

Analysing Surface Deformation in Surabaya from Sentinel-1A Data using DInSAR Method

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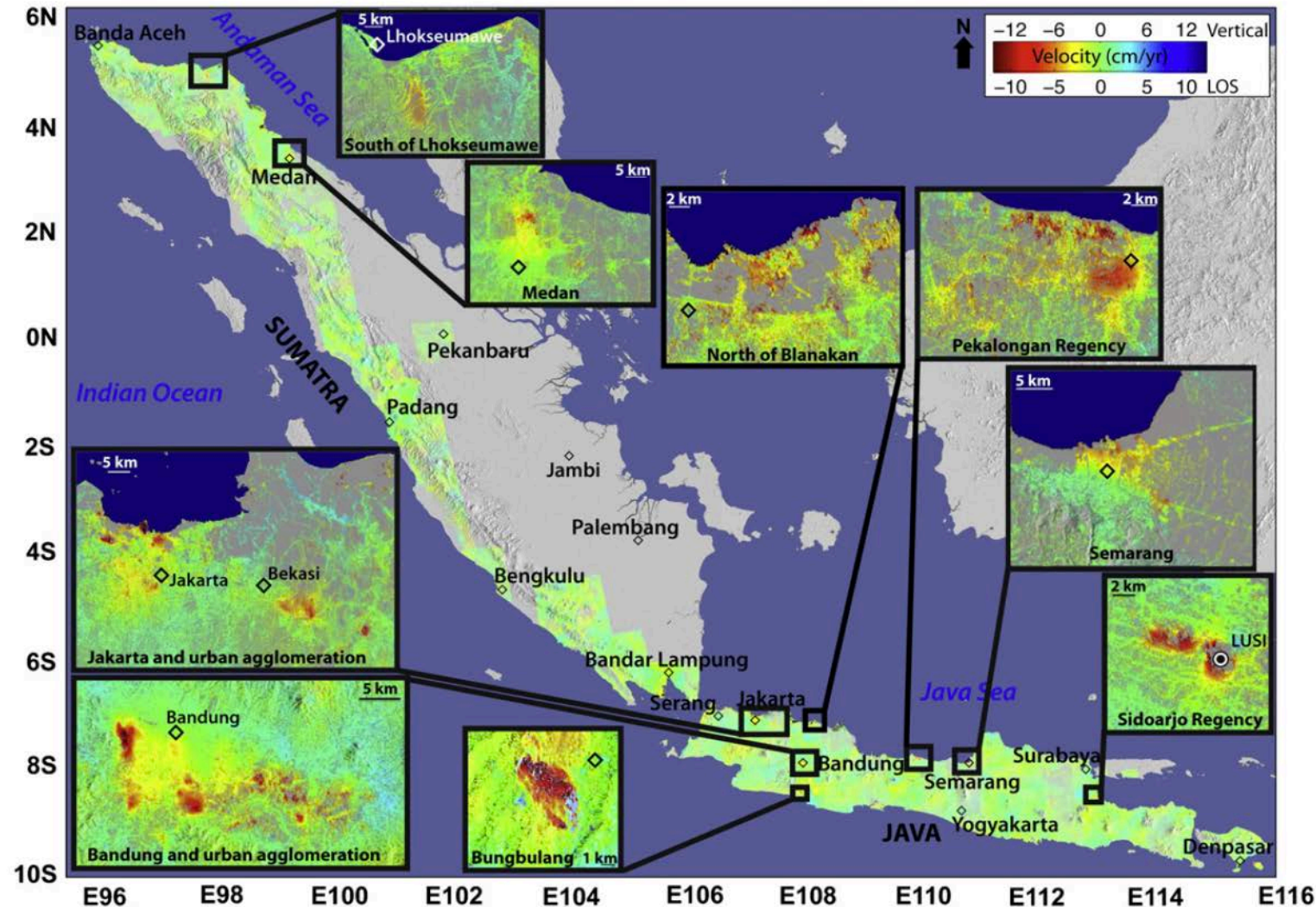
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Education Background : PhD – Geodesy
Curtin University, Western Australia
MPhil – Surveying & Mapping
Curtin University, Western Australia
ST – Teknik Geodesi
Institut Teknologi Bandung

Averaged 2006–2009 LOS velocity map of Sumatra, Java, and Bali, Indonesia, from ALOS InSAR time-series analysis (Chaussard et al, 2013)



Introduction



- Surabaya is the second largest city in Indonesia that has been predicted to suffer surface deformation.
- The surface deformation in Surabaya is triggered by many factors such as ground water extraction, load of infrastructures and constructions, and geologic condition of Surabaya that dominated by alluvial consolidation.
- The location of Surabaya on the coastal area also can be a force factor for the surface deformation.

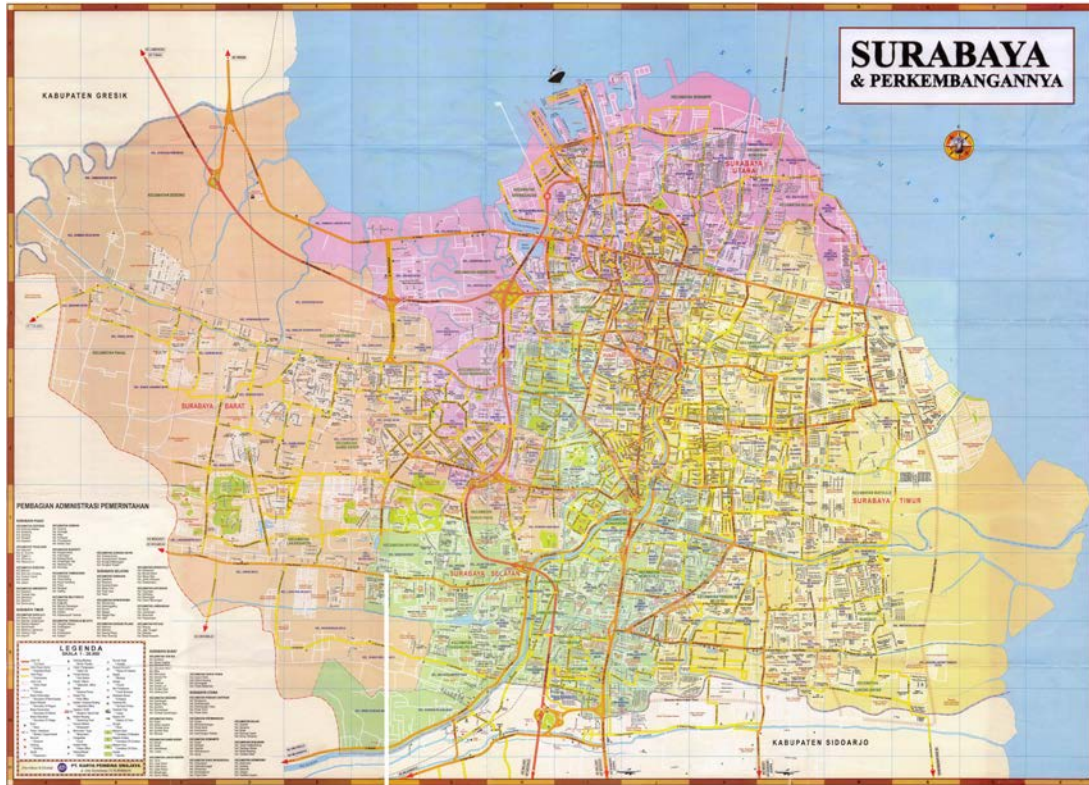
Research Aims



- To examine the model of surface deformation in Surabaya.
- To observe the areas in Surabaya that suffer from land subsidence.
- To quantify the surface deformation in Surabaya.

Study area : Surabaya City





- Location : 112,75° E ; 7,25° S
- Area : ± 326,36 km²
- Population : 2.765.487
- Most of the regions are lowland, which is around 3 - 6 m above the sea level. Except on the south region, the elevation is up to 25 - 50 m above the sea level.

Surabaya Administration Area	Soil Type
Center	Alluvial, silt
North	Alluvial and alluvial not volcanic ash
East	Alluvial, silt, sand deposits
West	Alluvial and not volcanic ash, alluvial not volcanic ash
South	Alluvial and not volcanic ash, silt, sand sediment mud

Methodology



- Data :
 - Sentinel-1A Level 1 SLC
 - DEM SRTM 30x30m
- Technique:
 - Differential Interferometry SAR (DInSAR)
- Software :
 - GMTSAR for SAR processing
 - GMT for plotting

Sentinel-1A Data

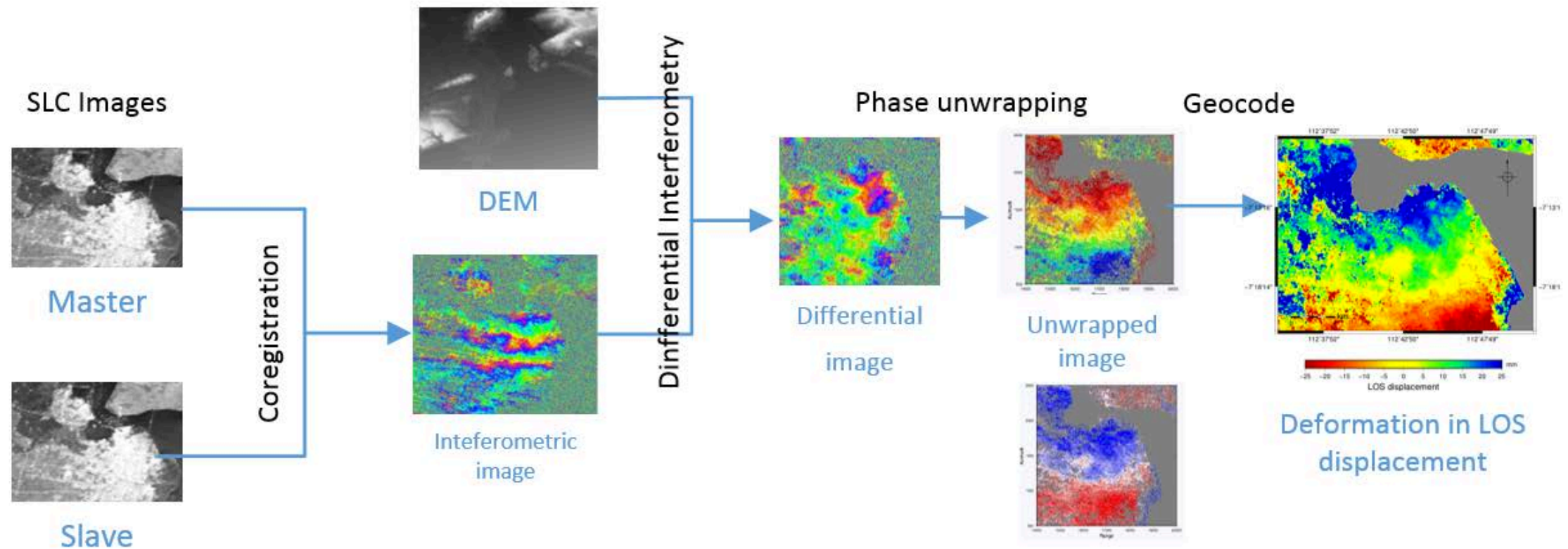


- Level 1 – Single Look Complex



Mode	Resolution rg x az	Pixel spacing rg x az	Number of looks	ENL
SM	1.7x4.3 m to 3.6x4.9 m	1.5x3.6 m to 3.1x4.1 m	1x1	1
IW	2.7x22 m to 3.5x22 m	2.3x17.4 m	1x1	1
EW	7.9x43 m to 15x43 m	5.9x34.7 m	1x1	1
WV	2.0x4.8 m and 3.1x4.8 m	1.7x4.1 m and 2.7x4.1 m	1x1	1

