GNSS and Ionospheric Data Products for Disaster Prevention and Aviation in Magnetic Low-Latitude Regions Phase II

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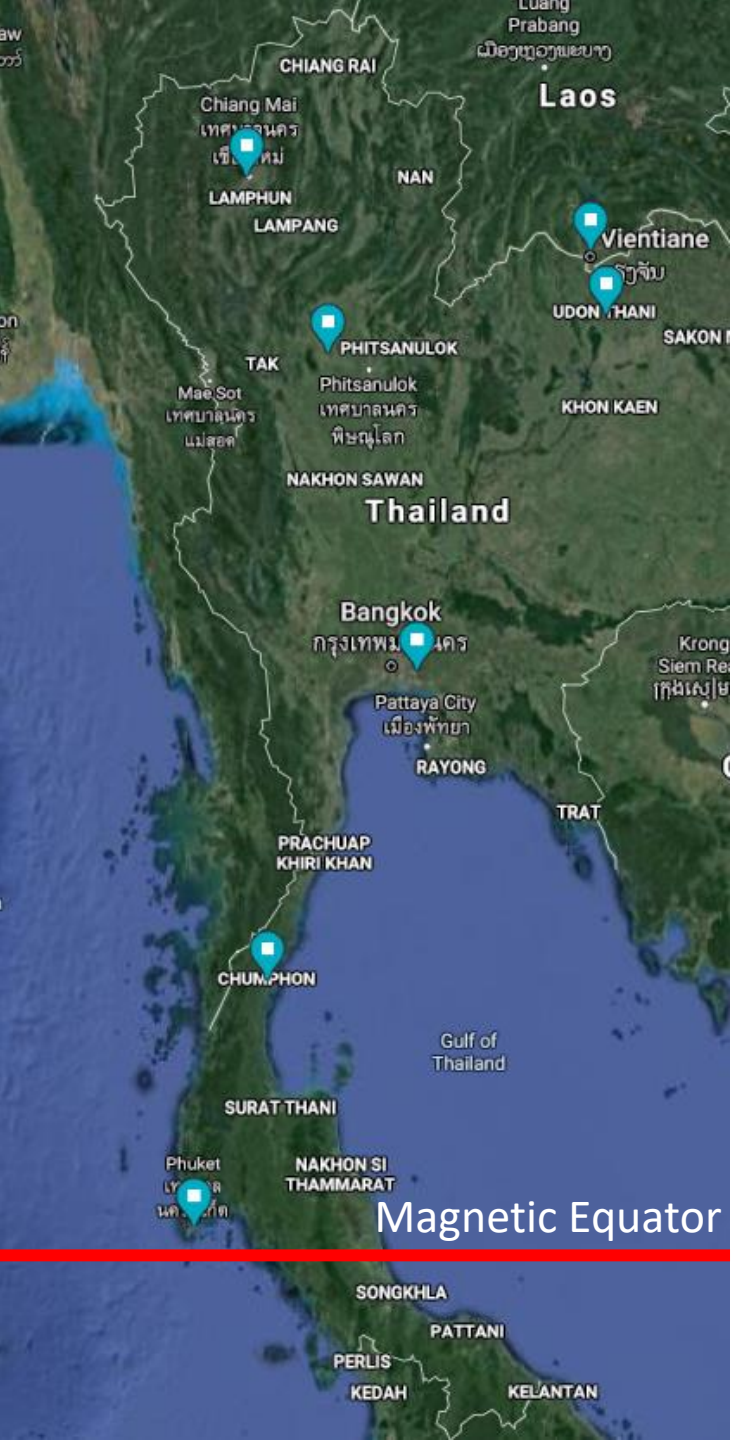


Background

- The ionosphere in the magnetic low-latitude and the magnetic equator regions is observed to be highly unstable due to unique disturbance events, resulting degradation in performances of communication and navigation.
- Ionospheric irregularities need to be analyzed or forecasted based on the collected data including GNSS and other related data from the station networks in the regions.
- Based on them, data products and predictions models can be implemented for positioning, navigation, communications, aviation, especially in this magnetic low-latitude region.
- Phase I of ASEAN IVO project (2018-2020) was successfully accomplished to expend GNSS and ionospheric monitoring system and to implement data products and prediction models for disaster prevention and aviation in magnetic low-latitude regions.

