

Deintensification of typhoon Soulik by a rapid ocean destratification in the coastal waters of west Jeju Island, Korea

21 May 2019

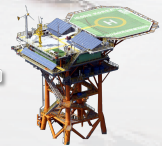
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Cliff Watkins*, M.W. Kim, Y.B. Son, J.Y. Jeong and J.S. Shim

Marine Disaster Research Center, KIOST

*Center for Ocean Observing Leadership, DMCS, Rutgers Univ.

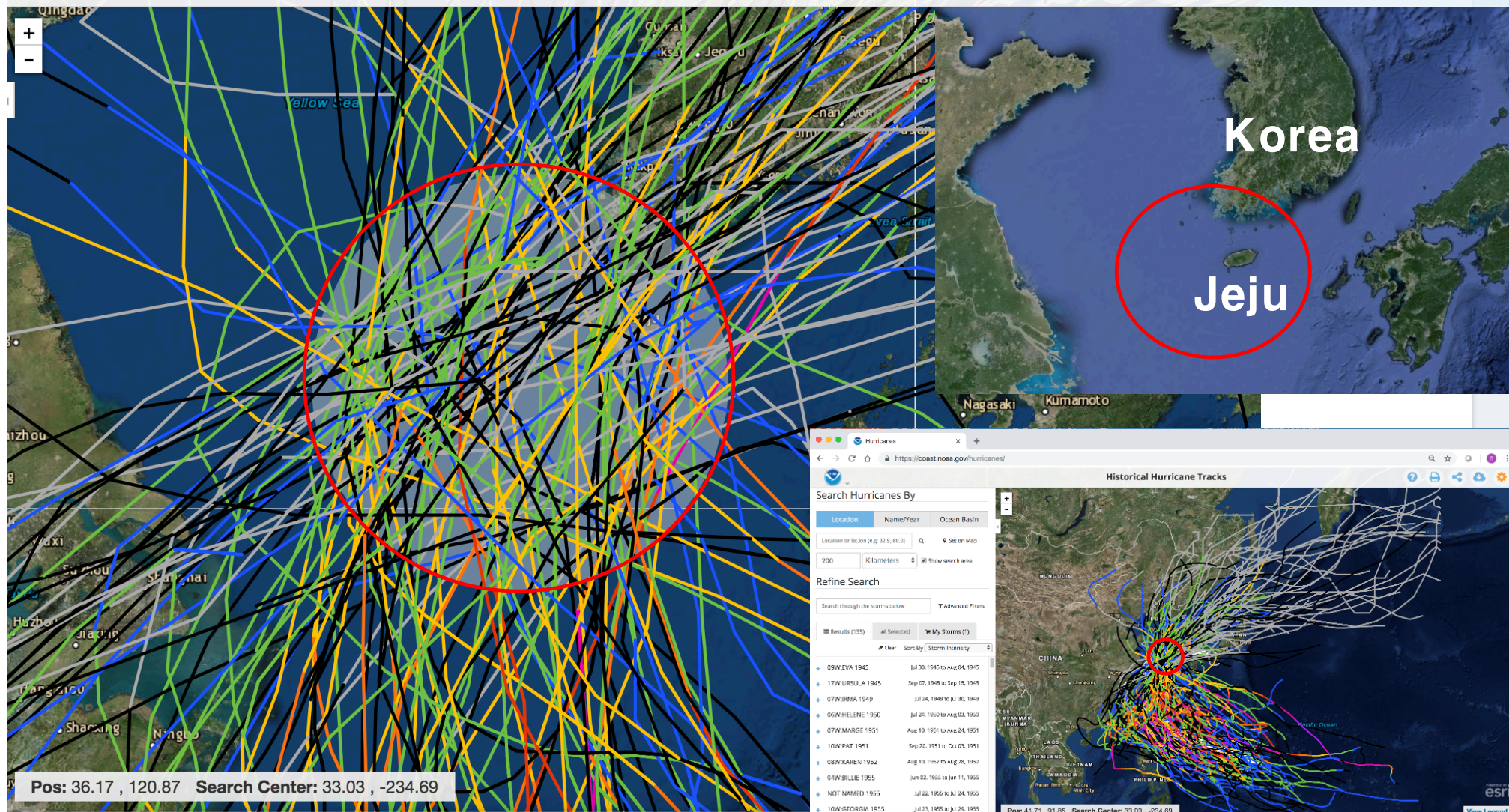
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- 2 Glider Deployment at Jeju
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- 4 Glider Observation
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- 6 Conclusions



1 Historical Typhoon Tracks for a 200km circle

Historical Hurricane Tracks



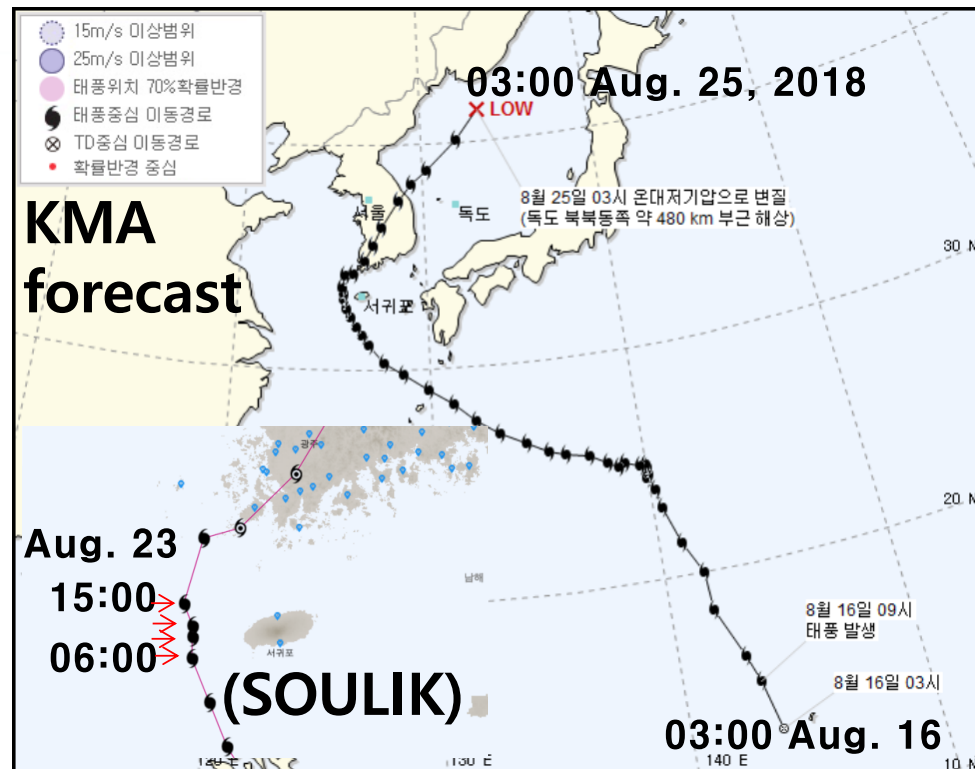
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2 Typhoon SOULIK(1819)

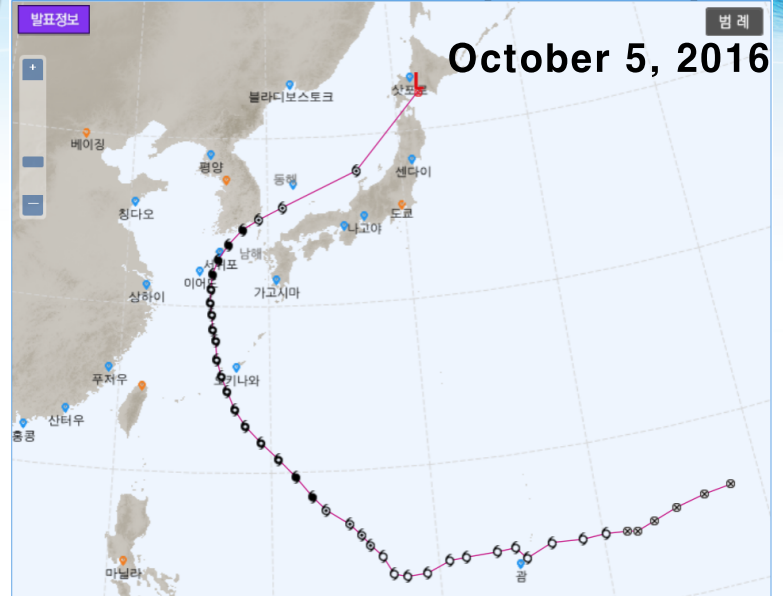
- Recently, typhoons (speed) are getting strong (decreased) in the West Pacific Ocean due to sea surface temperature increased by global warming.



Speed of Typhoon SOULIK was about 4km/h at 13:00 on Aug. 23 due to weak Jet Stream in the Northern East Asia according to the KMA report.

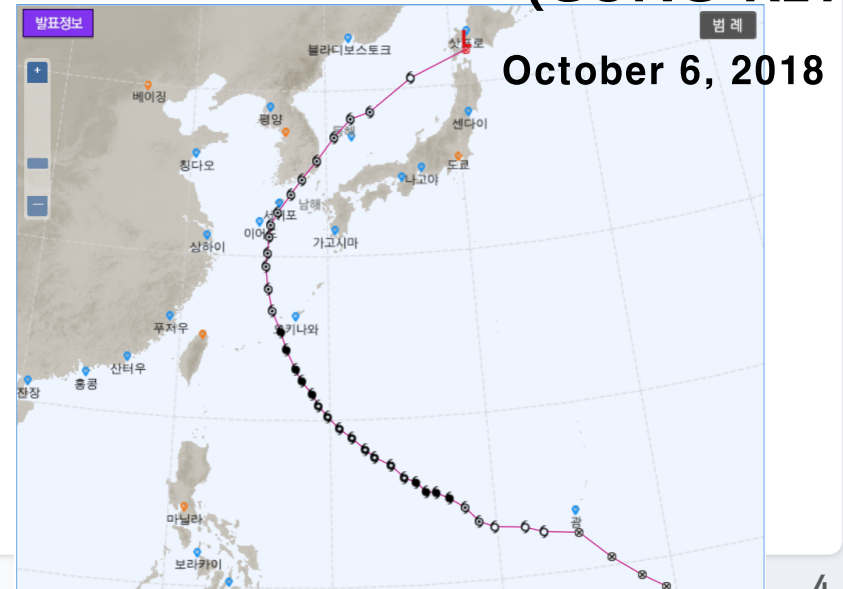
2016년 제18호 태풍 차바(CHABA) (CHABA)

제18호 태풍 차바(CHABA)는 태국에서 제출한 이름으로 꽃의 한 종류임.

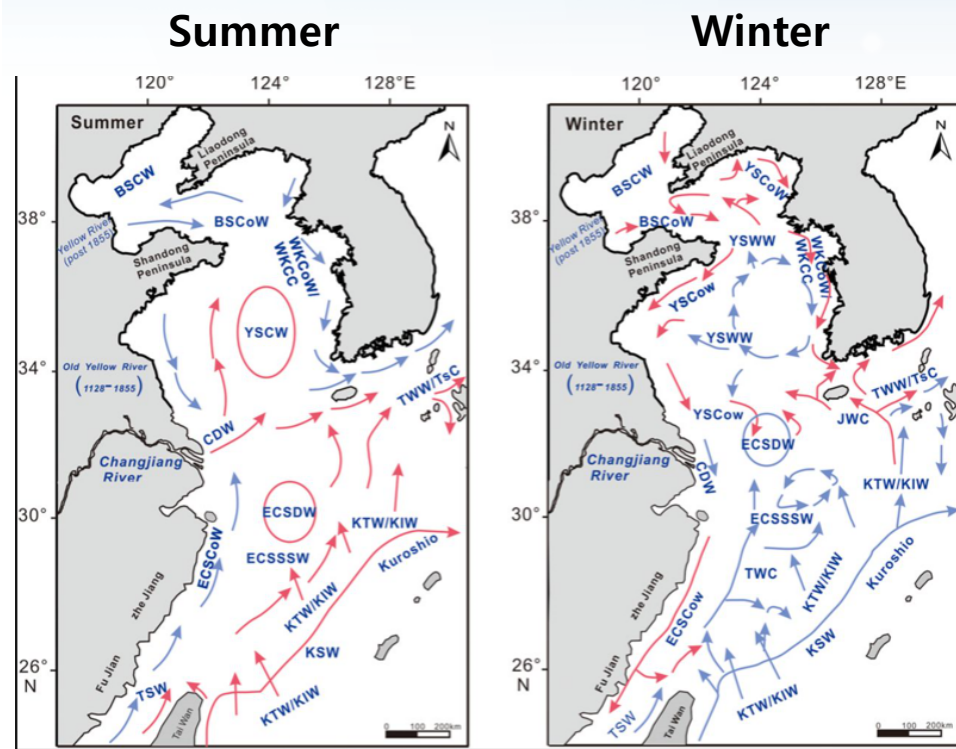
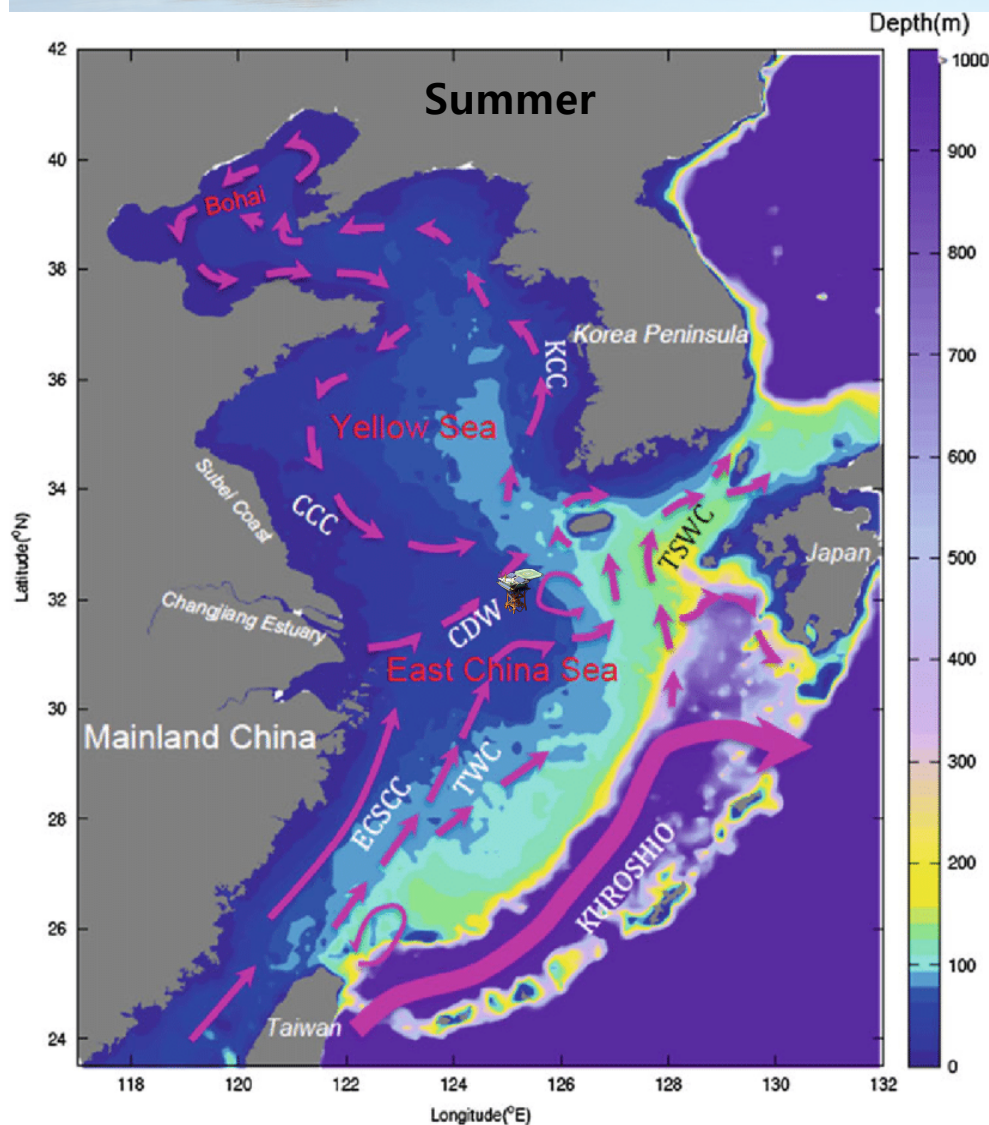