Deformation from DInSAR method





Data Set

TABEL 1. Sentinel-1A Interferogram data used in this study

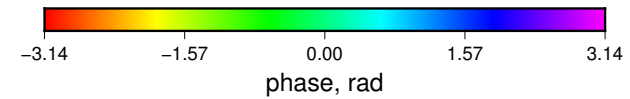
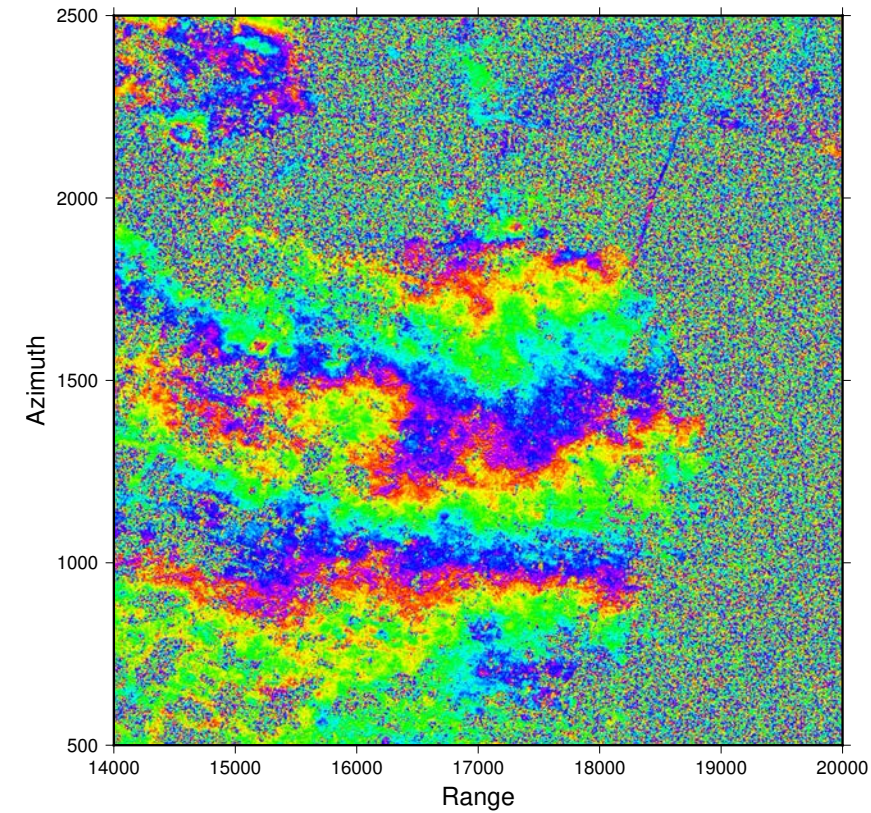
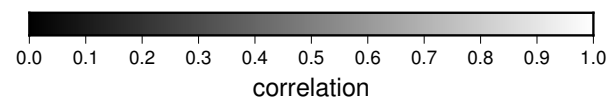
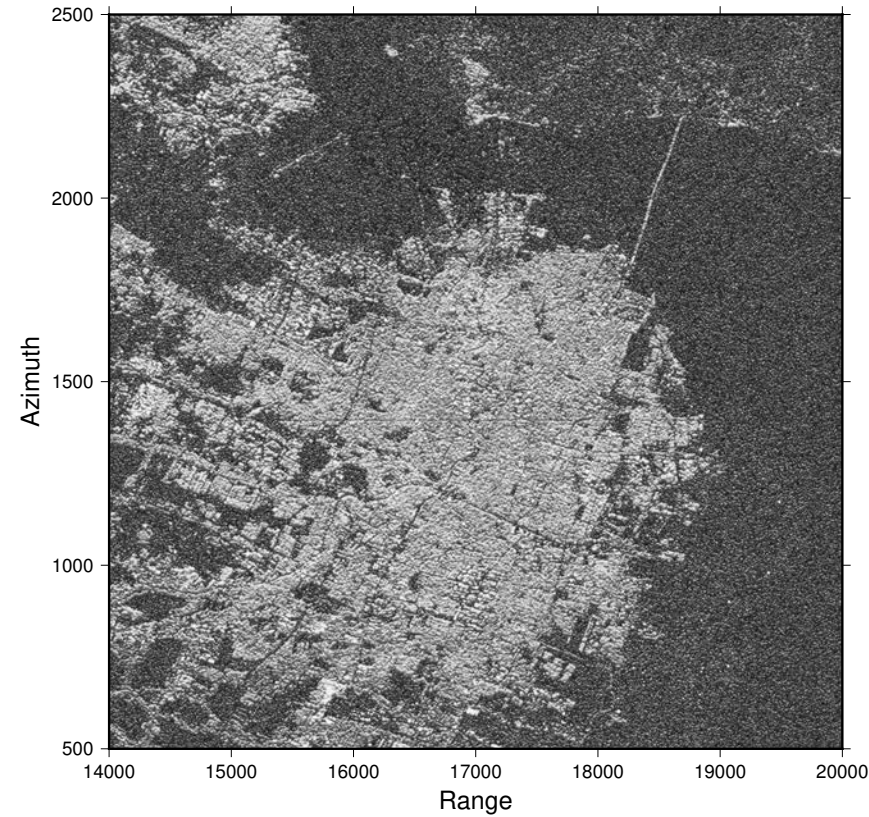
Series number	Master image date	Slave image date	Baseline perpendicular (m)	Baseline parallel (m)	Baseline temporal (days)
1	25 Mei 2015	22 Sept2015	27.73	-1.06	120
2	22 Sept 2015	20 Jan2016	24.90	39.59	120
3	20 Jan 2016	19 Mei 2016	26.10	2.37	120
4	19 Mei 2016	16 Sept 2016	-19.97	1.42	120

Results & Findings

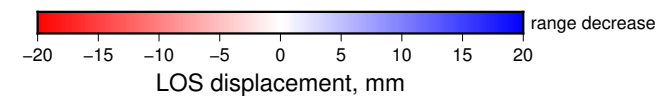
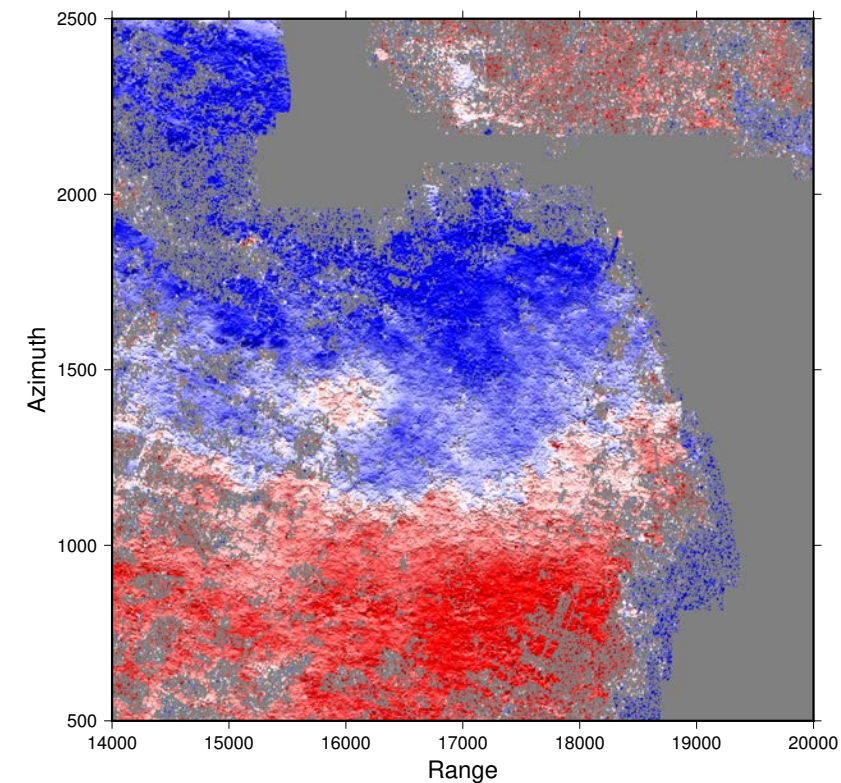
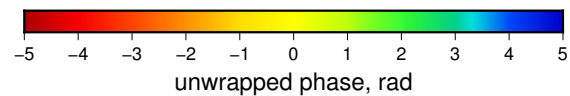
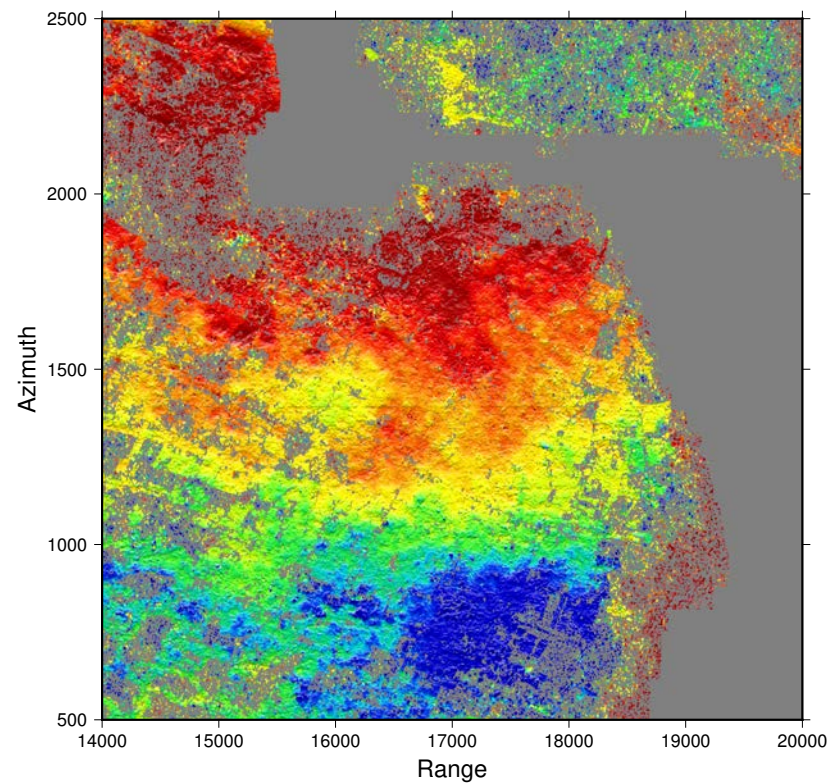


- Surface deformation
 - May 2015 to September 2015
 - September 2015 to January 2016
 - January 2016 to May 2016
 - May 2016 to September 2016
- Comparison of the results with other studies

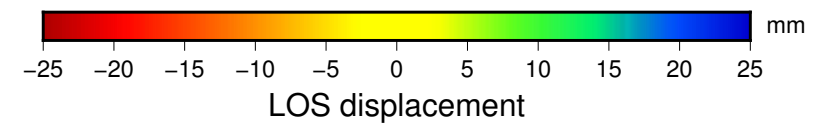
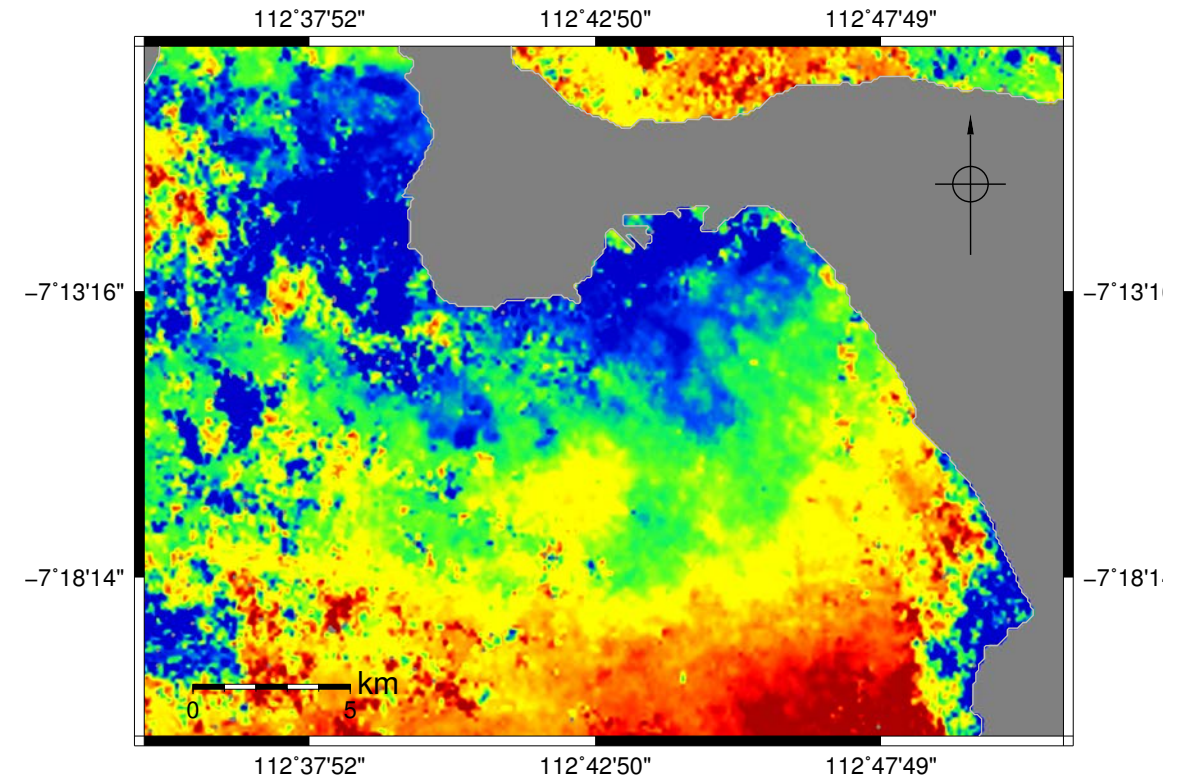
Pair 1 : May 2015 – September 2015