Targets of this Project

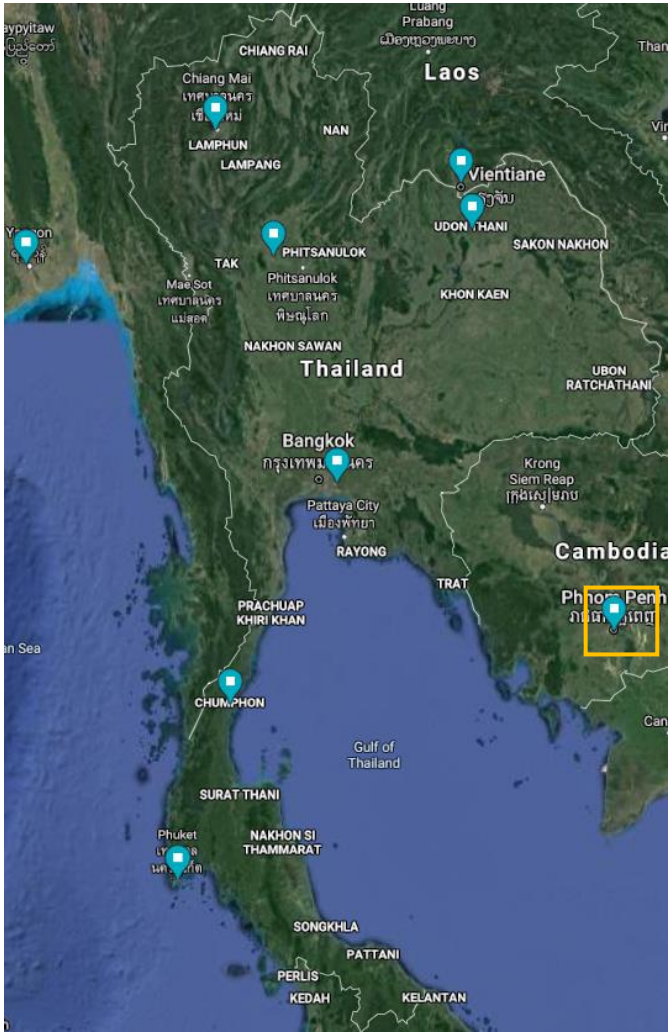
To expand GNSS and ionospheric monitoring system into Cambodia

To upgrade data products and disturbance prediction models for disaster prevention and aviation developed in Phase I

To develop a low-cost real-time kinematics (RTK) receiver system and test its performance during Plasma Bubble using the collected data from the newly installed GNSS receivers in Phase I

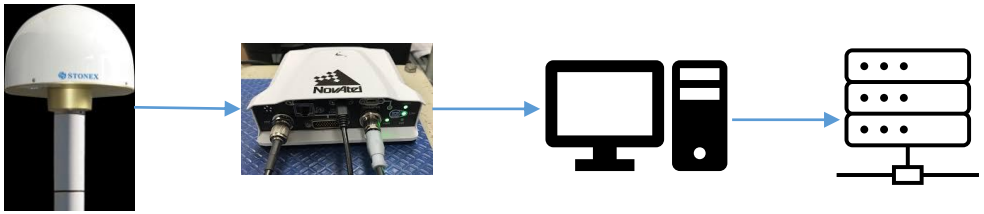
To establish a GNSS and SW Excellence Center at KMITL and conduct capacity building for disseminating the knowledge on GNSS and Ionosphere

