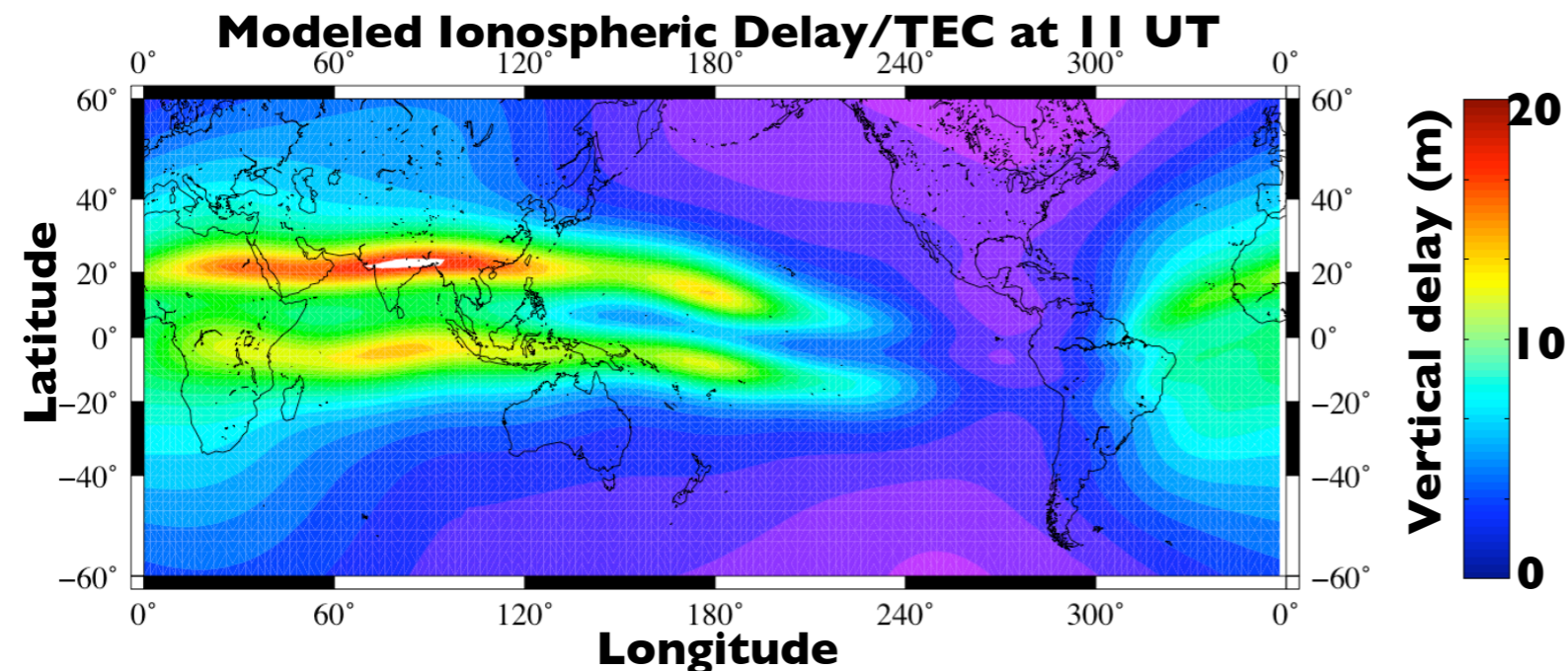
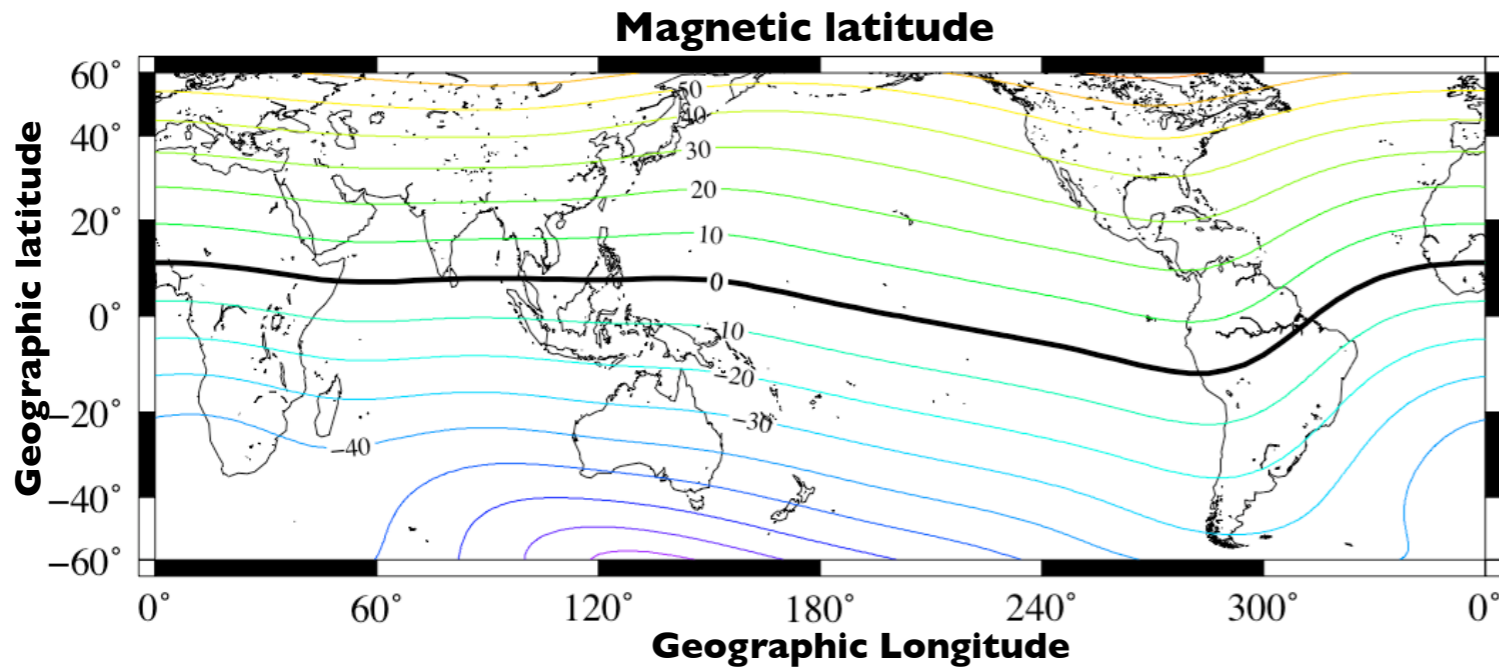


