Vertical Motions in Greater Bangkok Area after the 2004 Sumatra-Andaman Earthquake from GPS Observations and Its Prediction based on the Geophysical Modelling

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Hainan Dao
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Pulau Siberut
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KEPULAUAN NATUNA
PEGUNUNGAN BARISAN
Billiton
Madura
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Lombok
Flores
Pulau Bangka
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Outline

- Introduction
- GPS Data Processing Strategy
- Horizontal displacement after the Earthquake
- Vertical motion after the Earthquake
- Geophysical modelling
- Concluding remarks

Introduction

- The Greater Bangkok area regularly experiences annual floods. Business and daily lives are seriously affected by flood. Flood protection system has been built.
- The rate of land subsidence and sea level change in the area of Greater Bangkok has not yet been robustly determined.
- The land subsidence and sea level change are further complicated by the deformation of land caused by pre-, co- and post-seismic motion.
- During 2009-2010, the Thailand-EU joint research project so-called ***'GEO2TECDI'*** proposed the use of 3 space geodetic techniques (GPS/GNSS, InSAR and SALT) to monitor the surface motion, land subsidence and sea level change in Thailand.


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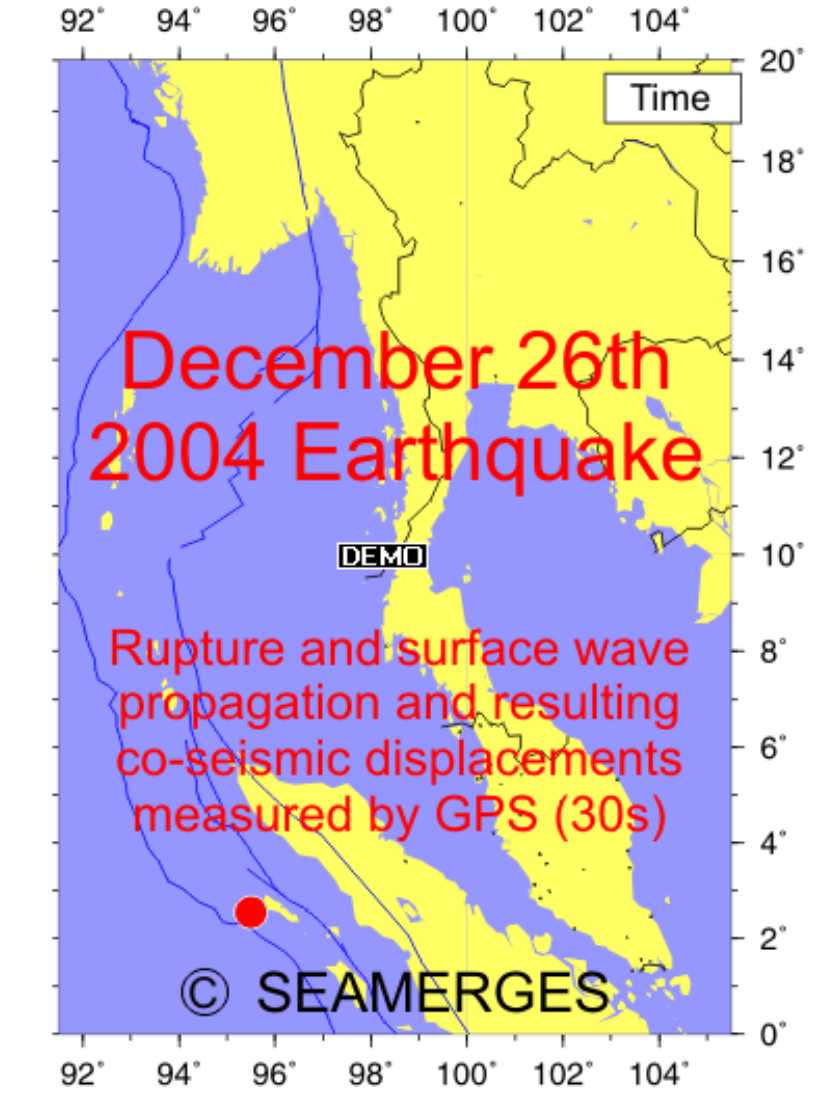
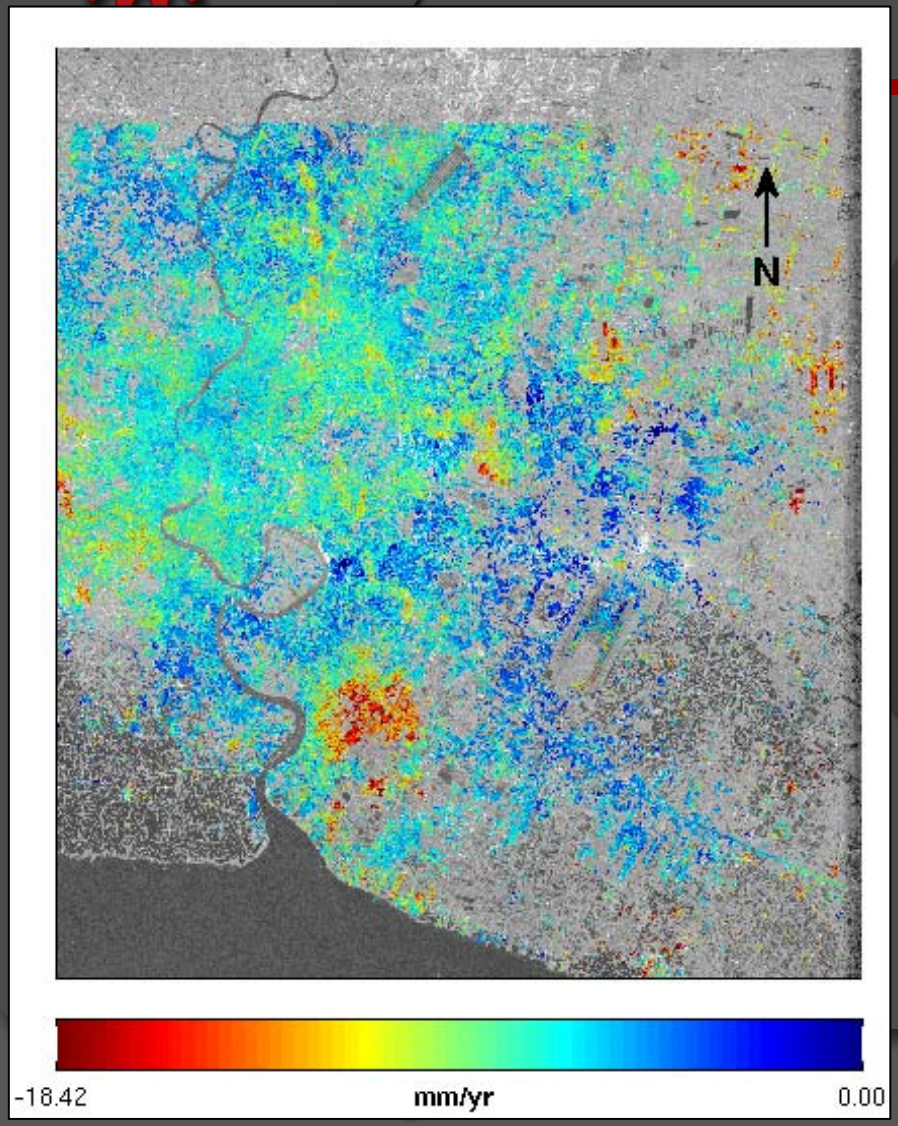
Horizontal displacement during the Sumatra-Andaman earthquake