2018년 제25호 태풍 콩레이(KONG-REY) (GONG-REY)

제25호 태풍 콩레이(KONG-REY)는 캄보디아에서 제출한 이름으로 산의 이름임.

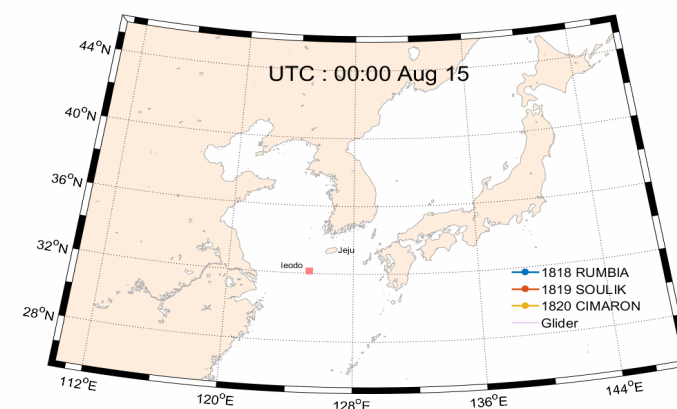
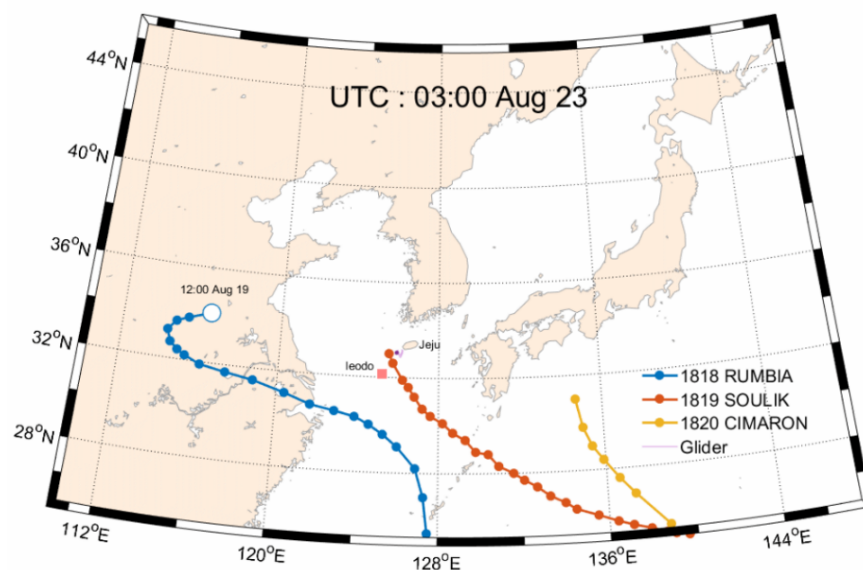


3 Yellow Sea Circulation in Summer



4 Glider Deployment at Jeju Island, Korea

- Purpose : Understanding of ocean mixing observed by an underwater glider during in summer 2018 over tidally dominated and highly stratified waters west of Jeju Island
- Location : from Jeju Unjin port (Moslpo) to IEODO station (original target)
- Period : 09:20 Aug. 15 (Deployment) ~ 10:00 Aug. 25 (Recovery)
- Glider : RU22 (SLOCUM) of RUCOOL, DMCS, Rutgers Univ.
- Sensors : CTD (Temp., Sal., Density), OBS (Turbidity), Chlorophyll-a, C-DOM etc.
- Operation : Marine Disaster Research Center, KIOST and COOL, DMCS, Rutgers Univ.

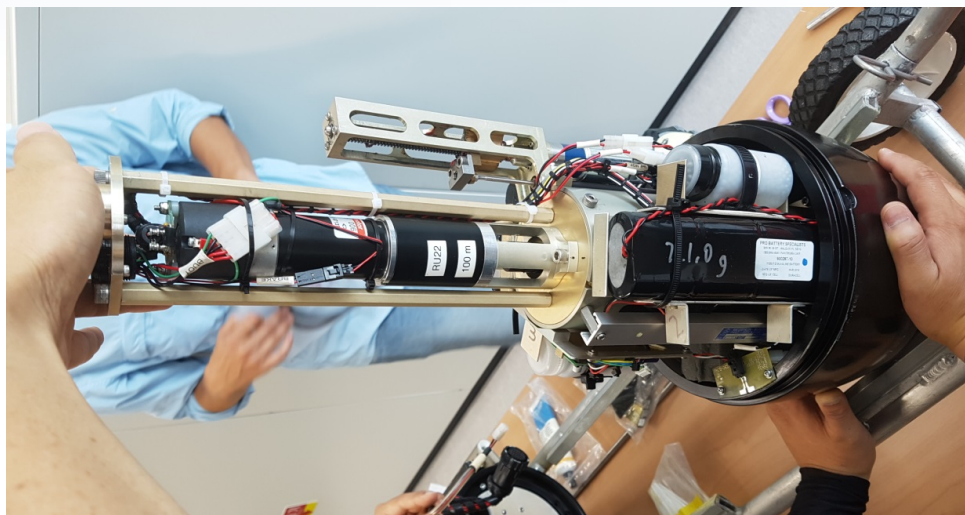


Typhoon Tracks (1818~1820)

5 Preparation for Glider Deployment

- Speed : 20~30cm/s, Distance : 15~20 km/day, Data transition : every 2~3 hours
- Battery duration : about 30 days

※ Glider preparation (Aug.14)



6 Glider Deployment

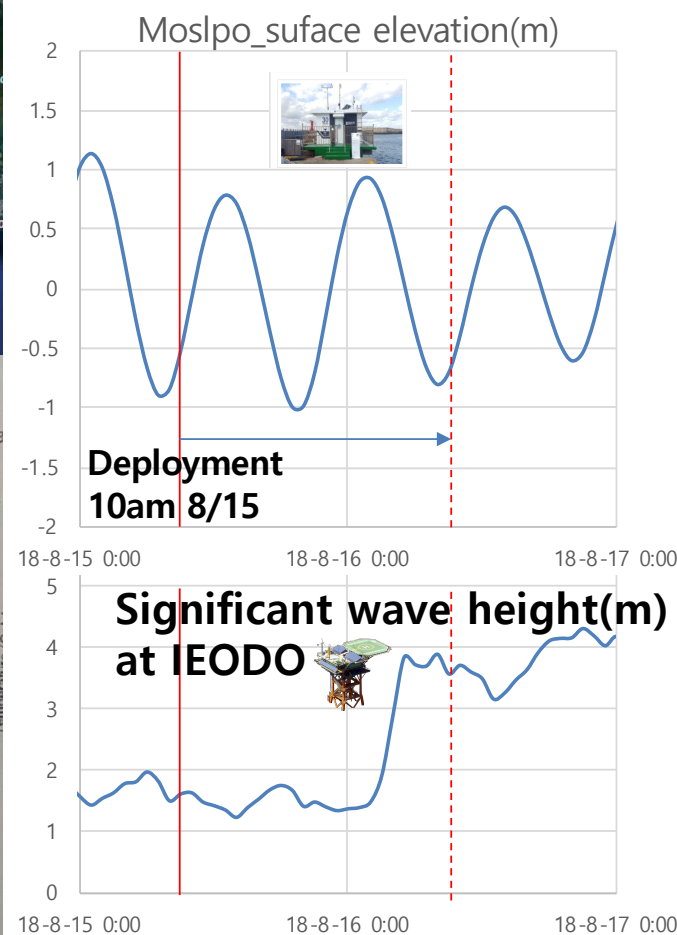
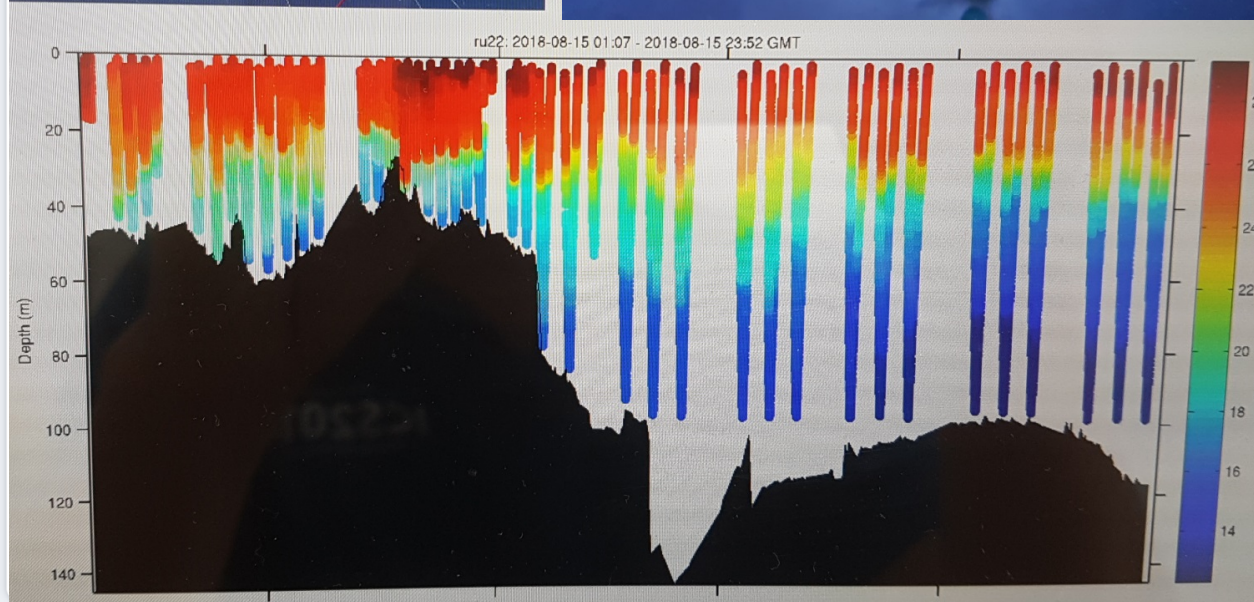
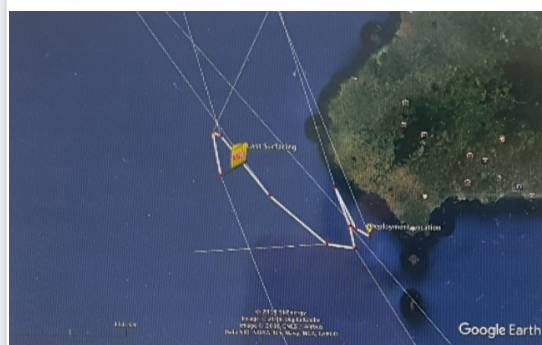
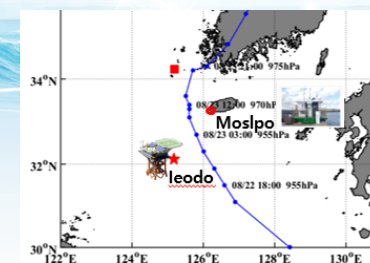
- Deployment Location : about 3 km from Unjin port, Jeju Island
- Observation Period : **09:20 Aug. 15, 2018**

2 Deployment



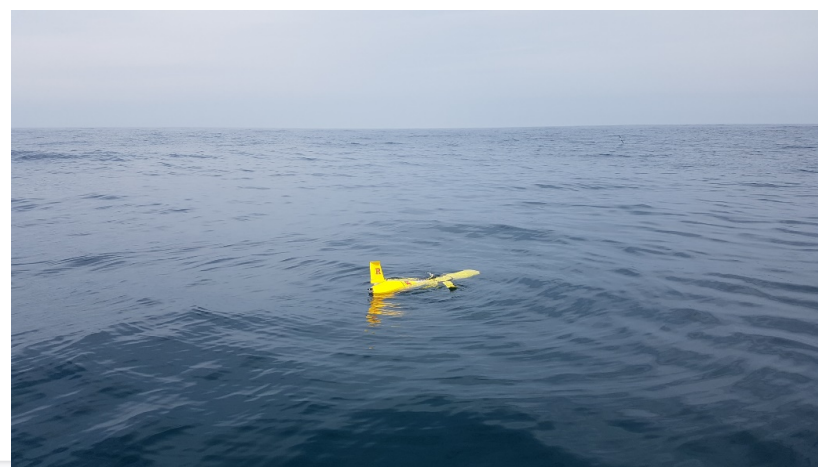
7 Glider Deployment

- Deployment location : about 3 km away from Unjin port, Jeju Island
- Deployment : 09:20 Aug. 15 (**Dived about at 10:00**), 2018
- ※ Drifted toward Northwest along the coast affected by strong flood tidal current