Status of Ionospheric data collection and analysis for GNSS in Japan

Susumu Saito, Takayuki Yoshihara, Seigo Fujita,
Takeyasu Sakai, and Kazuaki Hoshinoo
Electronic Navigation Research Institute, Japan

Geomagnetic/Ionospheric condition

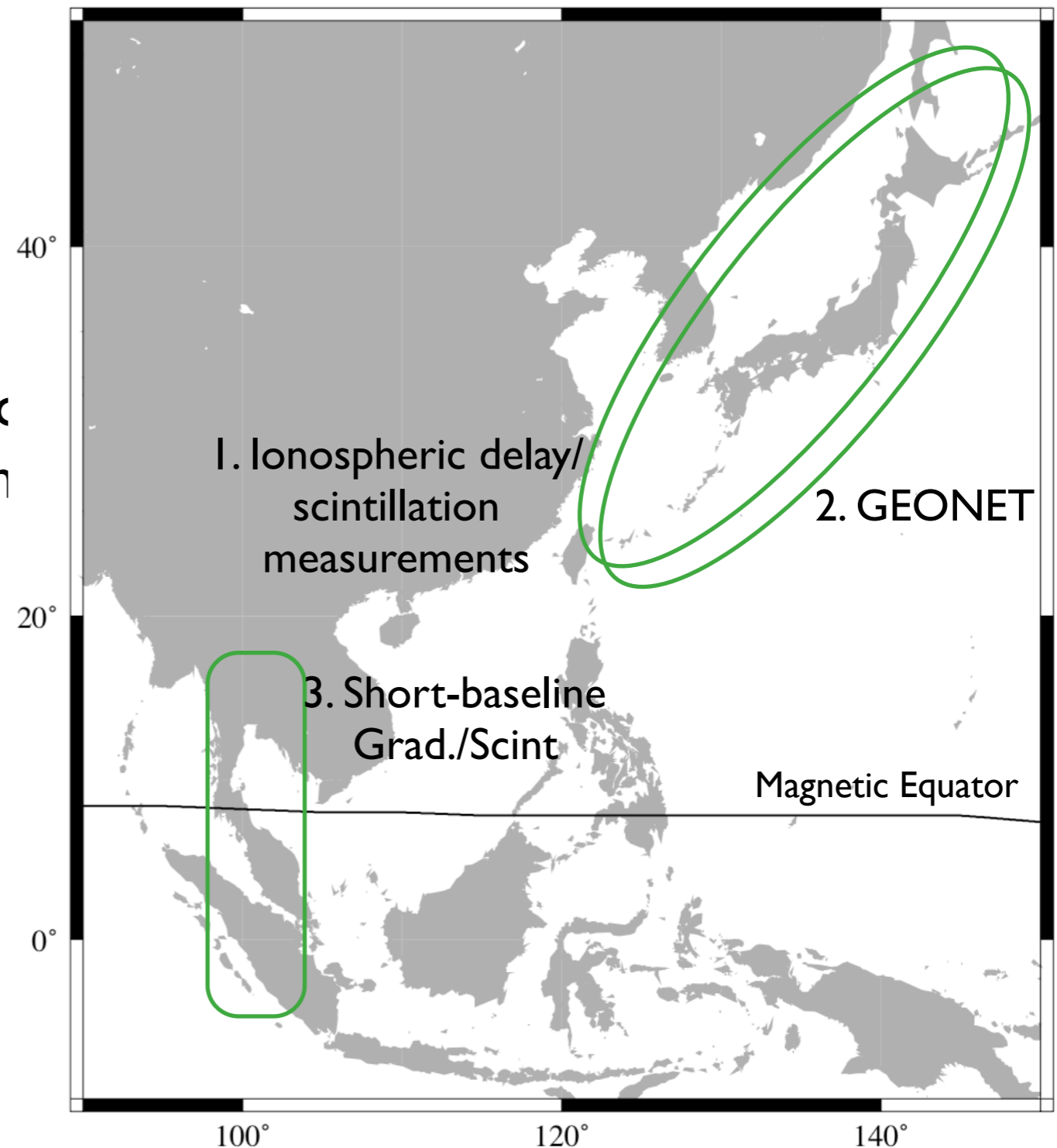


* Most of States in the APAC region is located in the mid- to low magnetic latitude region.

* Both the ionospheric disturbances in mid- and low magnetic latitude need considered.

ENRI ENRI's activities in ionospheric observation

1. Ionospheric delay/scintillation monitoring in Japan including a short baseline measurement system
2. 1 Hz realtime data collection from 200 GPS receivers selected from 1200+ GEONET stations operated by Geospatial Information Authority of Japan (former Geographical Survey Institute).