Expanding GNSS and Ionospheric Monitoring System into Cambodia



Methods

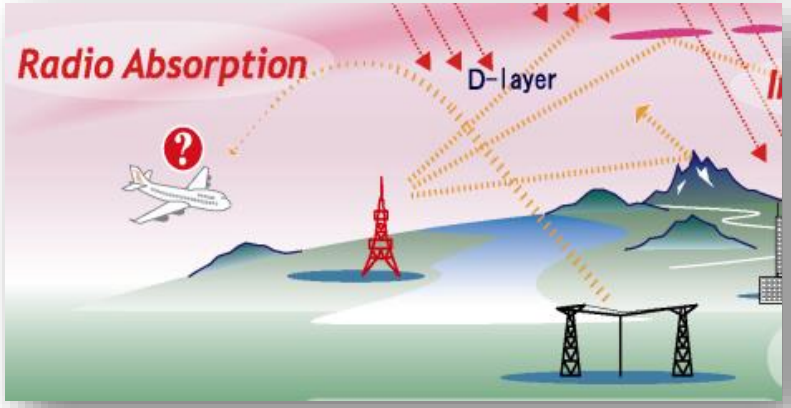
- ✓ Install additional new dual-frequency GNSS receiver station at Phnom Penh, Cambodia.
- ✓ Collect the GNSS data from the stations in the network in daily or near real-time and then share to them to NICT and other partnered institutes for academic research.

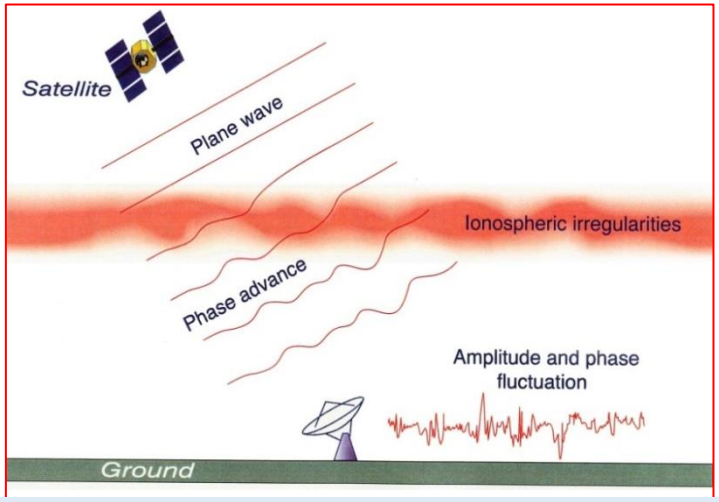


In Phase I, two GNSS receiver stations have been installed at Yangon, Myanmar and Vientiane, Laos.