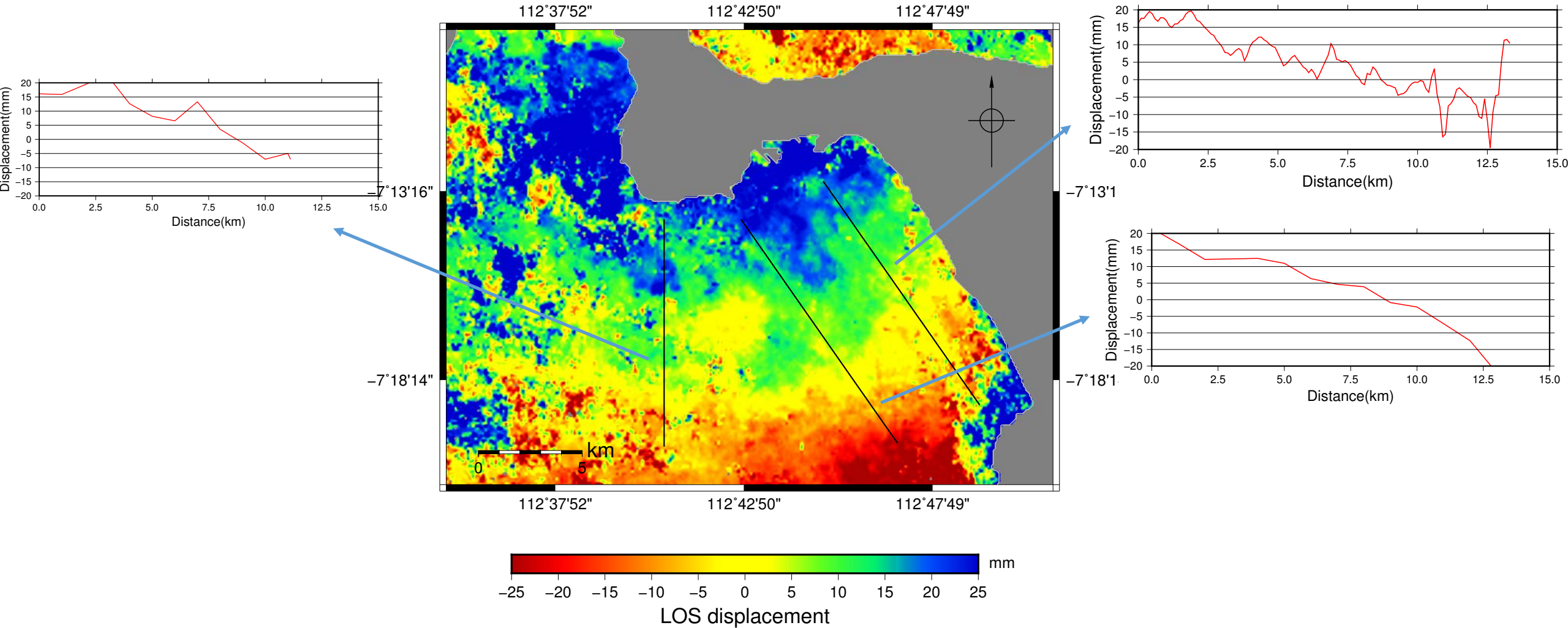
Pair 1 : May 2015 – September 2015



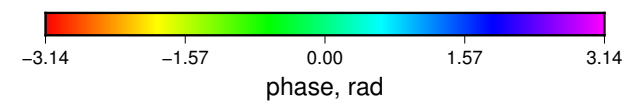
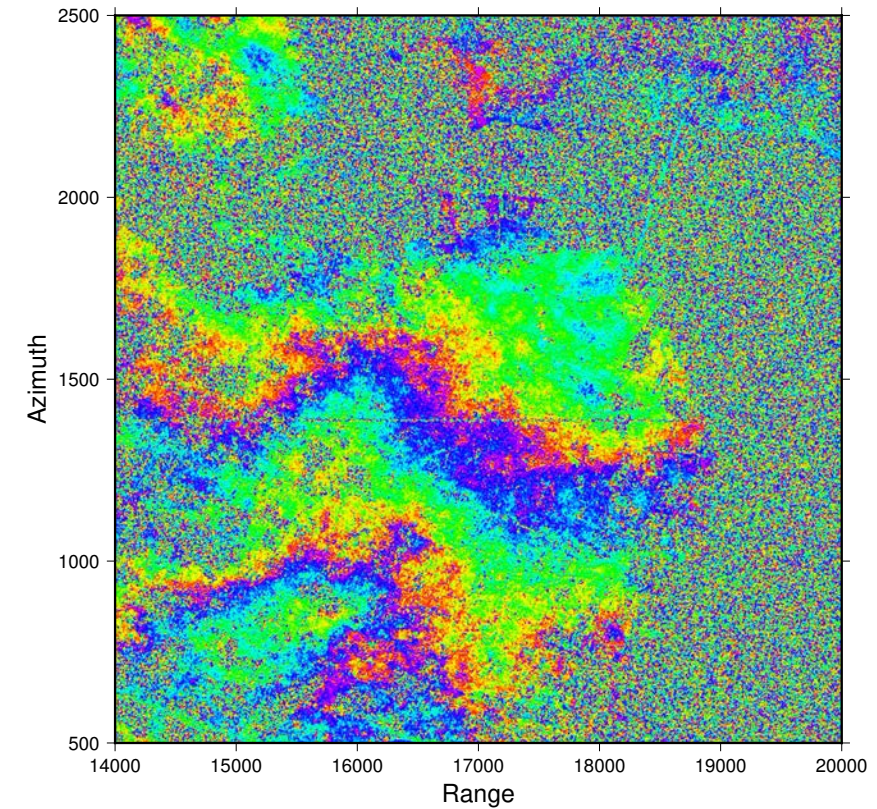
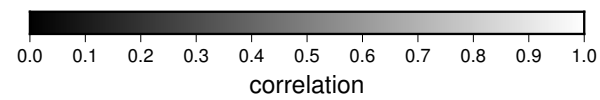
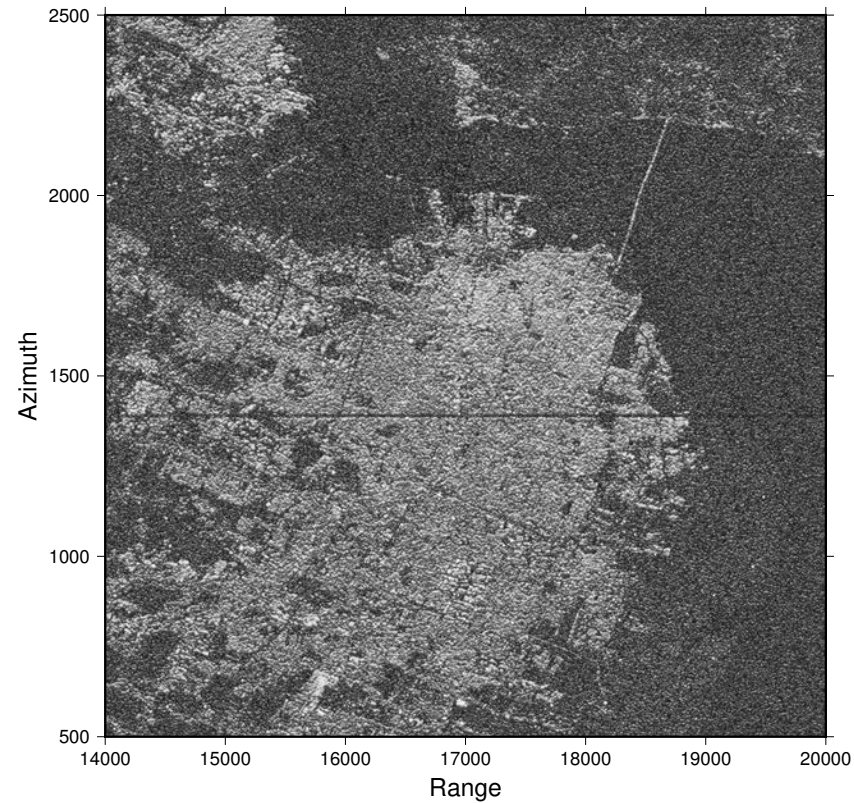
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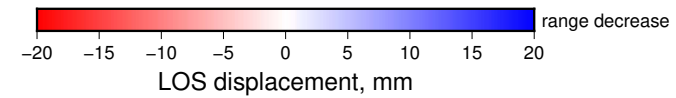
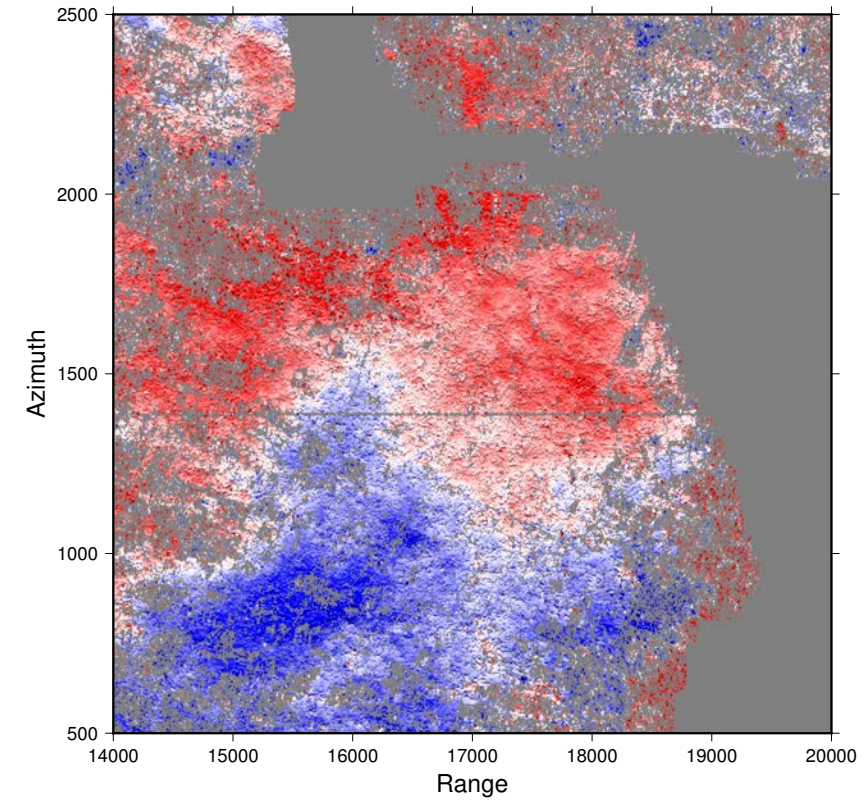
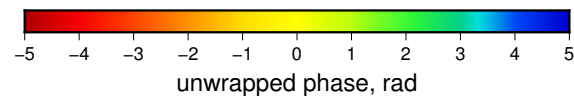
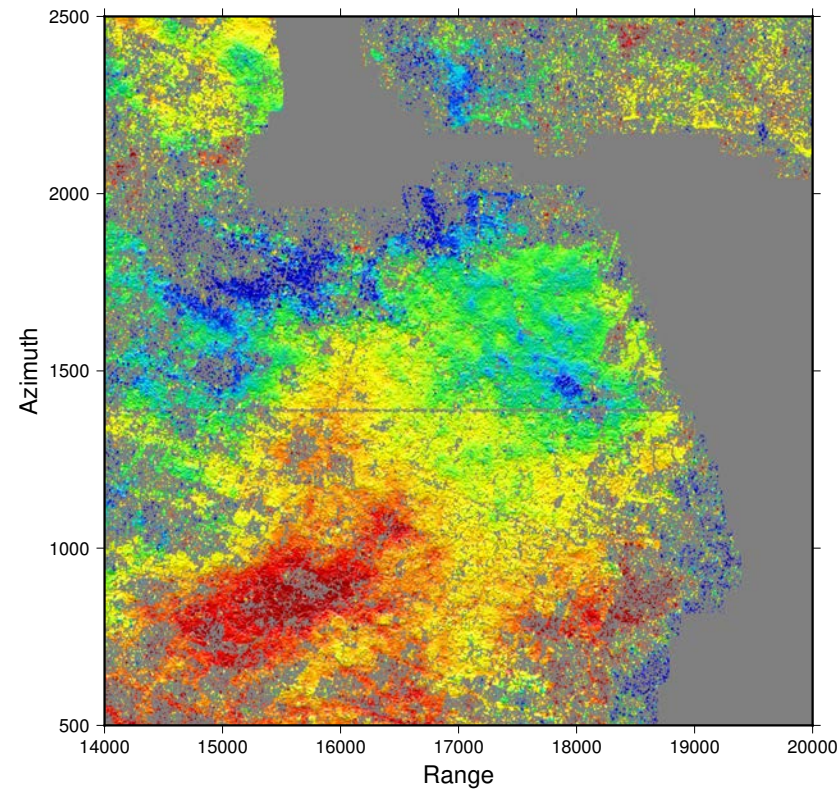
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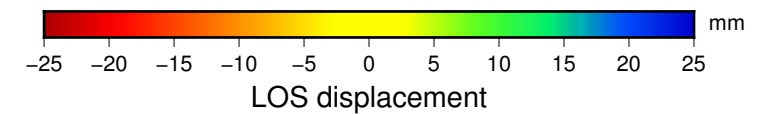
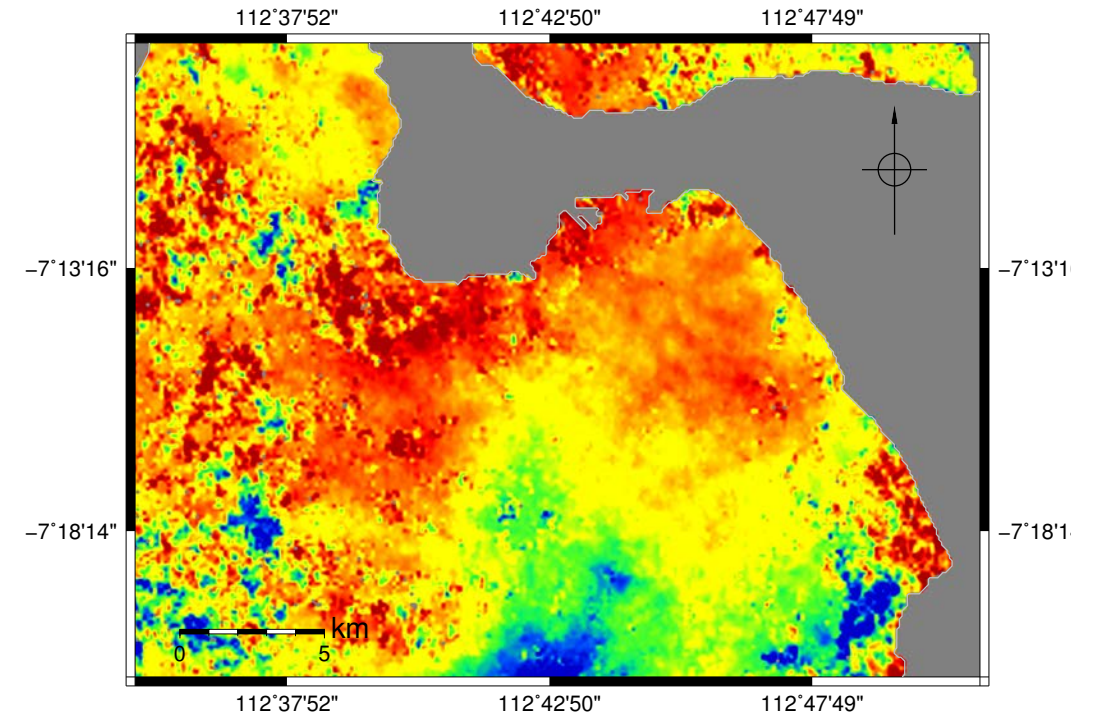
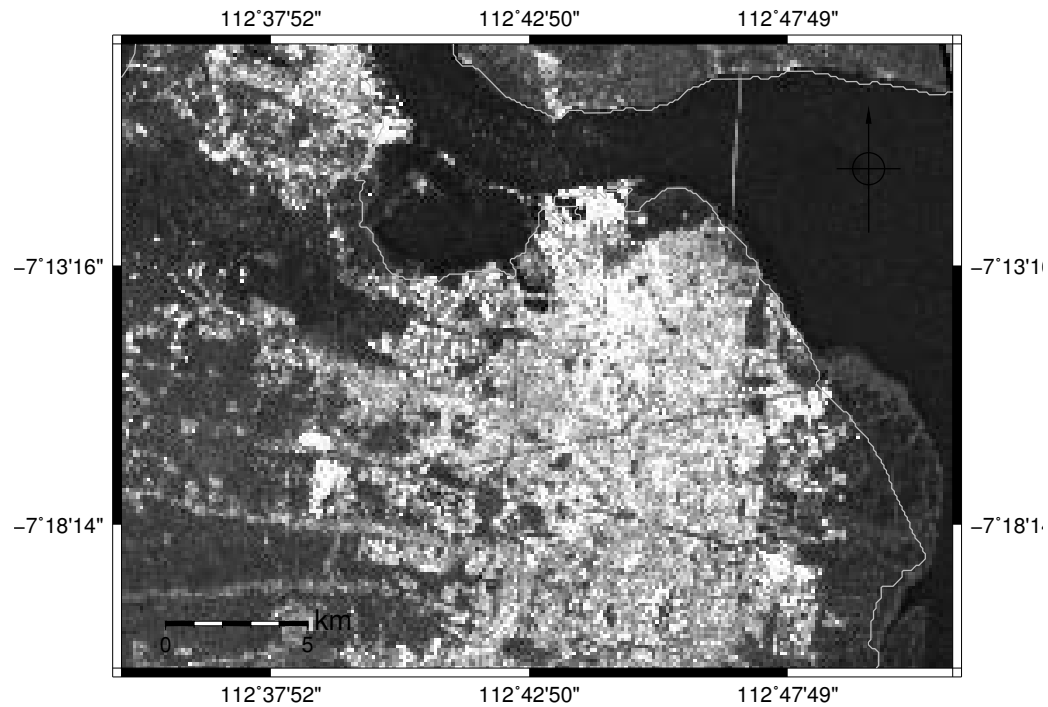
Pair 2 : September 2015 – January 2016



