Precise InSAR analysis for detection of volcanic deformation

火山性地殻変動の検出に向けた高精度SAR干渉解析

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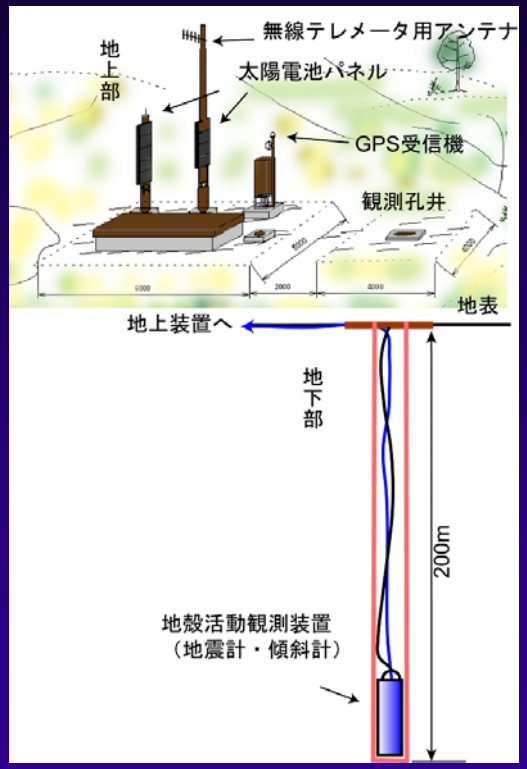
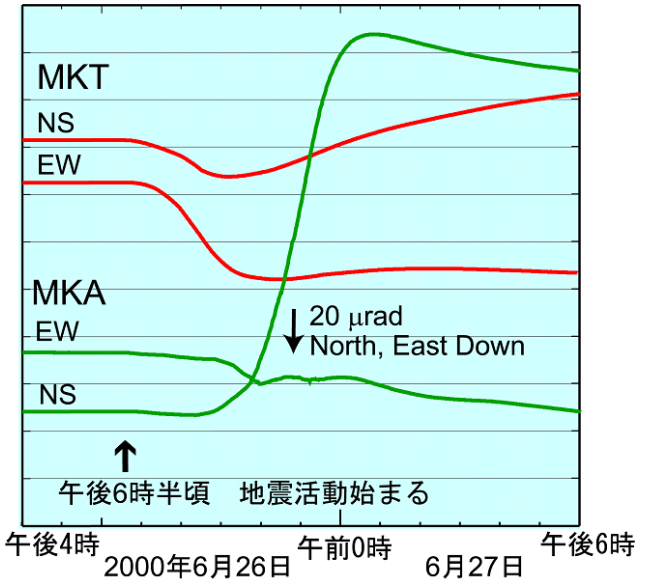
NIED Volcano Observation Network

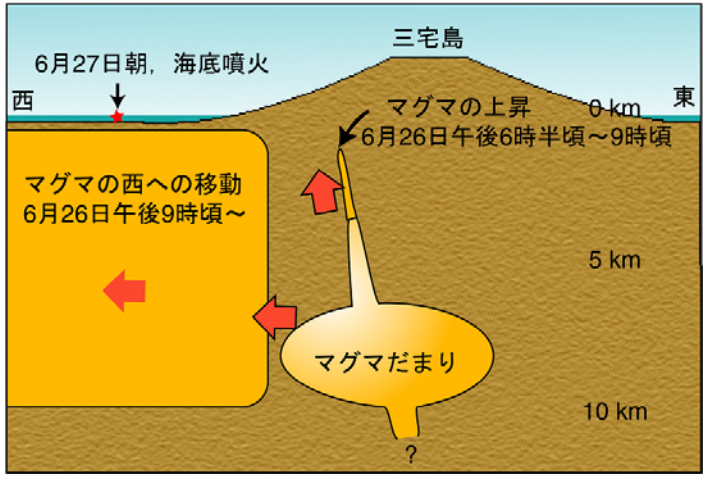
The 6th observation station of Mt. Fuji

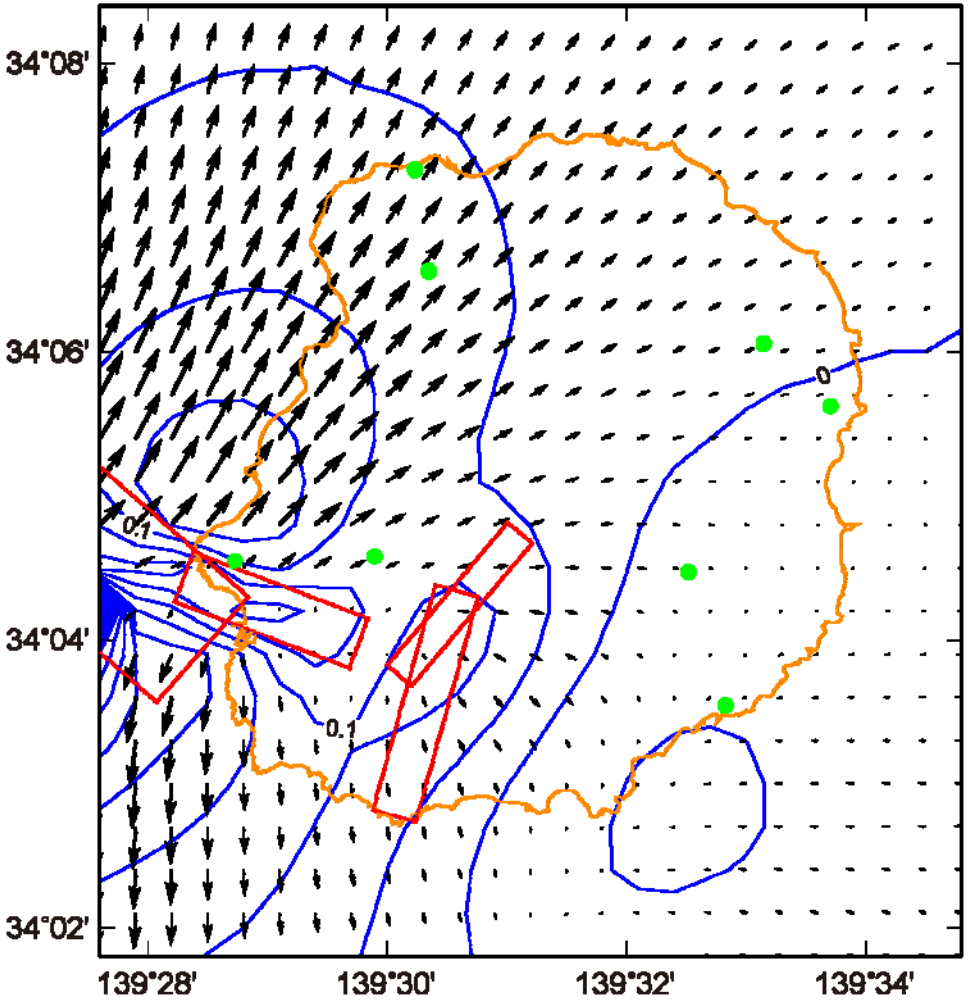


Seismometer, Magnetometer, GPS,
Tiltmeter, Strainmeter, Gravitmeter

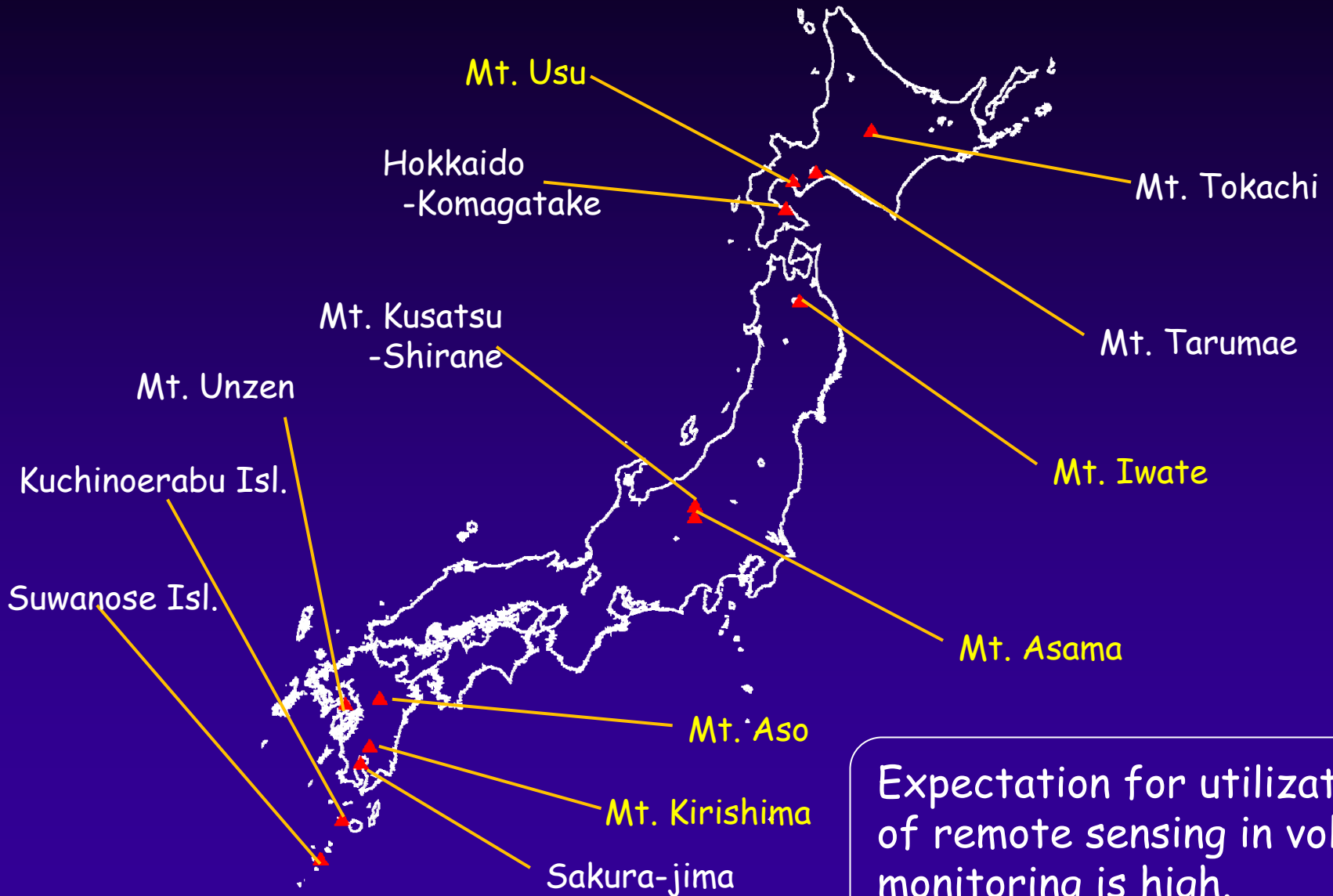
Deformation of 2000 Miyakejima eruption (Ueda et al., 2005)







New observation network (Plan)



Expectation for utilization of remote sensing in volcano monitoring is high.