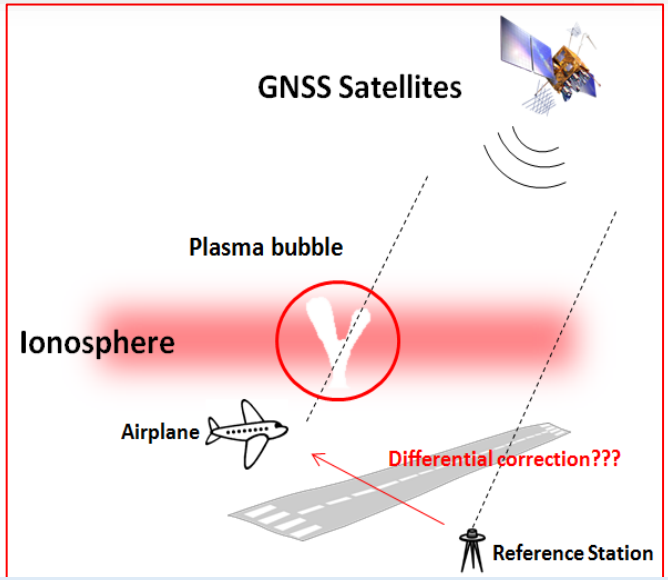
Iono Disturbance Effects & Monitoring

HF Communications in aircrafts, ships (commercial, military)
➔ Ionosonde, GNSS





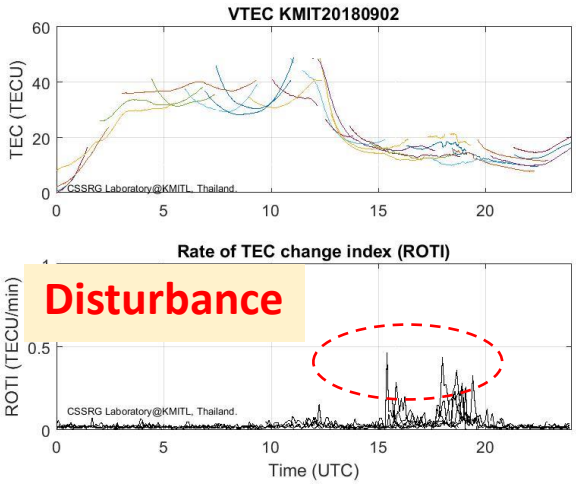
Scintillations, Loss-of-lock in GNSS signals
➔ GNSS, Beacon

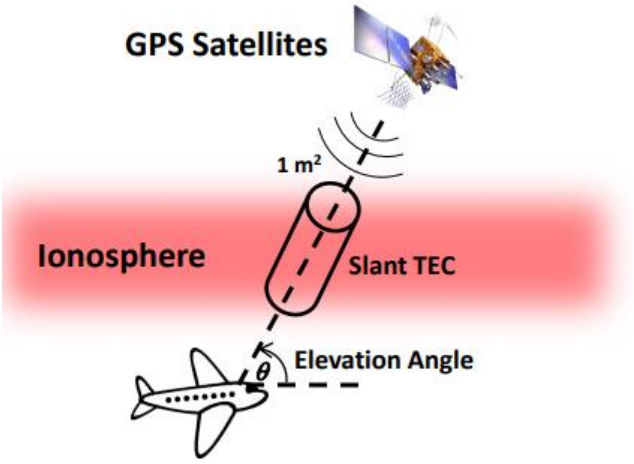


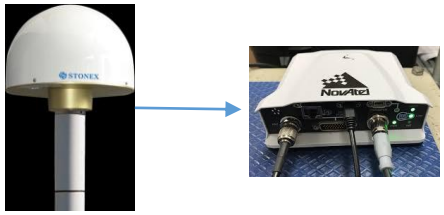
Navigation, Positioning
➔ GNSS, VHF Radar

Ionospheric Observation using GNSS signals

- The real-time total electron content (TEC) can provide accurate ionospheric delay for the positioning and navigation systems.
- The rate Of TEC change Index (ROTI) can help in observing and detecting the ionospheric disturbances.
- The TEC is the amount of free electrons along the path of the electromagnetic wave between each satellite and receiver and can be calculated with the GNSS data from the receiver stations.







GNSS receiver stations

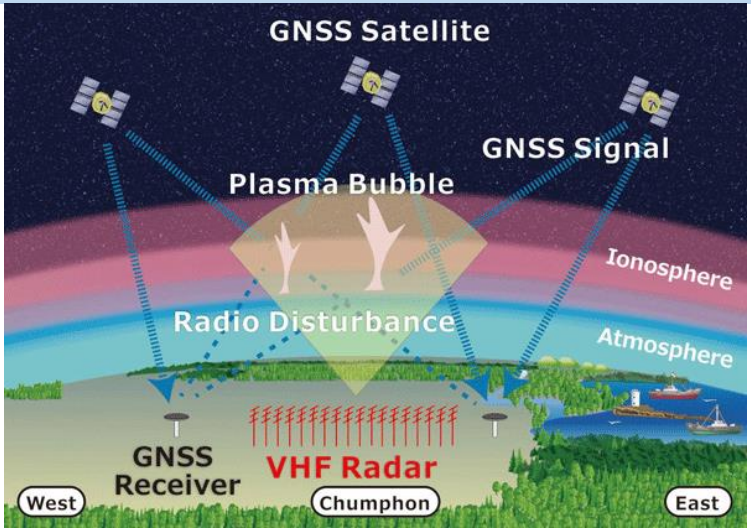
Ionospheric Observation using Ionosonde

- The spread F events are used to indicate the bottom-side ionospheric disturbance.
- They can be observed from Ionogram record generated by Chumphon Ionosonde station.
- They can be predicted and analyzed using ROTI, Virtual height h'Fand other parameters.
- The critical frequency of the F2 layer (foF2), Virtual height (h'F), and maximum usable frequency (MUF) which are also important for communications can be scaled from Ionogram.