8 Glider Recovery

- Deployment Location : about 3 km from Unjin port, Jeju Island
- Observation Period : 09:20 Aug. 15 ~ **10:00 Aug. 25**, 2018
- Recovery Location : about 15 km from Unjin port, Jeju Island



9 leodo Ocean Research Station (IORS)

- 37 km south of Socheong Island
- Depth : 50 m
- Completed in Oct. 2014

Socheongcho ORS
(SORS)

- 190 km west of Gunsan city
- Depth : 80 m
- Moored in Sep. 2007

Yellow Sea Buoy
(YSB)

- 47 km south-west of Gageo Island
- Depth : 15 m
- Completed in Oct. 2009

Gageocho ORS
(GORS)

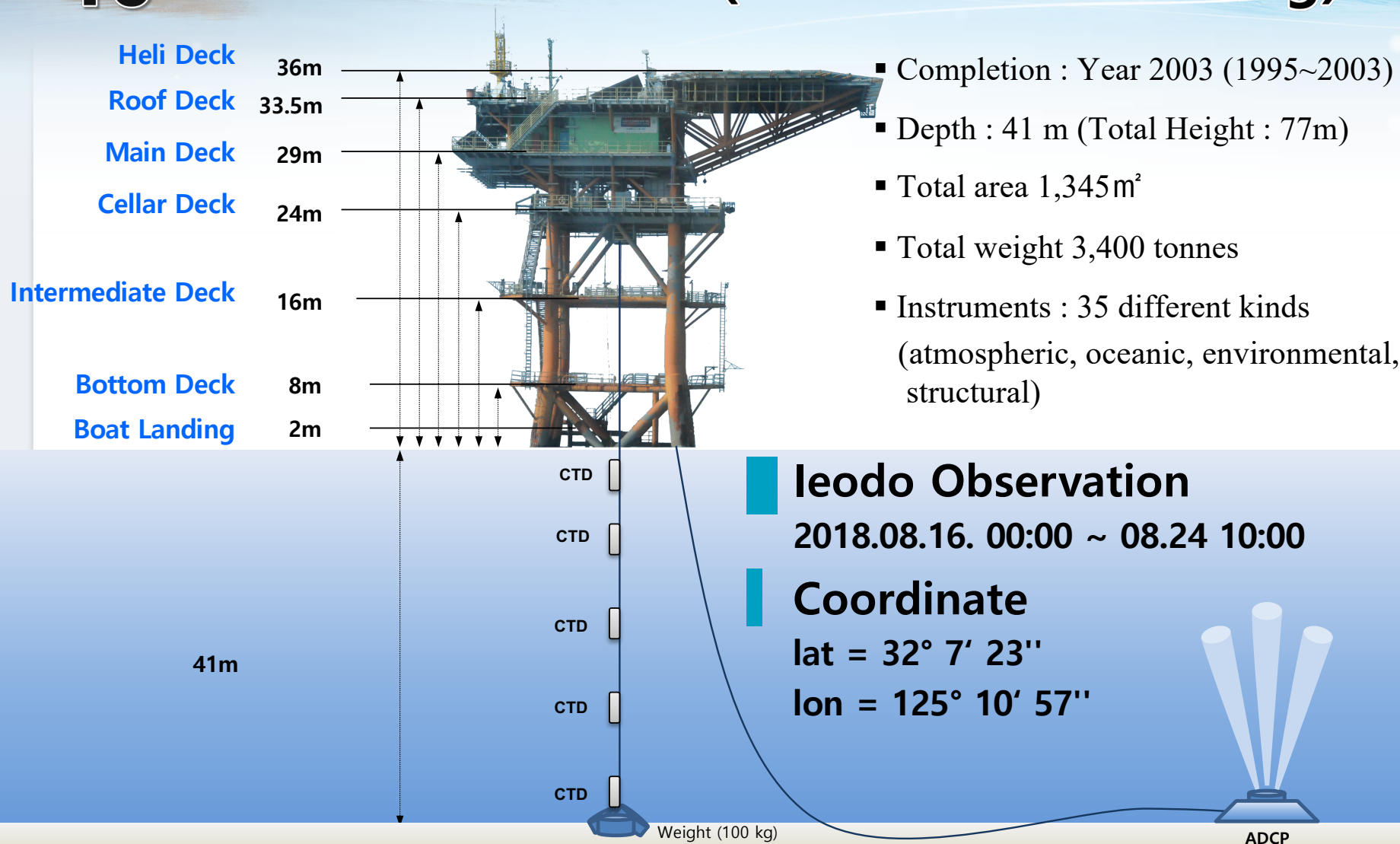
- 149 km south-west of Mara Island of Jeju
- Depth : 41 m
- Completed in Jun. 2003

leodo ORS
(IORS)

Korea

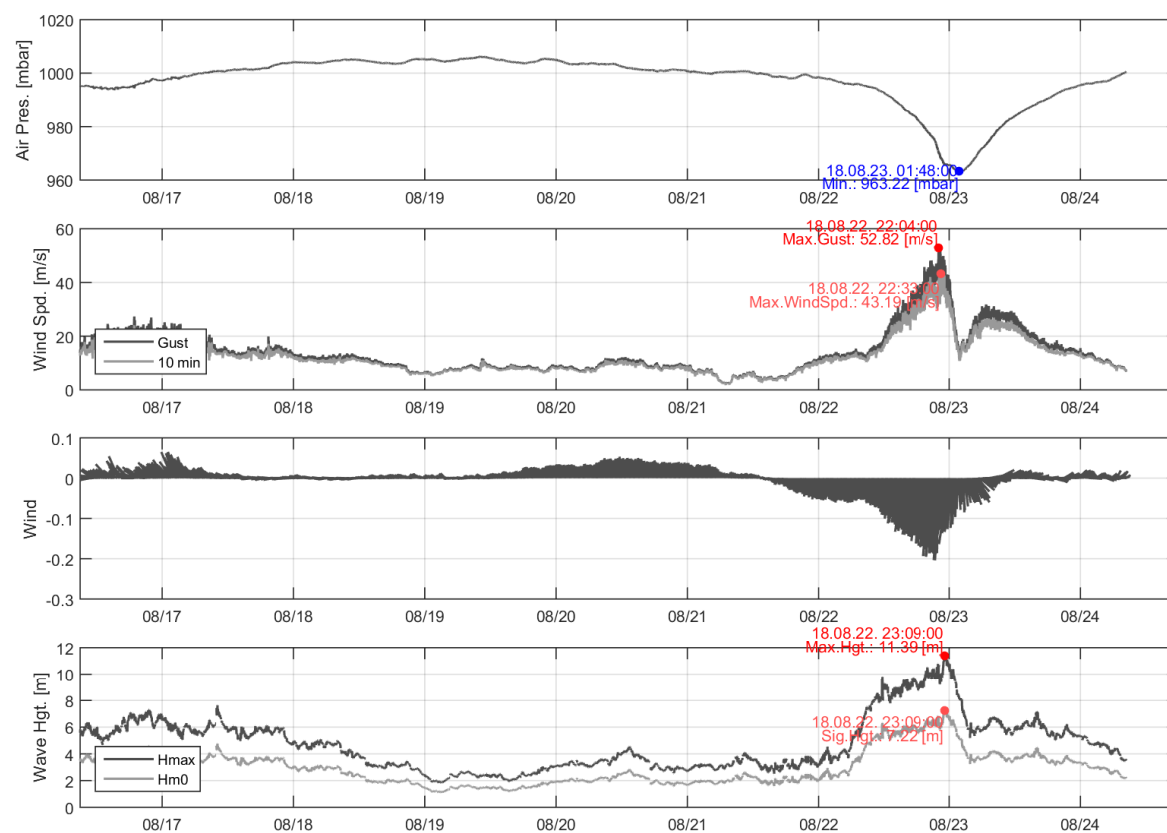
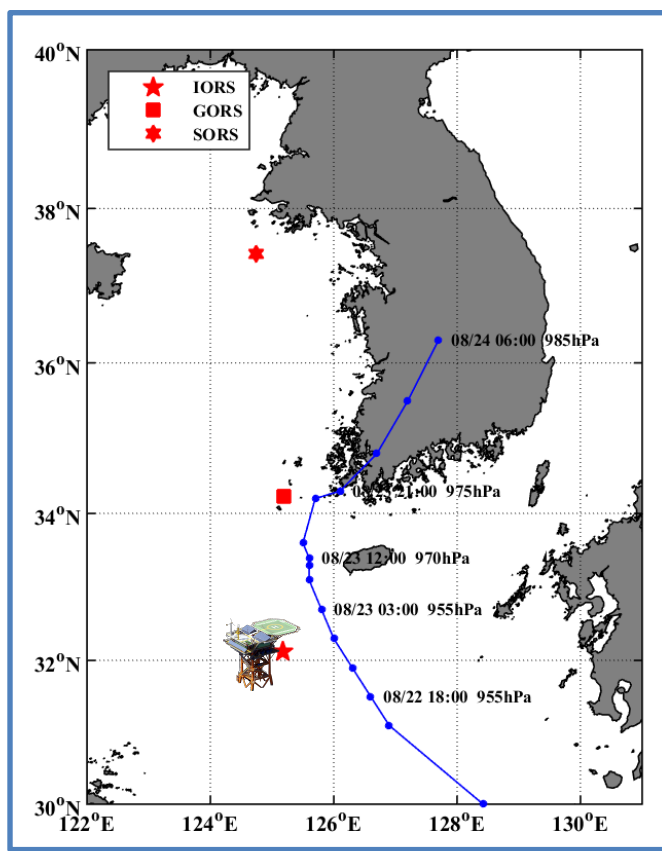


10 leodo Observation (real-time monitoring)



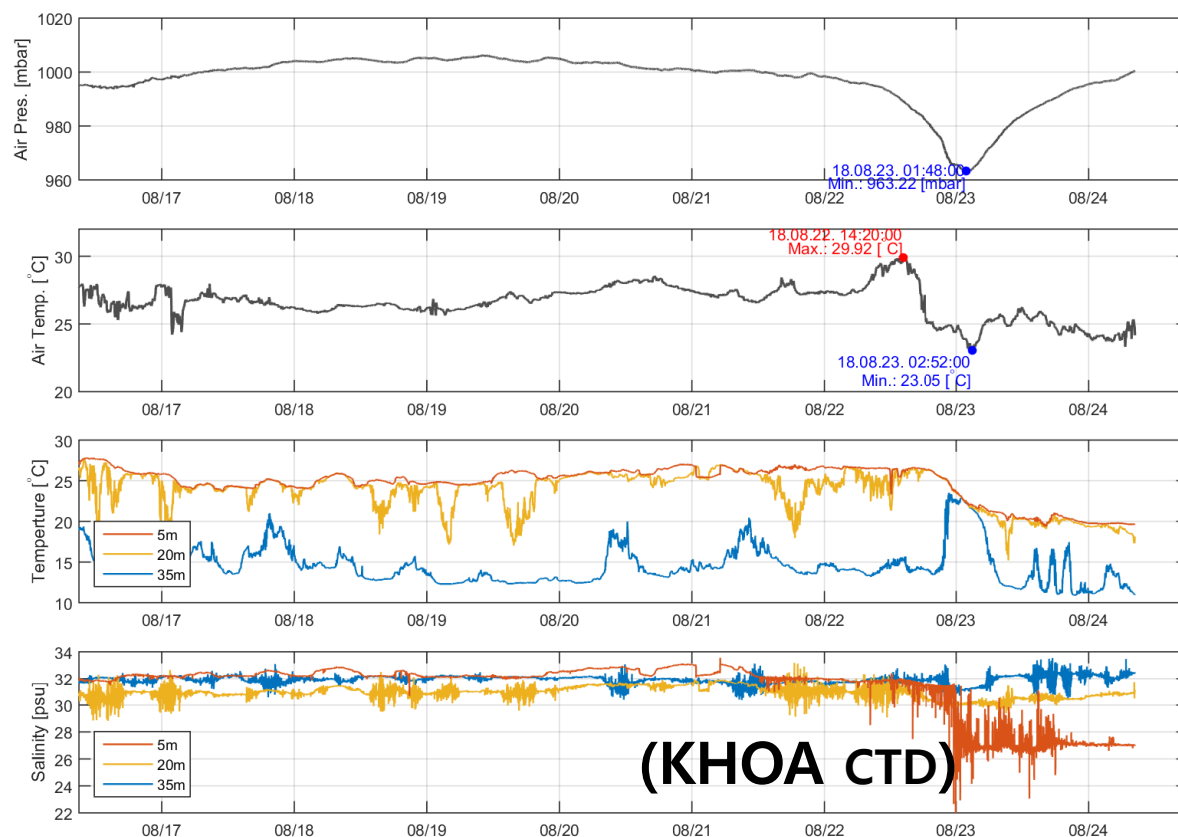
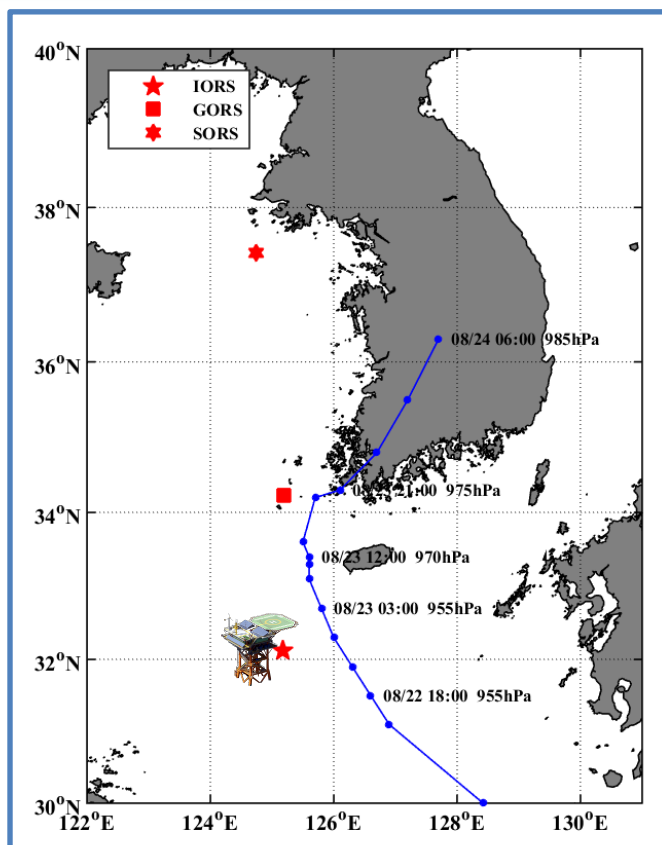
11 Jeodo Observation (Real-time monitoring)