Pair 2 : September 2015 – January 2016

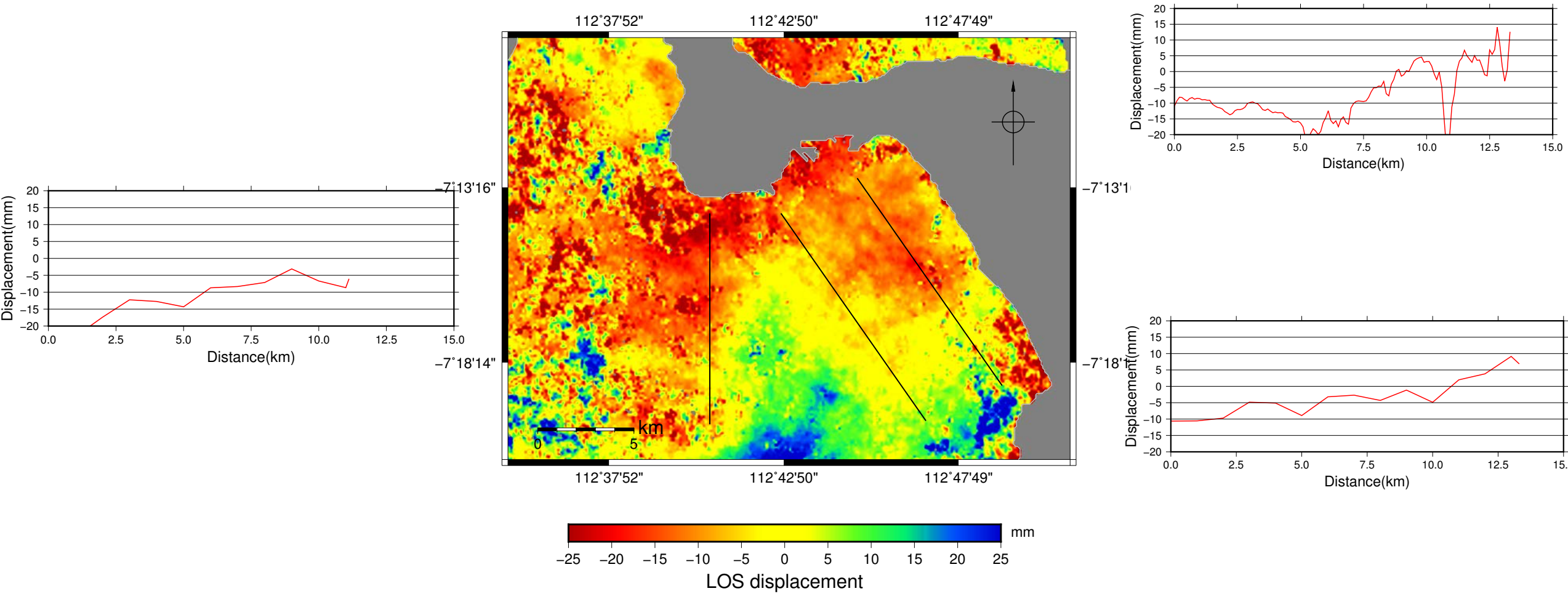


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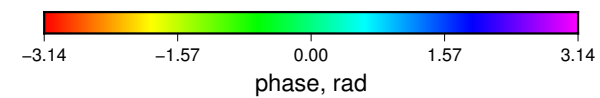
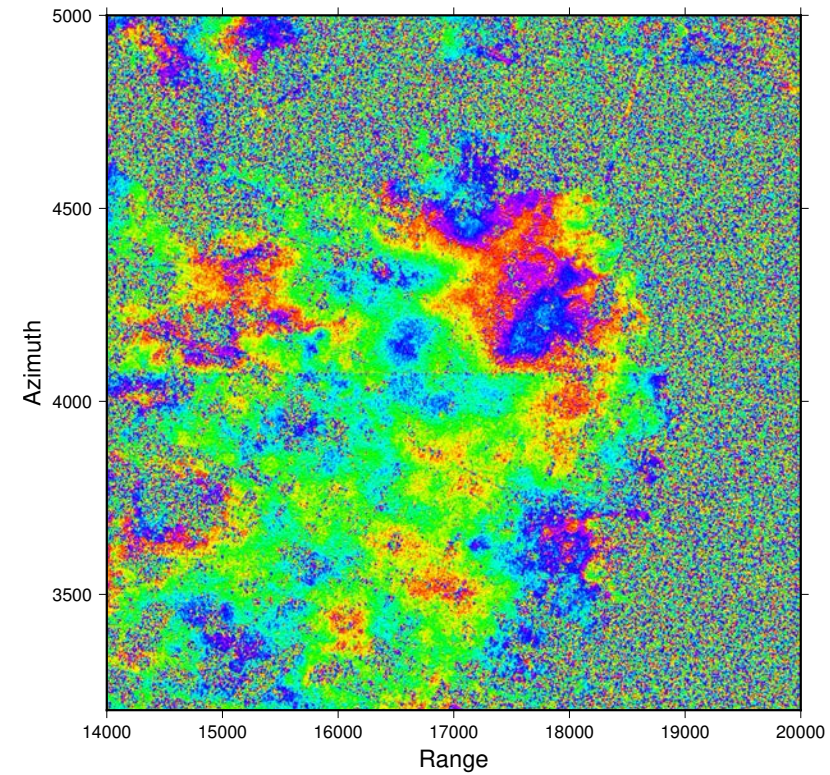
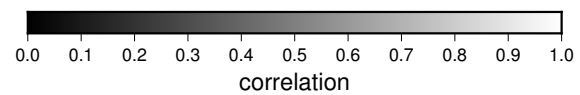
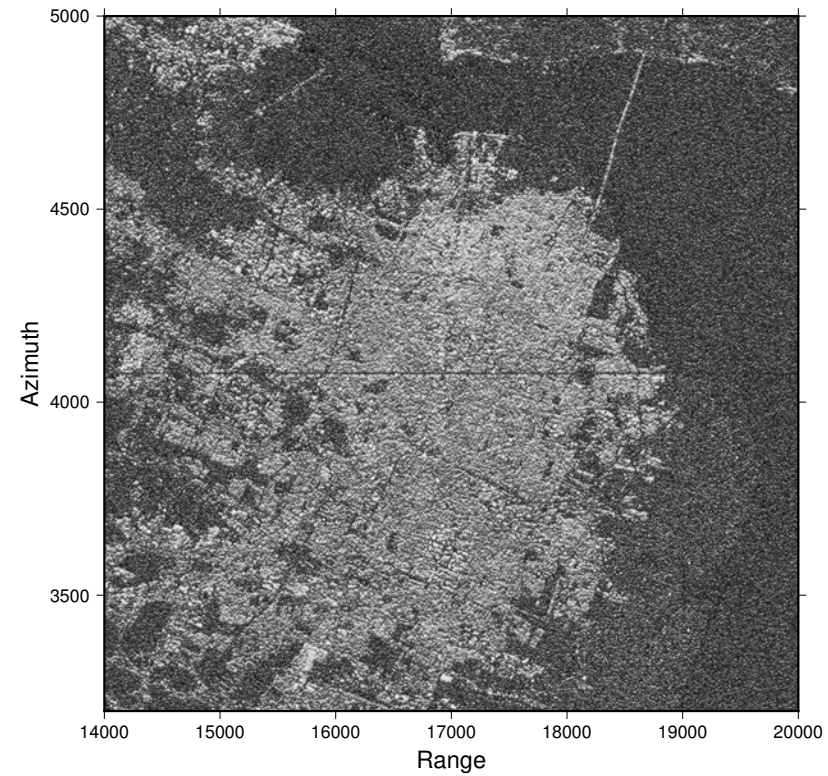