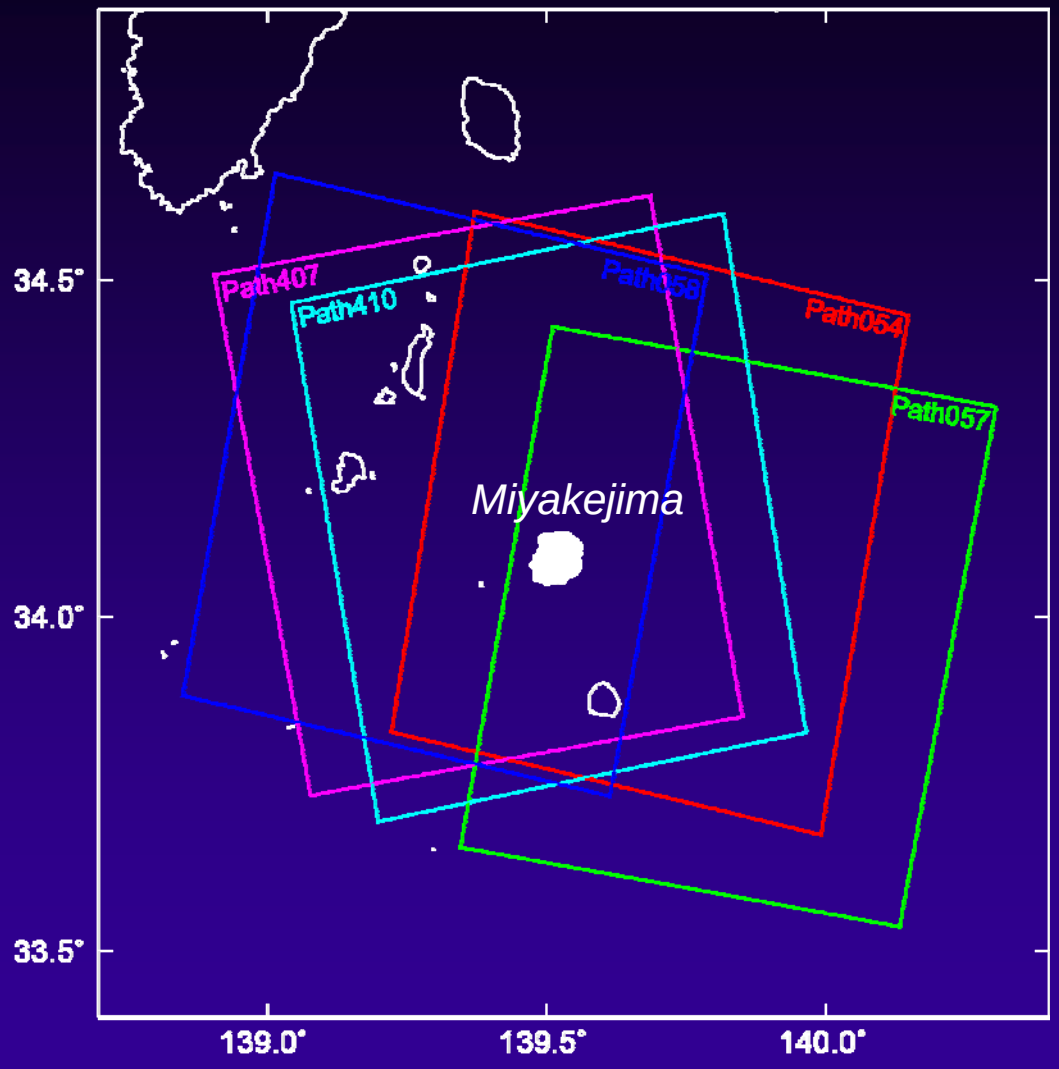
Problems of monitoring by present InSAR

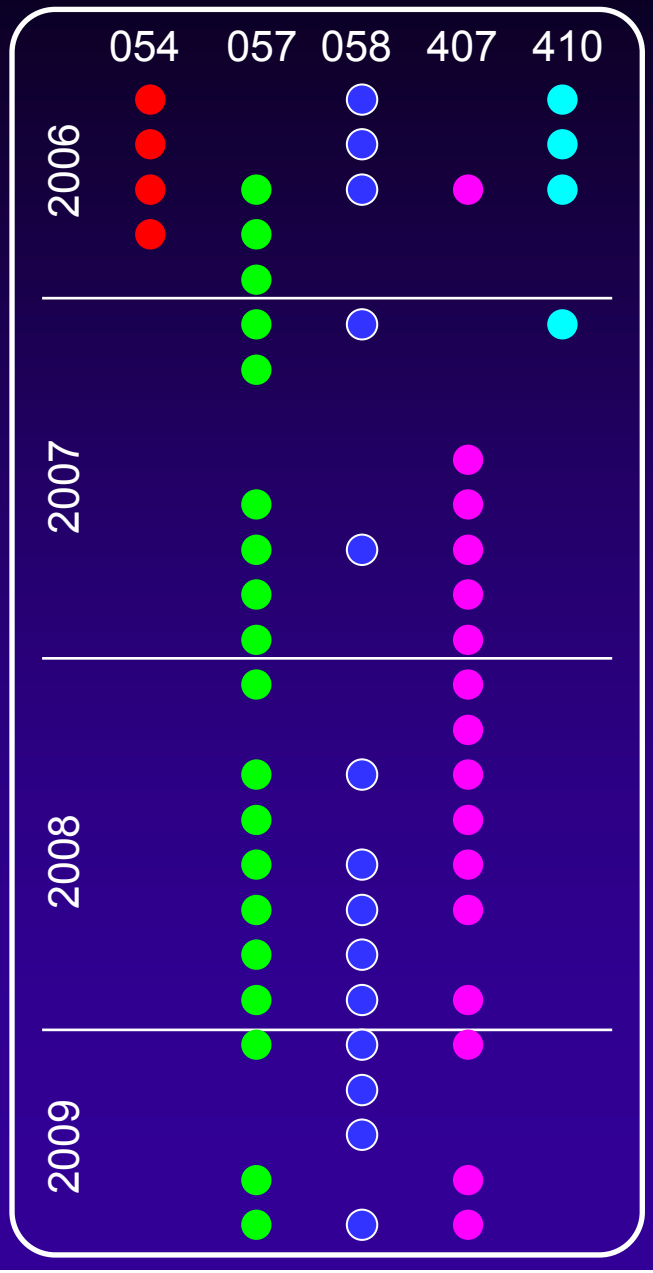
- Detection accuracy
  - Noise often exceeds 5cm
  - Uncertainty of accuracy
- Temporal resolution
  - Repeat cycle of ALOS is 46 days.

This talk

As a step of it, we want to make it possible to detect time-series of deformation precisely.