- Min Air Pressure : 963.22 hPa (01:48 Aug. 23)
- Max Wind speed : 43.19 m/s (22:33 Aug. 22), Gust speed : 52.82 m/s (22:04 Aug. 22)
- Hs : 7.22 m, Hmax : 11.39 m (23:09 Aug. 22)



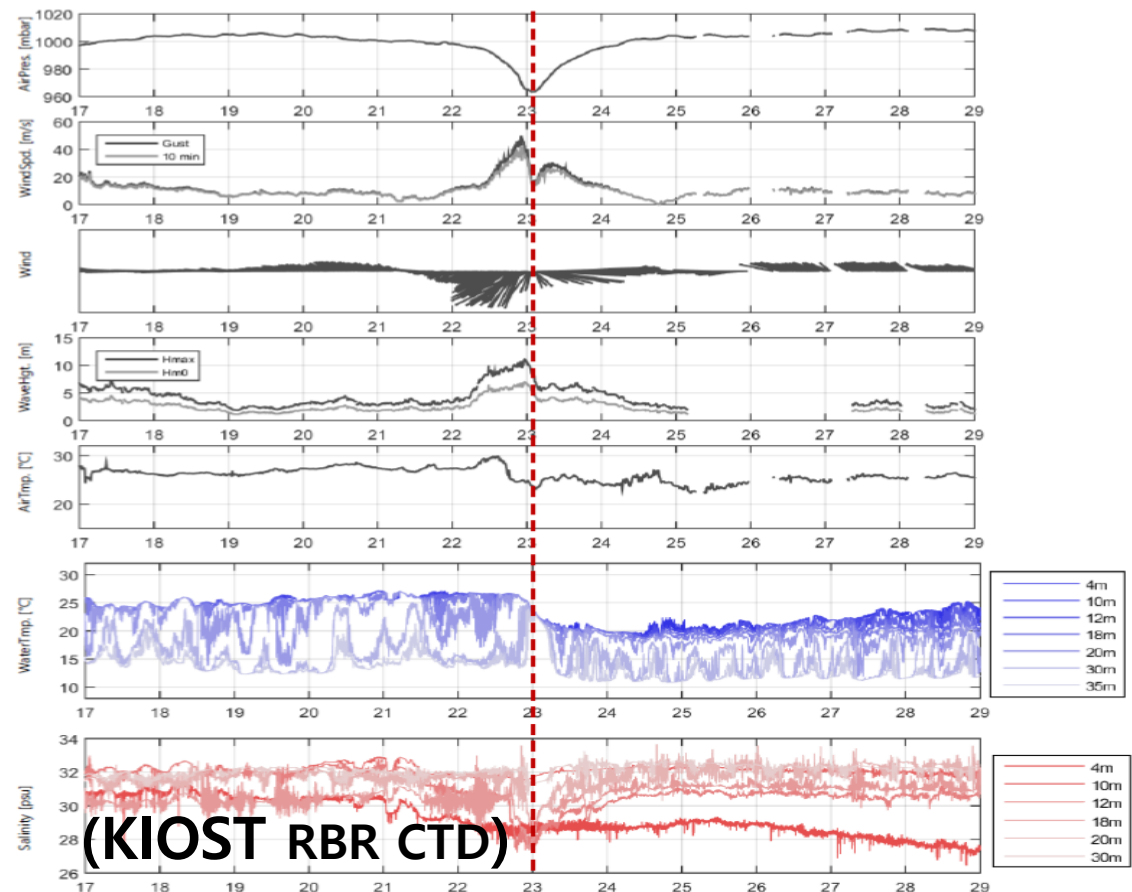
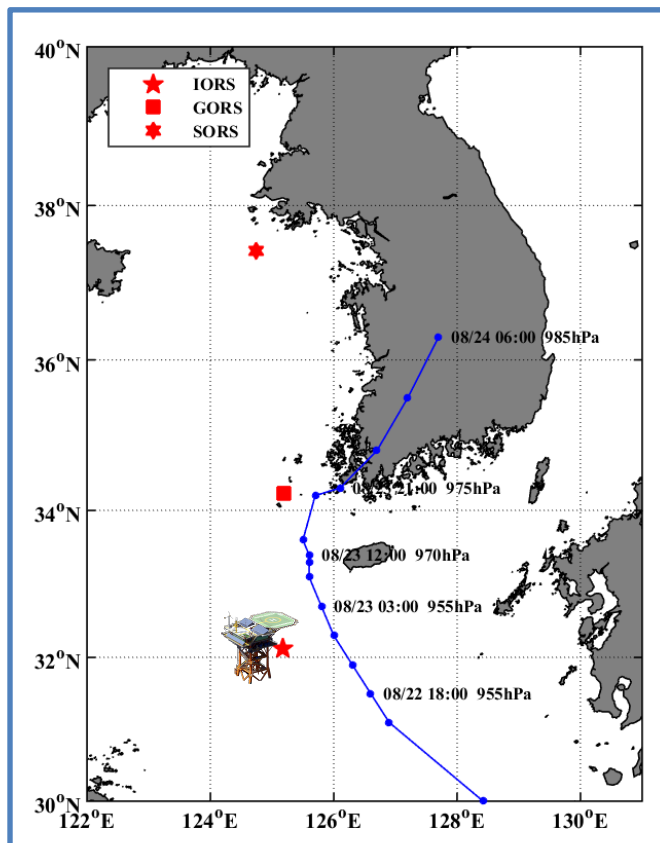
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- Hs : 7.22 m, Hmax : 11.39 m (23:09 Aug. 22)
- Bottom Temperature(35 m): 14° -> 23° increased, Surface Salinity(5 m): 32 -> 27 psu**

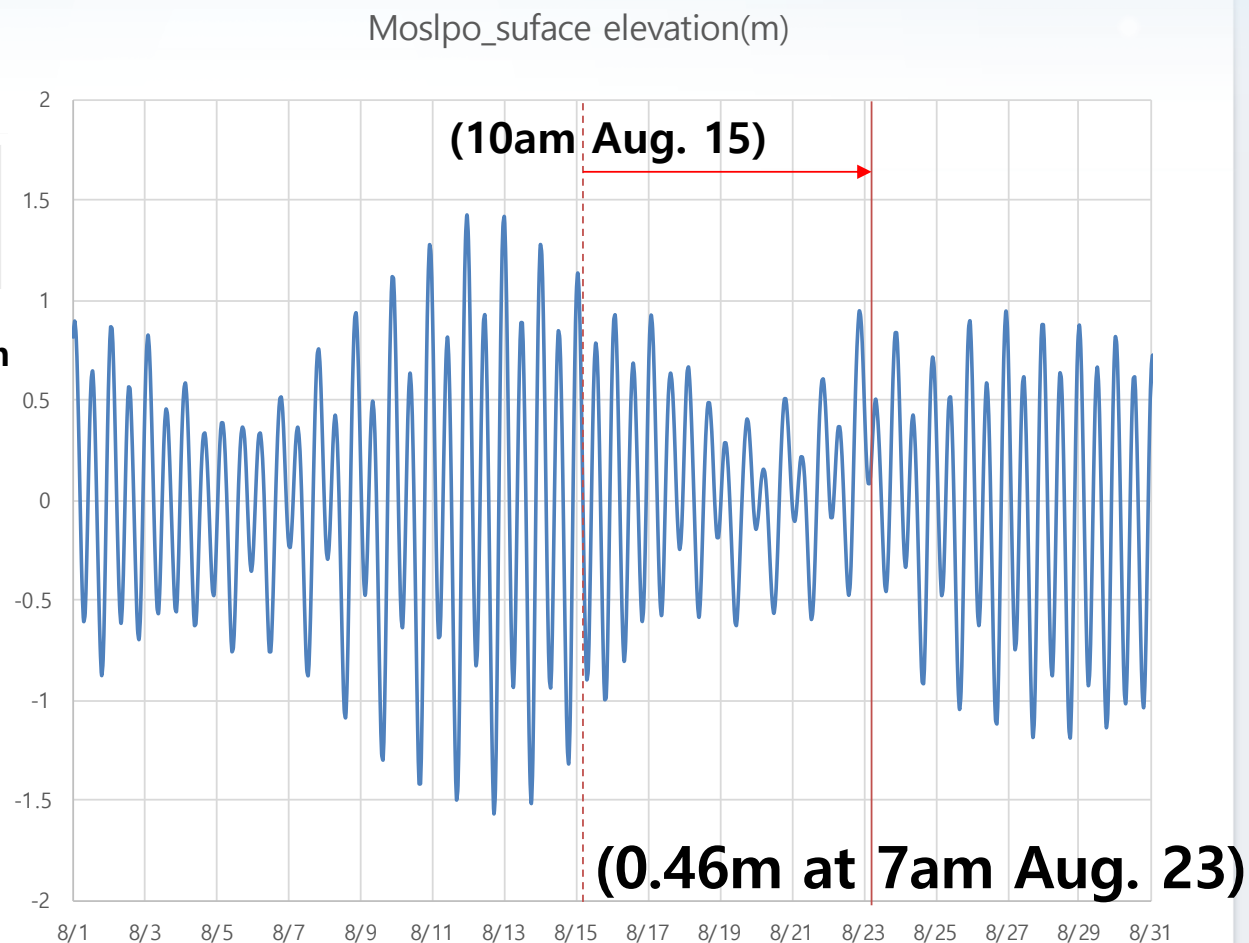
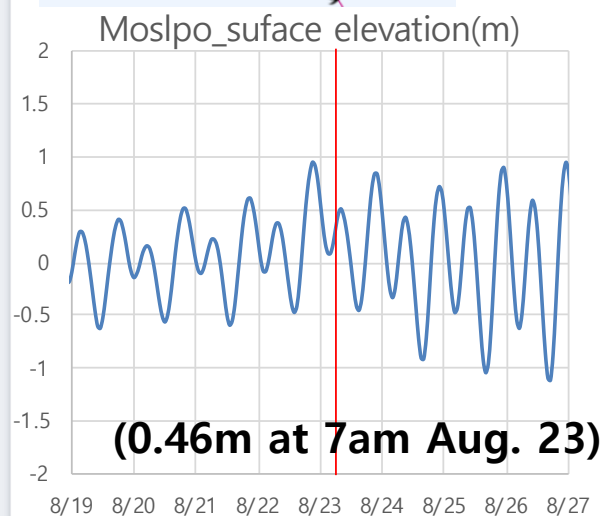
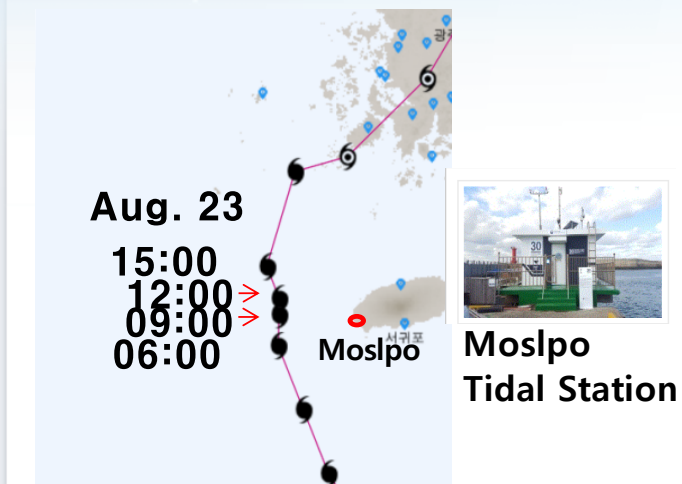


13 Jeodo Observation (RBR CTD Sensor)

- Min Air Pressure : 963.22 hPa (01:48 Aug. 23)
- Max Wind speed : 43.19 m/s (22:33 Aug. 22), Gust speed : 52.82 m/s (22:04 Aug. 22)
- Hs : 7.22 m, Hmax : 11.39 m (23:09 Aug. 22)
- Bottom Temperature(35 m): 14° -> 23° increased, Surface Salinity(5 m): 32 -> 27 psu**



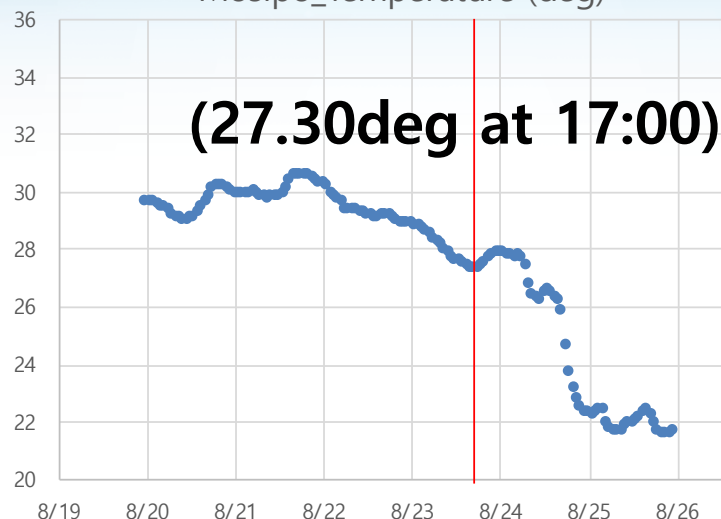
14 Moslpo Tidal Station (KHOA)



