | -0.9410, | -0.4231, | -0.7913 | , -0.7391, | -0.0142, | -0.7576, | -1.0236, | -1.0550, | -1.0021, | 2007.8371, 2007.9342, | , 2008.1228, |
| 2010 3305 2010 4259 2010 6173 2010 1 | -0.8540, | -0.8580, | -1.0034, | -0.8529 | 0 00.11 | | | 0. 0000544 | | 0 0000 | 0 0100 | 0 0700 | | 2010.0394, 2010.1337, | , 2010.2502, |
| List of Dates: 19920608T09:49:13Z. 1992 | 1, | 40.79613, | 14.55526 | , 23.69, | -0.0841, | 0.5550467,-0 | 0.0/08348, | 0.3309511, | 0.9409856, | 0.0000, | -0.6489, | 0.6/13, | 0.4659, | 0802T09:49:17Z, 19930 | 906T09:49:18 |
| 19931011T09:49:14Z, 19931115T09:49:08Z, | 0.3871, | -0.3206, | -0.2056, | -0.3410, | 0.3008, | -0.9633, | -0.1709, | -0.6272, | -0.2120, | -0.3700, | -0.6062, | -1.3241, | -1.0061, | 19951109T09:49:21Z, | |
| 19951213T09:49:21Z, 19951214T09:49:23Z, | -1.2058, | 0.0382, | -0.4689, | -1.1392, | -1.6203, | -1.2624, | -0.9336, | , -1.1100, | -0.9320, | -1.6653, | -1.2112, | -1.2797, | -1.2244, | 19960919T09:49:19Z, | |
| 19961024T09:49:19Z, 19961128T09:49:14Z, | -1.2644, | -0.5793, | -0.5549, | -1.1882, | -0.8539, | -0.5611, | -0.9347 | , -0.8108, | -1.3637, | -0.6868, | -0.6813, | -0.6416, | -0.7490, | 19971218T09:49:12Z, | |
| 19980226T09:49:10Z, 19980507T09:49:13Z, | -0.4043, | -0.4973, | -0.3890, | -0.3513, | -0.0088, | -1.1278, | -0.4046 | -0.3960, | -0.4018, | -0.0544, | -0.9219, | -1.0493, | -1.1079, | 19990527T09:49:14Z, | |
| 19990/01/09:49:112, 19990805/09:49:082, | -0.7512. | -1.0596. | -1.3980. | -0.9368. | -1.0472. | -1.0496. | -0.8935 | -0.5025. | -0.3689. | -0.8782. | -0.6977. | -1.1389. | -1.2191. | 20000/20109:49:1/2, | |
| 20000024109:49:242, 20000928109:49:242, 20021107700.10.147 20021212700.47.367 | -1.8293. | -0.8277. | -1.2254. | -0.9360. | 0.2584. | 0.0701. | 0.3300 | -0.3589. | -0.4467. | 0.4078. | -0.9137. | -1.2769. | -2.1279. | 20021003109:47:412, | |
| 20021107109:19:142, 20021212109:47:302, 20040311T09:19:19:217, 20040415T09:19:187 | -1 0331 | -1 0727 | -1 1611 | -1 4169 | -1 8877 | -2 2804 | -1 9156 | -1 7966 | -1 8981 | -2 3272 | -2 3595 | -2 1116 | -1 8899 | 20050505T09:47:537 | |
| 20050609T09:47:55Z, 20050714T09:19:26Z | _2 5220 | _0 9900 | _0 0552 | _1 2004 | _1 10077, | 1 5966 | -2 1249 | _1 0204 | _1 9167 | -2 2727 | _1 9677 | _1 0001 | _1 4506 | 20060316T09:19:11Z, | |
| 20060525T09:19:17Z, 20060525T09:47:51Z | -2. 5229, | 1 0762 | 1 0425 | 1 6272 | 1 7004 | -1.3600, | 1 2120 | , -1.9394, | -1.0107, | 1 5531, | -1.00/7, | 1 0453 | -1.4390, | 20070510T09:19:16Z, | |
| 20070719T09:19:18Z, 20070823T09:47:37Z, | -1.5900, | -1.9702, | -1.0423, | -1.03/3, | -1.7994, | -1.4034, | -1.3130 | , -1.9079, | -1.5500, | -1.5551, | -2.0012, | -1.0455, | -0.9475, | 20080911T09:19:08Z, | |
| 20080911T09:49:07Z, 20081016T09:19:10Z, | -2.5125, | -2.1403, | -1.90/3, | -0.9833, | -1.24/1, | -0./116, | -1.0134, | , -0.8116, | -1.2904, | -1./194, | -1.2028, | -1.3464, | -2.0929, | 20091105T09:19:05Z, | |
