The First Results of Analysing GPS Observations at IEODO Ocean Research Station in Korea

Byungmoon PARK
Department of Geoinformatics, University of Seoul, Korea

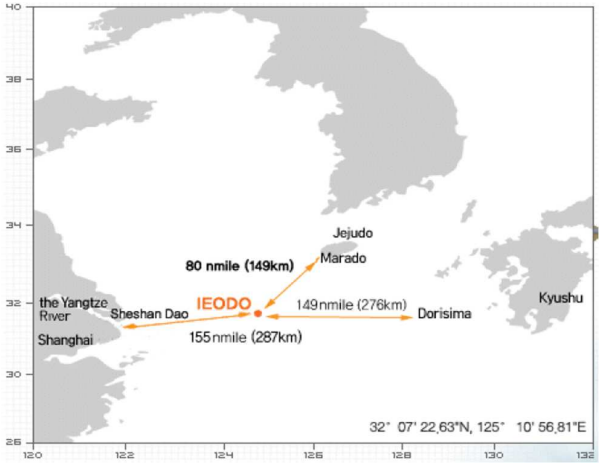
Dr. Tajul Ariffin Musa
GNSS & Geodynamics Research Group
Department of Geoinformation, Universiti Teknologi Malaysia, Malaysia

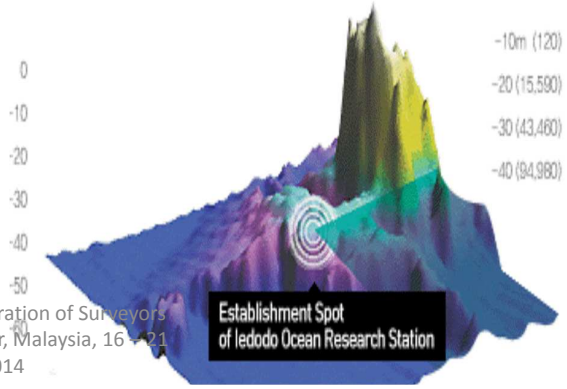
A/Prof. Hungkyu Lee
Department Of Civil Engineering, Changwon National University, Korea

Prof. Yunsoo Choi, Mr. Hasu Yoon, Mr. Changsun CHO
Department of Geoinformatics, University of Seoul, Korea

The IEODO

- **A submerged rock** of which shallow peak is 4.6m in depth within Korea's territorial line in the EAST Sea. Depth of its base is about 40m.
- **Located about 149Km** from the southern-most island of Korea (Marado Island).
- It stretches about 600m north-south and 750m east-west.
- It makes steep slopes in south and east and rather gentle slopes in north and west.





IEODO OCEAN RESEARCH STATION(IORS)

