Technology and application of Petrel gliders

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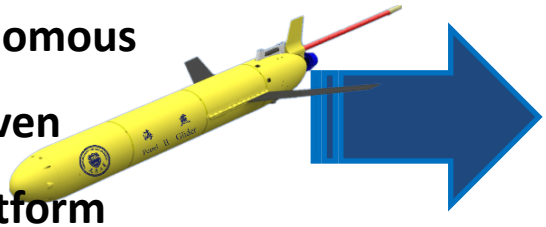
1 Petrel Underwater Glider

Underwater Glider

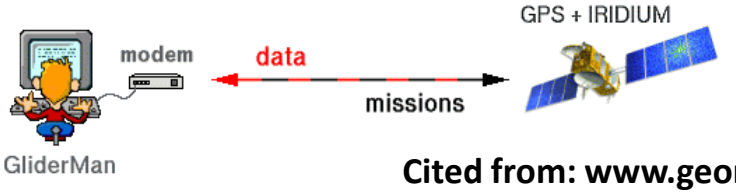
Unmanned Autonomous

Buoyancy-Driven

Observation Platform

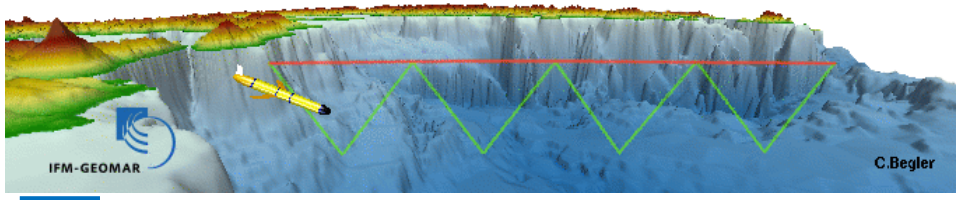


Operating principle

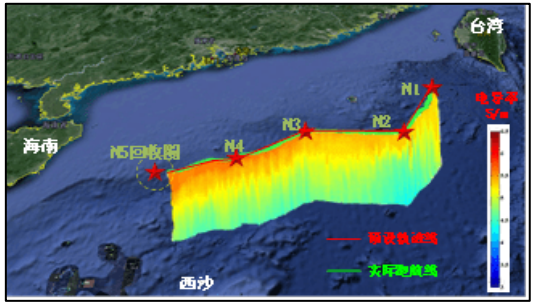


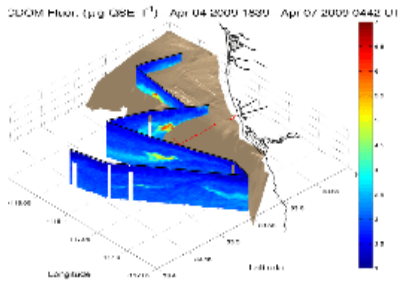
Cited from: www.geomar.de

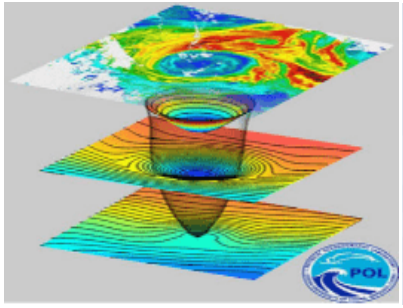
Observational Sea Trial

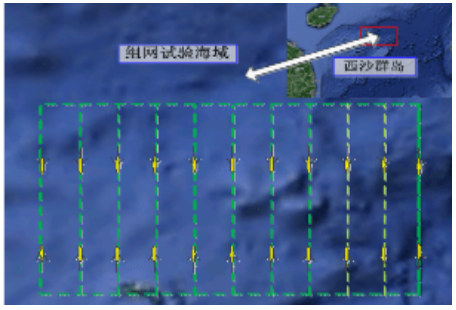


Material and data





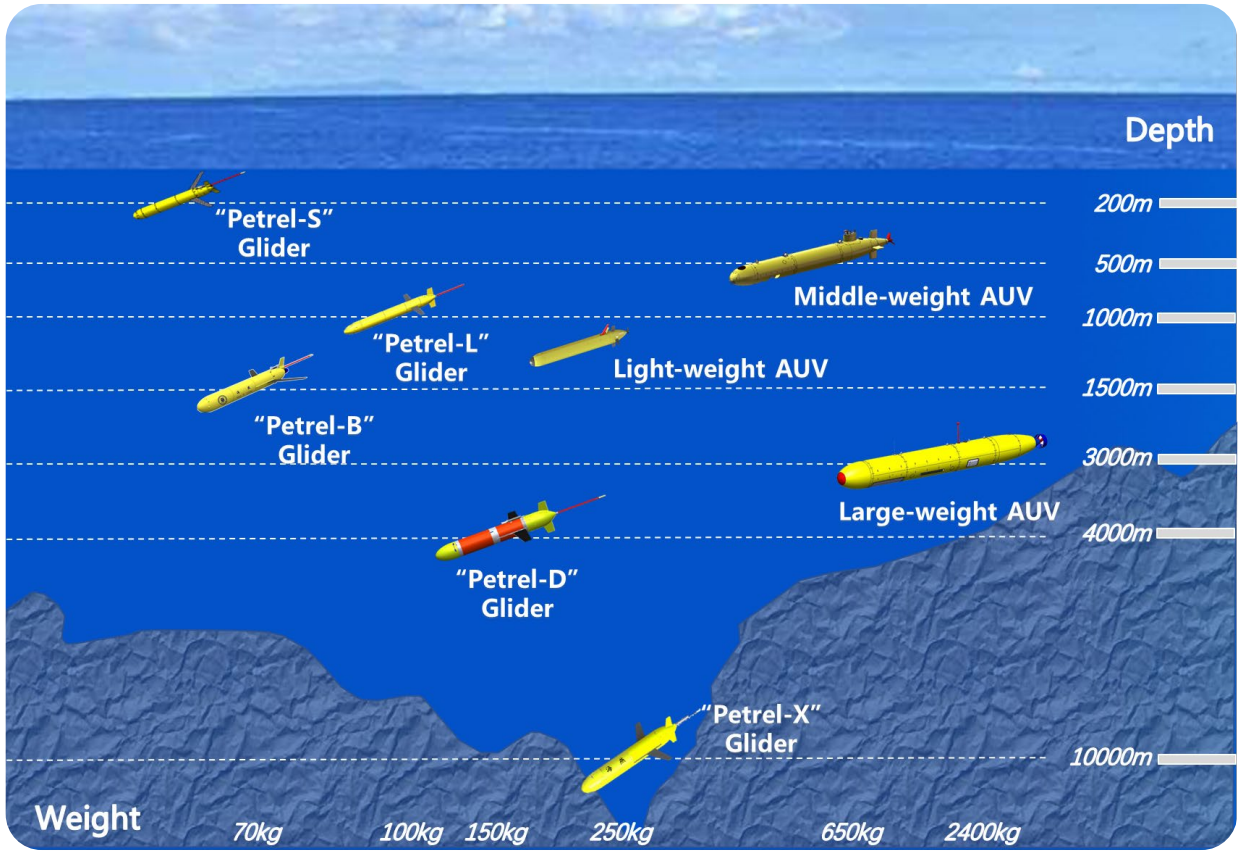




1 Petrel Underwater Glider

➢ Underwater Glider Pedigree

- Working depth: 200m/1000m/1500m 4000m/11000m
- Weight:70kg/100kg /150kg/250kg



➢ AUV

- Light-weight AUV
- Middle-weight AUV
- Large-weight AUV

1 Petrel Underwater Glider

- CTD/Dissolved oxygen sensor
- Microstructure turbulence profiler
- ADCP
- Hydrophone
- Underwater acoustic communication set
- Turbidity meter
- Chlorophyll fluorimeter
- γ-ray sensor/radiometer
- Optical backscatter sensor
- Phycobilin sensor
- Electromagnetic sensor