| 20091210109:19:012, 20100114109:19:042, | -0.6/30, | -1.1094, | -1./3/5, | -1.2930, | -1.0544, | -1.3064, | -0.7911, | , -1.55/6, | -1.2899, | -1.5970, | -1.2159, | -1.481/, | -0.9565, | | |
| Reference Point: 14 605127 41 204173 | -1.8565, | -1.5177, | -1.3892, | -2.3523, | -2.1114, | -1.5432, | -1.8544, | , -1.9770, | -1.8833, | -2.2069, | -1.9684, | -2.6540, | -1.9523, | | |
| Applied Corrections: n/a | -2.2804, | -1.9461, | -2.4001, | -1.9420 | | | | | | | | | | | |
| Applied Filter: none | 2, | 40.79610, | 14.55526 | , 23.39, | -0.1246, | 0.5990841,-0 | 0.0708348, | 0.3309514, | 0.9409854, | 0.0000, | 0.7673, | 1.3539, | 1.5718, | | |
| Map of incidence angle for geotiff: n/a | 1.4283, | 0.8956, | 0.9227, | 0.4100, | 1.2002, | -0.0099, | 0.8860, | 0.5134, | 0.8030, | 0.7781, | 0.4034, | -0.0901, | -0.2394, | | |
| Lookup table from radar to ground: n/a | -0.4342. | 0.4551. | 0.3762. | -0.1230. | -0.5861. | -0.2110. | 0.0237 | -0.0258. | -0.1176. | -0.0072. | -0.5681. | -0.4695. | 0.0238. | | |
| Inputs_ID: inputIDs.txt | 0.2228. | -0.6481. | 0.2543. | 0.1261. | -0.0197. | 0.2637. | -0.1321. | 0.4251. | 0.0647. | 0.0923. | 0.3694. | 0.2032. | 0.3776. | | |
| L1ST_ot_interrerograms_osear n/a | 0.3921 | 0.7701 | 0.5940 | 0.3039 | 0.2618 | 0.3538 | 0 1894 | 0.4781 | 1.0522 | 1.0297 | 0.9890 | 0.2202 | 0.2093 | | |
| TD. Lat. Lon. Tor | 0 2427 | -0 2103 | 0 0633 | 0 2440 | -0 1825 | -0 0385 | 0 4358 | 0 3300 | 0 4128 | 0 2776 | -0 7135 | 0 1250 | -0 2733 | | |
| 0. 40.79619. 14.55528. 23.6 | 0.7205 | 0.2195, | 0 4222 | 1 6197 | 0.5010 | -010303, | 1 0700 | 0 1459 | 1 2077 | 1 1209 | 0, 2126 | 0.1235, | 0 0121 | 0.3526. 0.0883. | -0.2442. |
| 0.1199, -0.9397, -0.0916, -0.5175 | -0.7305, | 0.2247, | 0.4232, | 1.1250 | 1. 3400, | 0.4050, | 1.1001 | , -0.1430, | 1.20//, | 1.1590, | -0.2130, | 1 7272 | -0.0434, | -0.0618, -0.3687, | -0.3964, |
| -0.2656, -0.3921, -0.1357, -0.716 | -0.3375, | -0.3543, | -0.5903, | -1.1259, | -1.2409, | -1.4953, | -1.1901, | , -1.4550, | -0.9181, | -1.1048, | -2.0907, | -1./2/2, | -1.0397, | -0.6371, -0.8101, | 0.0341, |
| -0.2904, -0.4609, -0.6353, -0.552 | -0.9131, | -1.3514, | -0.7922, | -0.5565, | -0.6128, | -0.38/8, | -0.8495 | , -1.3844, | -1.0523, | -1.8036, | -1.3288, | -0.4339, | -1.2589, | -0.1390, -0.8602, | -1.1585, |
| 0.0320, -0.2427, -0.2448, -0.6898 | -1.1261, | -1.2041, | -0.6286, | -1.0501, | -0.9099, | -0.8544, | -0.4754 | , -1.1869, | -0.4668, | -1.2417, | -1.0946, | -1.1087, | -0.4443, | -1.4829, -0.9601, | -0.7658, |
| 0.0430, -0.2961, -0.6888, -0.8383 | -0.7035, | -0.9435, | -1.2550, | -1.4827, | -0.6577, | -0.3015, | -0.5599, | , 0.1924, | -0.6888, | -0.1675, | -0.5282, | -0.6011, | -1.1320, | 0.4468, 0.0352, | -0.1421, |