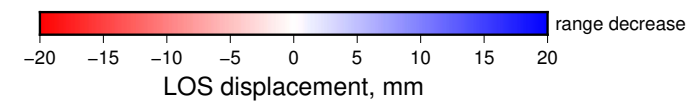
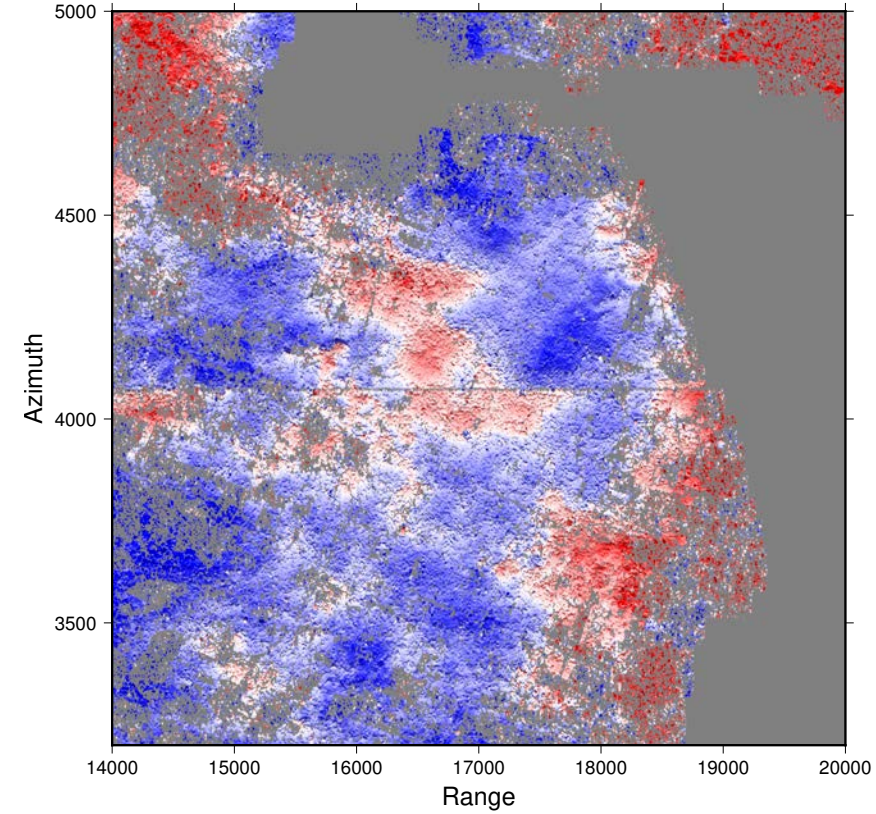
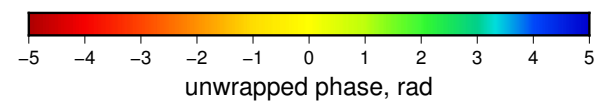
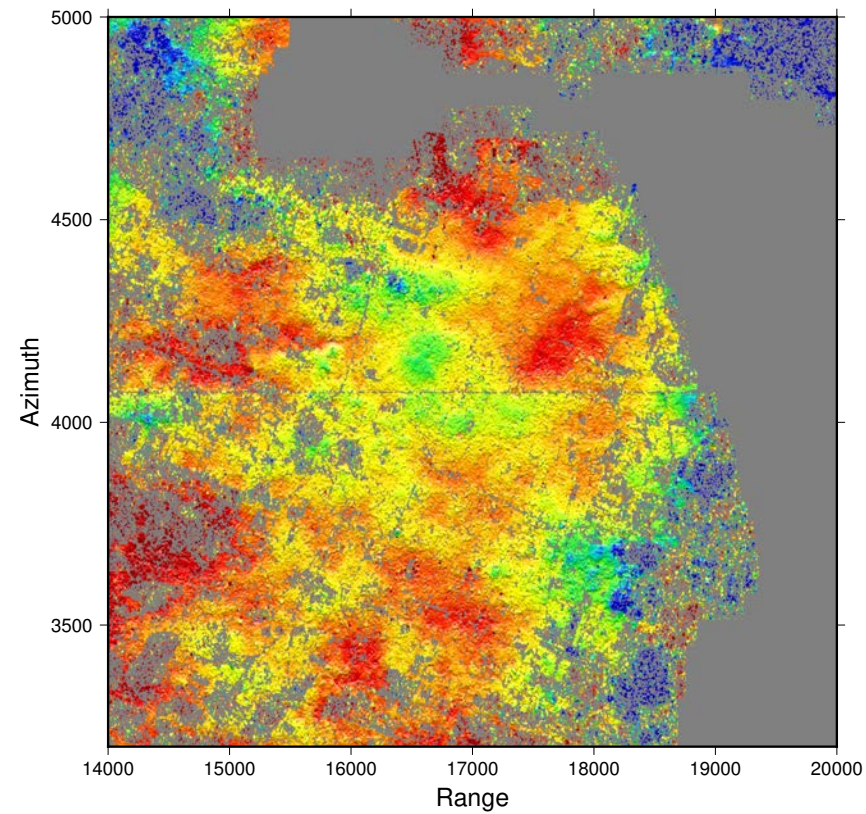
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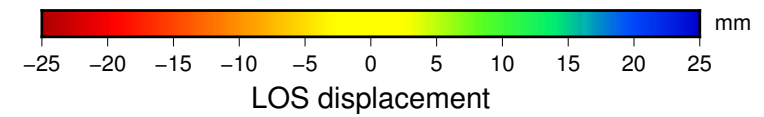
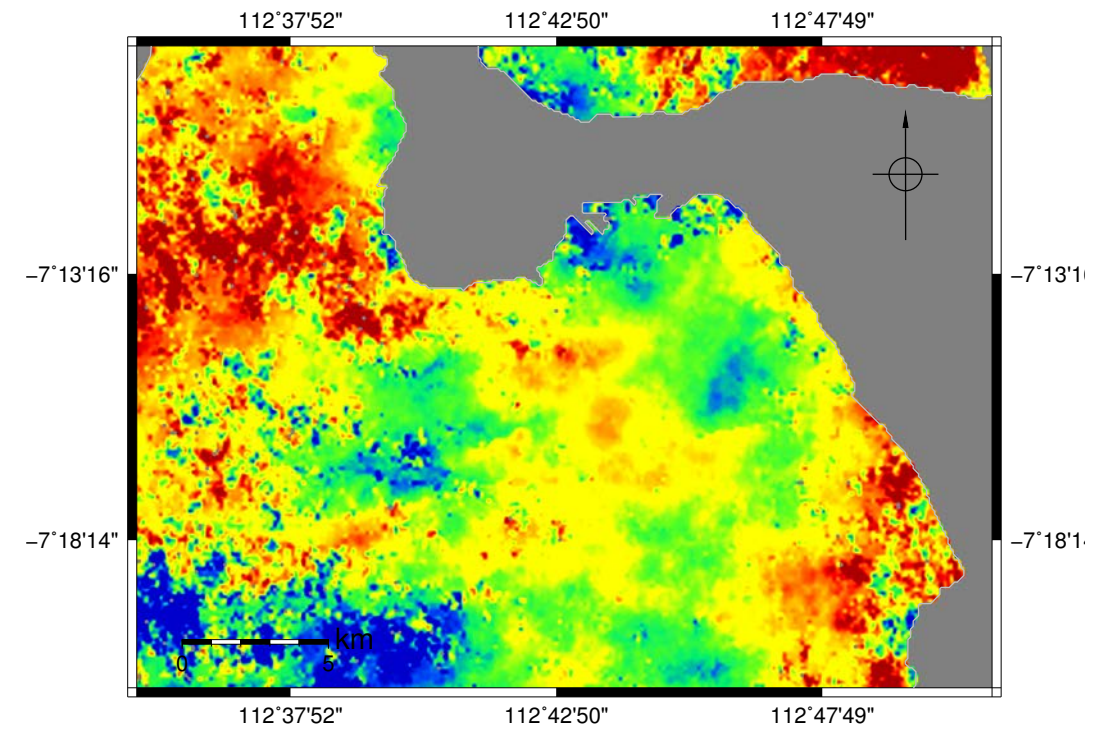
Pair 3 : January 2016 – May 2016



Pair 3 : January 2016 – May 2016

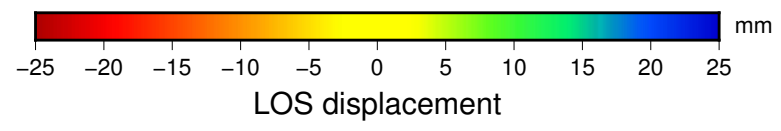
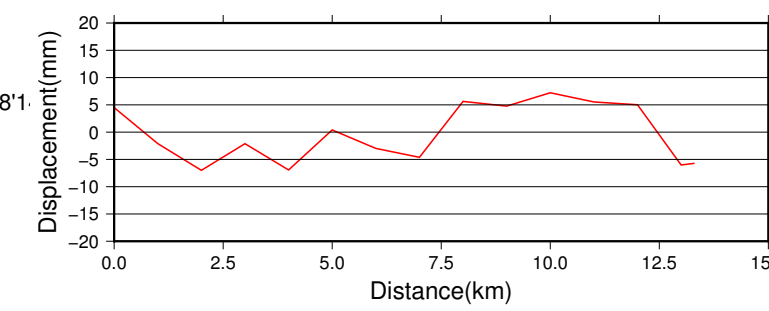
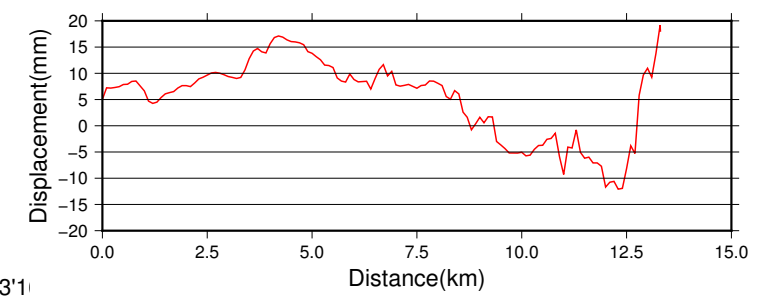
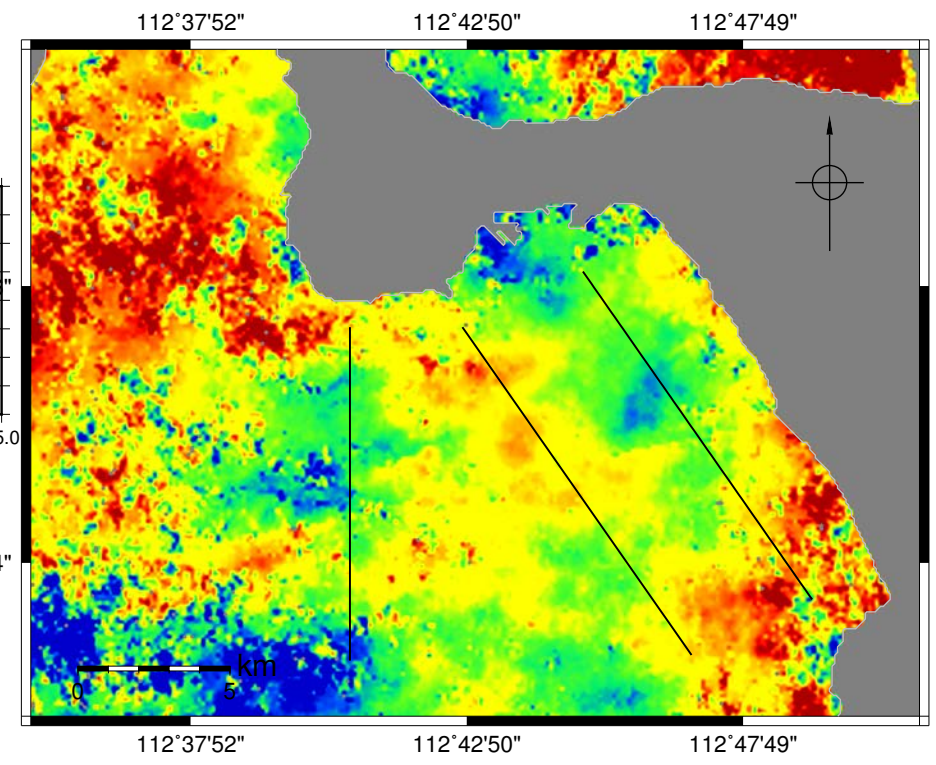
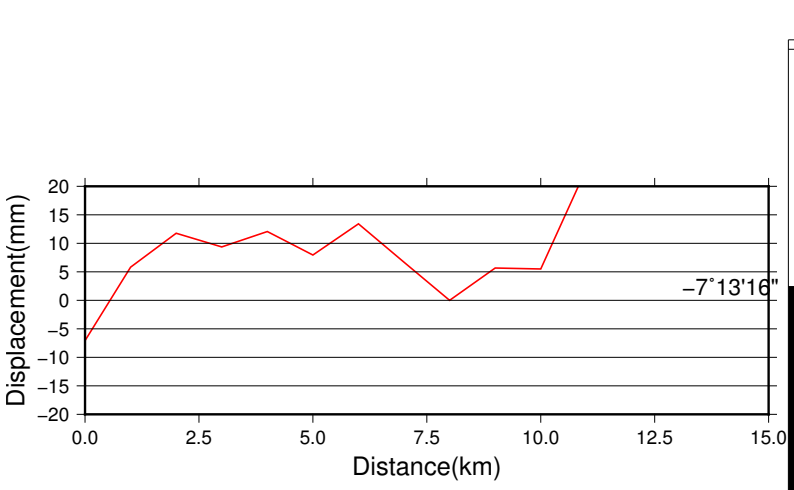