- ……

Application Fields

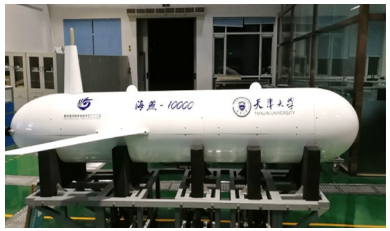
- Dynamic Environmental Parameters Observation
- Acoustic parameters observation
- Ecological and biochemical parameters observation

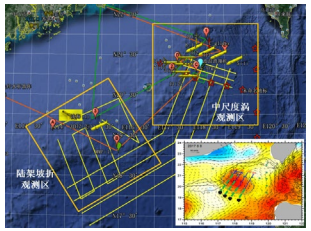
1 Petrel Underwater Glider

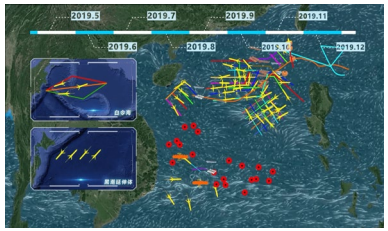
Data Highlights

Currently, Petrel gliders have completed more than 50,000 profiles in total, with a total voyage of more than 150,000 km.

- In July 2020, Petrel-X ^{PLUS} glider dove to 10,619m and created a new world record;
- Till May 2020, Petrel-L long-endurance underwater glider had operated for duration of more than 300 days and endurance of more than 4,000km ;
- Since May 2019, Petrel gliders have performed large-scale network observation of the ocean phenomena in South China Sea, including mesoscale eddies and typhoons;
- During June-July 2017, 7 Petrel gliders formed a network and completed the world's first underwater-glider-based typhoon observation.





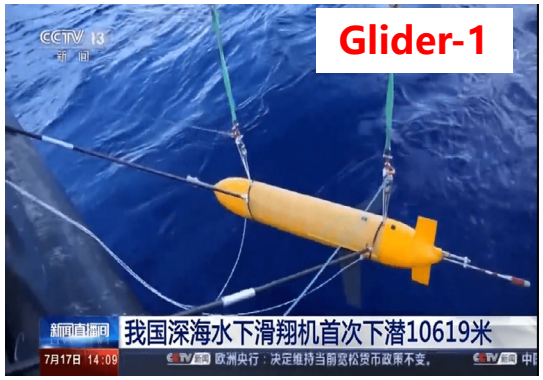


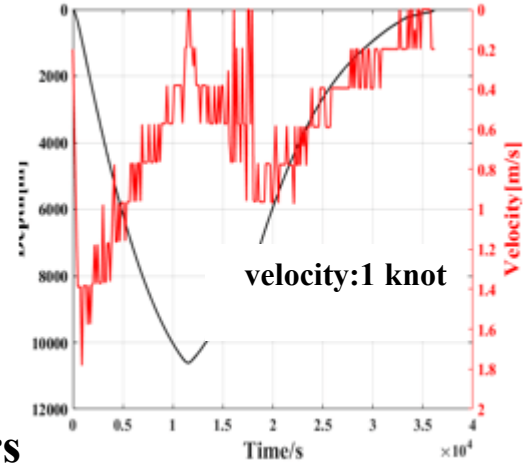
1 Petrel Underwater Glider

New World Record (2020)

