

平成19年度京都大学防災研究所特別教育研究経費(拠点形成)研究集会

平成19年度東京大学地震研究所共同利用・PIXEL共催

衛星搭載型合成開口レーダーを用いた地震・火山災害ポテンシャル評価手法の高度化・効率化

2008年(平成20年)1月16日

InSARによる2007年スマトラ島 南部沖地震の地殻変動

Crustal Deformation of 2007 Southern Sumatra Earthquake Observed by SAR Interferometry

国土地理院

飛田幹男・小沢慎三郎・宇根 寛・雨貝知美・藤原みどり・鈴木 啓・矢来博司

Mikio TOBITA, S. Ozawa, H. Une, T. Amagai, M. Fujiwara, A. Suzuki, H. Yarai

Geographical Survey Institute (GSI)

E-mail: [tobita\(a\)gsi.go.jp](mailto:tobita(a)gsi.go.jp)

謝辞 Acknowledgment

「だいち」のデータは、国土地理院とJAXAの「陸域観測技術衛星データによる地理情報の把握等に関する共同研究」に基づき、国土地理院がJAXAから購入したものである。データの著作権はMETI, JAXAにあります。

GSI purchased PALSAR data under the terms of MOU (Agreement on Cooperative Research Project) between JAXA and GSI.

Southern Sumatra Earthquake in 2007

September 12, 2007

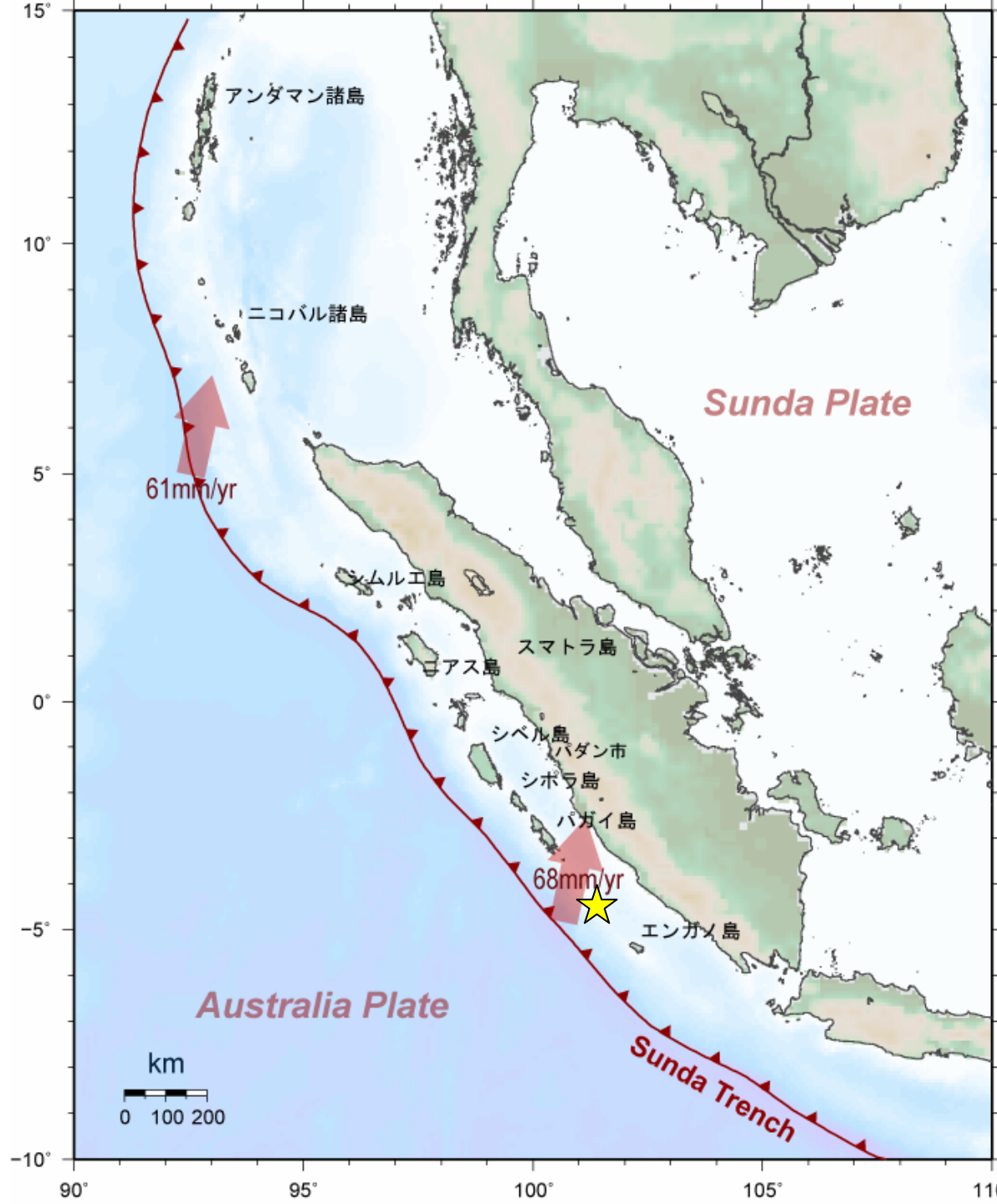
18:10 (Local time)

Depth: 30 km

Mw 8.4 (USGS)

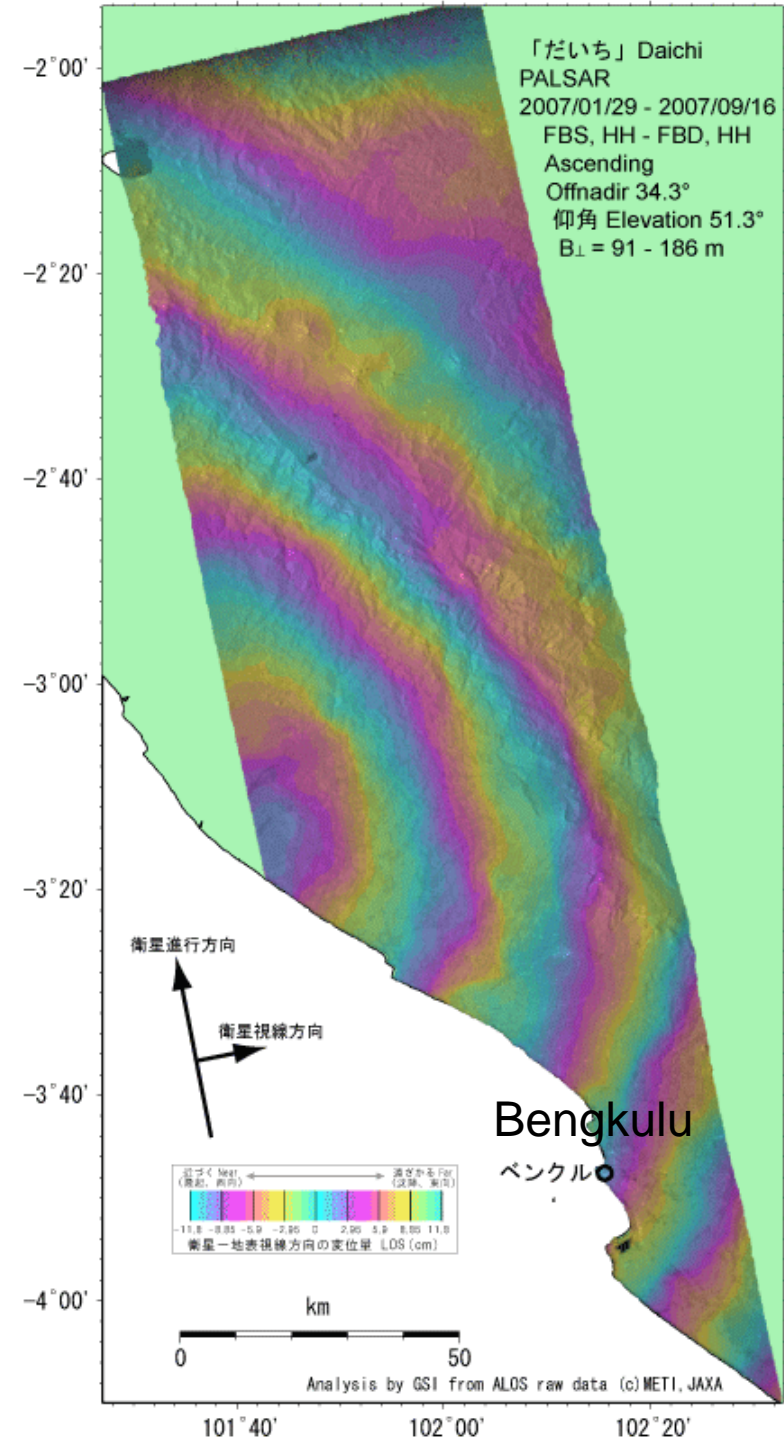
死者数 25名

Sunda plateとAustralia
plateのプレート境界で発
生した逆断層型の地震



Daichi Interferogram of 2007 S. Sumatra Earthquake around Bengkulu, Indonesia

Jan 29 – Sep. 16, 2007 (Coseismic)
4 scenes were concatenated.
Completely correlated!



Past Study: Presented at Padang, Indonesia in August, 2005.