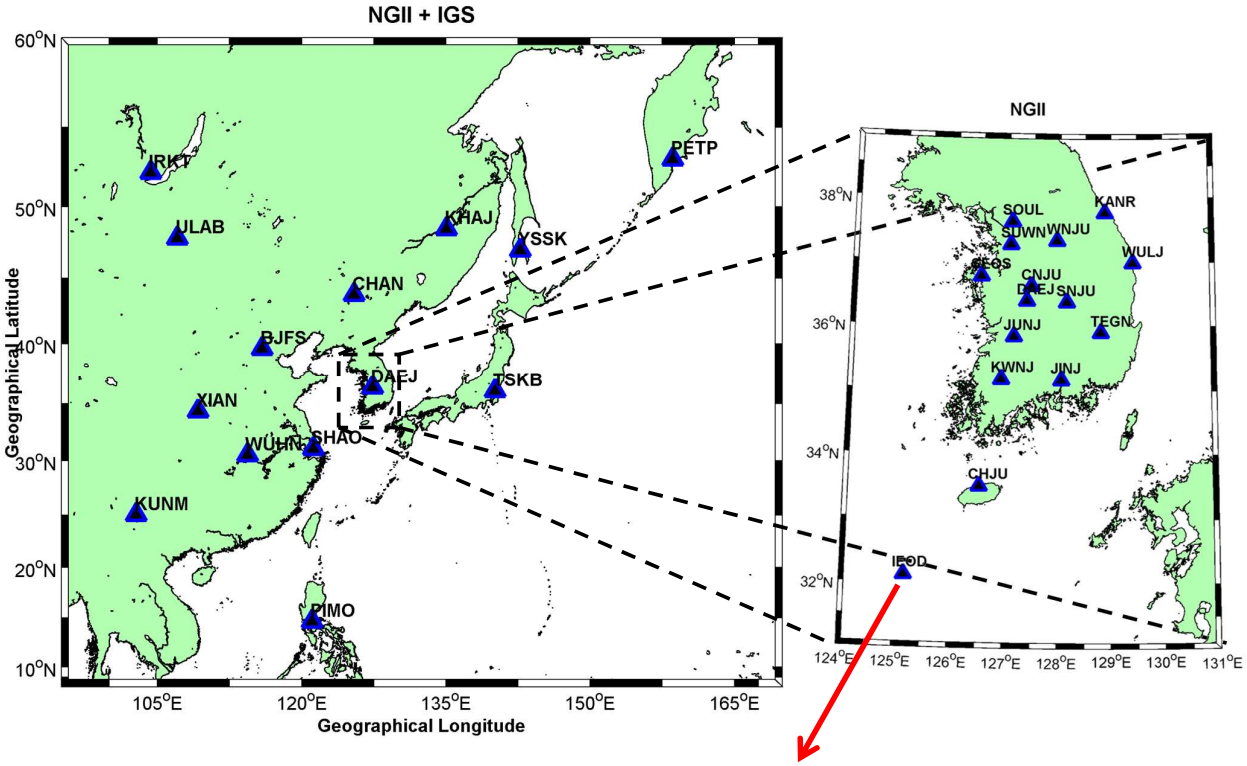
- Constructed in 2003 **to cope with natural disasters**, such as earthquake, Typhoon and ocean climate change.
- Structure
  - Jacket: 32.5m X 12m X 50.5m (1,258ton)
  - Deck: 24m X 21m X 23.2m (950ton)
  - Pile: Φ60"(404.8m), Φ72"(241.2m)
- **Observation Sensors (about 50)**
  - Atmosphere: wind speed, temperature & humidity, digital barometric sensors etc.
  - Ocean: wave radar, sea level monitor, etc.
  - Environment: aerosol, CO2 flux observers, atmosphere analyzer, etc.
  - Structure monitoring
  - **GNSS equipment**: Trimble NetRS with TRM41249.00 (2009); Trimble NetRS9 with TRM55971.00 (2013)

All the observed data is provided in either real-time or near real-time via INTERNET (iedodo.khoa.go.kr/eng)

RESEARCH OBJECTIVES

- International collaborative project between **UTM GNSS & Geodynamics Research Group** and the **Society of IEODO research** has been commenced to process **GNSS observation at IORS**.
- Internationally funded by the Society of IEODO research community that *recognize UTM expertise and knowledge-based service*.
- The main objective is to study applicability of GNSS for scientific researches:
  - ***Determination of Coordinate & Velocity Vector;***
  - ***GPS/GNSS Meteorology (total zenith delay, ZPD) ;***
  - ***GPS/GNSS Space Weather (total electronic content, TEC).***