"Petrel-X PLUS" Glider

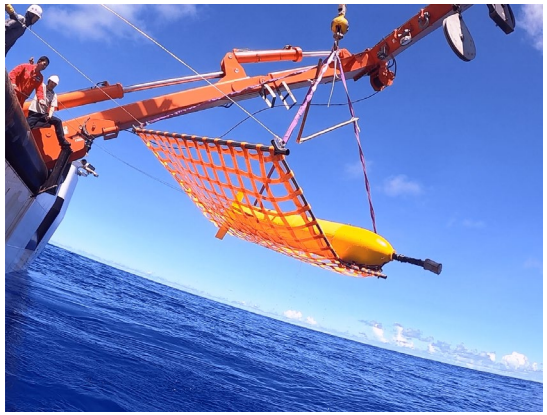
Deployment

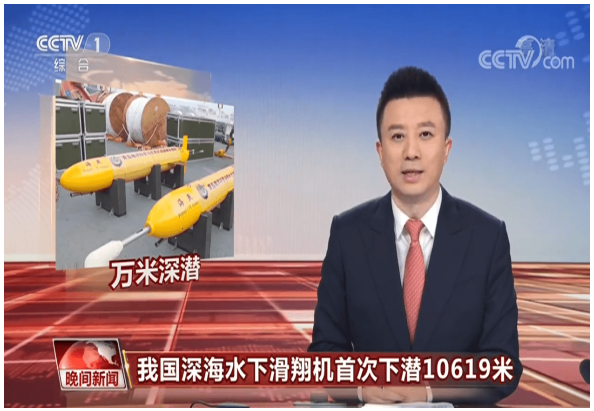


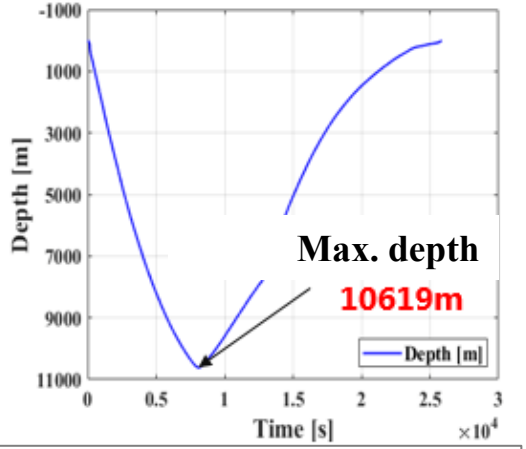


Technology and application of Petrel gliders

Recovery



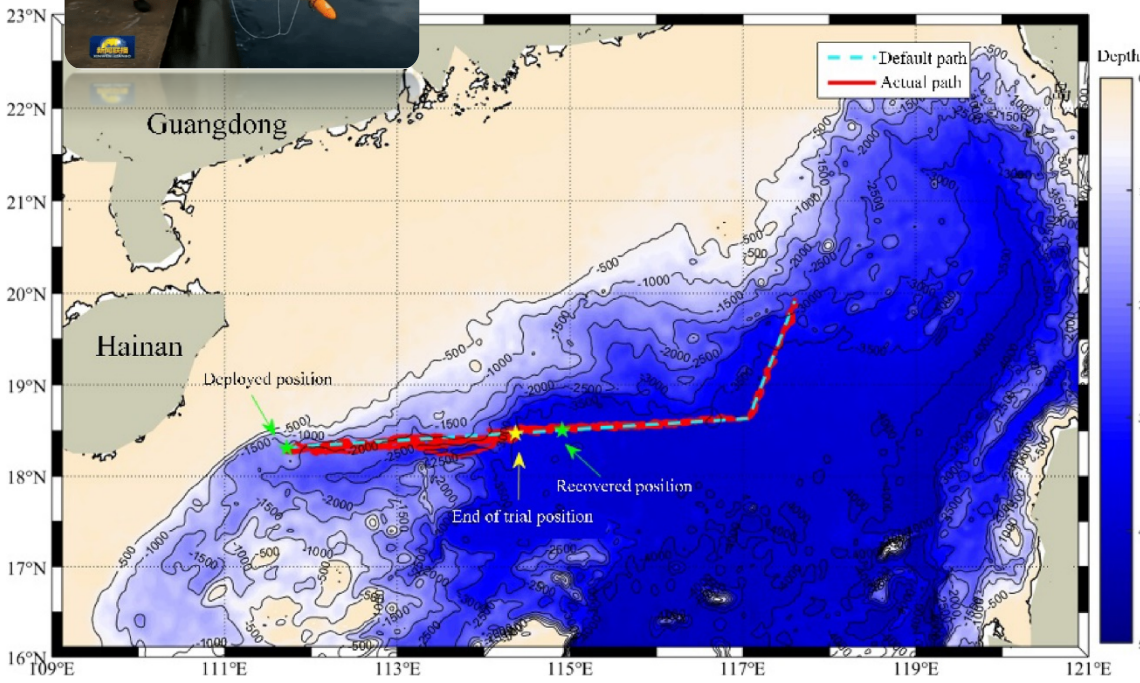




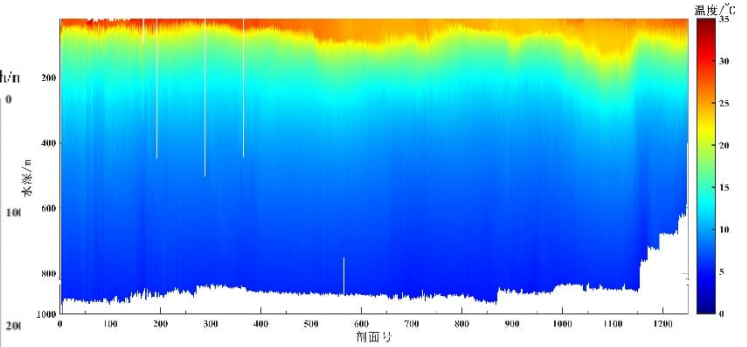
In July 2020, "Petrel-X PLUS" glider performed a comprehensive survey and dove to 10,245m, 10,347m, and **10,619**m in three profiles, breaking the **world record for deepest dive** by underwater glider.

