Delivering quality multi-parameter data from on-line monitoring network in estuaries and bays: a case study in the Bohai Sea

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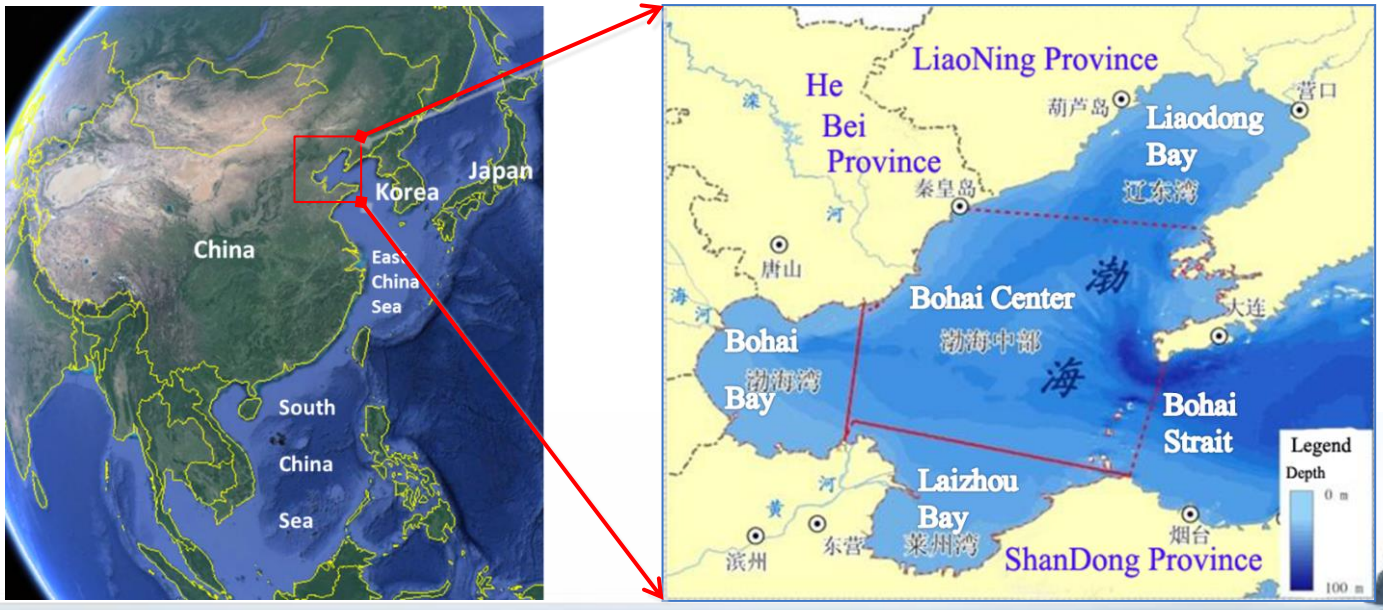
Outline

- The on-line monitoring network in the Bohai Sea
- A node in the Liaohe river estuary
- Summary and outlook

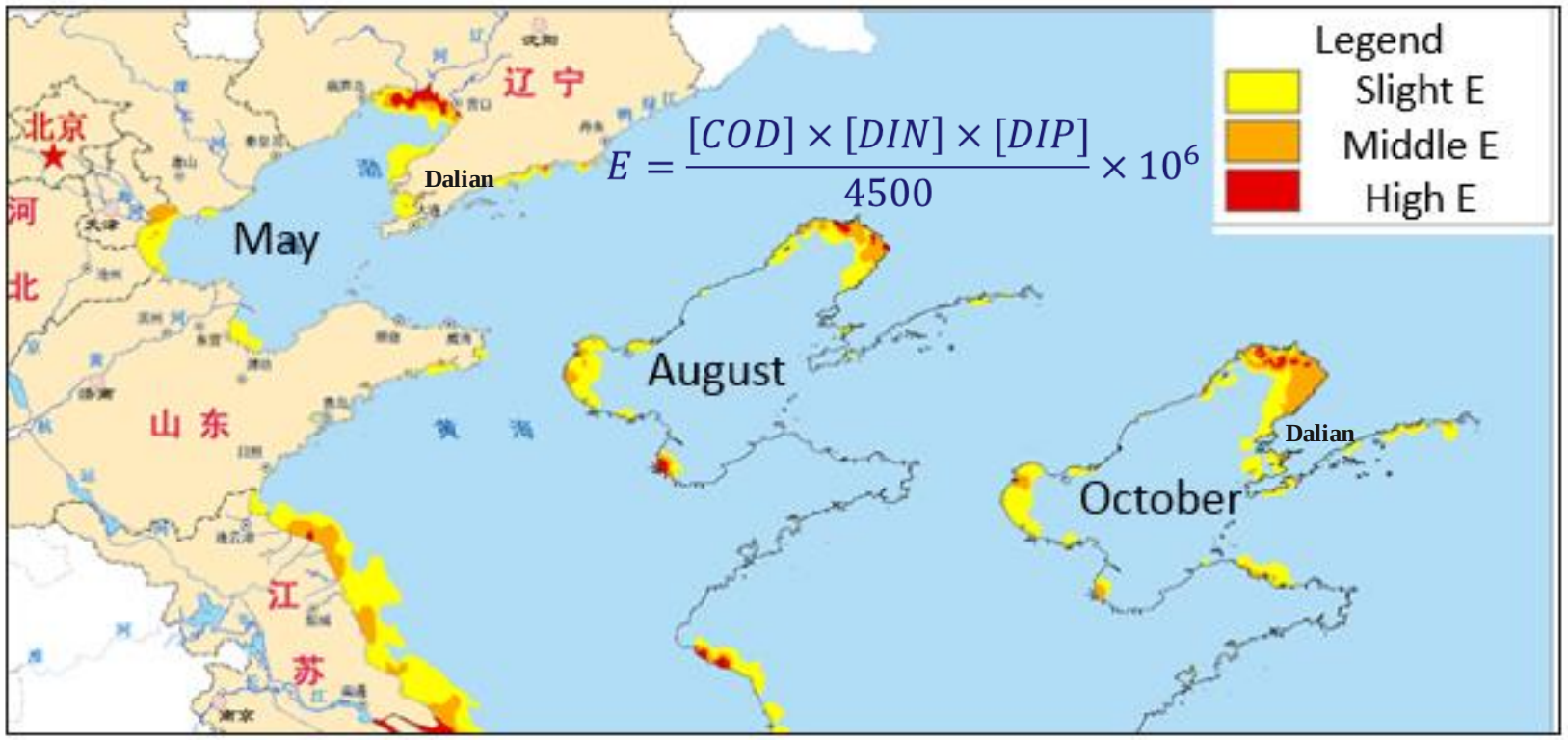
1.1 Brief of the Bohai Sea

- **Location and overview**
  - semi-enclosed marginal sea of the NW Pacific with 77 000 km^2
  - divided in four parts: Liaodong Bay, Bohai Bay, Laizhou Bay and the central part
  - connects to the Yellow Sea with the Bohai Strait