3. Short baseline ionosphere gradient/scintillation system in Thailand and Indonesia.

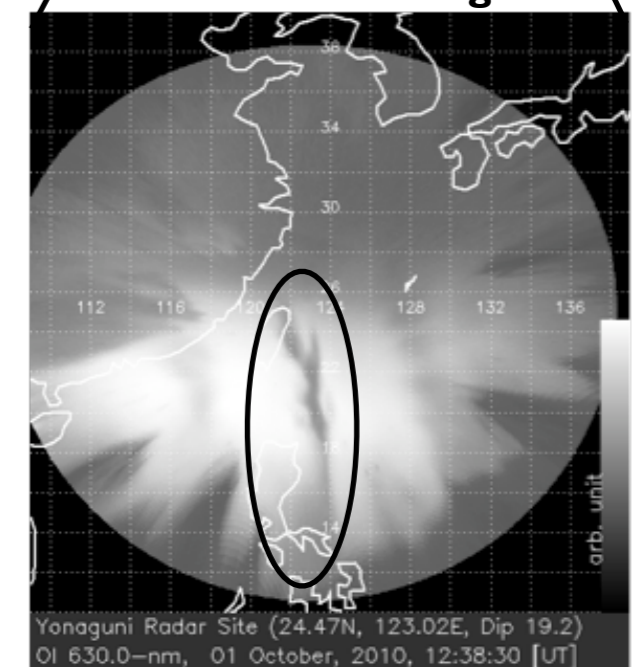


Ionospheric delay/scintillation network over Japan

- * Five stations are operated by ENRI from Wakkanai (North) to Yonaguni (Southwest).
- * All stations are equipped with scintillation receivers (GSV-4000/4004B) and dual-frequency receivers
- * Ishigaki is a network of five stations with short separation (0.4-1.6 km)
 - precise gradient and drift velocity measurements
- * Yonaguni is equipped with an all-sky airglow imager to support ionospheric delay/scintillation measurements.
 - 2-D images of plasma bubbles