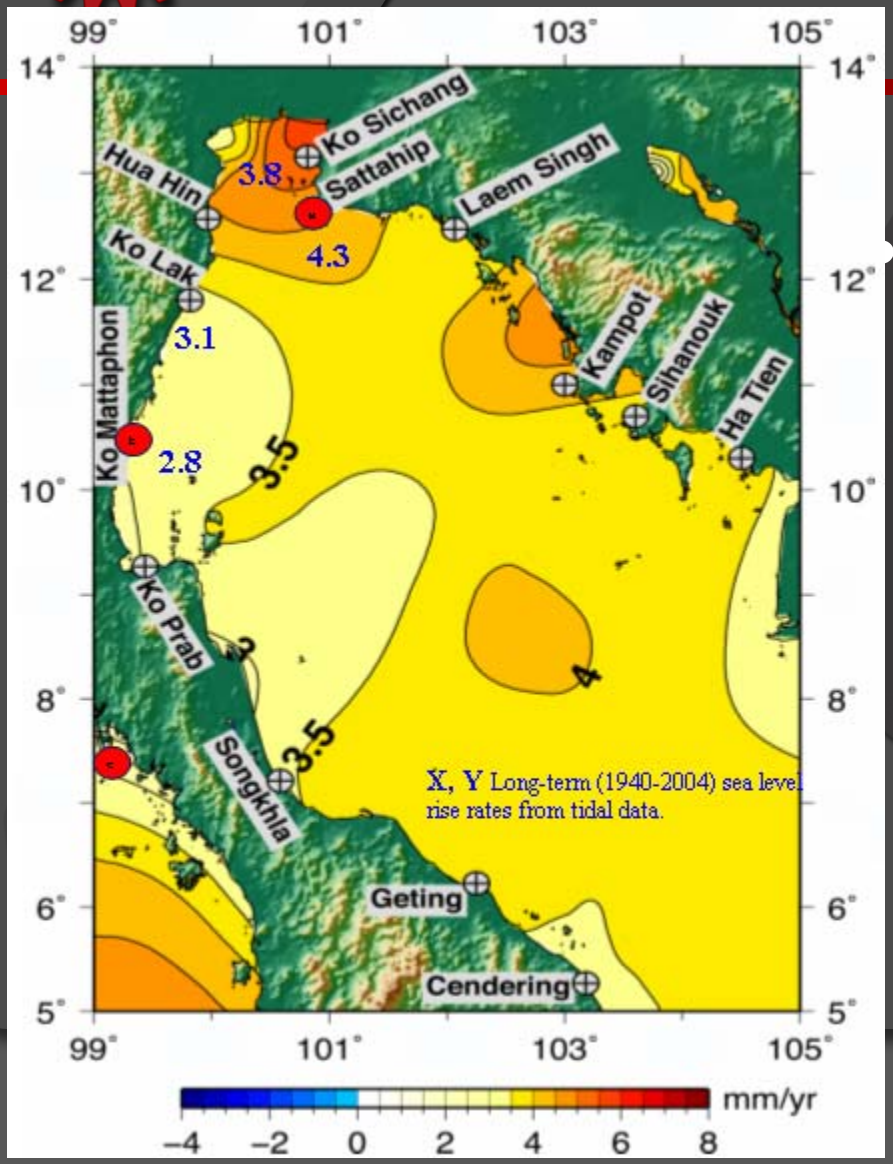
http://www.deos.tudelft.nl/seamerges

InSAR; Land subsidence



InSAR is showing the land subsidence rate at 15-25 mm per year in Bangkok area

SALT: Sea level change



- The sea level rise is around 4-5 mm per year in the Thai gulf from the SALT and tide gauge data.

Introduction

- This talk will only focus on the GPS results and its geophysical modelling.
- The Thai geodetic network has been regularly observed with GPS since 1994 thru several collaborative projects such as GEODYSSEA, SEAMERGES and GEO2TECDI. The plate motion between 1994 and 2004 are well determined in Thailand.
- After the occurrence of the 9.2 Mw Sumatra-Andaman earthquake on the 26th December 2004, horizontal displacements were evident at different magnitudes in many SE Asia countries.