GNSS CORS Network Coverage

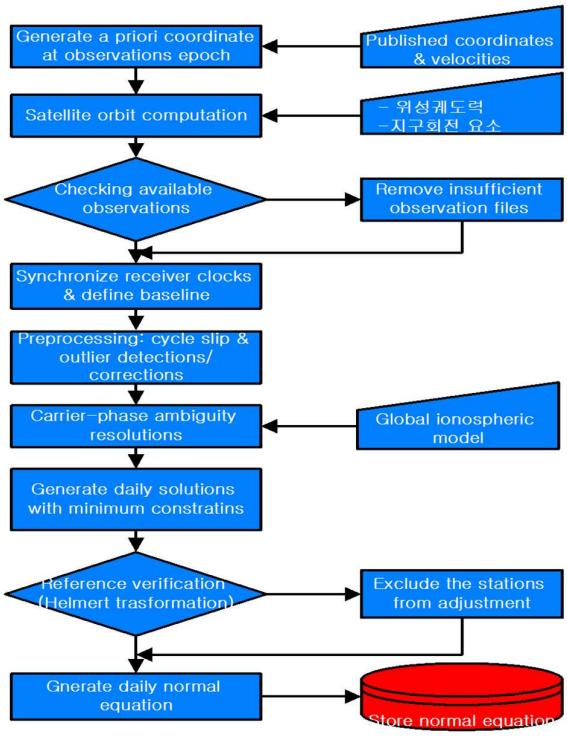


IEODO Station

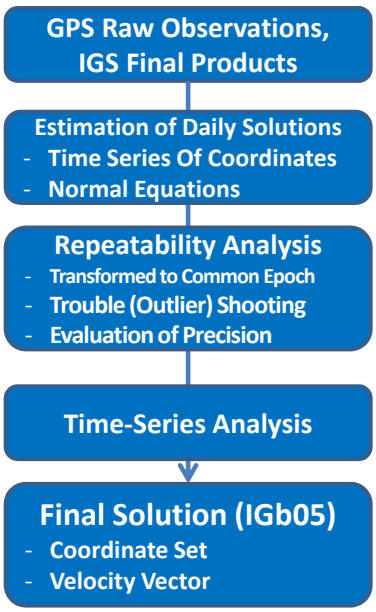
GPS Data Processing Strategy: Parameters and Options

Parameters	Descriptions
Initial Coordinates	- KORS: Published coordinates by NGII in 2010 Velocities are computed by the NUVEL-1 model - IGS: Both coordinates and velocities were extracted from **IGb08.SNZ**
Satellite orbits & Earth orientation parameters	- IGS final products - **Reference frames of Orbit and EOP were transferred to IGb08** 14 using transformation parameters (Kuba, 2002)
Antenna phase center correction	IGS absolute phase center correction model (IGS08.ATX)
Ocean tidal model	GOT00.2 model (long period tides from FE99) provided by Onsala Space Observatory
Tropospheric delay	Estimate troposheric zenith delay parameters at stations
Ionospheric effect	Use carrier-phase L3 observations for parameter estimations
Ambiguity resolution	Quasi-Ionosphere Free (QIF) with global ionospereic model estimated by Center for Orbit Determination in Europe
Normal equation combination	**Sequential least squares adjustment**
Datum definition	**Minimum constrains adjustment** by constraining Helmert transformation parameters at IGS reference stations