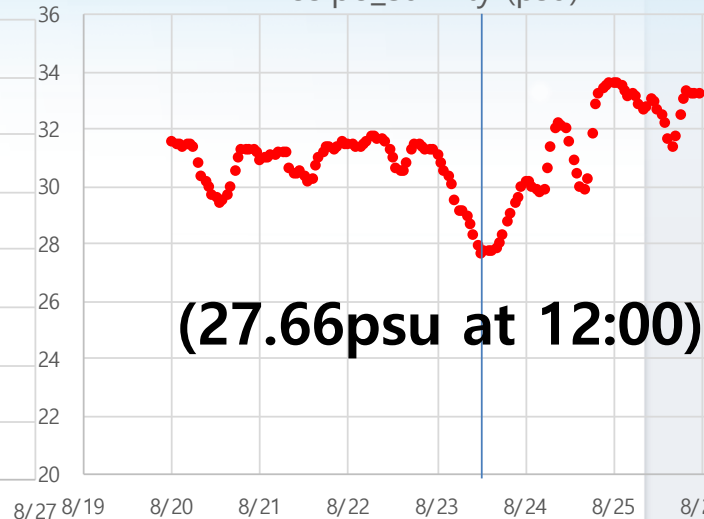
15 Moslpo Tidal Station (KHOA)



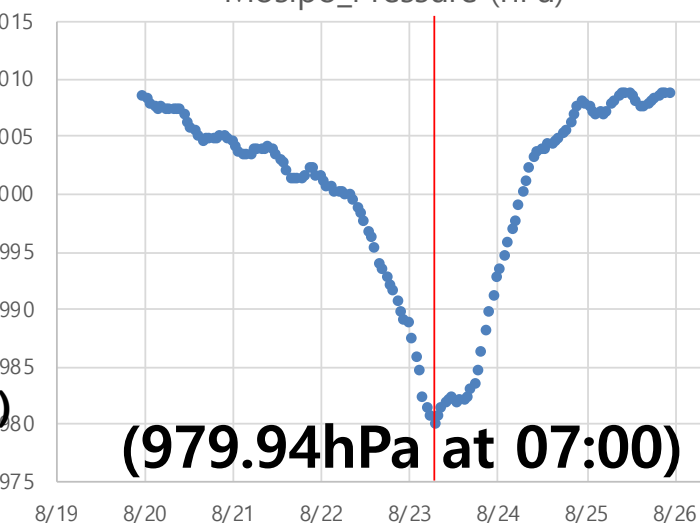
Moslpo_Temperature (deg)



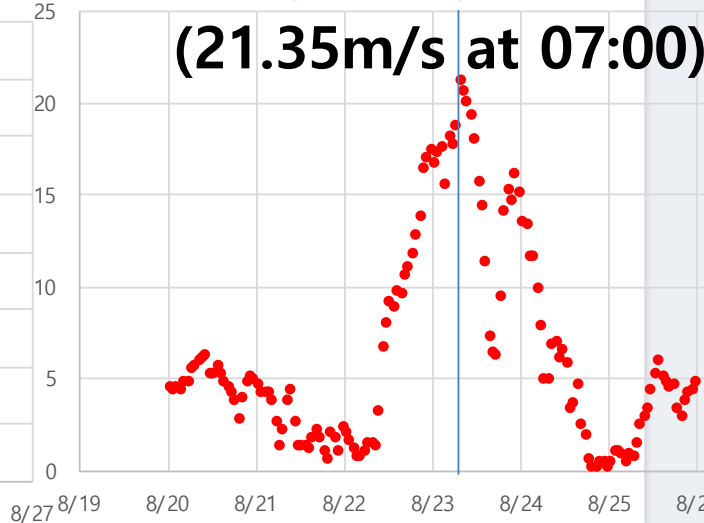
Moslpo_Salinity (psu)



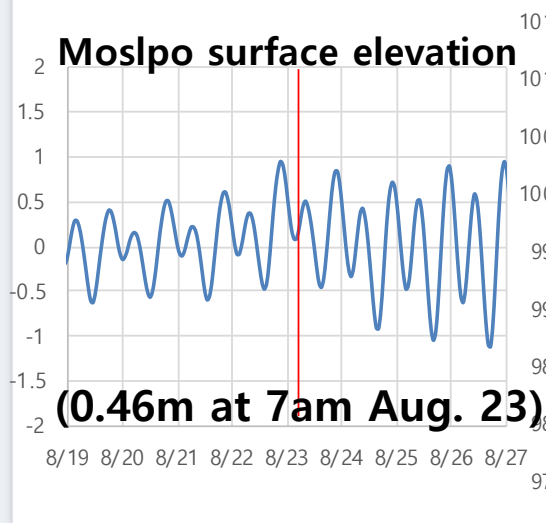
Moslpo_Pressure (hPa)



Moslpo_Wind Speed (m/s)

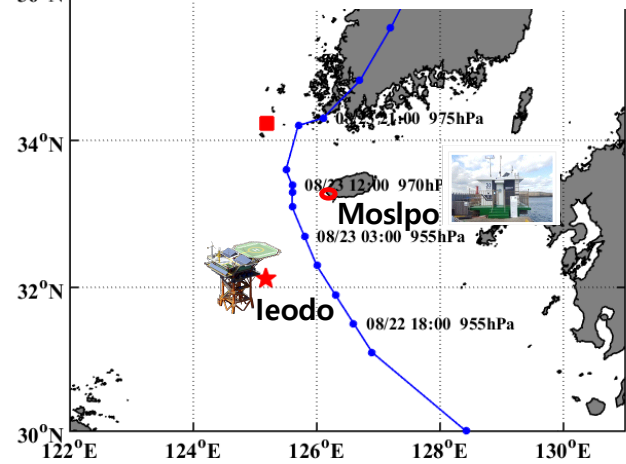
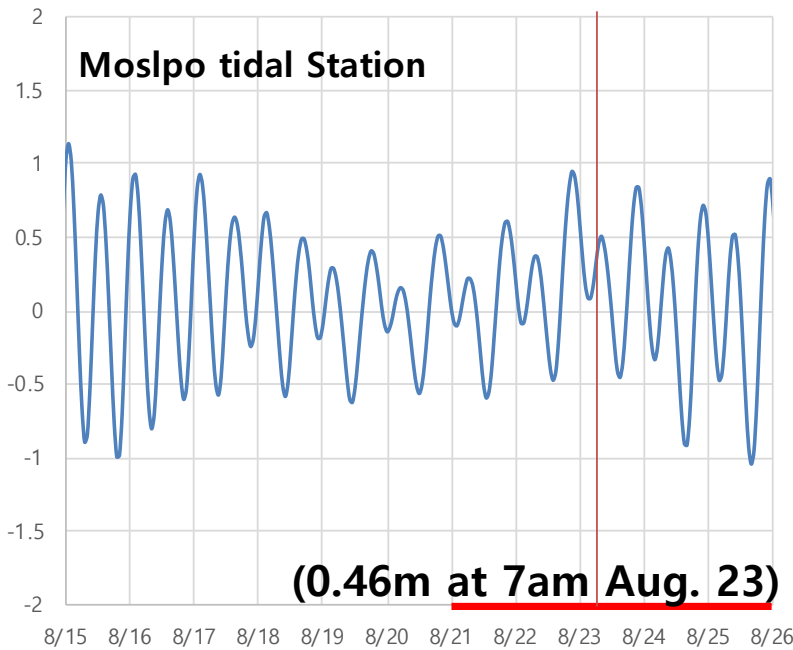


Moslpo surface elevation



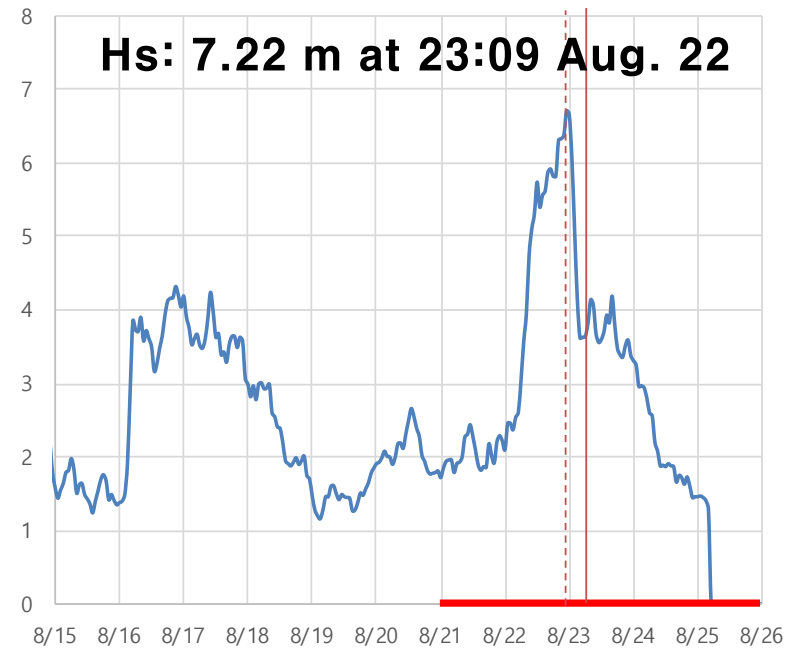
16 Moslpo (η) vs. leodo (Hs)

Moslpo_suface elevation(m)



IEODO_significant wave height(m)

Hs: 7.22 m at 23:09 Aug. 22

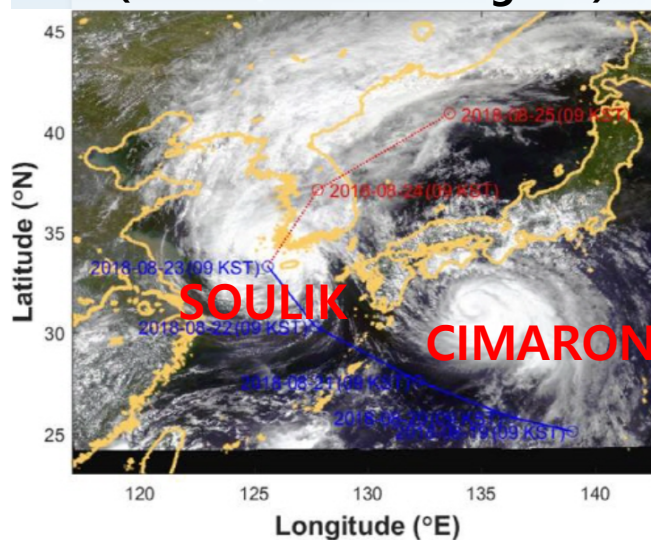


IEODO_significant wave height(m)

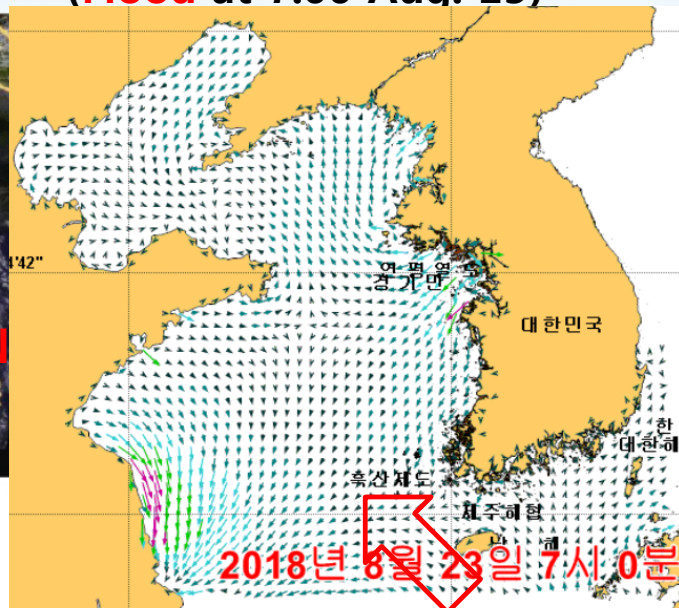


17 Tidal Current Prediction (KHOA)

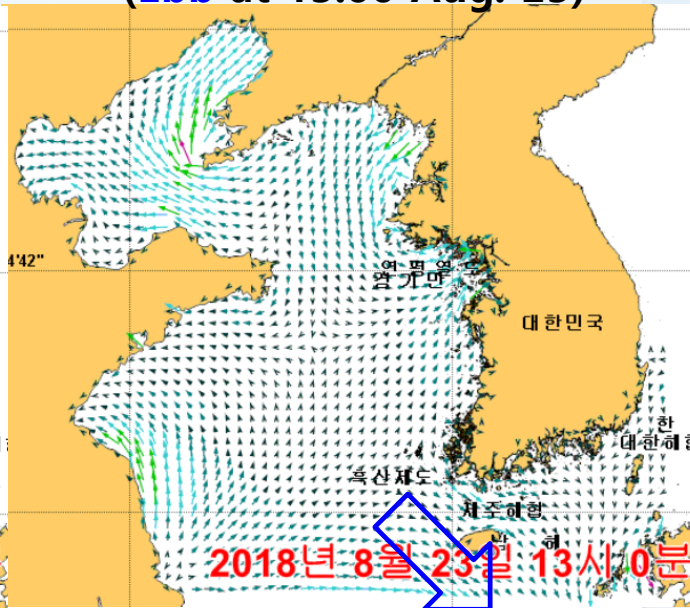
(GOCI at 12:00 Aug. 23)



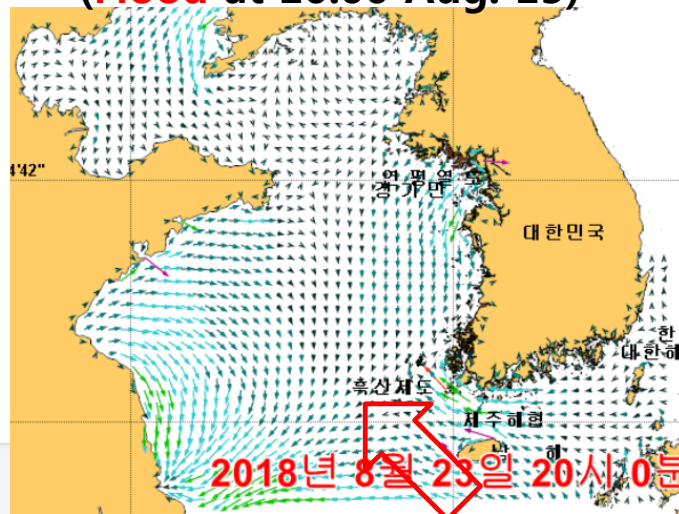
(Flood at 7:00 Aug. 23)