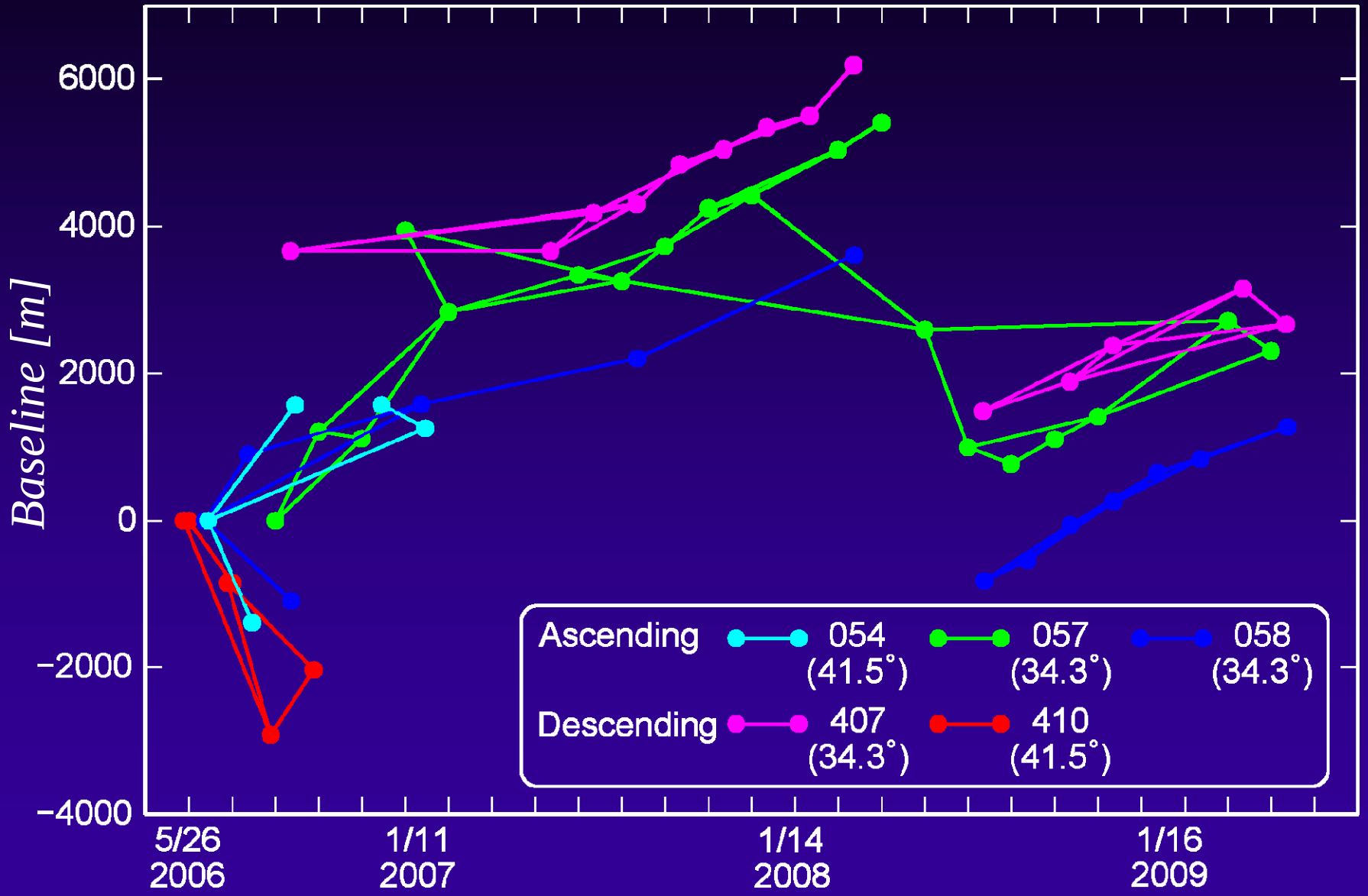
PALSAR data of Miyakejima





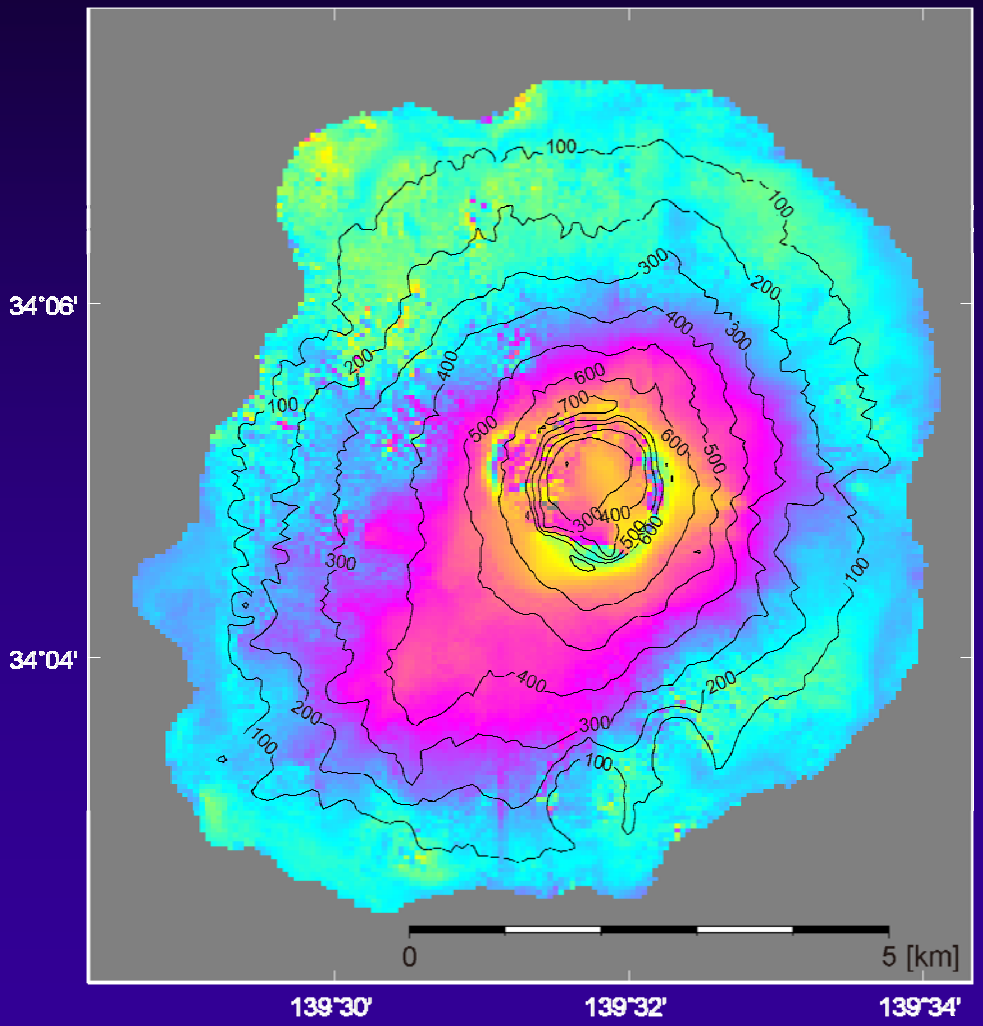
	054	057	058	407	410
2006	8/21	8/26	9/12	9/11	9/16

Interferometric pair (70 pairs)

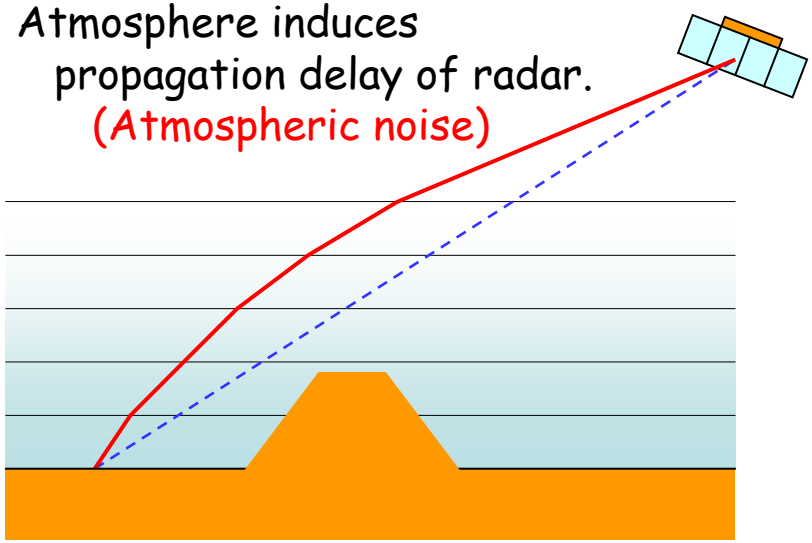


Atmospheric noise

Path: 057(D,34.3), 2008/8/31 – 2009/1/16



Atmosphere induces propagation delay of radar. (Atmospheric noise)



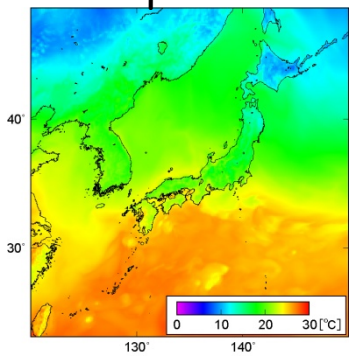
Atmospheric noise reduction:

- Linear approximation with elevation (e.g., Fujiwara et al., 1999)
- Simulation from numerical weather model (e.g., Shimada, 1999, Otsuka et al., 2002)

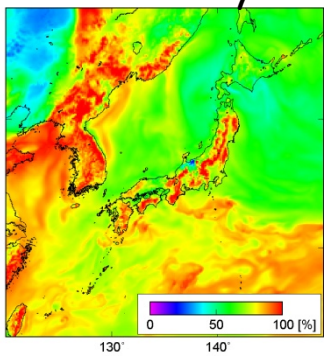
Atm.-delay simulation from weather model

JMA Meso-Scale Model (MSM)

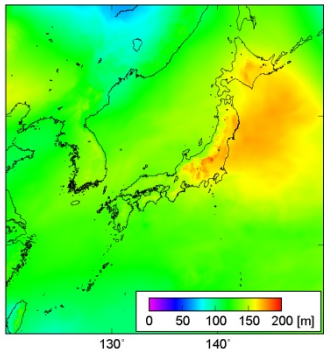
Temperature



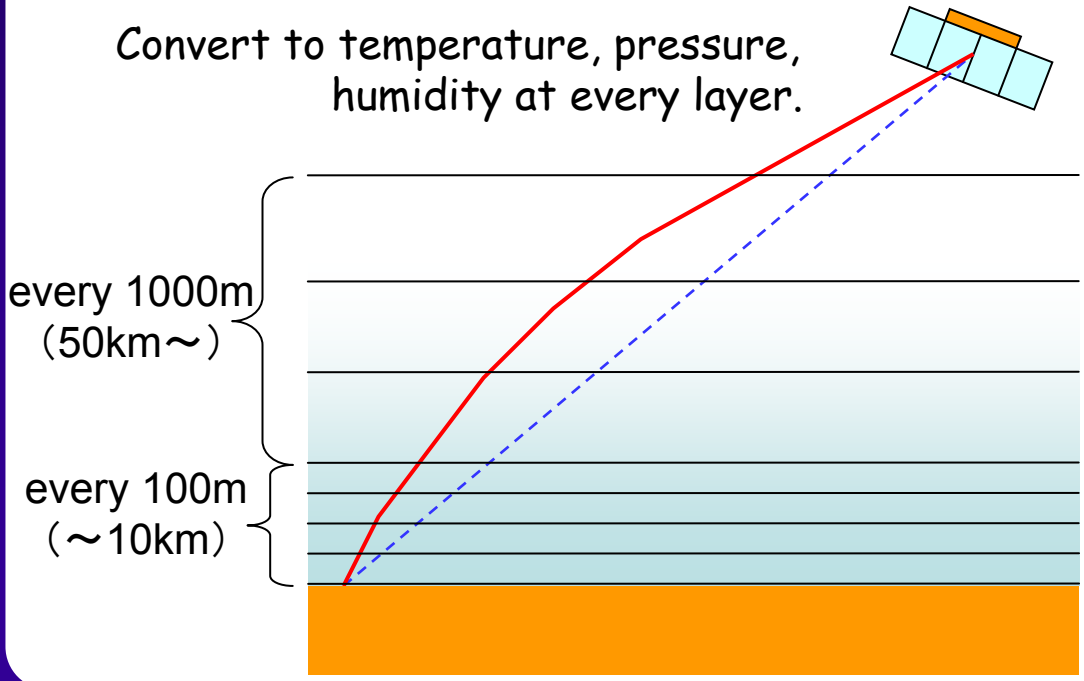
Humidity



Isobaric pressure height



Convert to temperature, pressure, humidity at every layer.