CONCLUSION

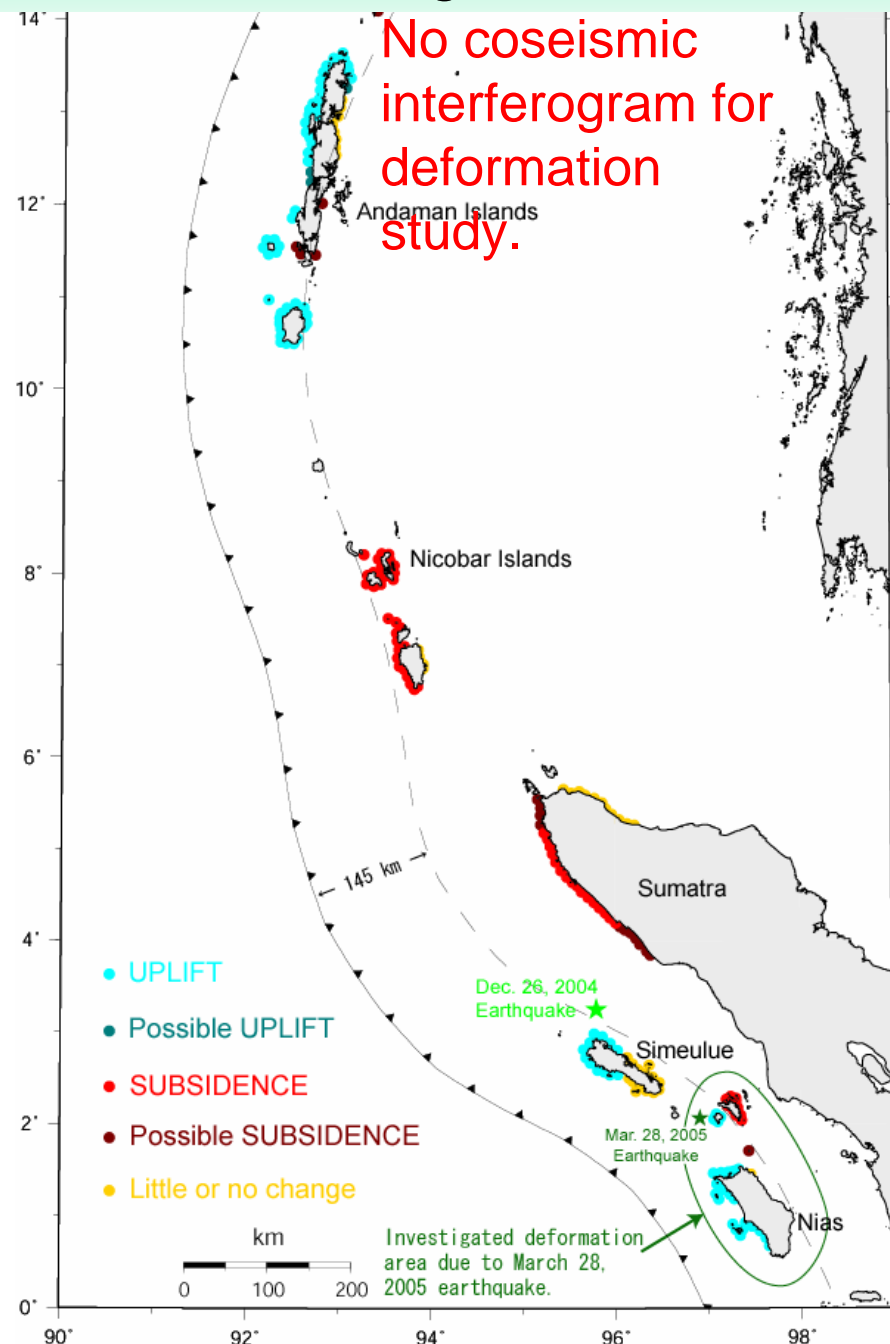
- (1) We processed about 60 scenes of SAR data and made a map showing vertical displacements of the ruptured area caused by the 2004&2005 Sumatra earthquakes.
- (2) Two earthquakes ruptured about 1,670 km long area.
- (3) A line approximately 145 km east from the trench separates west uplifted zone from east subsided zone.

“Just a coincidence?”

“Nature is more complicated.”

“But this is also the fact...”

Tobita et al., Outline of vertical displacement of the 2004 and 2005 Sumatra earthquakes revealed by satellite radar imagery, EPS, 58, e1-e4, 2006.

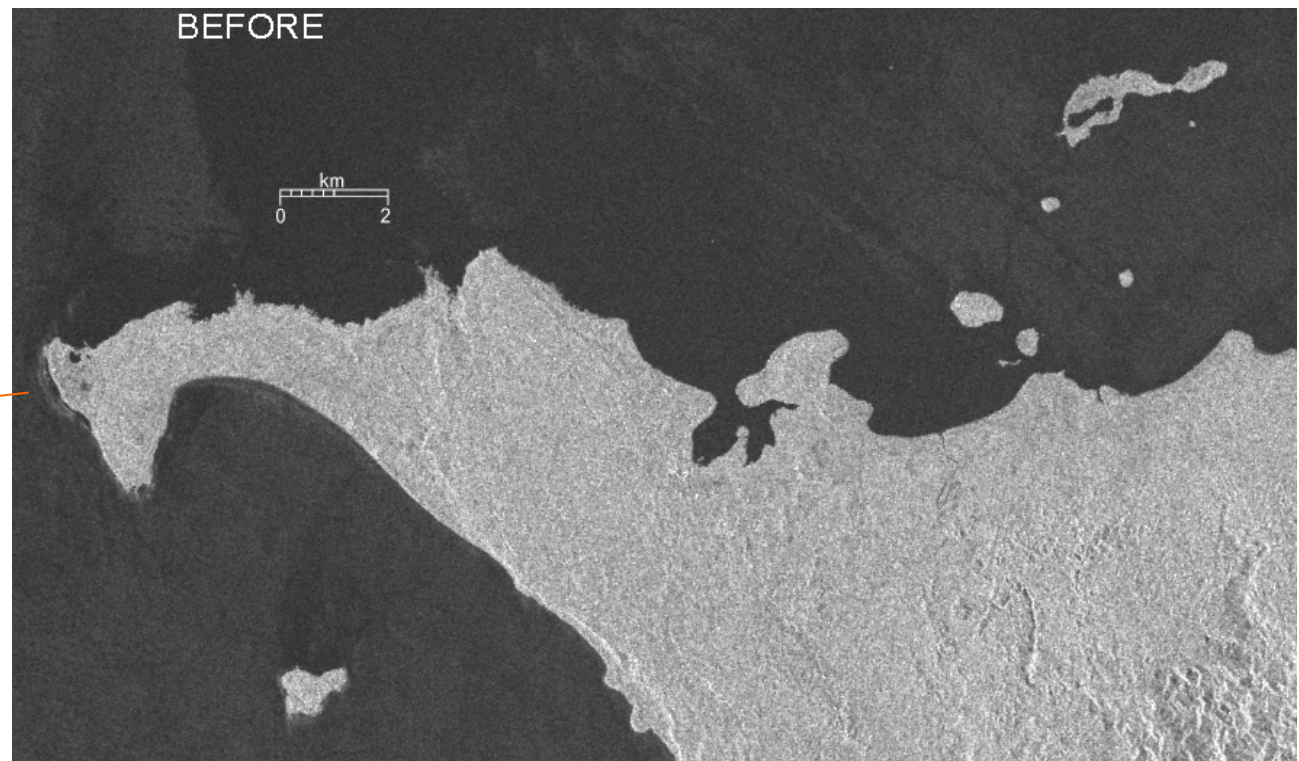
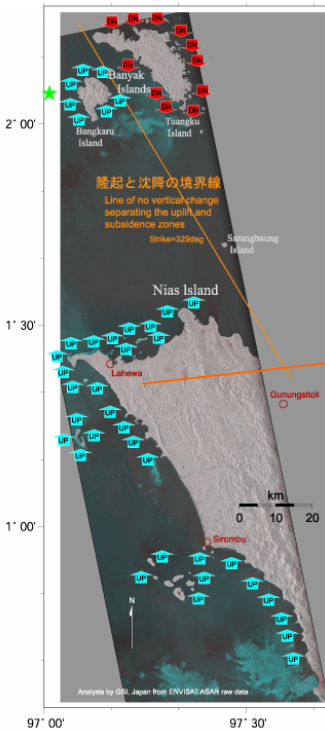


Past Study: Presented at Padang, Indonesia in August, 2005.

Coastal changes in Nias I. caused by the 2005 Sumatra earthquake extracted from SAR images

More than 10 new islands were created, which length is 100 m to 1.5 km.

emergence due to uplift



ENVISAT ASAR images of Nias island, Indonesia

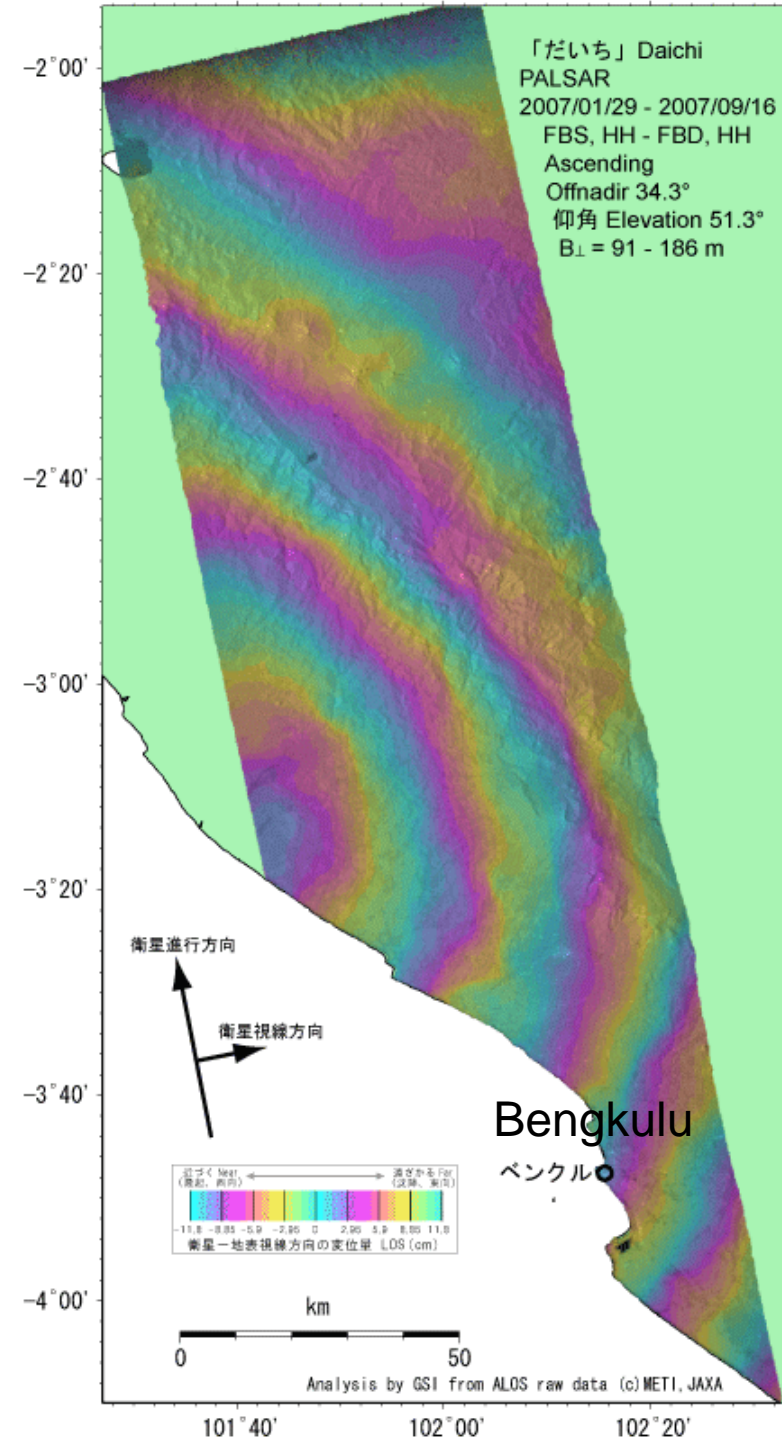
Daichi Interferogram of 2007 S. Sumatra Earthquake around Bengkulu, Indonesia

Jan 29 – Sep. 16, 2007 (Coseismic)

4 scenes were concatenated.