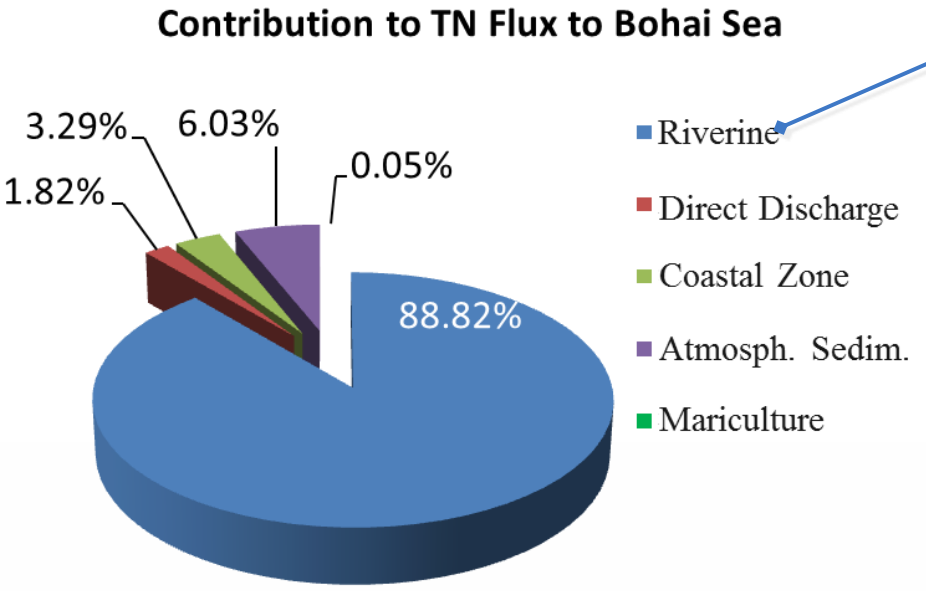


1.2 Its problems

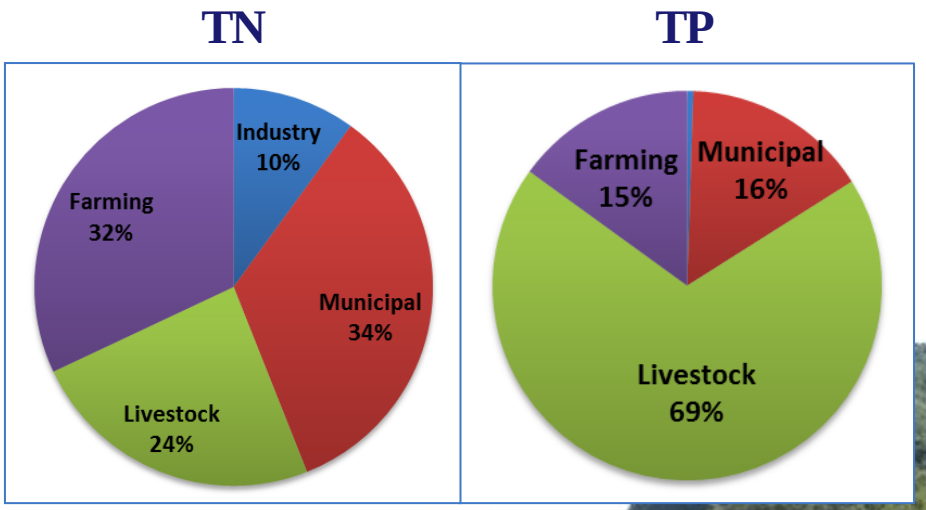
- **High eutrophication level in coastal waters**
  - high DIN and phosphate concentration
  - regions with high eutrophication level (*E*>3)：all the three bays and Dalian coastal area



- **Increasing pollutant discharges**
  - more than 80% pollutants are from land-based discharge
    - 80% of pollutants discharged into the sea are through rivers;
    - among which, NP agriculture sources contribute to 56% TN、84% TP

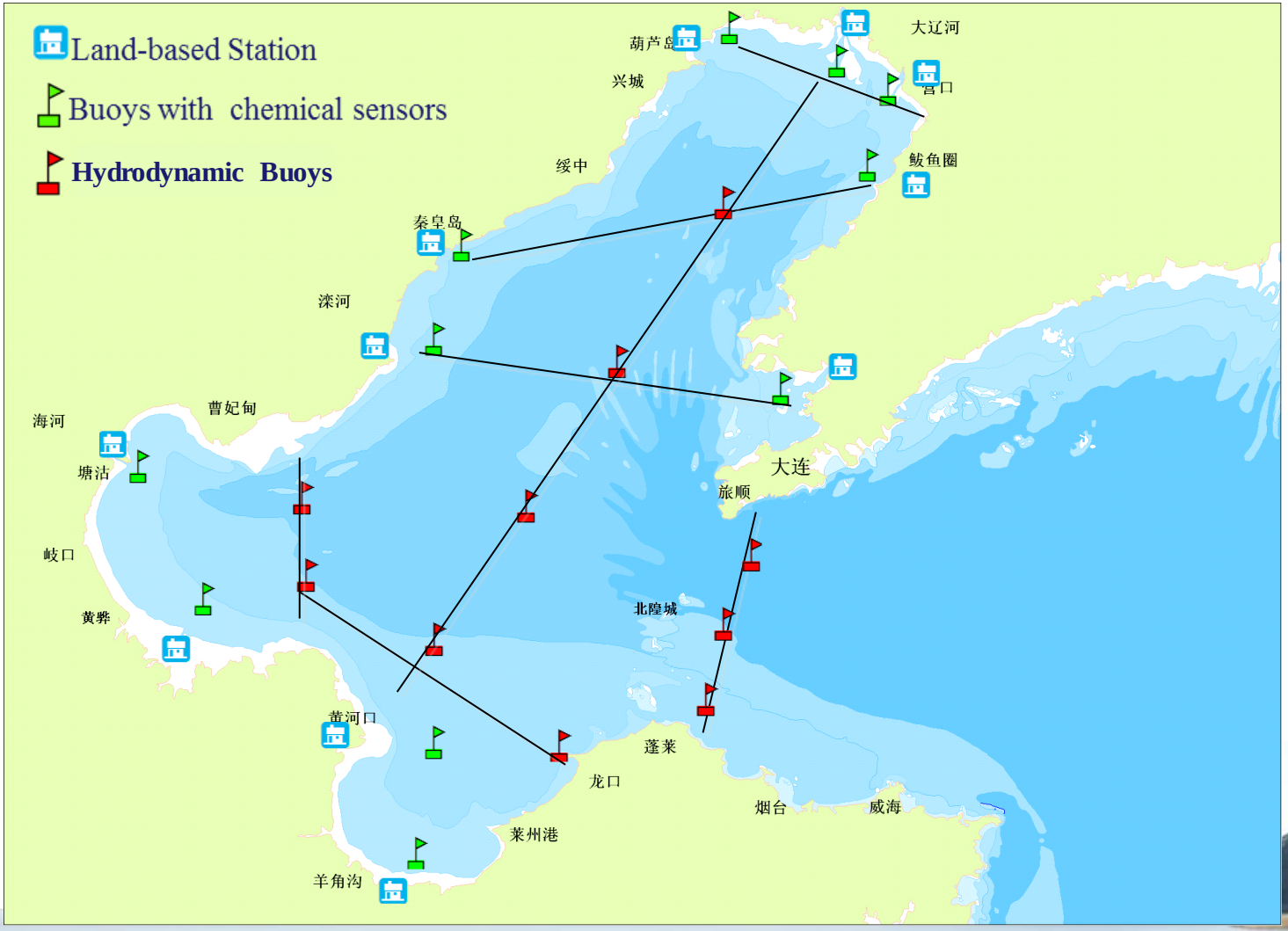


Land-based discharging sources for:



1.3 Overview of the on-line monitoring network

- Land-based stations, buoys with different sensors



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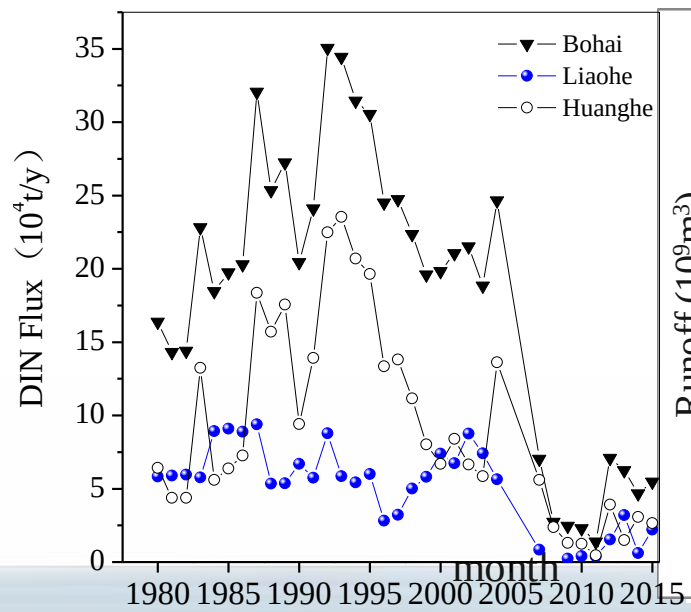
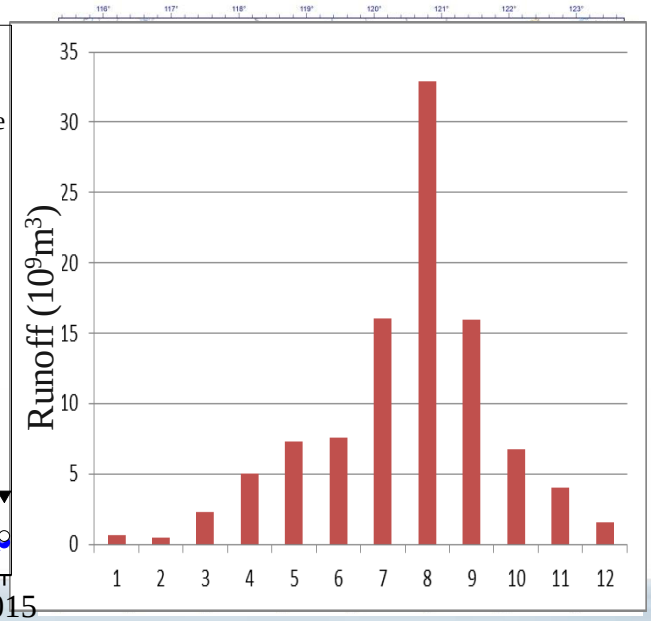
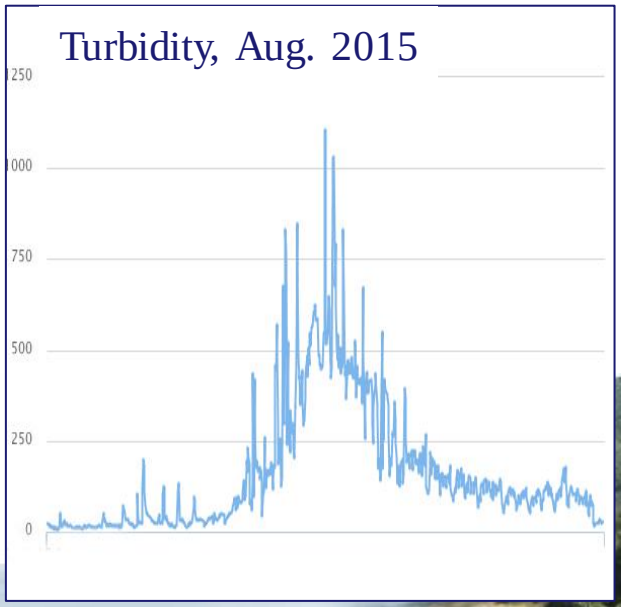
2.1 Why Liaohe river estuary

