SAR Data Exploitation

Analisi Dati SAR con I Satelliti COSMO-SkyMed

CC(AN) Filippo Biondi (Ph.D)

SAR Data Exploitation

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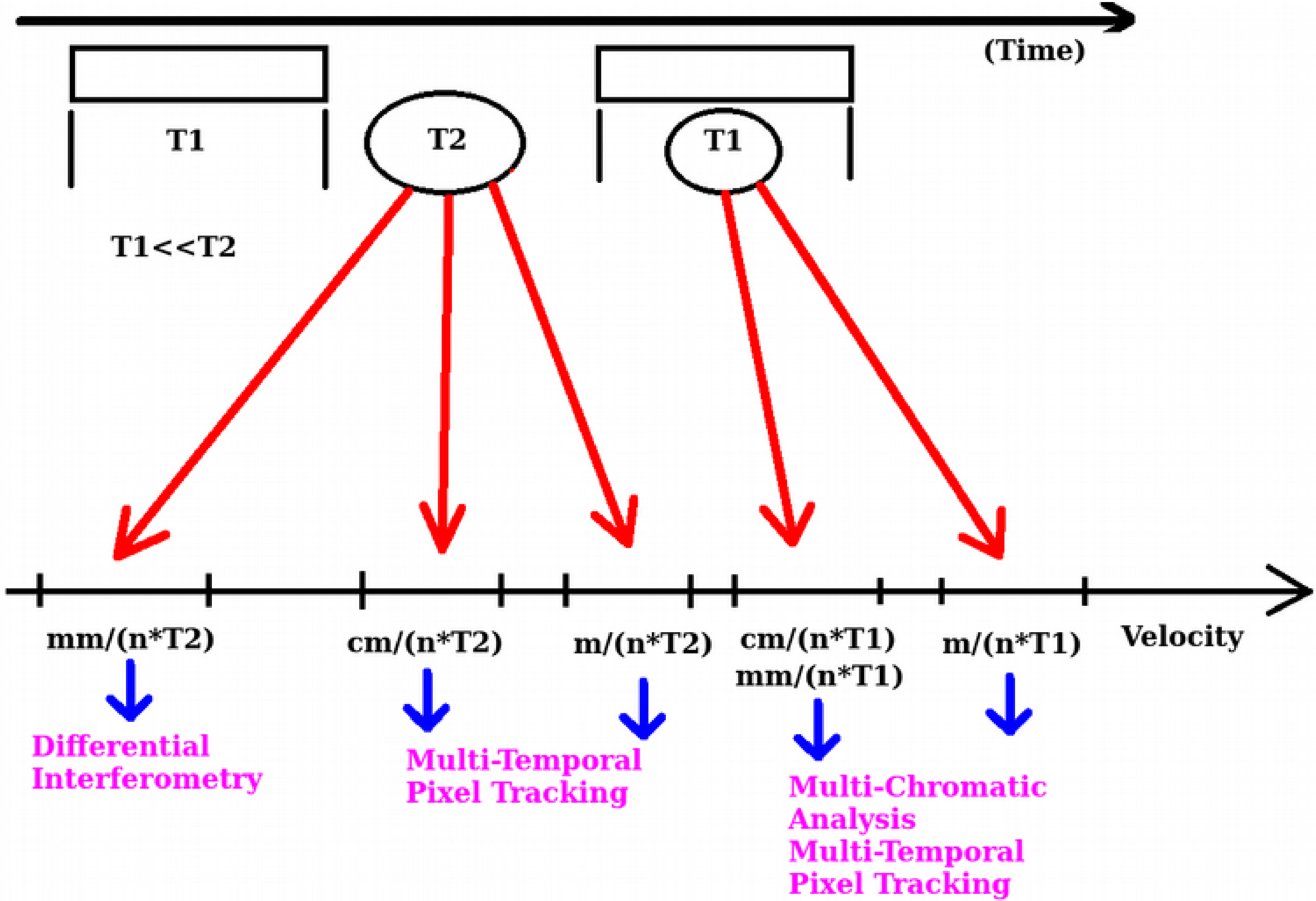
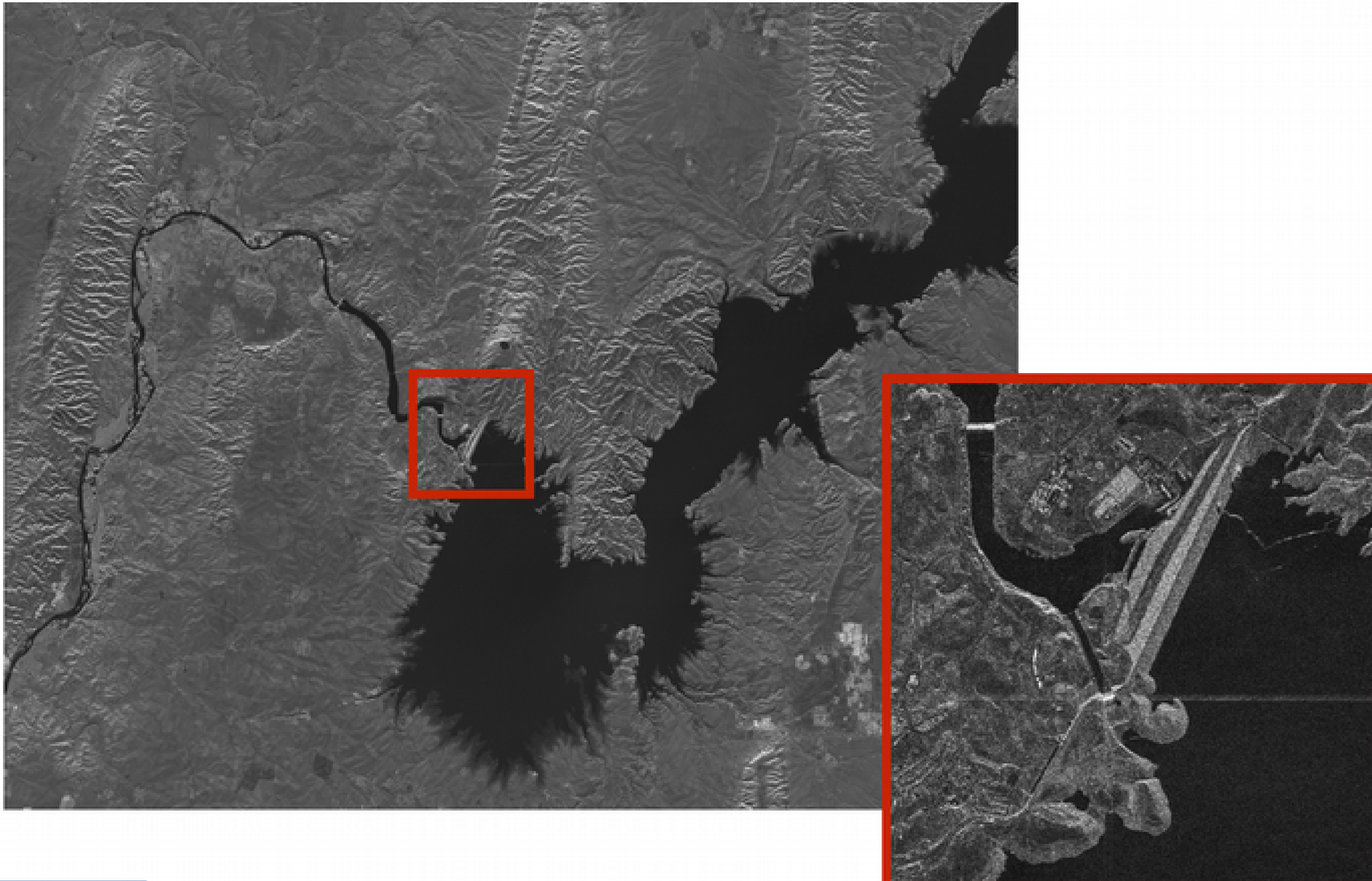


Mosul dam – description



SAR Temporal Analysis

- 62 STRIPMAP COSMO-SkyMed data processed;
- Fast multi coregistration;
- (62x62)/2=1922 interferograms;
- First acquisition date: 31/12/2012;
- Last acquisition date: 23/06/2015;
- Dynamic D-InSAR and Persistent Scatterers Interferometry.

PS: Coherent information extraction from stable radar targets. This information is present along all the coherences estimated from all the temporal series of the SAR images.

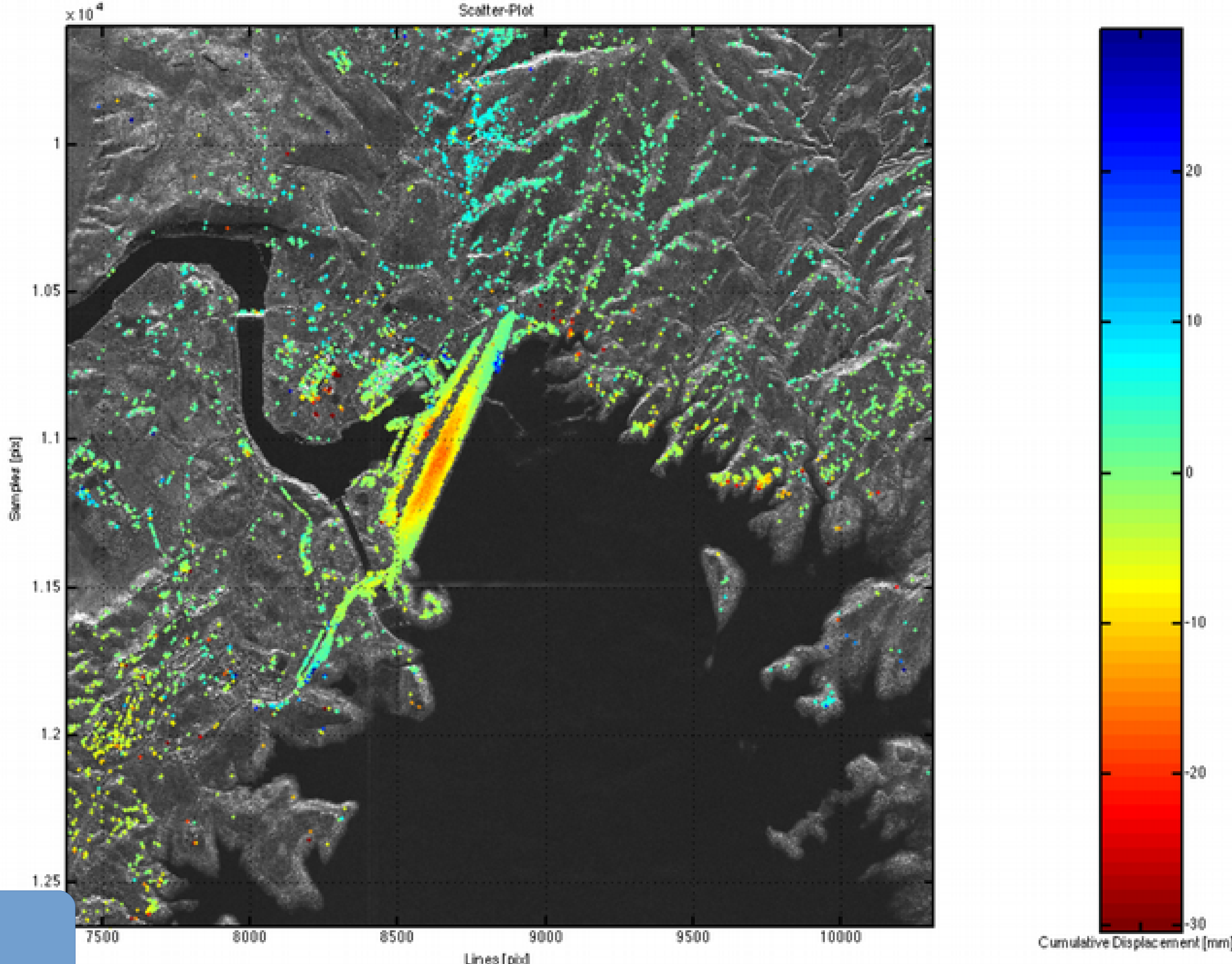
The signal processing technique allows the estimation of the terrain subsidence with millimeter precision.

PS can also be a valid substitute of the differential GPS.

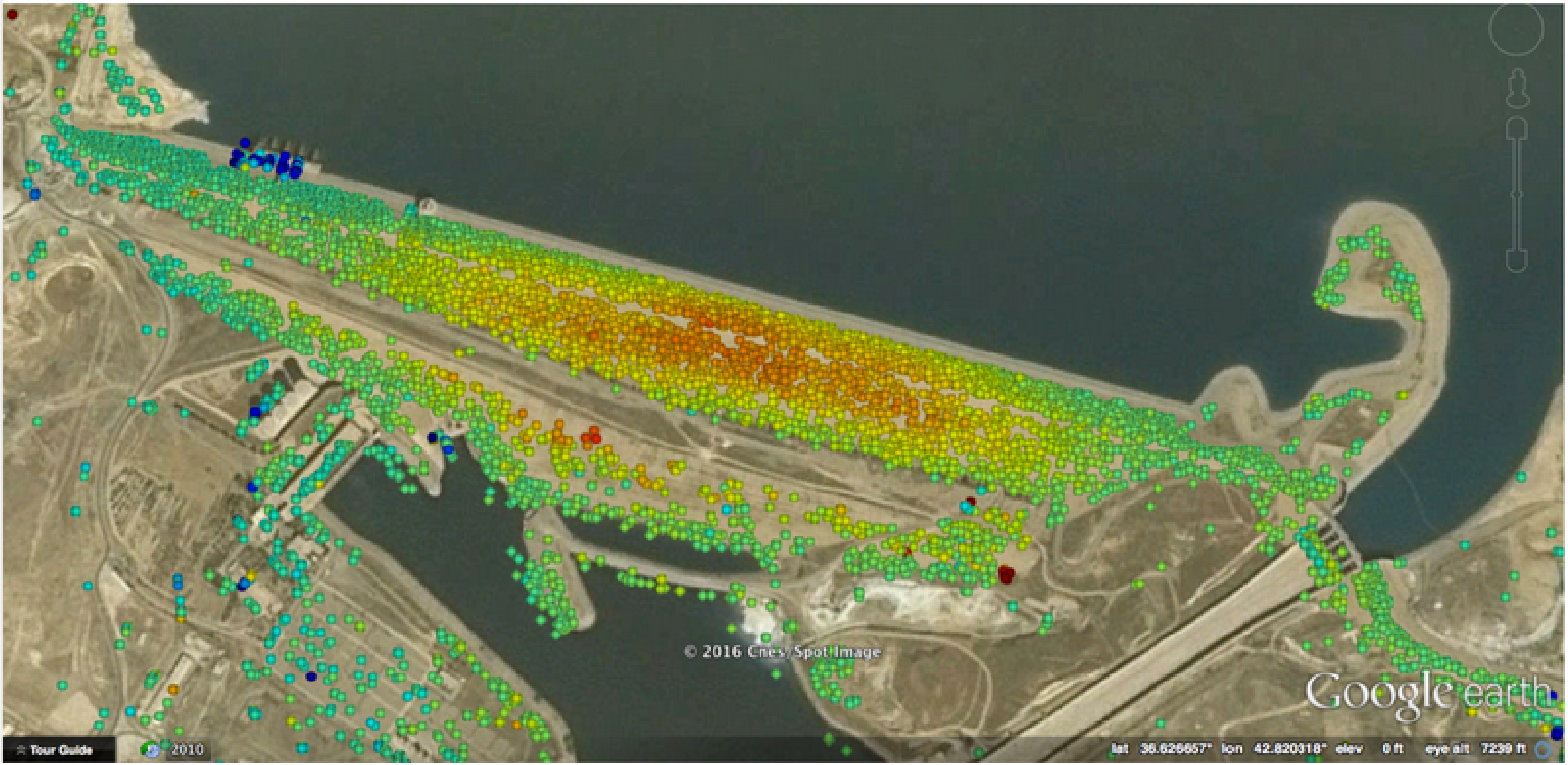
PS – good

PS – bad

Subsidence Analysis

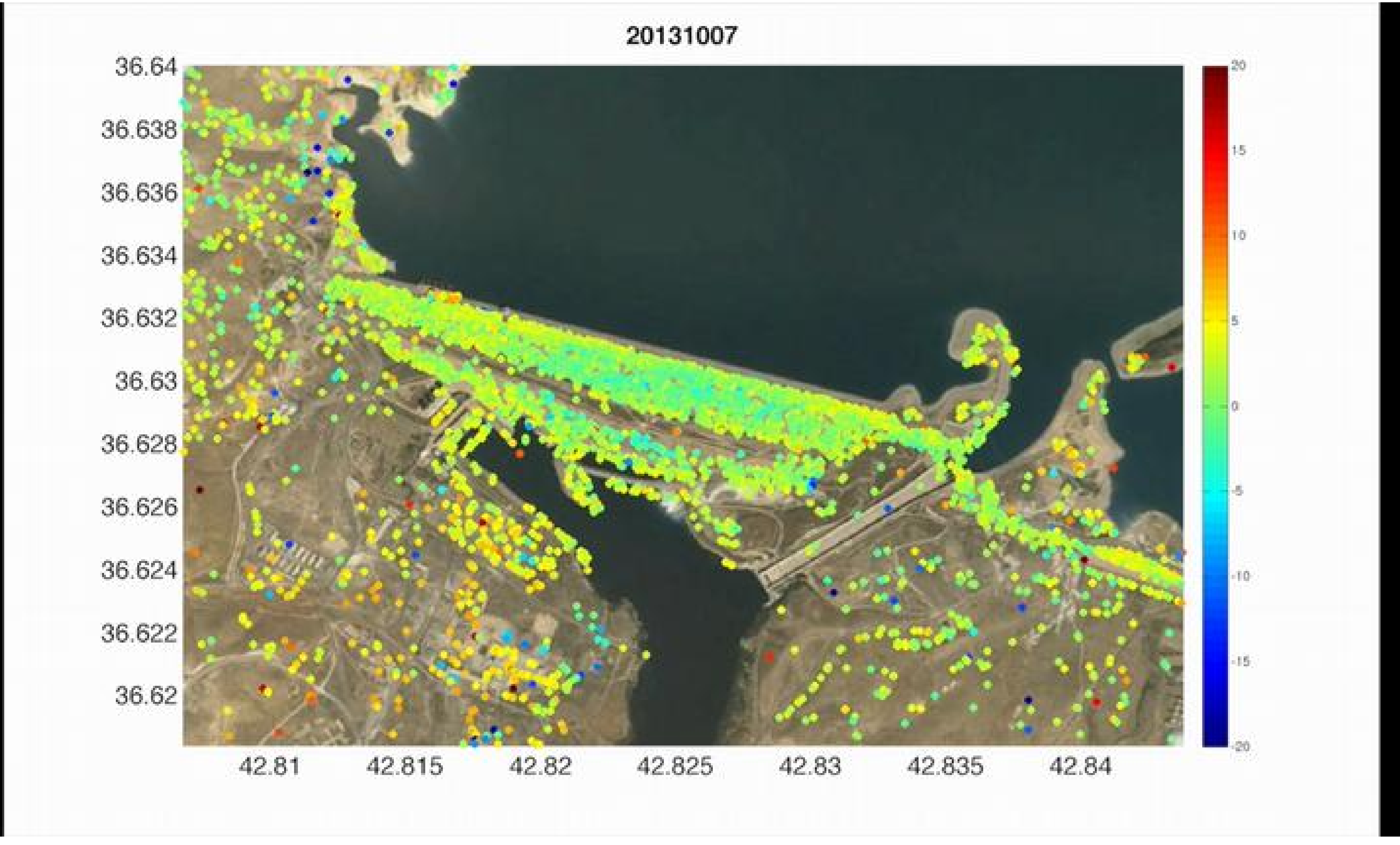


Subsidence Analysis



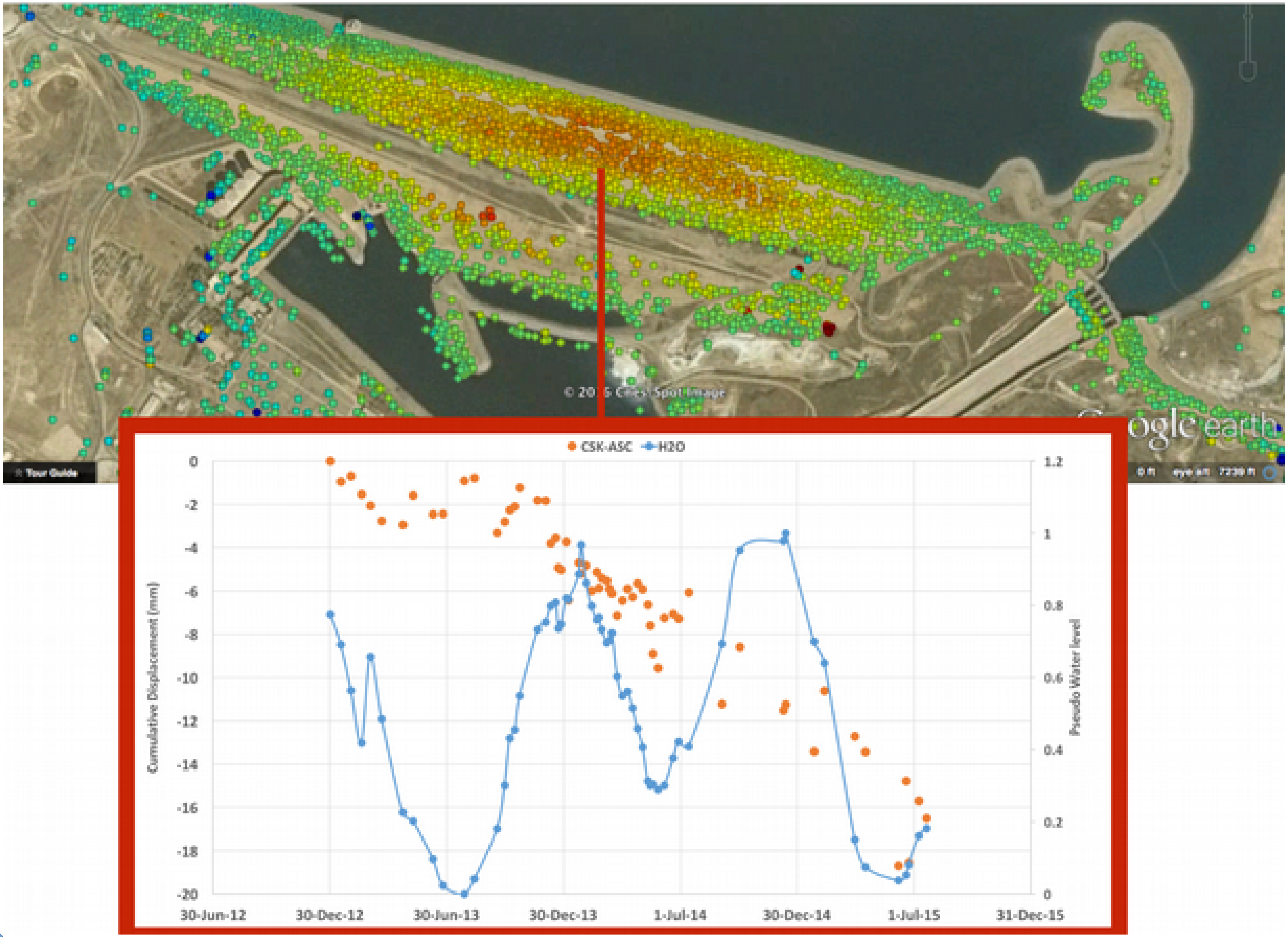
Geo-located Permanent Scatterers

Subsidence Analysis



PS – Dynamic Video

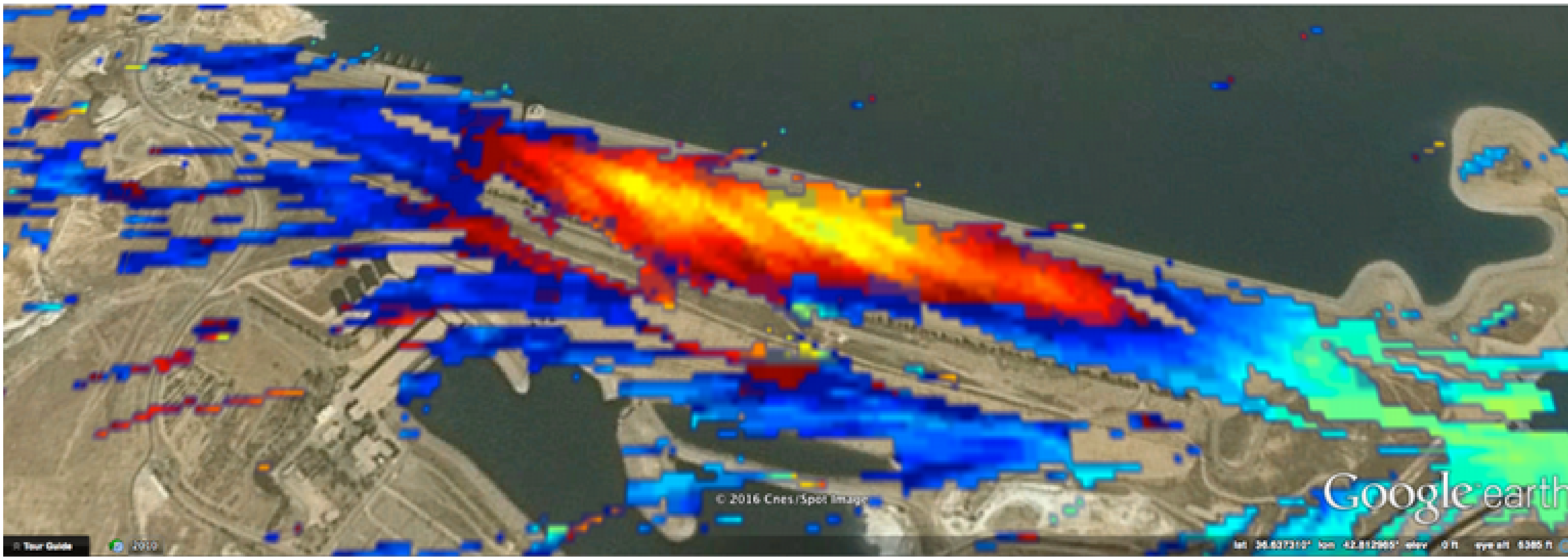
Subsidence Analysis



ENVISAT-CSK Data Fusion

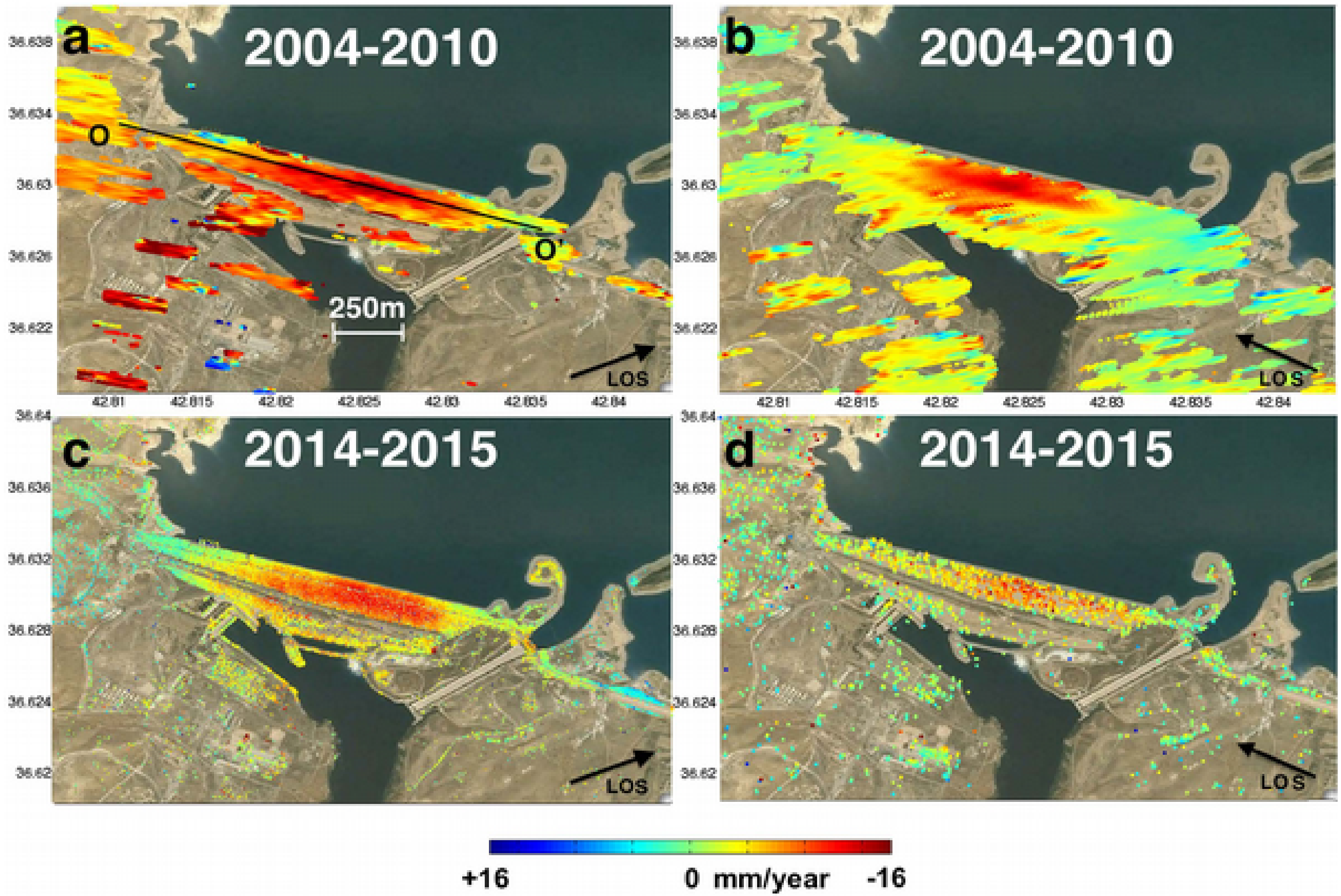
ENVISAT 2004 - 2010

ENVISAT-CSK Data Fusion



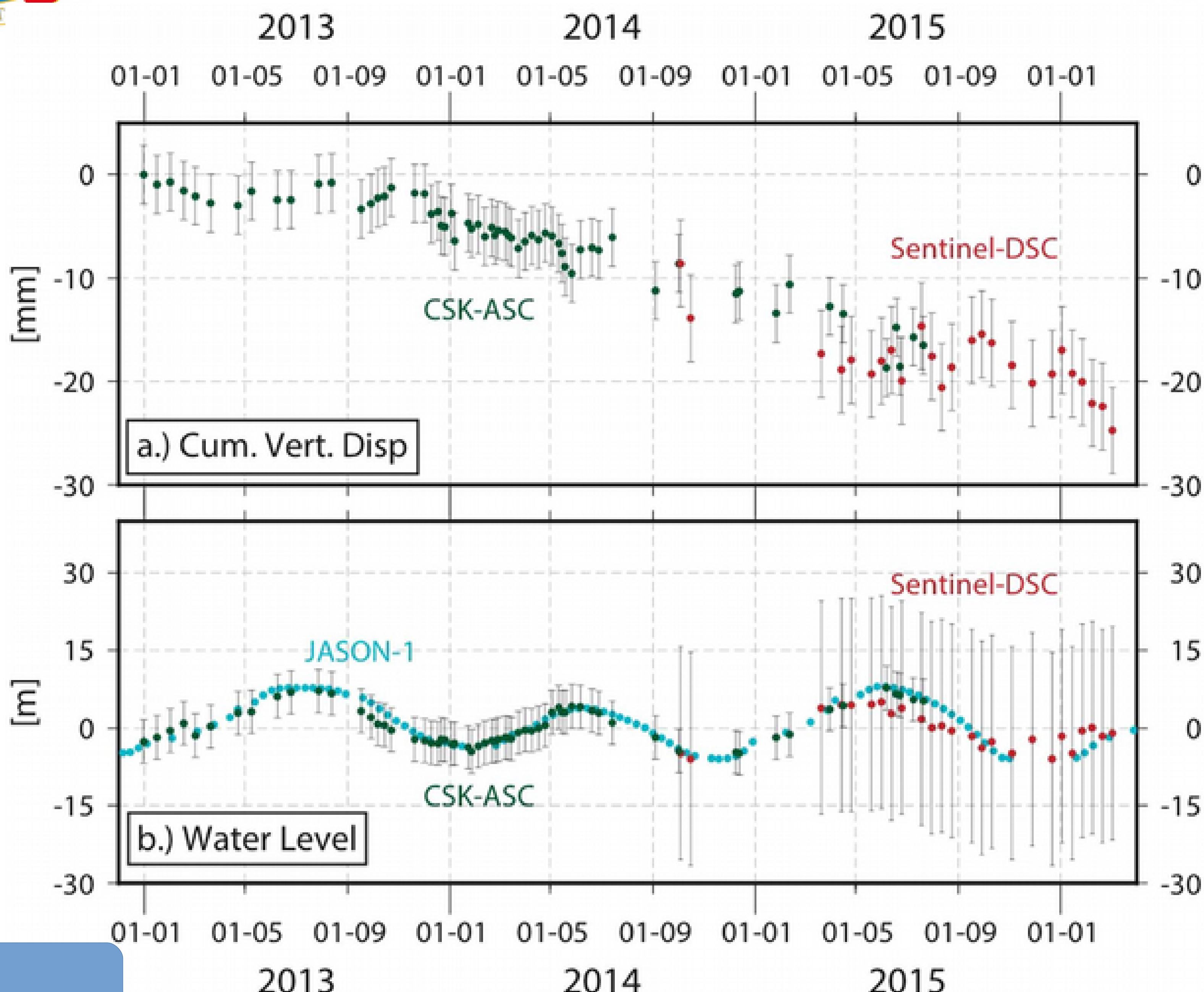
ENVISAT PS processing results

ENVISAT-CSK Data Fusion



(a): ENVISAT; (b): ENVISAT; (c): CSK; (d): Sentinel.