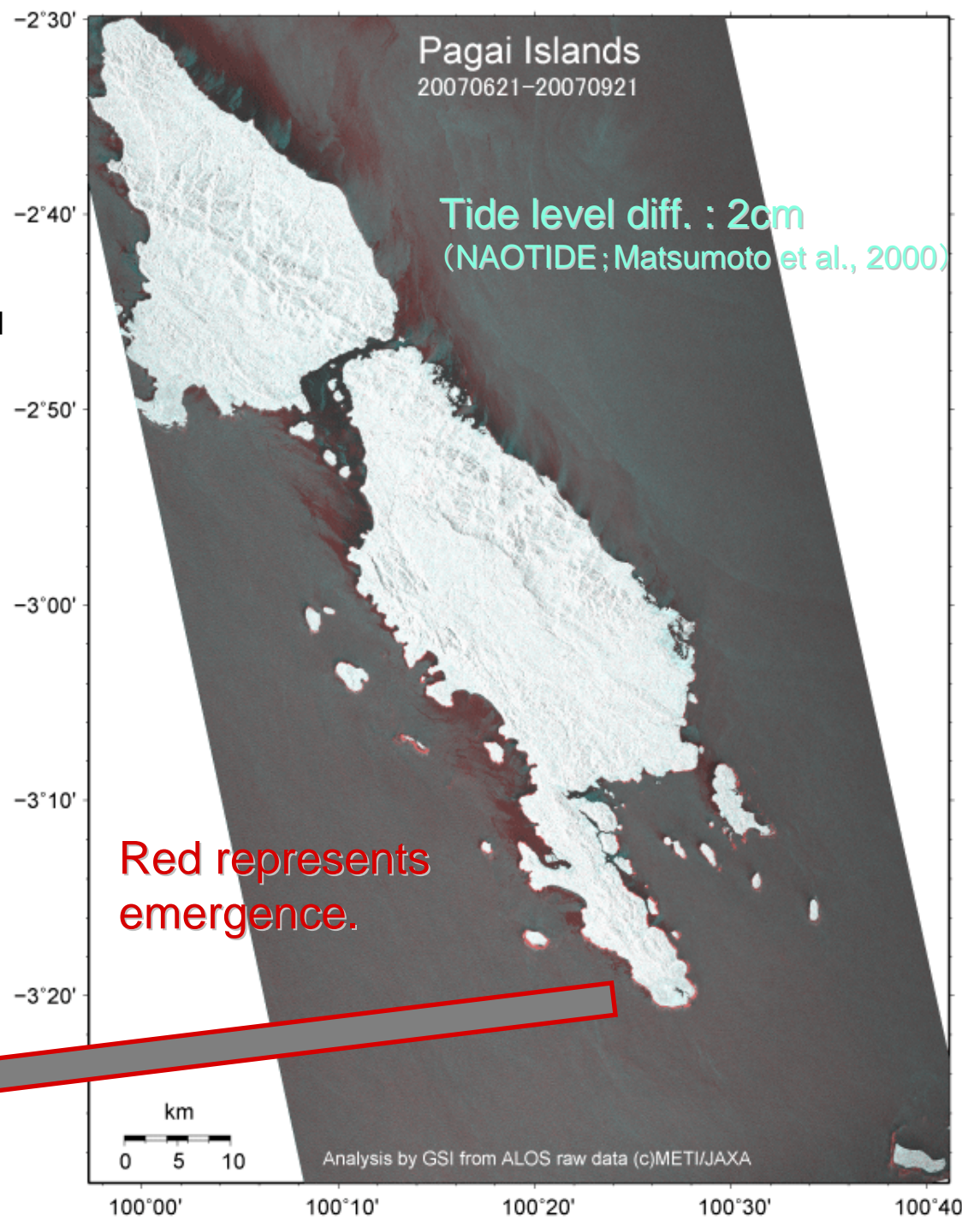
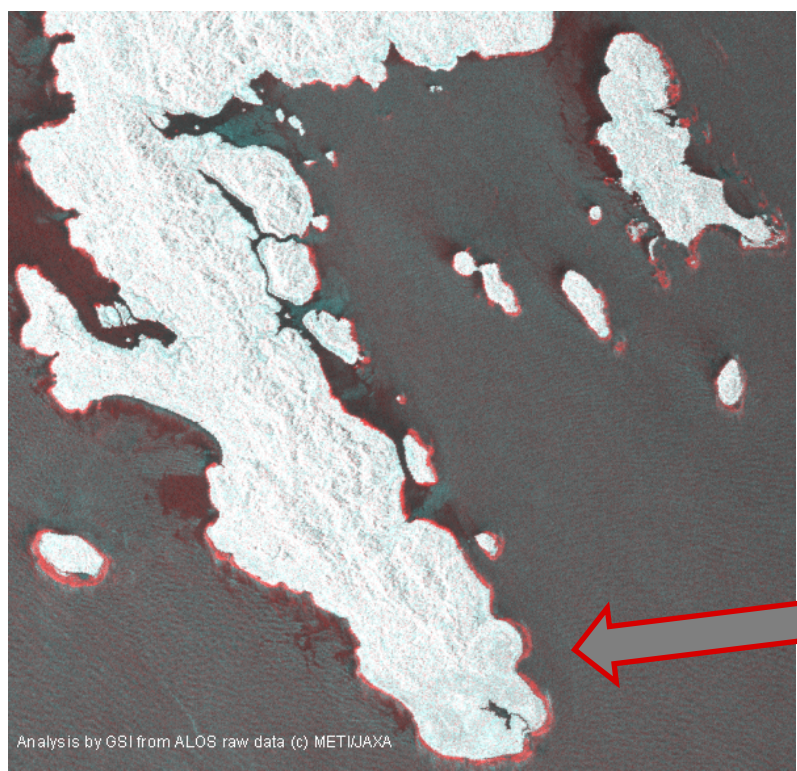
Completely correlated!

「PALSARは極めて高性能である」ことがわかる。



Coseismic uplift of S. Pagai Is. extracted from comparison of SAR intensity

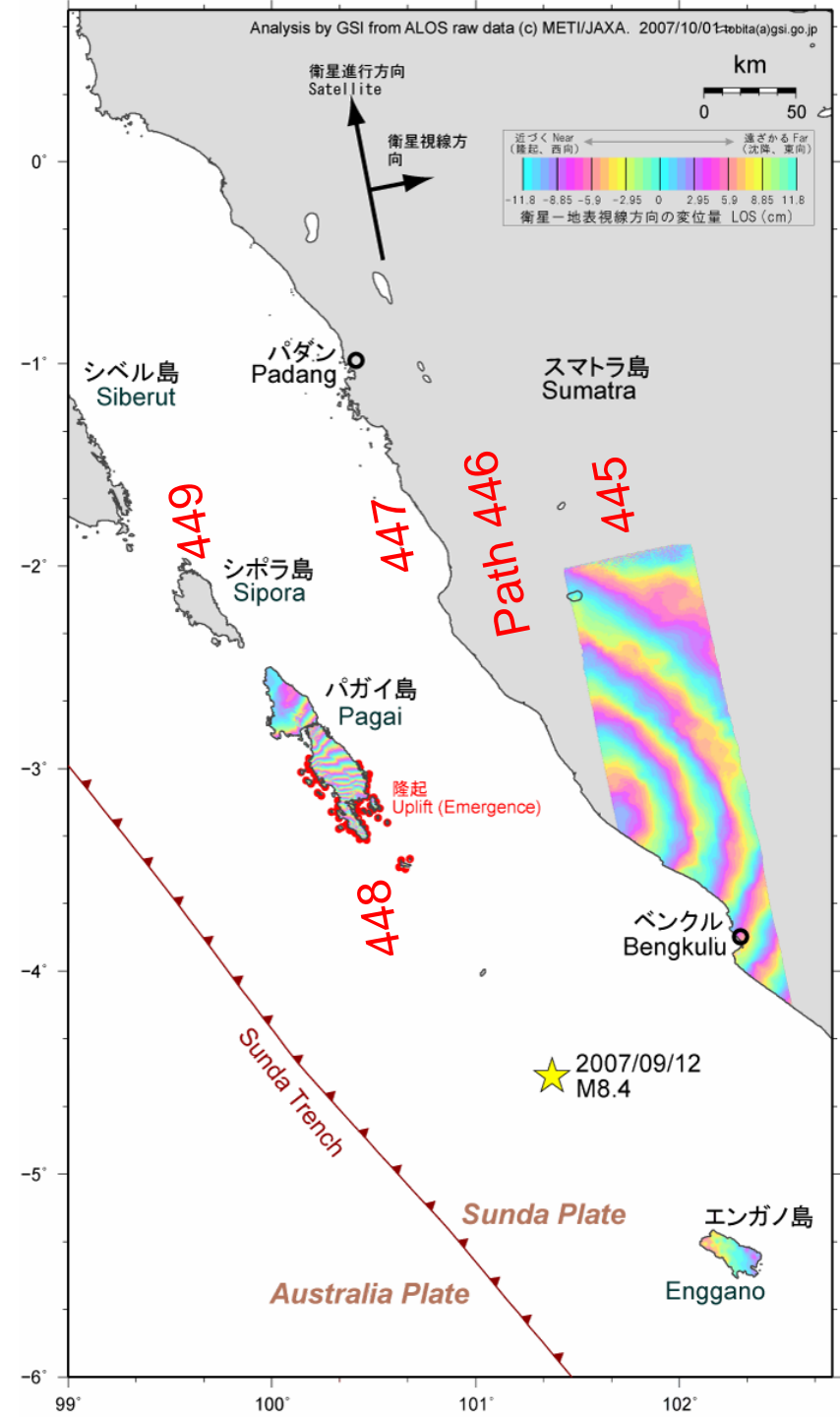
2007 earthquake pushes up cluster of 6 new islands.
The emergence had increased the size of small islets and even produced more than six new small islets. The length of the maximum islet is approximately 1.6 km.
Up to 500 m wide emergence of reef is seen in the bottom left island in this image.