- **Particularities**
  - the biggest rive in the Liaodong Bay carrying high N and P fluxes into the sea, resulting in high eutrophication level of the estuary and adjacent
  - a typical North China river with <u>seasonal runoff pattern</u> and <u>high turbidity</u> in its maritime section

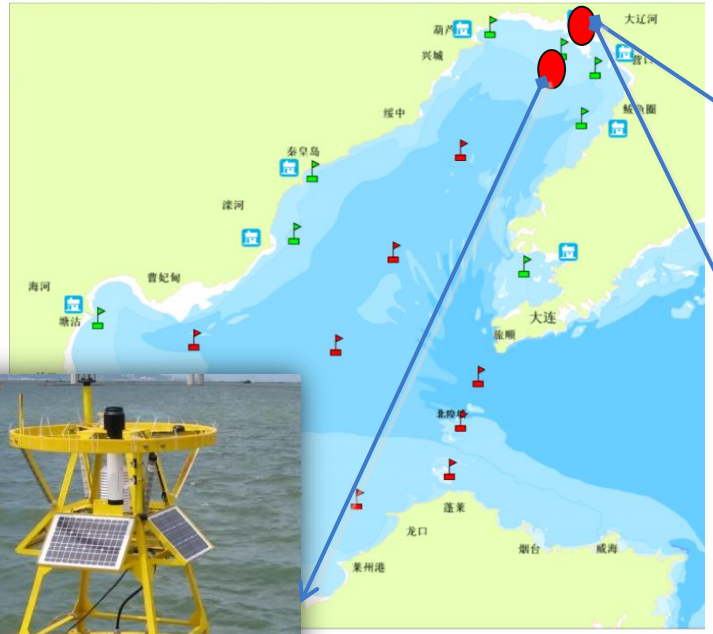






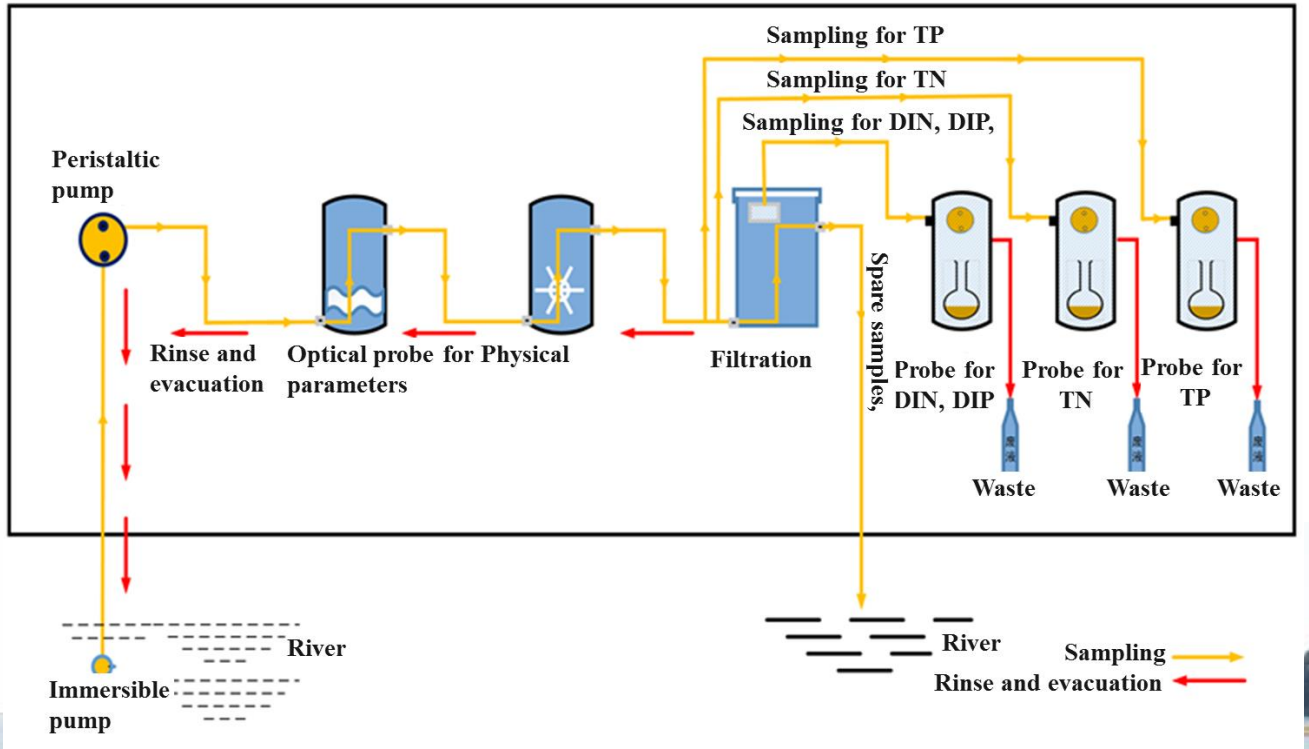
2.2 The Liaohe on-line monitoring station

- **Synchronized observation of pressure-effect**
  - end of the maritime section of Liaohe：land-based station→get the pollutant discharge
  - mouth of Liaohe：buoys→monitor the water quality

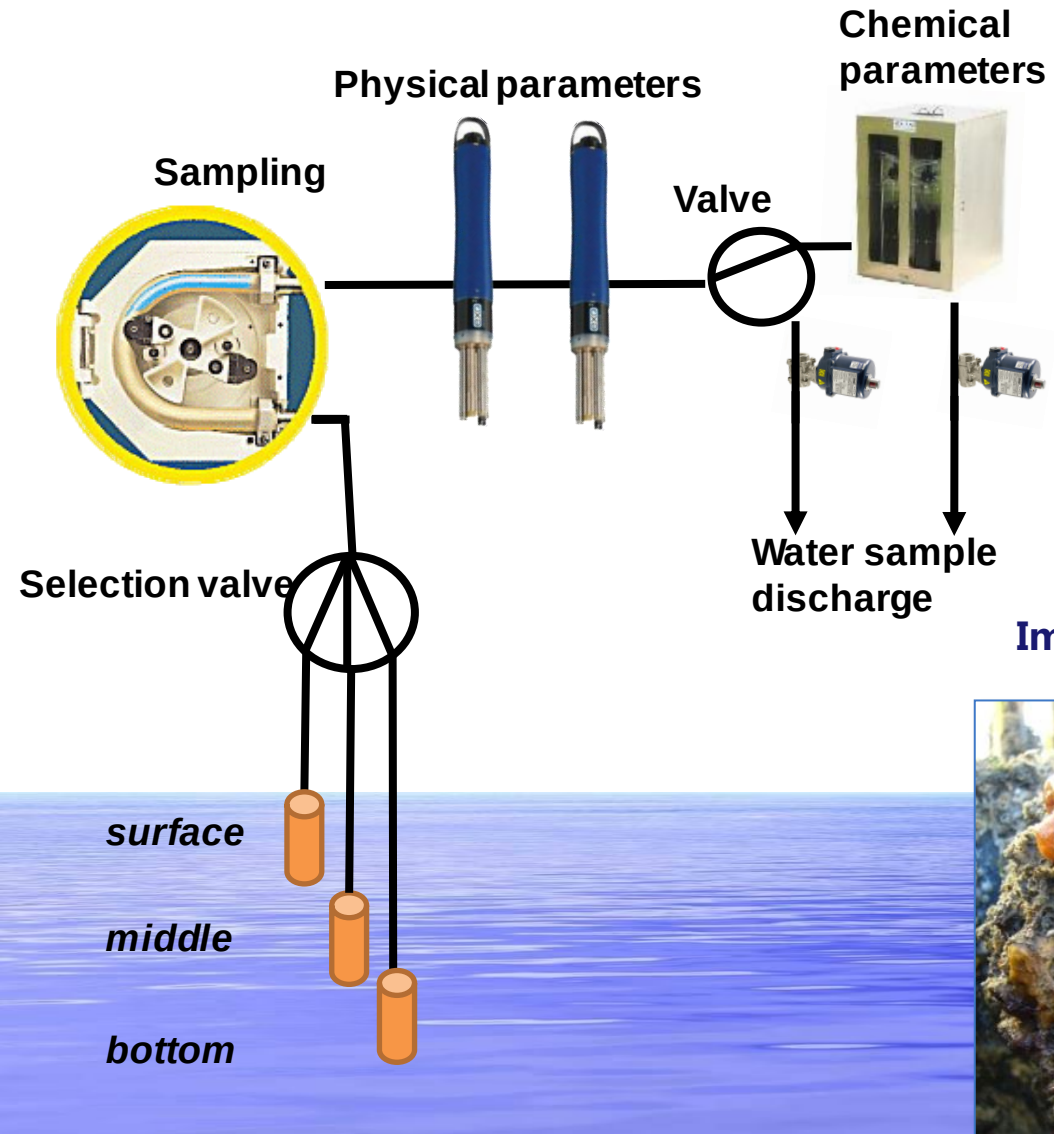


- **Advantages of land-based on-line monitoring station**
  - stable, flexible and sustainable
  - easy to obtain reliable chemical data via the application of wet chemistry method:
    - DIN
    - Phosphate
    - TN
    - TP
    - VPCs,
    - …