Reflectivity

$$(n-1)\times 10^6$$

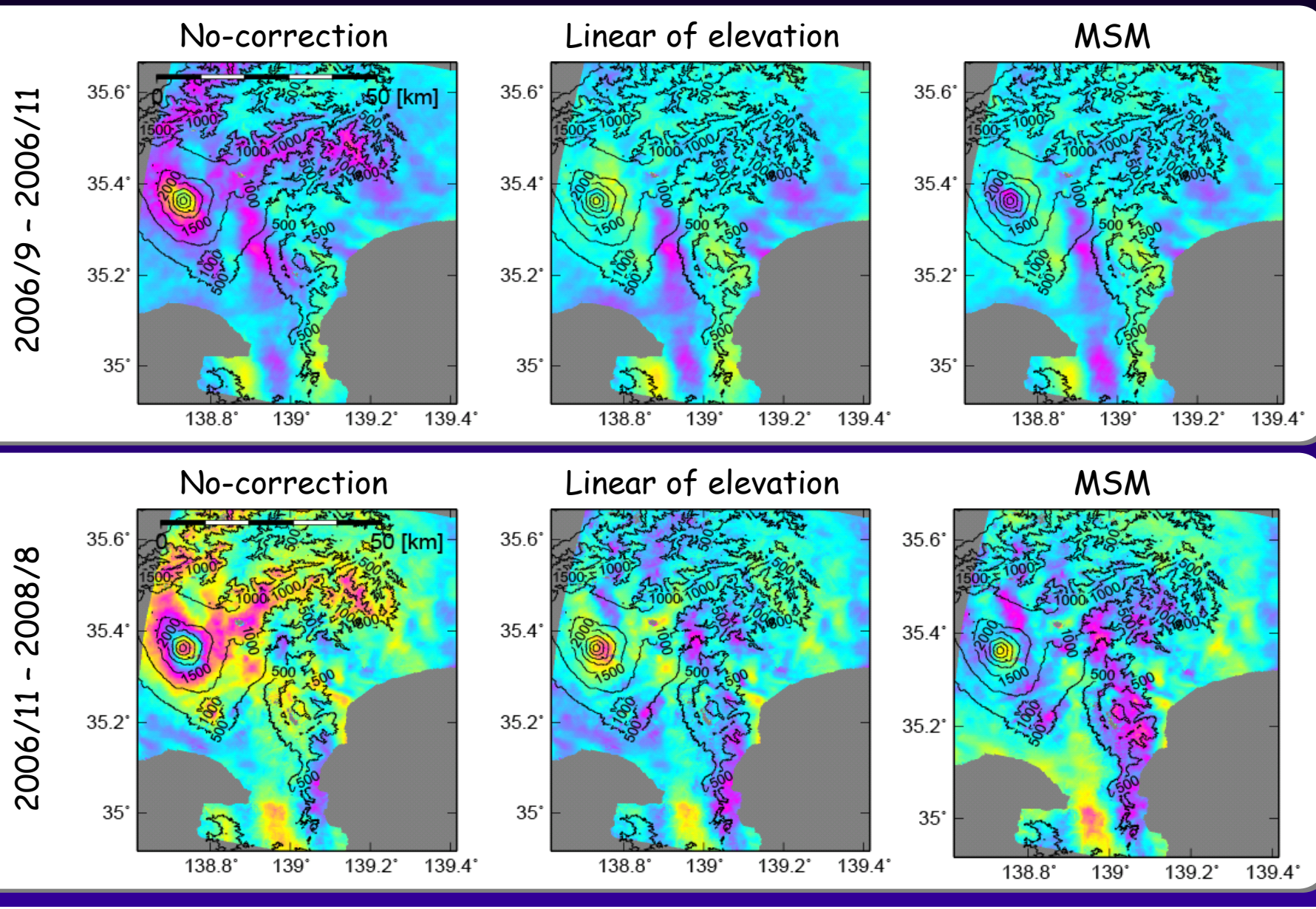
$$= K_1 \frac{P_d}{T} + K_2 \frac{P_v}{T} + K_3 \frac{P_v}{T^2}$$

P_d: partial pressure of dry air
P_v: partial pressure of water vapor
T: temperature

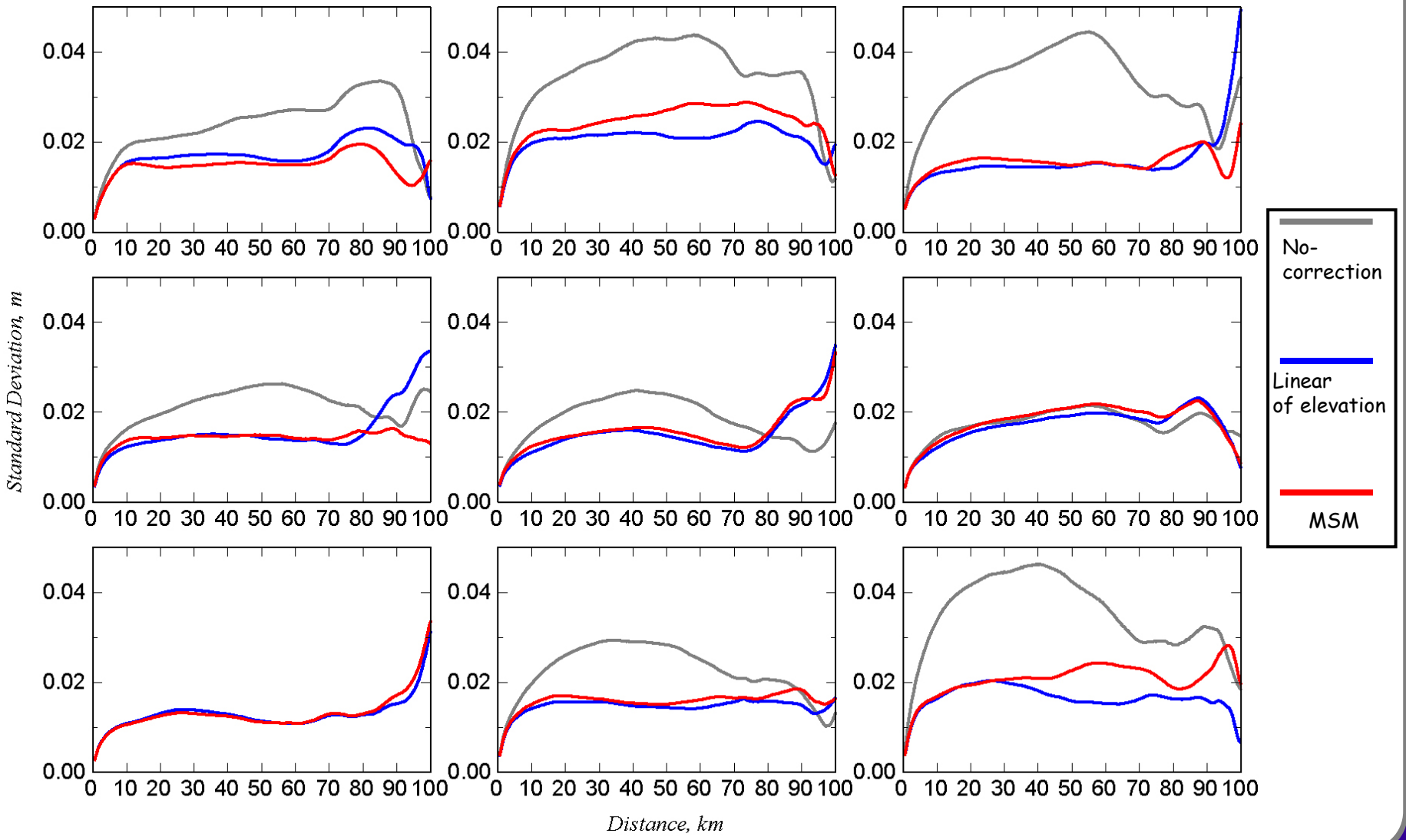
Estimation of radar propagation path by ray-tracing method.