GPS Data Processing Strategy: Procedure

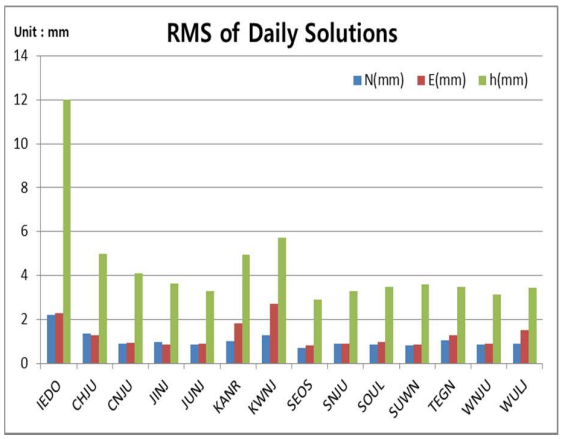


<Daily Processing Procedure>

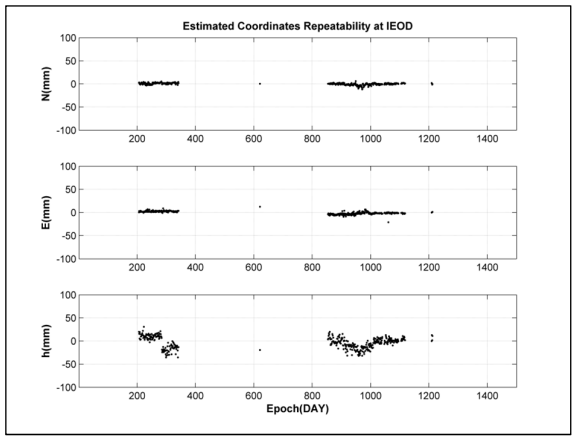


<Procedure to Estimate the Final Solution>

Repeatability of Daily Solutions



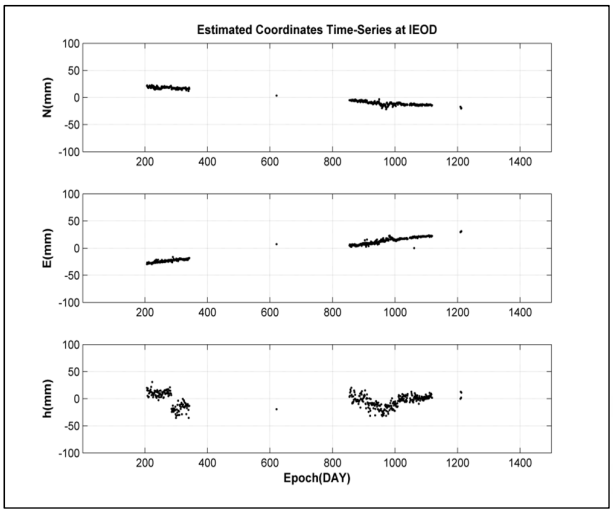
<RMS of Daily Solutions>



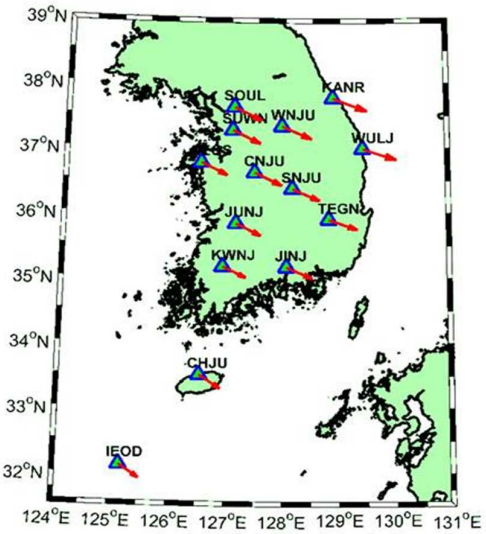
<Repeatability of Daily Solutions>

- The horizontal: 1 to 2 mm,
- The vertical: around 5mm.
- The vertical RMS of the IEODO is relatively larger than the others.

Velocity Vector Estimation



<Daily Solutions of IEODO>



<Station Velocity Vectors>

- North-South (NS) : -13.7mm
- East-West (EW): 20.7mm
- Normal (h): 2.3mm

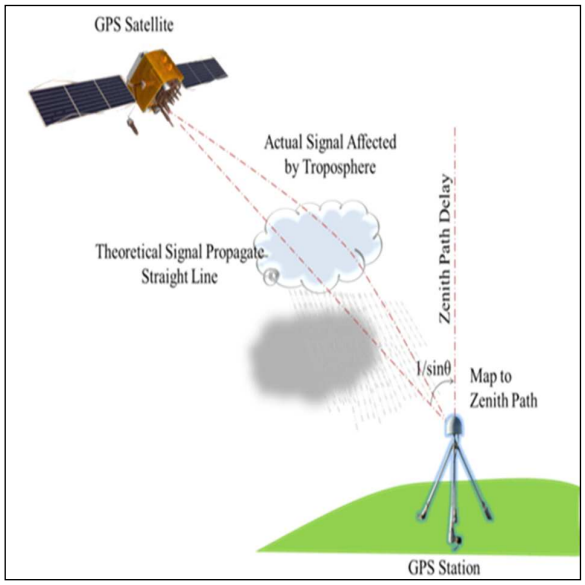
GPS Meteorology at IEODO Station during the Event of Typhoon MAERI (2011)