ENVISAT-CSK Data Fusion



CSK – Campotosto

L'Aquila – Abruzzo (Italy)

CSK – Campotosto

Location: L'Aquila (Abruzzo – Italy);
Height: 1313 meters;
Surface: 14 km^2;
Volume: 0.218 km^3;
Immission: Rio Fucino;
Emmission: Rio Fucino.

L'Aquila altitude= 721 meters

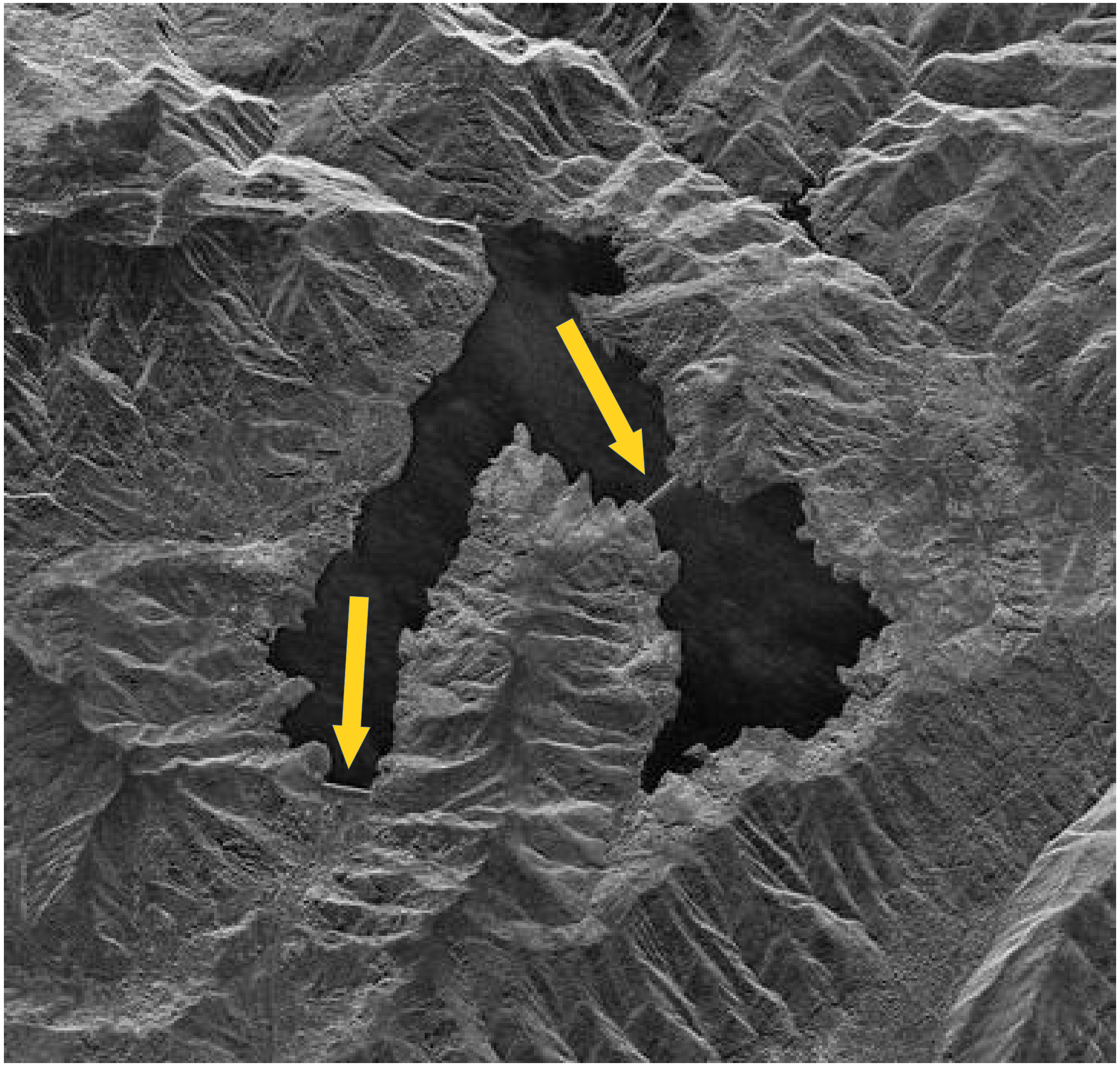
Campotosto – L'Aquila Height GAP= 592m

L'Aquila – Abruzzo (Italy)

CSK – Campotosto

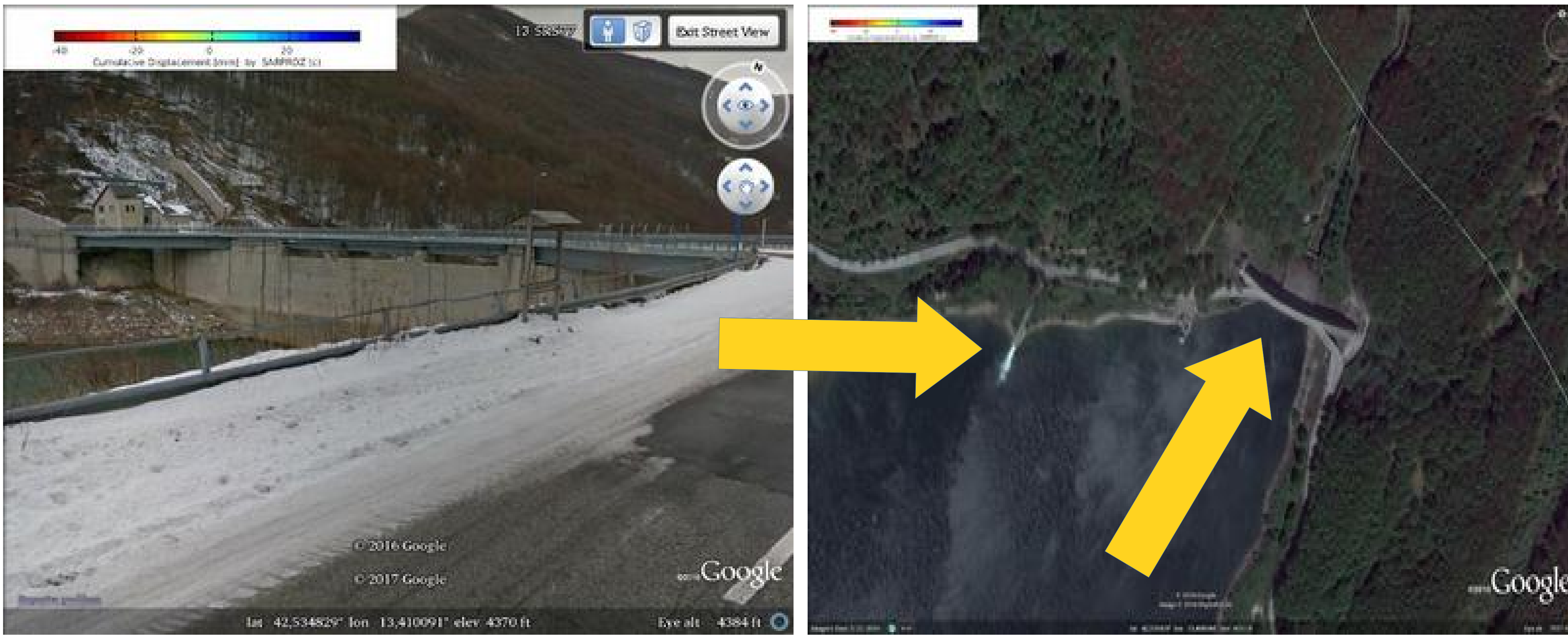
L'Aquila – Abruzzo (Italy)

CSK – Campotosto



Campotosto Lake – COSMO-SkyMed View

CSK – Campotosto



Campotosto – Rio Fucino dam

CSK – Campotosto

Campotosto – Poggio Cancelli dam

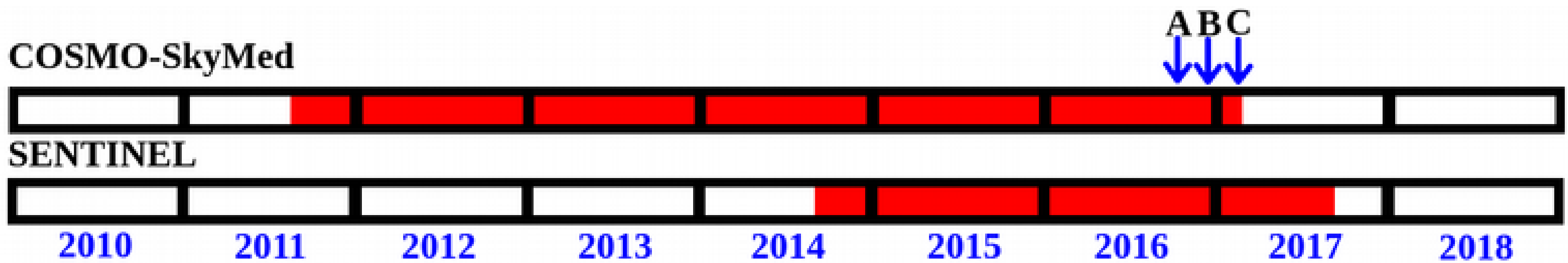
CSK – Campotosto

Campotosto – Sella Pedicate dam

CSK – Campotosto

Campotosto – Bridge

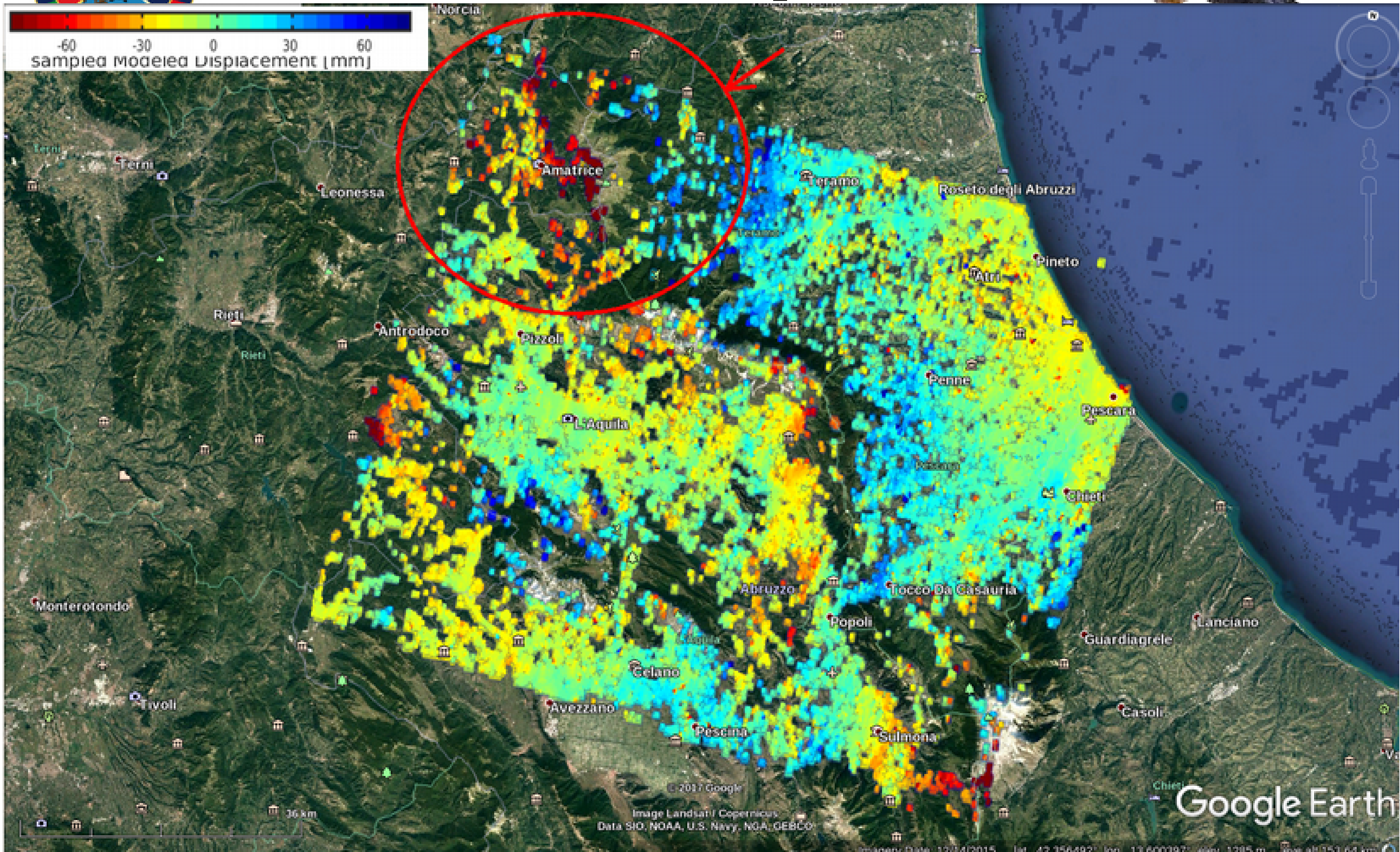
CSK – Campotosto



A= 6.0 Richter epicenter Rieti. Date: 2016-08-24. Time: 01:36:32. Geo: Lat. 42.6983 Lon. 13.2335
B= 5.4 Richter epicenter Macerata. Date: 2016-10-26. Time: 17:10:36.34. Geo: LAt. 42.8802 Lon. 13.1275
C= 5.0 Richter epicenter L'Aquila. Date 2017-01-18. Time: 13:33:36.76. Geo: Lat: 42.4773 Lon: 13.2807

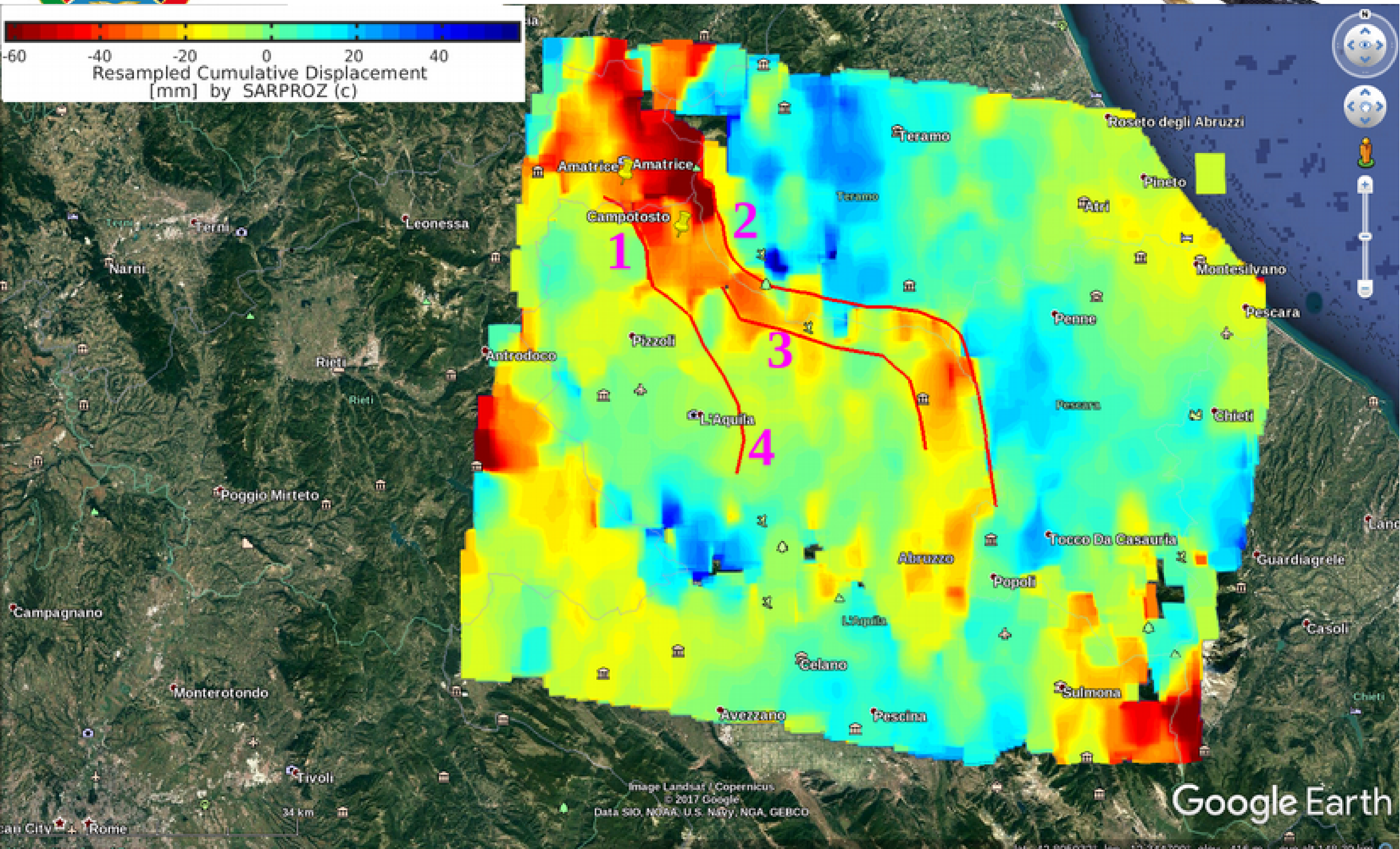
Campotosto – Bridge

CSK – Campotosto



Main Faults (Umbria and Abruzzo)

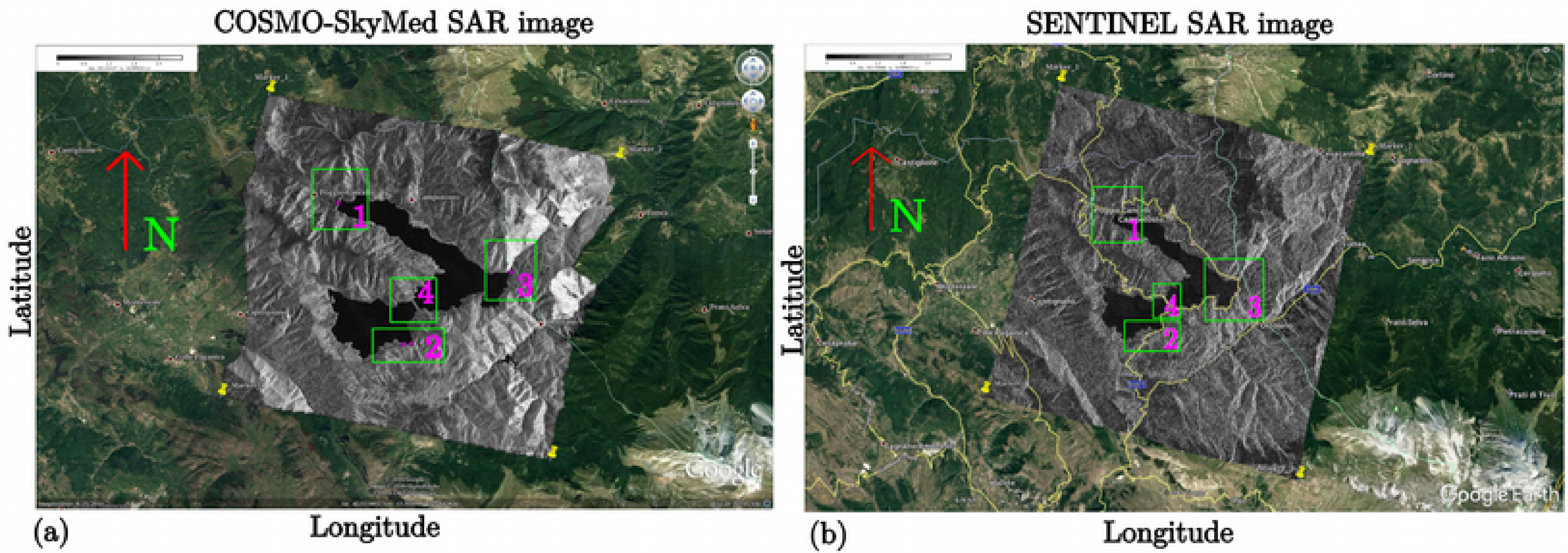
CSK – Campotosto



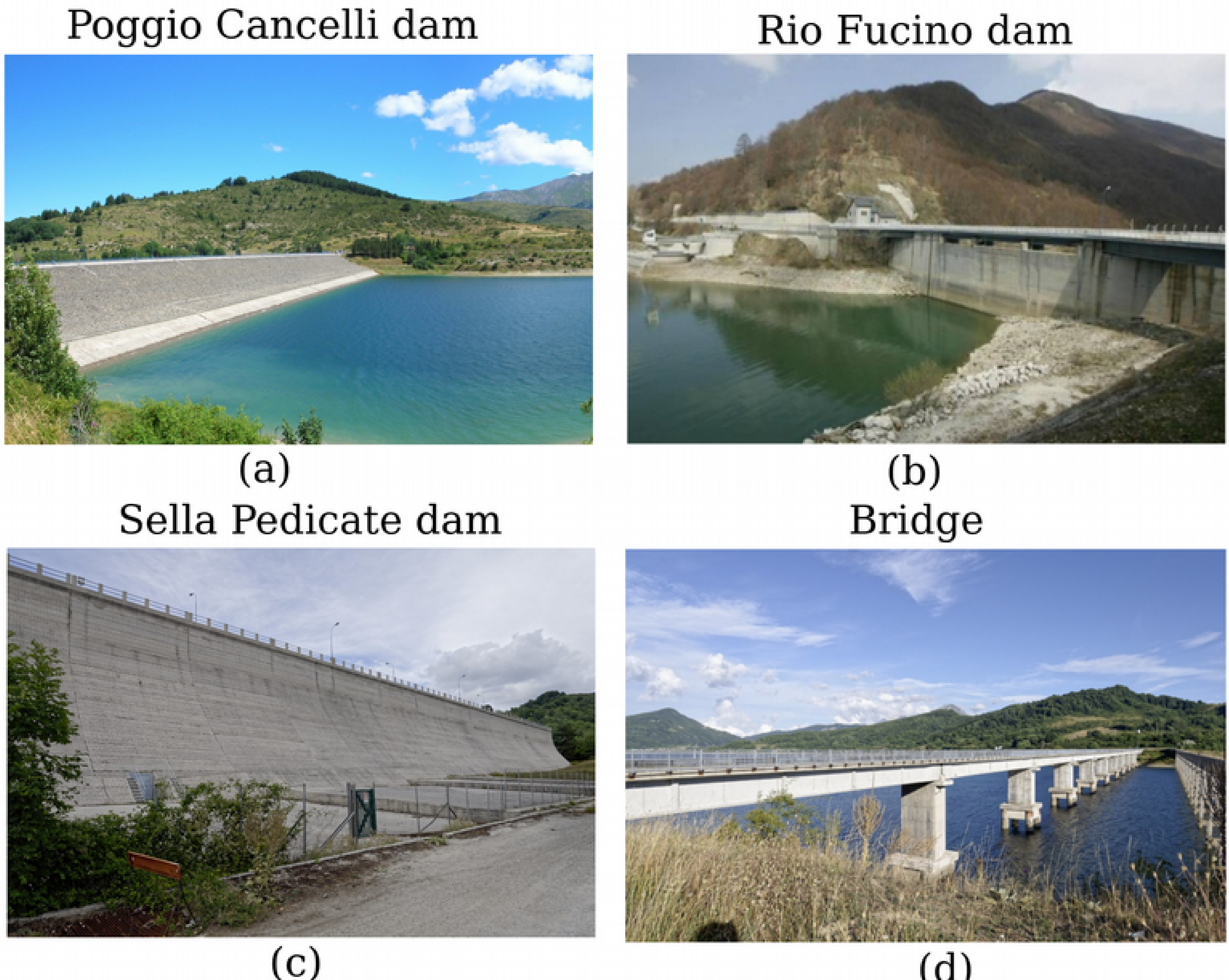
Main Faults (Umbria and Abruzzo)

SARPROZ ©
The SAR PROcessing tool by periZ

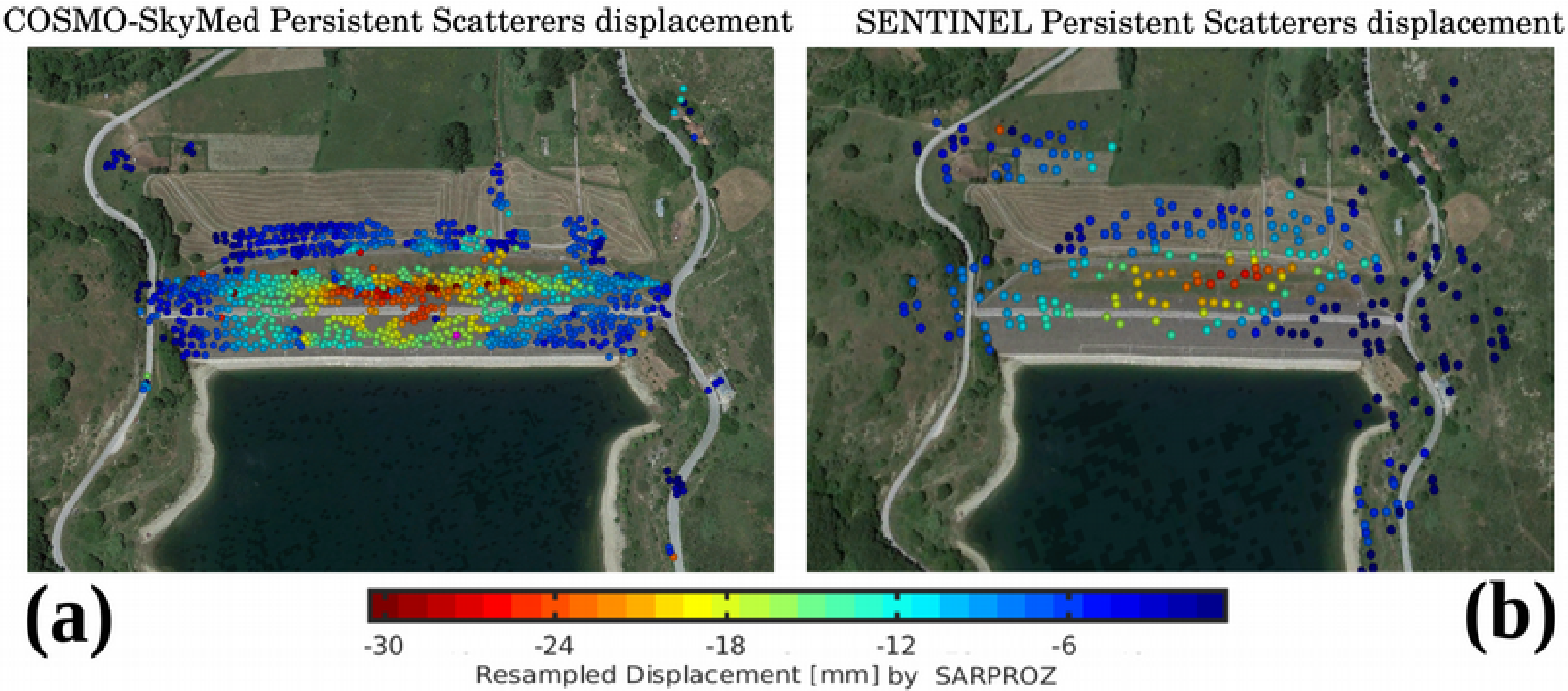
CSK – Campotosto



Main Faults (Umbria and Abruzzo)


Poggio Cancelli dam
(a)
Rio Fucino dam
(b)
Sella Pedicate dam
(c)
Bridge
(d)

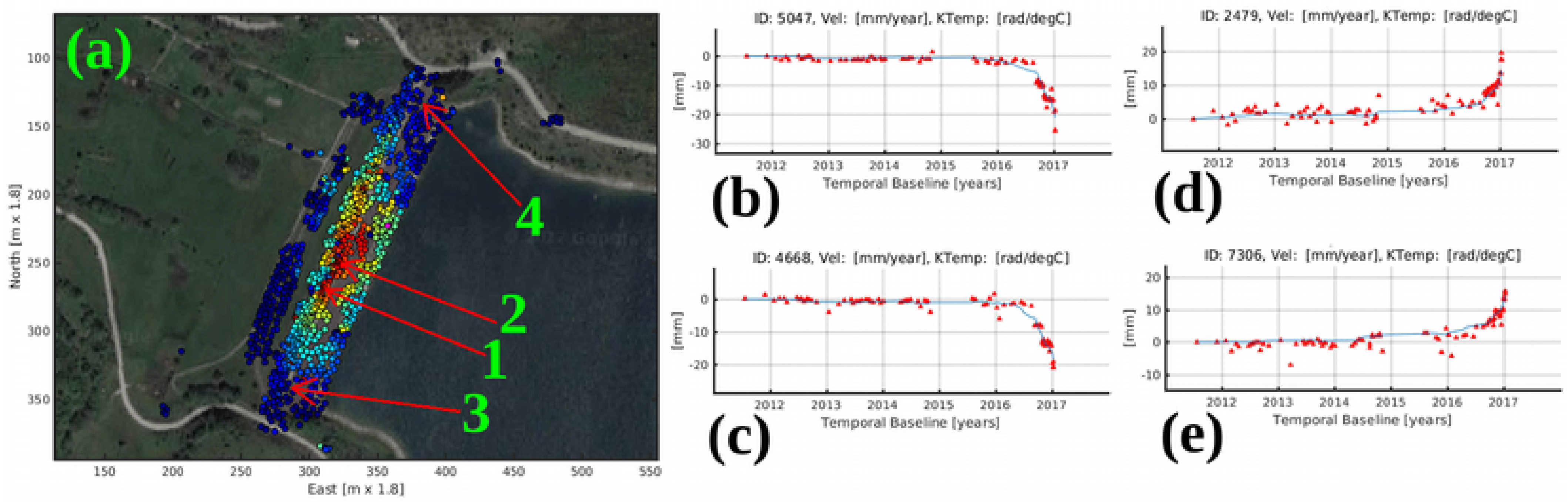
CSK – Campotosto



SARPROZ ©
The SAR PROcessing tool by periZ

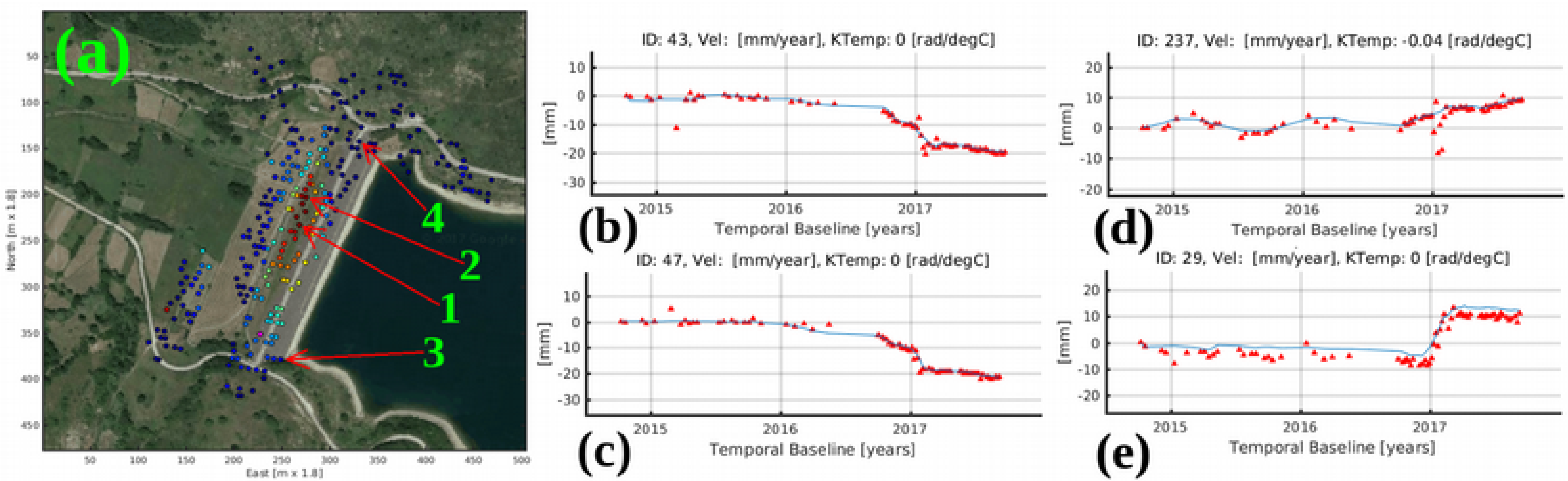
Main Faults (Umbria and Abruzzo)