- **Non-immersive segmented-flow detection**
  - During detection (5~10min): water sample segmentally pumped from the river to the sensors
  - Between detections (3~4h): pipelines rinsed and evacuated, sensors non-immersed in water sample

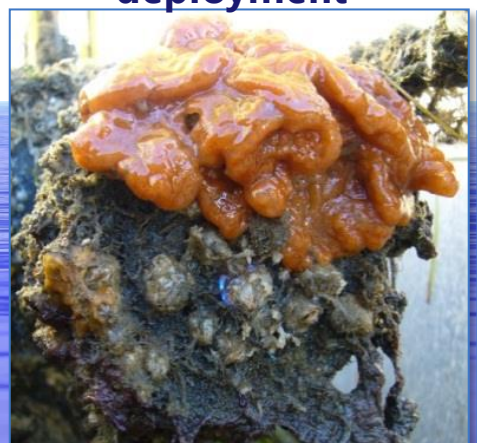


Non-immersive segmented-flow detection



- (1) monitoring all layers
- (2) anti bio-fouling

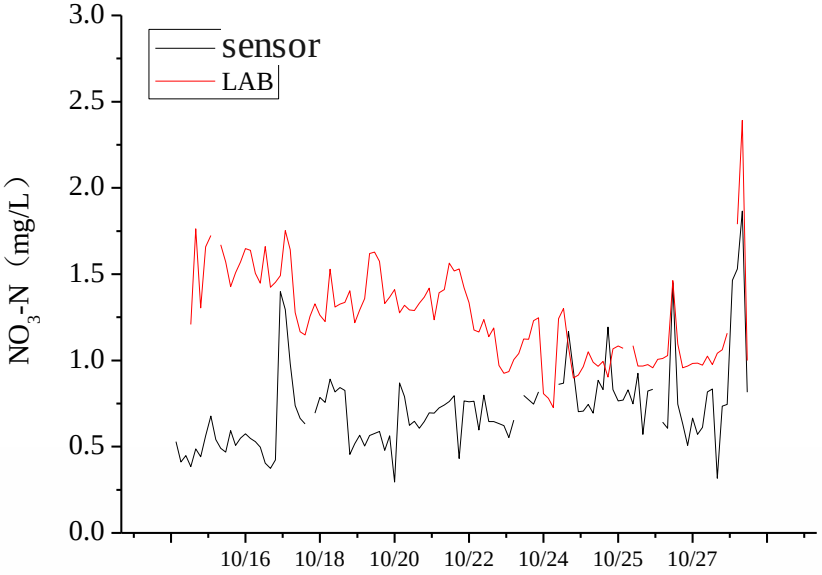
Immersion, 90days deployment

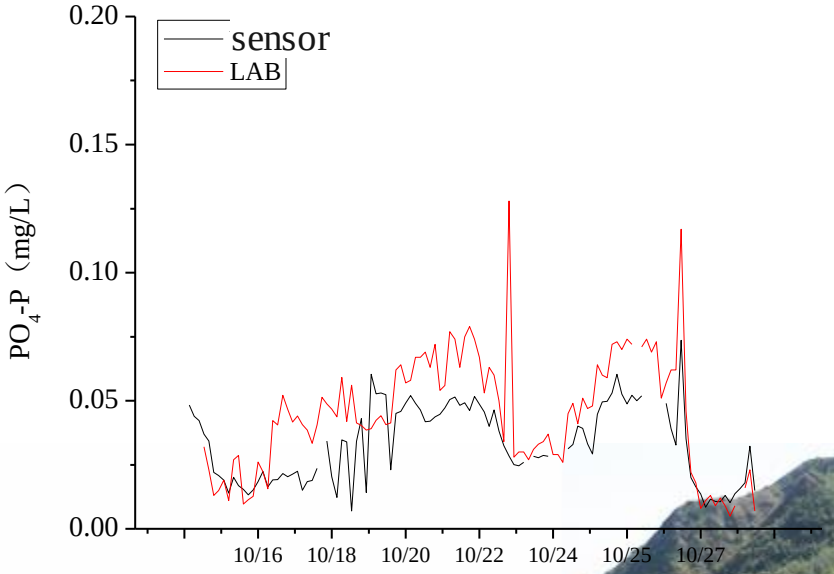


Non-immersion, 90days deployment

2.3 Nutrient sensor adjustment

- **(1) Wet chemical method: improve sensor performance with additional filter**
  - Observations from sensors (25μm filter) comparing to laboratory detection results
    - Filter membrane used in the lab.：0.45μm (HY/T 147.1-2013)
    - Sensors got lower value (-20%~-40% average), poor relativity





suspended particles in the water sample significantly affects the performance of the sensors!

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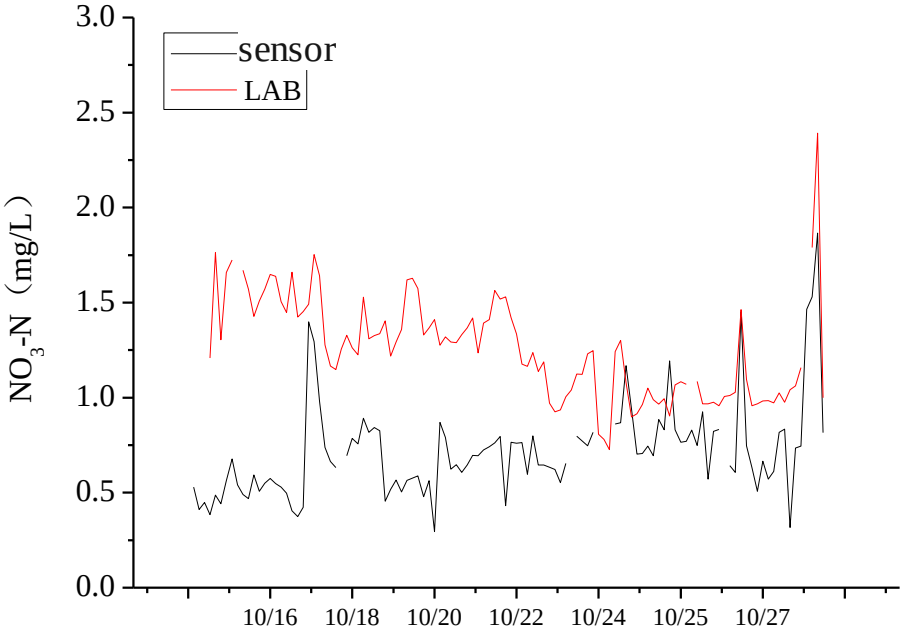
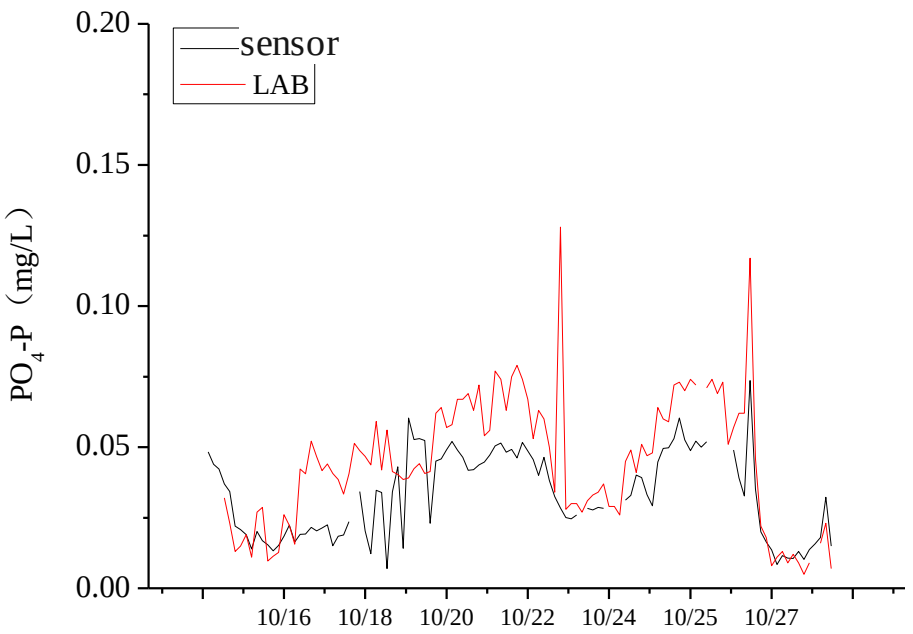
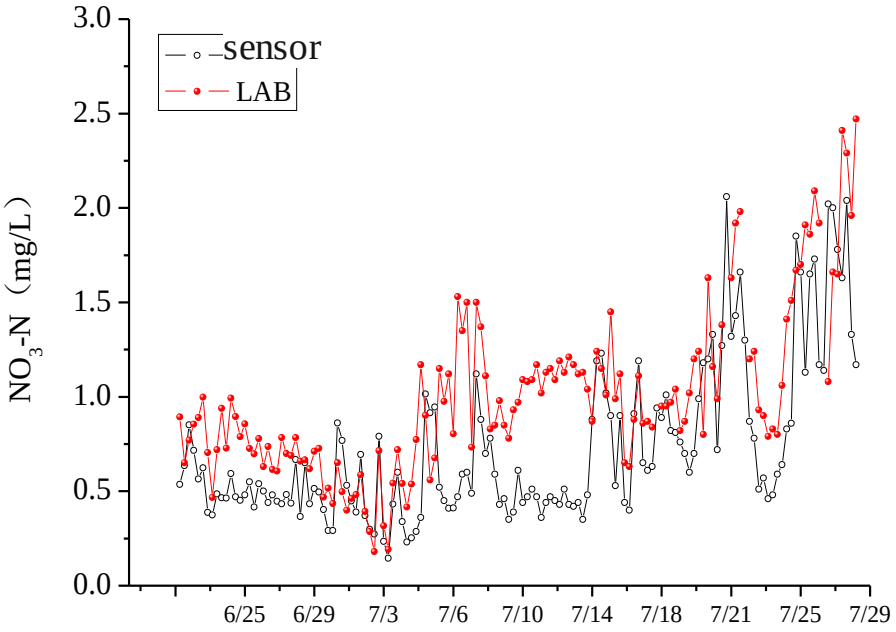
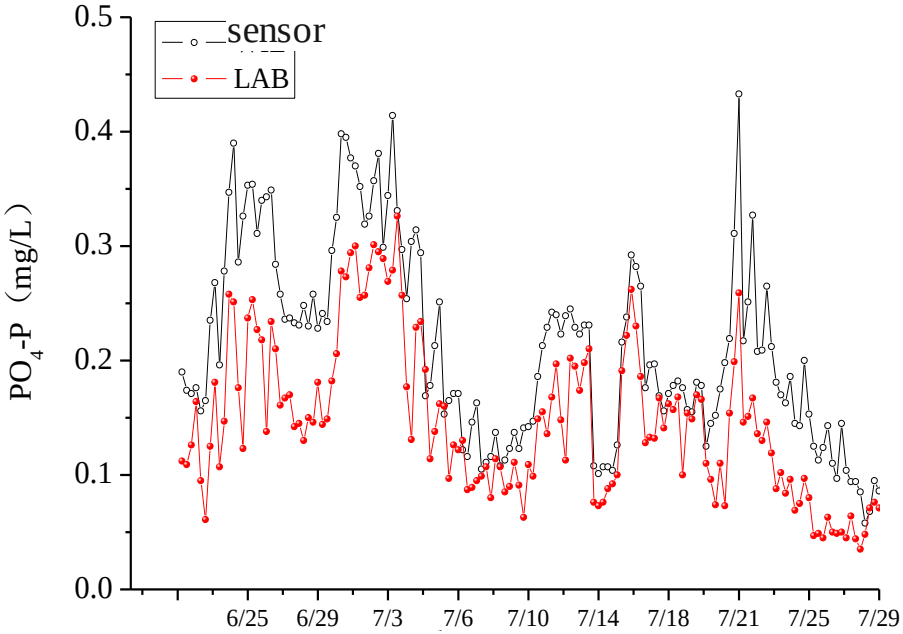