GPS METEOROLOGY

The Concept

- Atmospheric properties has induced delay to the GPS signal during propagation.

- GPS meteorologist view this delay not as errors but as atmospheric information.



- GPS measurement of atmospheric information provide zenith path delay (ZPD) which can be further explained as:

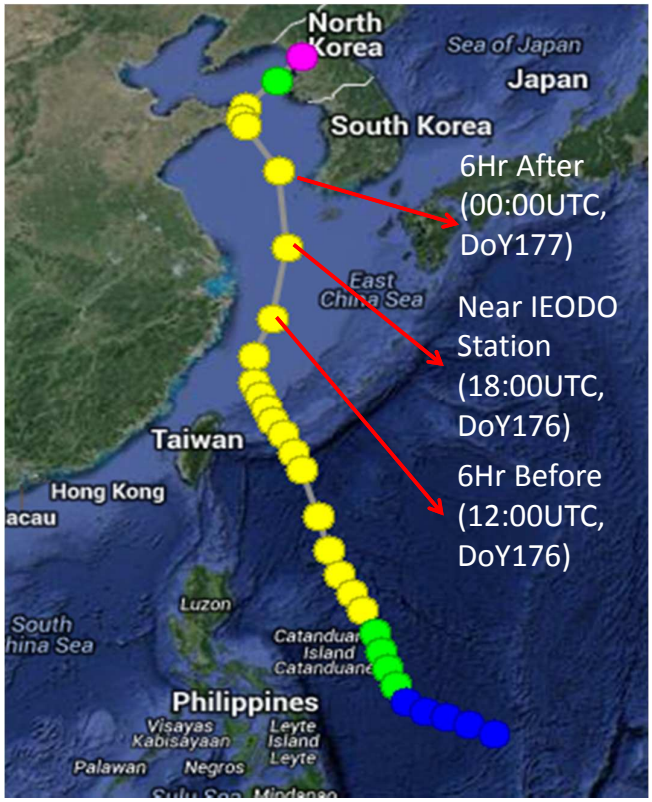
$$ZPD = ZHD + ZWD$$

ZHD - zenith hydrostatic delay (associated with dry gases)
ZWD - zenith wet delay (associated with water vapor)

MAERI TYPHOON

- **Meari Typhoon** started on 22nd - 27th June 2011 (DoY173 to DoY178) which originate from The Philippines.