Source: http://seg-web.nict.go.jp/sealion/

Ionospheric Observation using VHF Radar

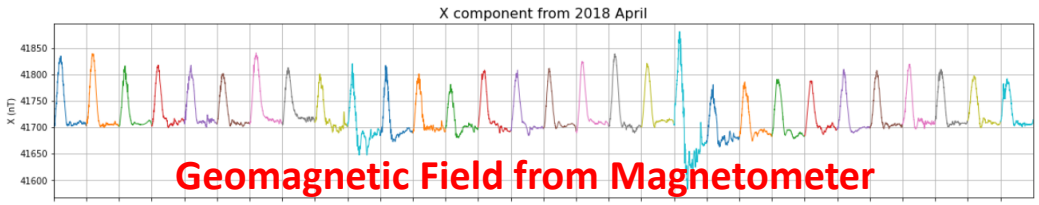
- Plasma bubbles phenomenon is one of the intense ionospheric disturbances.
- The newly installed VHF radar station at Chumphon by NICT is advantageous for the investigation of 'fresh' bubbles right at the magnetic equator location.
- The study of direction of plasma bubbles at different altitudes can help in the ionospheric disturbances in mid-latitude regions.

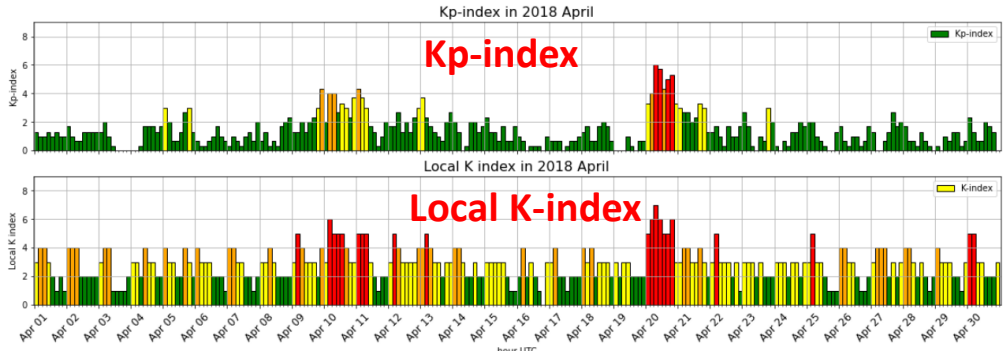


https://www.nict.go.jp/en/press/2020/01/16-1.html

Local K-index from Phuket Magnetometer

- Local K-index, also known as Station K-index is one of the widely used geomagnetic indices and it indicates the activity of earth's magnetic field or geomagnetic field tied to specific geographic locations.
- Since the dynamics of geomagnetic field in low latitudes and magnetic equator regions differs significantly from other region, the local K-index information can be helpful in forecasting Space Weather and the disturbances in GNSS systems and radio communications.

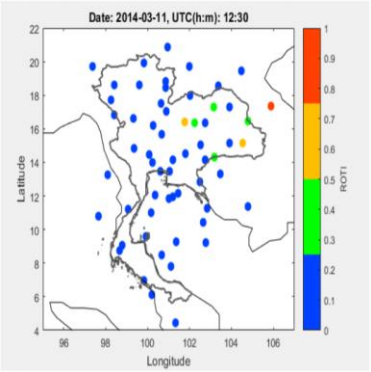




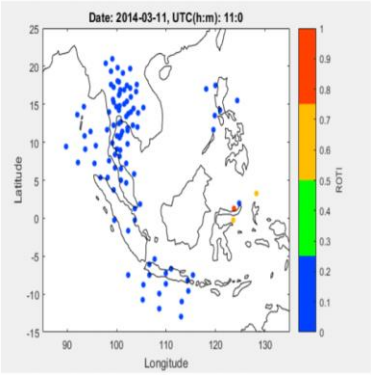
Upgrading Data Products and Prediction Models for Disaster Prevention and Aviation