suspended particles in the water sample significantly affects the performance of the sensors!

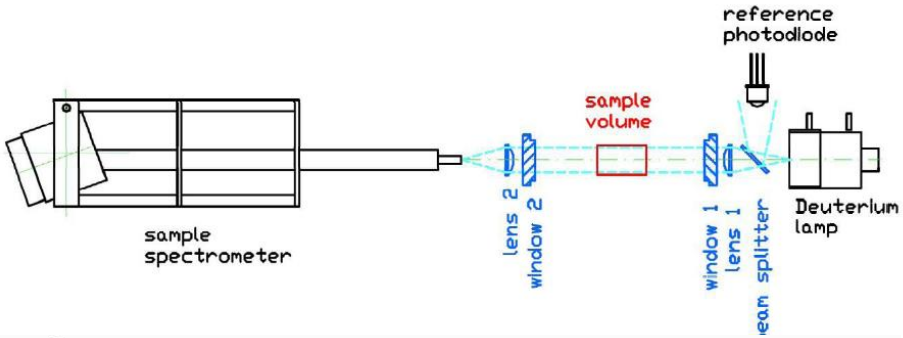
- Adjustment: 5μm filter plus 25μm filter before detection
  - The performance of the sensors of NO_3-N and PO_4-P improved: **recoveries** on calibration curve >90%; **average discrepancy < 20%** compared to Lab. detection

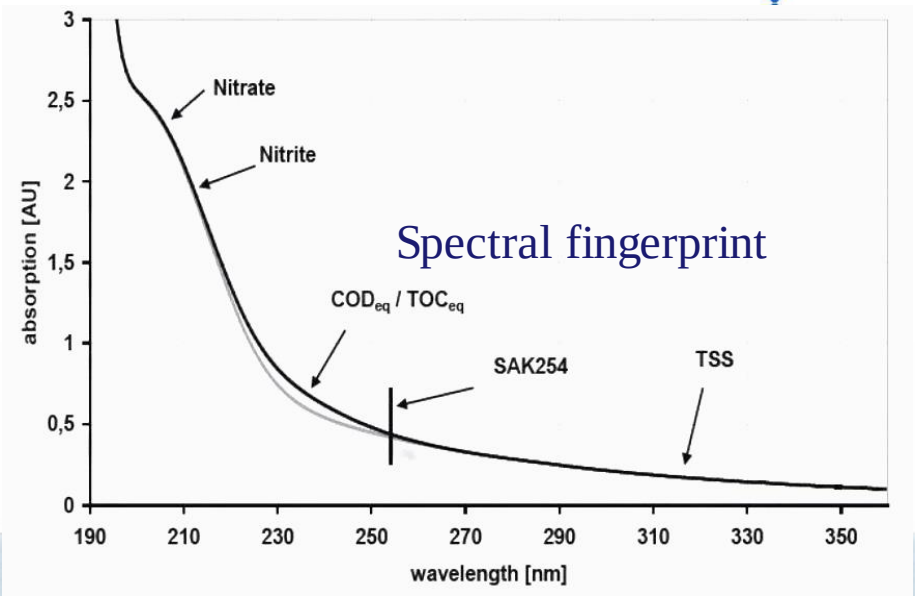




0.45 μm filter was **NOT** applicable for on-line filtration because of filter clogging.

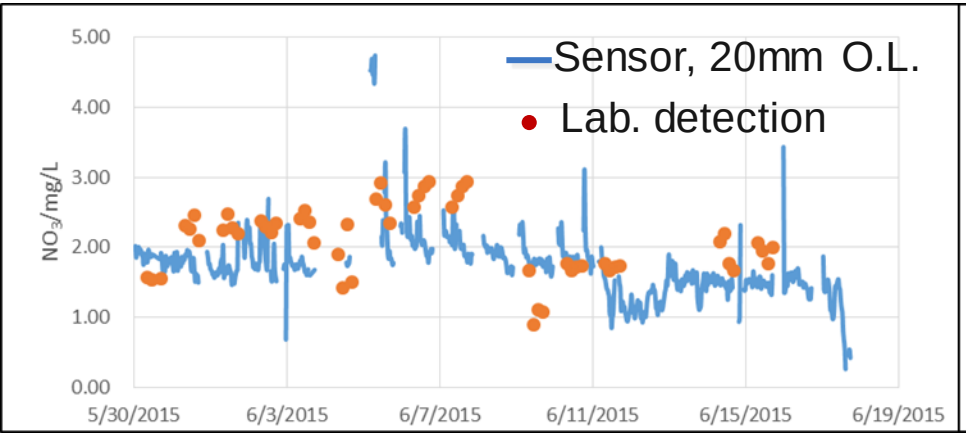
- **(2) Optical sensors performance adjustment**
  - Concentration of nitrate, nitrite and other chemicals are directly detected by full spectrum analysis