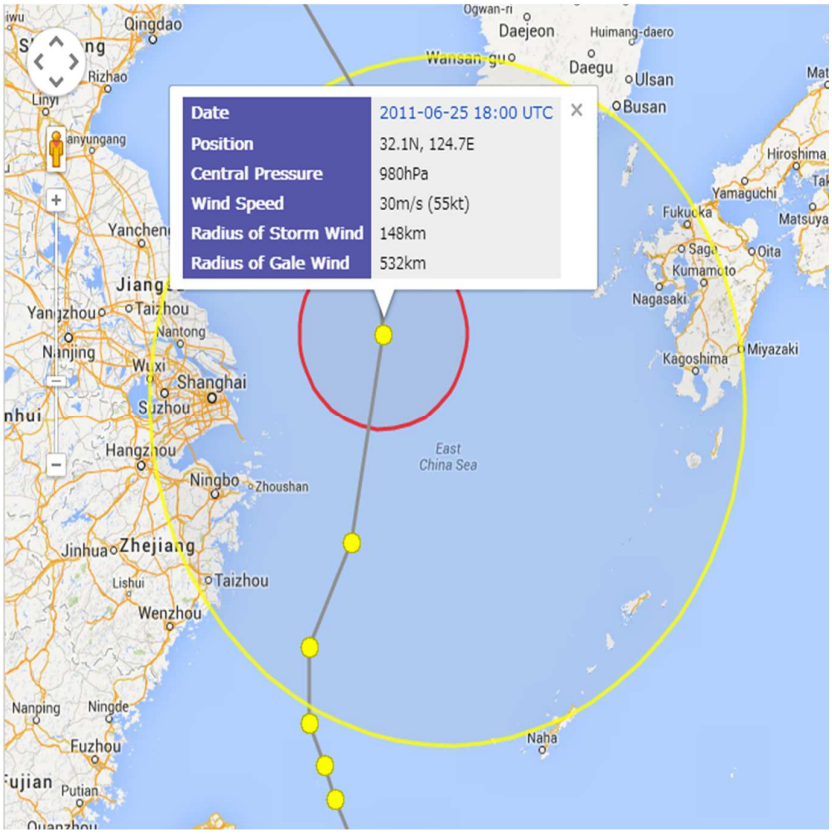
- The Typhoon arrived **'near' IEODO station in June 25th 2011** (DoY176), 1800 UTC.



Trajectory of Meari Typhoon
(according to Digital Typhoon http://agora.ex.nii.ac.jp/digital-typhoon/summary/wnp/g/201105.html.en)

MAERI TYPHOON

- Meteorological conditions once the Maeri Typhoon arrived 'near' IEODO station **in June 25th 2011** (DoY176), 1800 UTC.

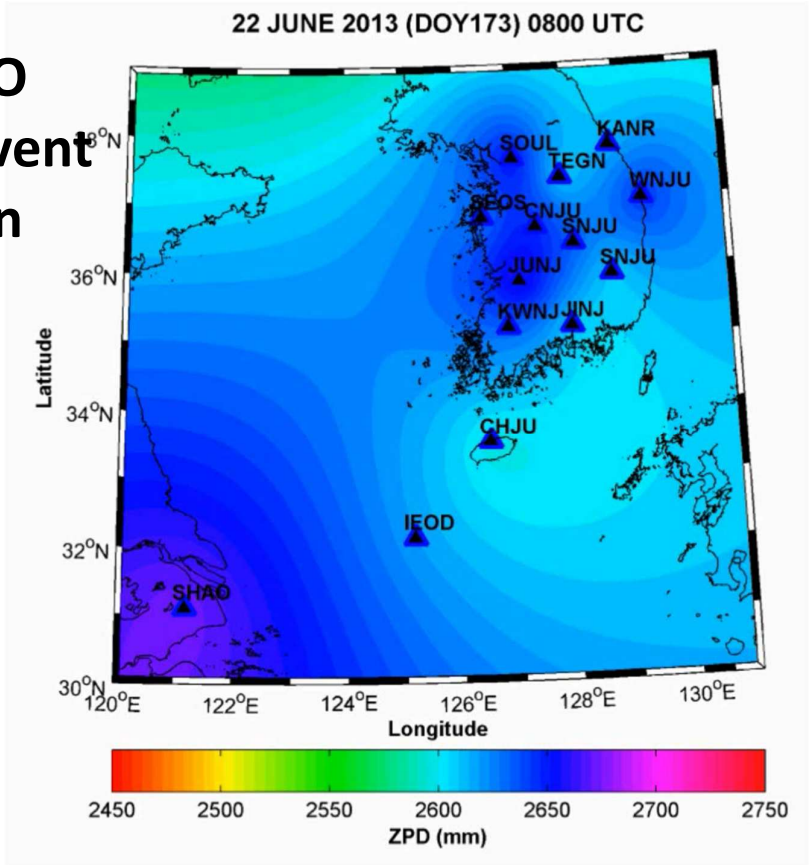


Trajectory of Meari Typhoon
(according to Digital Typhoon http://agora.ex.nii.ac.jp/digital-typhoon/summary/wnp/g/201105.html.en)