Methods

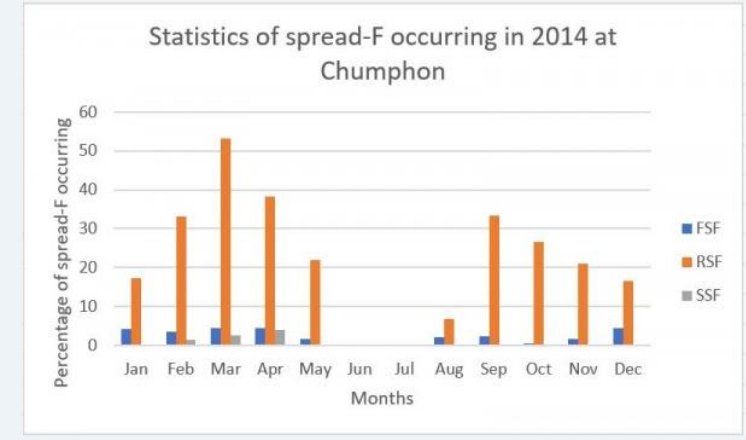
- ✓ Upgrade 2-D ROTI maps, near real-time TEC and ROTI maps for communication and aviation applications integrating the collected from the newly installed station.
- ✓ Improve the ionospheric data products and disturbance prediction model developed in Phase I with the help of AI and Machine Learning algorithms from ionosonde system at Chumphon station.
- ✓ Develop a near real-time system to generate local K-index using the geomagnetic field data from the magnetometer installed in Phuket.



Thailand



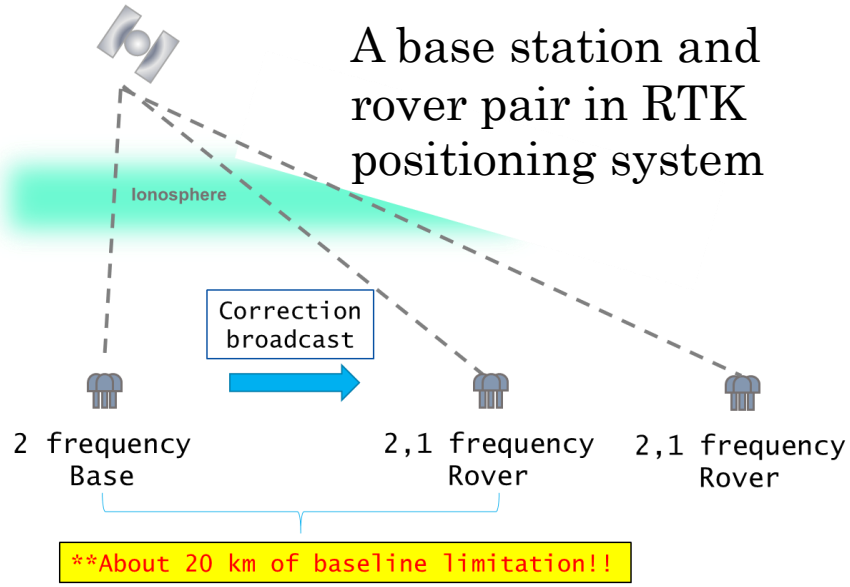
ASEAN



http://iono-gnss.kmitl.ac.th/?page_id=3306

Real-Time Kinematics (RTK) Receiver System

- RTK positioning is a carrier-based positioning technique in which the precision of position is improved using the real-time corrections information transmitted through the radio or internet channels from a reference station or interpolated virtual station.
- The RTK positioning aims to achieve up to centimeter-level accuracy in the applications such as land survey, agriculture, constructions, unmanned vehicle navigation etc.