SAR interferograms and distribution of uplifted coastline

We generated preseismic, coseismic and postseismic interferograms of ruptured area, paths 445, 446, 447, 448 and 449.

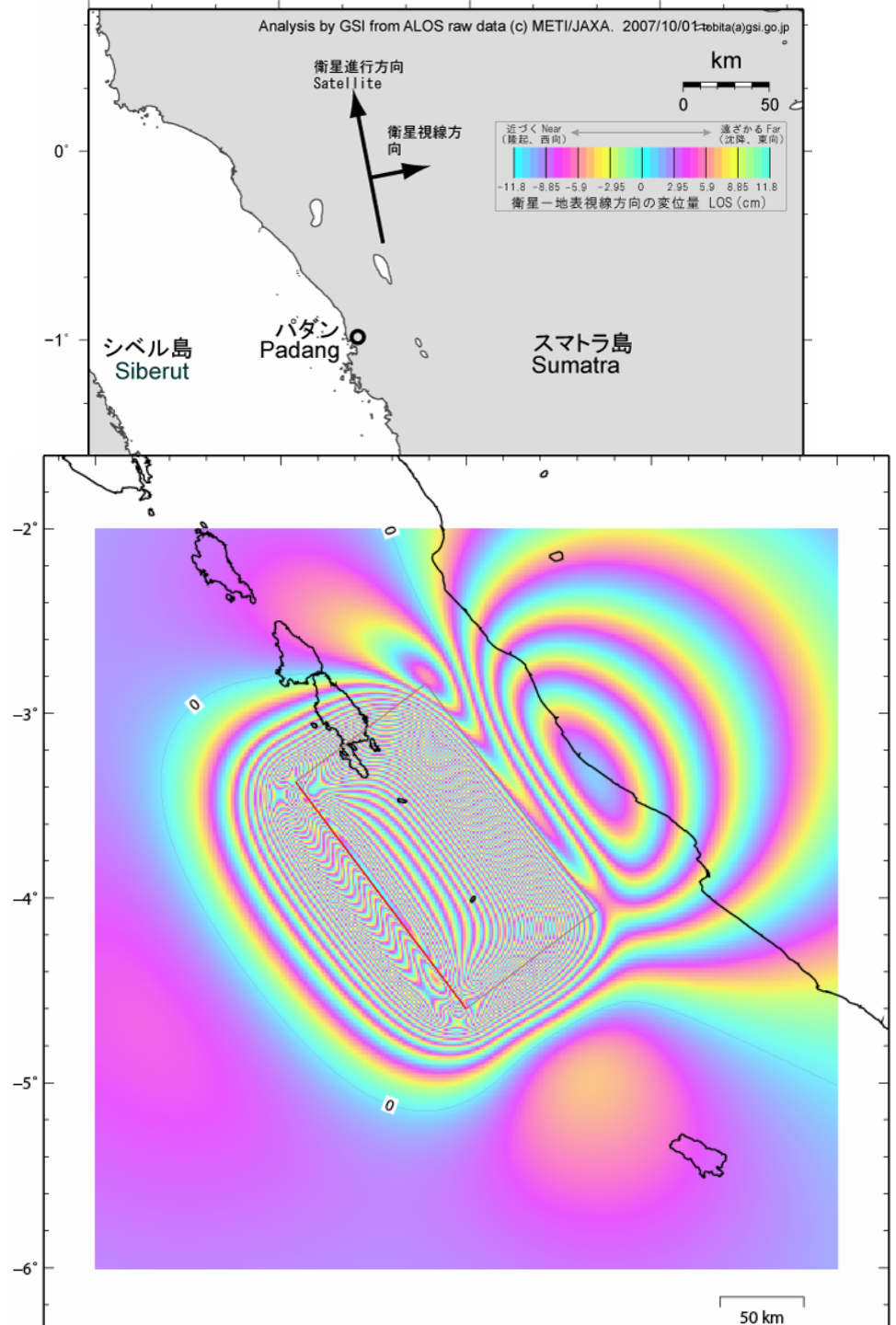
Interferograms with small atmospheric phase were selected for this study.



First approximation of SAR interferograms by a rectangular fault model

A rectangular fault model with uniform slip can explain roughly the phase gradients.

But this simple model cannot explain the phase in Pagai and Enggano islands in detail.



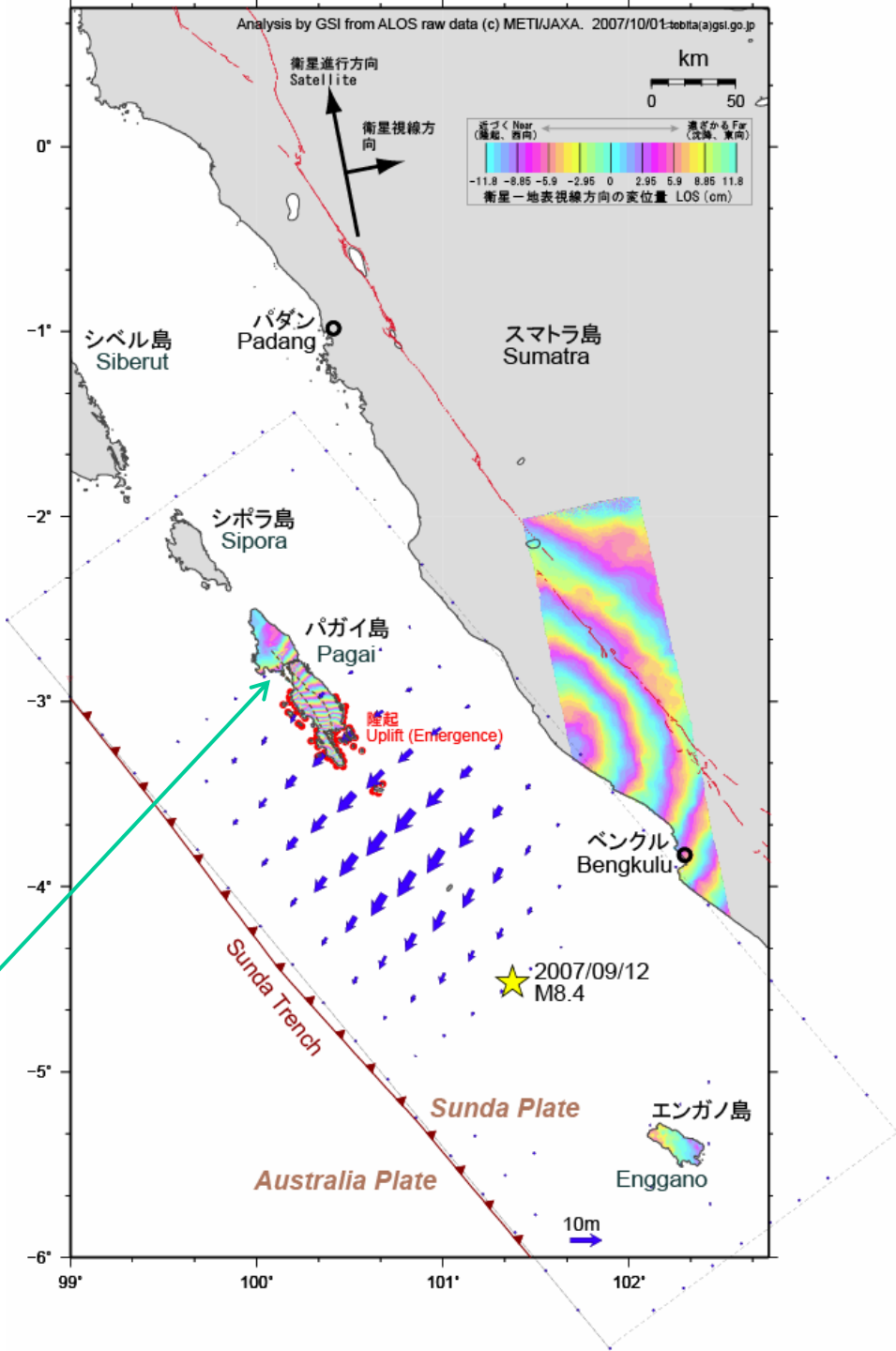
SAR interferograms and estimated slip distribution on the plate boundary

We estimated the **slip distribution** of the 2007 S. Sumatra Mw8.4 earthquake from displacements observed by Daichi (ALOS).

Assumed Dip: 12°

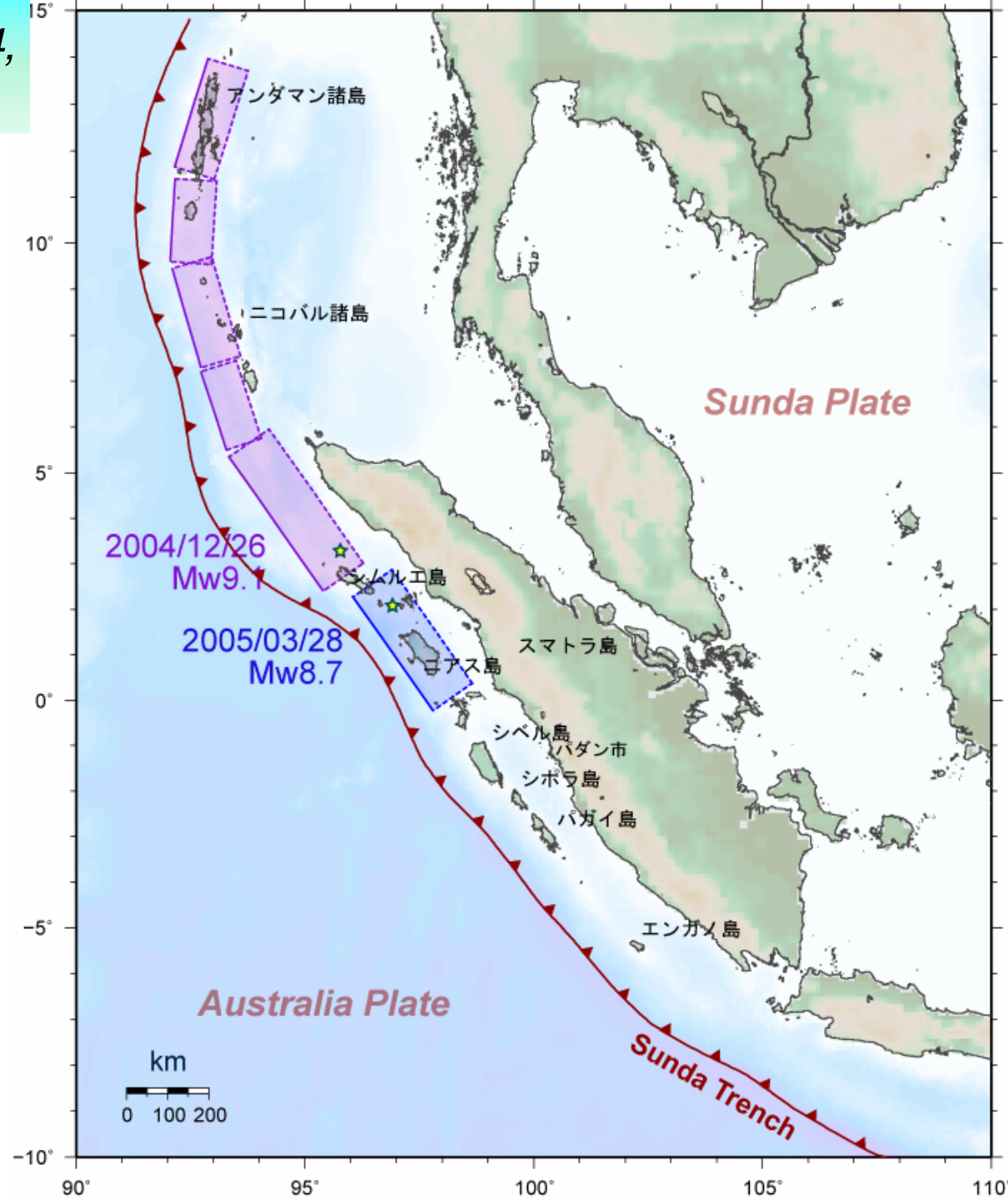
2007 event rupture is **260 km** long along Sunda Trench.