1 Petrel Underwater Glider

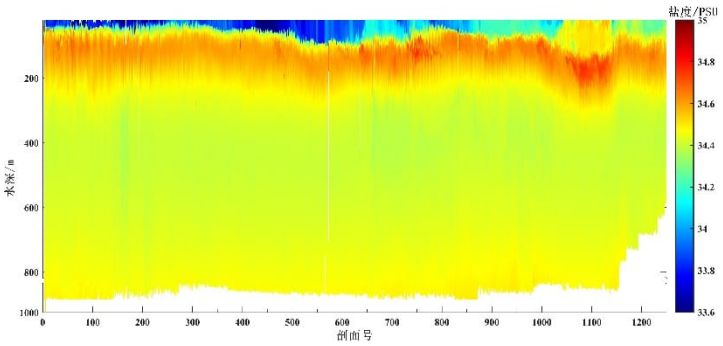
Petrel-L long-endurance glider



Temperature



Salinity



In 2020, Petrel-L travelled in South China Sea for 301 continuous days, completing 1250 profiles and a voyage of 4435 km.

2 Application in environmental observation (network)

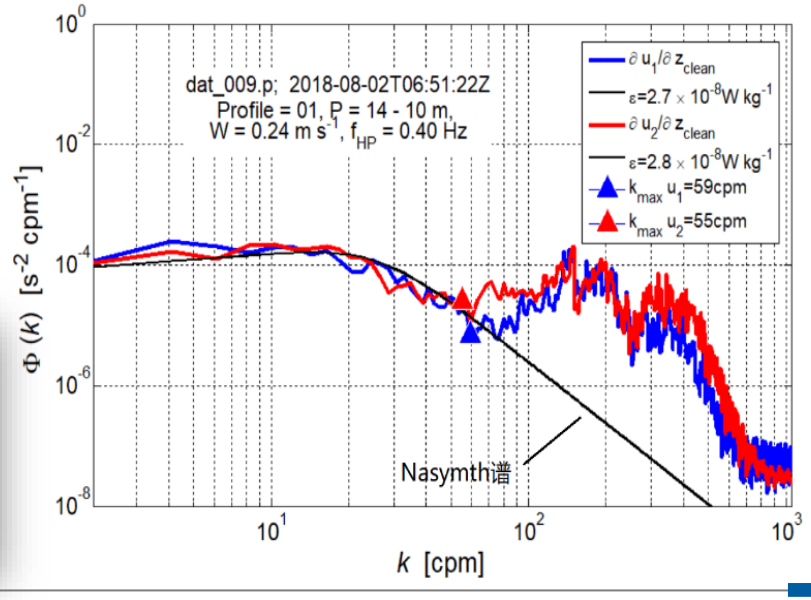
The 10th Chinese National Arctic Research Expedition

On August 25, 2019, the Petrel glider fleet carried out temperature, salinity and dissolved oxygen observation in the Bering Sea.