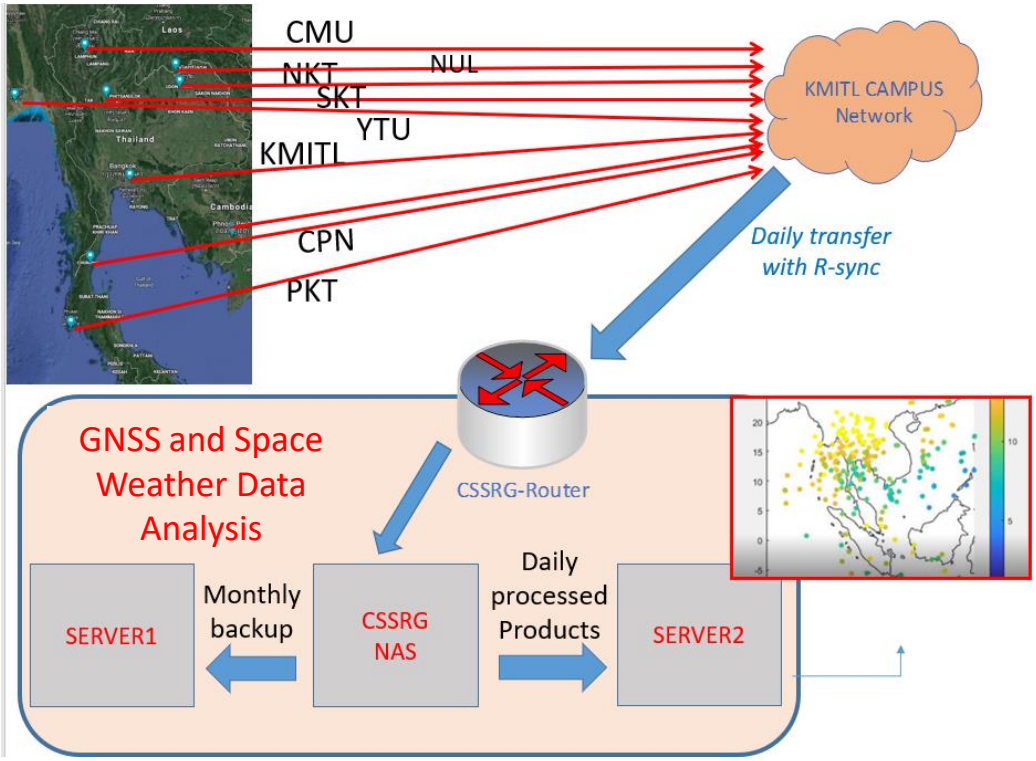
A base station and rover pair in RTK positioning system

Methods

- ✓ Implement a low-cost RTK receiver system.
- ✓ Test the system using the post-processed data from our station networks, particularly newly installed GNSS receivers in Phase I.

GNSS and SW Excellence Center at KMITL

The objective of the Excellence Center is to provide not only the data from our observation networks, but also disseminate the knowledge and research information on GNSS, Ionosphere and Space Weather Effects through various media and channels such as seminars, trainings, online materials etc. to academic institutes and industries in Thailand and the neighboring ASEAN countries.



Methods

- ✓ Organize capacity building for domestic network and partnered institutions.
- ✓ Conduct high-quality research works in this area collaboratively with partnered institutions.

Partnered Organizations

1. King Mongkut's Institute of Technology Ladkrabang(KMITL), Thailand
2. Chiangmai University (CMU), Thailand
3. Geo-Informatic and Space Technology Development Agency (GISTDA) , Thailand
4. National University of Laos (NUL), Lao PDR
5. Yangon Technological University (YTU), Myanmar
6. National Institute of Posts, Telecoms & ICT (NIPTICT), Cambodia
7. National Institute of Information and Communications Technology (NICT), Japan

Conclusion

- In this project as Phase II, we aim to expand ionospheric observational infrastructure further and perform data analysis from multi-sensor sources including GNSS receivers, ionosonde, magnetometer, and VHF radar station located at the magnetic equator and low-latitude regions.
- The heterogeneous data from these locations in the ASEAN region will be further analyzed and processed using Artificial Intelligent for studying and forecasting the irregularities and disturbances of ionosphere which affect the GNSS performances in the region.
- Moreover, this project plans to develop and investigate a real-time Kinematics (RTK) positioning system using the post-processed data from our stations as well as its performances under the ionospheric disturbances such as equatorial plasma bubbles (EPB).
- Importantly, this project also aims to establish a GNSS and Space Weather Excellence Center at KMITL, Thailand and to conduct a collaborative research studies with our partnered institutions.