North end of rupture is **between S. and N. Pagai Islands**.



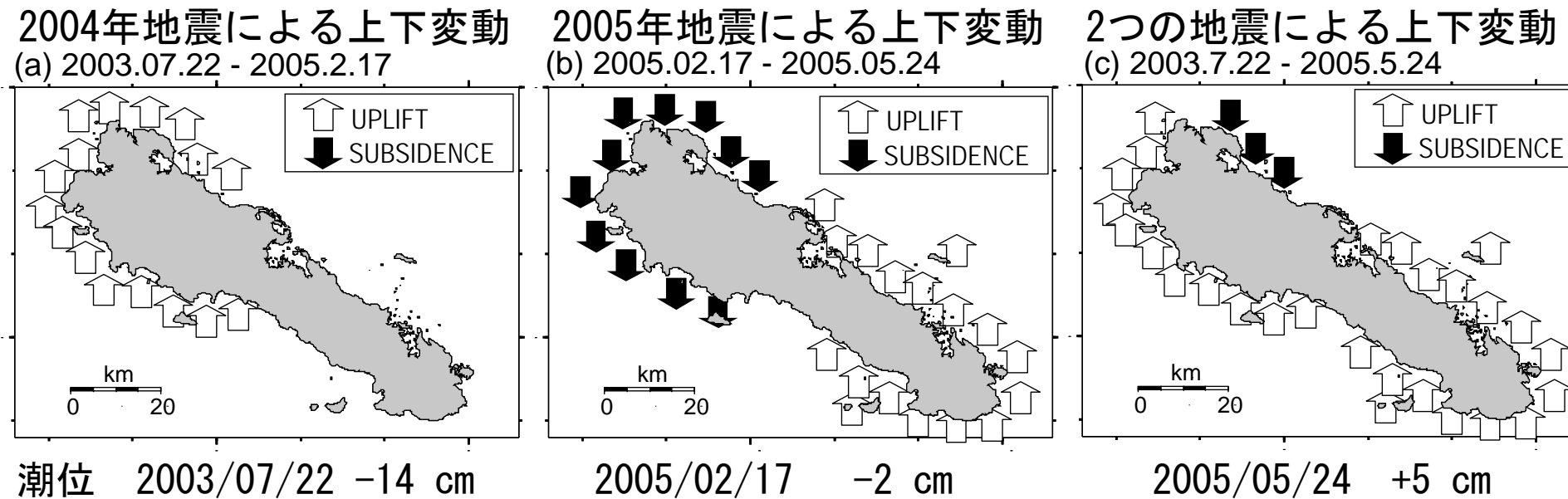
Past Study: *Suito et al., 2004, 2005; Tobita et al., 2005*

Location of source faults of the 2004 and 2005 earthquakes determined by SAR image analyses



Past Study: 地震学会2005年秋季 2005/10/21 11:00-11:12 A078
from Tobita et al., *Uplift and subsidence caused by 2004&2005 Sumatra earthquakes extracted from satellite radar imagery, the seismological society of Japan 2005 fall meeting.*

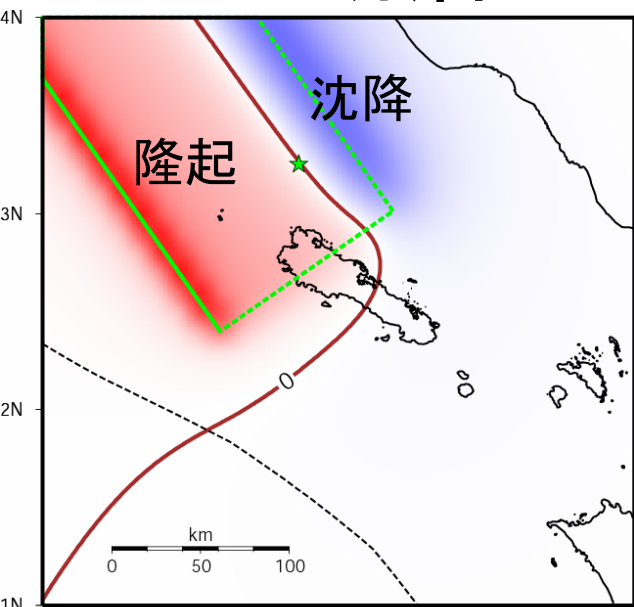
Uplift and subsidence of Simeulue Is. in 2004 and 2005 earthquakes シムルエ島での上下変動



Past Study: *Tobita et al., 2005*

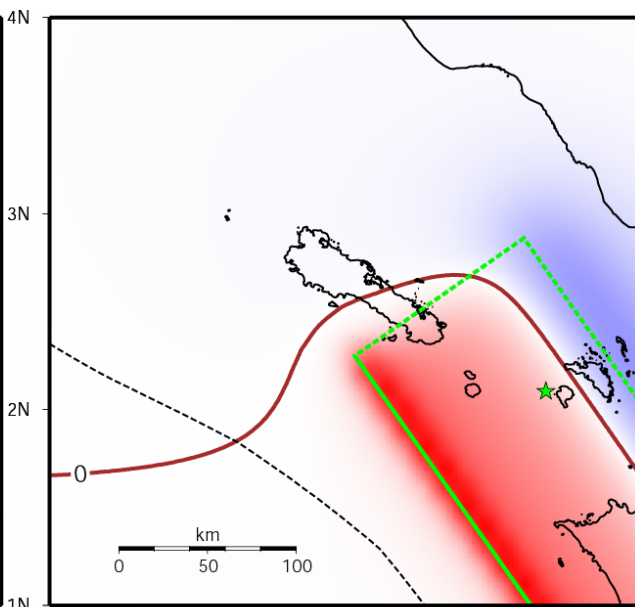
断層モデル

JAMSTEC, 山中氏, 八木氏の断層モデル
を参考に水藤が作成



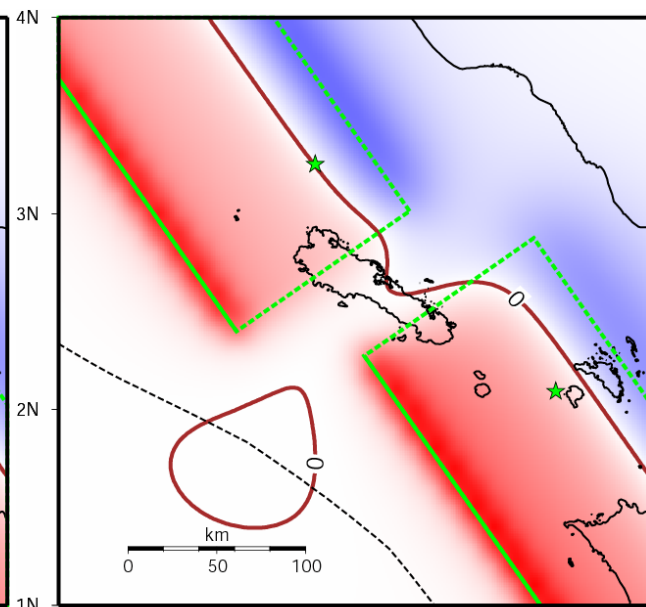
-500 -400 -300 -200 -100 0 100 200 300 400 500
Vertical Displacement (cm)

2004年地震



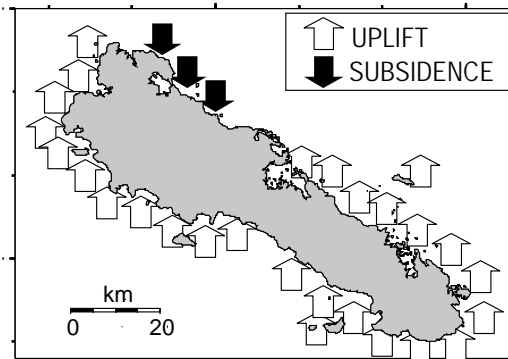
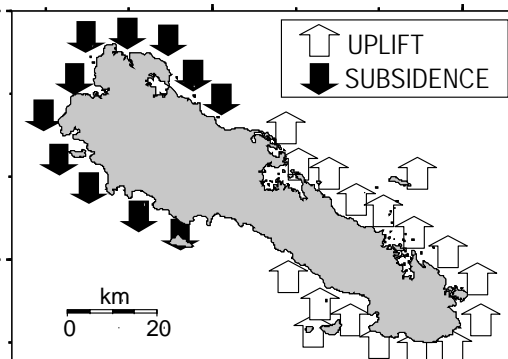
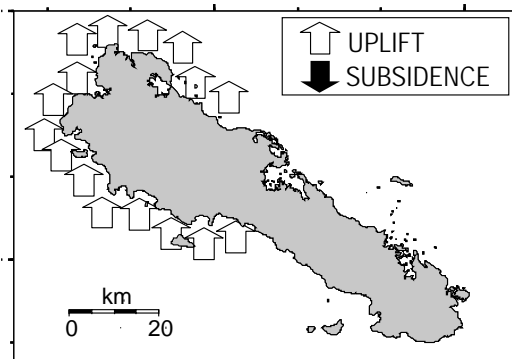
-500 -400 -300 -200 -100 0 100 200 300 400 500
Vertical Displacement (cm)

2005年地震



-500 -400 -300 -200 -100 0 100 200 300 400 500
Vertical Displacement (cm)

2つの地震



Past Study: 地震学会2005年秋季 2005/10/21 11:00-11:12 A078
from *Tobita et al., Uplift and subsidence caused by 2004&2005 Sumatra earthquakes extracted from satellite radar imagery, the seismological society of Japan 2005 fall meeting.*

結論 Conclusion of analysis of 2004 and 2005 earthquakes

海岸線の隆起沈降という上下地殻変動から推定される断層モデルによれば、2004年12月26日 と 2005年3月28日の地震の破壊域は、重なっておらず、約50kmの間隔で、隣接している。 Barrier?