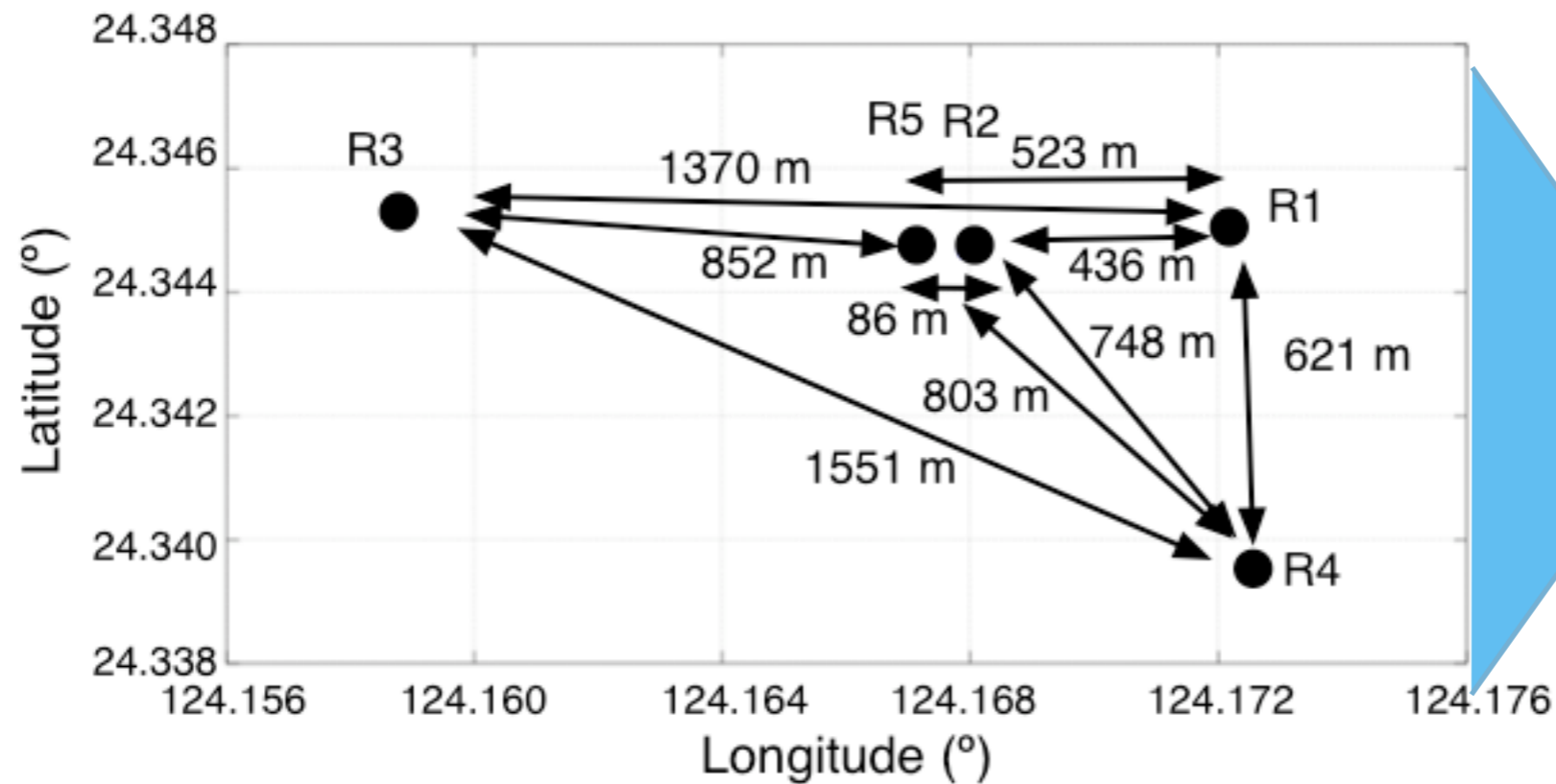


Plasma bubble image obtained at Yonaguni





Short baseline measurements in Ishigaki



- * Ishigaki Island in Southwest Japan (19.6° magnetic latitude) since 2008
- * Five stations with distances 0.4-1.6 km
- * Equipments
 - Receiver: NovAtel Euro-3, 2 Hz sampling and GSV-4004B
 - Antenna: NovAtel GPS-702-GG
- * Being operated since 2007.