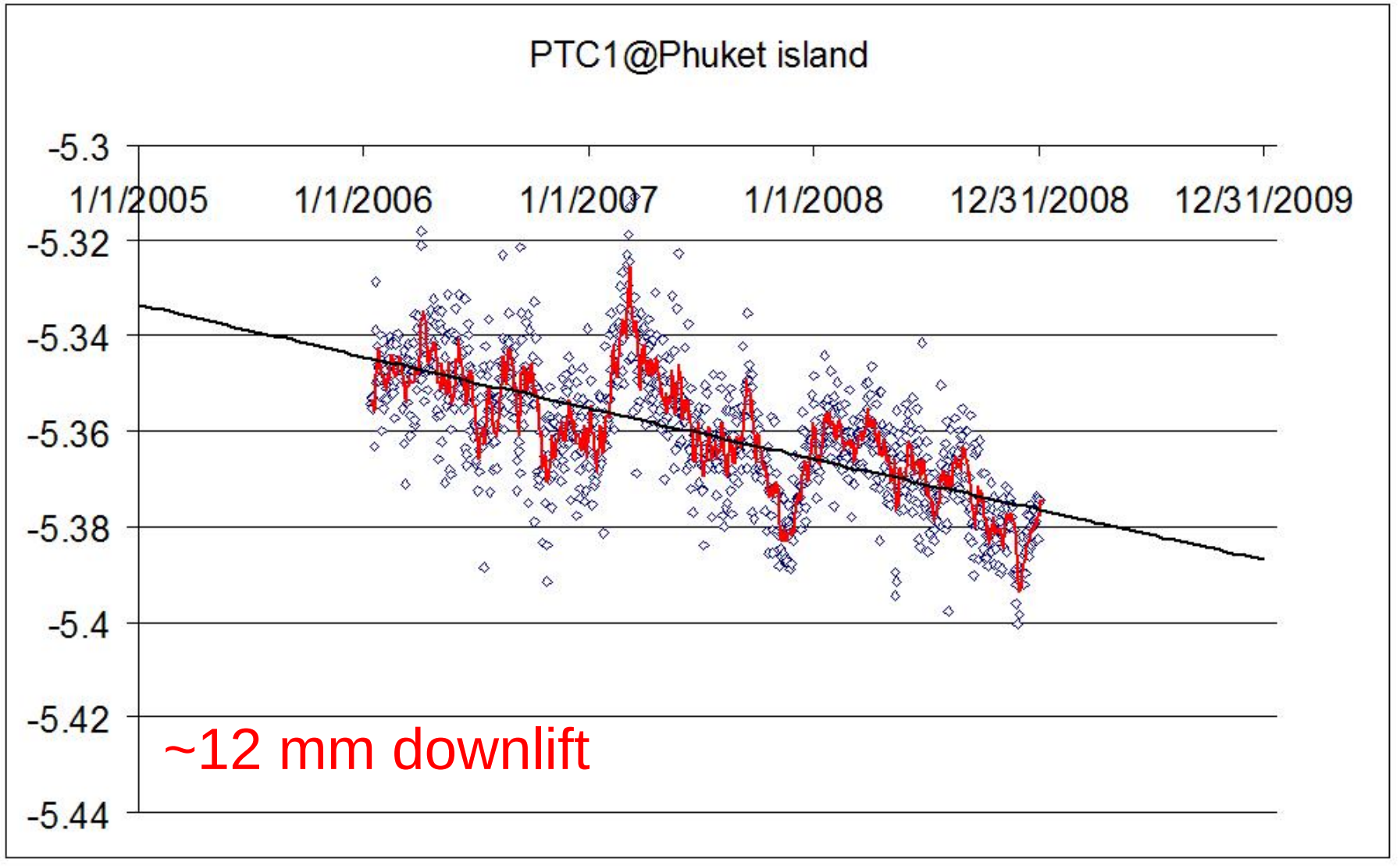
GPS data processing strategy

- Precise Point Positioning (PPP) technique is selected as a processing strategy.
- All GPS data were uniformly processed with the GIPSY-OASIS II software developed by the Jet Propulsion Laboratory (JPL).