2 Application in environmental observation (network)

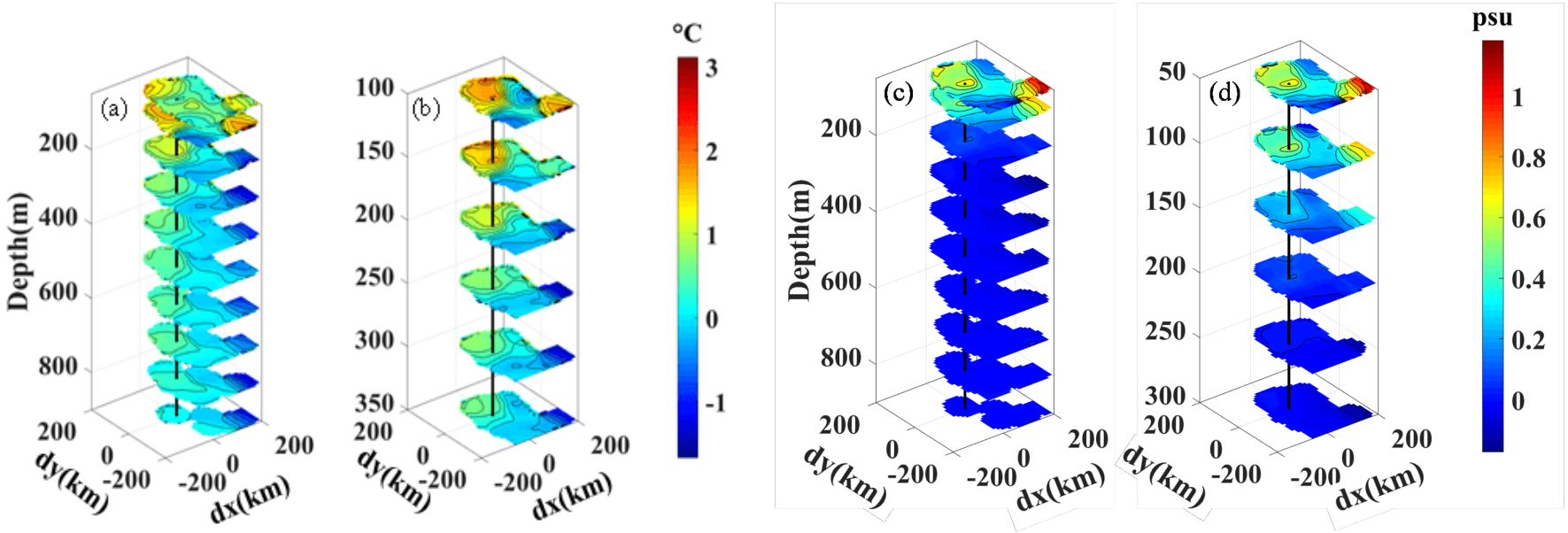
Sixth segment of China's first global ocean comprehensive scientific expedition, IODP Expedition 46

In April 2018, the Petrel gliders performed mission of the Sixth segment of China's first global ocean comprehensive scientific expedition, and conducted ocean turbulence observation for the first time.



2 Application in environmental observation (network)

In July 2017, Petrel gliders performed observation of the mesoscale eddy in the South China Sea, and the 3D structure analysis of the eddy was made based on the data obtained.

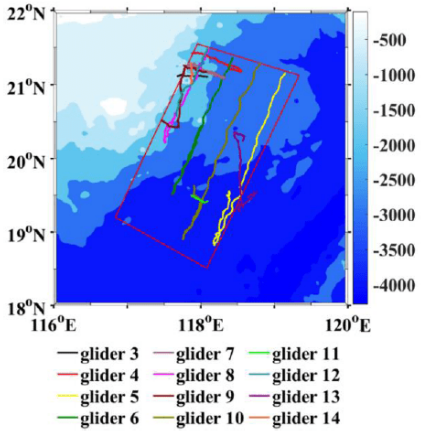


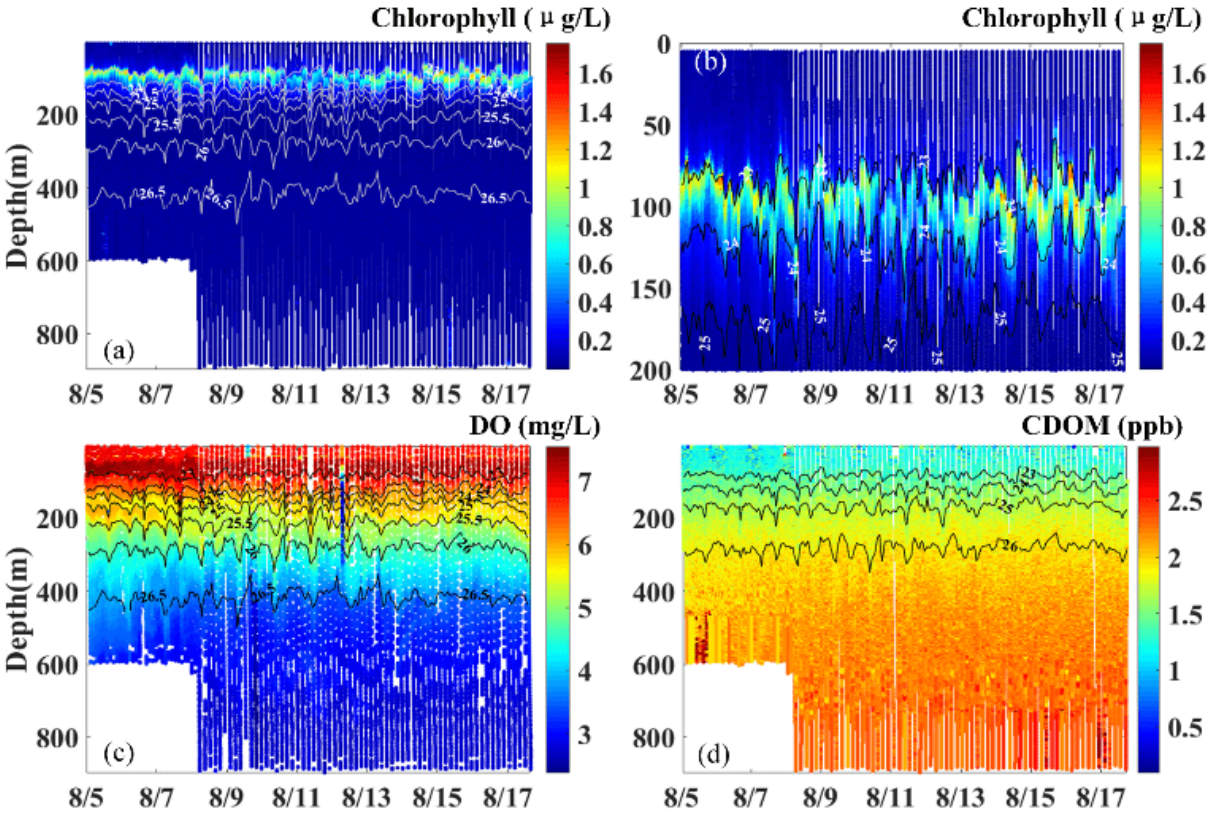
Three-dimensional analysis result of mesoscale eddy based on network observation data obtained by underwater gliders