CSK – Campotosto



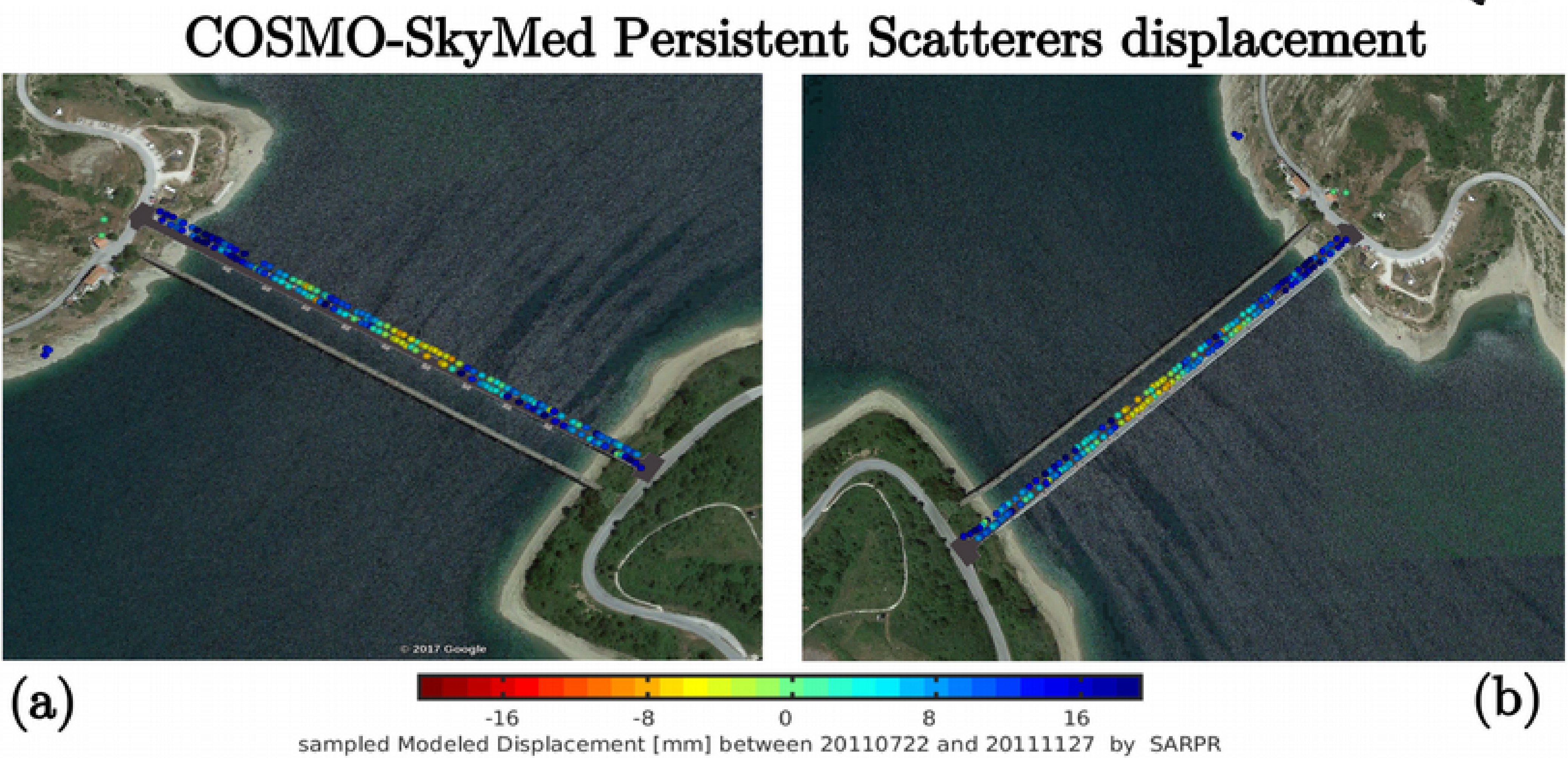
Main Faults (Umbria and Abruzzo)

CSK – Campotosto



Main Faults (Umbria and Abruzzo)

CSK – Campotosto



Main Faults (Umbria and Abruzzo)

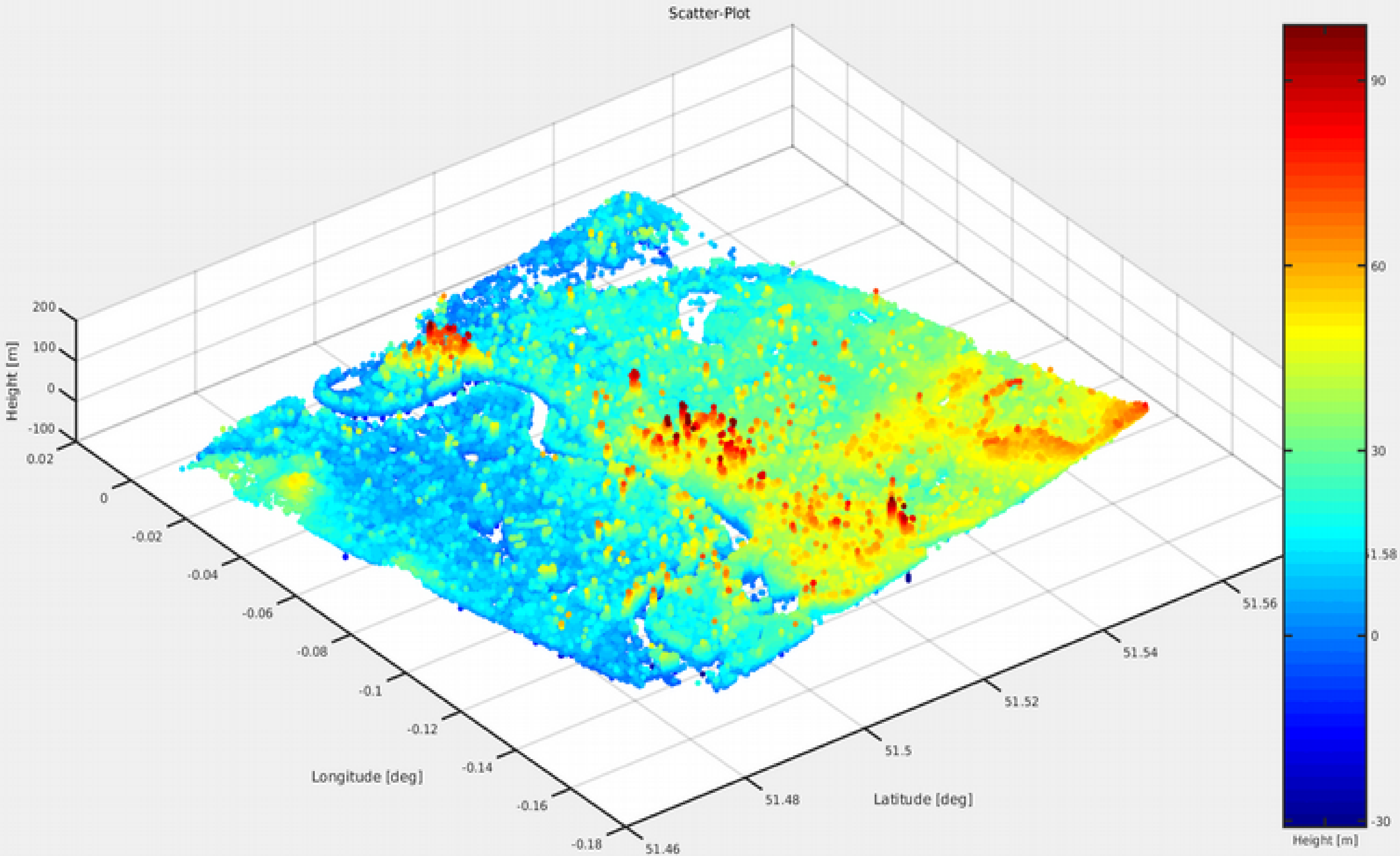
CSK – London

London Case – Displacement History

Temporal Analysis

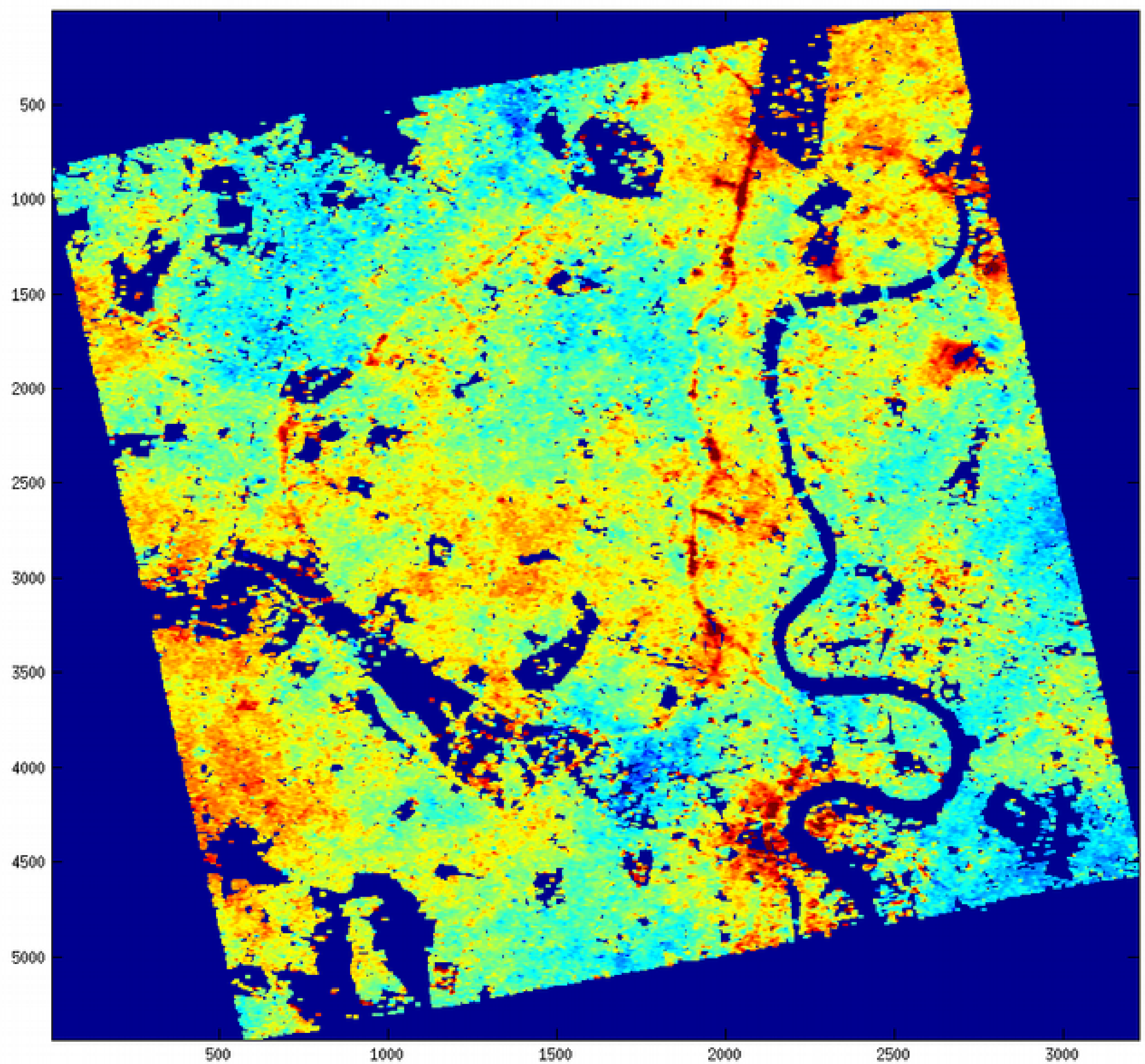
- 72 STRIPMAP COSMO-SkyMed data processed;
- Fast multi coregistration;
- (72x72)/2=2592 interferograms;
- First acquisition date: 31/12/2008;
- Last acquisition date: 23/06/2016;
- Dynamic D-InSAR and Persistent Scatterers Interferometry.

CSK – London

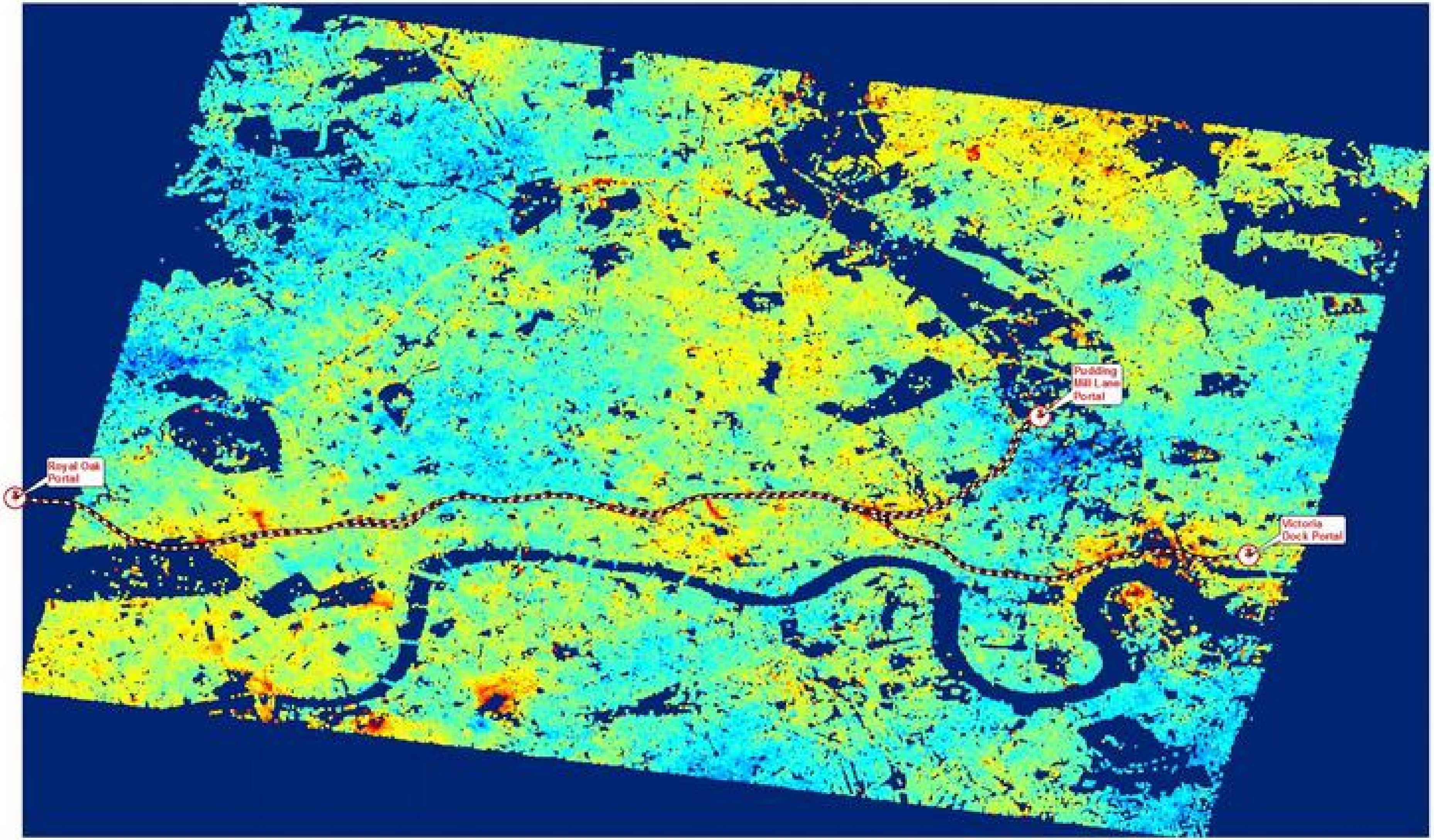


Scatter-Plot
Height [m]
200
100
0
-100
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
Longitude [deg]
51.46
51.48
51.5
51.52
51.54
51.56
Latitude [deg]
90
60
30
1.58
0
-30
Height [m]

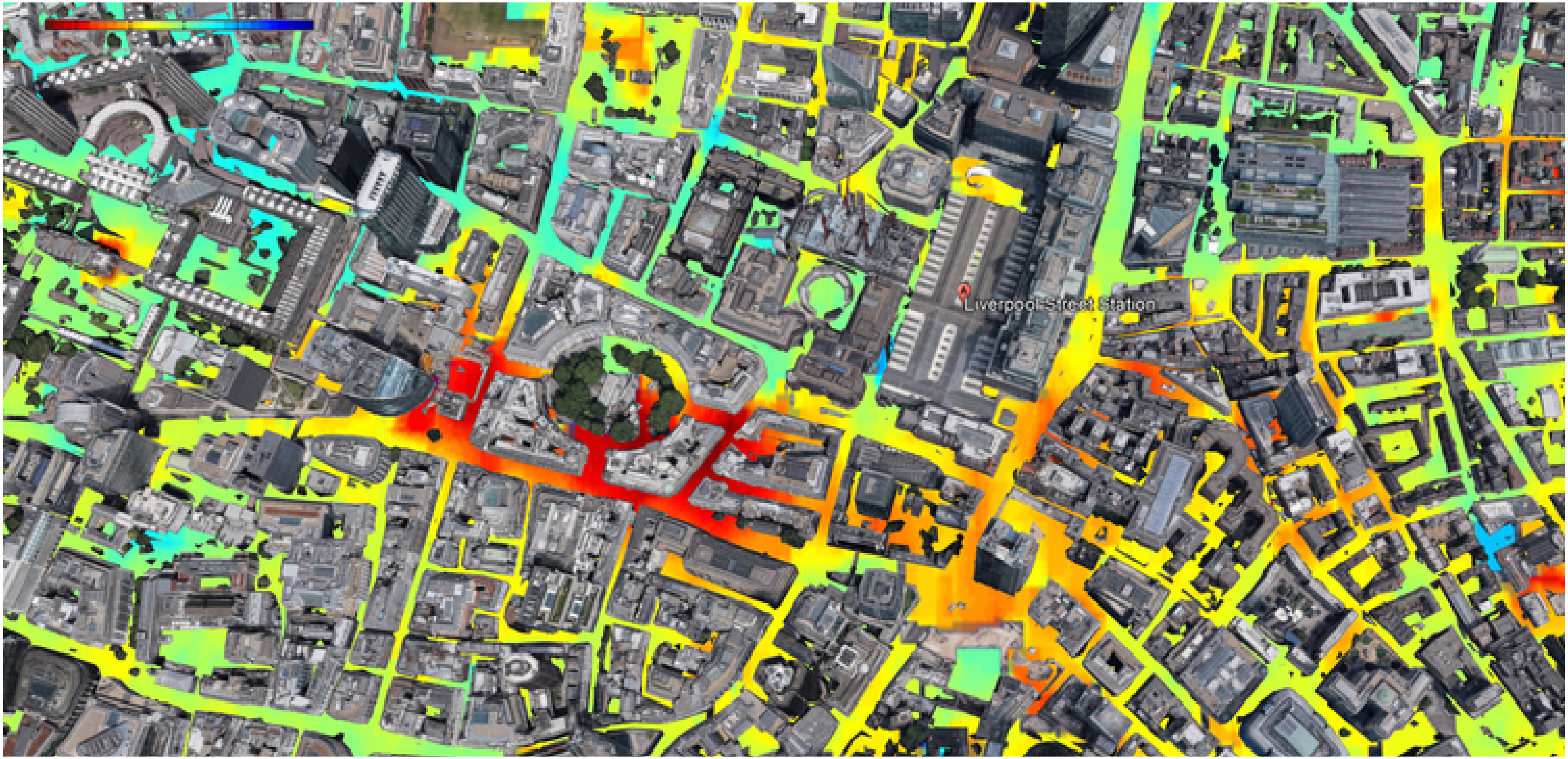
REPARTO INFORMAZIONI E SICUREZZA
C.I.T.S.



CSK – London

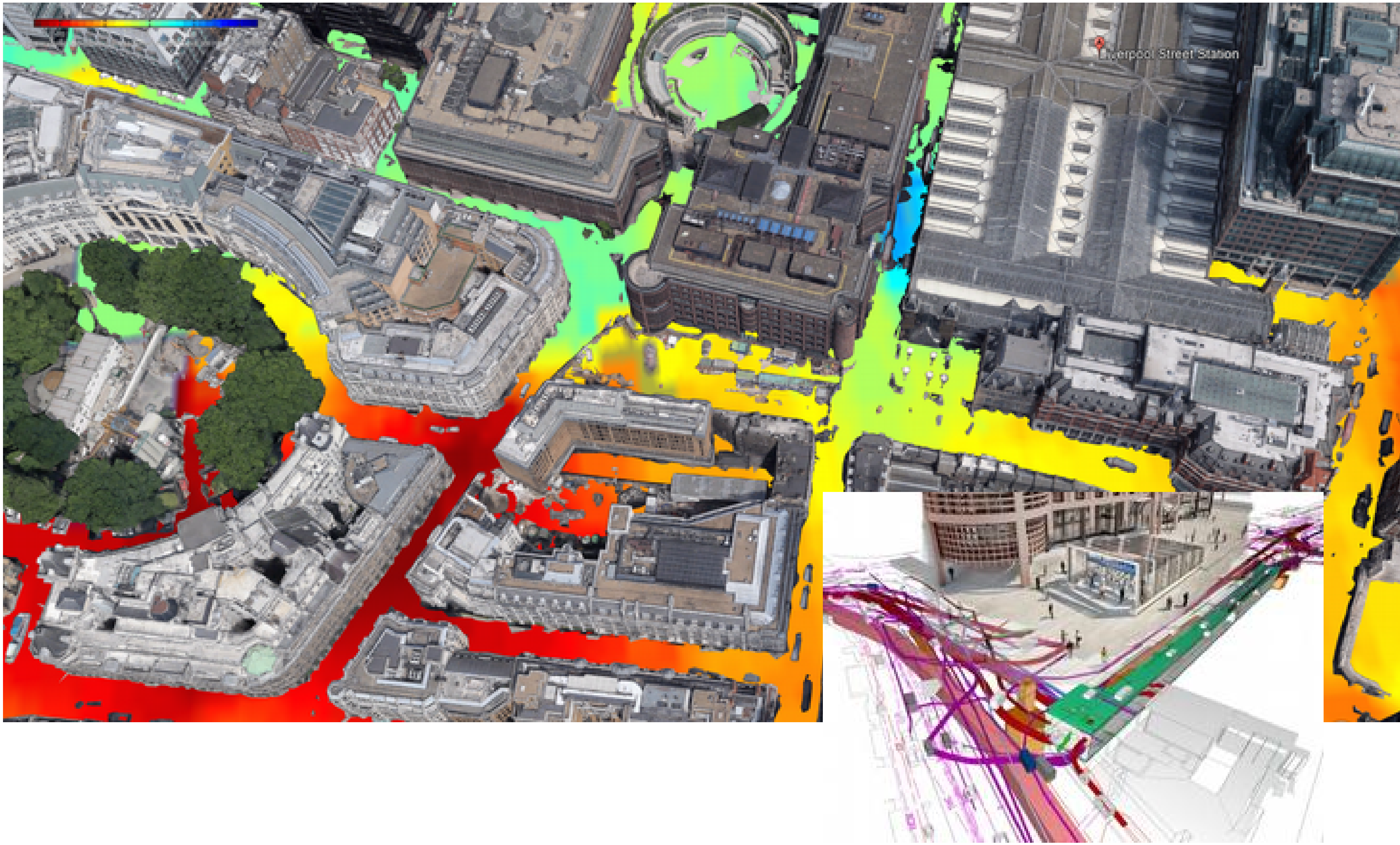

Royal Oak Portal
Pudding Mill Lane Portal
Victoria Dock Portal

CSK – London

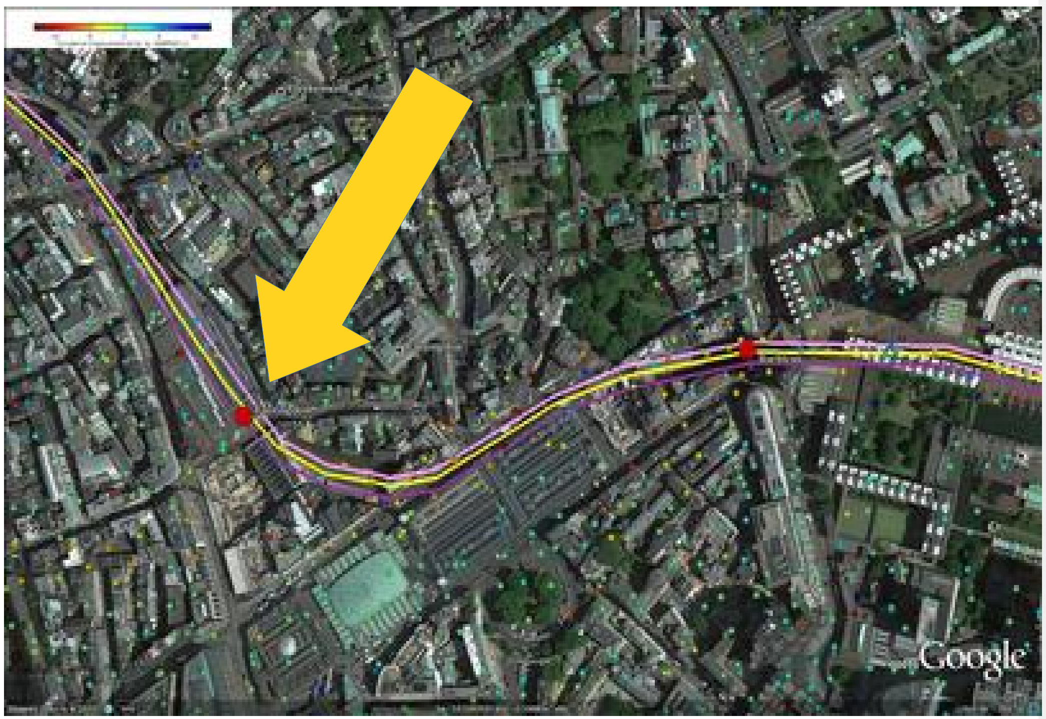


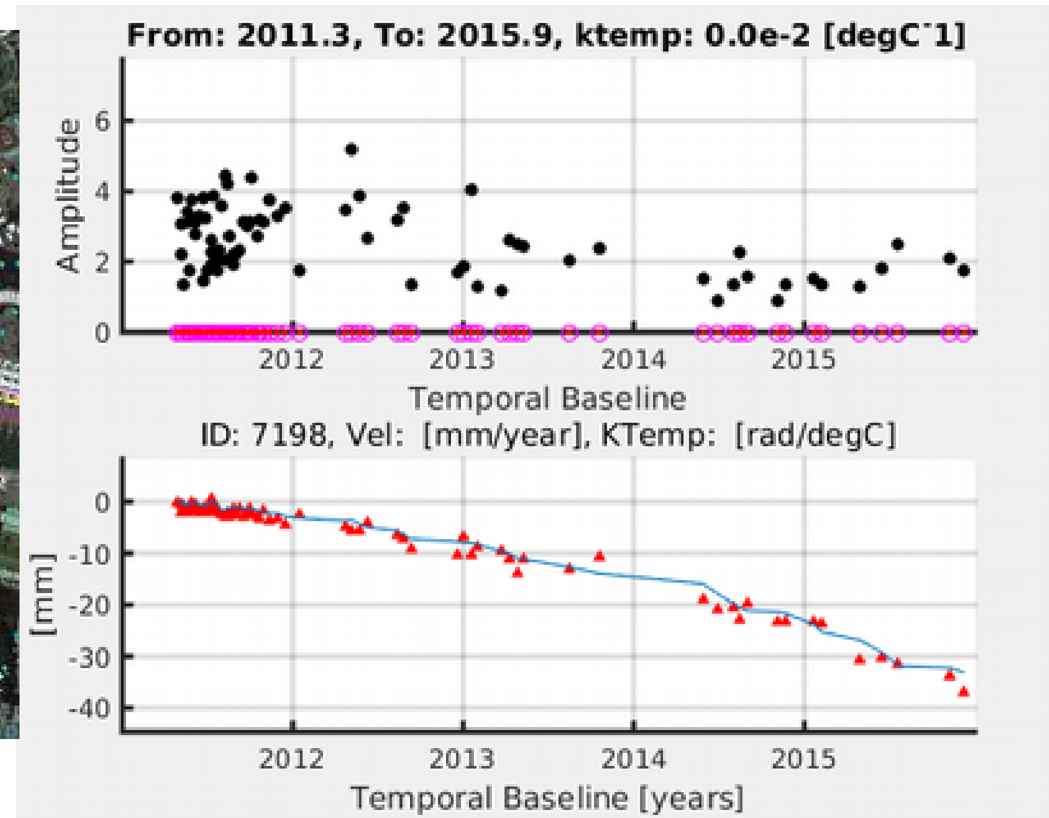
CSK – London

17 dicembre 2012



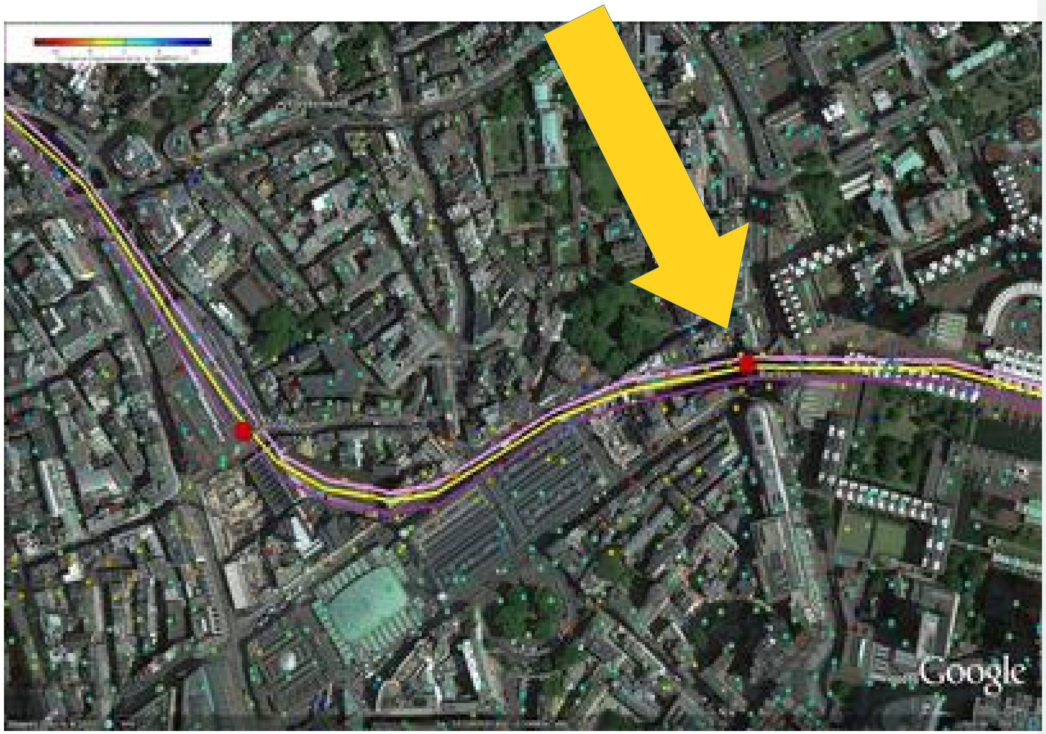
CSK – London

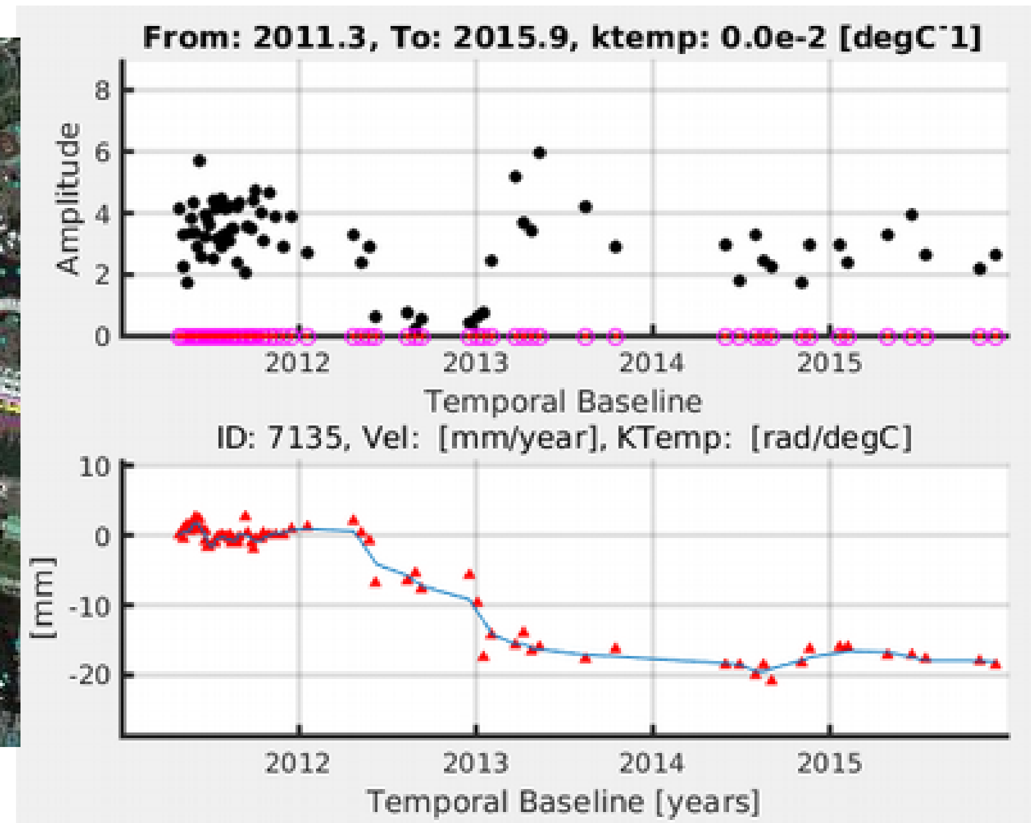




London – Displacement History (Barbican)