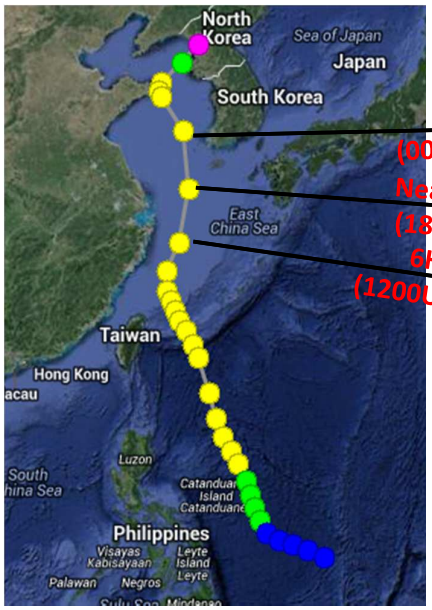
ZPD over Korean Peninsula & IEODO Station During the Event of MEARI Typhoon

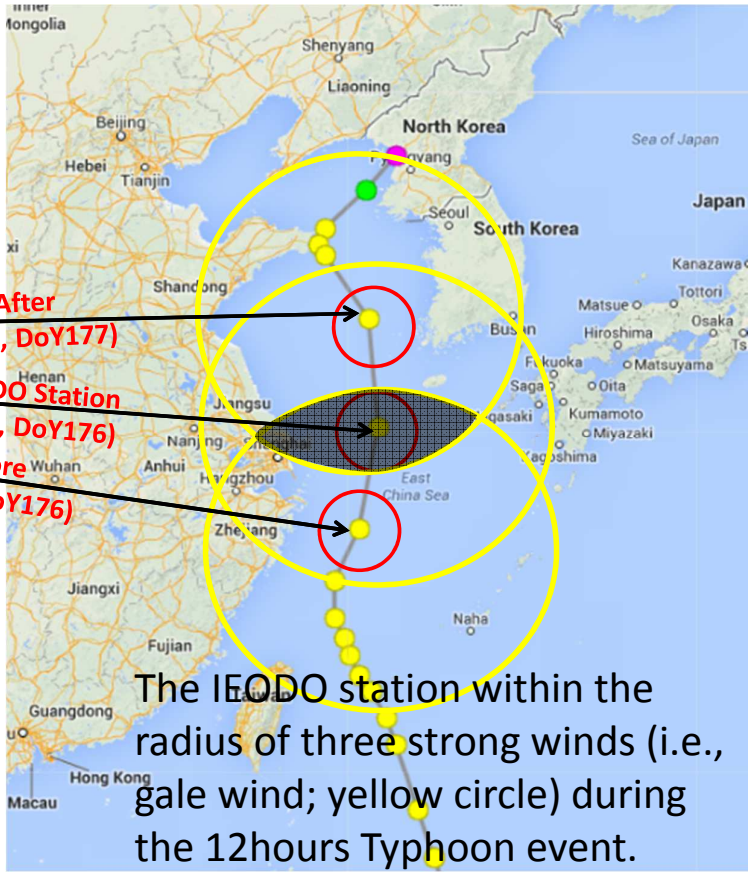
Animated ZPD over Korean Peninsula & IEODO station during the Meari Typhoon.