(a) Potential temperature anomaly above 900 m; (b) Potential temperature anomaly above 350 m; (c) Density anomaly above 900 m; (d) Density anomaly above 300 m

2 Application in environmental observation (network)

In 2017, Petrel glider performed biochemical observation in South China Sea.





Vertical distribution of chlorophyll, colored dissolved organic matter, and dissolved oxygen concentration

(a) Chlorophyll concentration;

(b) Chlorophyll concentration above 200m;

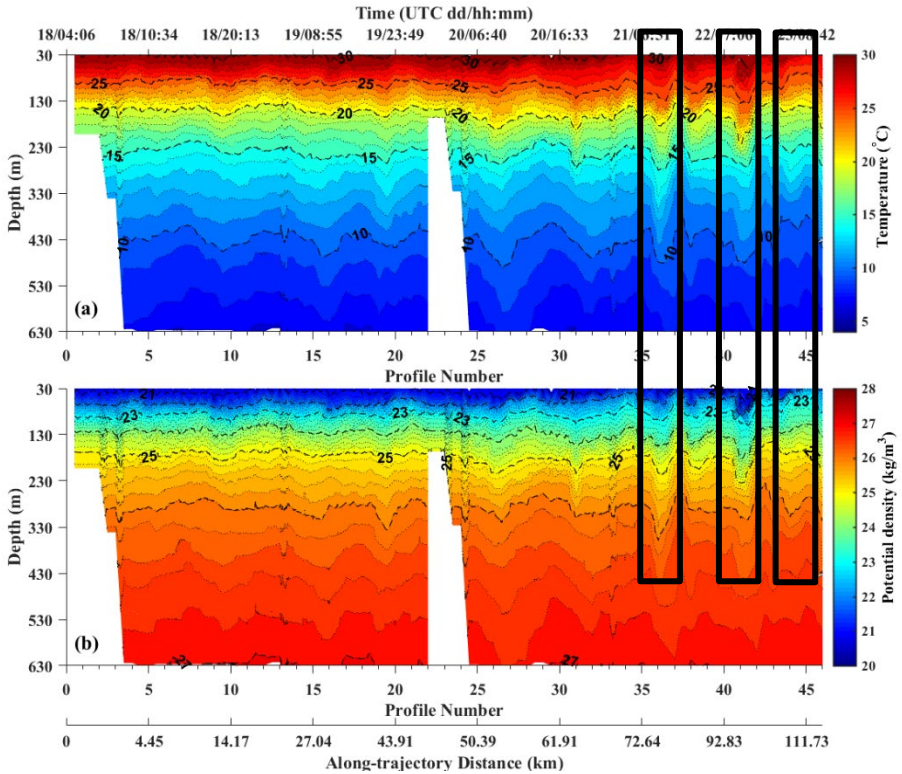
(c) Colored dissolved organic matter concentration;

(d) Dissolved oxygen concentration。

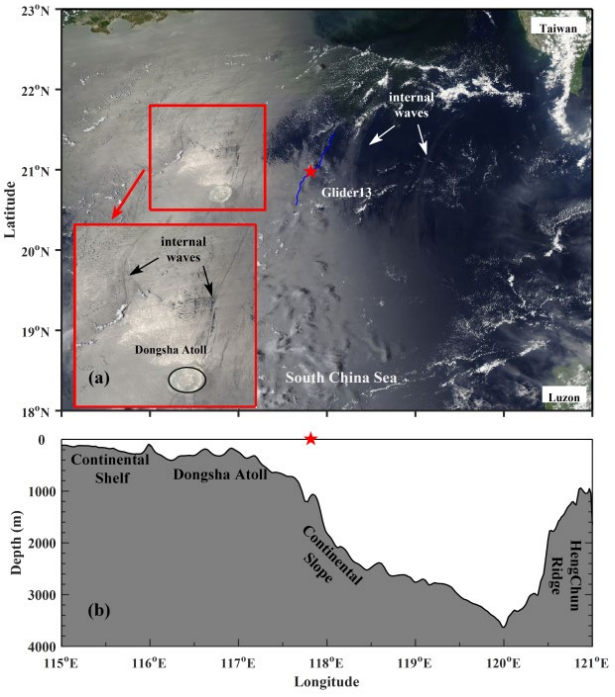
The black and grey contour lines denote the potential density.