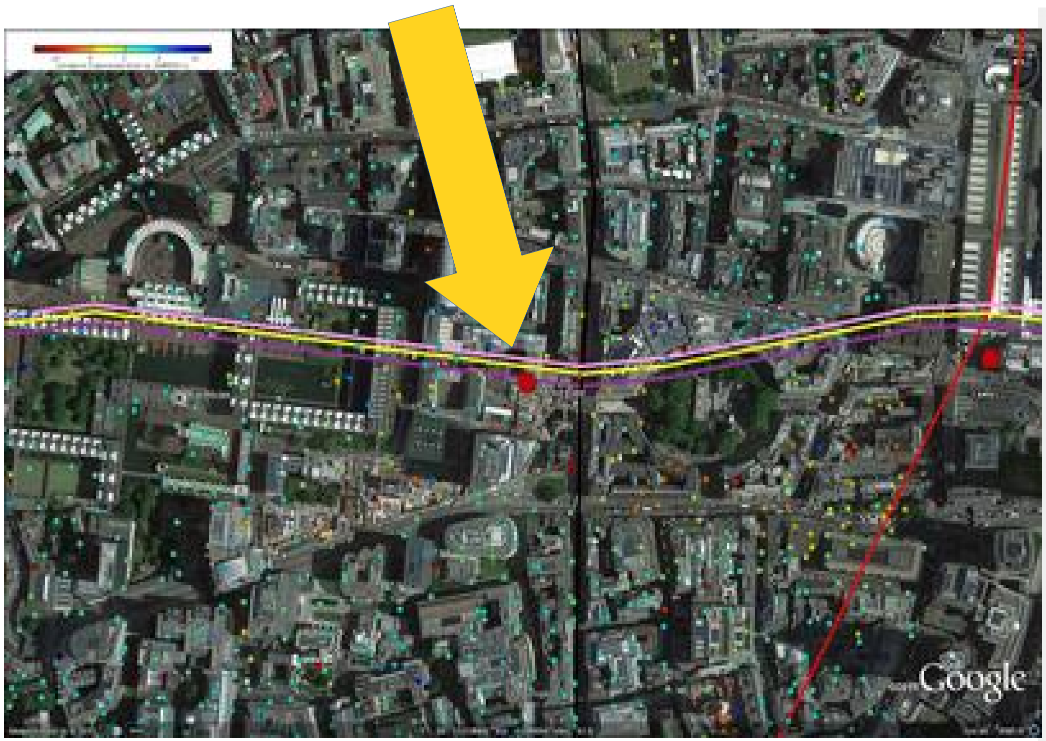
CSK – London

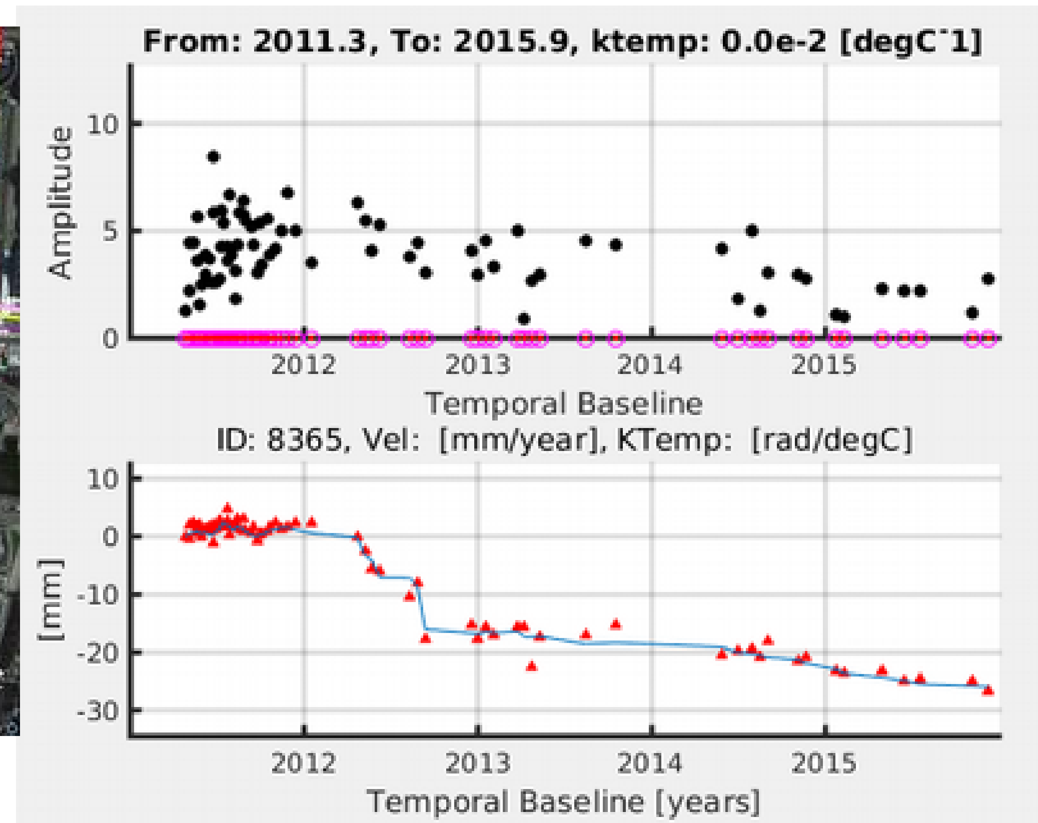




London – Displacement History (Farringdon)

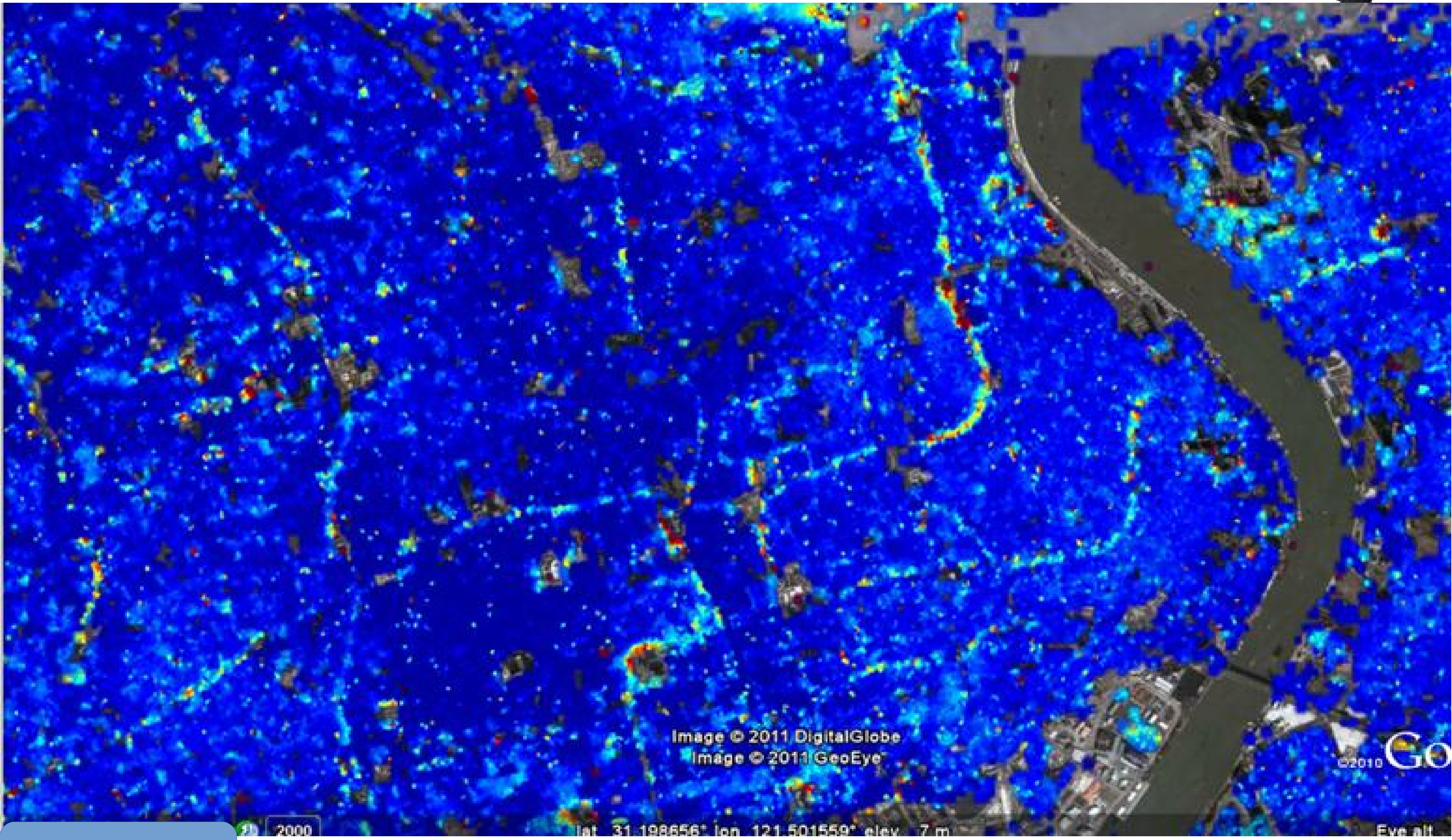
CSK – London





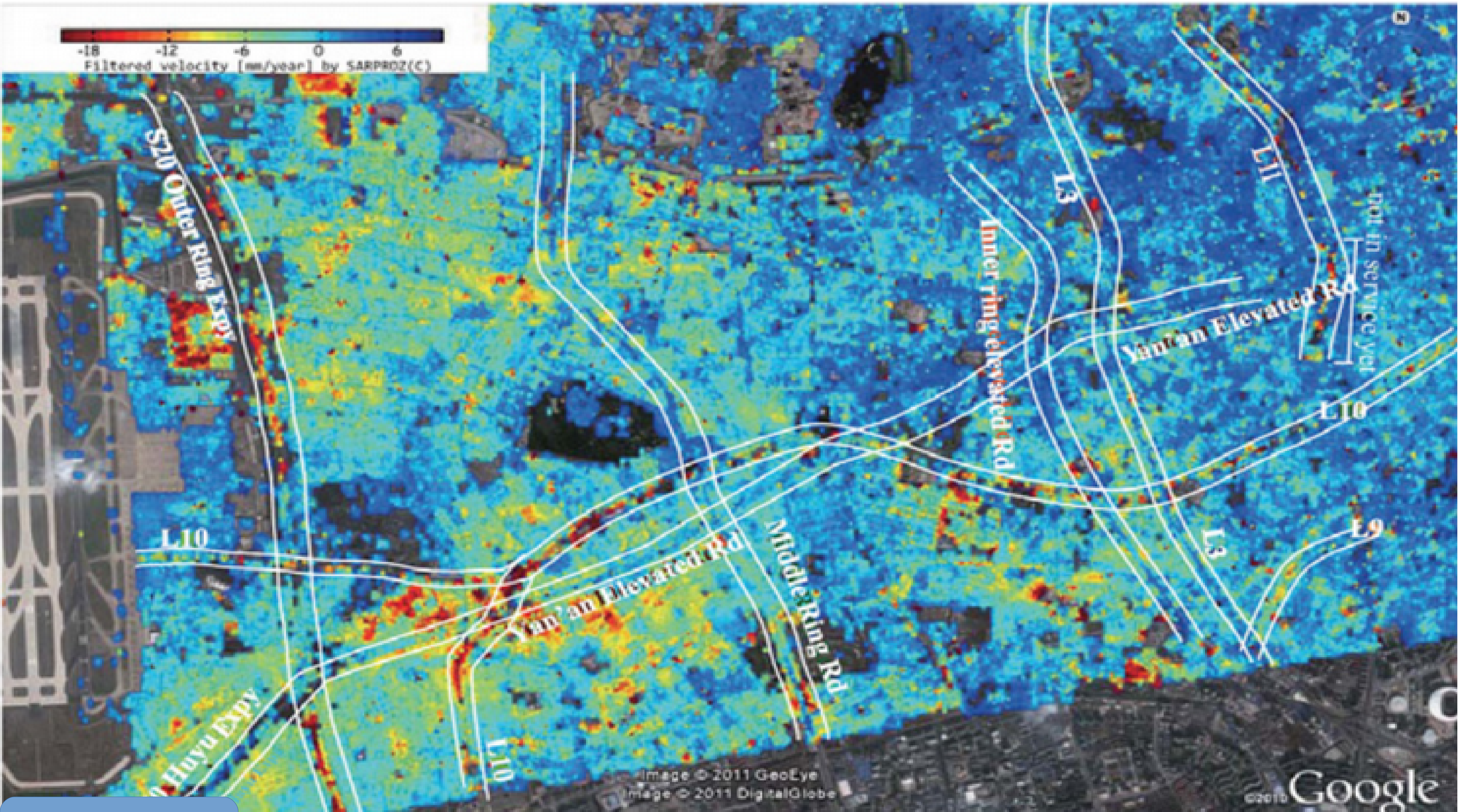
London – Displacement History (Moorgate)