Receiver system

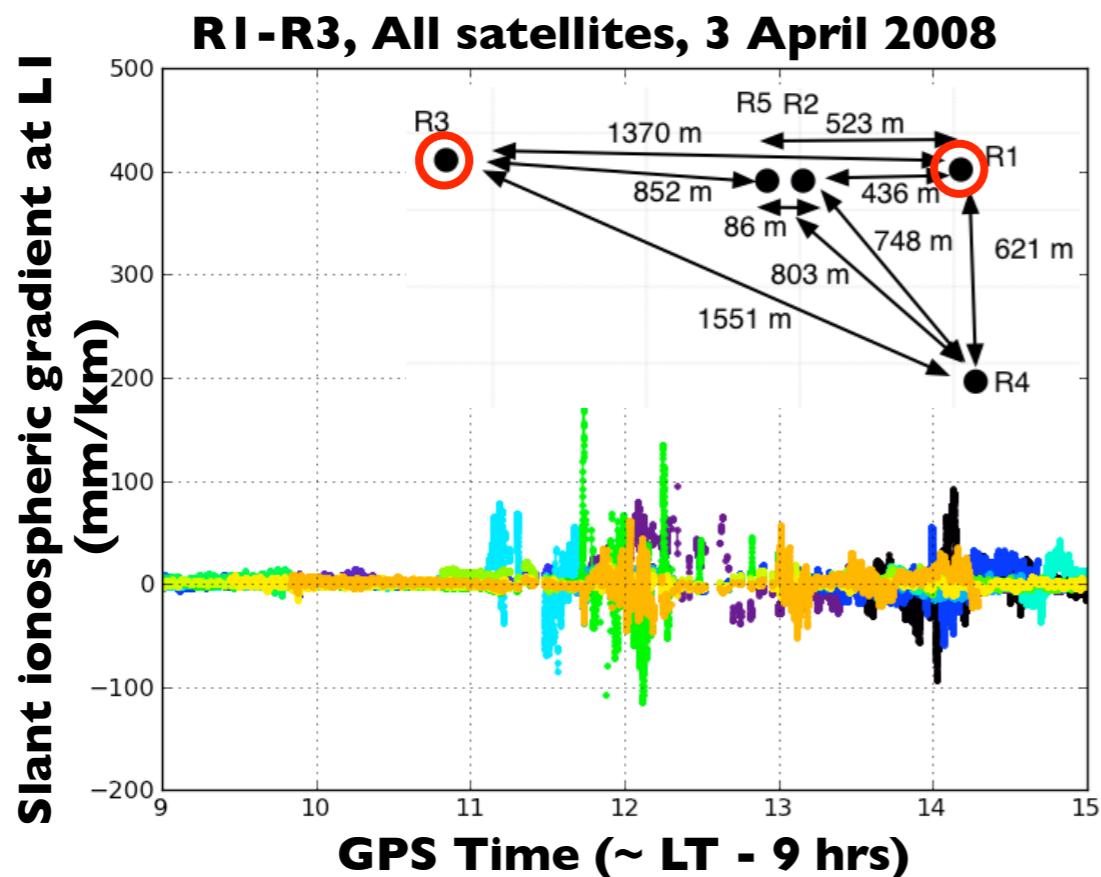


Antenna



Precise ionospheric gradient estimation

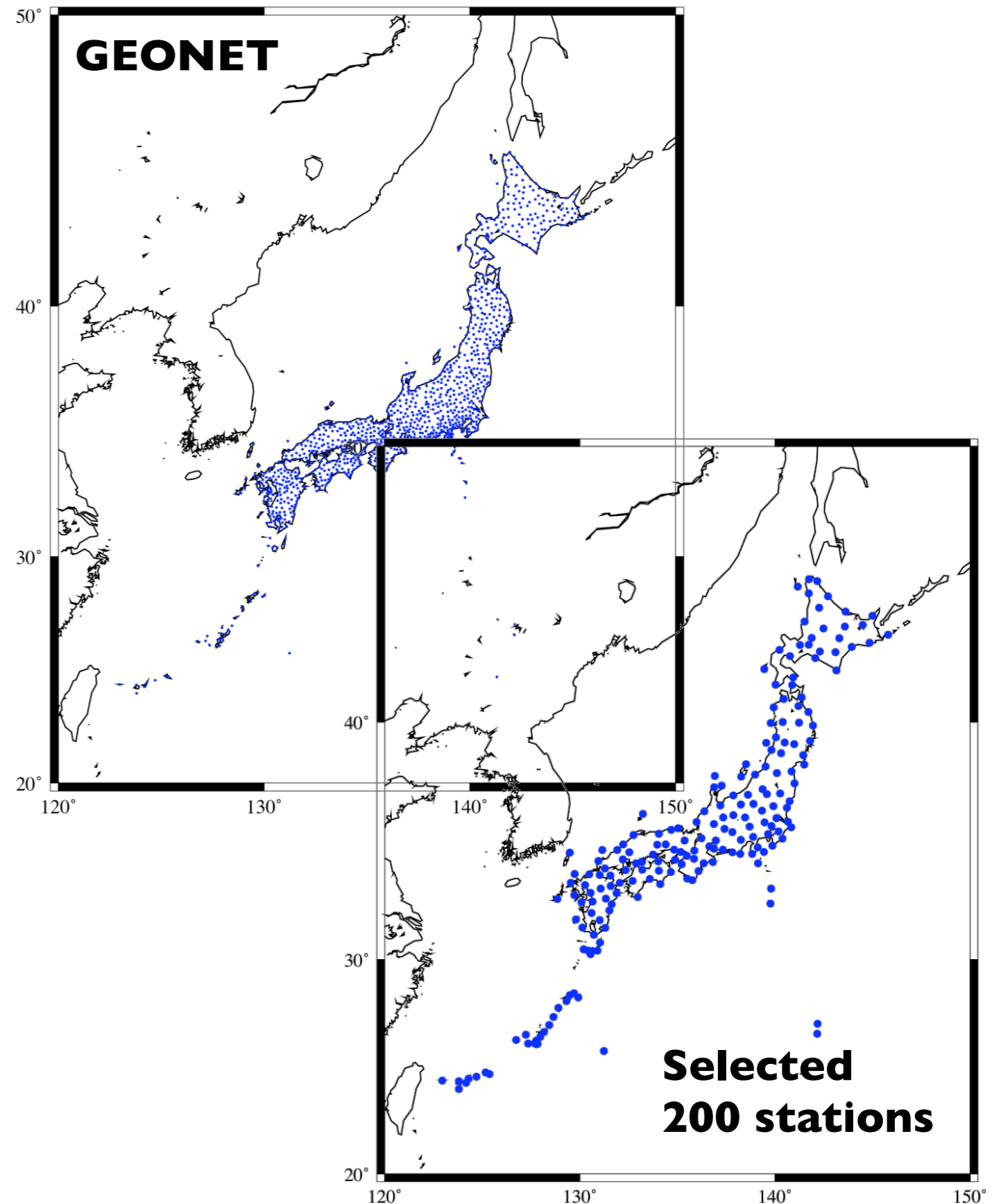
- * Fujita et al., J.Aero.Astro.Avi., 2011
- Estimates ionospheric delay difference between two receivers
- Based on single frequency carrier-phase measurements aided by code measurements
- Only L1 signal is needed: more robust in disturbed ionospheric conditions
- Free from inter-frequency bias problem



- * Ionospheric gradients can be estimated even in very disturbed conditions.
- * Very sensitivity permits accurate nominal gradient measurements.