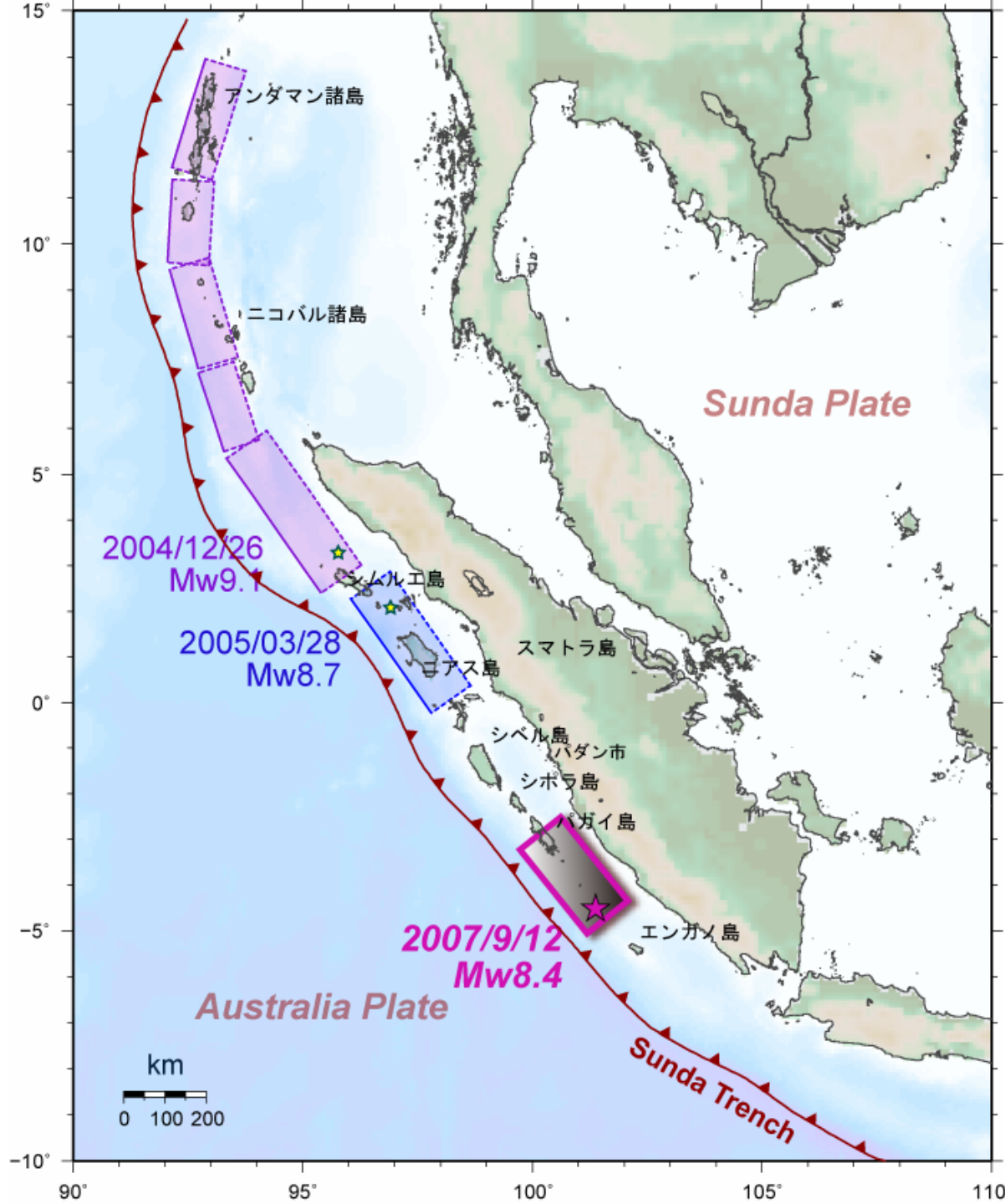
There is a gap between 2004 and 2005 ruptures.

The length of the gap is about 50 km.

Source fault of the 2007 earthquake determined by Daichi SAR image analyses

North end of rupture is between S. and N. Pagai Islands.

The length of the 2007 rupture is about 260 km.

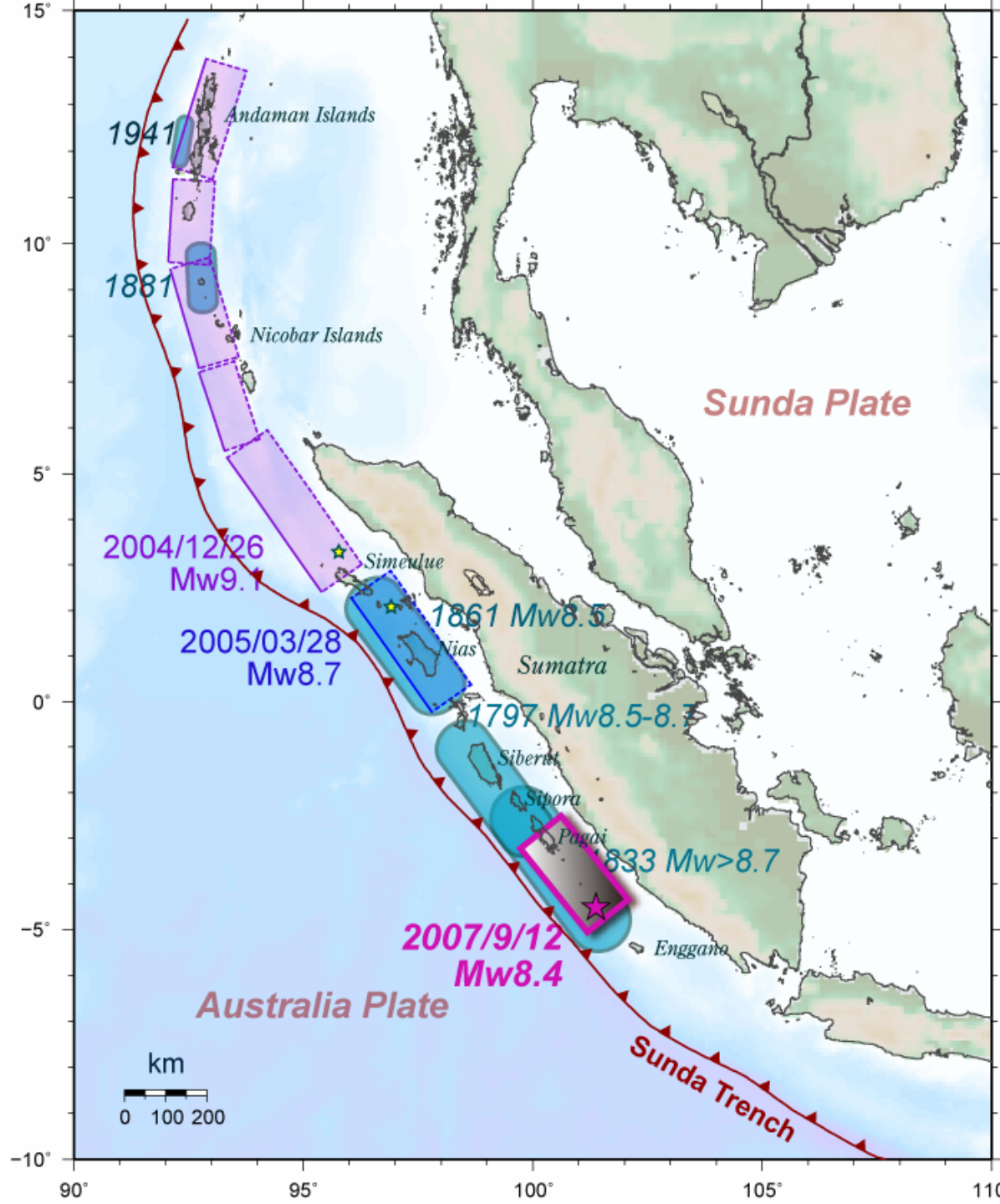


Source faults of recent events and historic earthquakes

Historic events are from Natawidjaja et al., 2006, Source parameters of the great Sumatran megathrust earthquakes of 1797 and 1833 inferred from coral microatolls, JGR.

2007 rupture area is a part of 1833 area excluding 1797 area.