2 Application in environmental observation (network)

During the survey in SCS, the Petrel glider captured the internal solitary waves (ISWs) and the thermohaline fluctuation is verified to be caused by the ISWs, according to the analysis of a MODIS true-color image.



Fluctuations of temperature, potential density fields observed by underwater gliders

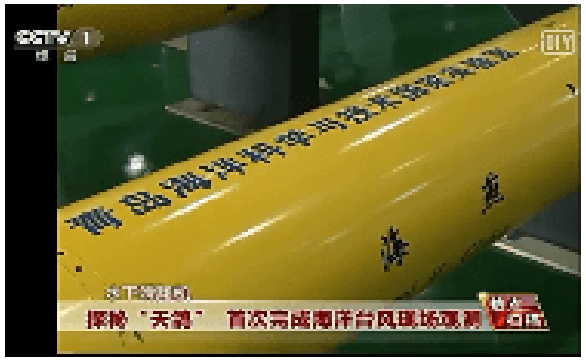


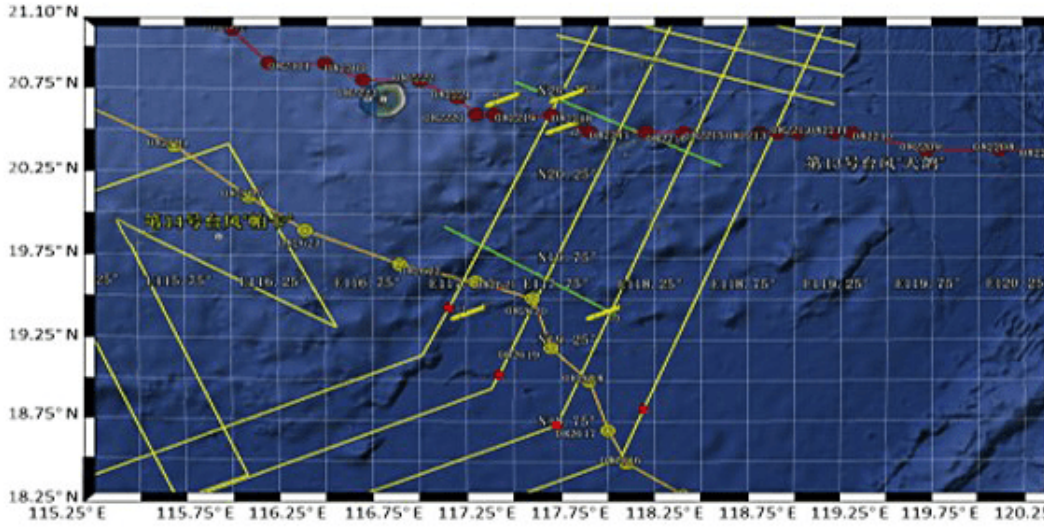
The ISW identified by a MODIS image

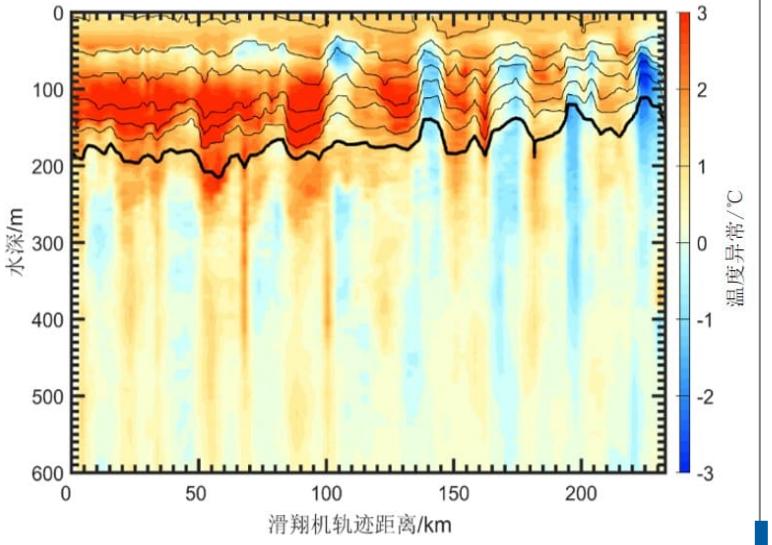
2 Application in environmental observation (network)

In 2017, Petrel made the first typhoon observation in South China Sea.

A fleet of 7 underwater gliders conducted the observation of typhoons “Hato” and “Pakhar”, and obtained continuous observation data of the sea area where the typhoons passed by.







3 Possible future cooperation

- **We can provide**

1) Gilder platforms, including multiple gilders of different working depths (1000m, 1500m, 4000m, etc.);

2) Sensors to acquire marine environment parameters, involving CTD, biochemistry, turbulence, optics, etc.;

3) Cooperation and exchange on glider technology, maintenance, data processing, etc.;

4) Data sharing: data obtained are shared by both parties.

- **We may need:**

1) Communication on the observation scheme, equipment required, etc., based on the specific observation task;

2) Ship support, for the deployment and recovery of glider;

3) Workshop support, for set-up of gliders and on-site communication.

Published papers

1. Underwater glider platform technology

[1]Shuxin Wang, Ming Yang, Wendong Niu, Yanhui Wang, Shaoqiong Yang, Lianhong Zhang and Jiajun Deng. Multidisciplinary design optimization of underwater glider for improving endurance. Structural and Multidisciplinary Optimization. 2021, 63 (6): 2835-2851. https://doi.org/10.1007/s00158-021-02844-z.