Estimation of delay along propagation path

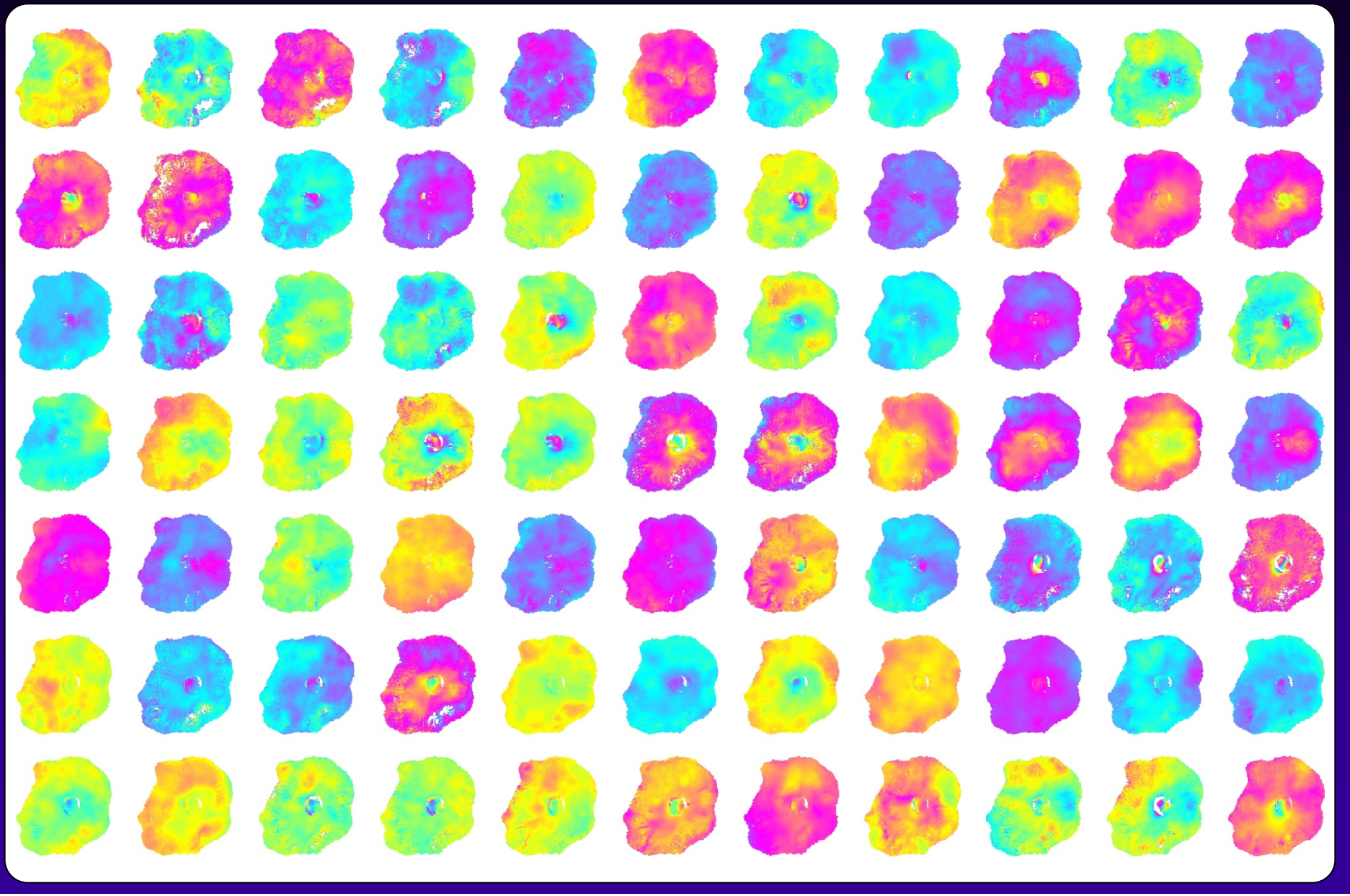
Application in Mt. Fuji



Standard deviation

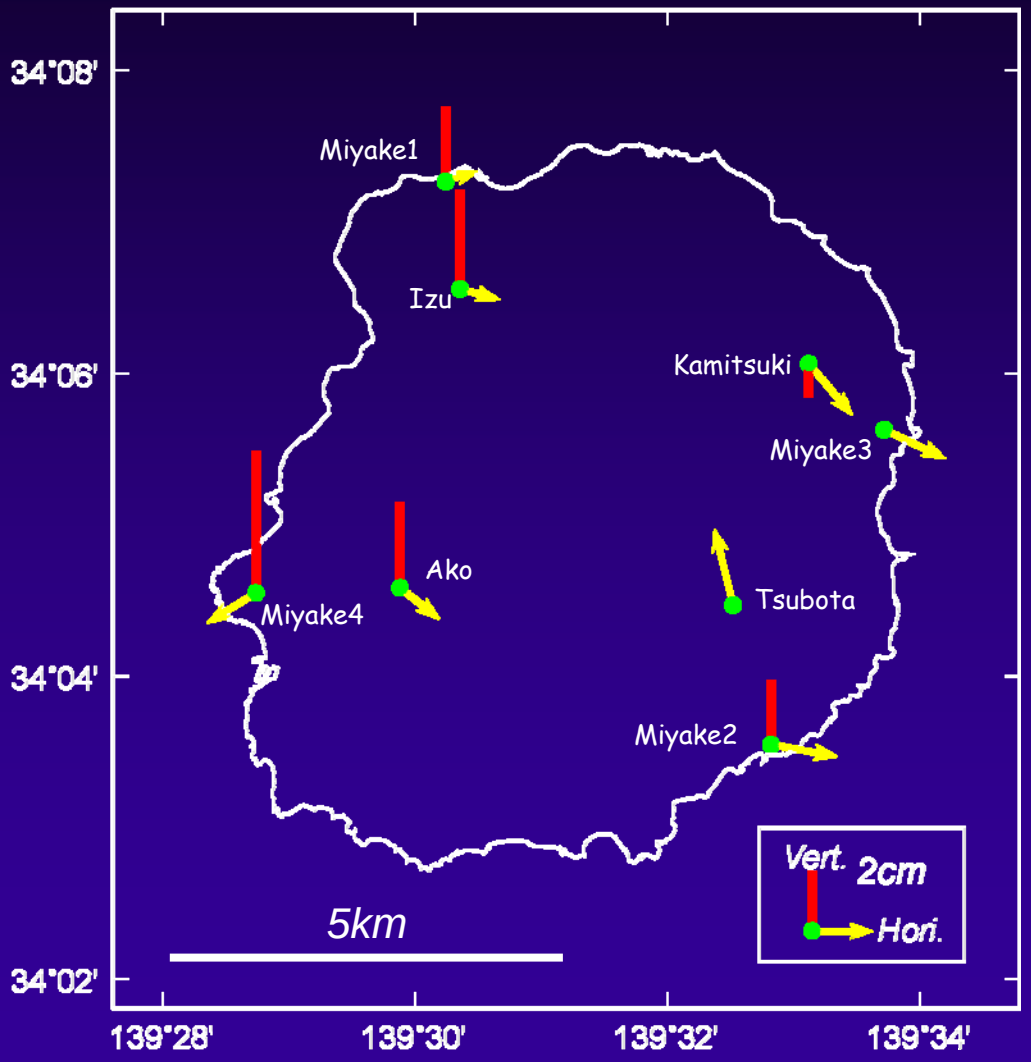


Interferograms subtracted sim. delay



Adjusted to GPS deformation

2006/5/26 - 2009/8/5



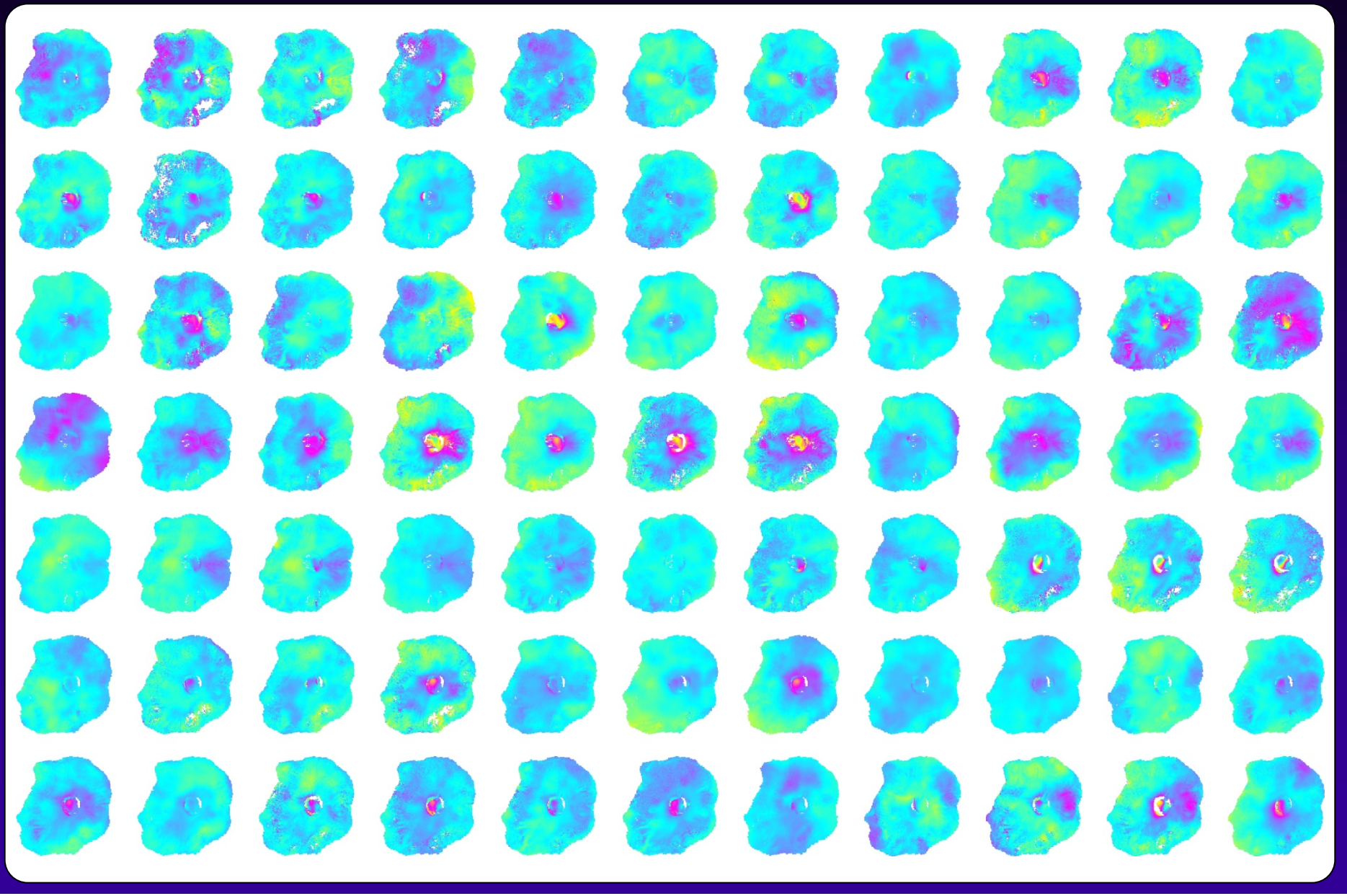
Assume remaining orbital fringe to be uniformly inclined plane.