- GPS data were processed in daily batches with the PPP strategy.
- The daily ambiguity-fixed solutions were combined into 7-day campaign averaged solutions using 7-parameter Helmert transformations.

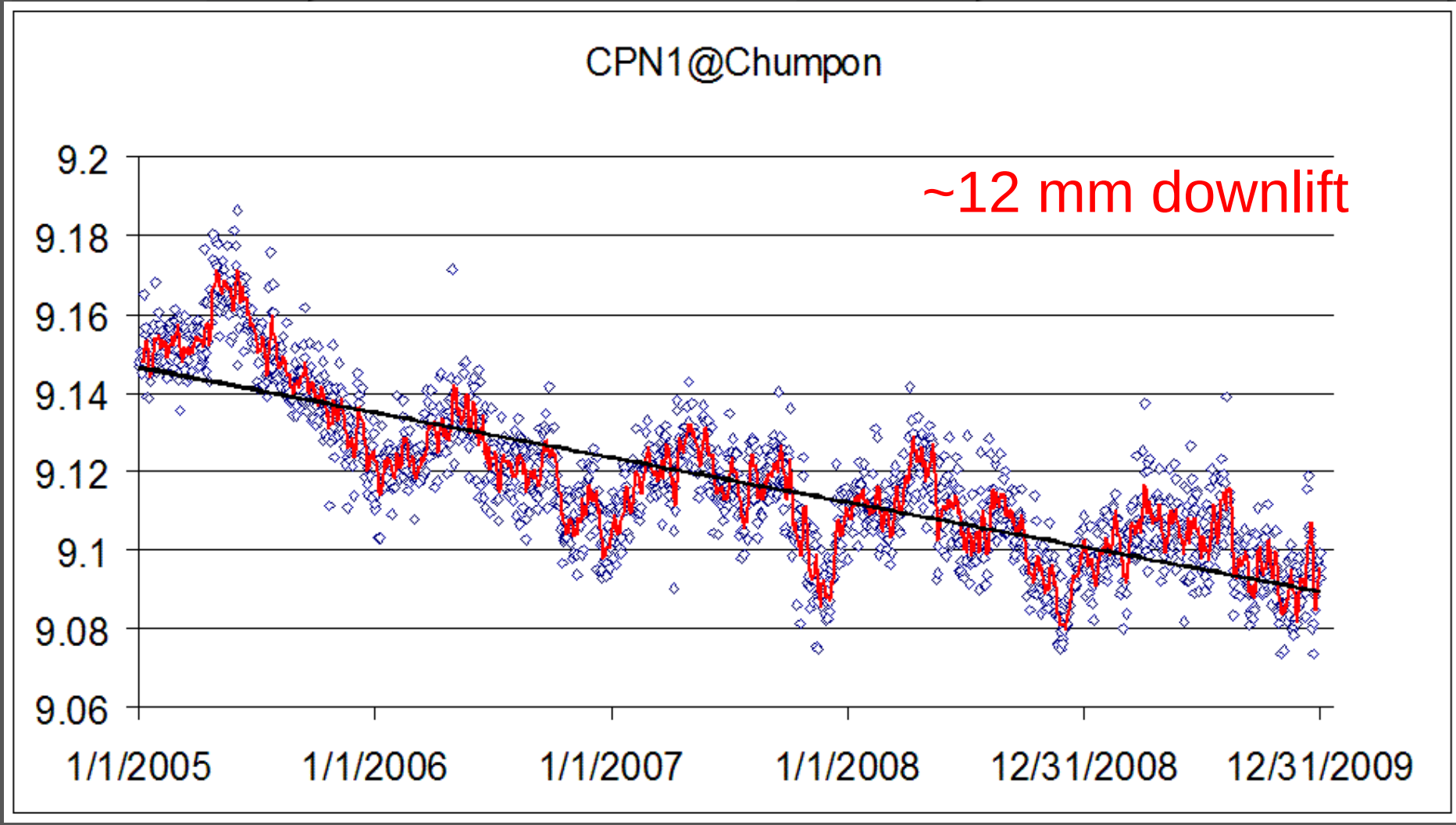
What about the vertical motion?