| -0.4231 -0.7913 -0.7391 -0.614 | -0 7378 | -1 0238 | -1 0556 -1 | 0021 -0 8540 | -0 8580 | -1 0634 | -0 8529 | | | · · · · · · · · · · · · · · · · · · · | | ·····, ····· | | -0.5007, -1.0707, | -0.9410, |
| 1. 40.79613. 14.55526. 23.6 | -0.0841 | 0.55504670.0 | 708348. 0.3309 | 511. 0.9409856. | 0.0000. | -0.6489. | 0.6713. 0. | 4659. 0.3871 | 0.3206. | -0.2056 | 0.3410. 0.30 | 080.9633. | -0.1709. | -0.62720.2120. | -0.3700. |
| -0.6062, -1.3241, -1.0061, -1.205 | 8, 0.0382, | -0.4689, | -1.1392, -1. | 6203, -1.2624 | , -0.9336 | , -1.1100, | -0.9320, - | 1.6653, -1.21 | 12, -1.2797 | -1.2244, | -1.2644, -0. | 5793, -0.554 | 9, -1.1882. | -0.8539, -0.5611, | -0.9347, |
| -0.8108, -1.3637, -0.6868, -0.681 | 3, -0.6416, | -0.7490, | -0.4043, -0. | 4973, -0.3890 | , -0.3513 | , -0.0088, | -1.1278, - | 0.4046, -0.39 | 60, -0.4018 | -0.0544, | -0.9219, -1. | 0493, -1.107 | 9, -0.7512, | -1.0596, -1.3980, | -0.9368, |
| -1.0472, -1.0496, -0.8935, -0.502 | 25, -0.3689, | -0.8782, | -0.6977, -1. | 1389, -1.2191 | , -1.8293 | , -0.8277, | -1.2254, - | 0.9360, 0.25 | 84, 0.0701, | 0.3300, | -0.3589, -0. | 4467, 0.407 | 8, -0.9137, | -1.2769, -2.1279, | -1.9331, |
| -1.0727, -1.1611, -1.4169, -1.887 | 7, -2.2804, | -1.9156, | -1.7966, -1. | 8981, -2.3272 | 2, -2.3595 | , -2.1116, | -1.8899, - | 2.5229, -0.88 | | -1.3094, | -1.1083, -1. | 5866, -2.124 | 8, -1.9394, | -1.8167, -2.2737, | -1.8677, |
| -1.0891, -1.4596 , -1.5966 , -1.976 | 2, -1.8425, | -1.6373, | -1.7994, -1. | 4634, -1.3138 | s, -1.9679 | , -1.5566, | -1.5531, - | -2.0612, -1.84 | -0.9473, | -2.5125, | -2.1403, -1. | 90/3, -0.983 | 5, -1.2471, | -0.7116, -1.0134, | -0.8116, |
| -1.2904, -1.7194 , -1.2028 , $-1.346-1.5432$, -1.8544 , -1.0770 , -1.092 | -2.0929, | -1.0684 | -2.6540 -1 | 9523 _2 200/ | | , -1.3004, | -1.9420 | -1.28 | , -1.5970 | -1.2159, | -1.481/, -0. | a202, -1.820 | 5, -1.51//, | -1.3092, -2.3523, | -2.1114, |
| 2. 40.79610. 14.55526. 23.3 | 90.1246 | 0.59908410.0 | 708348. 0.3300 | 514. 0.9409854 | 0.0000 | 0.7673. | 1.3539. 1. | 5718. 1.4283 | 0,8956 | 0.9227. | 0.4100. 1.20 | 020.0099 | 0.8860. | 0.5134. 0.8030 | 0.7781. |
| 0.4034, -0.0901, -0.2394, -0.4342 | 0.4551. | 0.3762, - | -0.1230, -0.5 | 5861, -0.2110 | 0.0237. | -0.0258, | -0.1176, -0 | .0072, -0.568 | 31, -0.4695. | 0.0238, | 0.2228, -0.6 | 481, 0.2543 | , 0.1261, | -0.0197, 0.2637. | -0.1321, |
| 0.4251, 0.0647, 0.0923, 0.3694 | , 0.2032, | 0.3776, | 0.3921, 0.7 | 701, 0.5940, | 0.3039, | 0.2618, | 0.3538, 0 | .1894, 0.478 | 1, 1.0522, | 1.0297, | 0.9890, 0.2 | 202, 0.2093 | , 0.2427, | -0.2193, 0.0633, | 0.2440, |
| 1825, -0.0385, 0.4358, 0.330 | 0, 0.4128, | 0.2776, | -0.7135, 0. | 1259, -0.2733 | 3, -0.7305 | , 0.2247, | 0.4232, | 1.6182, 0.59 | 0.4830, | 1.0708, | -0.1458, 1. | 2877, 1.139 | 8, -0.2136, | -0.3718, -0.0434, | -0.3375 |