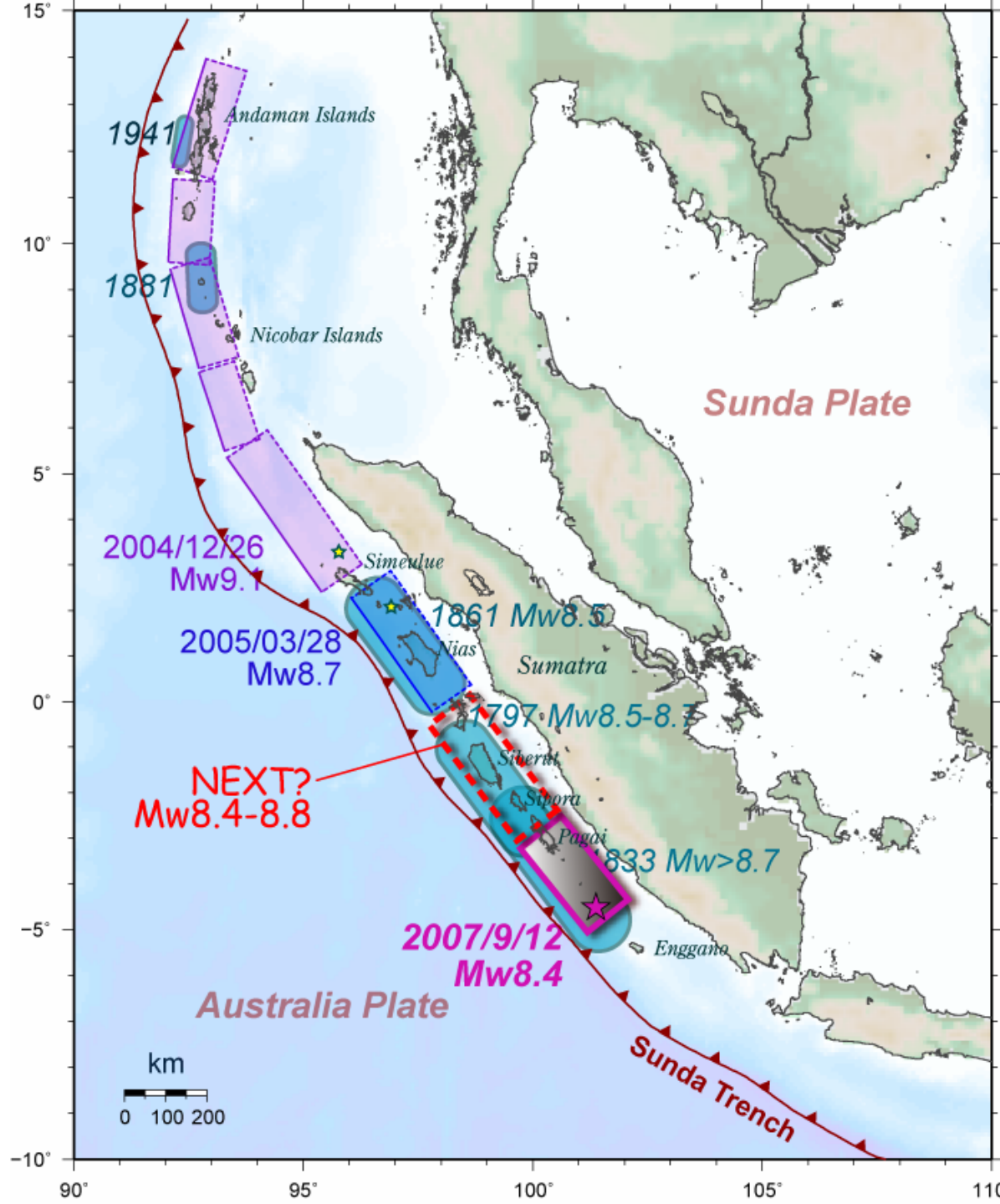
2007年の破壊域は、1833年の破壊域の一部で、1797年の破壊域を除いた領域と推定される。



Possible megathrust earthquake

The length of a seismic gap off-Padang between the 2007 and the 2005 ruptures is about **370 km**.

パダン沖の巨大地震
空白域の長さは、約
370kmと推定された。
北側は210年間、南側
は174年間地震が起
こっていない。



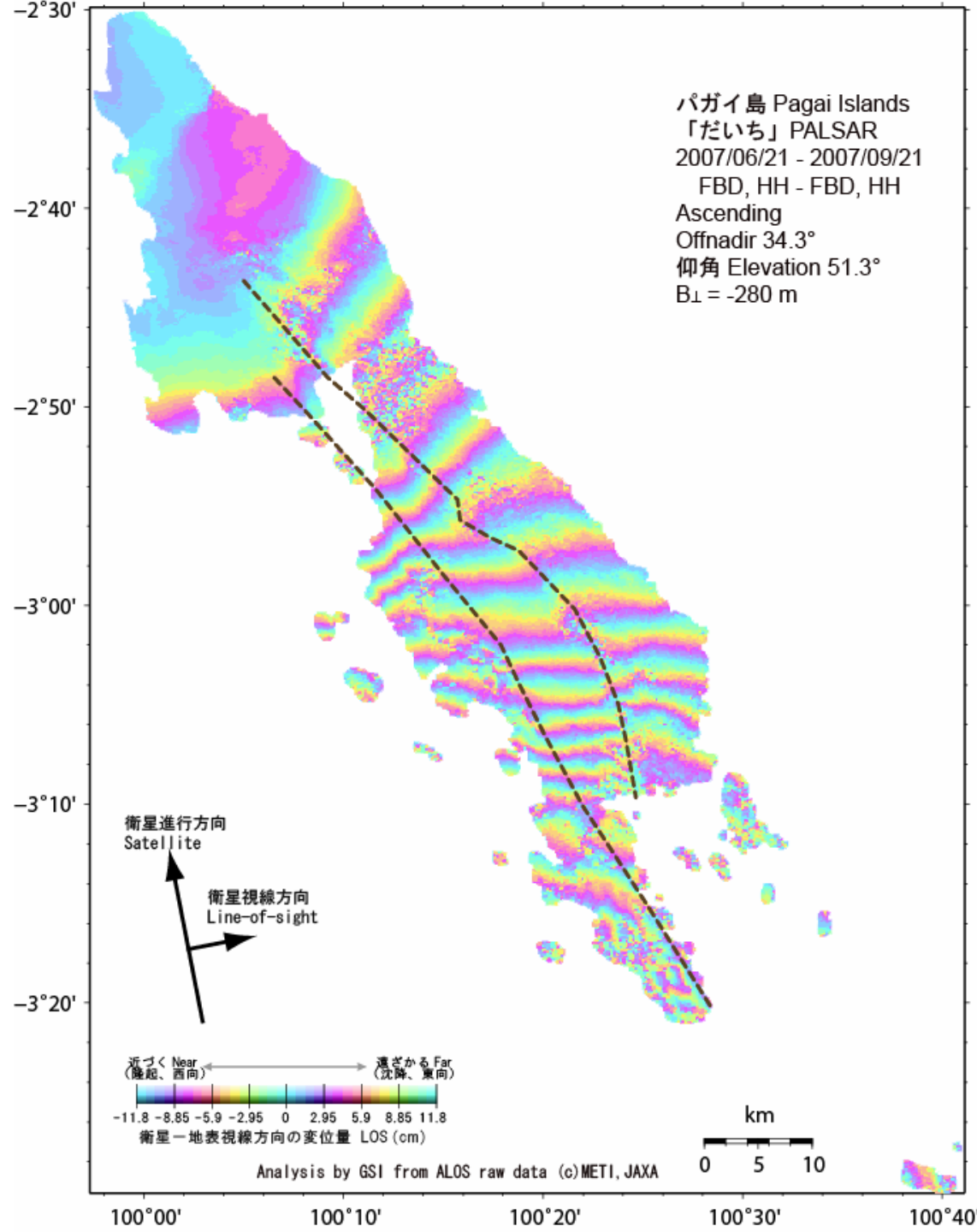
Daichi Interferogram of Pagai Islands

June 21 – Sep. 21

coseismic-1

Phase discontinuities
Surface faults (not source
fault)

位相の不連続線→震源断層
ではない地表断層

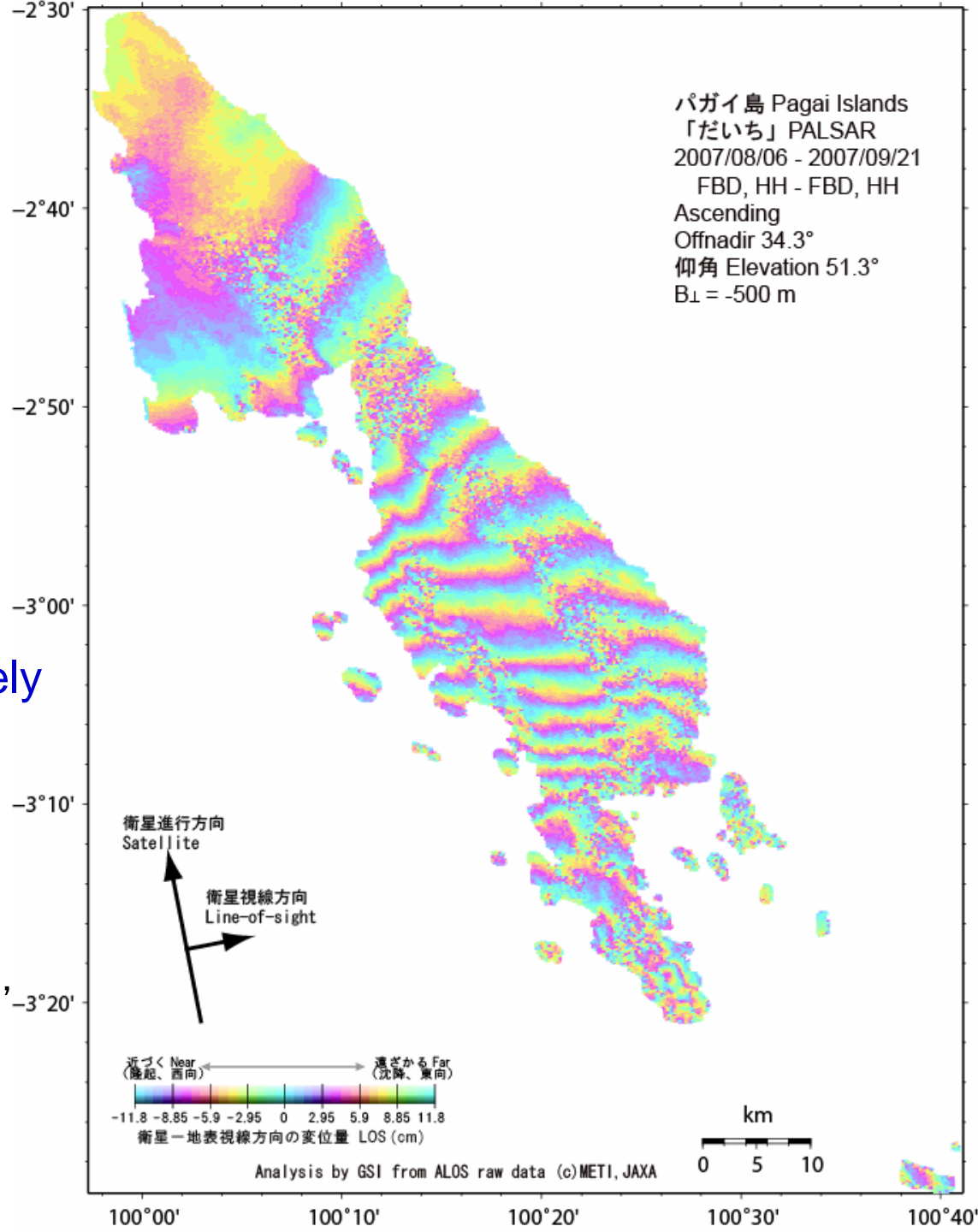


Daichi Interferogram of Pagai Islands Aug. 06 – Sep. 21

co seismic-2

Two discontinuities of phase were found in Pagai Islands (Pulau Pagai).
These probably show that the portion between two normal faults subsided (~10cm) relatively when the South Pagai Island uplifted coseismically.