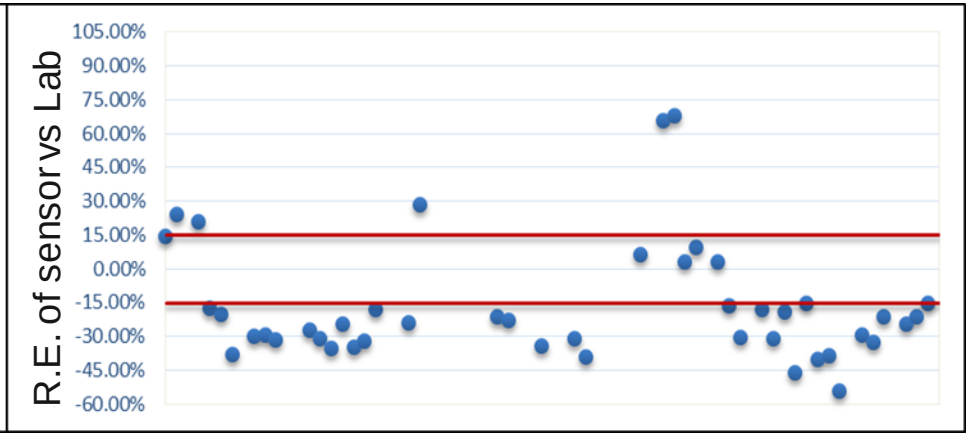


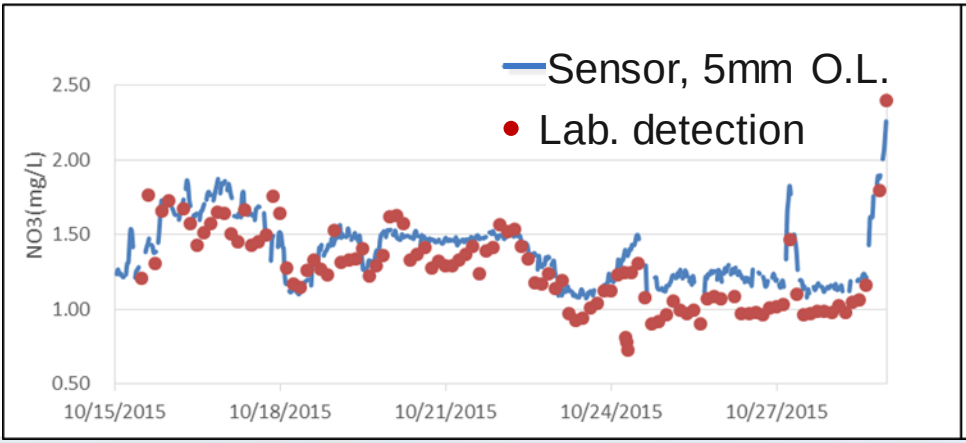


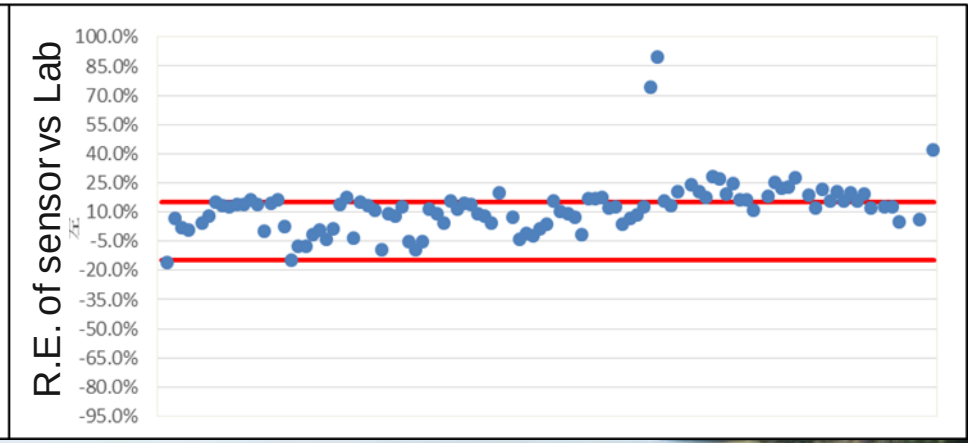
Advantages: no wet chemical reaction
Defects: suspended particles affected

- Adjustment: optical length of the full spectrum sensor
  - 20mm optical length：high sensitivity，high relative errors
  - 5mm optical length：low sensitivity，low noise，better performance









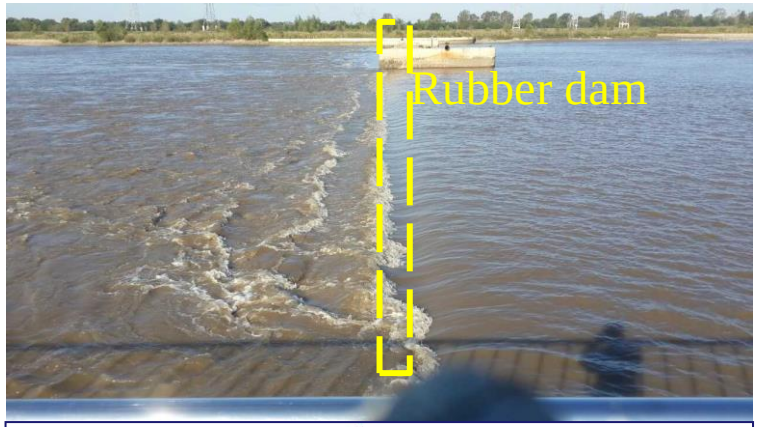
2.4 The on-line monitoring on the river runoff

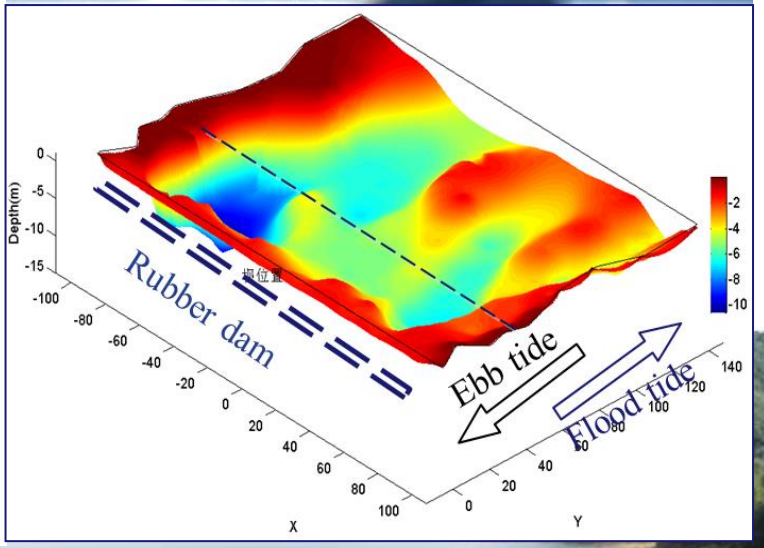
- **Difficulties**
  - The relationship among water level, velocity and runoff is not stable

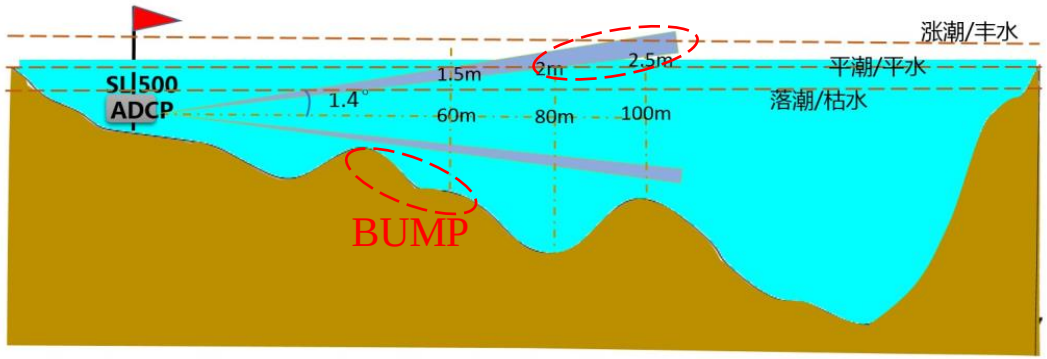
① Seasonal variable runoff, controlled by a rubber dam

② Irregular river-bed with bumps, prevents the effective use of the slope ADCP

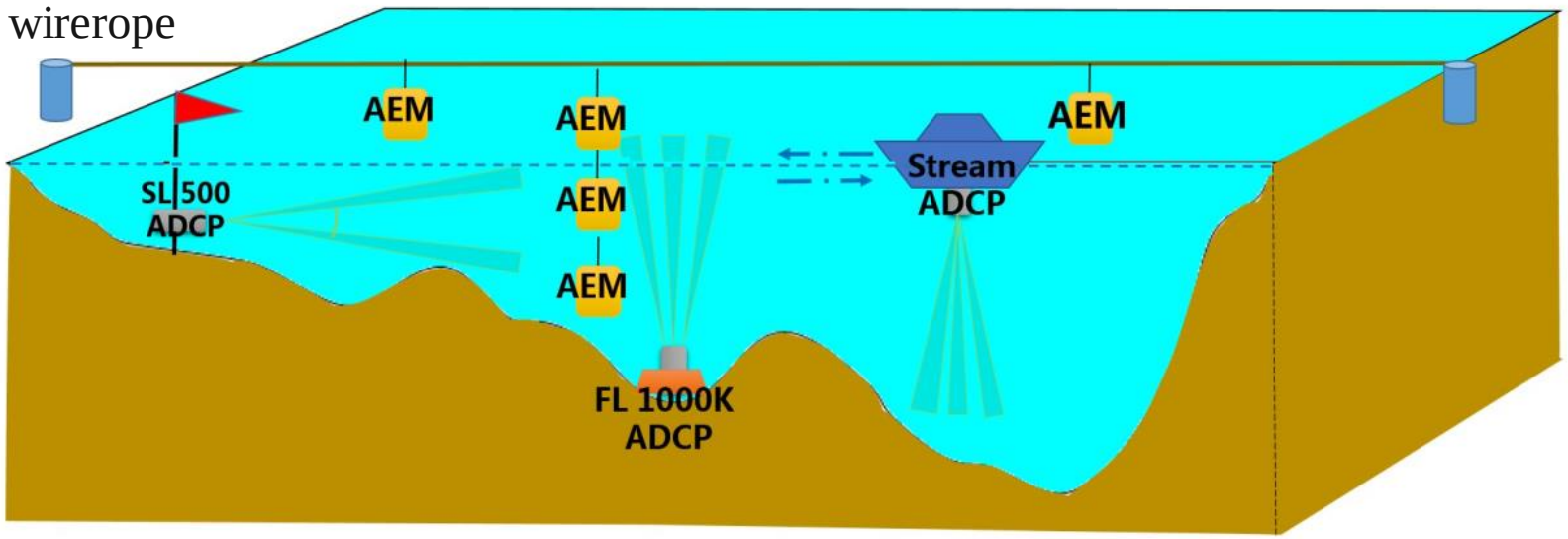
③ Irregular bathymetry with shallow water

