

## Report for the year 2017 and future activities

### SOLAS China

**compiled by: Minhan Dai & Huiwang Gao**

*This report has two parts:*

- **Part 1:** reporting of activities in the period of January 2017 – Jan-Feb 2018
- **Part 2:** reporting on planned activities for 2018/2019 and 2020.

*The information provided will be used for reporting, fundraising, networking, strategic development and updating of the live web-based implementation plan. As much as possible, please indicate the specific SOLAS 2015-2025 Science Plan Themes addressed by each activity or specify an overlap between Themes or Cross-Cutting Themes.*

- 1 Greenhouse gases and the oceans; N2O paper?
  - 2 Air-sea interfaces and fluxes of mass and energy;
  - 3 Atmospheric deposition and ocean biogeochemistry;
  - 4 Interconnections between aerosols, clouds, and marine ecosystems;
  - 5 Ocean biogeochemical control on atmospheric chemistry;
- Integrated studies;  
Environmental impacts of geoengineering;  
Science and society.

**IMPORTANT:** *This report should reflect the efforts of the SOLAS community in the entire country you are representing (all universities, institutes, lab, units, groups, cities).*

#### **PART 1 - Activities from January 2017 to Jan/Feb 2018**

##### **1. Scientific highlight**

*Describe one scientific highlight with a title, text (max. 200 words), a figure with legend and full references. Please focus on a result that would not have happened without SOLAS, and we are most interested in results of international collaborations. (If you wish to include more than one highlight, feel free to do so).*

**Title:** Aerosols as a source of dissolved black carbon to the ocean

**Text:** Dissolved black carbon (DBC) is by far the largest known refractory dissolved organic carbon (DOC) pool in the ocean. It can persist in the open ocean for tens of thousands of years, having a much slower average turnover rate than black carbon in soils. Therefore, the cycling of DBC in the ocean is a crucial component of the global carbon budget, and it is important to constrain the sources and sinks of oceanic DBC. Atmospheric deposition could significantly contribute to the oceanic DBC pool, but respective information is lacking.

To study the contribution of atmospheric deposition to the oceanic DBC pool, we carried out an aerosol sampling campaign in spring 2015 that extended from the China coastal seas (the Yellow Sea and the East China Sea) to the northwestern Pacific Ocean. We quantified water-soluble organic carbon (WSOC), and water-soluble black carbon (WSBC) in the aerosol samples. The atmospheric dry deposition of WSBC is estimated to be ~40% of the riverine input to the China coastal seas during the dust outbreak season. The molecular composition of atmospheric WSBC determined by ultrahigh-resolution Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR-MS), reveals similar soil-derived sources as for riverine discharge. WSBC is significantly

positively correlated with WSOC in marine aerosols, and WSBC contributes on average  $2.8 \pm 0.65\%$  to the total WSOC. Based on this relationship, the global atmospheric deposition of DBC to the ocean is estimated to be  $1.8 \pm 0.83 \text{ Tg yr}^{-1}$ . The global WSBC flux from atmospheric deposition is much smaller than the global riverine DBC flux ( $26 \text{ Tg yr}^{-1}$ ). Nonetheless, atmospheric WSBC deposition alone can support the oceanic DBC turnover at an average rate of  $\sim 6700 \text{ yr}$ , demonstrating the significance of atmospheric deposition. Recent studies found that biomass burning also releases labile OC, and the entire continuum of pyrogenic organic matter and anticipated changes of atmospheric fluxes should be considered in assessments of potential impacts on ecosystems at regional and global scales. Future changes in both dust and biomass burning activities may potentially affect the deposition of WSBC in marine environments.