Sentinel-1 wide Coverage: the Napoli Bay area



Stable InSAR analyses require at least two-three years of data, especially for the removal of Atmospheric artefacts that are quite severe for Sentinel IW Interferograms





Sentinel-1: a Small Baseline constellation

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Sentinel-1 SBAS results on the Napoli Bay area: Preliminary Results

descending orbits



Atmospheric artefacts are difficult to be removed (very large swath, wider beams, etc ...)

Accurate estimates require a (stable) population of more than three years, thus facilitating the removal of all the disturbances affecting Sentinel-1 Deformation Time-Series

LOS <-6 cm/year

07 October 2014 – 06 April 2017

81 SLC

NEW DATA ARE NEEDED FOR ASSESSING THE QUALITY OF ACHIEVED RESULTS AND MAKE THEM MORE STABLE !!!!

>6



Radiometric Calibration of di SAR Images

Algorithm development







Radiometric Calibration of the SAR Images: A New Formulation



SAR image analysis

Investigate the soil consumption effects through the analysis of the detected reflectivity changes and of the retrieved surface displacements

- sigma naught (σ⁰) maps: SAR images have to be properly radiometrically calibrated (including the effect of topography) and geocoded.
- Multitemporal analysis of the σ⁰ variation
- Vegetation consumption, vegetation mortality, soil alteration





An Example: VH Sigma Naugth Difference Maps



Darker areas correspond to an area affected by fires in Sardinia. Similar analyses will be provided for the monitoring of the backscattered signal variations <u>in urban scenarios</u>