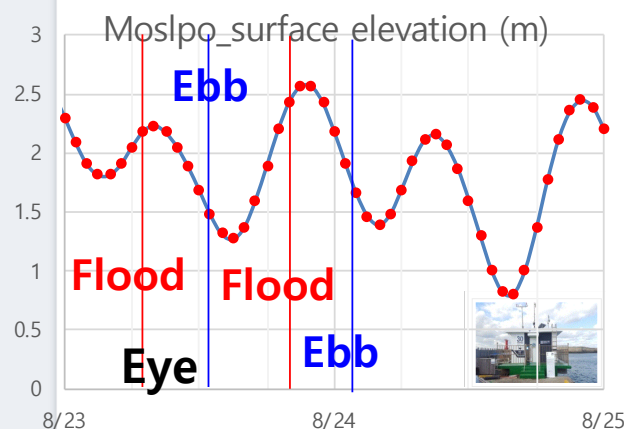
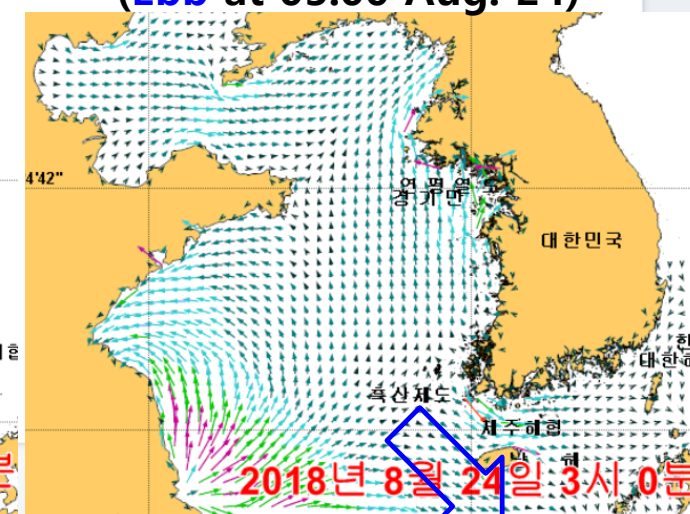
(Ebb at 13:00 Aug. 23)



(Flood at 20:00 Aug. 23)



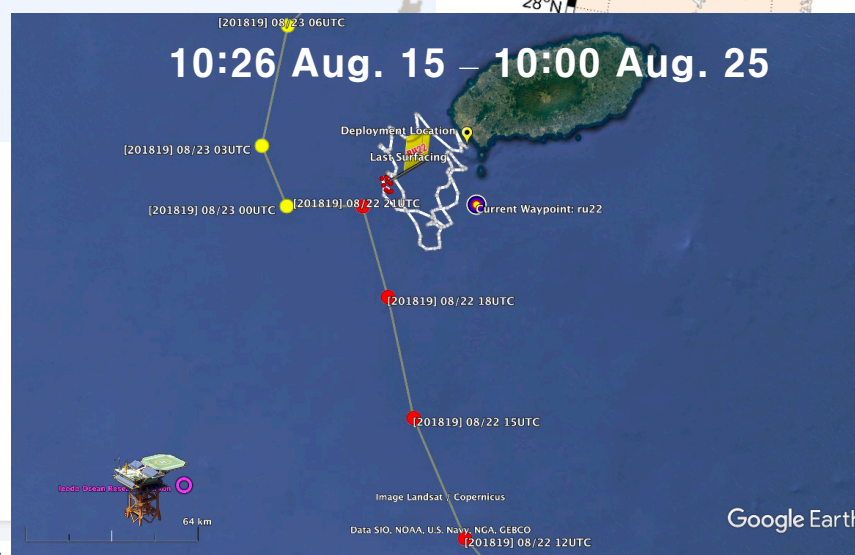
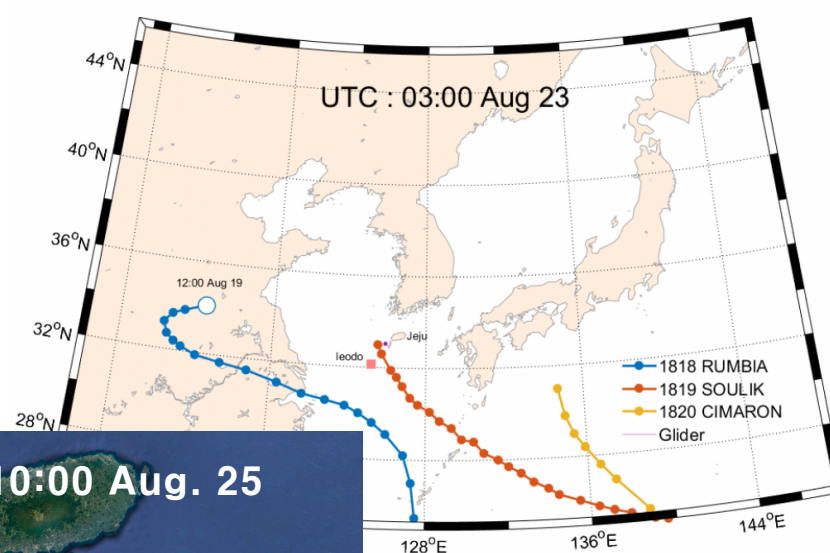
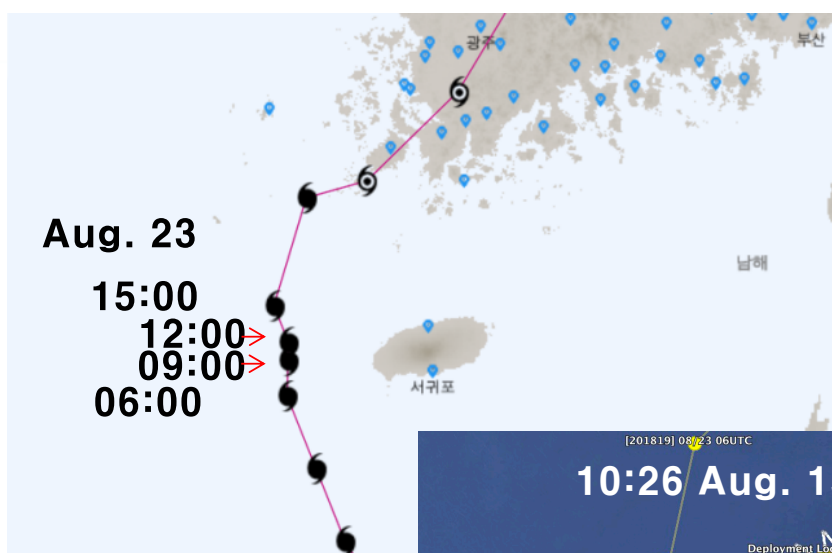
(Ebb at 03:00 Aug. 24)



(07:00 Aug.23
~03:00 Aug.24)

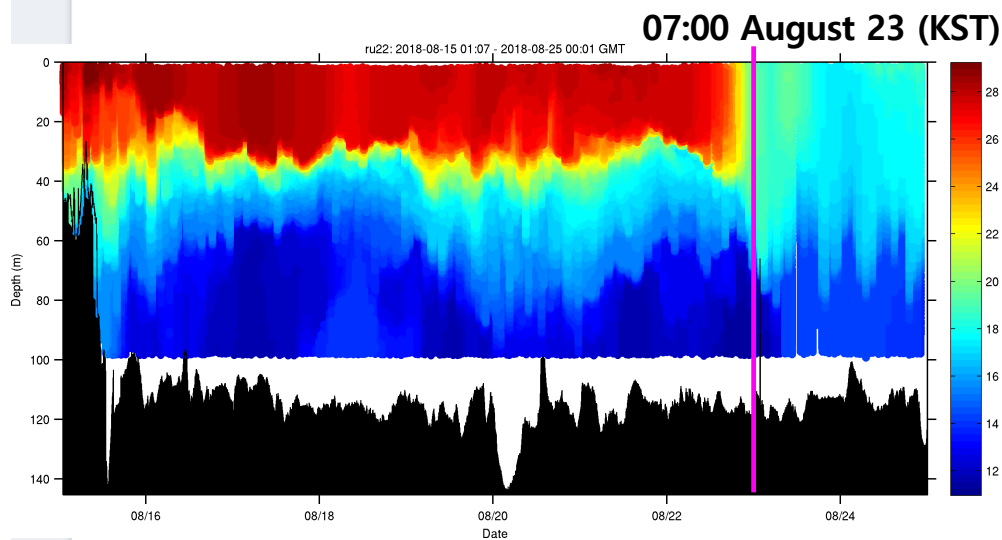
18 Glider Observation

- Typhoon SOULIK directly affected to the Glider, west Jeju Island, 06:00~15:00 Aug. 23
- Glider closely approached about 25km to the Typhoon SOULIK at 07:00, Aug. 23 (KST)
- ※ Glider was drifted Northward affected by high waves of the typhoon SOULIK

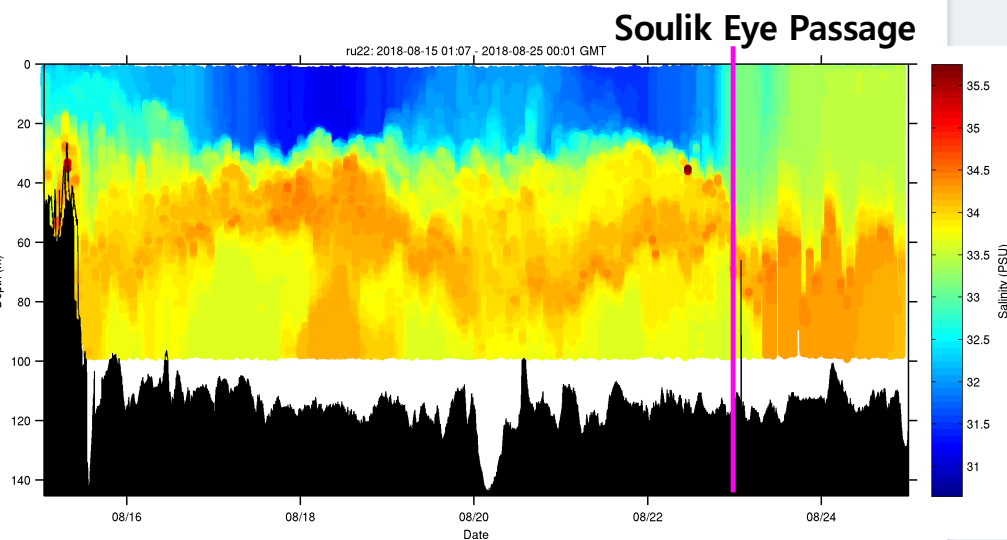


19 Glider Observation

- Min Pressure : 963.22 hPa (01:48 Aug. 23)
- Max Wind speed : 43.19 m/s (22:33 Aug. 22), Gust speed : 52.82 m/s (22:04 Aug. 22)
- Hs : 7.22 m, Hmax : 11.39 m (23:09 Aug. 22)
- Glider closely approached about 25 km to the Typhoon SOULIK at 07:00 Aug. 23
- Surface Temperature decreased: ($27.5^{\circ} \rightarrow 16.5^{\circ} \downarrow$), Salinity increased: (31psu $\rightarrow$ 33psu $\uparrow$)



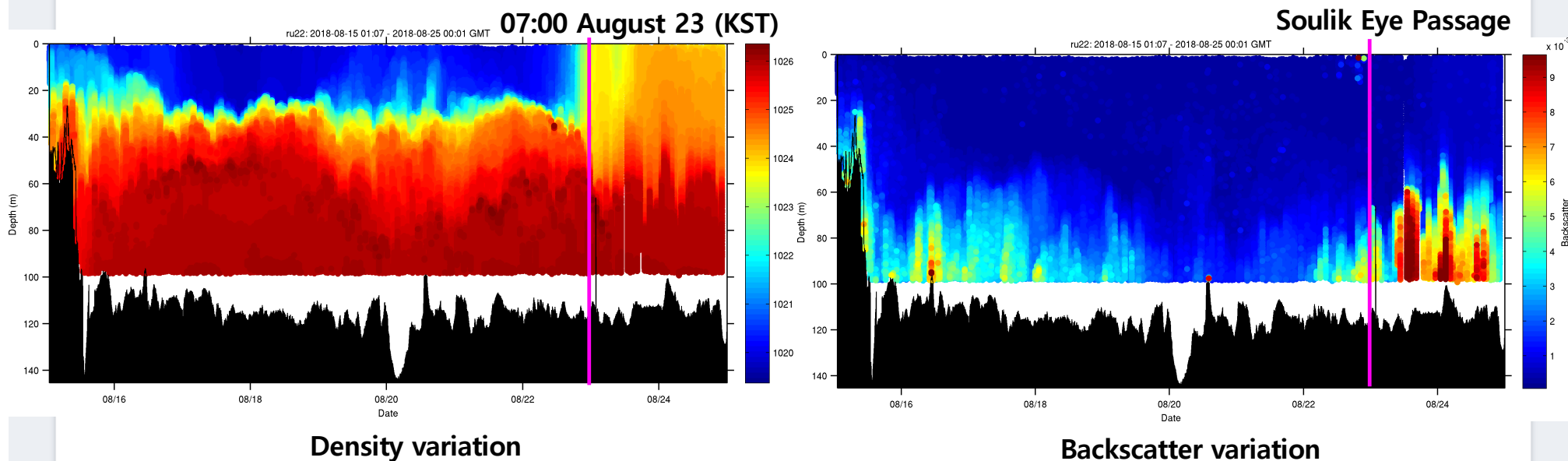
Temperature variation



Salinity variation

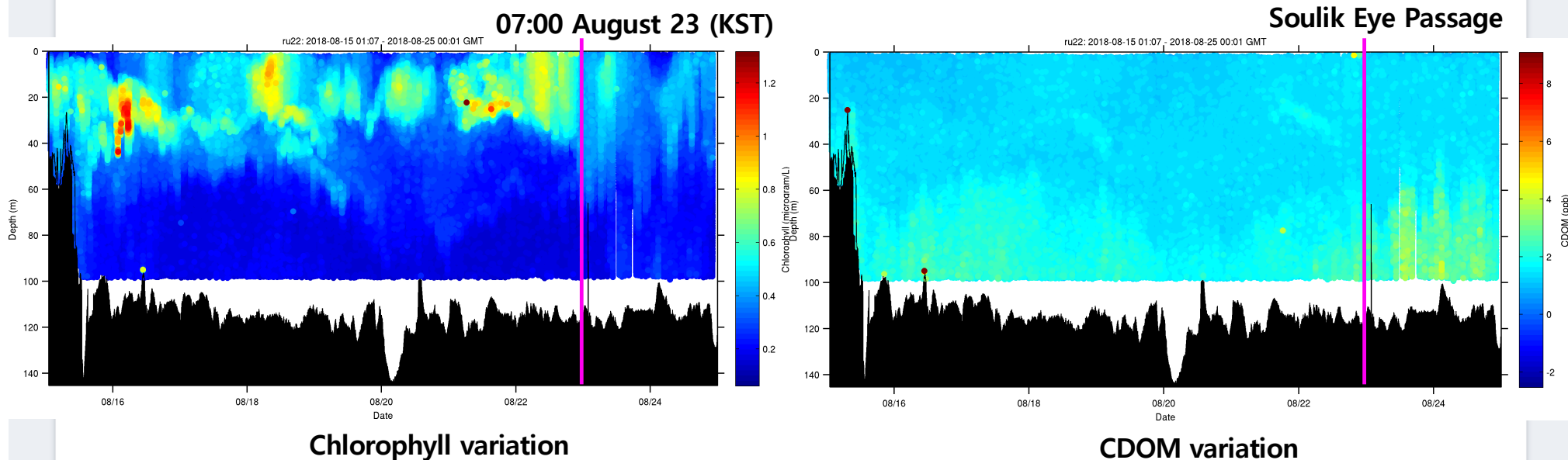
20 Glider Observation

- Min Pressure : 963.22 hPa (01:48 Aug. 23)
- Max Wind speed : 43.19 m/s (22:33 Aug. 22), Gust speed : 52.82 m/s (22:04 Aug. 22)
- Hs : 7.22 m, Hmax : 11.39 m (23:09 Aug. 22)
- Glider closely approached about 25 km to the Typhoon SOULIK at 07:00 Aug. 23
- Surface Density increased ($1020^{\circ} \rightarrow 1024^{\circ} \uparrow$), Bottom Turbidity increased