Estimate its plane, adjusting to GPS result.

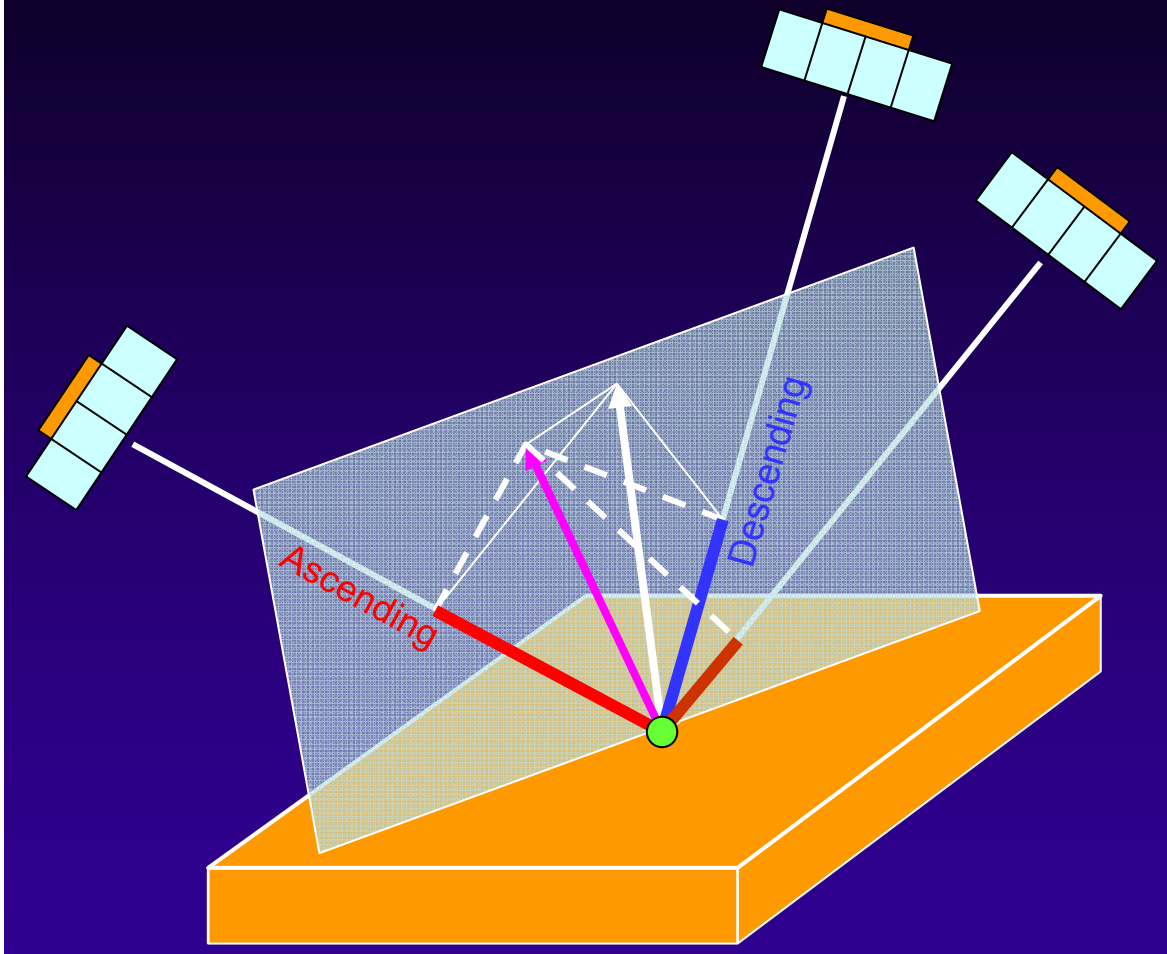
Fixed site of GPS result is Mikurajima.

(20km south-southeast)

Interferograms (adujusted to GPS)



Estimation of 2-D temporal change



Horizontal direction of co-plane is almost east-west (quasi-EW), vertical direction inclines 10 degree from vertical to south (quasi-UD).

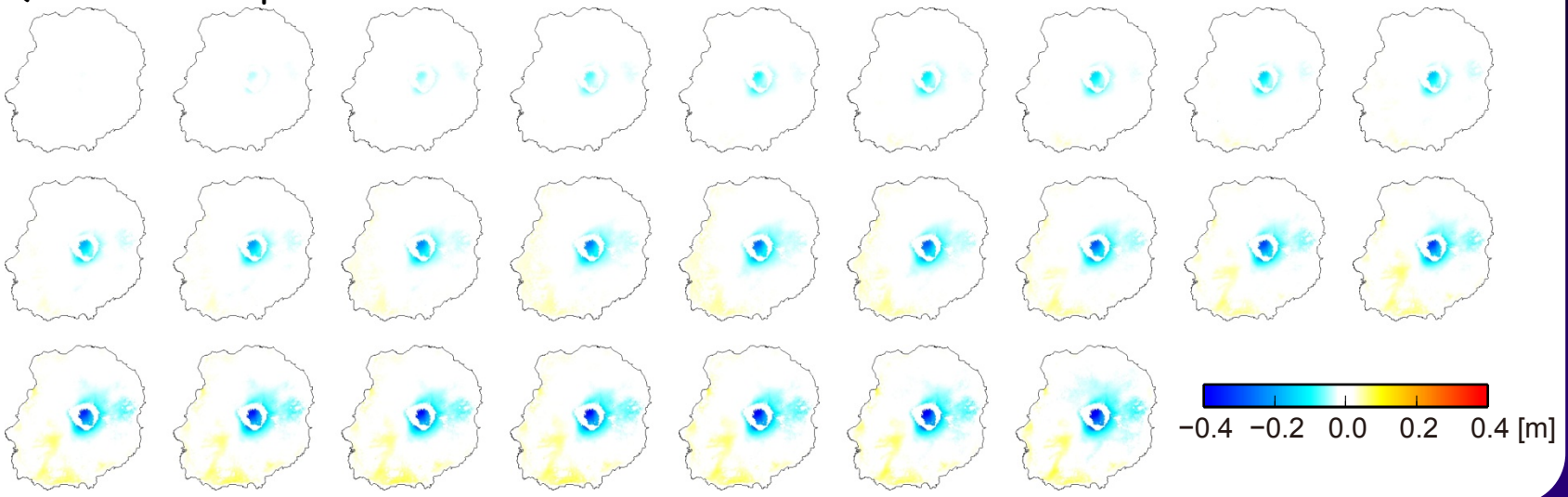
Quasi-UD and quasi-EW components of displacements are estimated from interferograms by least square analysis.

Smoothness constraint is used for noise reduction and for interpolation.

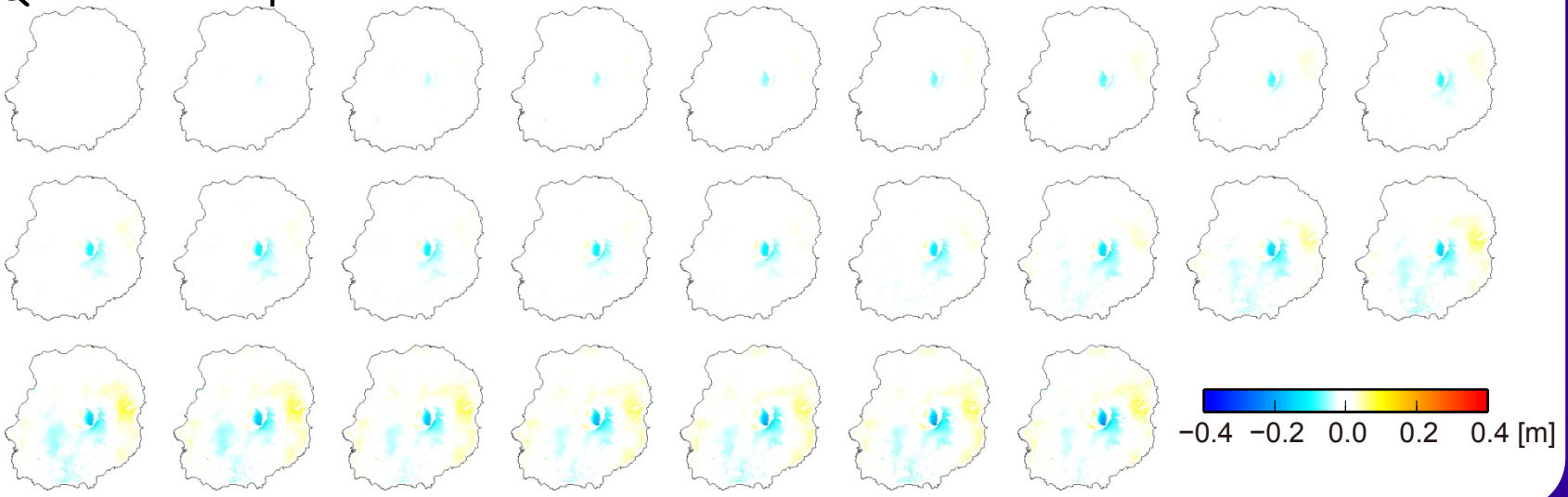
DEM error is estimated simultaneously (large error was not estimated).