22nd - 27th June 2011 (DoY173 to DoY178)



MAERI TYPHOON

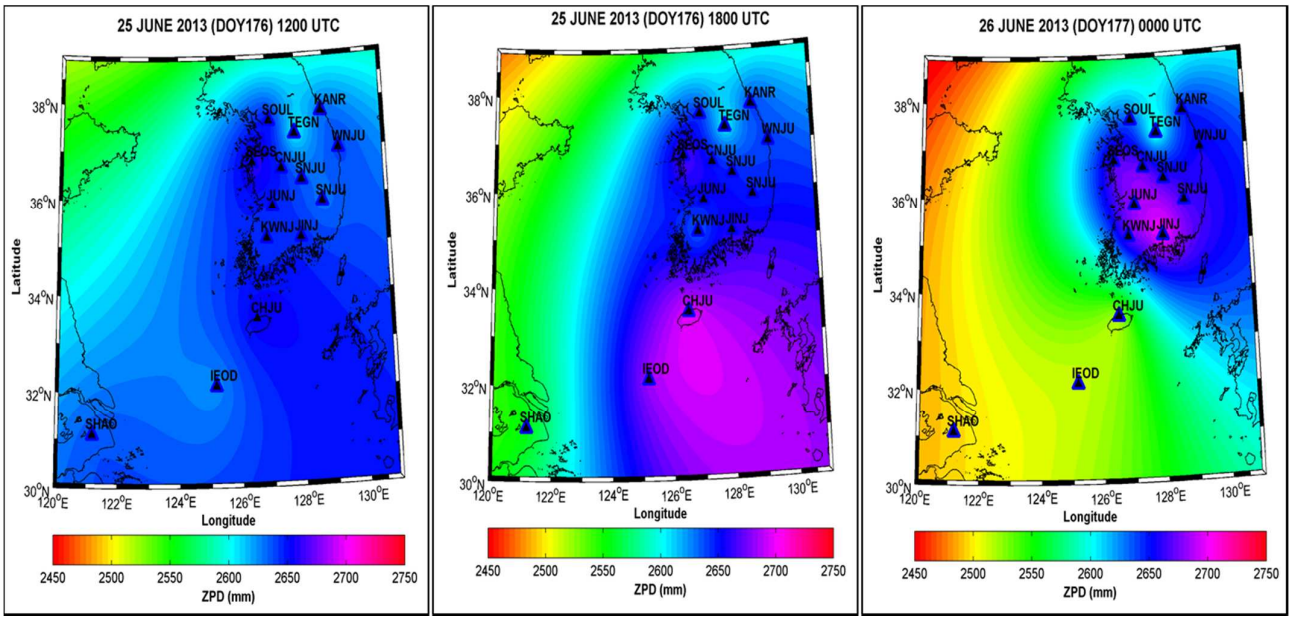




The IEODO station within the radius of three strong winds (i.e., gale wind; yellow circle) during the 12hours Typhoon event.

Trajectory of Meari Typhoon (according to Digital Typhoon http://agora.ex.nii.ac.jp/digital-typhoon/summary/wnp/g/201105.html.en)

Spatiotemporal of ZPD Over Korean Peninsula & IEODO Station During the Event of MEARI Typhoon



1200UTC DoY176 **1800UTC DoY176** **0000UTC DoY177**

Concluding Remarks

- IEODO GPS data has been processed in this project together with 13 KORS and 10 IGS stations by the Bernese software; a total of 398 days of observations was analysed.
- The precision assessment of the daily solutions has revealed **few mm** level in the horizontal and **mostly 5 mm** in vertical component, respectively.
- The estimated velocity vector of the IEODO has similar trend with those in the Peninsular, which is toward southwest with magnitude **of 25mm/year**.
- A time series of the ZPD was preliminarily analysed together a trajectory of the typhoon MEARI from DoY 173 to 178 in 2011, indicating that the values **increase before and during** the passage of the typhoon and **decrease rapidly** after it passed.
- The spatiotemporal analysis of the ZPD revealed that the value **has high sensitivity** to geographical location of the typhoon.
- This project has **only focused on the ZPD** itself, so that derivation of PWV from the results will be carried out in near.

XXV International Federation of Surveyors
Congress, Kuala Lumpur, Malaysia, 16 – 21
June 2014