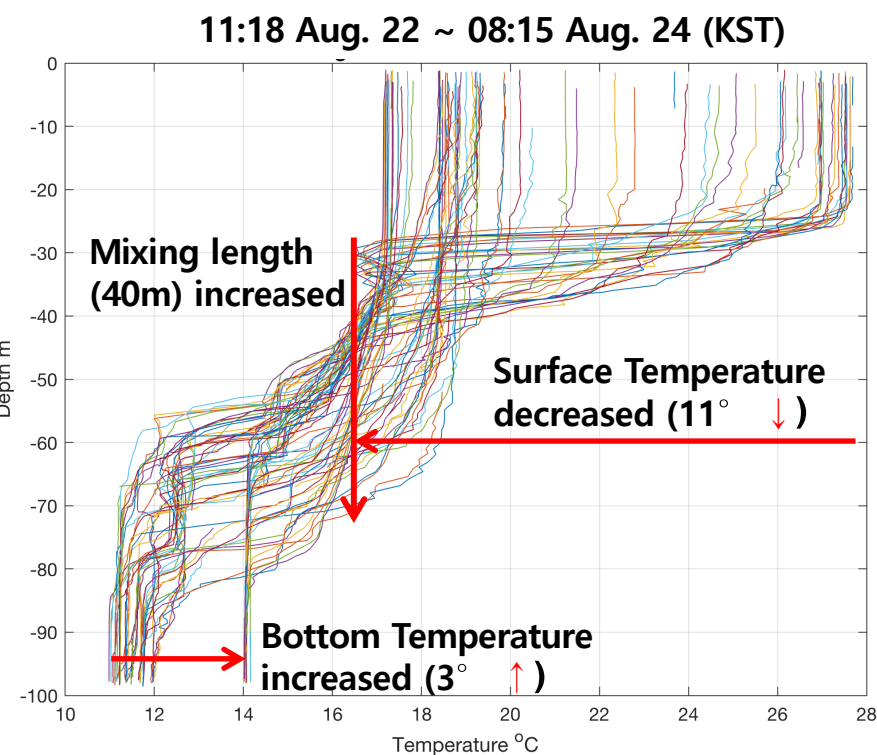
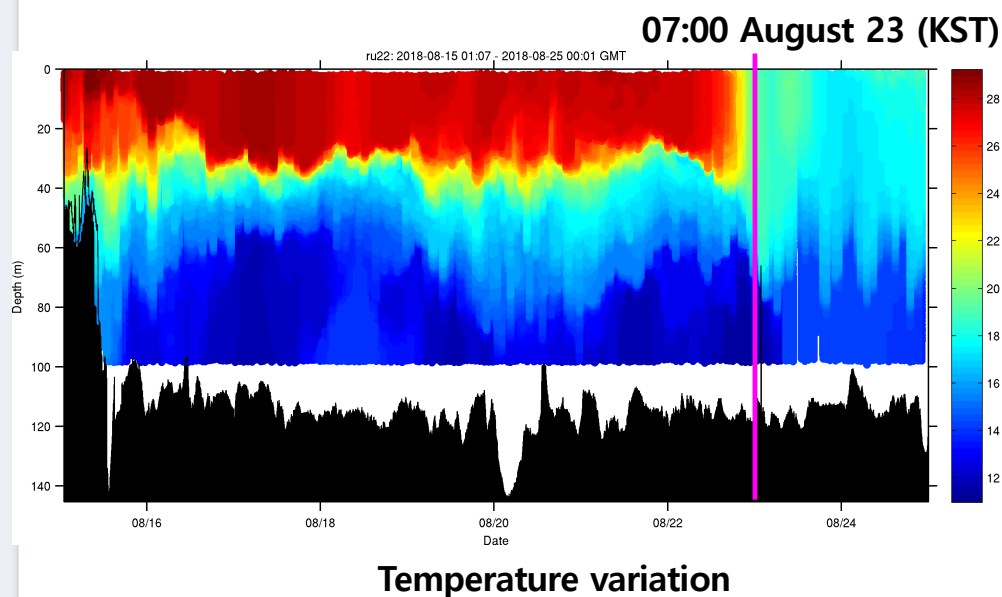
21 Glider Observation

- Min Pressure : 963.22 hPa (01:48 Aug. 23)
- Max Wind speed : 43.19 m/s (22:33 Aug. 22), Gust speed : 52.82 m/s (22:04 Aug. 22)
- Hs : 7.22 m, Hmax : 11.39 m (23:09 Aug. 22)
- Glider closely approached about 25 km to the Typhoon SOULIK at 07:00 Aug. 23
- Surface Chlorophyll decreased, Bottom Dissolved Organic Matter increased**

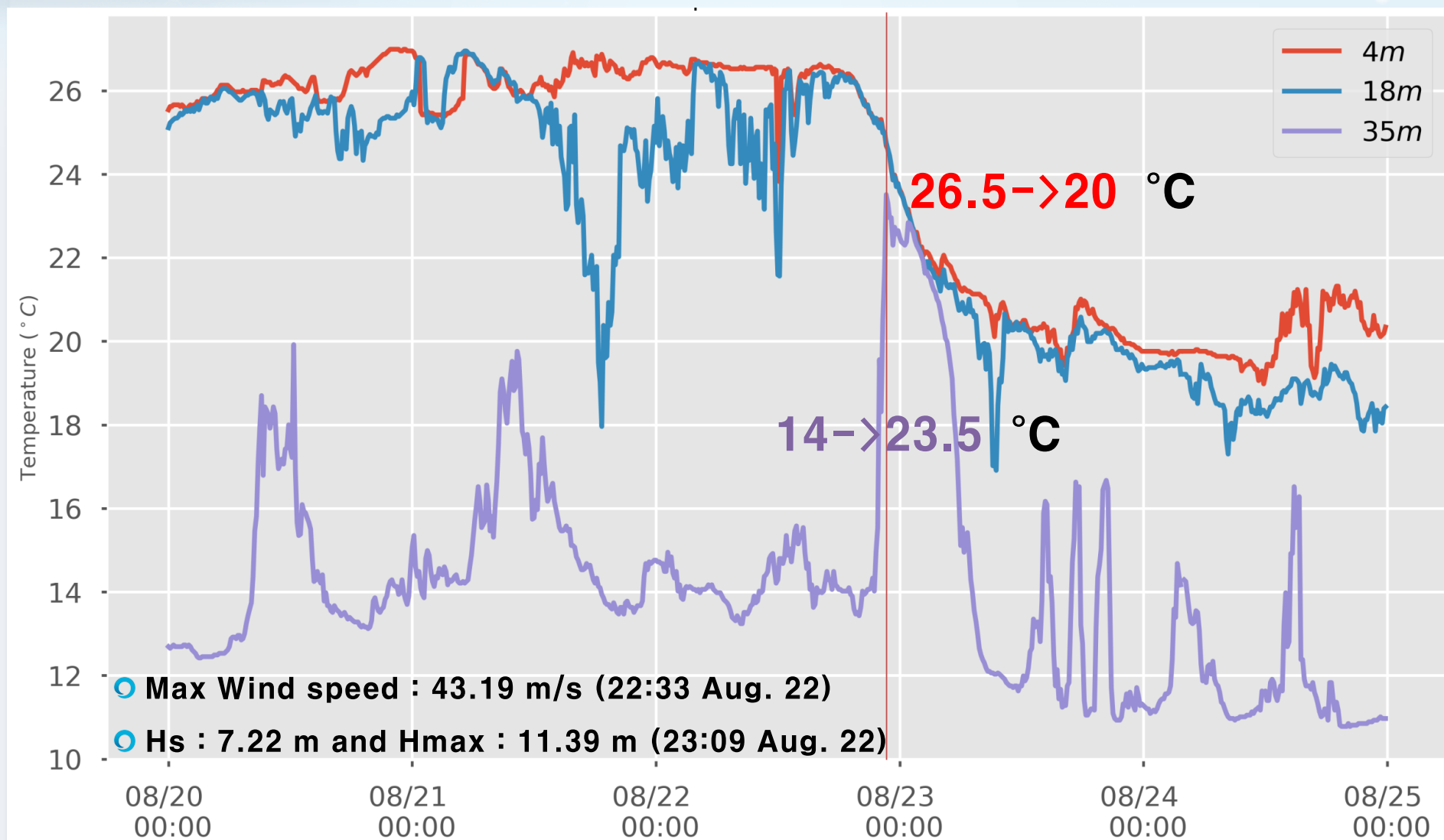


22 Glider Observation

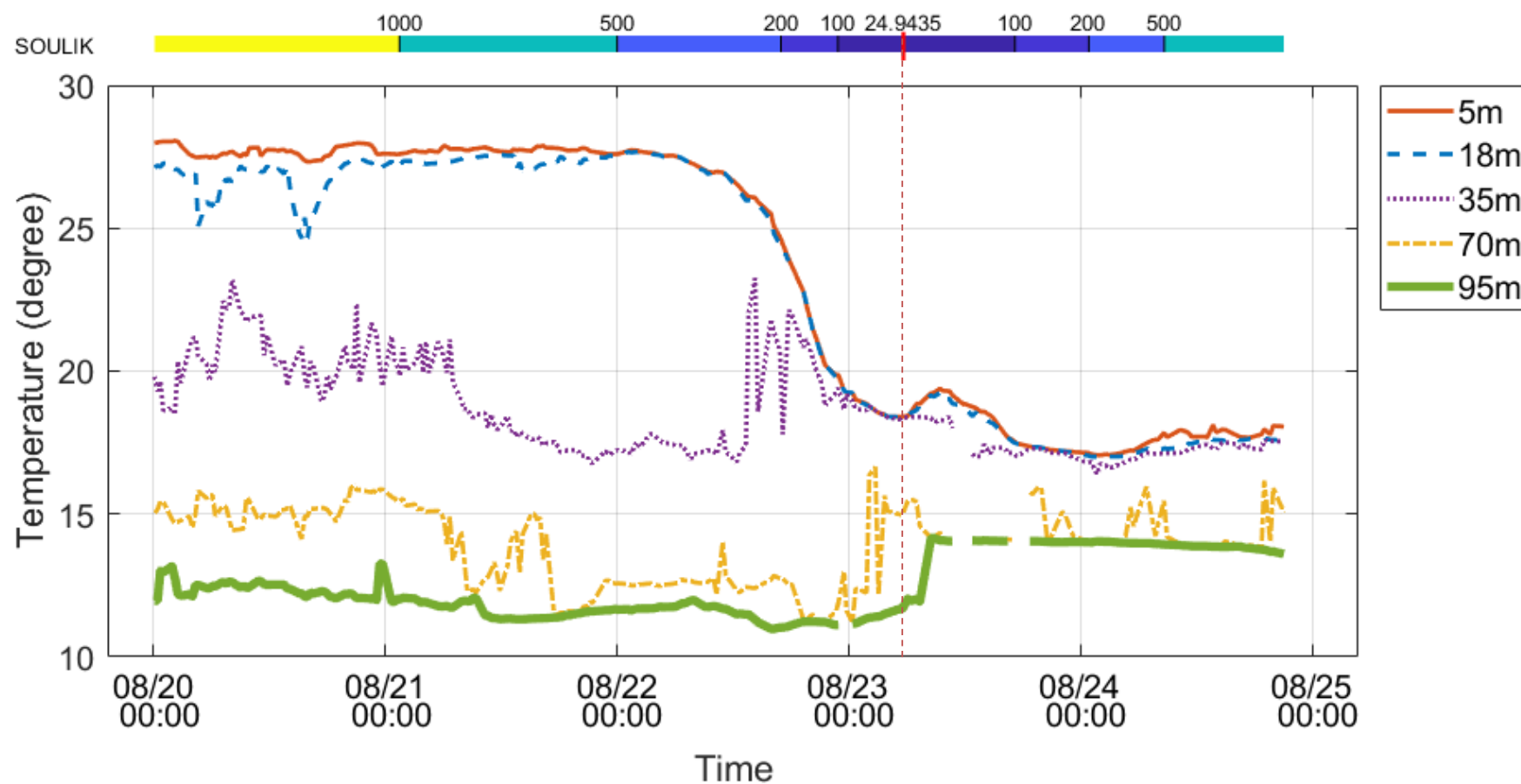
- Min Pressure : 963.22 hPa (01:48 Aug. 23)
- Max Wind speed : 43.19 m/s (22:33 Aug. 22), Gust speed : 52.82 m/s (22:04 Aug. 22)
- Hs : 7.22 m, Hmax : 11.39 m (23:09 Aug. 22)
- Glider closely approached about 25 km to the Typhoon SOULIK at 07:00 Aug. 23
- Temperature mixing: ($27.5^{\circ} \rightarrow 16.5^{\circ} \downarrow$), Salinity mixing: (31psu $\rightarrow$ 33psu $\uparrow$) at surface
- Mixing length was increased about 40 m from 30 to 70 m water depth