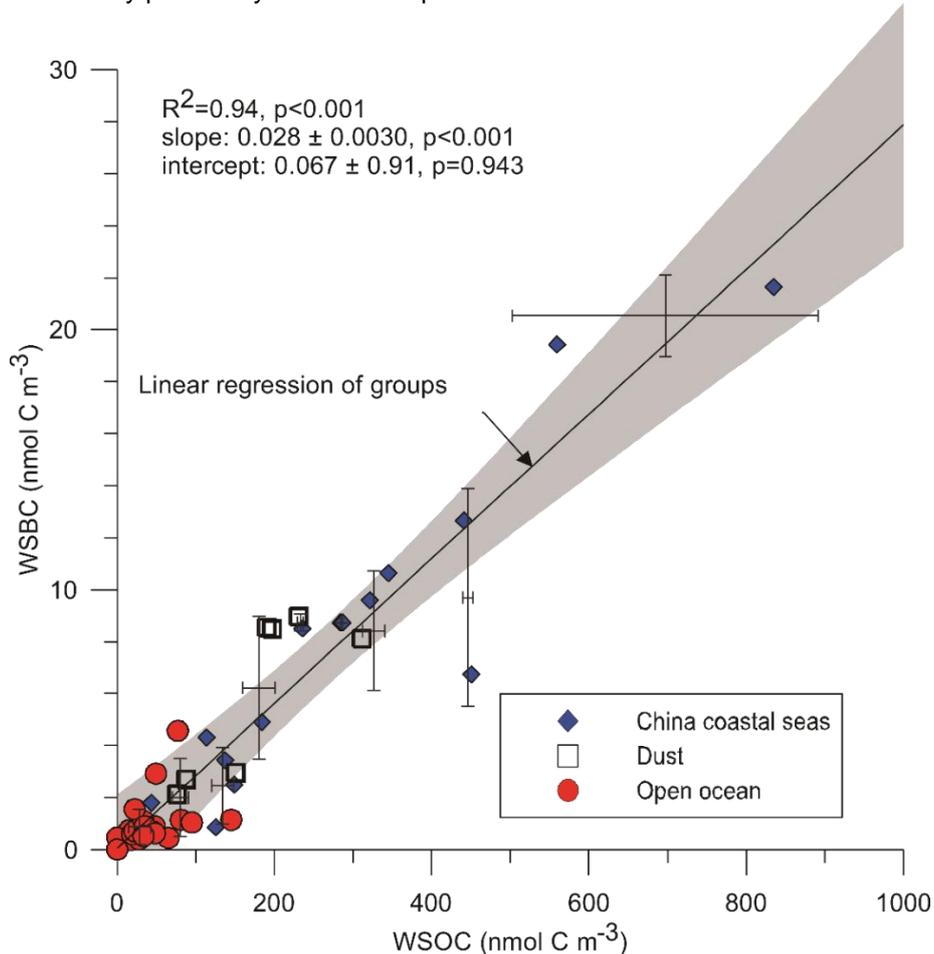


Figure: Relationship between water soluble black carbon and water soluble organic carbon. Error bars show the 1 s.d. of the average values for each concentration group. The statistics are for the regression of the average values. The grey area shows the 95% confidence interval of the linear regression

Citation: Bao, H. Y., Niggemann, J., Luo, L., Dittmar, T., Kao, S.J., 2017, Aerosols as a source of dissolved black carbon to the ocean. *Nature Communications*, 8, doi:10.1038/s41467-017-00437-3.

## 2. Activities/main accomplishments in 2017 (projects, field campaigns, events, model and data intercomparisons, capacity building, international collaborations, contributions to int. assessments such as IPCC, interactions with policy makers or socio-economics circles, social sciences, and media).