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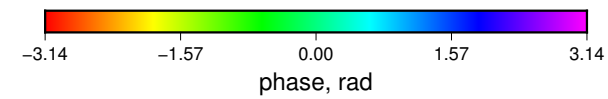
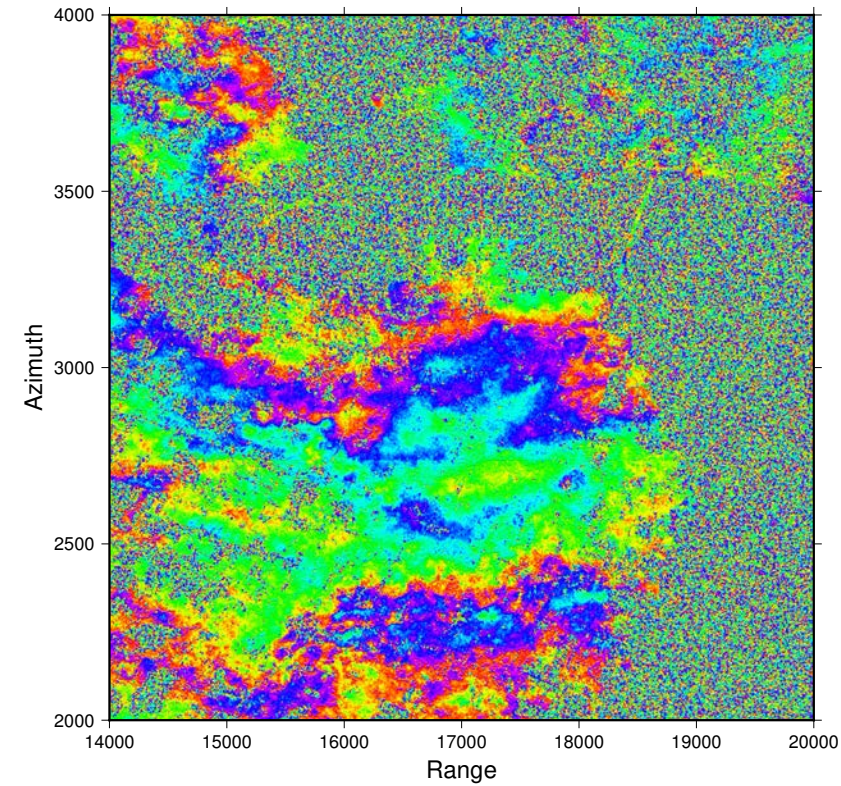
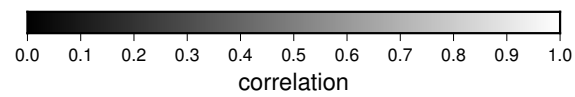
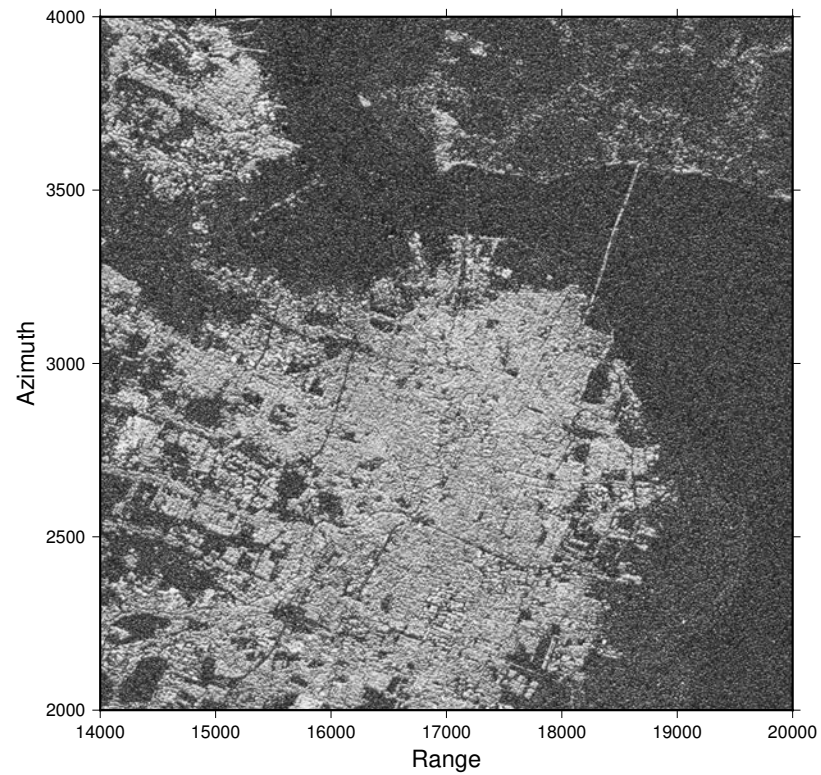




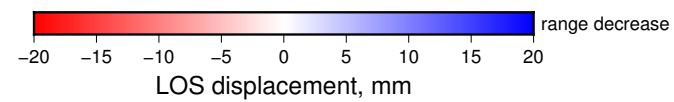
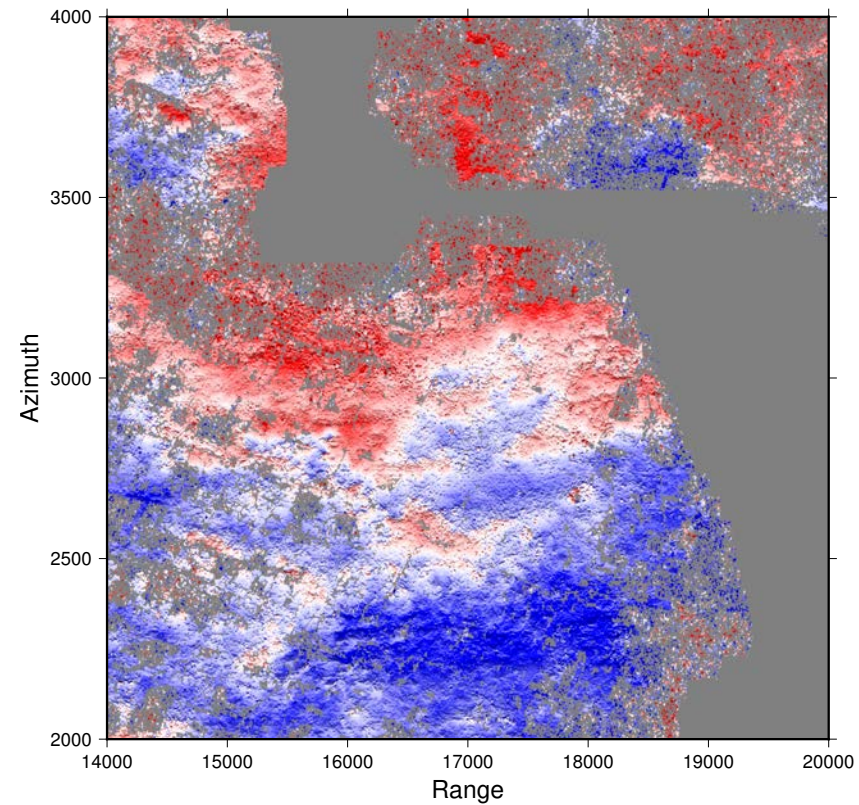
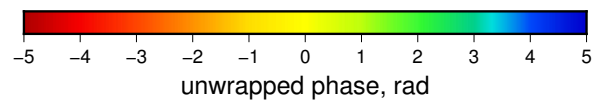
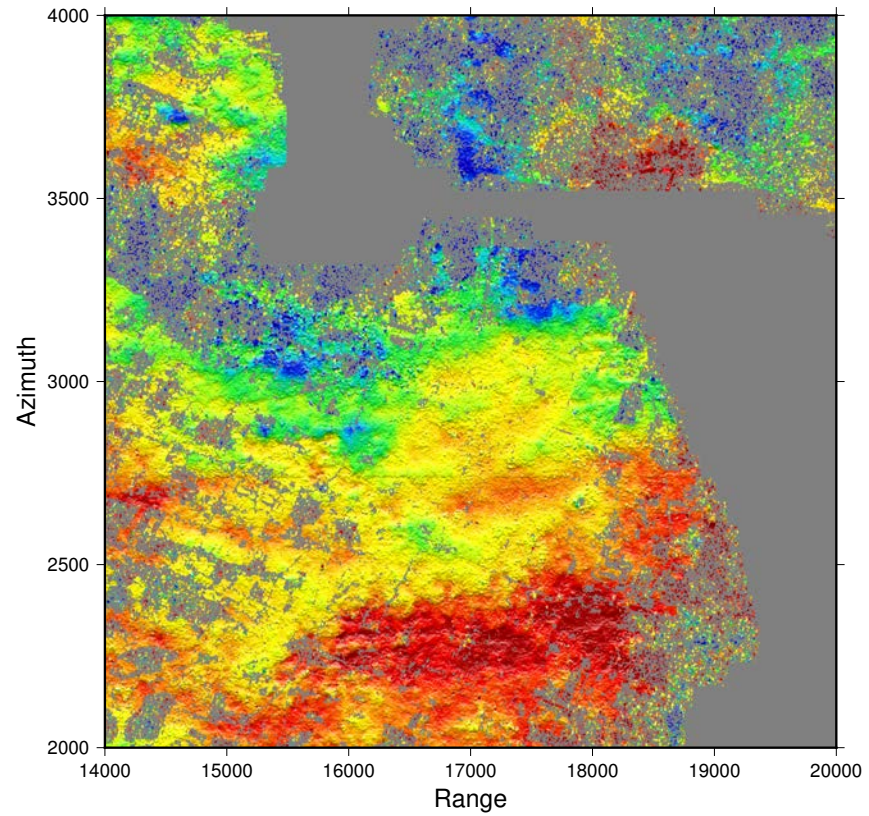
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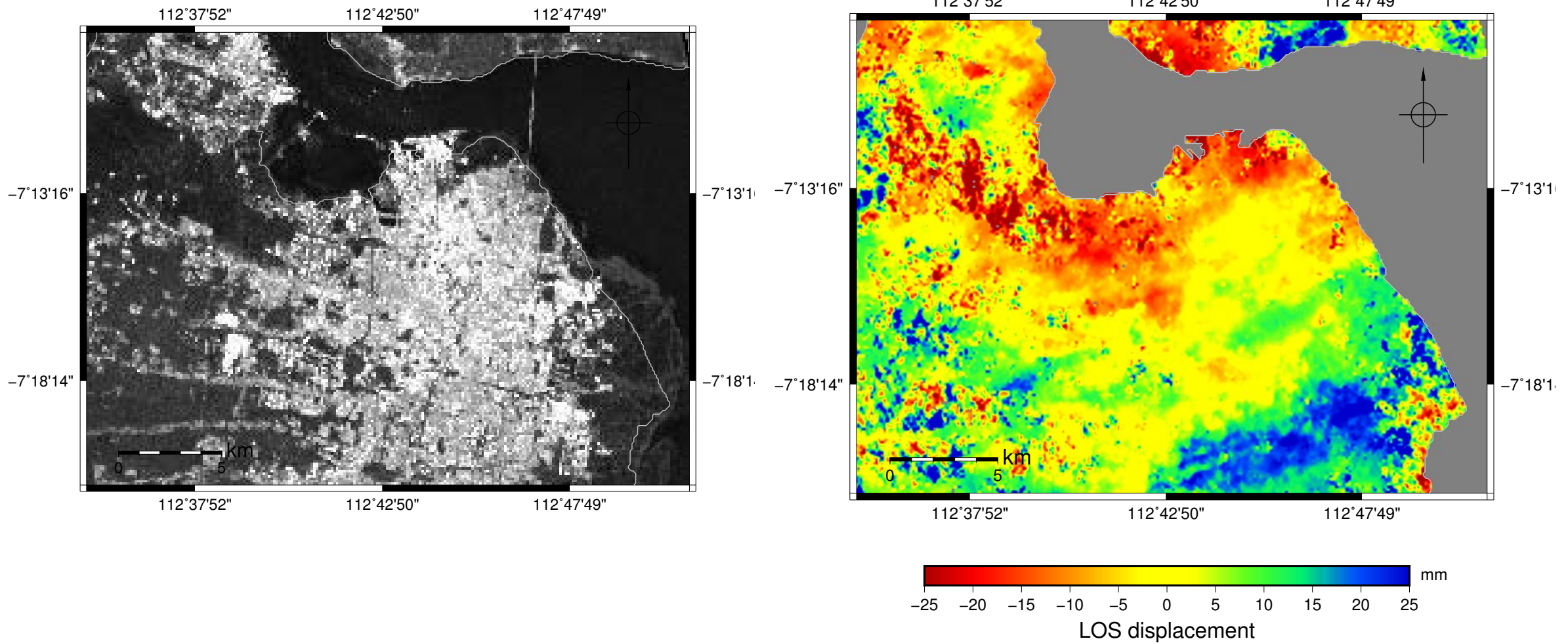
Pair 4 : May 2016 – September 2016