- Only CGPS data are used for the study of vertical motion
- Data from 4 CGPS stations (CMU1, KMI1, CPN1, PTC1) were kindly provided by NICT, Japan

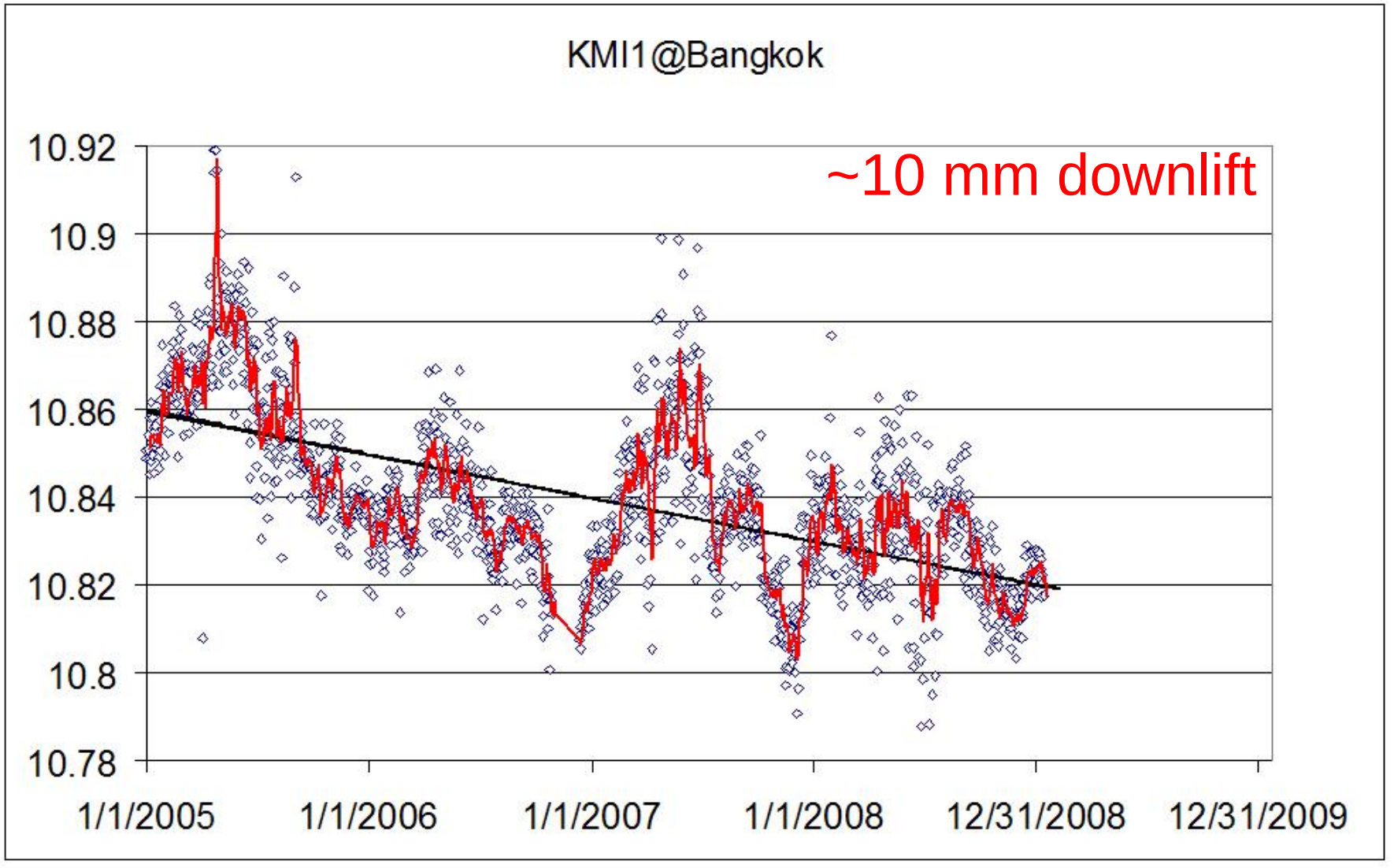
Vertical motion of CGPS in Phuket



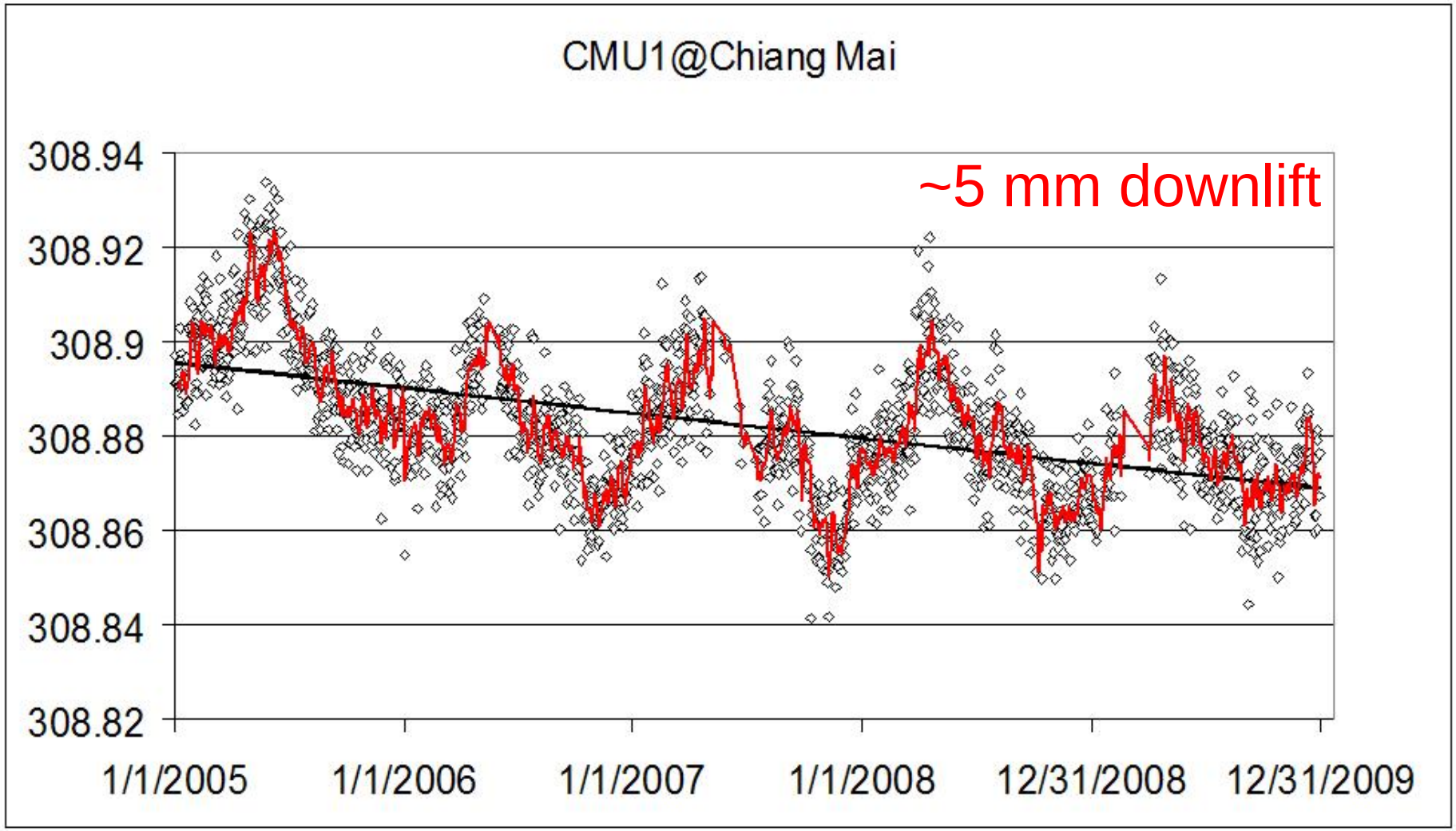
Vertical motion of CGPS in Chumphon



Vertical motion of CGPS in Bangkok