CSK – Shanghai



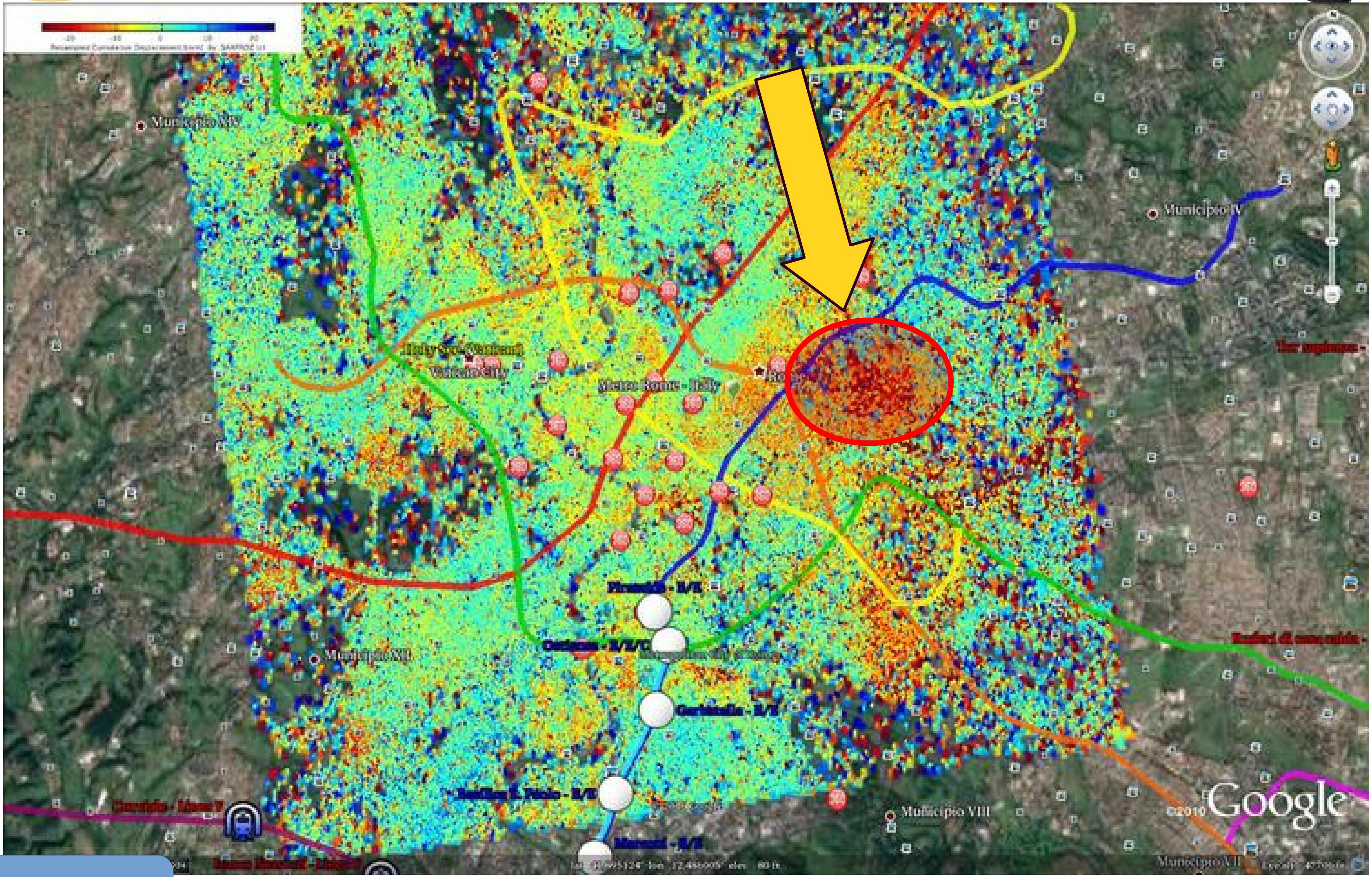
Shanghai – Displacement History

CSK – Shanghai



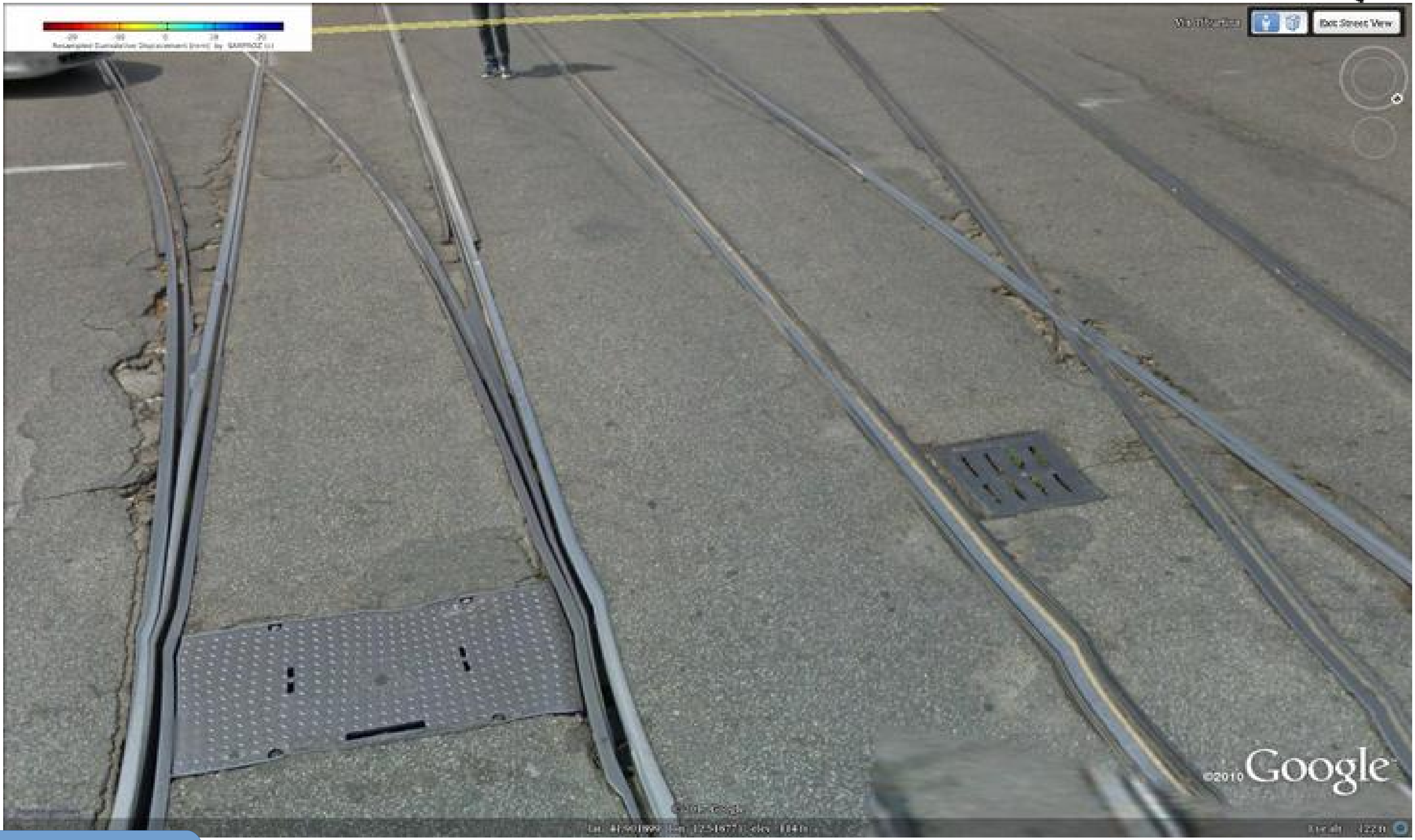
Shanghai – Displacement History

CSK – Rome



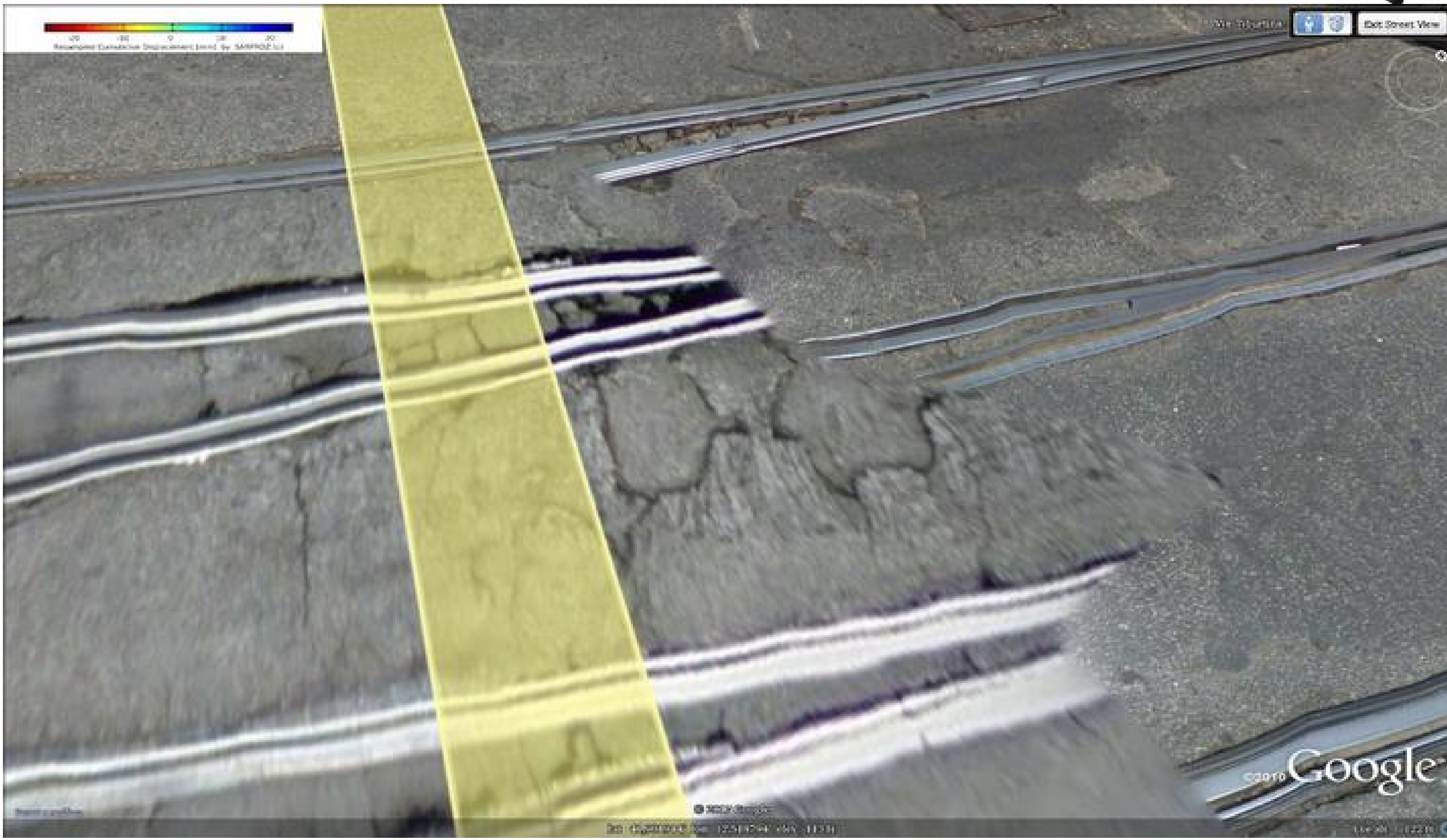
Rome – Displacement History

CSK – Rome



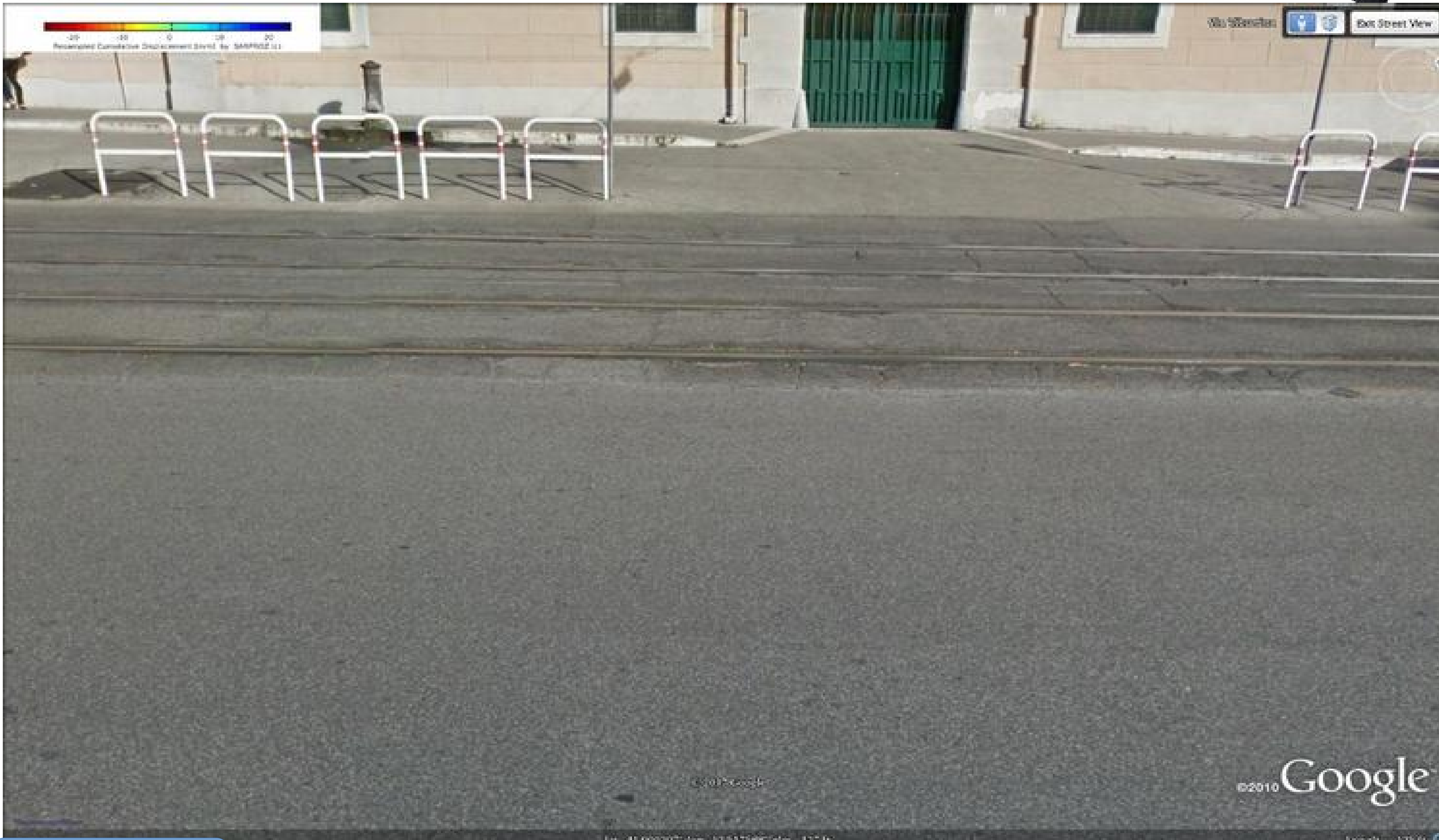
Rome – Displacement History

CSK – Rome



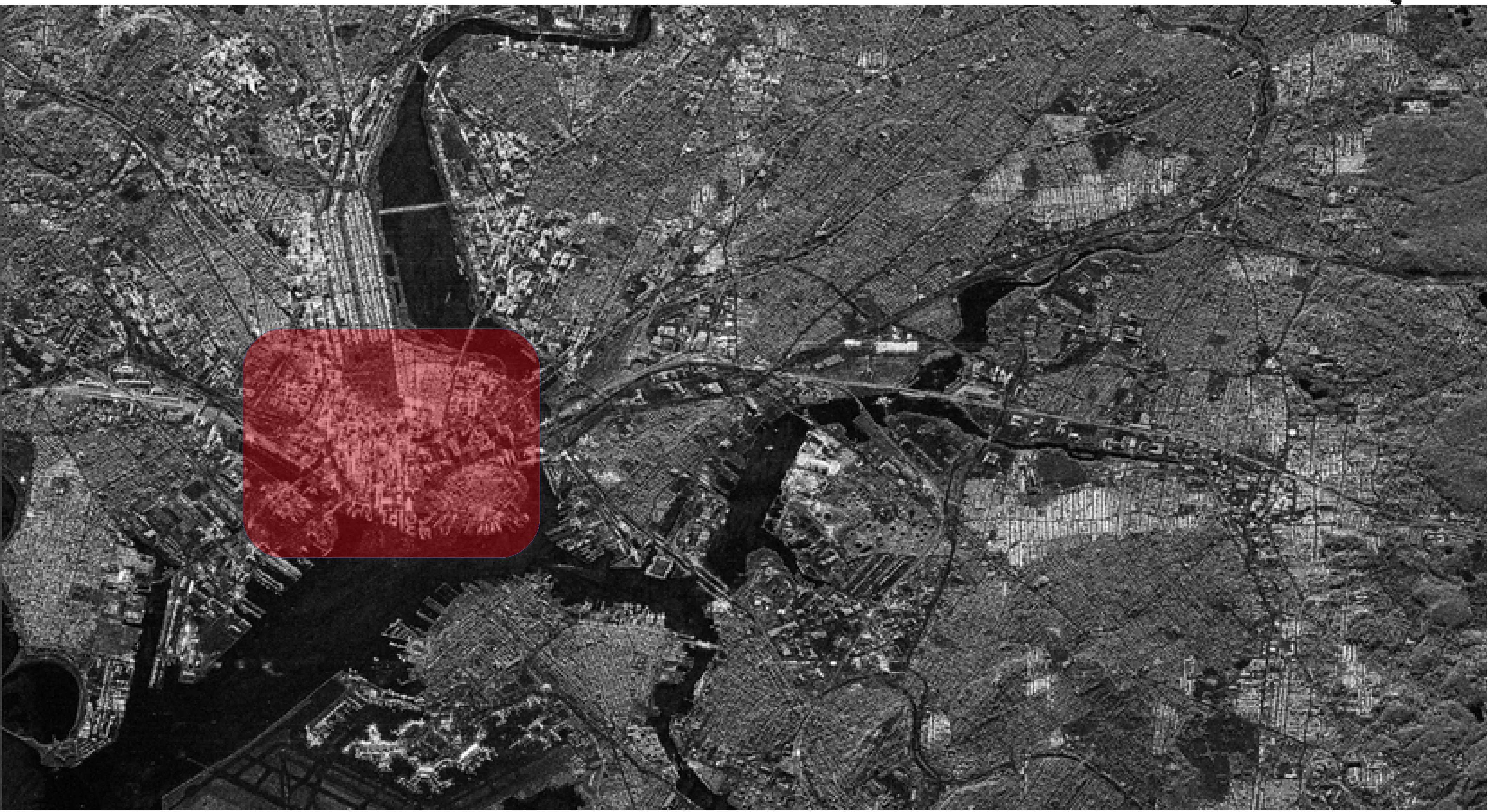
Rome – Displacement History

CSK – Rome



Rome – Displacement History

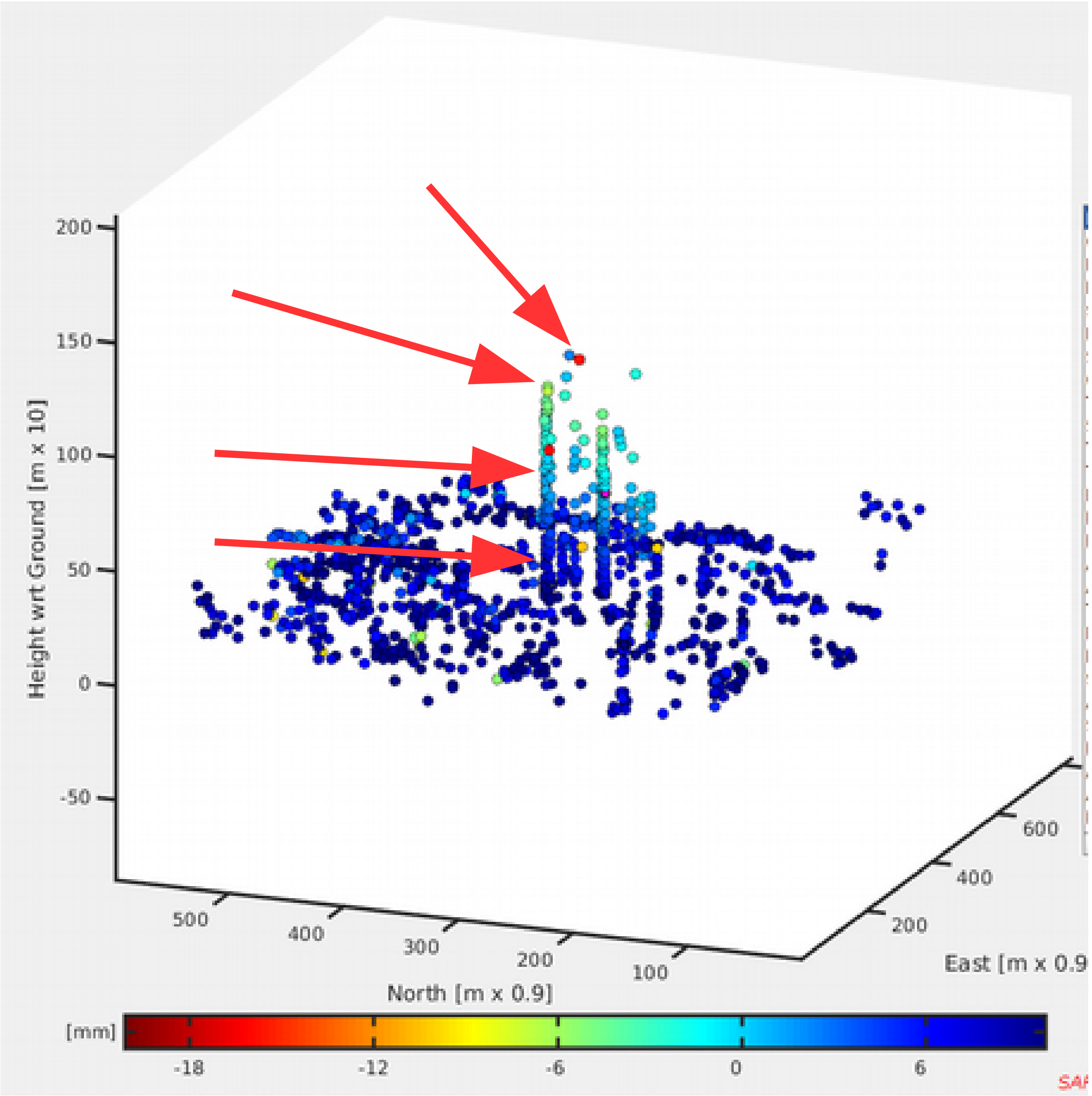
CSK – Boston



CSK – Boston

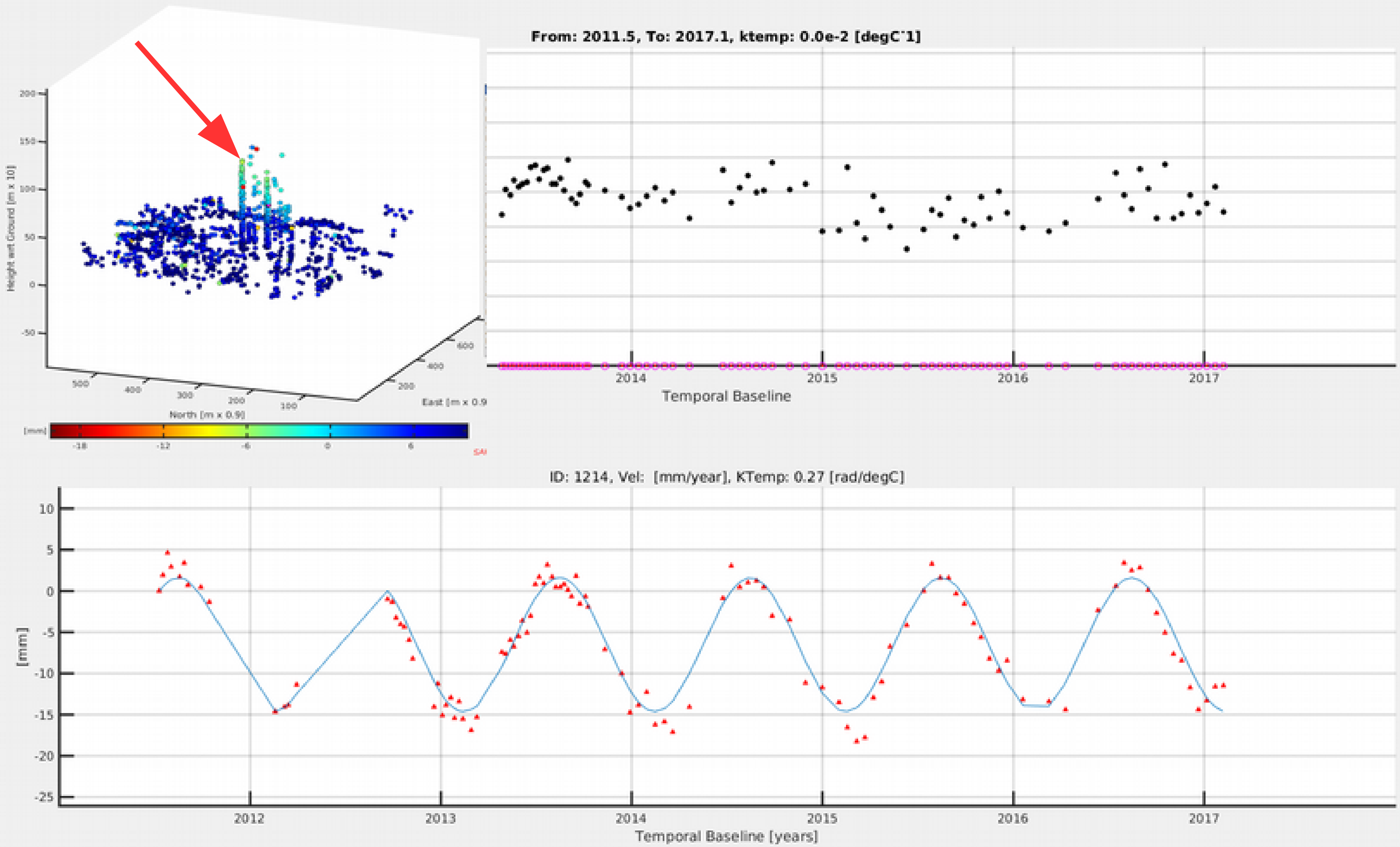
Boston – Displacement History

CSK – Boston

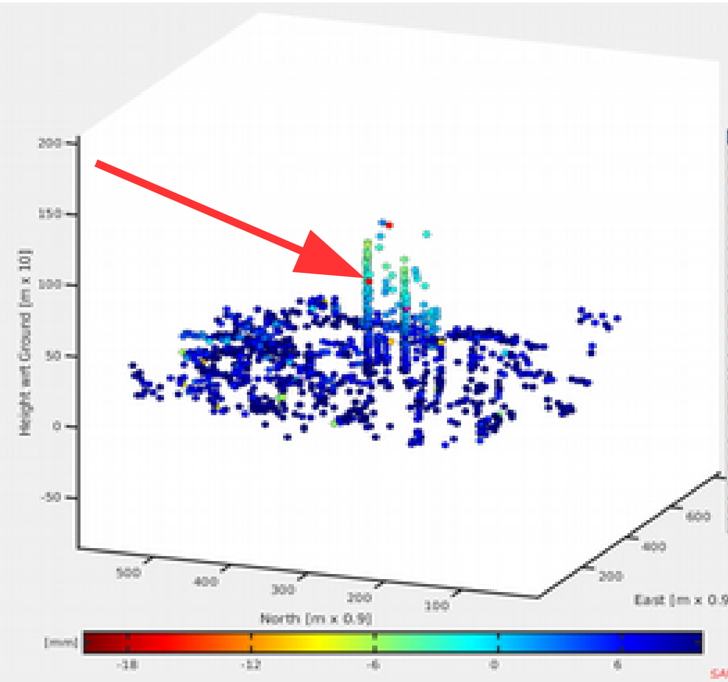


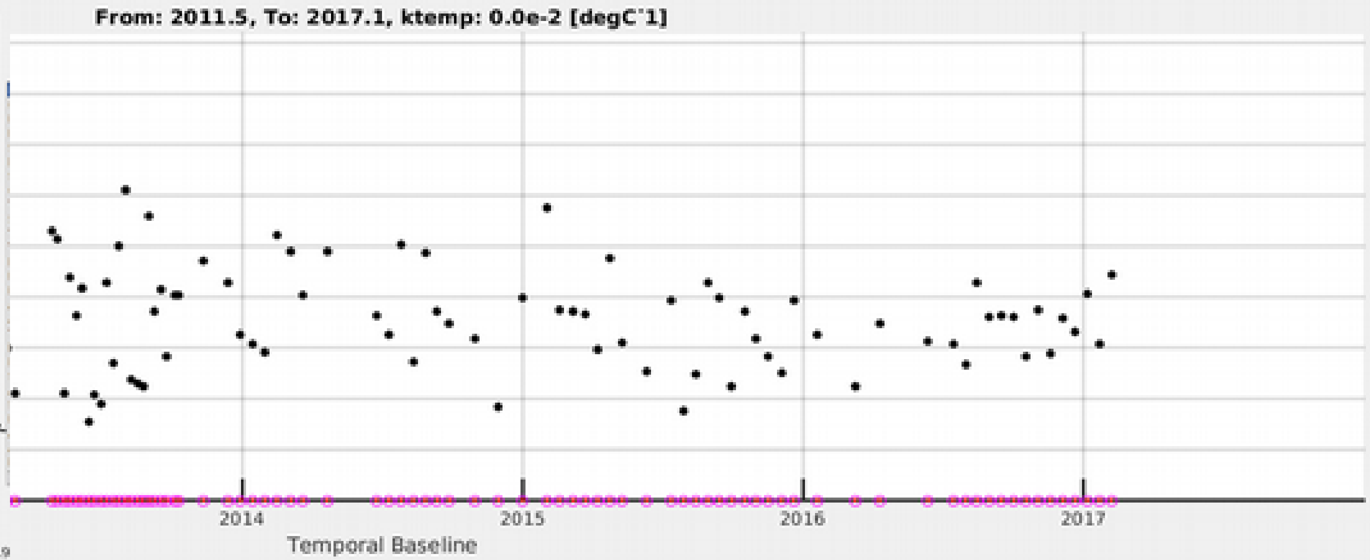
Boston – Displacement History

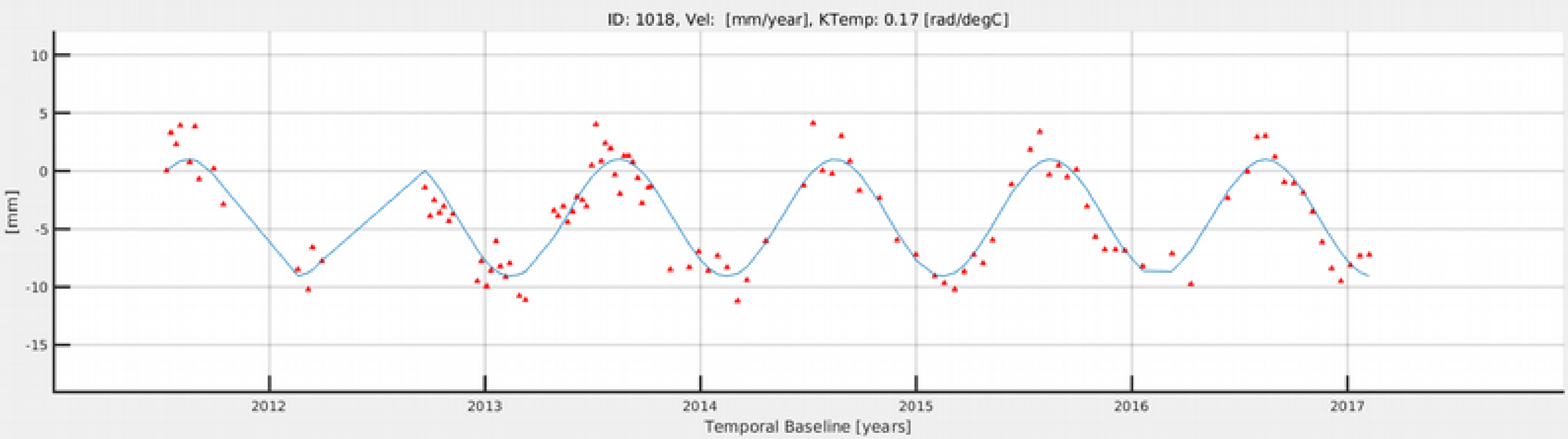
CSK – Boston


From: 2011.5, To: 2017.1, ktemp: 0.0e-2 [degC^-1]
Height wrt Ground [m x 10]
North [m x 0.9]
East [m x 0.9
[mm]
Temporal Baseline
ID: 1214, Vel: [mm/year], KTemp: 0.27 [rad/degC]
[mm]
Temporal Baseline [years]

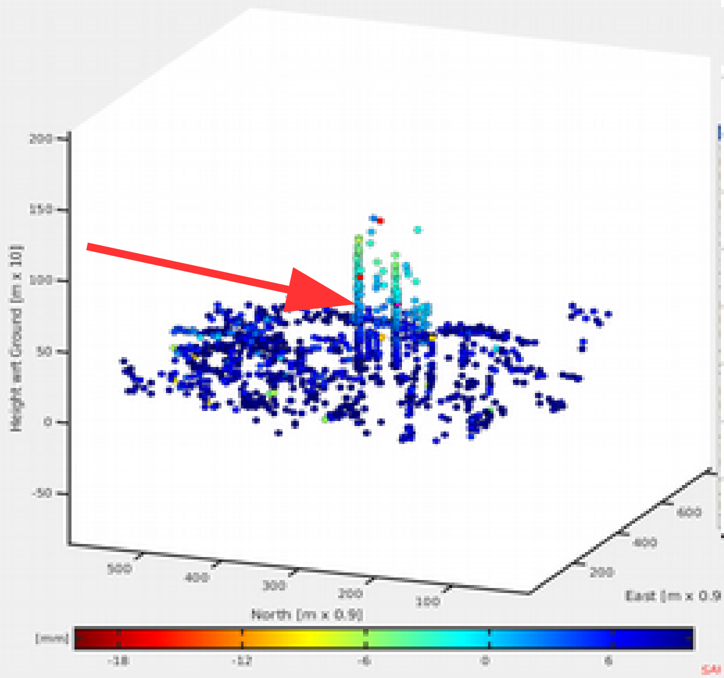
CSK – Boston


Height wrt Ground [m x 10]
North [m x 0.9]
East [m x 0.9
[mm]
-18
-12
-6
0
6

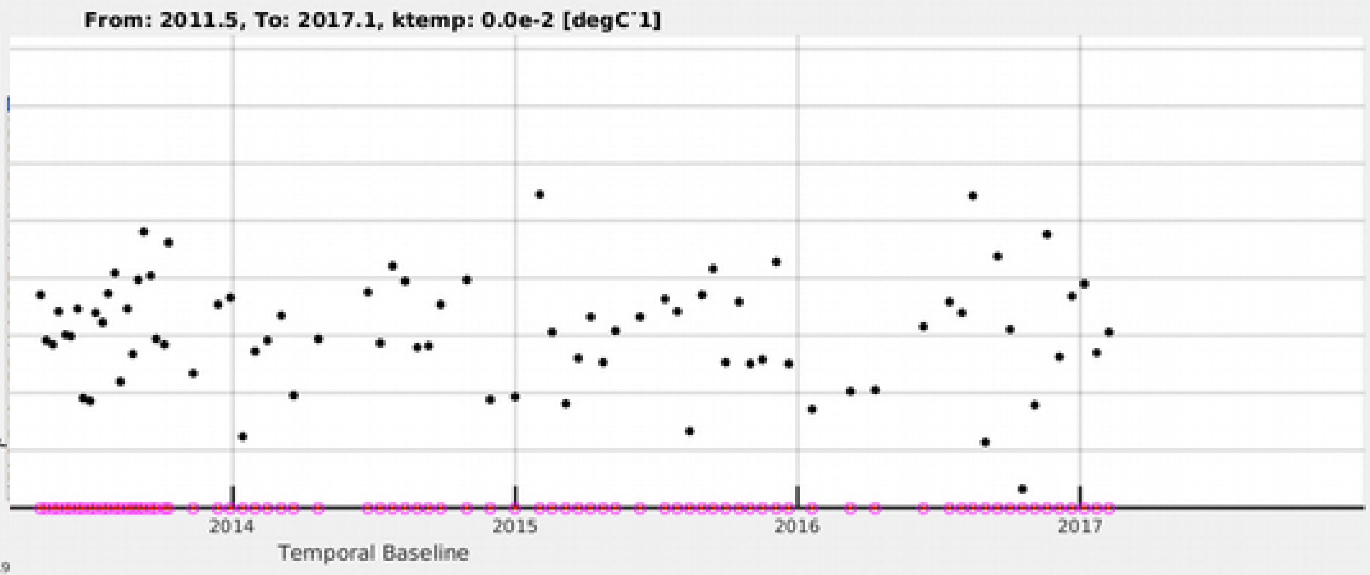

From: 2011.5, To: 2017.1, ktemp: 0.0e-2 [degC`1]
2014
2015
2016
2017
Temporal Baseline


ID: 1018, Vel: [mm/year], KTemp: 0.17 [rad/degC]
[mm]
10
5
0
-5
-10
-15
2012
2013
2014
2015
2016
2017
Temporal Baseline [years]

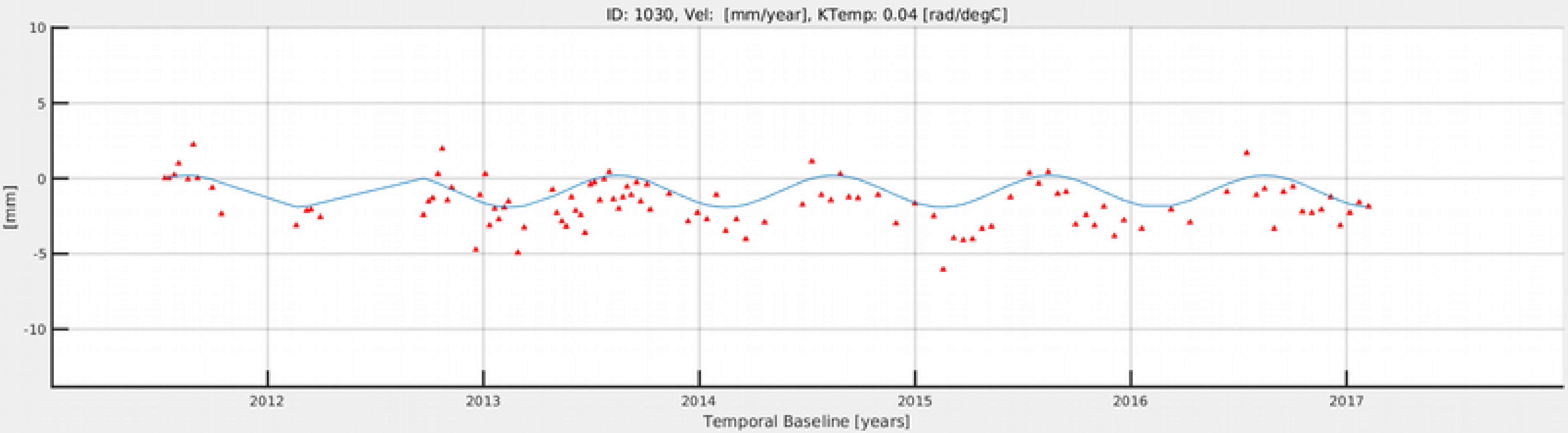
CSK – Boston



Height wrt Ground [m x 10]
North [m x 0.9]
East [m x 0.9
[mm]
-18
-12
-6
0
6

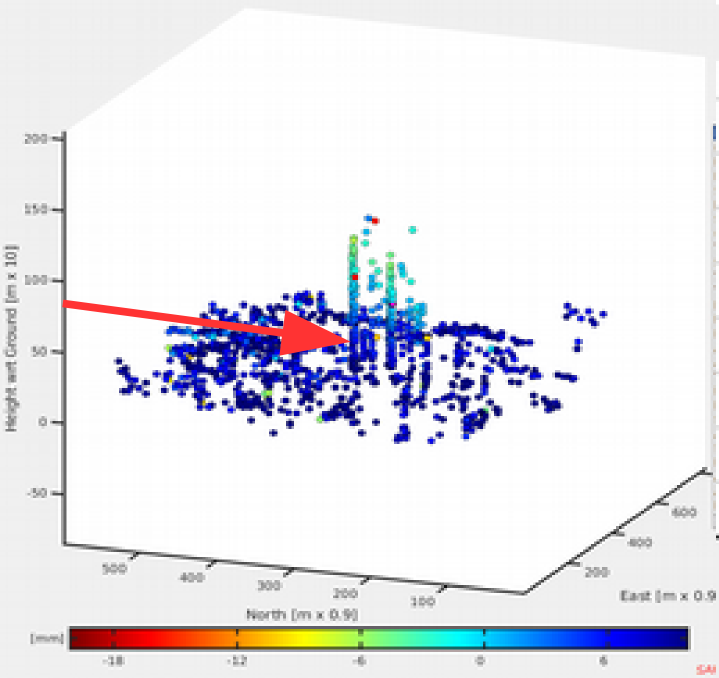


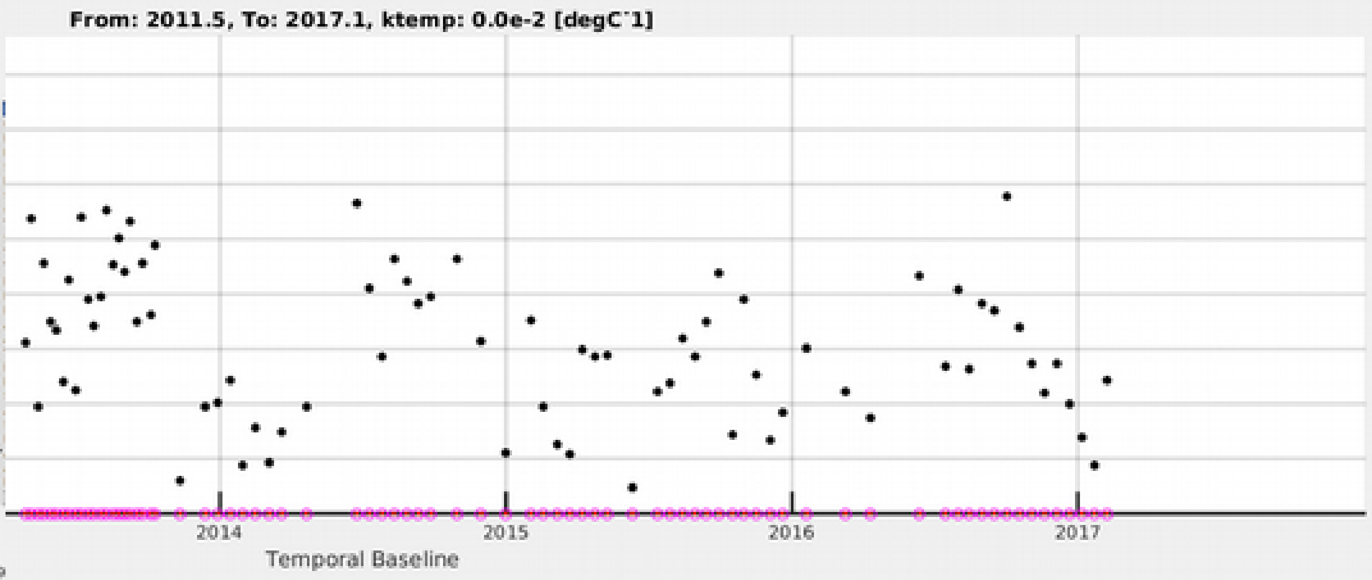
From: 2011.5, To: 2017.1, ktemp: 0.0e-2 [degC`1]
2014
2015
2016
2017
Temporal Baseline

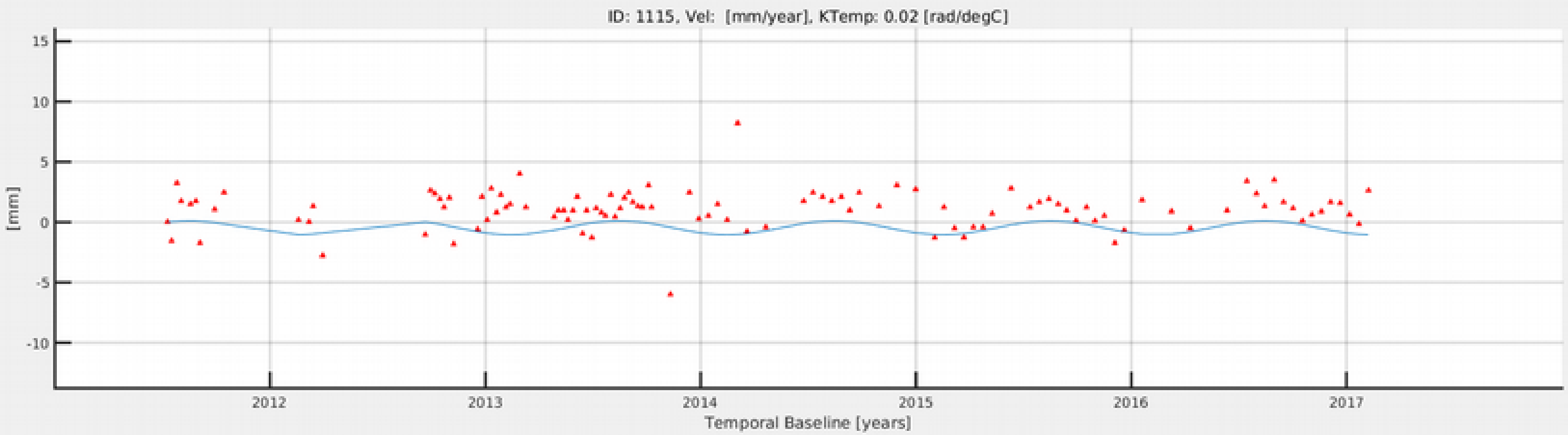


ID: 1030, Vel: [mm/year], KTemp: 0.04 [rad/degC]
10
5
0
-5
-10
[mm]
2012
2013
2014
2015
2016
2017
Temporal Baseline [years]

CSK – Boston


Height wrt Ground [m x 10]
200
150
100
50
0
-50
500
400
300
200
100
North [m x 0.9]
600
400
200
East [m x 0.9
[mm]
-18
-12
-6
0
6


From: 2011.5, To: 2017.1, ktemp: 0.0e-2 [degC^1]
2014
2015
2016
2017
Temporal Baseline


ID: 1115, Vel: [mm/year], KTemp: 0.02 [rad/degC]
15
10
5
0
-5
-10
[mm]
2012
2013
2014
2015
2016
2017
Temporal Baseline [years]

Polarimetric SAR

Applications of Polarimetry

Forest Vegetation

- Forest height
- Biomass quantity estimation
- Forest structure
- Canopy extinction
- Underlying topography

Agriculture

- Soil moisture content
- Soil roughness
- Height of vegetation layer
- Extinction of vegetation layer
- Moisture of vegetation layer

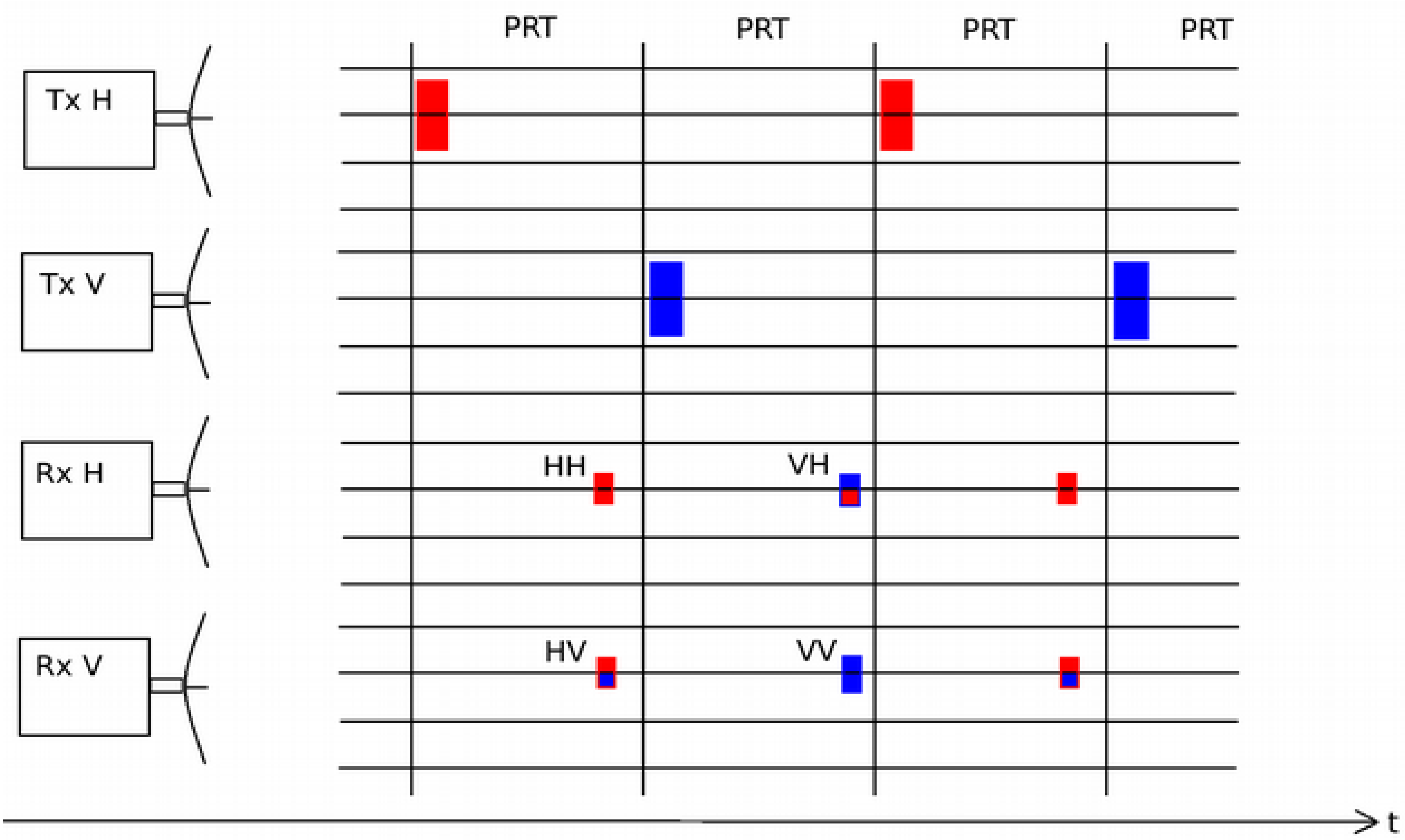
Snow and Ice

- Topography
- Penetration depth/density
- Snow ice layer
- Snow ice extinction
- Water equivalent