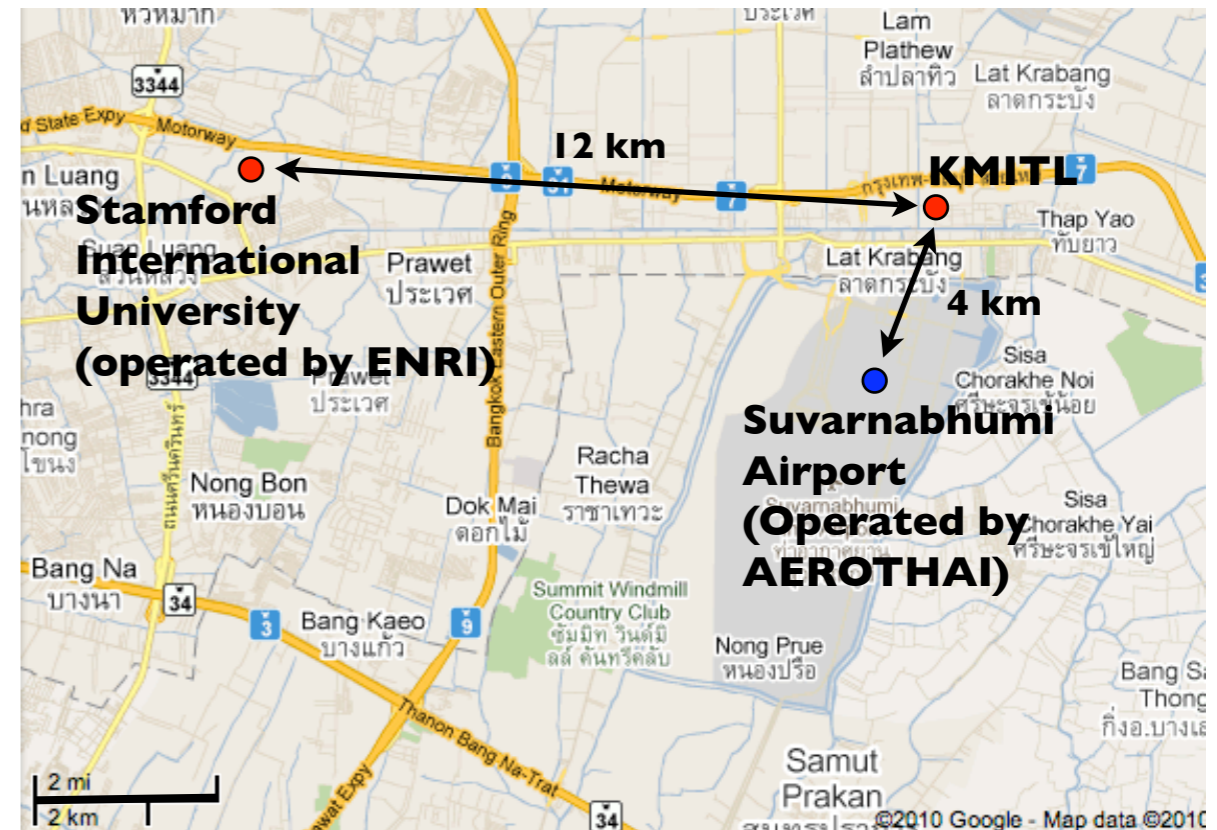
GEONET 1 Hz data collection

- * Realtime data collection from GPS Earth Observation Network (GEONET) at 1 Hz data rate.
- * GEONET data were used to determine σ_{iono} value used in GBAS prototype [Yoshihara et al., ION GNSS 2010] and the ionospheric threat model used for ENRI's CAT-I GBAS prototype.