Vertical motion of CGPS in Chiang Mai



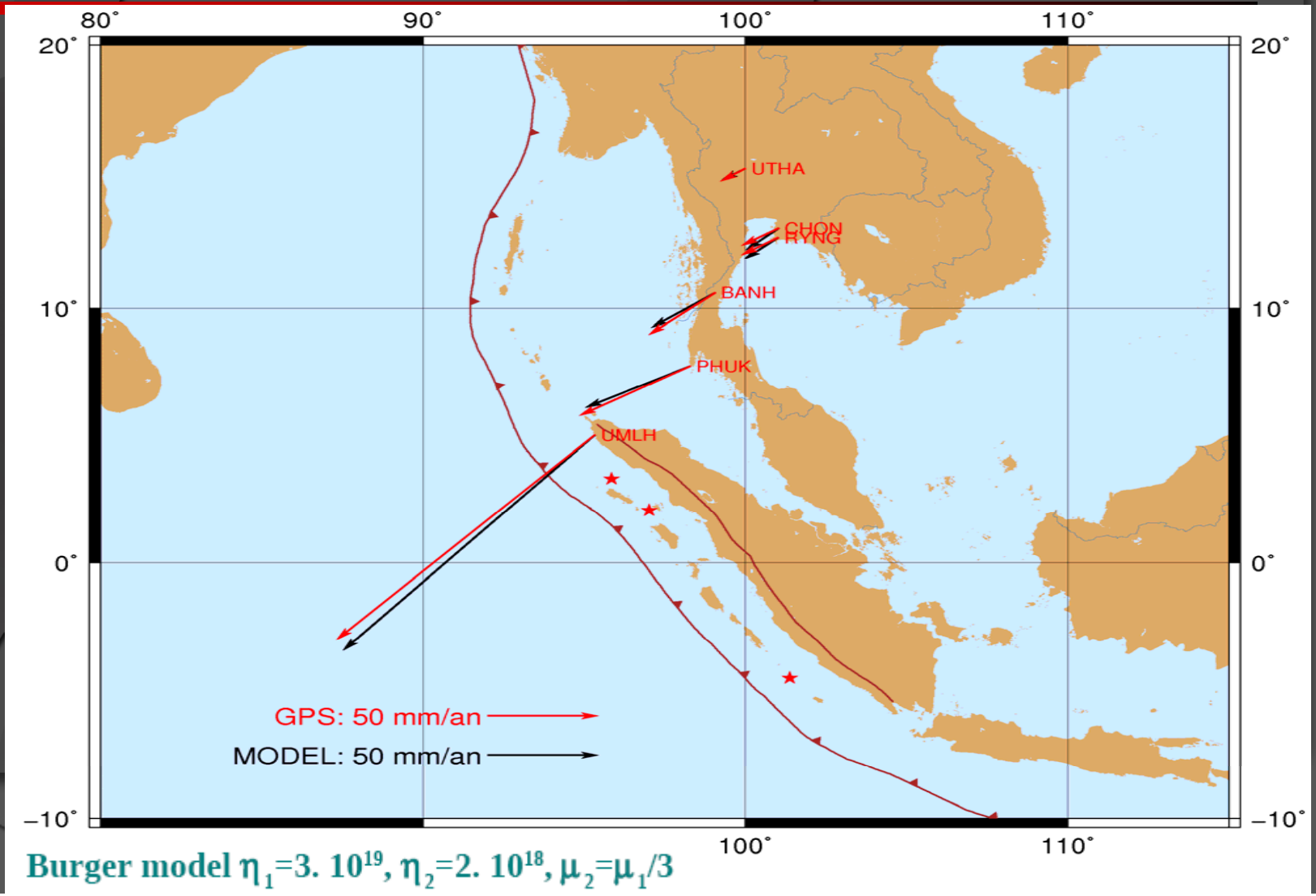
Vertical motion

- GPS results reveal that significant vertical downlifts after the Earthquake are around 12 mm/yr @ PTC1 & CPN1, 10 mm/yr @ KMI1 and 5 mm/yr @ CMU1.
- *How long this phenomenon will last for?*
- This question requires a geophysical model to provide an answer.