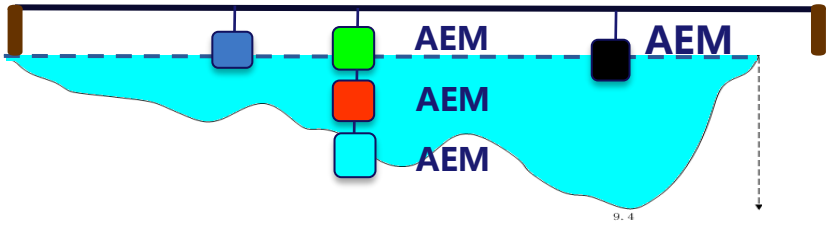






- **(1) On-line monitoring plan**
  - Long-term vertical profile： Flowquest 1000 ADCP
  - Long-term horizontal profile： Sontek SL 500 ADCP
  - Short-term surface, middle layer, bottom point current： Infinity-EM AEM USB
  - Short-term cruise survey： TRDI Stream ADCP



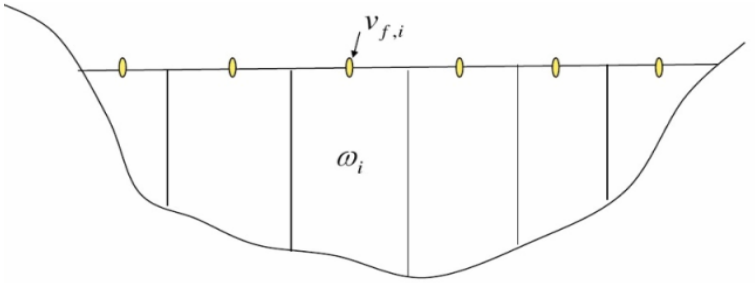


(2) Runoff calculation

Runoff is calculated with following equation

$$Q=\omega V_m$$

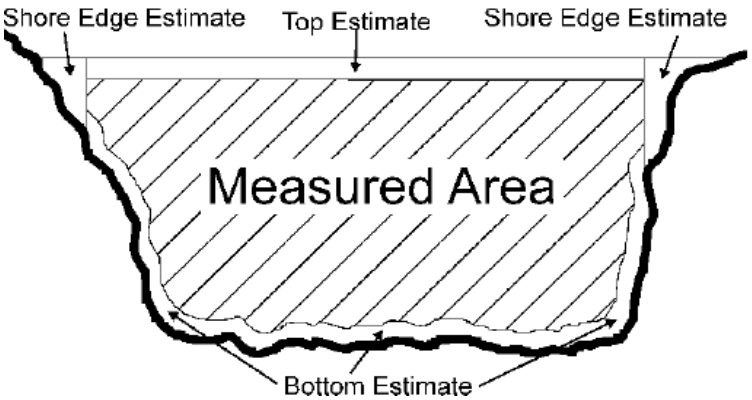
V_m *is the mean velocity*、 *ω is section area*。



To get V_m, the regression *a*, *b* have to be decided with following equations

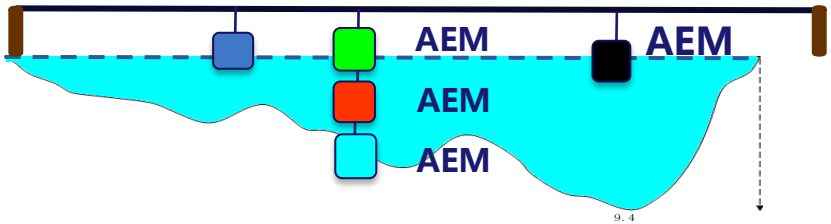
$$V = C + aV_f + bV_h$$

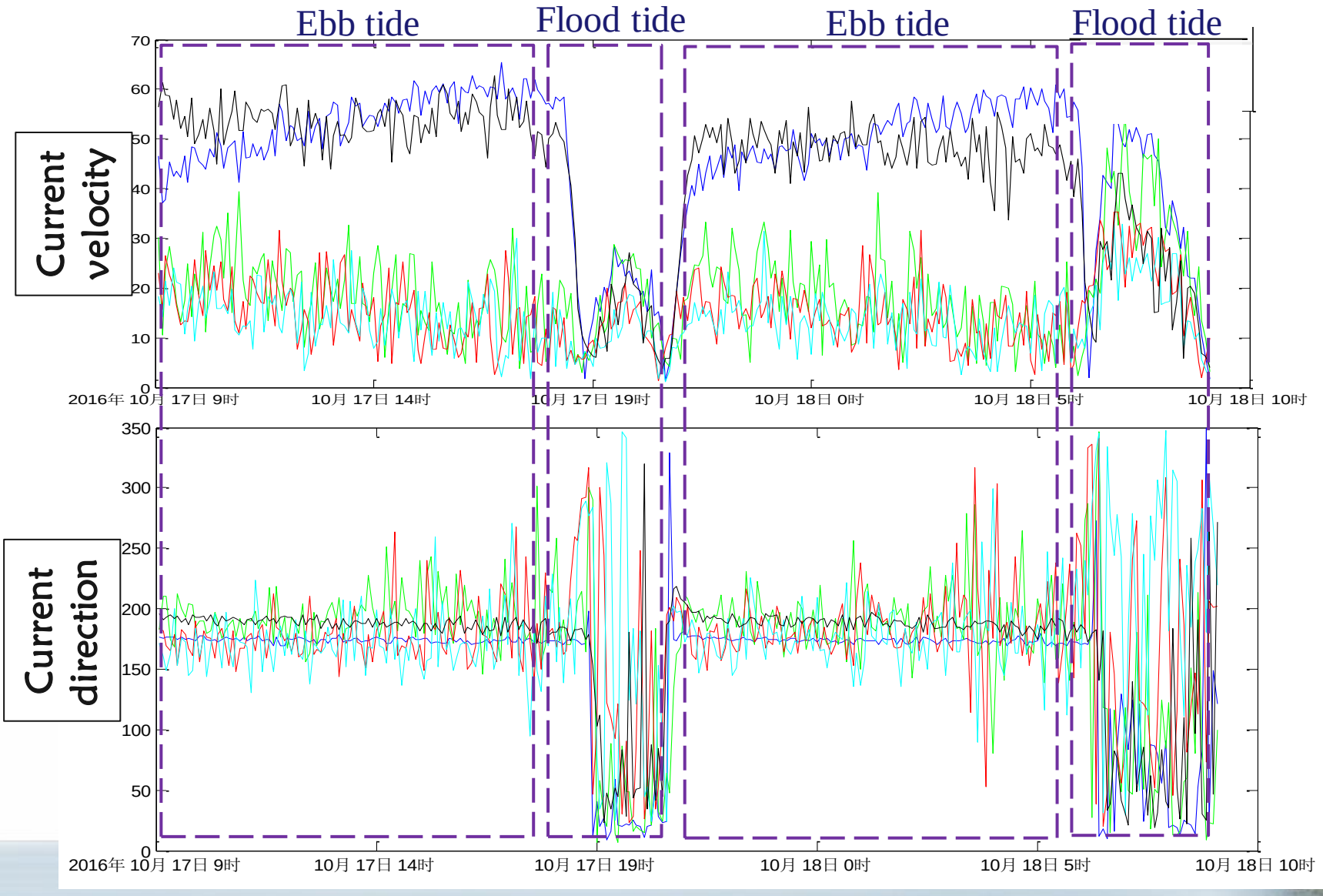
$$V = \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{bmatrix}, V_f = \begin{bmatrix} v_{f1} \\ v_{f2} \\ \vdots \\ v_{fn} \end{bmatrix}, V_h = \begin{bmatrix} v_{h1} \\ v_{h2} \\ \vdots \\ v_{hn} \end{bmatrix}$$