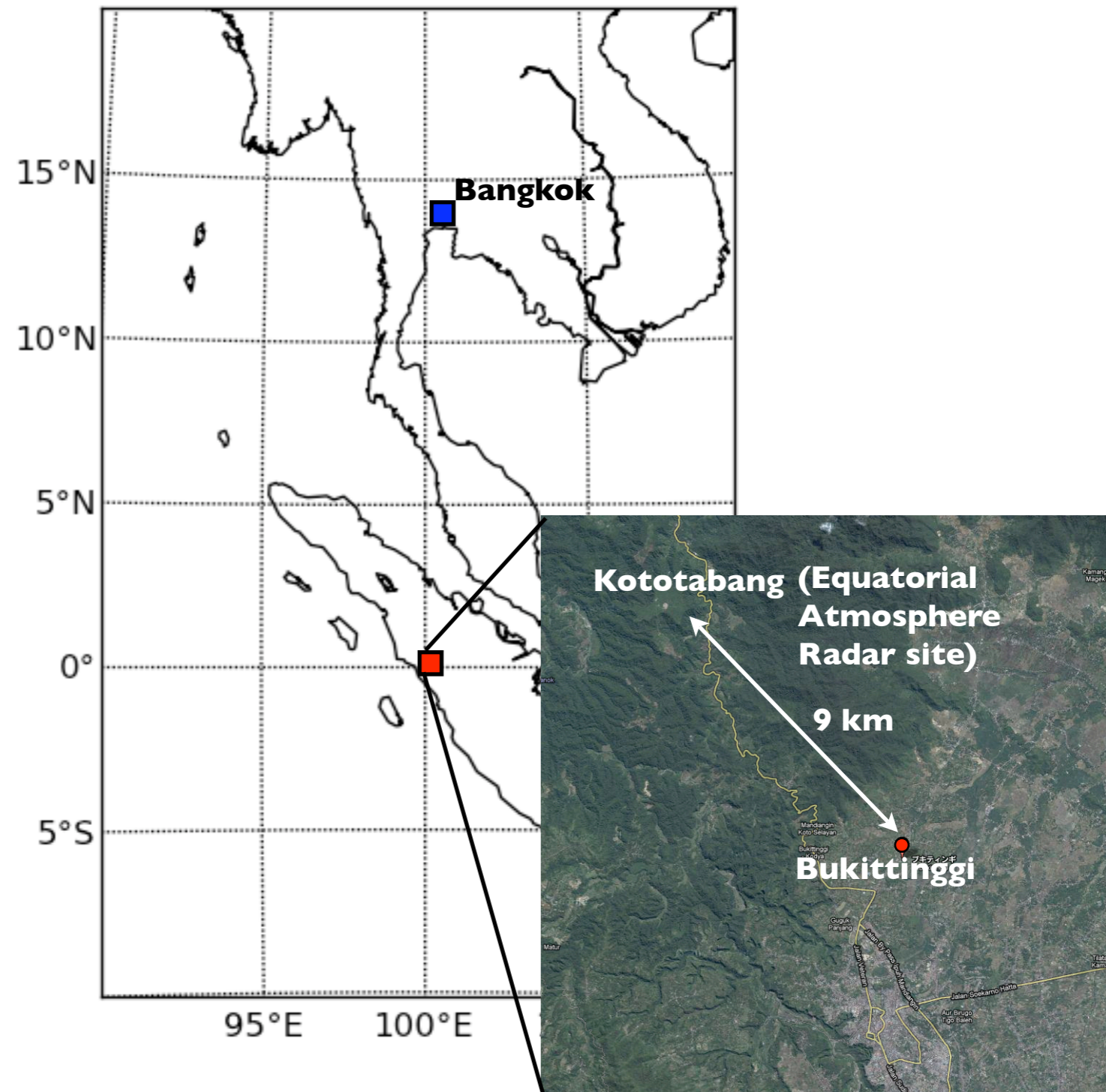
Short baseline ionosphere gradient/ scintillation system in Thailand

- * Short baseline ionosphere gradient measurements near Bangkok airport (KMITL-Stamford pair).
 - Joint project of ENRI and King Mongkut's Institute of Technology Ladkrabang (KMITL)
 - In operation since July 2011
- * AEROTHAI operates a GNSS receiver at the airport
 - KMITL, AEROTHAI, and ENRI collaborate for data collection, analysis, and sharing.



Short baseline ionosphere gradient/ scintillation system in Indonesia

- * A plan to install a pair of GNSS receivers near Kototabang, Indonesia.
 - Joint project with Nagoya University
 - Planned to start in 2012
- * A number of instruments for ionospheric observations including Equatorial Atmosphere Radar have been operated at Kototabang.
- * In the same meridian as the Bangkok system
 - latitudinal extent





Summary

- * ENRI has been collecting data from a number of stations in Japan and Southeast Asia.
 - Ionospheric delay/scintillation monitoring in Japan including a short baseline measurement system
 - 1 Hz realtime data collection from 200 GPS receivers selected from 1200+ GEONET stations
 - Short baseline ionosphere gradient/scintillation system in Thailand and Indonesia.
- * Precise ionospheric delay gradient estimation method has been developed in ENRI.
 - Very powerful tool to study low latitude ionospheric disturbance
- * ENRI is happy to share our experience for the ionospheric data collection, analysis, and sharing.