[2]Shuxin Wang, Ming Yang, Yanhui Wang, Shaoqiong Yang, Shiquan Lan and Xinhai Zhang. Optimization of Flight Parameters for Petrel-L Underwater Glider. IEEE Journal of Oceanic Engineering. 2021, 46(3): 817-828. https://doi.org/10.1109/JOE.2020.3030573. [4] Yanzhe Wang, Wendong Niu, Xiao Yu, Shaoqiong Yang, and Lianhong Zhang. Quantitative evaluation of motion performances of underwater gliders considering ocean currents. Ocean Engineering, 236 (2021): 109501. https://doi.org/10.1016/j.oceaneng.2021.109501.

[3]Ming Yang, Yanhui Wang, Shuxin Wang, Shaoqiong Yang, Yang Song and Lianhong Zhang. Motion parameter optimization for gliding strategy analysis of underwater gliders. Ocean Engineering, 2019, 191:106502. https://doi.org/10.1016/j.oceaneng.2019.106502

[4]Wendong Niu, Shuxin Wang, Yanhui Wang, Yang Song and Yaqiang Zhu. Stability analysis of hybrid-driven underwater glider. China Ocean Engineering. 2017, 31(5): 528-538. https://doi.org/10.1007/s13344-017-0061-y.

[5]Shuxin Wang, Xiujun Sun, Yanhui Wang*, Jianguo Wu, Xiaoming Wang. Dynamic modeling and motion simulation for a winged hybrid-driven underwater glider. China Ocean Engineering. 2011, 25(1): 97-112. https://doi.org/10.1007/s13344-011-0008-7.

Published papers

2. Multi underwater gliders' formation / Networking Technology

[1]Runfeng Zhang, Shaoqiong Yang, Yanhui Wang, Shuxin Wang, Zhongke Gao and Chenyi Luo. Three-dimensional regional oceanic element field reconstruction with multiple underwater gliders in the Northern South China Sea. Applied Ocean Research, 2020, 105: 102405. https://doi.org/10.1016/j.apor.2020.102405.

[2]Shufeng Li, Fumin Zhang, Shuxin Wang, Yanhui Wang and Shaoqiong Yang. Constructing the three-dimensional structure of an anticyclonic eddy with the optimal configuration of an underwater glider network. Applied Ocean Research, 2020, 95(8): 101893. https://doi.org/10.1016/j.apor.2019.101893.

[3] Dongyang Xue, Zhiliang Wu, Yanhui Wang and Shuxin Wang. Coordinate Control, Motion Optimization and Sea Experiment of a Fleet of Petrel-II Gliders. Chinese Journal of Mechanical Engineering. 2018, 31 (1):17. https://doi.org/10.1186/s10033-018-0210-0.

3. 10000 meters / deep-sea gliders in full ocean depth and theirs application

[1]Shuxin Wang, Haozhang Li, Yanhui Wang, Yuhong Liu, Hongwei Zhang and Shaoqiong Yang. Dynamic modeling and motion analysis for a dual-buoyancy-driven full ocean depth glider. Ocean Engineering. 2019. 187. 106163. https://doi.org/10.1016/j.oceaneng.2019.106163

Published papers

4. Underwater gliders' application technology (including sensors integration application)

[1]Wei Ma, Yanhui Wang, Shuxin Wang, Hongwei Zhang, Han Zhang and Qiyong Gong. Absolute Current Estimation and Sea-Trial Application of Glider-Mounted AD2CP. Journal of Coastal Research, 2019, 35(6): 1343-1350. https://doi.org/10.2112/JCOASTRES-D-18-00176.1.

[2]Wei Ma, Yanhui Wang, Shuxin Wang, Gege Li and Shaoqiong Yang. Optimization of hydrodynamic parameters for underwater glider based on the electromagnetic velocity sensor. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science. 2019, 233(14): 5019-5032. https://doi.org/10.1177/0954406219840372.

[3]Yuhong Liu, Yanpeng Yang, Yanhui Wang, Shiquan Lan, Shuxin Wang and Lianhong Zhang. Vibration Analysis of the Free-Falling Microstructure Profiler. Journal of Vibration and Acoustics. 2016, 138(6): 061012. https://doi.org/10.1115/1.4034378.

[4]Yanhui Wang, Tianyu Xu, Zhiliang Wu, Yuhong Liu and Shuxin Wang. Structure Optimal Design and Performance Test of Airfoil Shear Probes. IEEE Sensors journal. 2015, 15 (1): 27-36. https://doi.org/10.1109/JSEN.2014.2336853.

5. Data quality control and application of underwater gliders

[1]Yanhui Wang, Chenyi Luo, Shaoqiong Yang, Wei Ma, Wendong Niu and Hualong Liu. Modified Thermal Lag Correction of CTD Data from Underwater Gliders. Journal of Coastal Research. 2020. 99. (sp1). 137-143. https://doi.org/10.2112/SI99-020.1.

[2]Yanhui Wang, Xinrui Shen, Shaoqiong Yang and Zhong-Ke Gao. Three-dimensional dynamic analysis of observed mesoscale eddy in the South China Sea based on complex network theory. EPL (Europhysics Letters). 2019, 128(6):60005. https://doi.org/10.1209/0295-5075/128/60005.

Thank you!
Welcome to cooperate.

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