Urban Areas

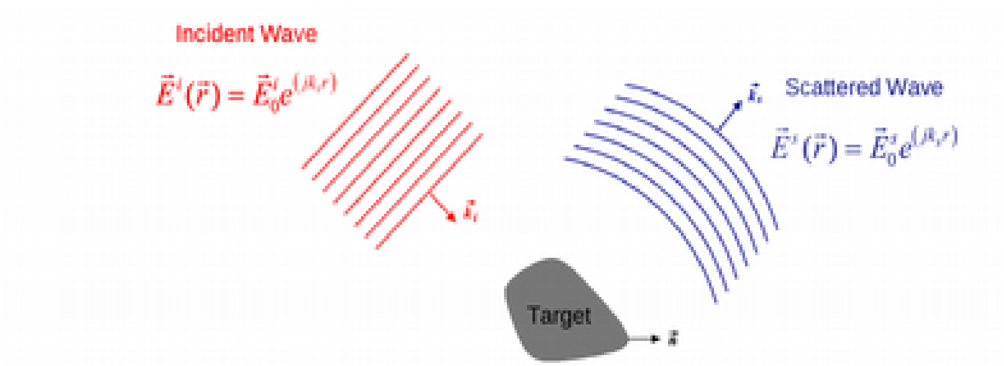
- Geometric proprieties
- Dielectric properties
- Precise DEM reconstruction

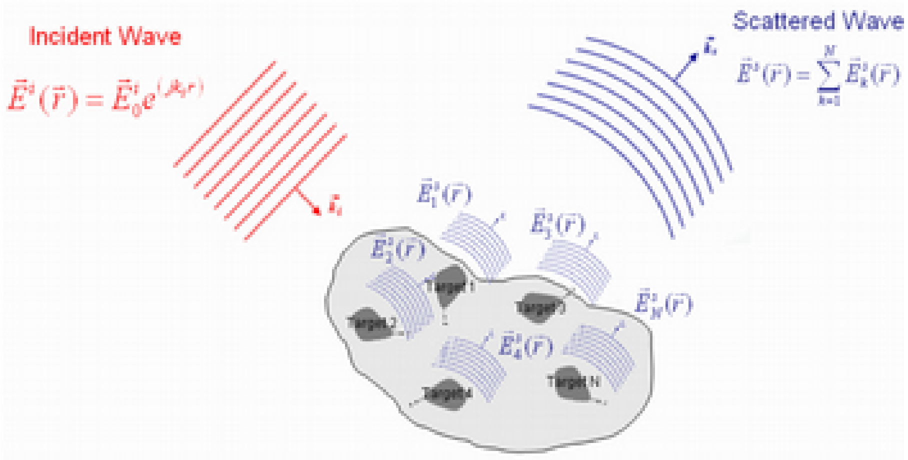
Polarimetric SAR



Polarimetric SAR

Interaction of the electromagnetic waves with the nature of matter



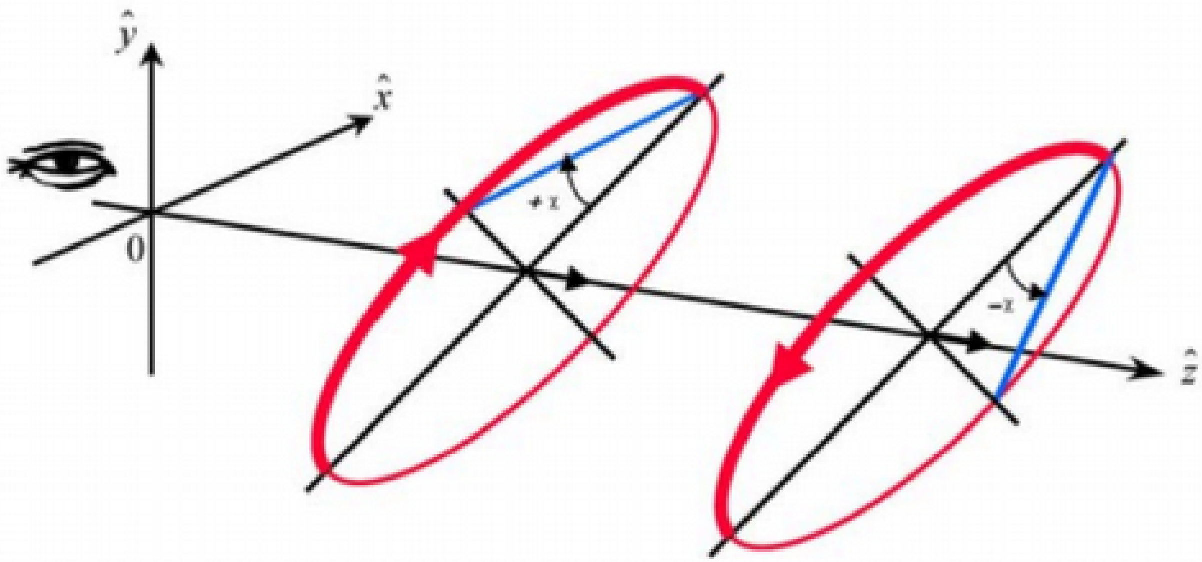


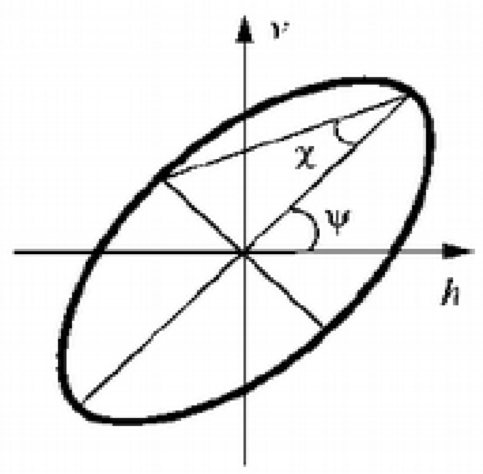
$$dP_r = \frac{P_t G_t}{4\pi R_t^2}\sigma^0 ds \frac{A_r}{4\pi R_r^2}$$

σ_0 Depends also on polarization

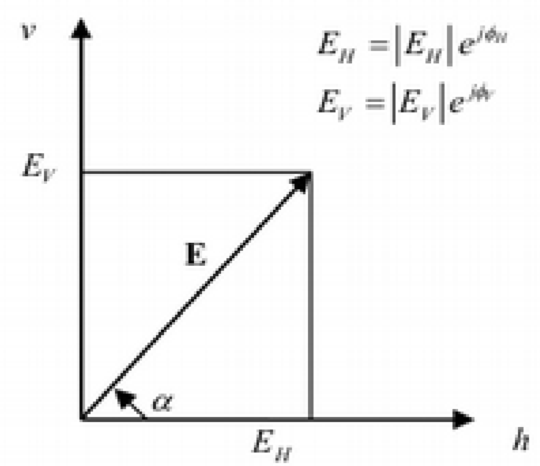
Polarimetric SAR

Classical electromagnetic wave configuration



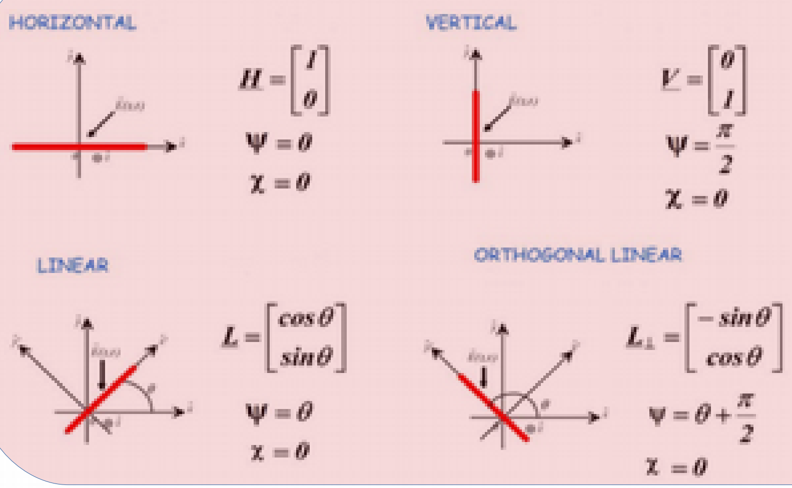


(b) Orientation ψ and Ellipticity χ Angles.

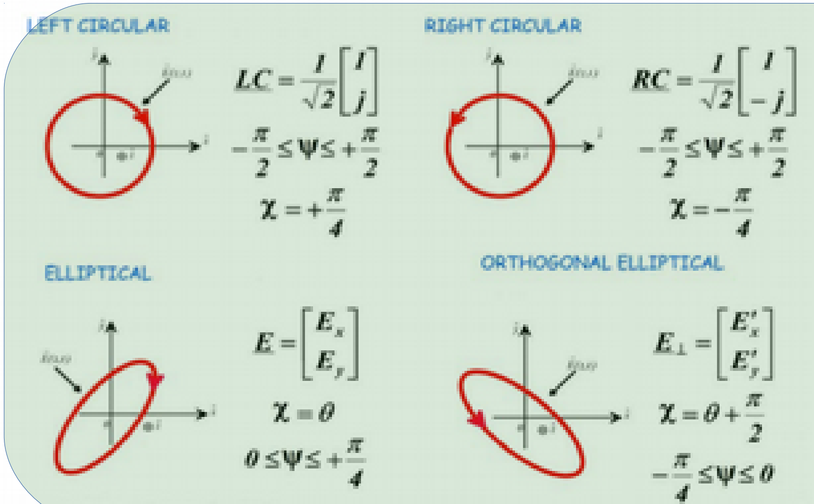


(c) Electric Field Vector.

Polarimetric SAR

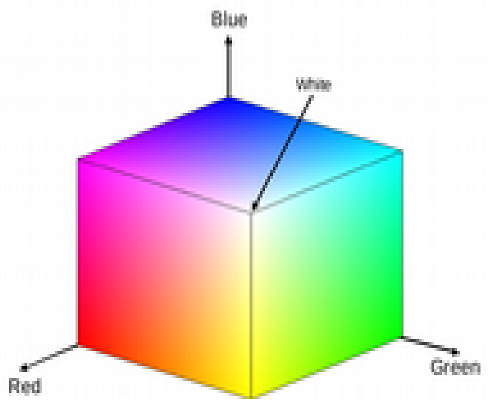


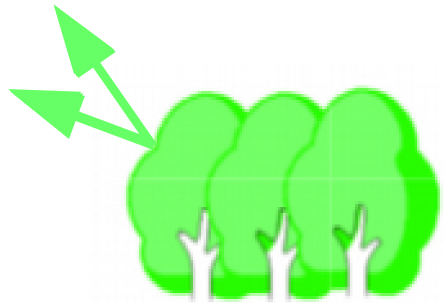
Linear
(Remote Sensing)

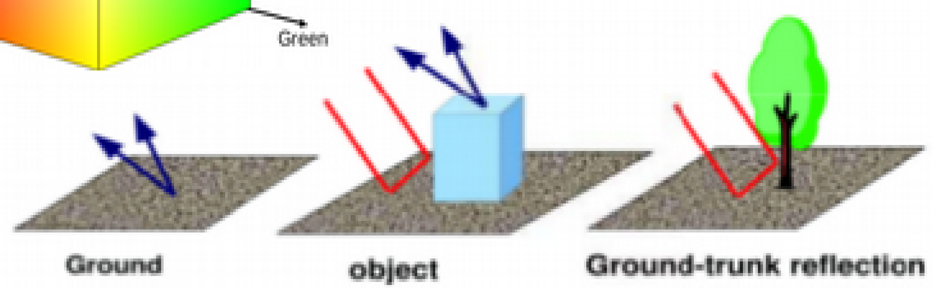


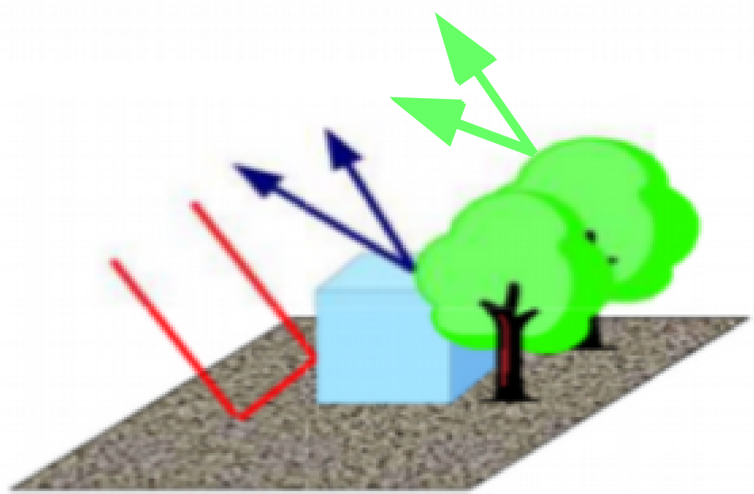
Non Linear
(Telecommunications)

Polarimetric SAR (PolSAR)









Volume scattering

Volume scattering $\|HV + VH\|$

Dual polarimetric

Single bounce scattering $\|HH + VV\|$

Double bounce scattering $\|HH - VV\|$

Full polarimetric

$\|HH + VV\|$

$\|HH - VV\|$

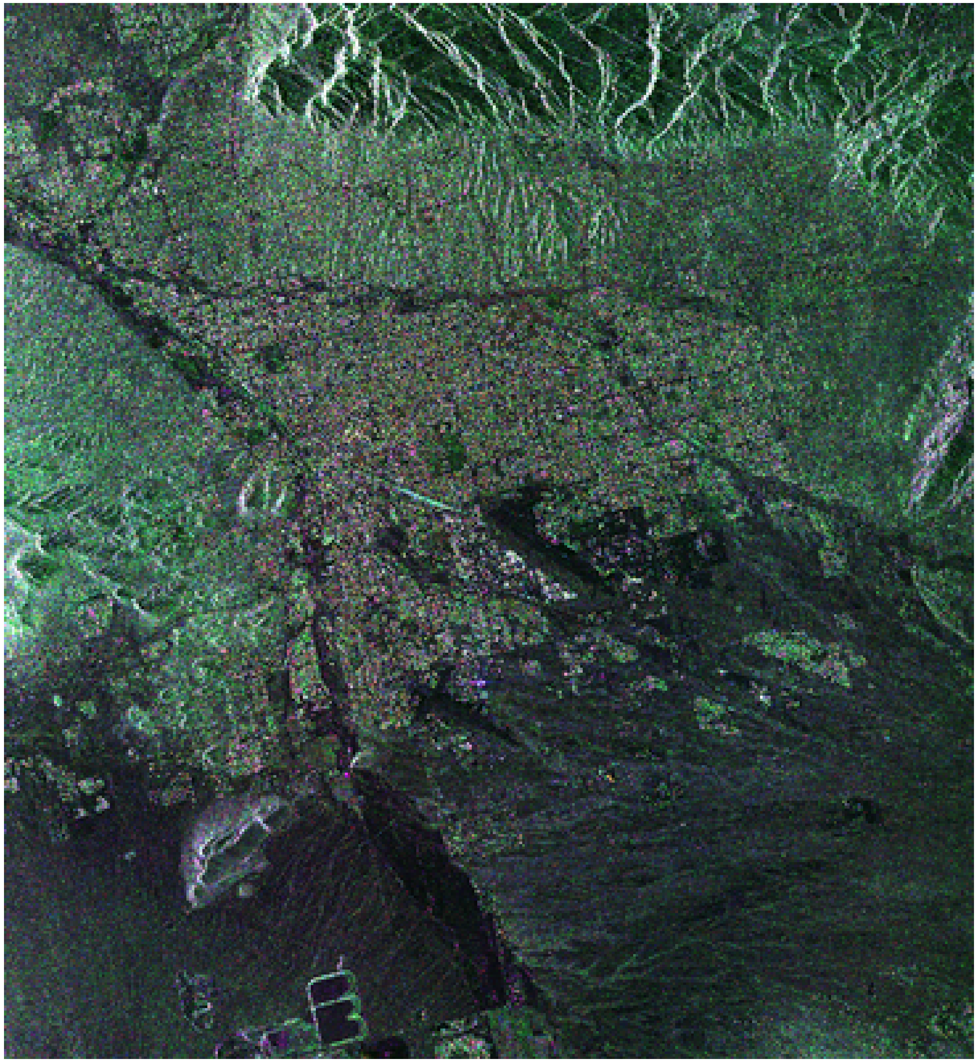
$\|HV + VH\|$

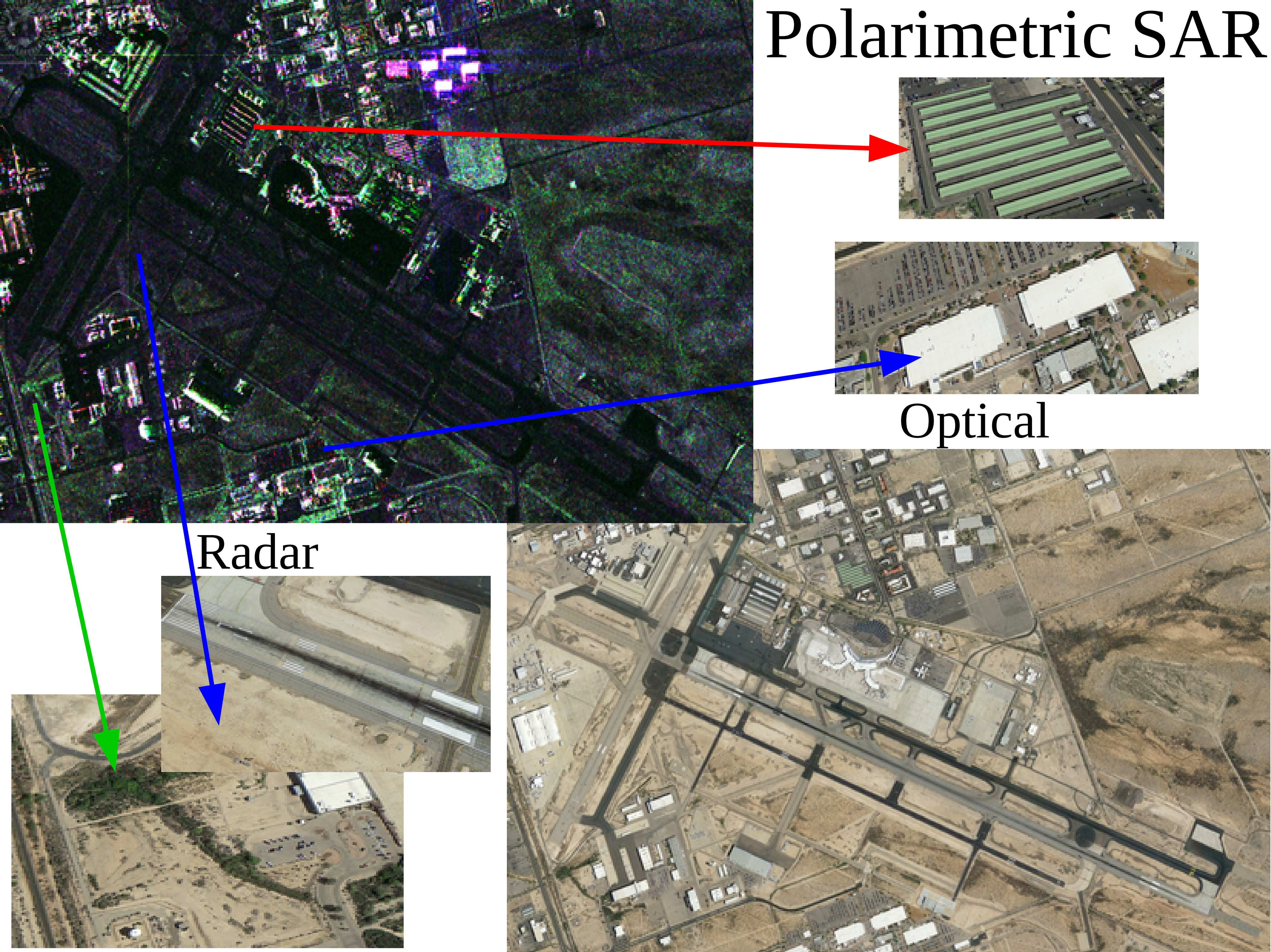
Polarimetric SAR

CSK data (multi-temporal Full-Pol)