### ● Cruise and field experiment

- The water and mass exchange of Luzon Strait were investigated based on large-scale observations of a cruise conducted onboard R/V *Dongfanghong II* during July 11- August 11, 2017. Parameters related to the air-sea  $\text{CO}_2$  fluxes and carbonate system were collected. This cruise was supported by National Natural Science Foundation of China (NSFC) Open Research Cruise, which is funded by Shiptime Sharing Project of NSFC. (Theme 1)
- A summer cruise was conducted onboard R/V TAN KAH KEE during June 5-27, 2017 in the Southern South China Sea basin, from where there are sparse data on the carbon budget and ocean acidification. This cruise was supported by project "Carbon Cycle in South China Sea:

budget, controls & global implications (CHOICE-C II)" and "Marine Carbon sequestration: multiscale regulation and response to global changes (MACRO)" funded by the Ministry of Science and Technology (MOST) of China. (Theme 1)

- A winter cruise was conducted onboard R/V TAN KAH KEE during January 14 - February 4, 2018, which focused on the water exchange of Luzon Strait and the coupling processes between the upper ocean and the deep ocean. This cruise was supported by CHOICE-C II project and MACRO project funded by the MOST of China. (Theme 1)
- During the spring time (March-May) in 2017, we carried out dust (natural source) and haze particle (anthropogenic source) addition microcosm experiments in the South China Sea. Chl *a*, nutrients, and phytoplankton community structure (including micro, nano, and pico size cells) were determined to reflect phytoplankton growth in the surface seawater to atmospheric deposition from different sources. (Theme 3)
- Aerosol samples were collected from South China Sea during June 9 – June 26, 2017. Water soluble organic carbon and water soluble black carbon will be measured to understand the transport of biomass burning derived organic carbon to the ocean. This cruise was supported by National Natural Science Foundation of China (NSFC) No. 2015CB954000 and Ministry of Science and Technology of the People's Republic of China (No. 2016YFA0601200). (Theme 3)
- A SOLAS cruise campaign was conducted in April 2017 on the Yellow Sea and East China Sea to study the distributions, air-sea fluxes and biogeochemical cycles of trace gases (i.e. CH<sub>4</sub>, N<sub>2</sub>O, DMS, CO<sub>2</sub>, CO, Halogens) in the atmosphere and the seawater. (Theme 1)

### ● Projects

NSFC innovative research group: Nitrogen cycle under global change (2018-2023), Leading PI: Shuh-Ji Kao from Xiamen University, budget 10.5 million CNY. (Theme 1)

NSFC program: Utilizing ultrahigh resolution mass spectrometry and molecular markers to characterize the molecular composition and fate of atmospheric dissolved organic carbon in the South China Sea (2018-2020), Leading PI: Hongyan Bao from Xiamen University (Theme 3)

NSFC general program: Effects of multiphase reactions for atmospheric organic acid on deposition ice nucleation efficiency of particles (2018-2021), leading PI: Bingbing Wang from Xiamen University (Theme 3)

### ● Infrastructure

- A 78-m long new research vessel with the capacity of SOLAS and trace metal researches was formally delivered to Xiamen University on March 28, 2017.
- Ocean University of China's (OUC) new deep-sea research vessel (Dong Fang Hong 3) was launched on January 16, 2018. This new research vessel with the capacity of SOLAS researches will be delivered to OUC and put to use by the end of 2018.
- The first phase of the Dongshan Swire Marine Station of Xiamen University (D-SMART) was completed on May 31, 2017. Research at D-SMART will focus on monitoring the impact of human activity induced climate change on the marine ecosystem. Long-term observation platform for the environmental elements at the ocean-land-atmosphere interfaces will be established at D-SMART.

### ● Workshop organized

The Third Xiamen Symposium on Marine Environmental Sciences (3rd XMAS), Xiamen, China, January 9-11, 2017.

CHOICE-C II Annual Meeting, Dongshan, China, October 18-21, 2017.

Annual project meeting for a 973 program (Major State Basic Research Development Program of China, No. 2014CB953702, project title: Response of nitrogen cycle and primary productivity to atmospheric deposition, and climate feedback), Xiamen, China, October 28-October 30, 2017.