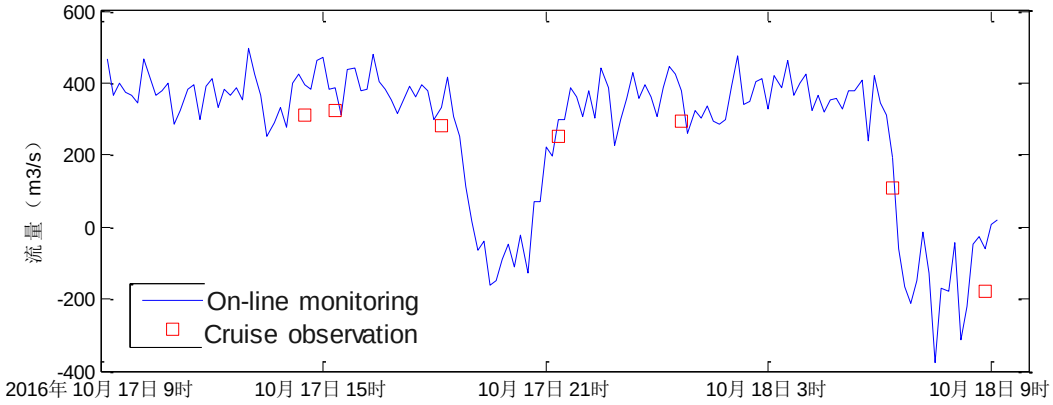
V_f and *V_h are velocities measured by **AEMs** and **FL 1000K**, V are velocities measured by **Stream ADCP***

(3) The current distribution during ebb tide and flood tide

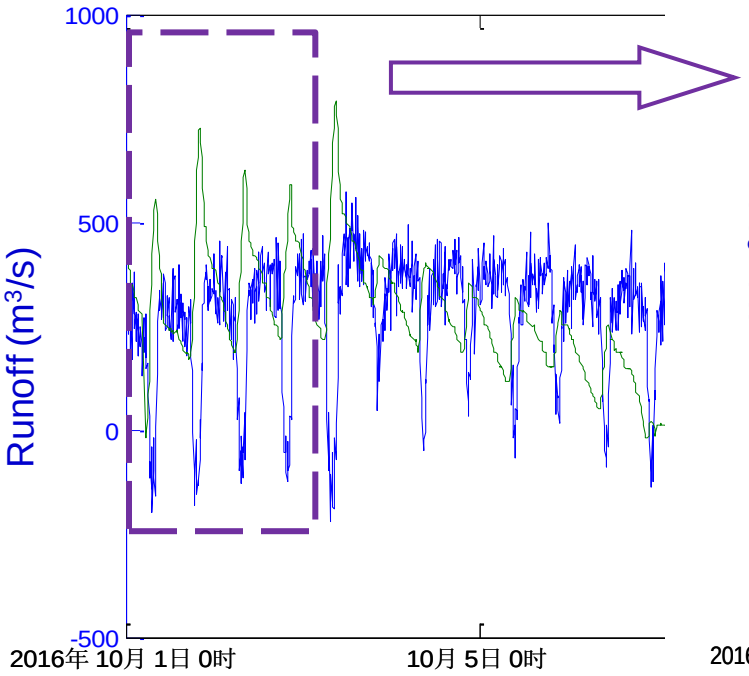


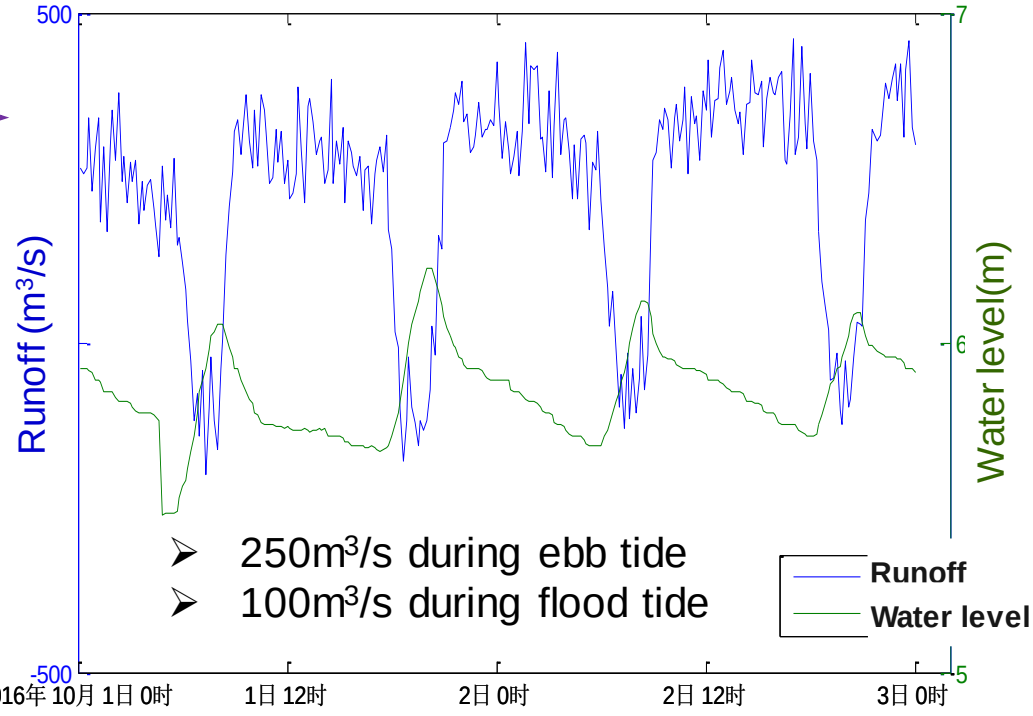


(4) Runoff comparison between On-line monitoring and cruise observation



(5) The runoff results





- 250m³/s during ebb tide
- 100m³/s during flood tide

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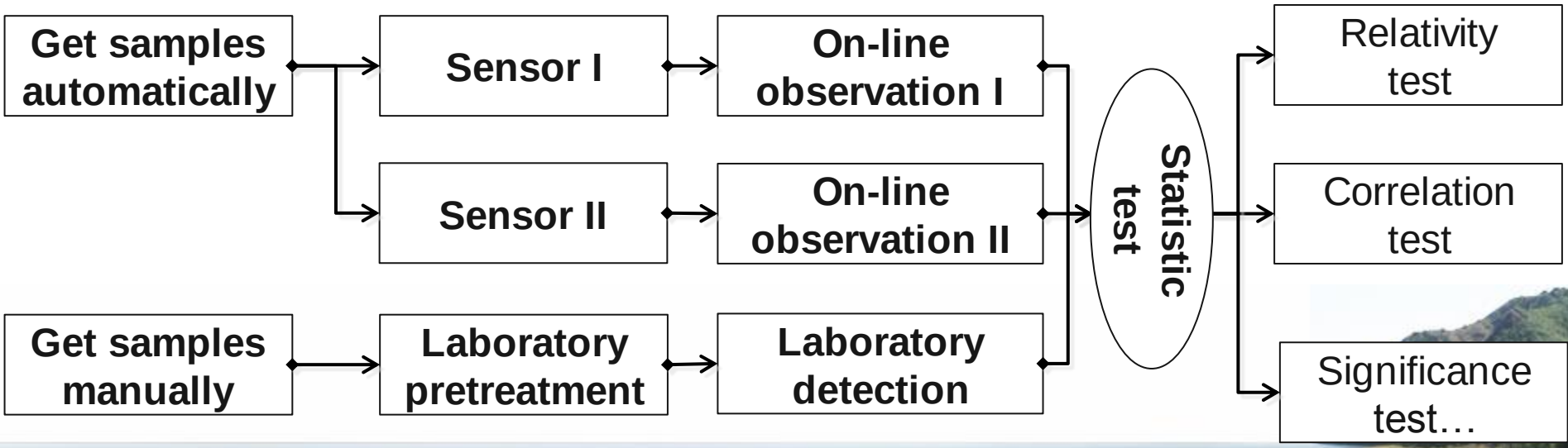
3.1 What we learn from Liaohe river station

- **The advantages in deploying land-base station are**
  - stable platform for sensors ensuring better data quality
  - easy for maintenance, prevent bio-fouling
- **Biological & chemical parameters on-line monitoring in rivers**
  - more filters procedure will minimize the effects of contamination and improve the data quality
  - Trios OPUS optical sensors with shorter optical length is more suitable for measuring nitrate concentration in rivers with high turbidity
- **On-line monitoring on the river outfall**
  - Multiple observation methods are required for on-line monitoring on the river runoff when the river transverse section is irregular

3.2 Suggestions for QA/QC protocol of sensors

- **Performance test of sensors**
  - newly recruited/renewed：calibration curve, detection limit, recovery and span shift
  - Routine maintenance monthly：calibration curve, recovery, accuracy, precision
  - Comparison tests seasonally: On-line monitoring vs. Laboratory method



- **Weekly routing inspection**
  - status of the on-line monitoring platform hardware
  - abnormal records of the monitoring process
- **Monthly maintenance**
  - replenishment of chemical reagents
  - rinsing the pipelines and detection cells
  - cleaning the sensors and filters and so on…

Before

After

3.3 Outlook

- **Further improvement of the sensors' performance**
  - Integrate wet chemical method and full spectrum sensors
  - Dissolved nutrients → TN and TP
- **Improve the accuracy of the on-line monitoring system on the river outfall**
  - Establish velocity-water level-runoff correlation in different seasons
  - On-line deployed of the seabed based observation platform
- **Improve the synchronization of land-based station and buoys**
  - Comparison between sensors in surface water and sea water
  - On-line monitoring data into numerical model to create public service product

Thanks