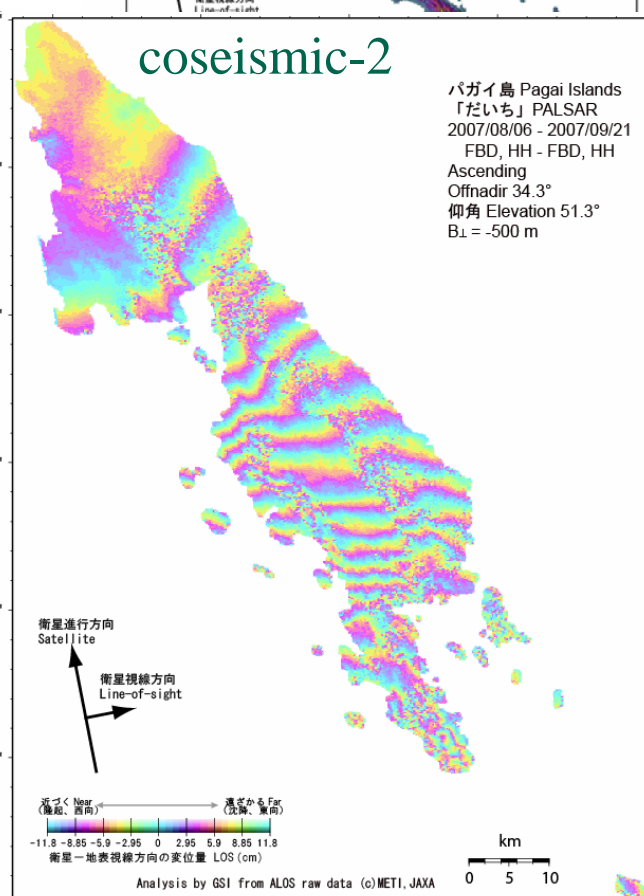
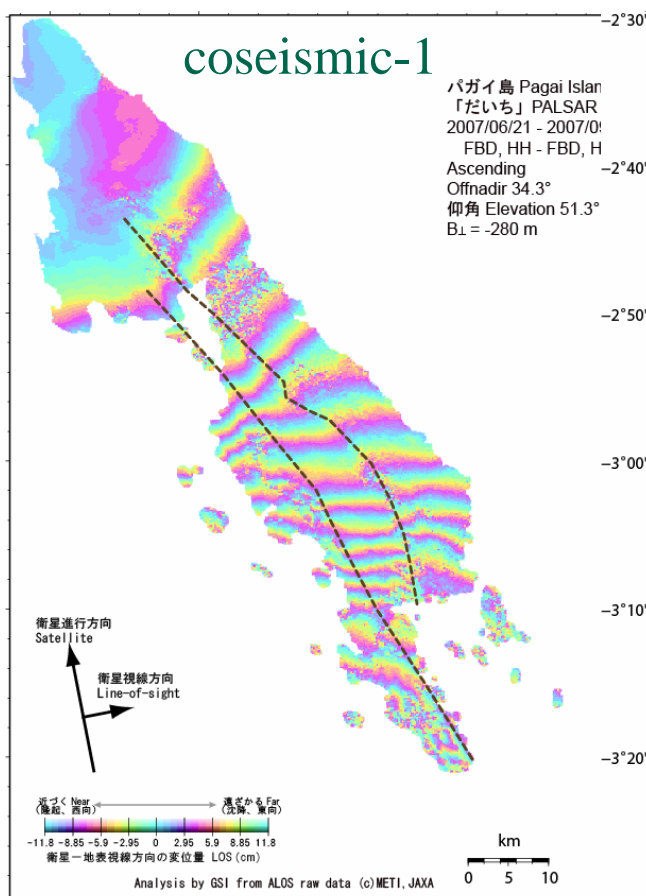
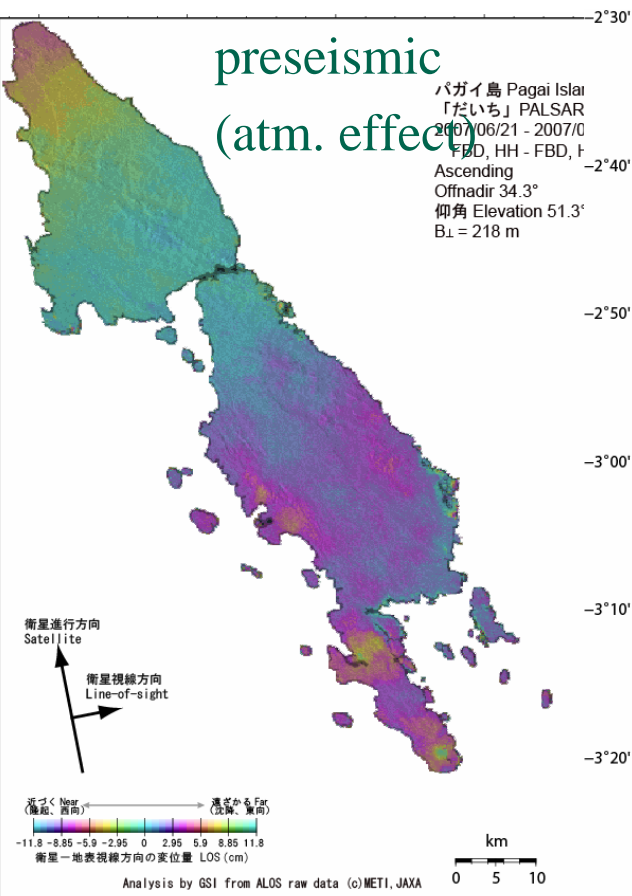
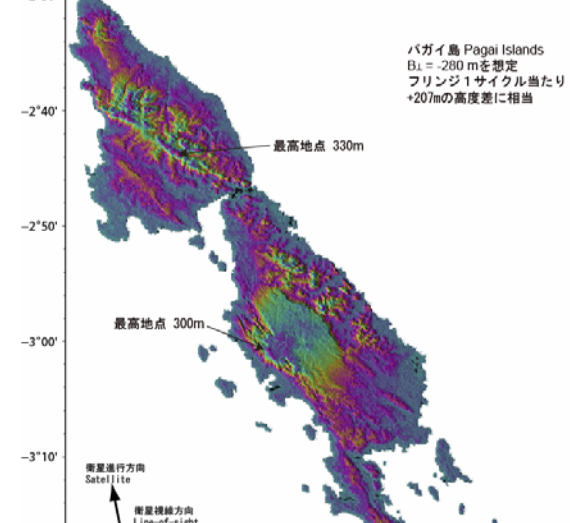
パガイ島の隆起の際に、2つの正断層の間が最大約10cm沈降した、と考えている。



Daichi Interferograms of Pagai Islands

topographic
fringe

- True signal (not artifact)
- 1.8 m (max) LOS displacement is due to slip of the main fault
- Two surface faults

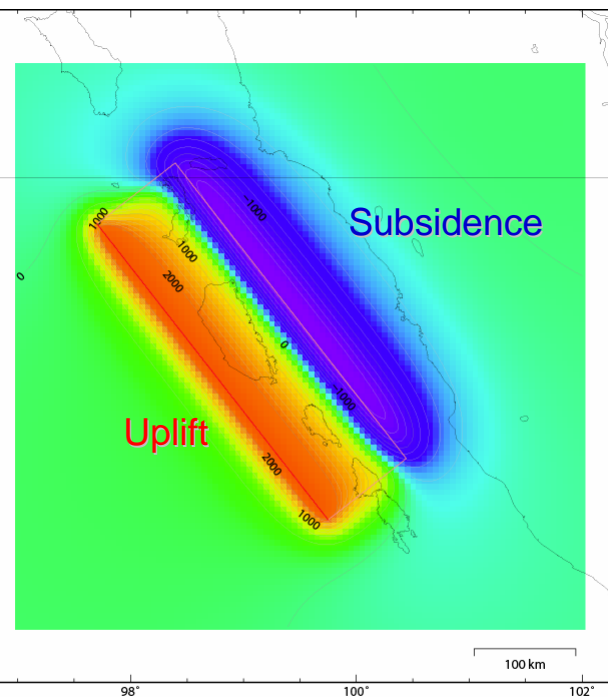
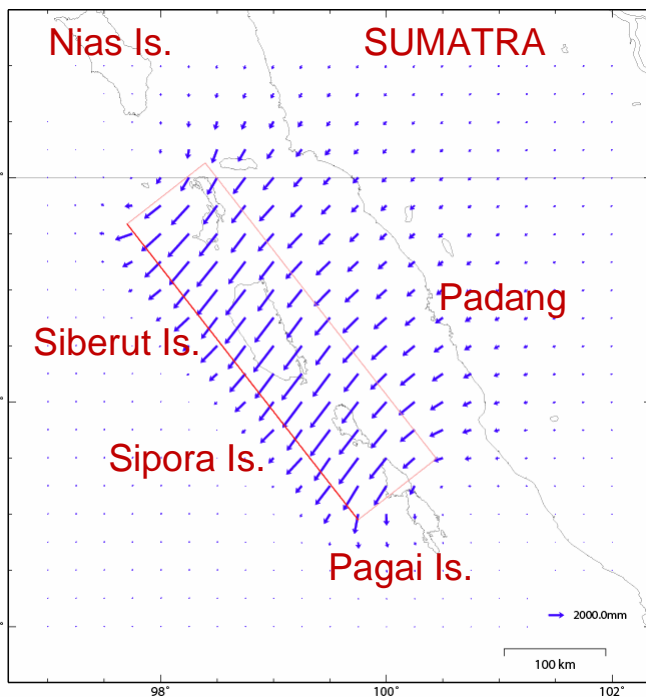


A possible gap-filling megathrust earthquake off Padang

Horizontal

Vertical

Daichi LOS



Asc 34.3°

予想されるEventによる地殻変動は，Siberut島，Sipora島のPALSAR干渉画像で詳細に観測される可能性が高い。地震前の予兆の有無も確認する必要がある。

Padangや沖の島々（Sikuai島等）では若干の沈降が予想され，津波の被害が増幅されるセンスである。

Conclusion まとめ

- Estimated the **slip distribution** of the 2007 S. Sumatra Mw8.4 earthquake from Daichi (ALOS) interferograms.
- The length of a seismic gap off Padang between the 2007 and the 2005 ruptures is approximately **370 km**.
- Two **discontinuities of phase** were found in **Pagai Islands** (Pulau Pagai), which probably show that the **portion between two normal faults subsided relatively** when the South Pagai Island uplifted coseismically.