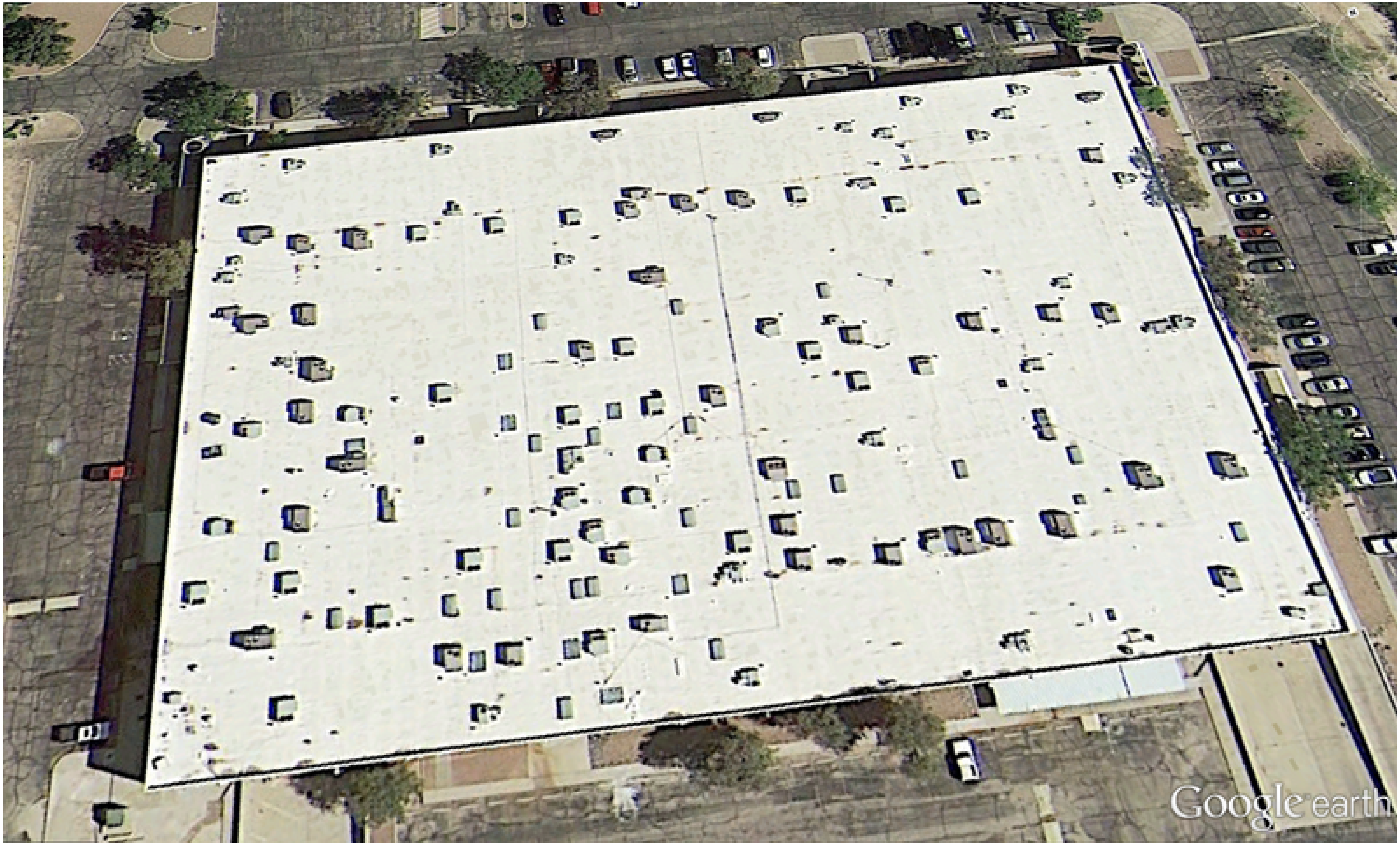
Optical

Radar

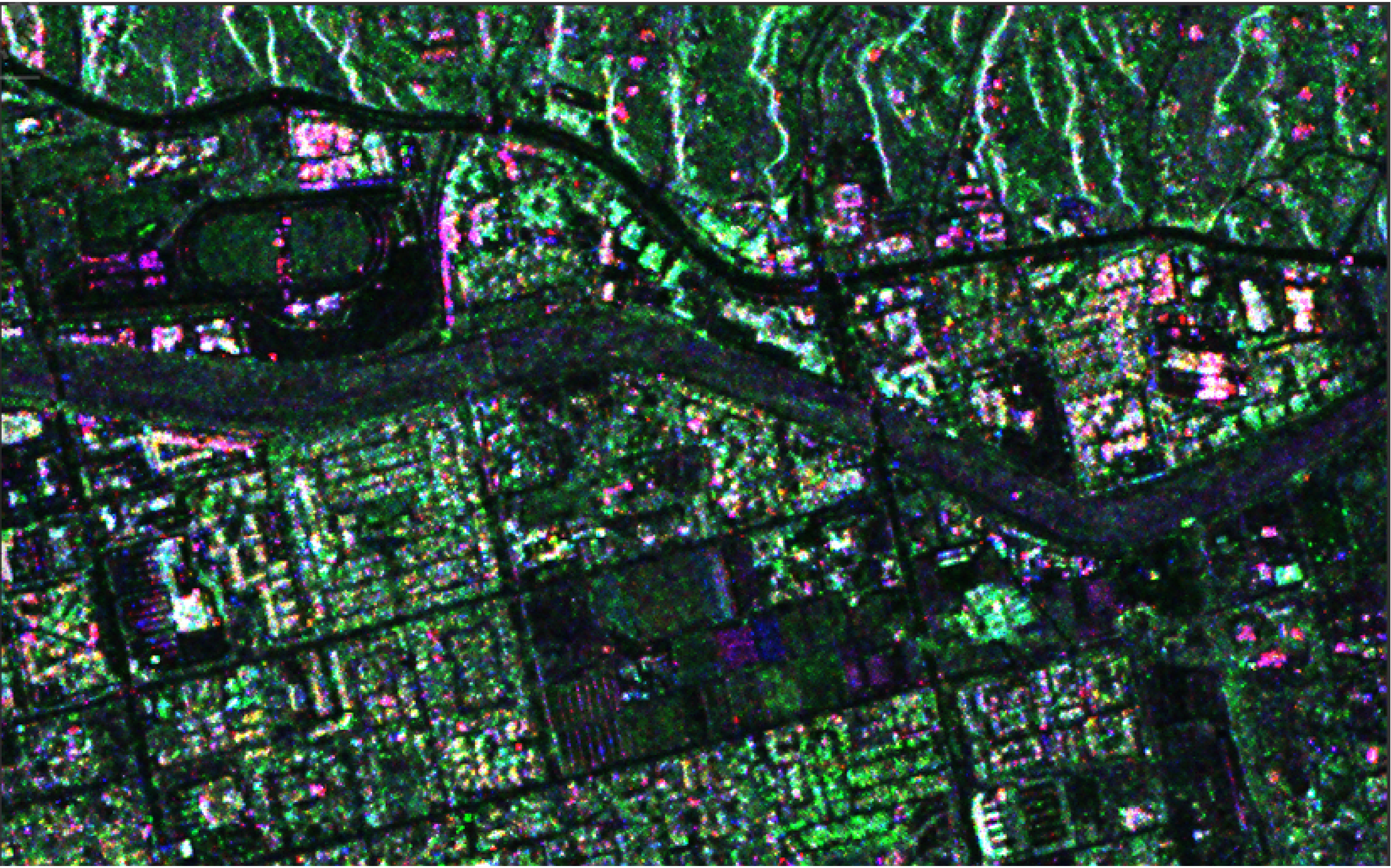



Polarimetric SAR
Optical
Radar

Polarimetric SAR

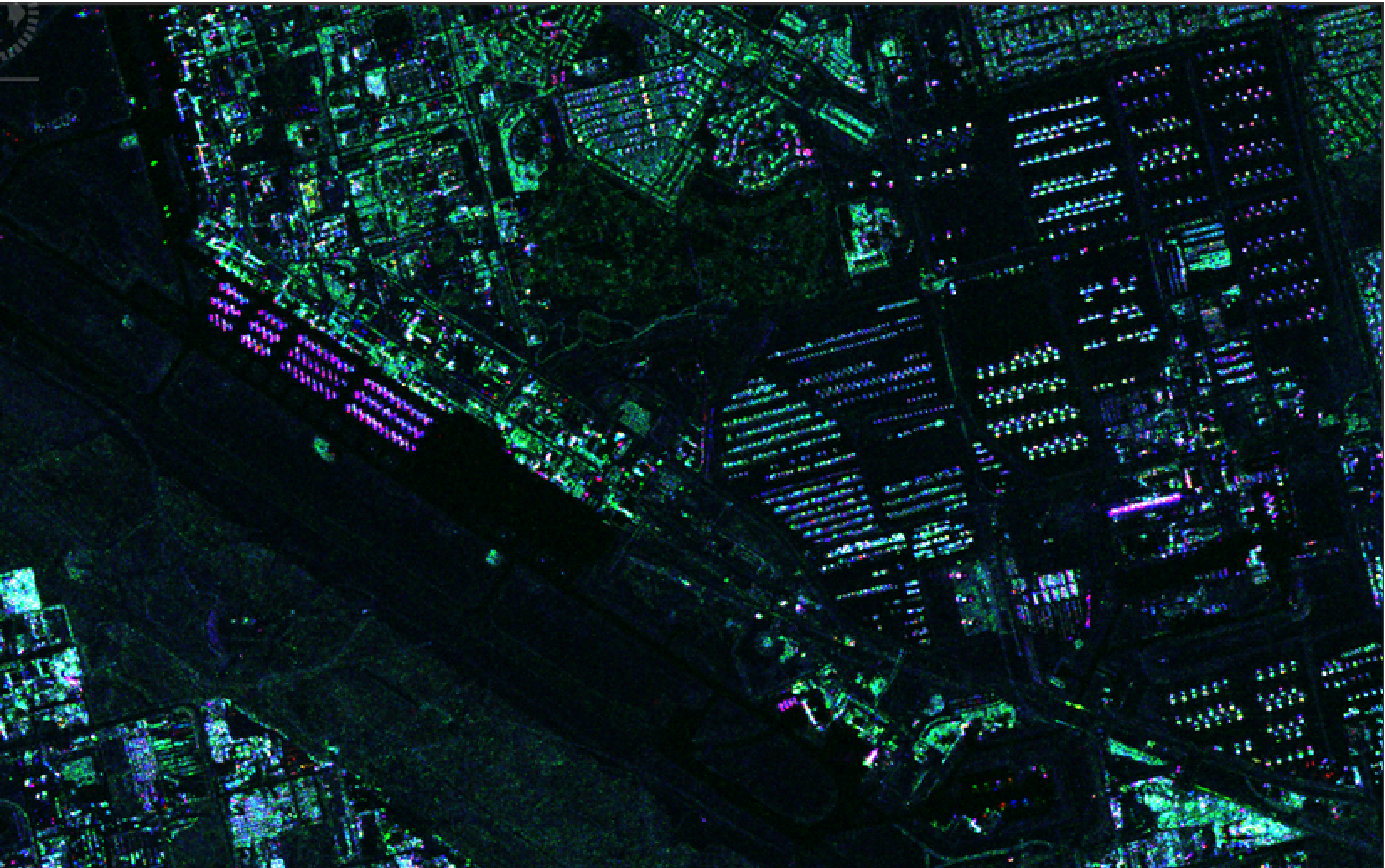


Polarimetric SAR



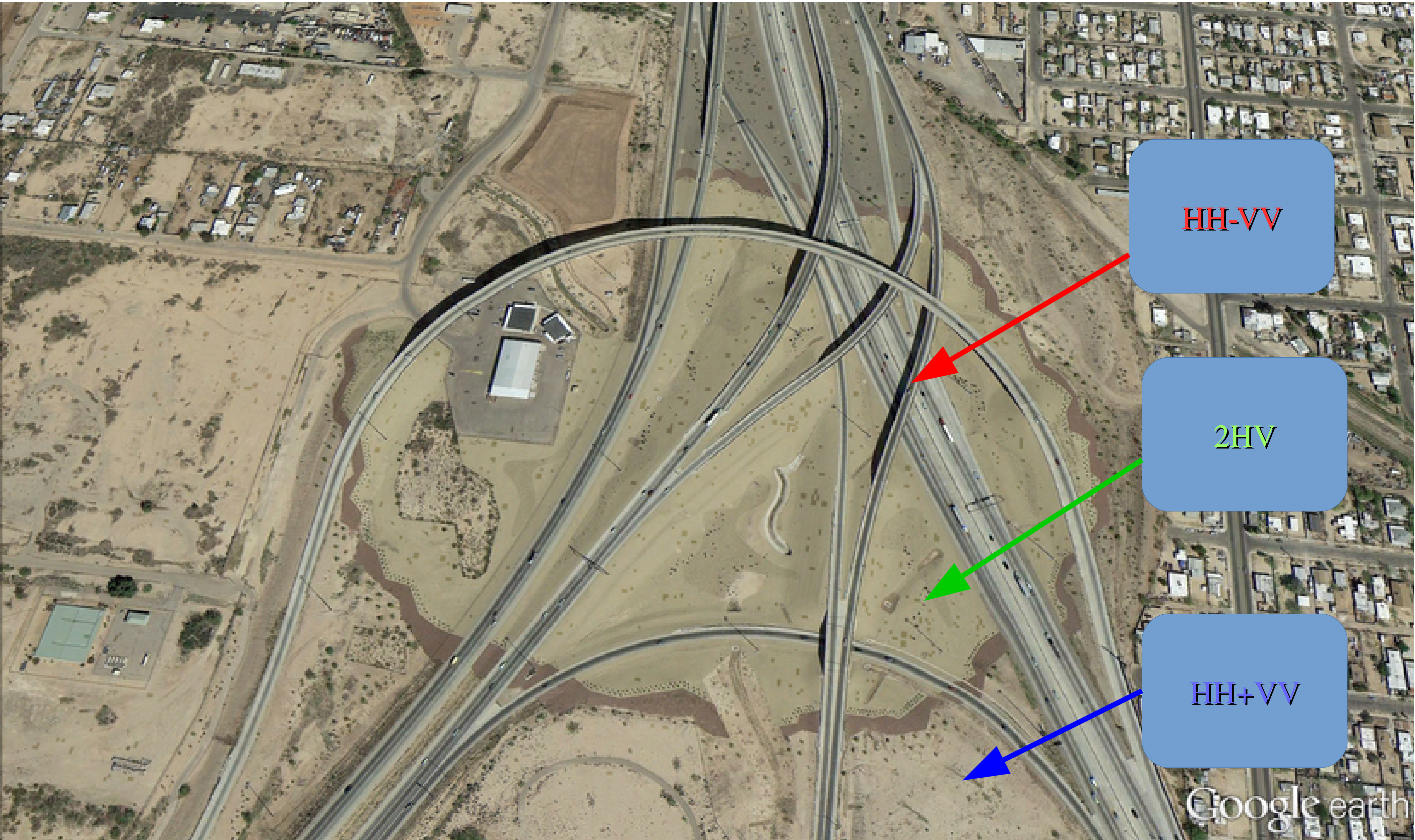
Polarimetric SAR

Polarimetric SAR



Polarimetric SAR

Polarimetric SAR

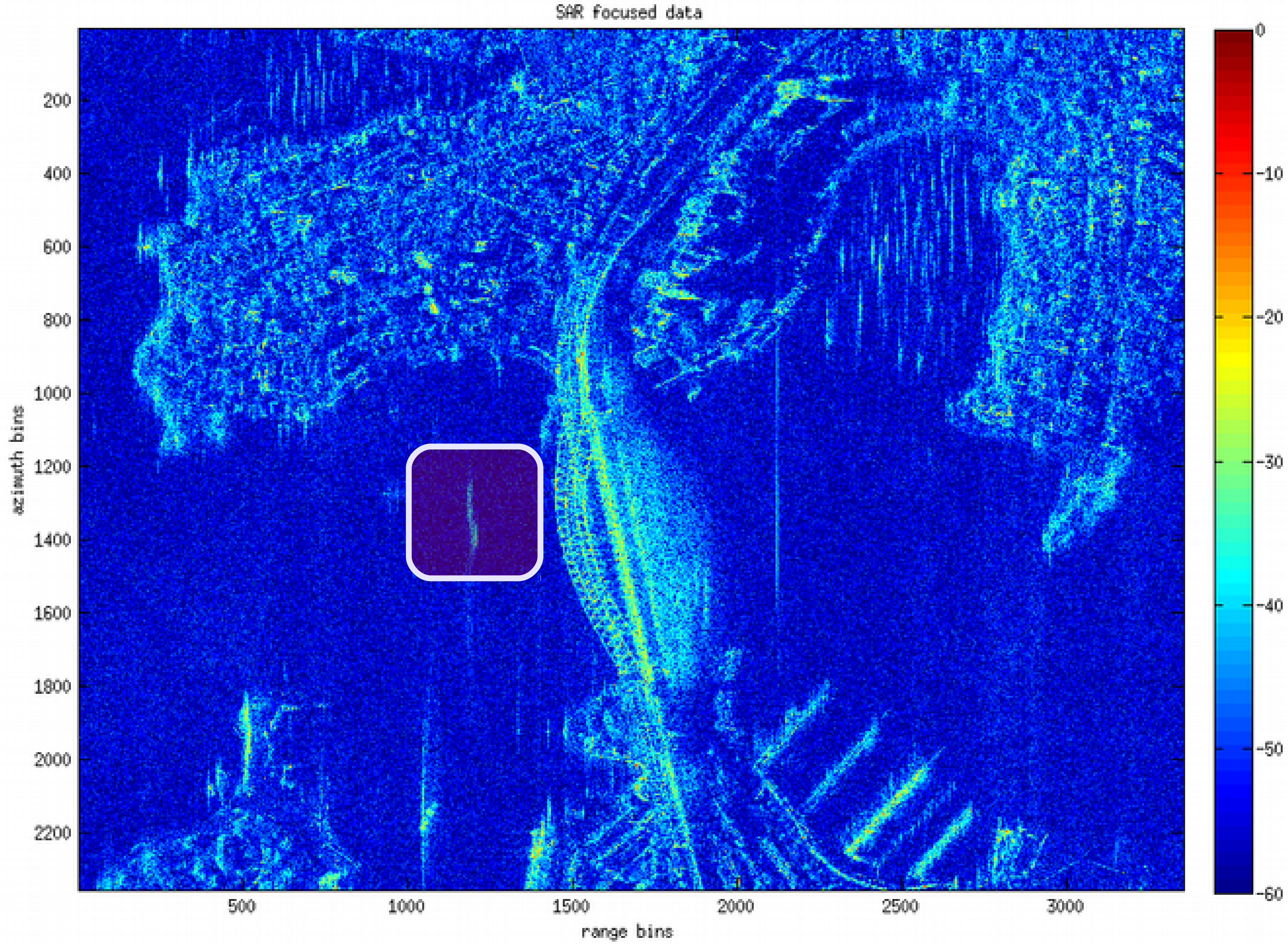


Polarimetric SAR

Polarimetric SAR

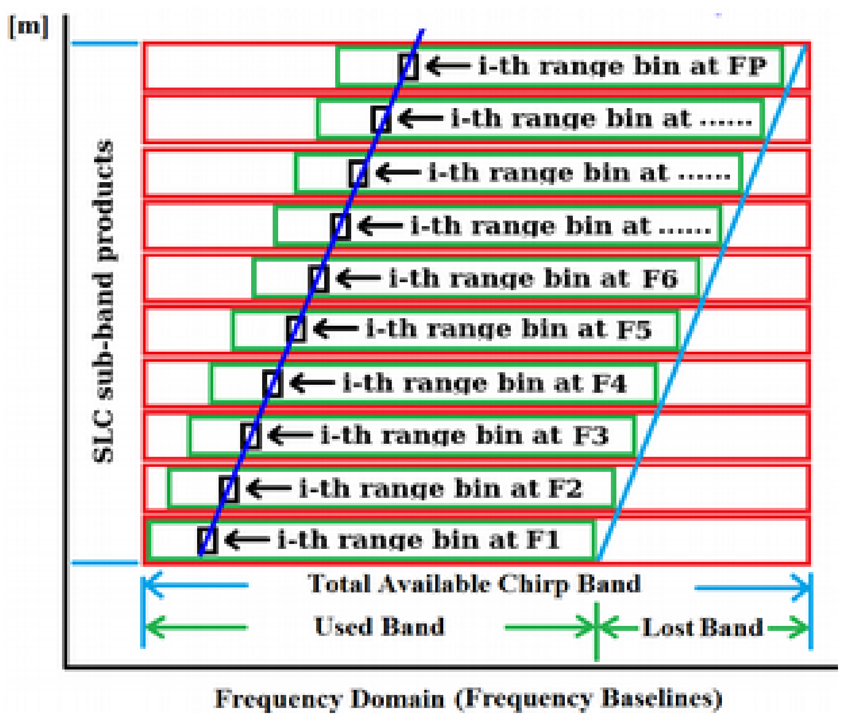
Polarimetric SAR

Experimental Results



Multi Chromatic Analysis (MCA) State of the Art

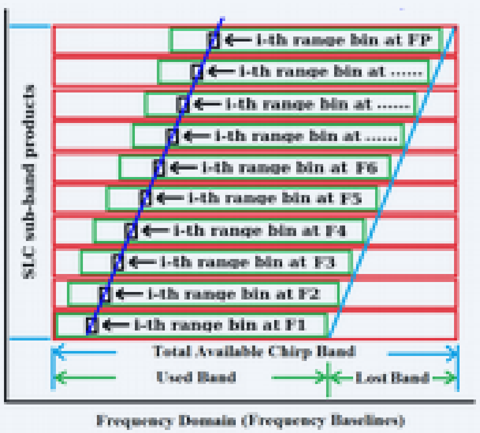
Multi Chromatic Analysis
Range-Doppler Sub-apertures



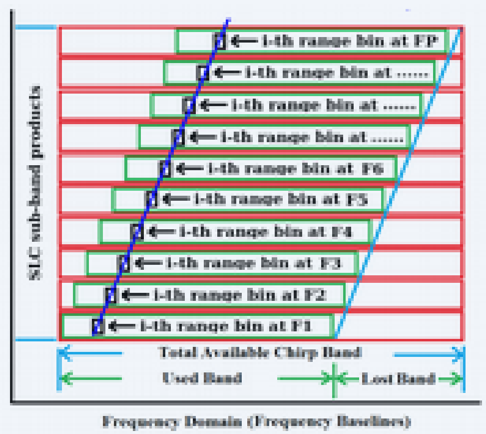
- Range → InSAR
- Azimuth → MTI-SAR

Multi Chromatic Analysis (MCA) State of the Art

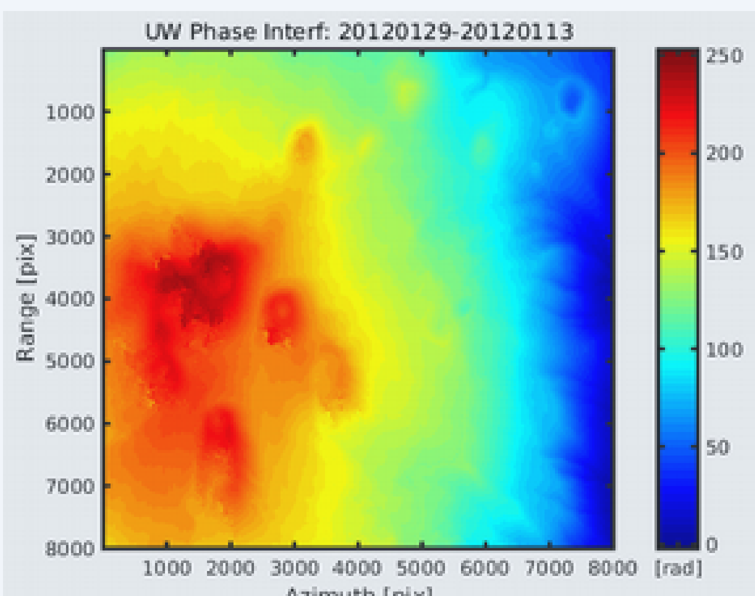
MCA in Range



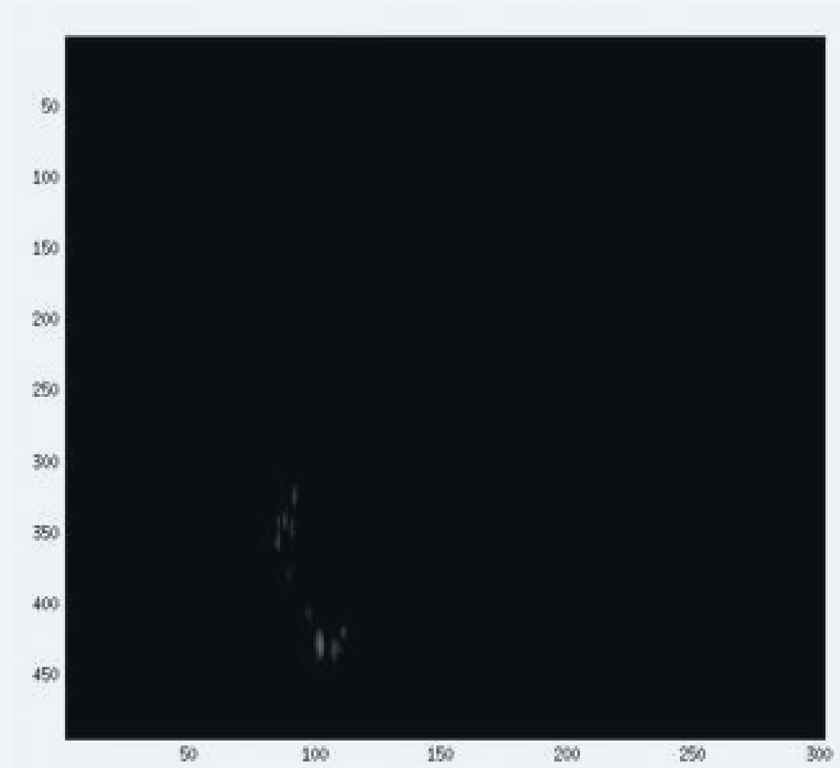
Master



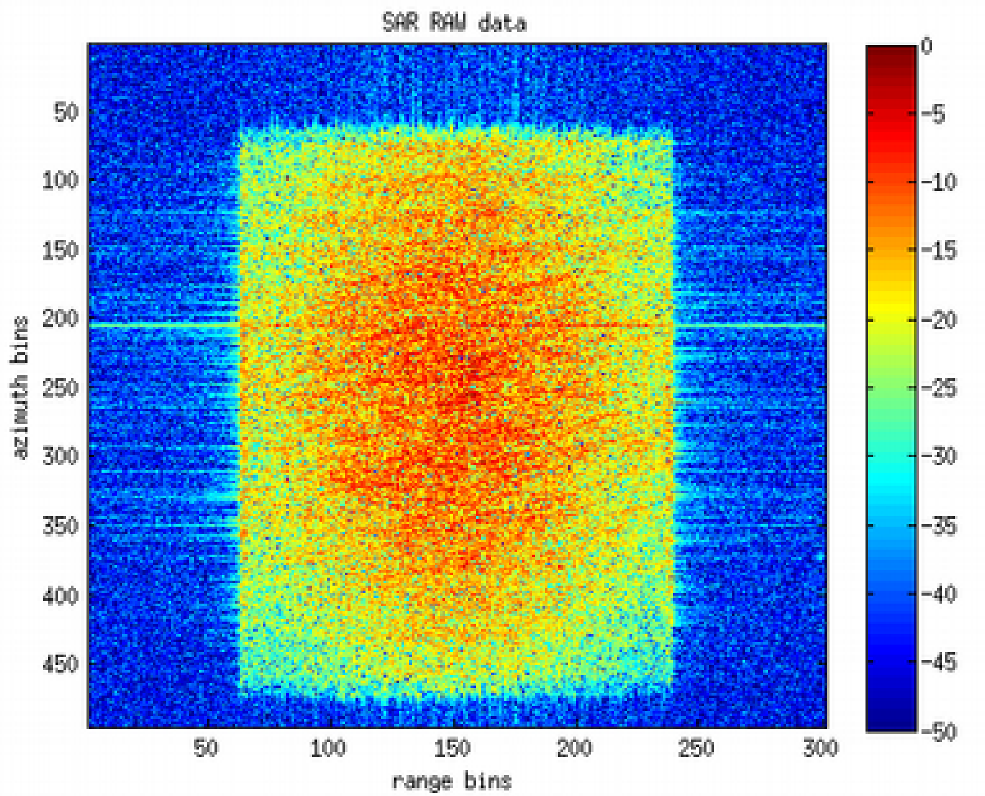
Slave



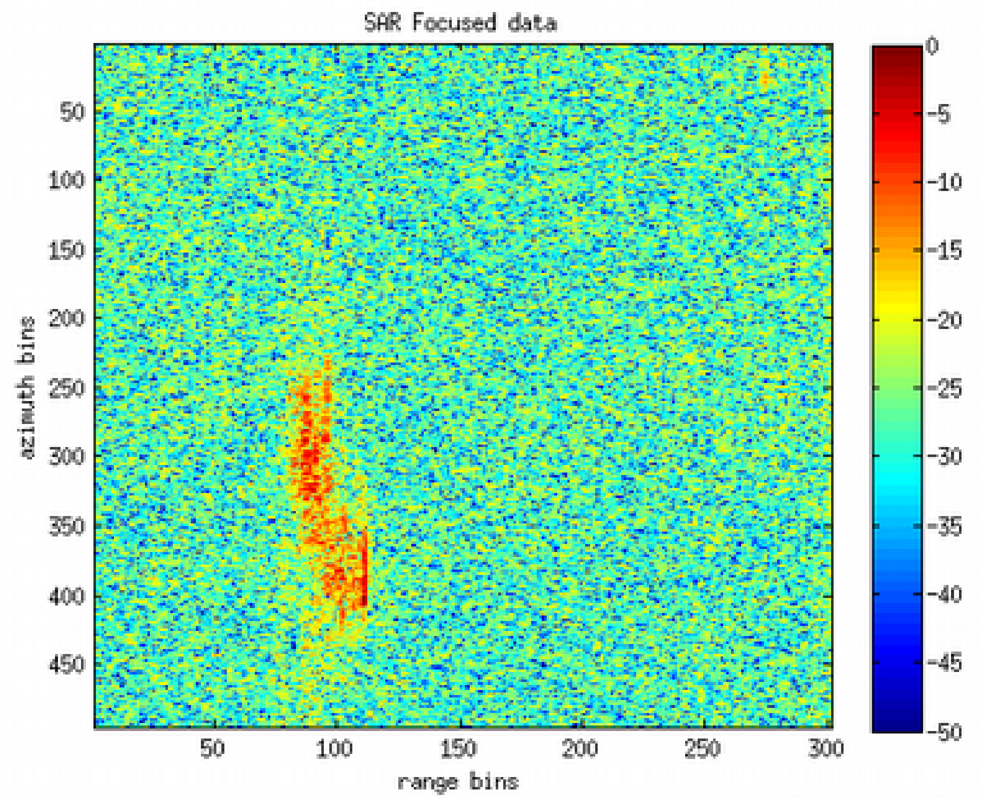
MCA in Azimuth



Experimental Results

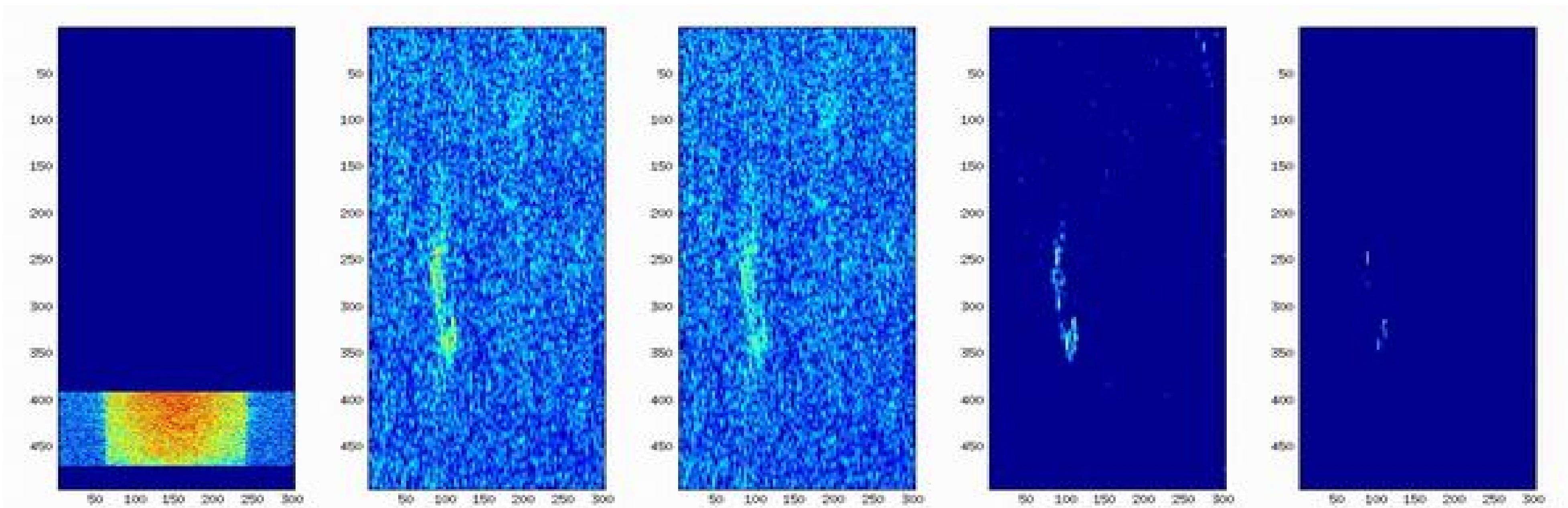


SAR RAW Data



SAR Focused Data

Experimental Results



SAR RAW Data

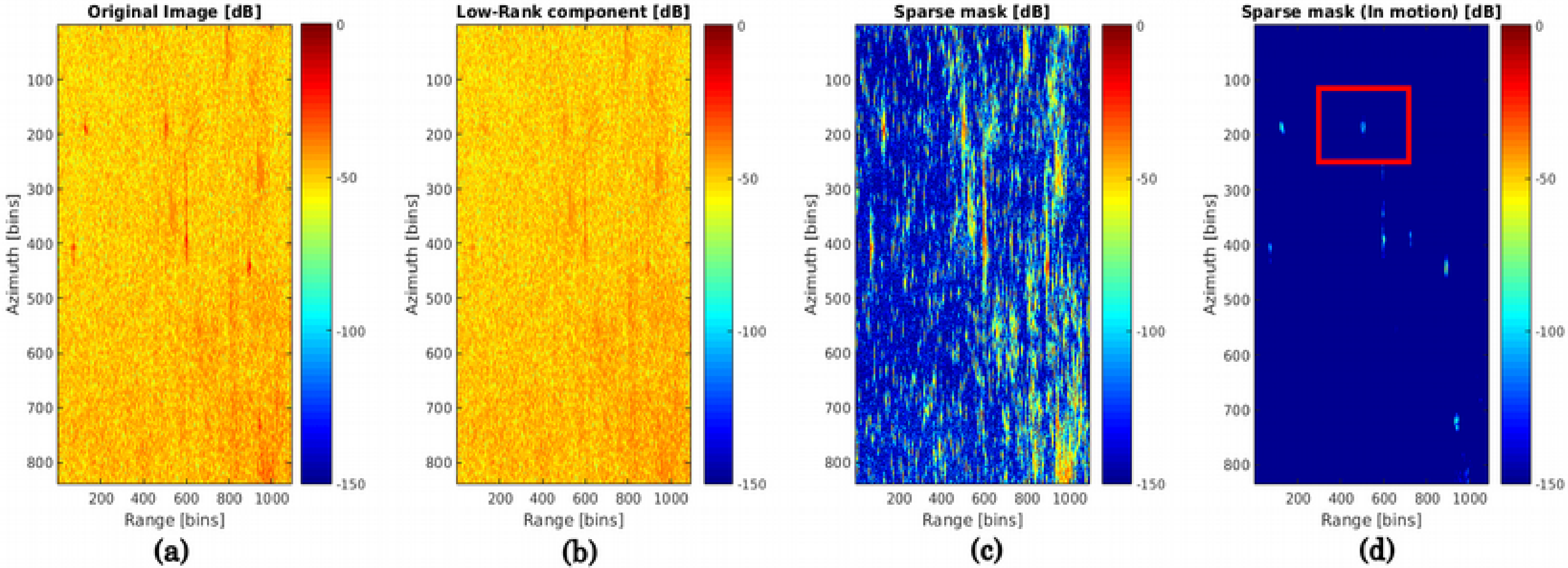
Original SAR Data

Low-Rank Component

Sparse Component

Sparse Cpmponent (in Motion)

Experimental Results



Original SAR Data

Low-Rank Component

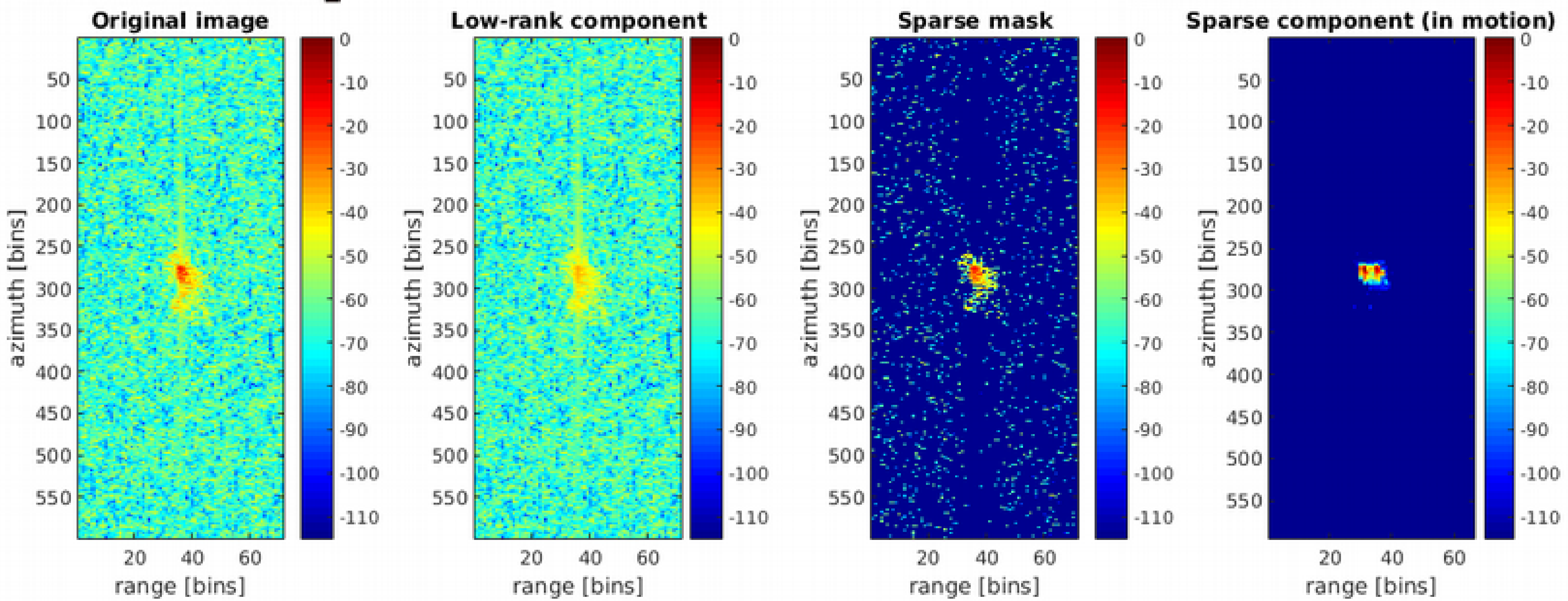
Sparse Component

Sparse Component (in Motion)

CoSeRa 2016

Experimental Results

Fraunhofer FHR



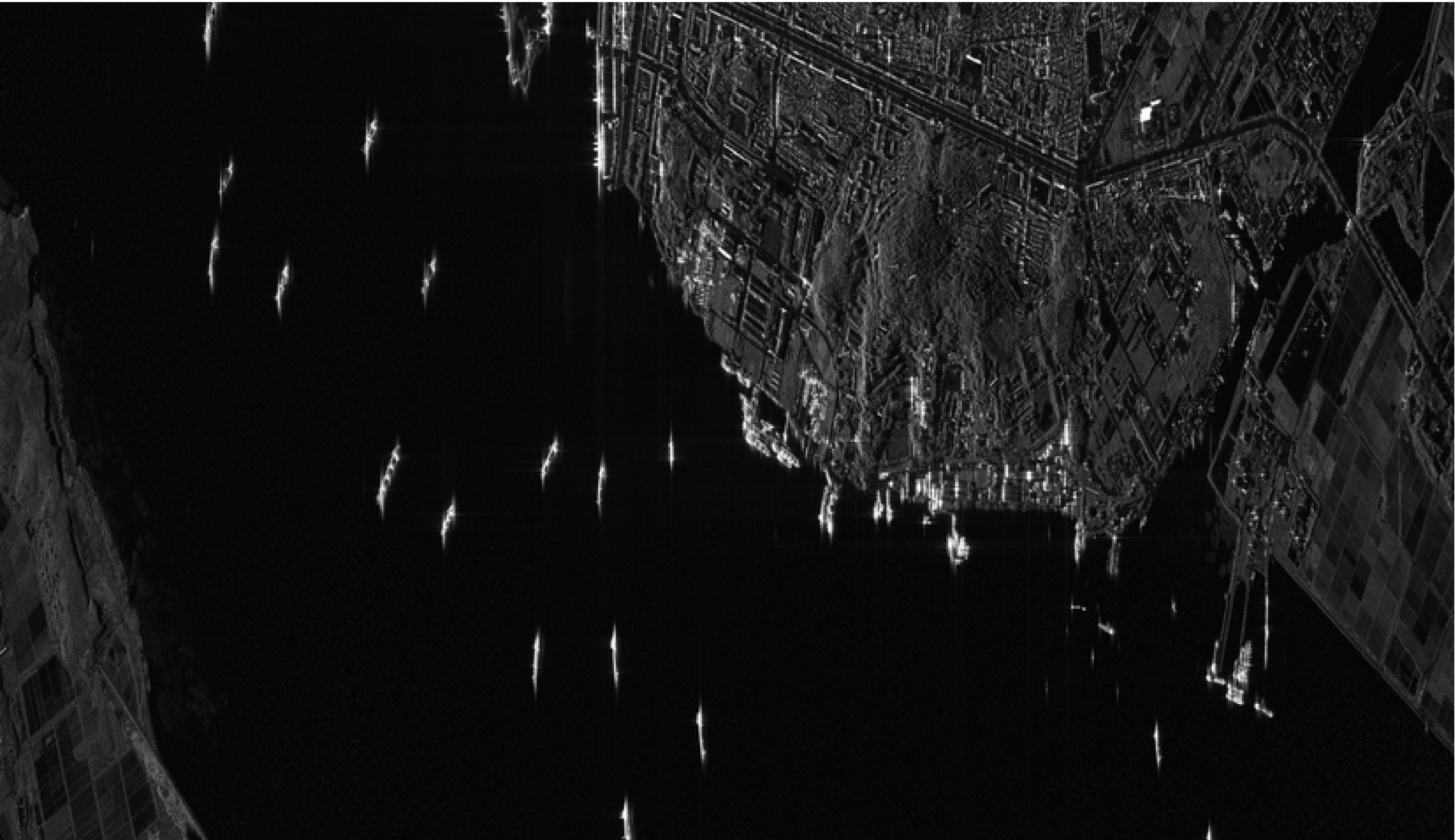
Original SAR Data

Low-Rank Component

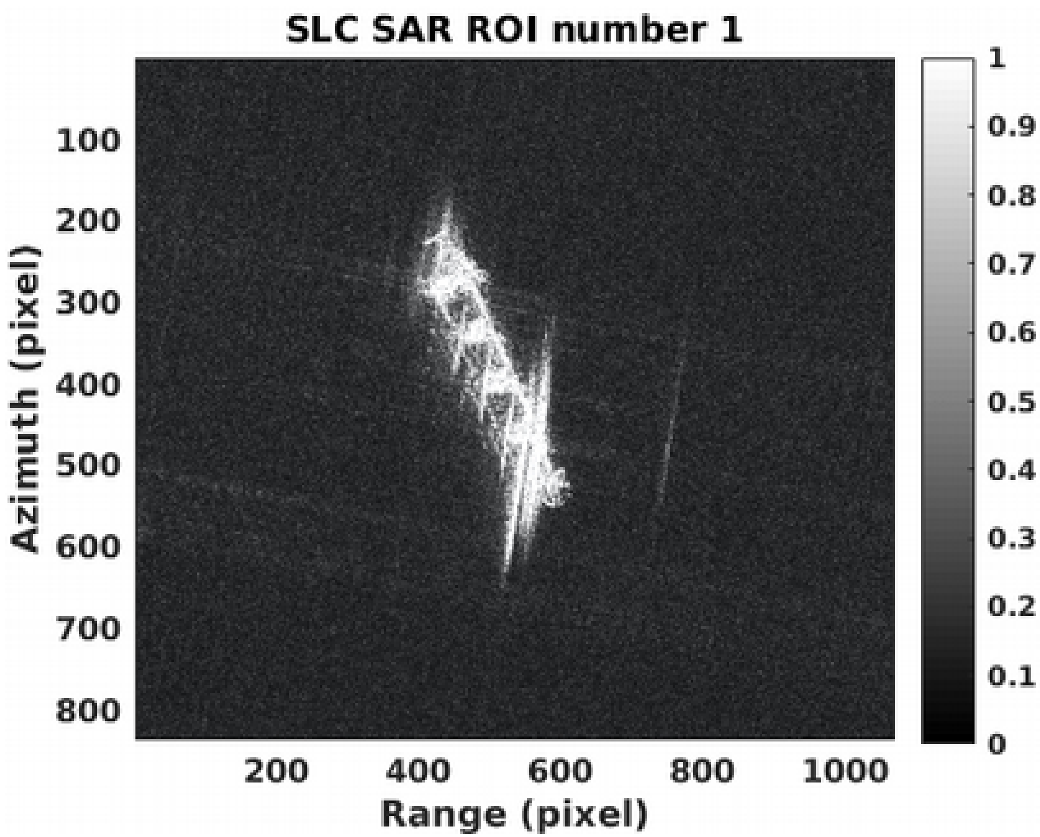
Sparse Component

Sparse Component (in Motion)