Geophysical modelling

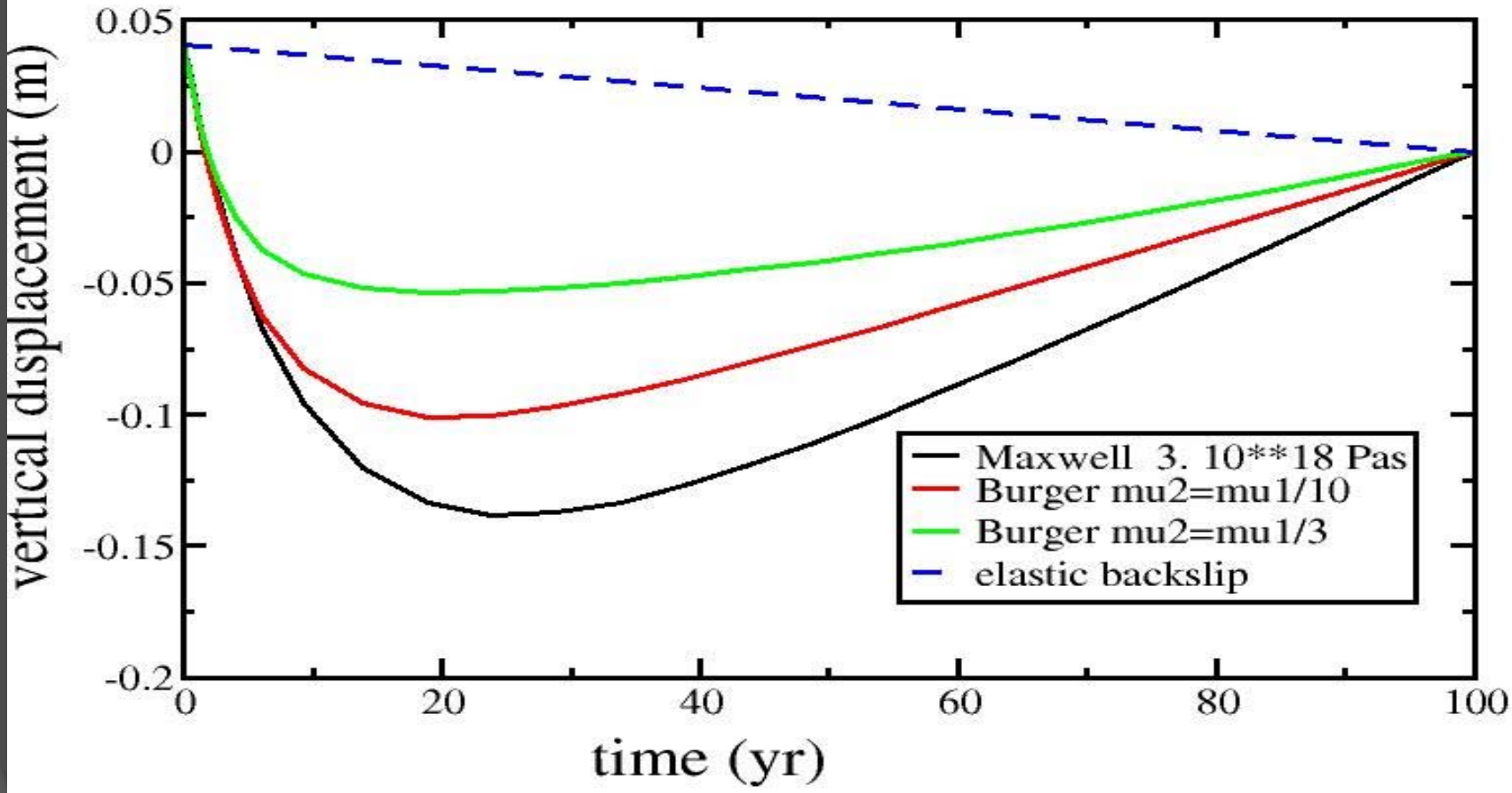
- Carried out by our colleagues at ENS, France.
- The analysis of Sumatra Earthquake has convinced us that post-seismic motions required visco-elastic relaxation in the asthenosphere.
- Our preferred model involved burger rheology.

Good fit to the far-field horizontal post-seismic motions



Burger model $\eta_1=3.\ 10^{19}$, $\eta_2=2.\ 10^{18}$, $\mu_2=\mu_1/3$

Comparing between diff. models



Concluding Remarks

- The characteristics of this subsidence as function of time will be important for discussing some of the mechanical properties of the system, hence for understanding Earthquake genesis. Even taking into account the present model uncertainties, the total subsidence in Thailand should be moderate (<30cm)
- The 3 phenomena (vertical downlift, land subsidence, sea level rise) have a considerable impact in the greater Bangkok area

ACKNOWLEDGEMENTS

- Thanks for the organizing committee for supporting me to attend this meeting.
- Thailand Research Fund (TRF) for funding the RDG5330029 project
- EC EUROPAID Thailand-EC Cooperation Facility for funding the GEO2TECDI-SONG
- Project partners and associate agencies i.e. TUDelft, ENS, TUDarmstadt, RTSD and NICT (Japan) for their valuable data contributions and discussions