Temporal change of 2-D deformation

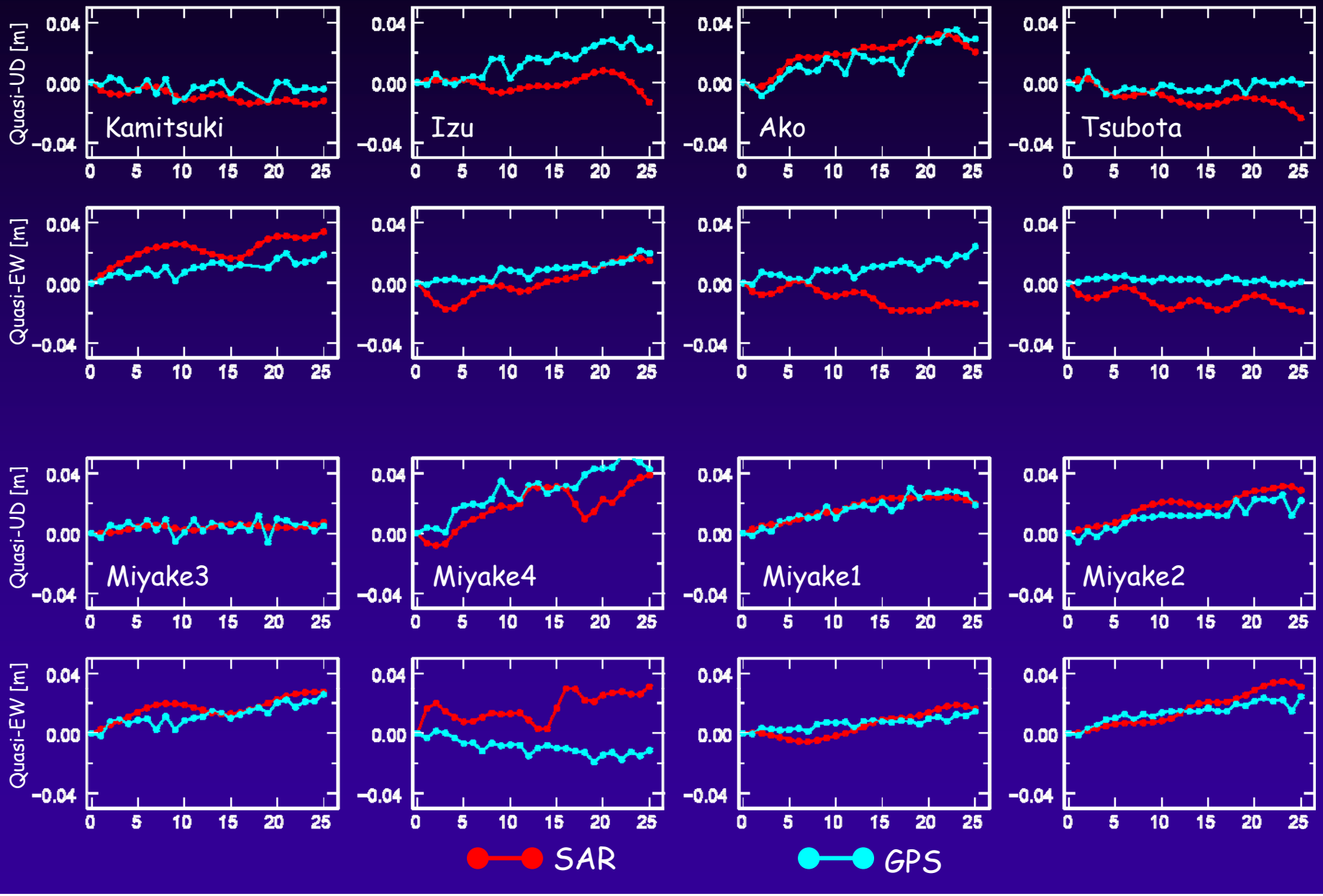
Quasi-UD component



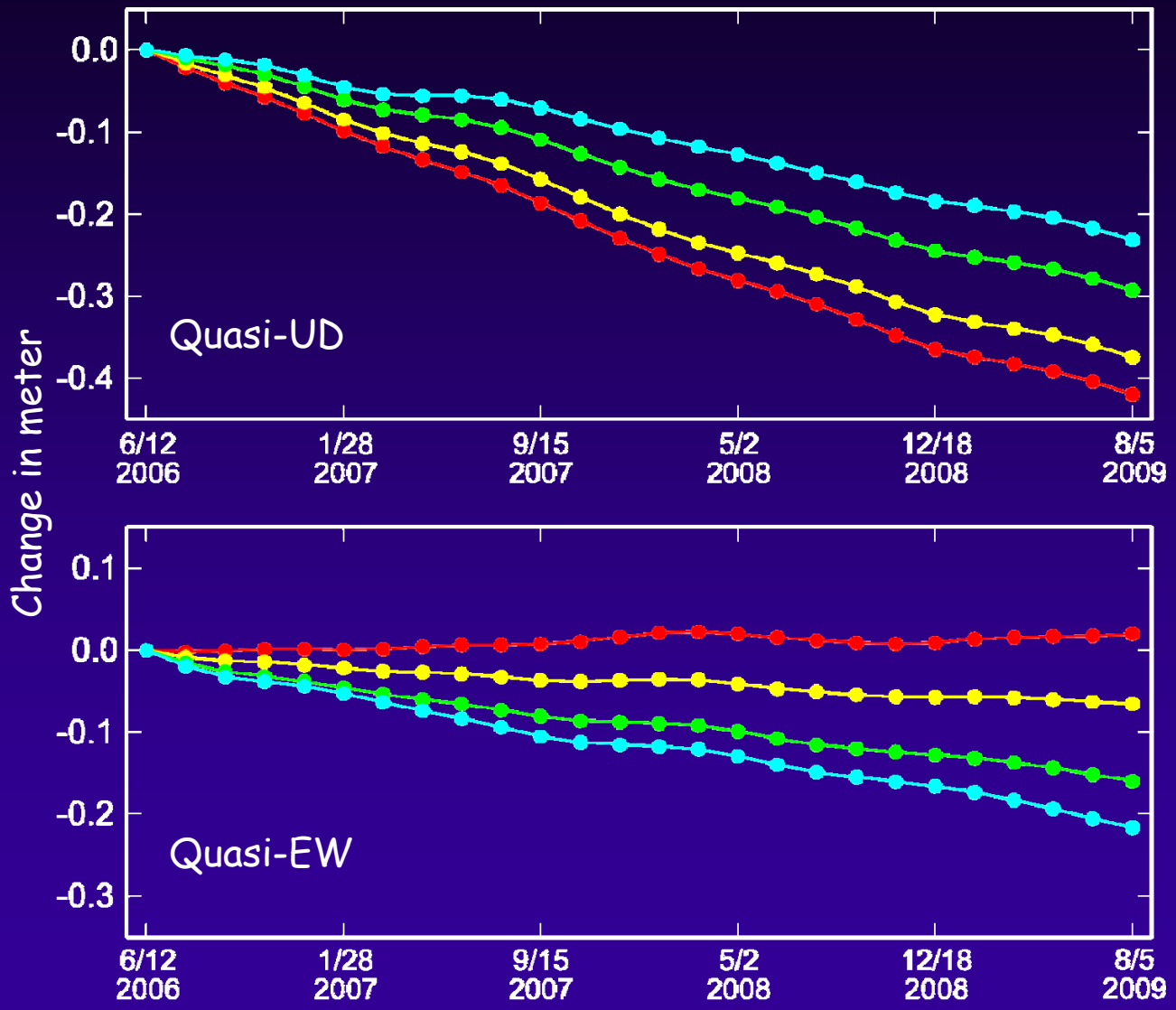
Quasi-EW component

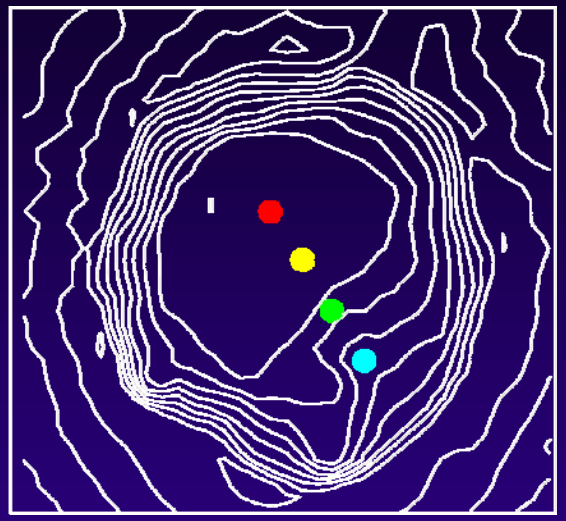


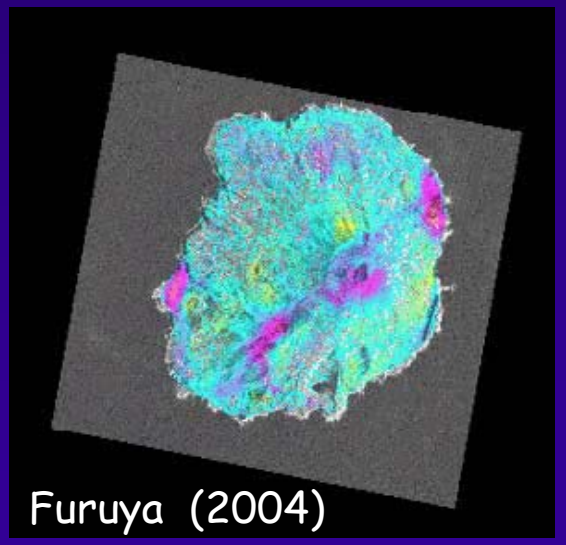
Comparison between SAR and GPS



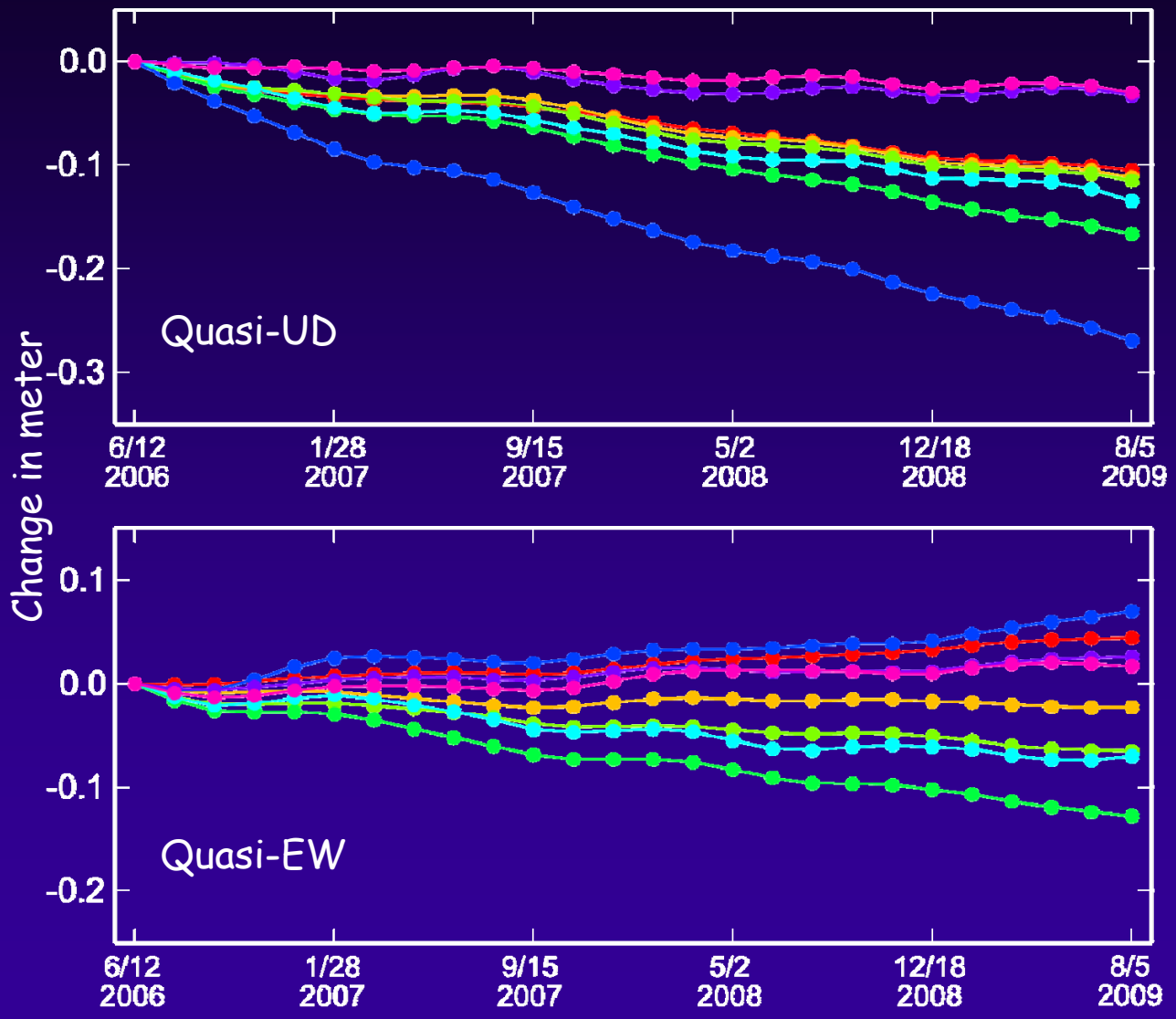
Deformation in crater bottom

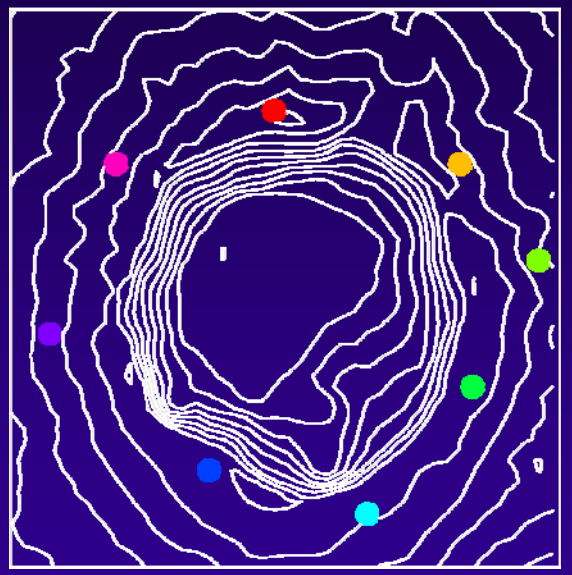




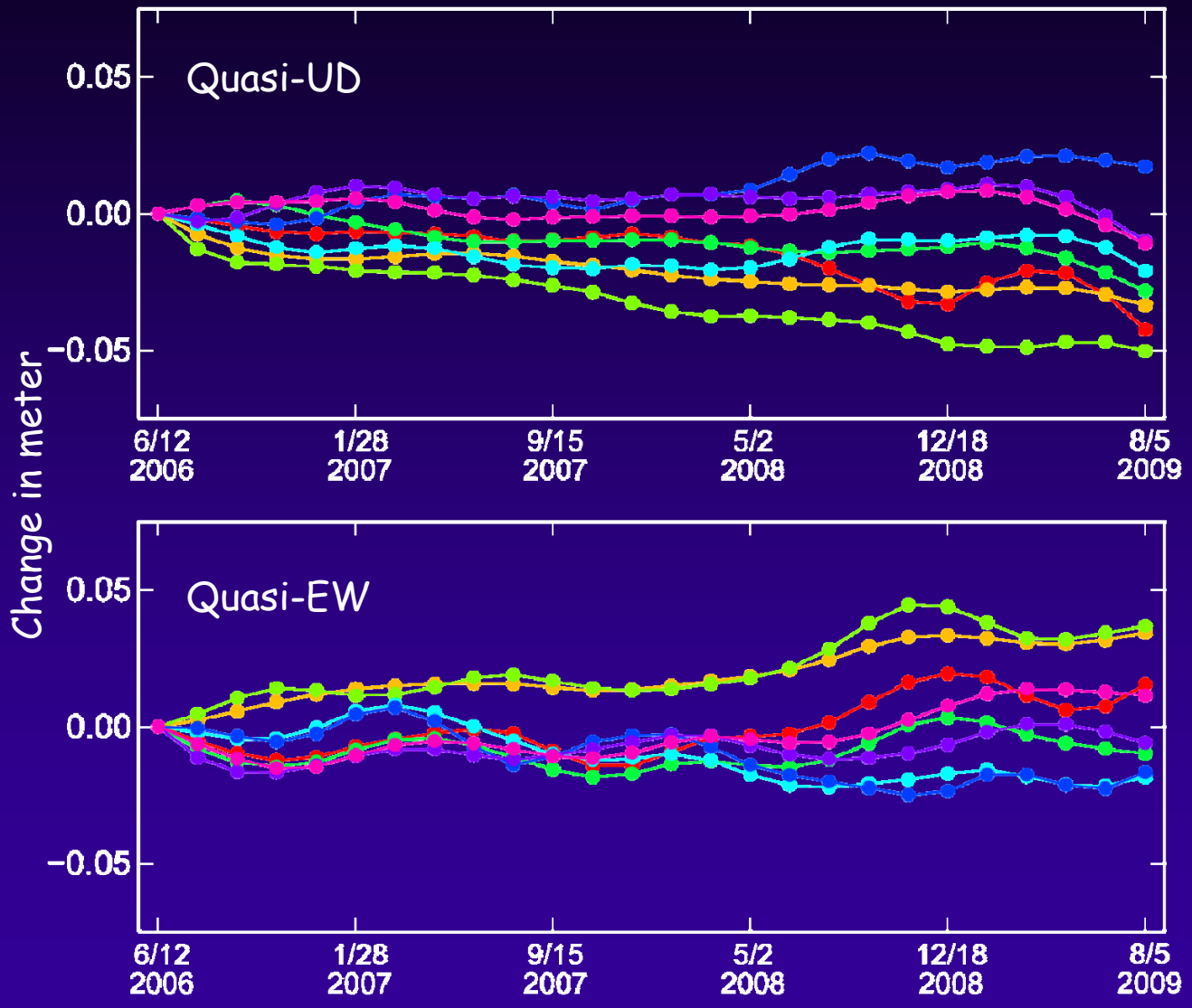


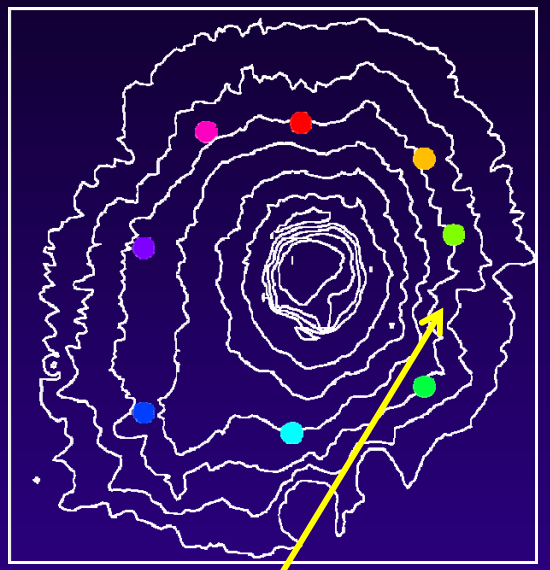
Deformation around crater rim





Deformation in mountainside





Summary

- We attempted to detect precise time-series of deformation by least-square estimation using multi-pass interferograms with smoothness constraint and by atmospheric delay simulation from numerical weather model.
- Noise must be reduced based on the theory of least-square estimation, but ...
- There is much room for improvement.
- Efficient utilization of ALOS and ALOS-2 interferograms.

Acknowledgements

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