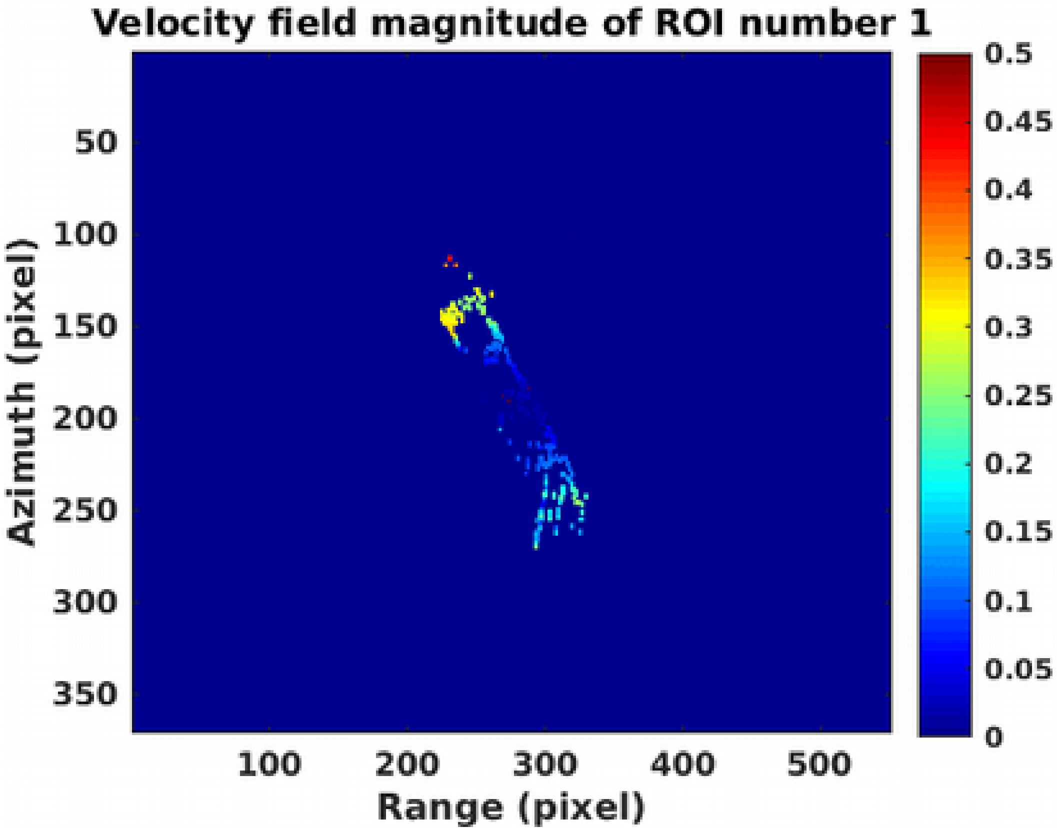
Experimental Results



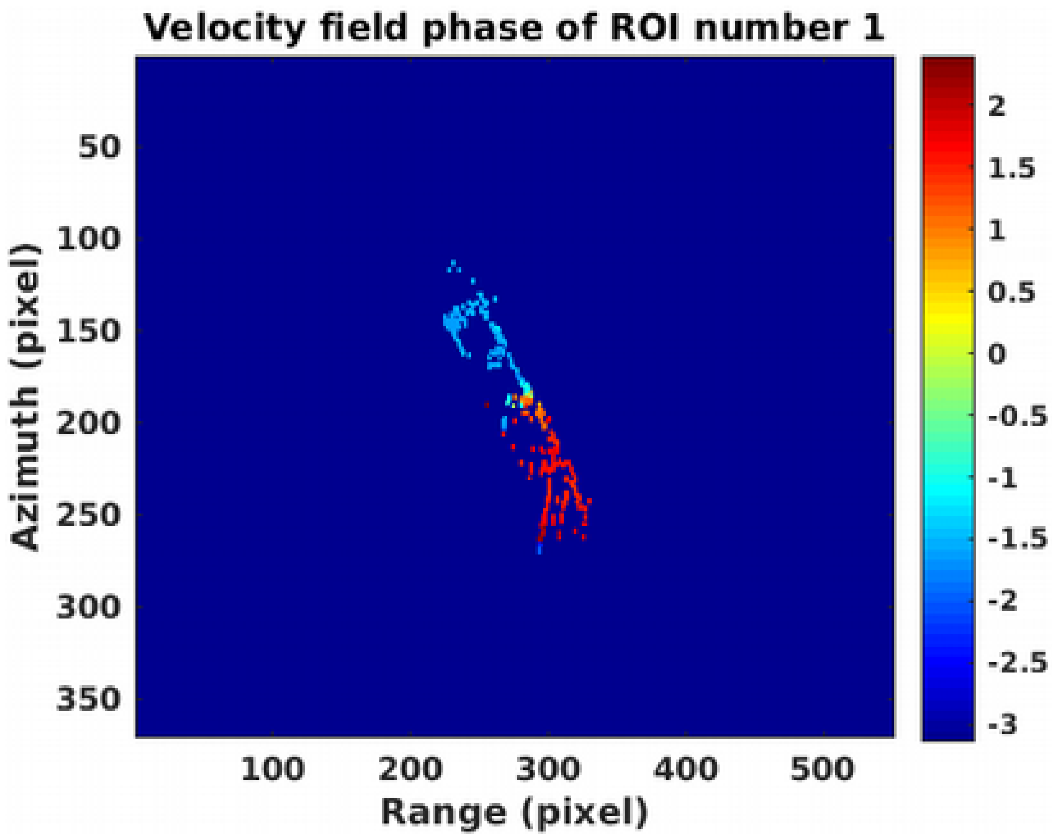
Experimental Results



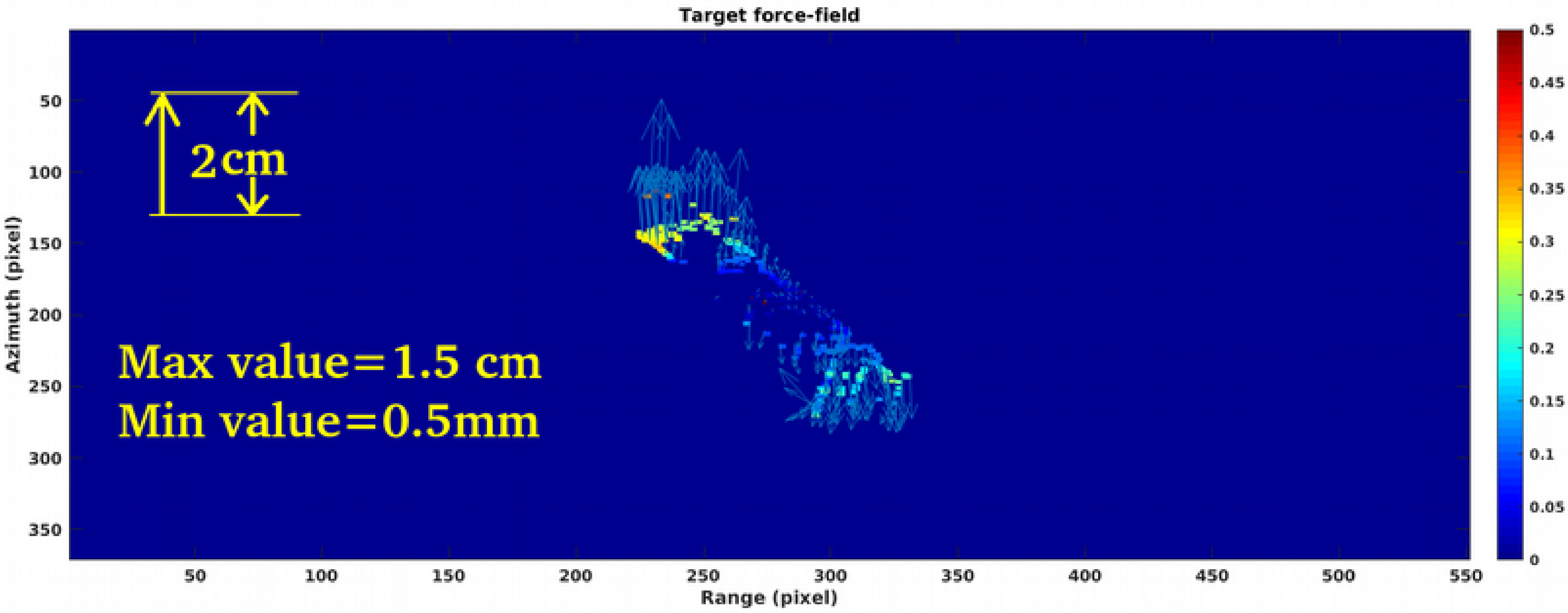
Experimental Results



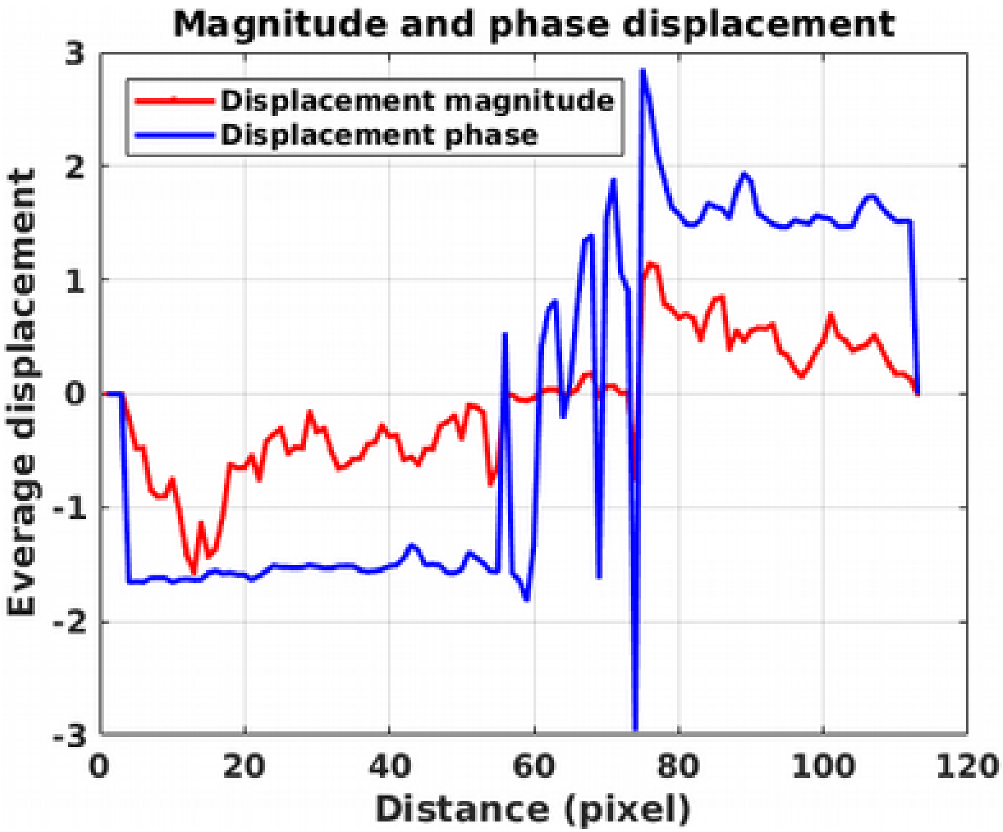
Experimental Results

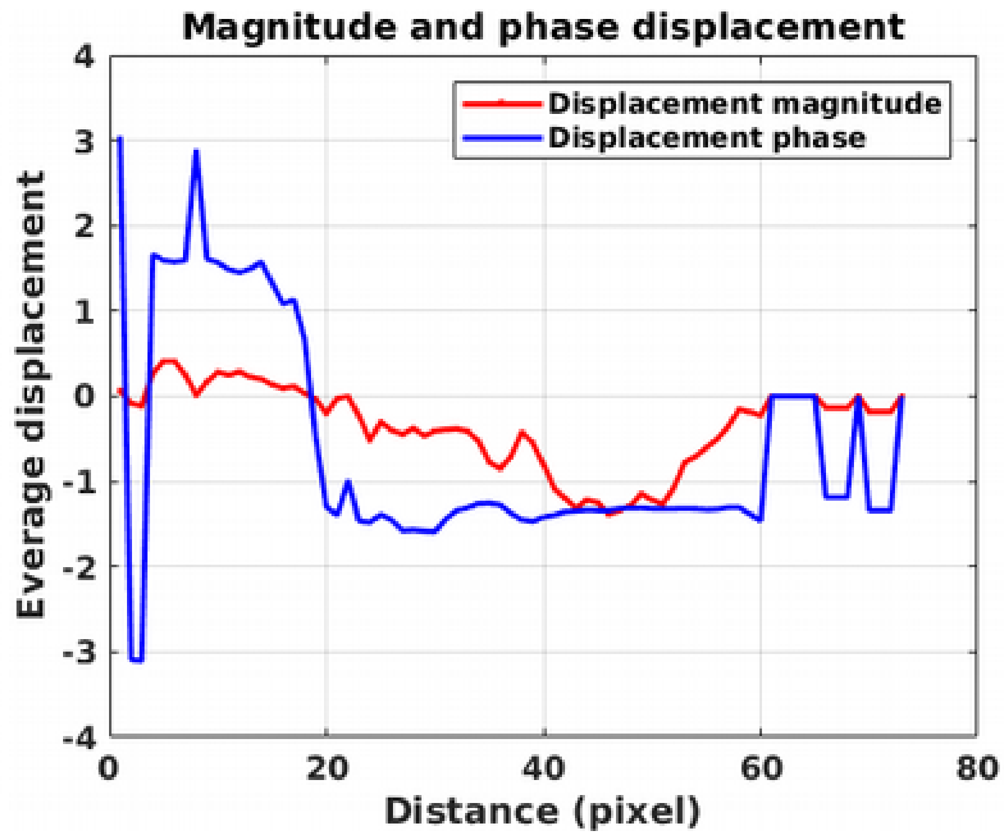


Experimental Results

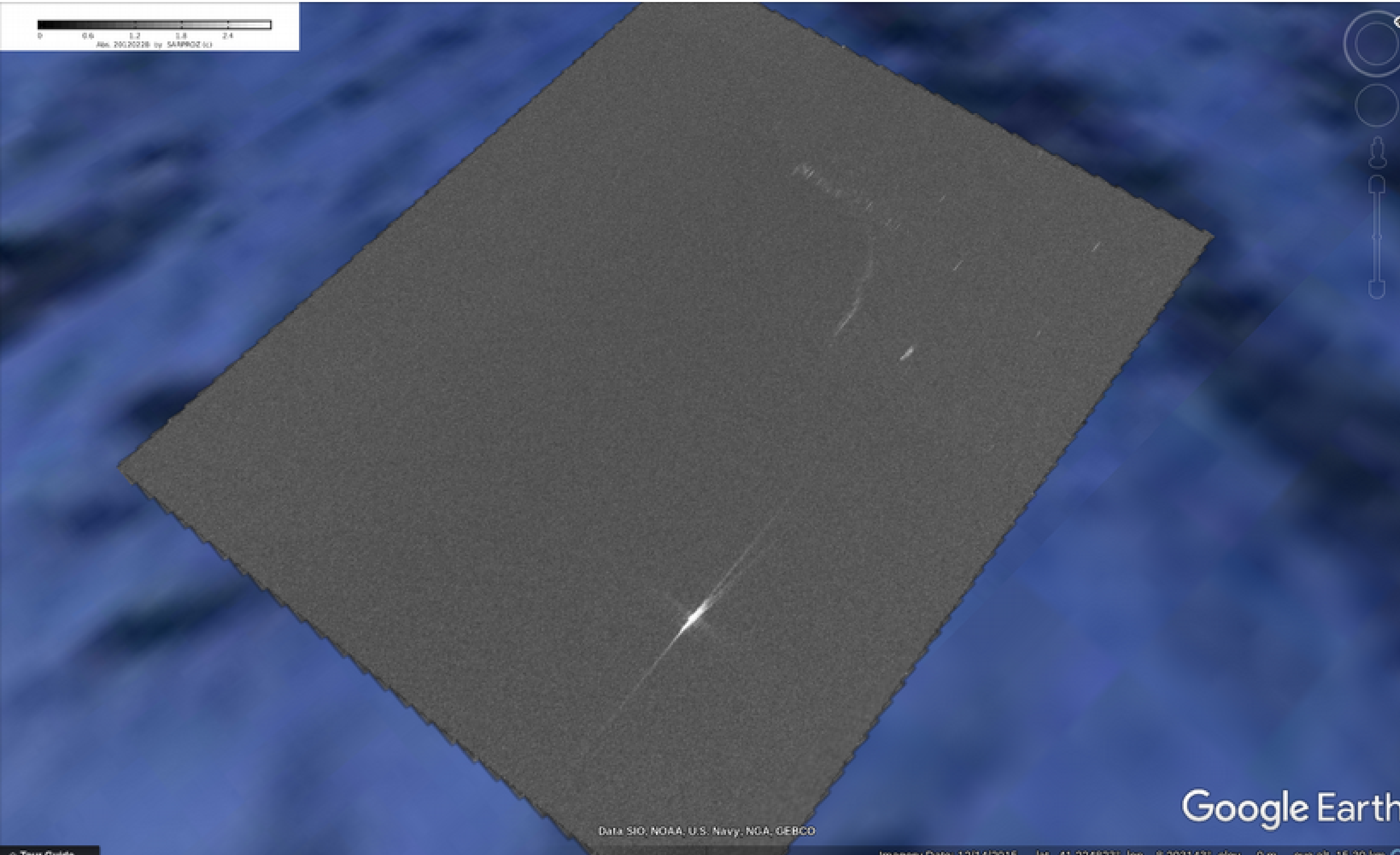


Experimental Results

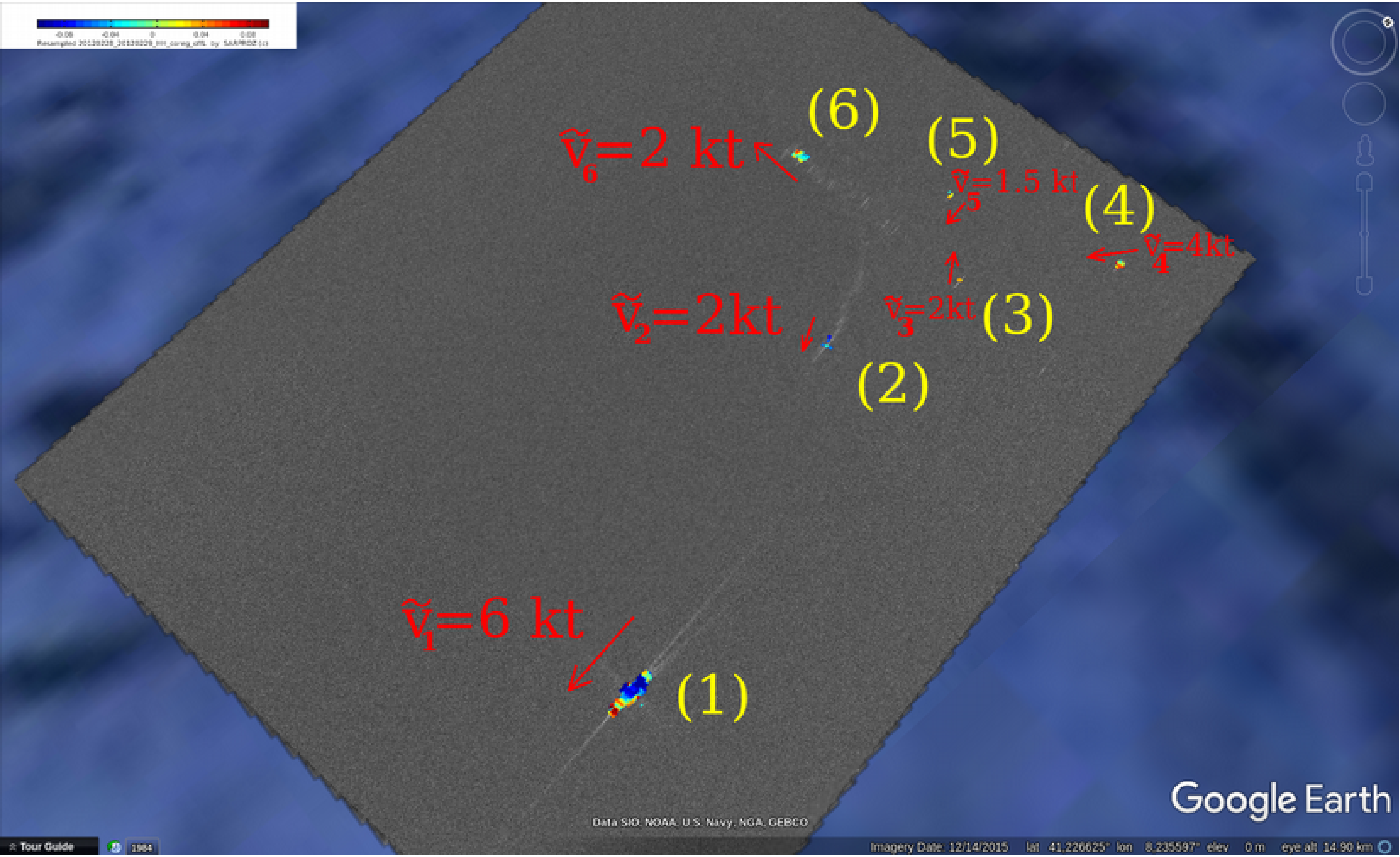




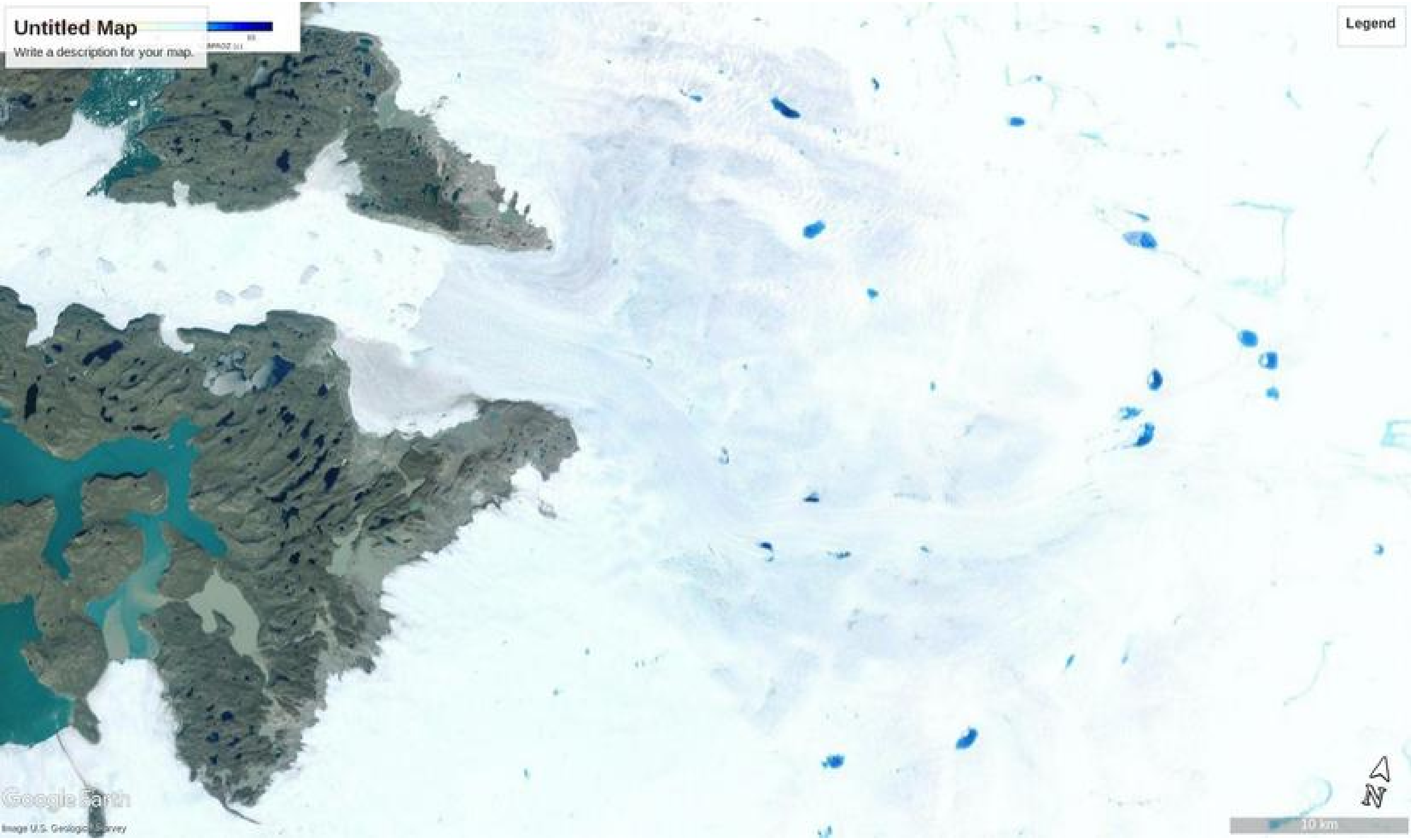
Experimental Results



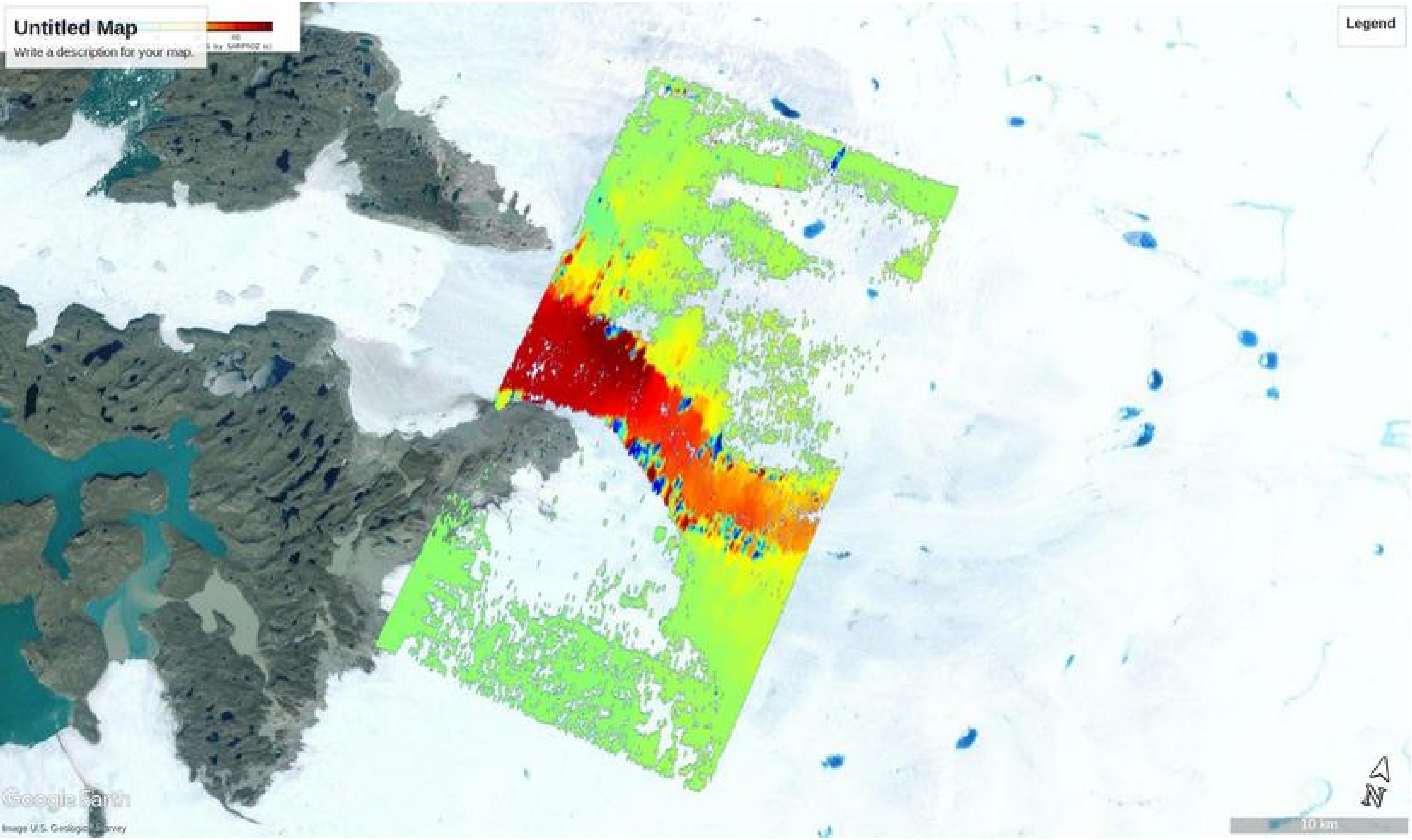
Experimental Results



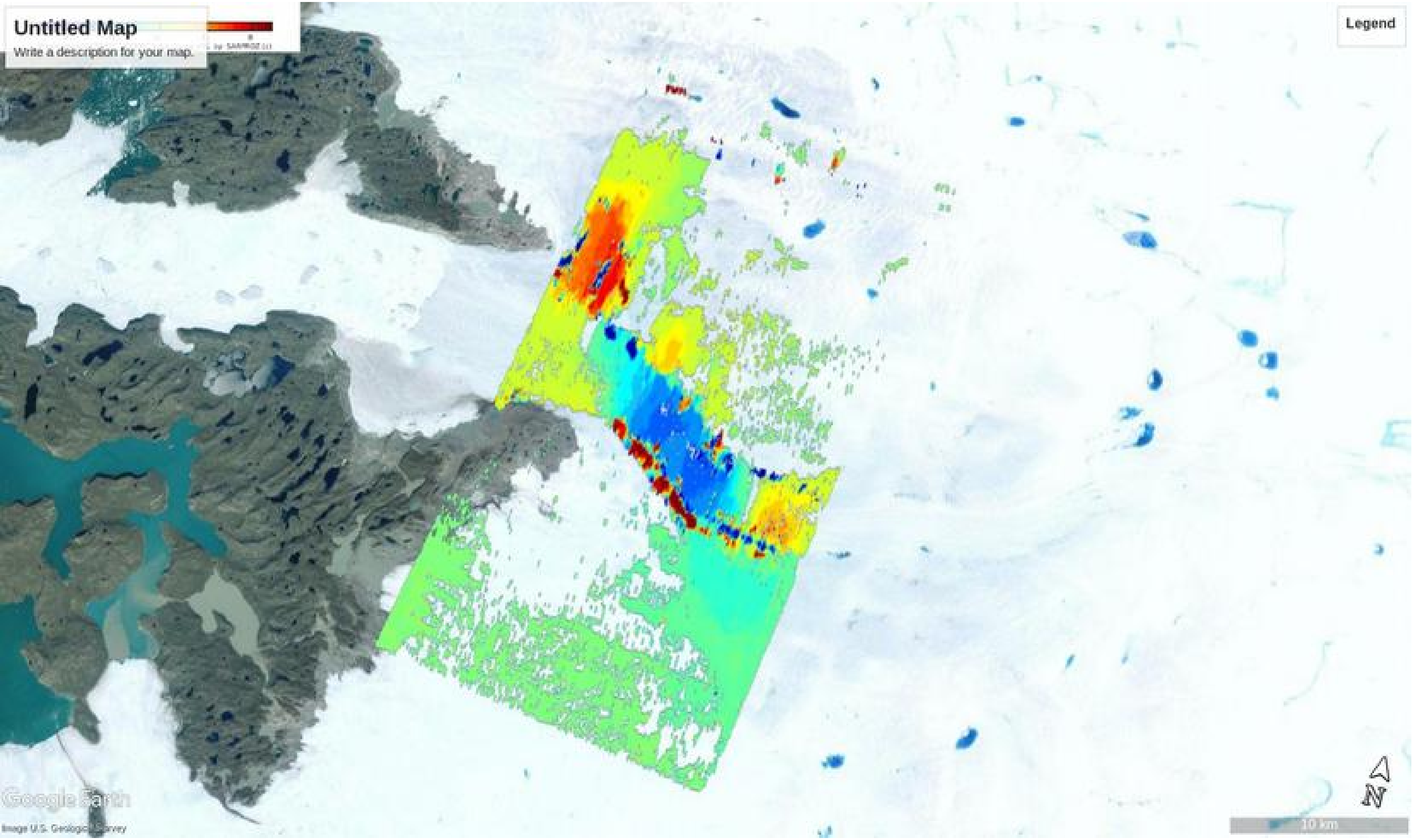
Experimental Results



Experimental Results



Experimental Results



Experimental Results

Experimental Results

Experimental Results