Pair 4 : May 2016 – September 2016

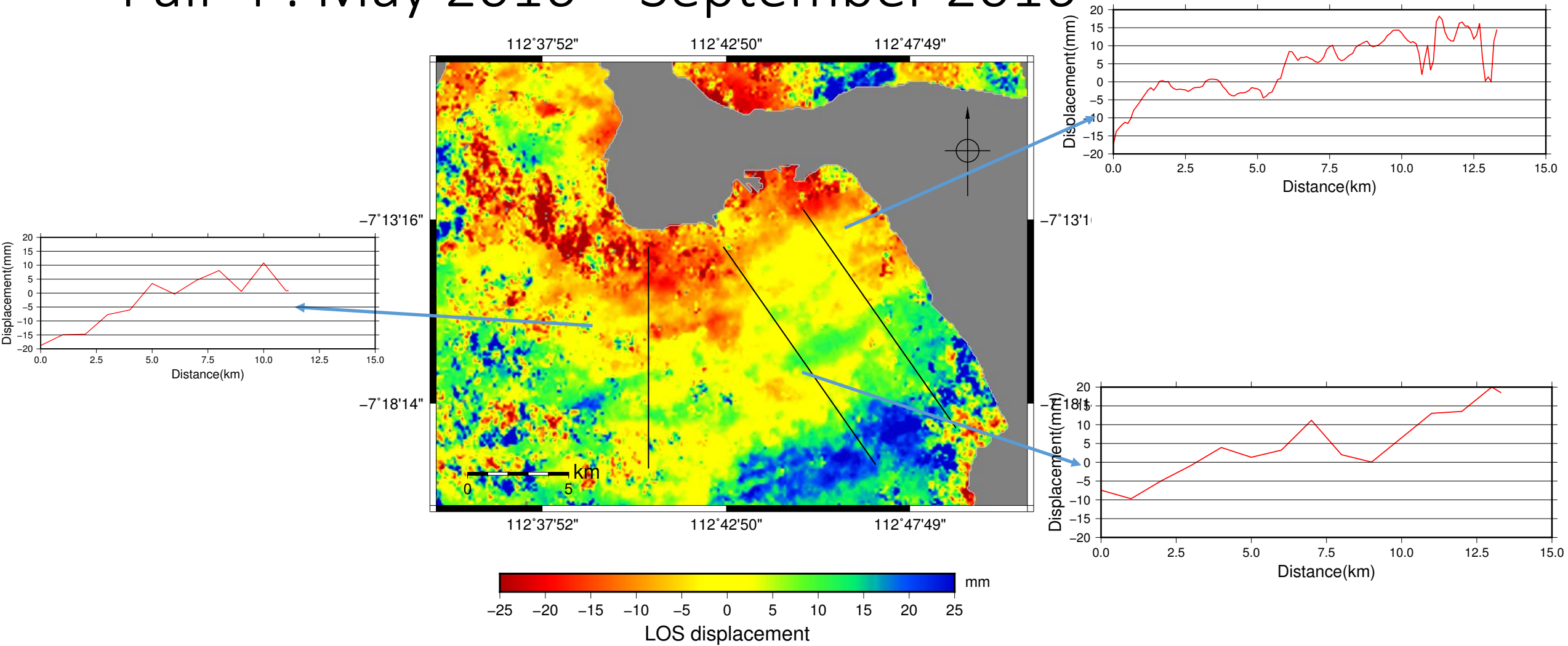


Pair 4 : May 2016 – September 2016





Pair 4 : May 2016 – September 2016



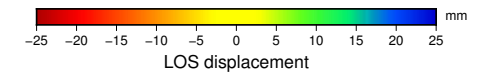
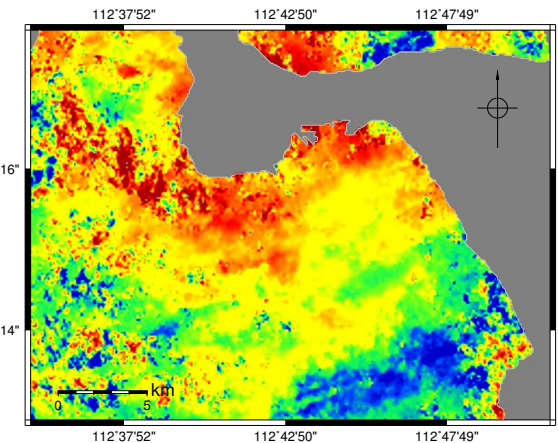
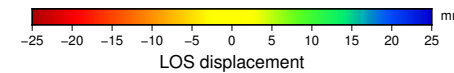
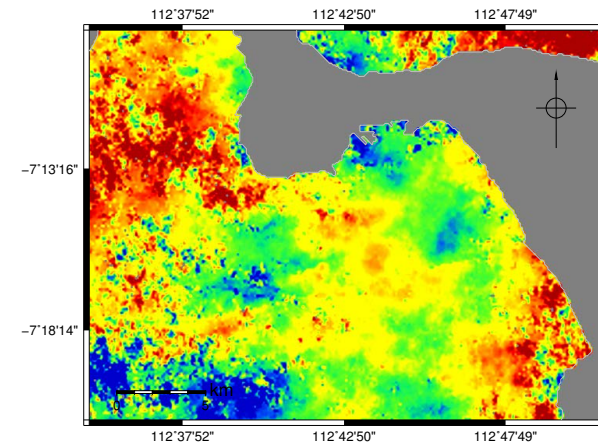
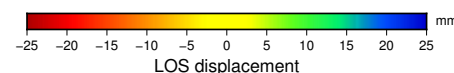
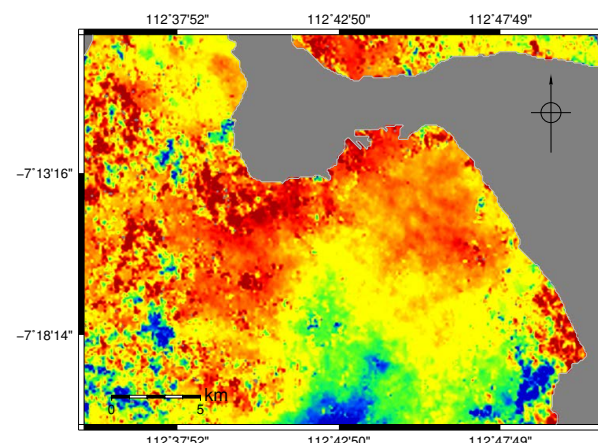
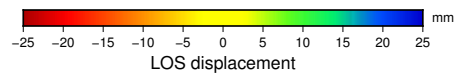
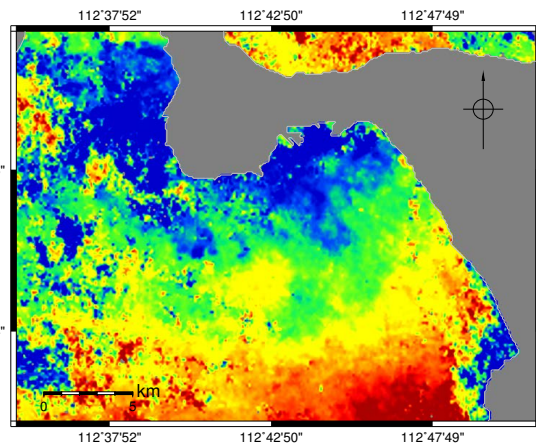
Displacement from Four DInSAR pairs

May 2015 – Sept 2015

Sept 2015 – Jan 2016

Jan 2016 – May 2016

May 2016 – Sept 2016



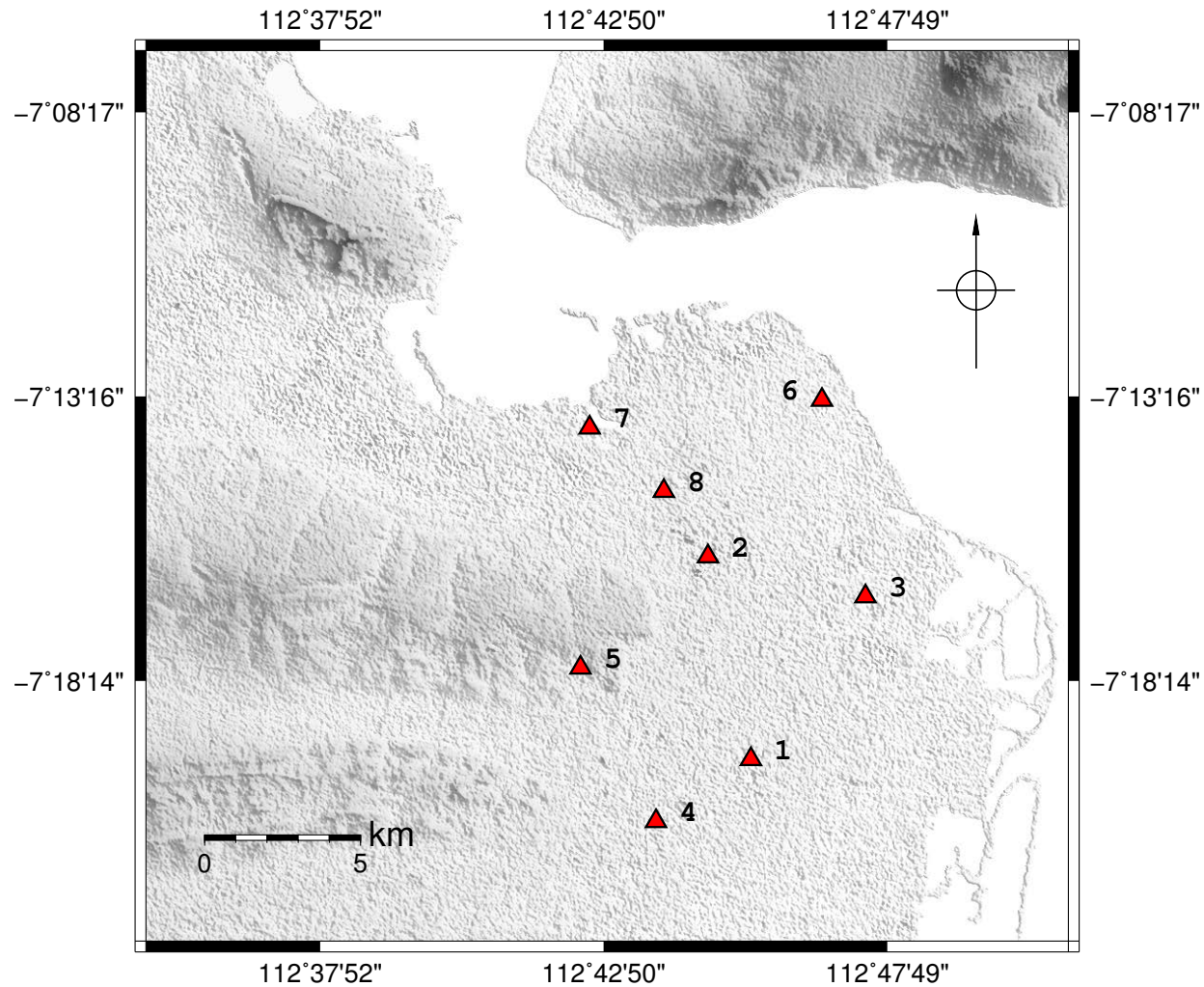
Max: 70.45 mm
 Min: - 58.57 mm
 Mean: 2.35 mm
 Std: 16.42 mm
 RMS: 16.58 mm