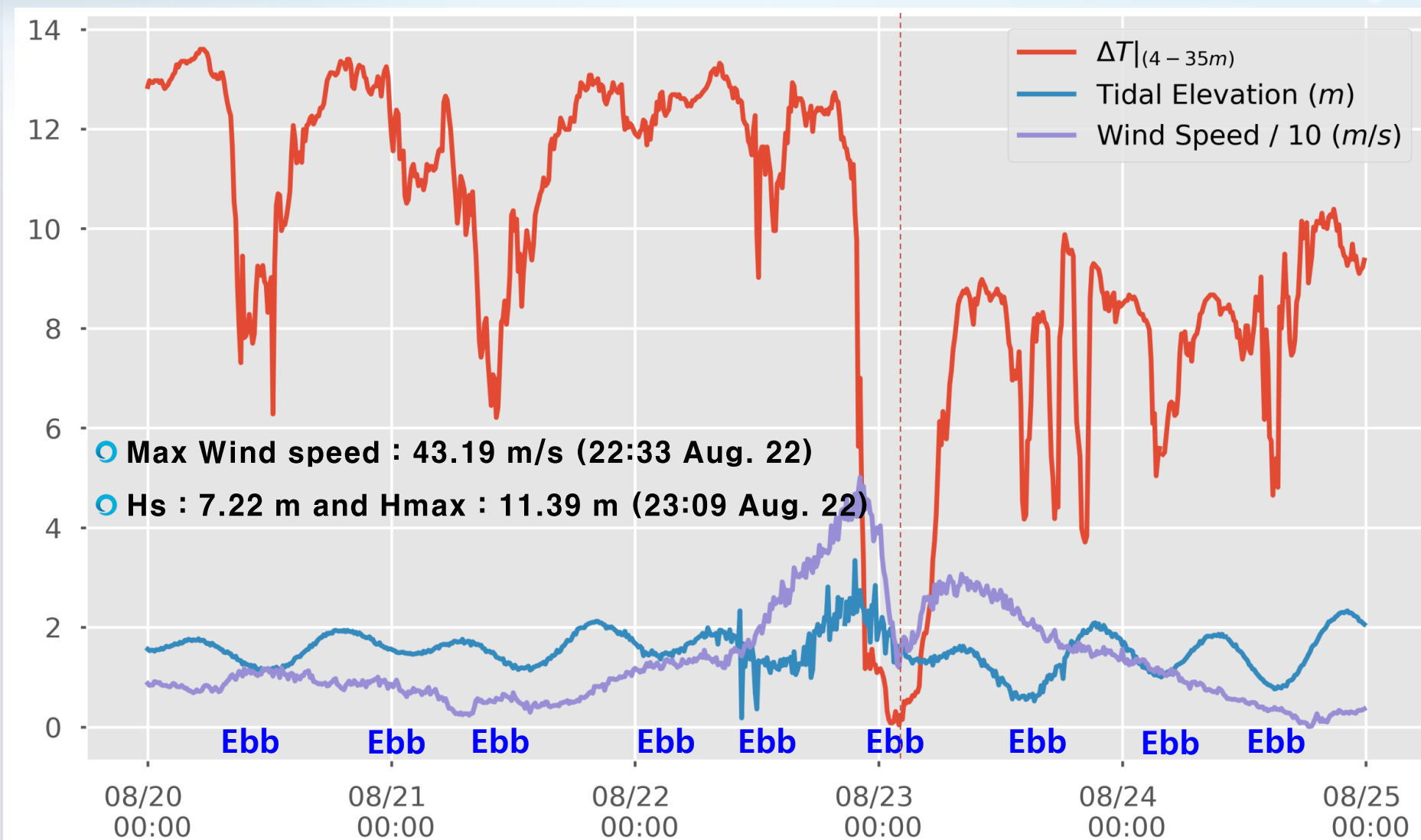
23 Data Analysis (IEODO: Rapid ocean mixing)



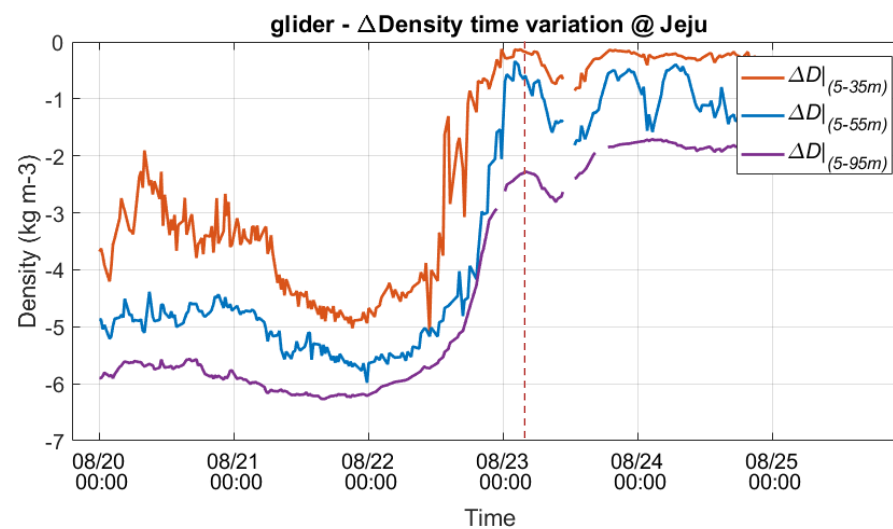
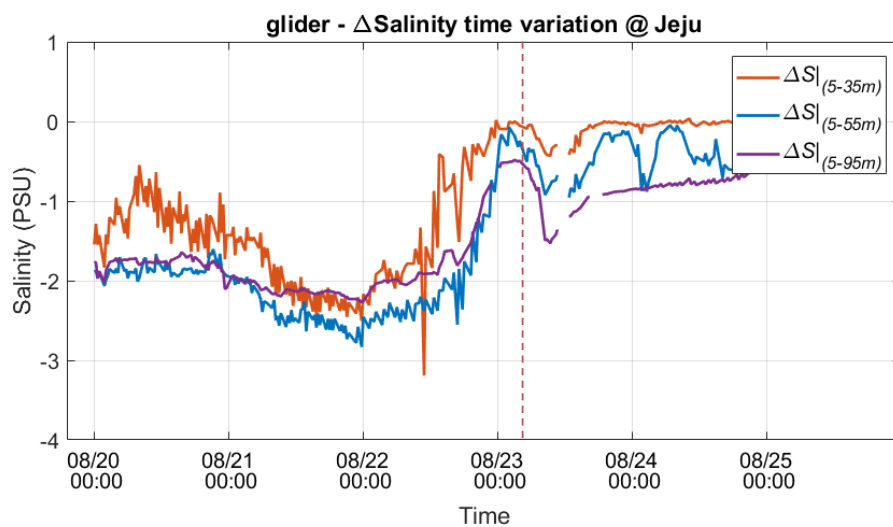
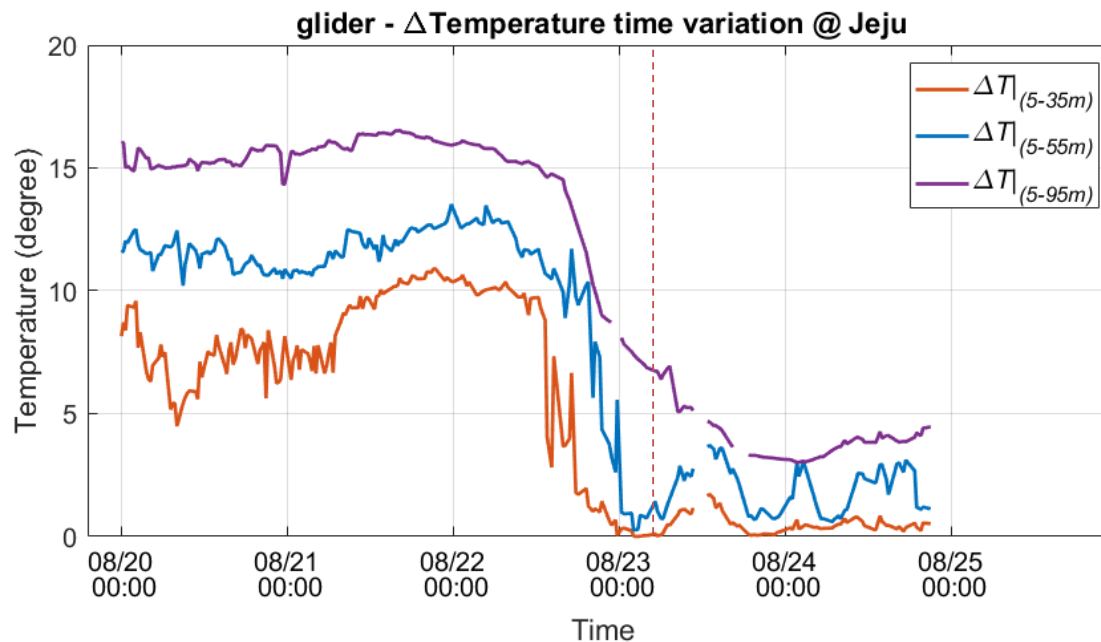
23 Data Analysis (Glider: Rapid ocean mixing)



24 Data Analysis (IEODO: ΔT vs tides and winds)

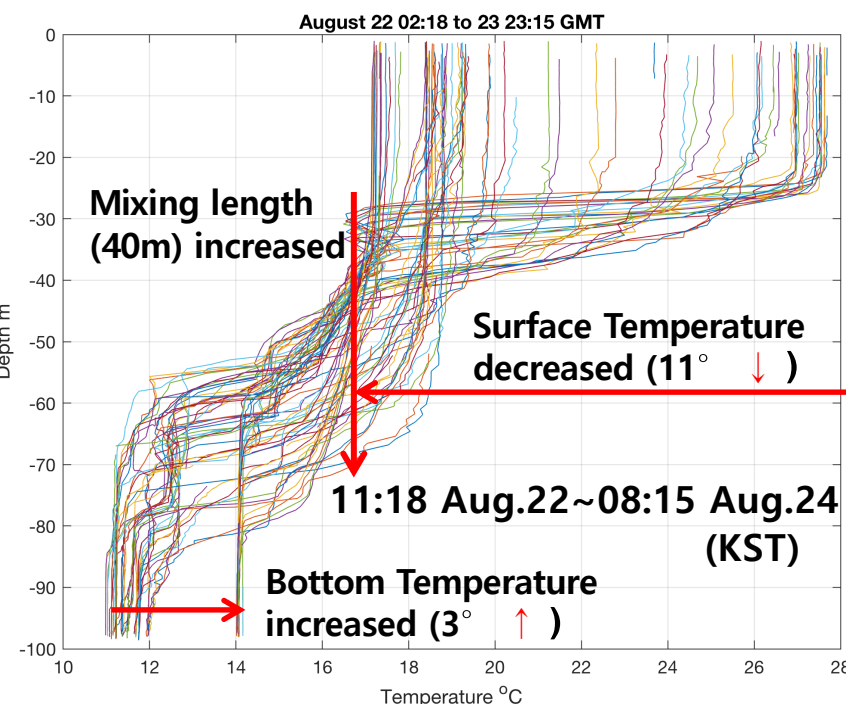
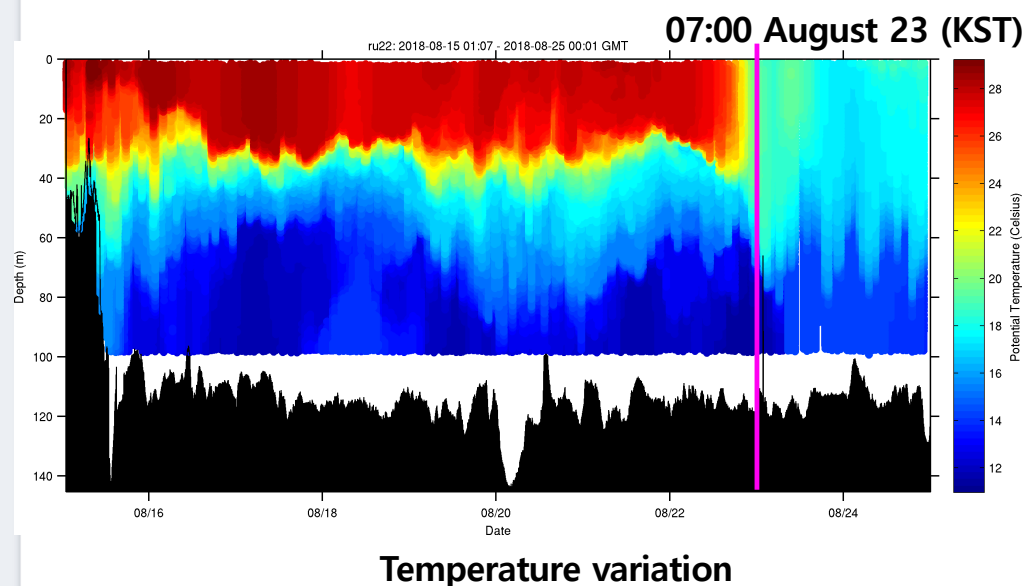


24 Data Analysis (Glider: ΔT , ΔS , ΔD)



25 Conclusions

- Typhoon SOULIK was observed at tidally dominated and stratified waters of Jeju, Korea
- IEODO observation: Pressure 963.22 hPa (01:48 8/23, KST), Hs 7.22 m (23:09 8/23, 2018)
- Glider closely approached about 25 km to the typhoon SOULIK at 07:00, August 23 (KST)
- **Ocean mixing**: Surface Temperature decreased ($27.5^{\circ} \rightarrow 16.5^{\circ}$, $11^{\circ} \downarrow$), Salinity increased
- **Mixing length layer** was increased about **40 m** from 30 to 70 m by the typhoon SOULIK
- **Rapid mixing** coincided with **a tidal transition** before/after sustained winds and waves
- **Rapid ocean destratification** was observed by **Typhoon Soulik and its interaction with** tidally dominated and highly stratified coastal ocean waters west of Jeju, Korea



Thank you