Max: 59.49 mm
 Min: - 51.89 mm
 Mean: - 3.52 mm
 Std: 11.79 mm
 RMS: 12.31 mm

Max: 74.21 mm
 Min: - 71.33 mm
 Mean: 1.54 mm
 Std: 14.21 mm
 RMS: 14.29 mm

Max: 50.10 mm
 Min: - 57.47 mm
 Mean: 0.89 mm
 Std: 12.22 mm
 RMS: 12.25 mm

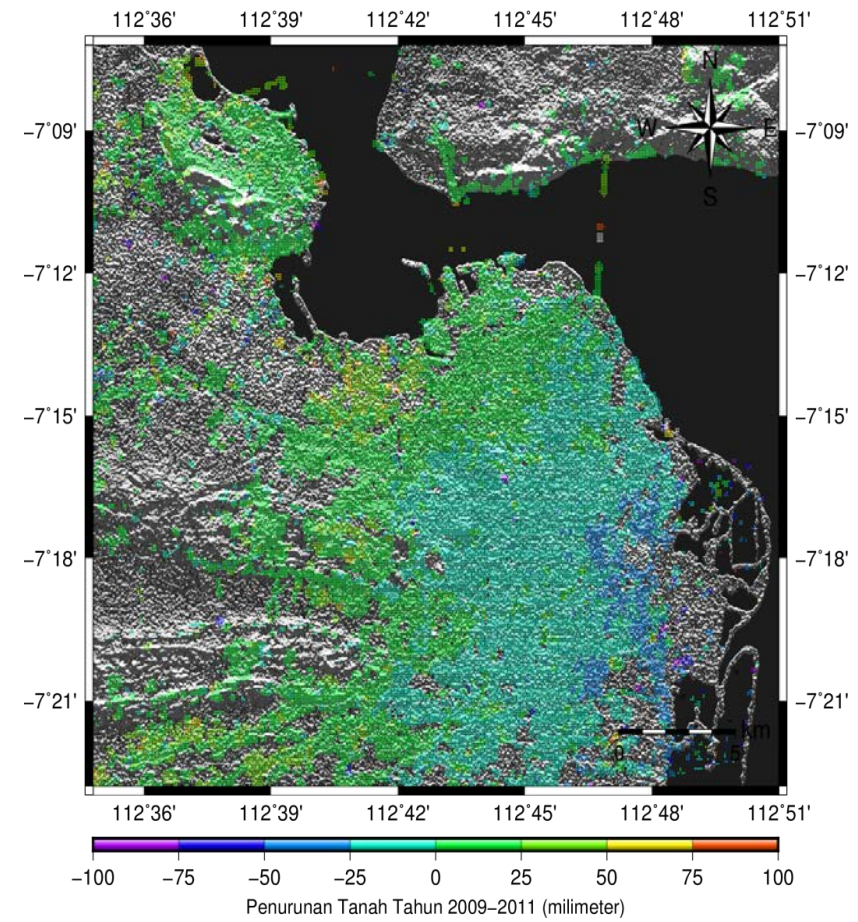
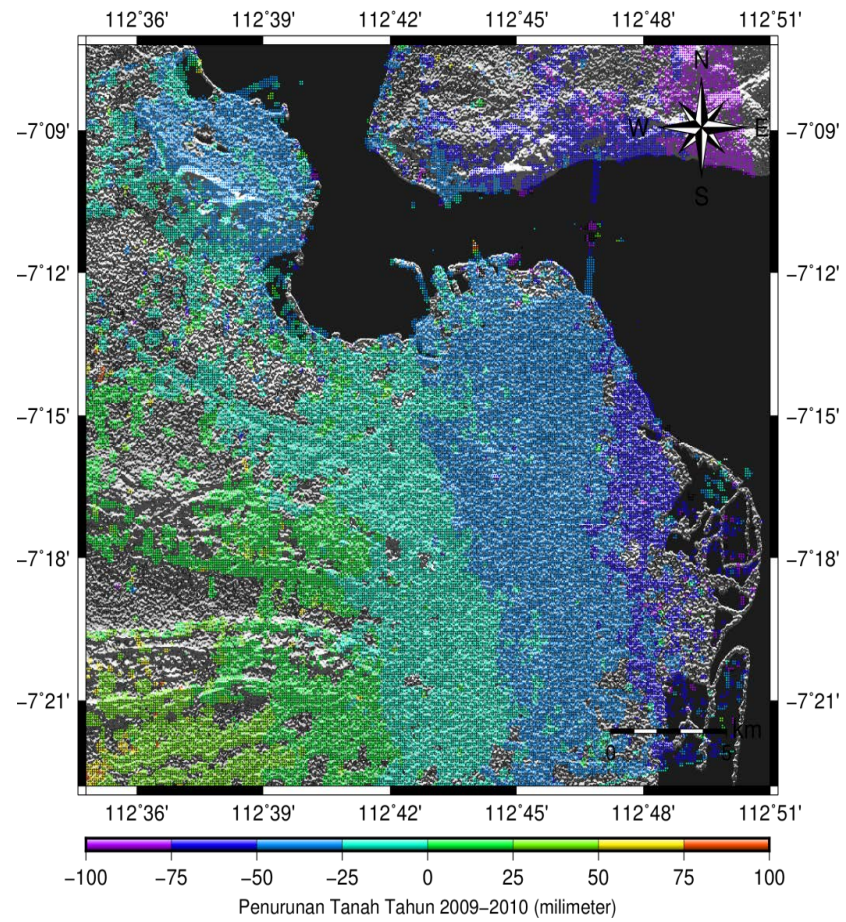
GPS measurement points



GPS point	Location
1	Rungkut
2	Kota
3	ITS
4	Waru
5	Sby Barat
6	Kenjeran
7	Kalianak
8	Pasarturi



Hasil *Land Subsidence* dari data ALOS PALSAR tahun 2009-2011 (Resmi et al, 2016)

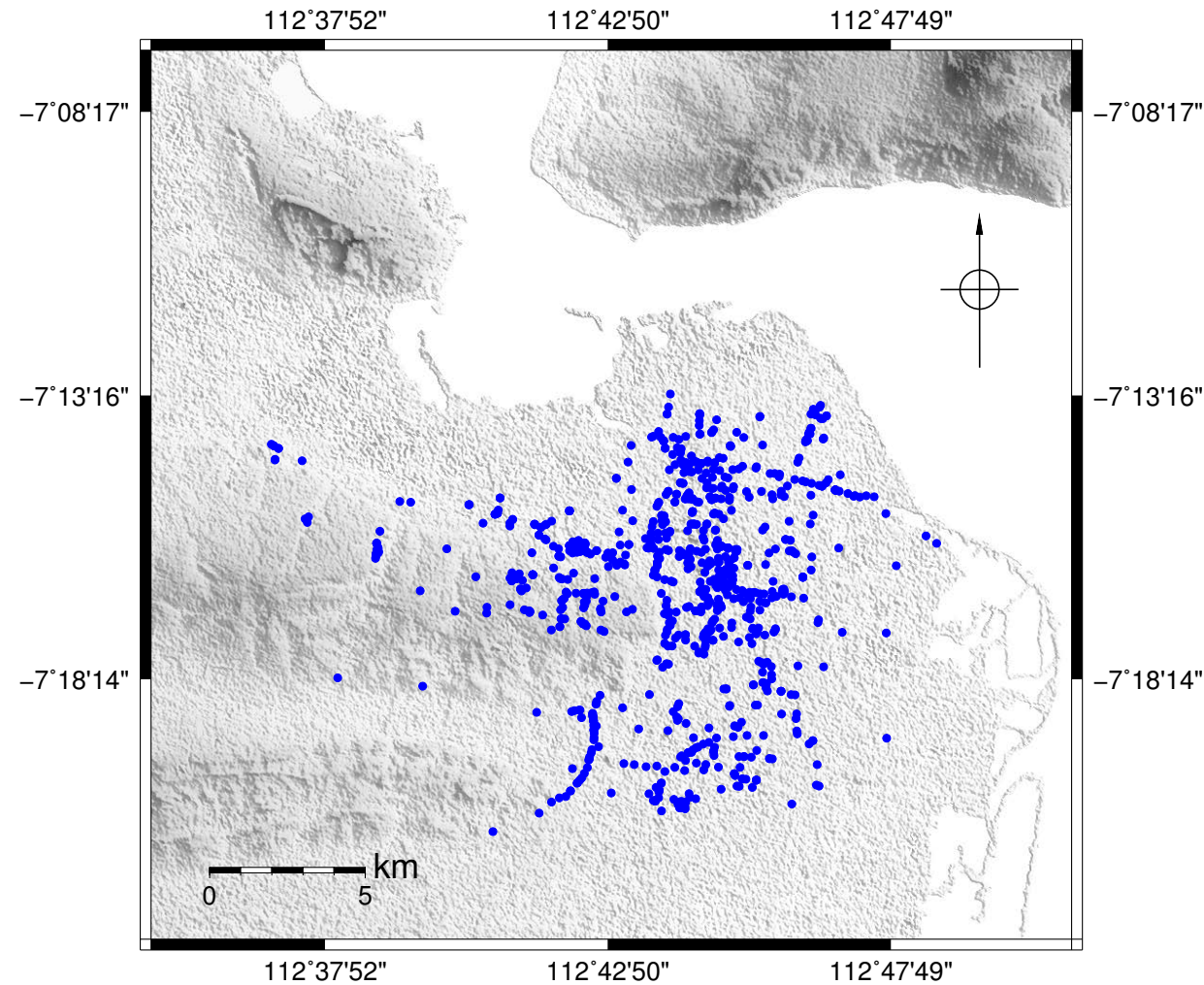




Comparison with other studies

Sample point	Location	Handoko et al, 2011 (GPS measurement)	Resmi et al, 2016 (DInSAR ALOS PALSAR)	This research (DInSAR Sentinel-1A)			
		2007-2010	2009-2011	052015-092015	092015-012016	012016-052016	052016-092016
		Vertical displacement (mm)	LOS displacement (mm)	LOS displacement (mm)			
1	Rungkut	-70.53	-51.55	-14.42	1.84	4.84	18.16
2	Kota	-46.54	-50.77	0.72	10.74	-6.73	6.15
3	ITS	30.54	25.01	0.75	-2.46	3.88	3.55
4	Waru	-5.99	-15.14	-14.16	14.17	5.39	19.45
5	Sby Barat	-0.64	-1.61	10.92	-9.33	-0.11	4.53
6	Kenjeran	4.94	24.28	22.28	-14.53	-1.76	-4.84
7	Kalianak	11.96	4.29	10.51	-5.52	-0.39	-5.23
8	Pasarturi	13.22	14.18	20.12	-6.38	-4.22	1.27

Distribution of ground water wells



Conclusion



- The surface deformation in Surabaya occurs in the form of subsidence and uplift .
- Comparison with other studies shows that the pattern of surface deformation is not very clear. But it can be confirmed that the coastal area of Surabaya suffer from subsidence more than other areas.
- The average rate of deformation from May 2015 to September 2016 is varies from $-3.52\text{mm}/4\text{months}$ to $+2.35\text{ mm}/4\text{months}$

Recommendations



- To confirm the findings in study, comparison with more accurate data is needed, for example GNSS measurements.
- Other SAR processing method such as PS-InSAR can be applied to gain more accurate deformation rate.
- It would be good to check the groundwater extraction over Surabaya area.



THANK YOU