### ● International interactions and collaborations

Minhan Dai, SOLAS in Asia, Jan 23-25, 2017, The 5<sup>th</sup> workshop on Future Earth in Asia, Kyoto, Japan.

Minhan Dai co-chaired the theme “Chemistry of Ocean (past, present and future)” at the Goldschmidt 2017 conference, Aug. 13-18, 2017, Paris, France.

Prof. Huiwang Gao from Ocean University of China and Prof. Mitsuo Uematsu from Tokyo University co-chaired a session on “Atmospheric Deposition and Biogeochemical Interaction Processes” in the 10<sup>th</sup> WESTPAC/IOC international conference in Qingdao on April 17, 2017.

Prof. Huiwang Gao and Prof. Guiling Zhang attended the meeting of international SOLAS Scientific Steering Committee held in Italy on June 19-21, 2017.

● **Human dimensions (outreach, capacity building, public engagement etc.)**

The 6<sup>th</sup> Xiamen University Ocean Sciences Open House was held on November 5, 2017, Zhou-Long-Quan Building, Xiang’An Campus, Xiamen University, China.

● **Events**

Prof. Minhan Dai from Xiamen University, past SOLAS SSC member and China-SOLAS vice president, was elected as Academician of Chinese Academy of Sciences in 2017.

**3. Top 5 publications in 2017 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.**

1. Du, C., Liu, Z., Kao, S.J., Dai, M.H., 2017, Diapycnal fluxes of nutrients in an oligotrophic oceanic regime: the South China Sea, *Geophysical Research Letters*, 44, doi: 10.1002/2017GL074921.
2. Bao, H. Y., Niggemann, J., Luo, L., Dittmar, T., Kao, S.J., 2017, Aerosols as a source of dissolved black carbon to the ocean. *Nature Communications*, doi:10.1038/s41467-017-00437-3.
3. Luo, L., Kao, S.J., Bao, H., Xiao, H., Xiao, H., Yao, X., Gao, H.W., Li, J.W., Lu, Y.Y., 2017, Sources of reactive nitrogen in marine aerosol over the northwest Pacific Ocean in spring, *Atmospheric Chemistry & Physics*, doi: 10.5194/acp-2017-846.
4. Li, W., Xu, L., Liu, X., Zhang, J., Lin, Y., Yao, X., Gao, H., Zhang, D., Chen, J., Wang, W., Harrison, R., Zhang, X., Shao, L., Fu, P., Nenes, A., Shi, Z., 2017, Air pollution–aerosol interactions produce more bioavailable iron for ocean ecosystems. *Science advances*, 3(3), doi: 10.1126/sciadv.1601749.
5. Wang, F. J., Chen, Y., Guo, Z. G., Gao, H. W., Mackey, K. R., Yao, X. H., Zhuang, G., Paytan, A., 2017, Combined effects of iron and copper from atmospheric dry deposition on ocean productivity. *Geophysical Research Letters*, 44(5), 2546-2555, doi: 10.1002/2016GL072349.
6. Shan J., Zhang H.-H., Zhang, J., Yang G.-P., 2017. Spatiotemporal distribution characteristics and environmental control factors of biogenic dimethylated sulfur compounds in the East China Sea during spring and autumn. *Limnology and Oceanography*, DOI: 10.1002/lno.10737
7. Li J.-L., Zhang H.-H., Yang G.-P., 2017. Distribution and sea-to-air flux of isoprene in the East China Sea and the South Yellow Sea during summer. *Chemosphere*, 178, 291-300, <http://dx.doi.org/10.1016/j.chemosphere.2017.03.037>
8. He Z., Liu Q.-L., Zhang Y.-J., Yang G.-P., 2017. Distribution and sea-to-air fluxes of volatile halocarbons in the Bohai Sea and Northern Yellow Sea during spring. *Science of the Total Environment*, 584-585, 546-553, <http://dx.doi.org/10.1016/j.scitotenv.2017.01.065>
9. Wu M., Chen L., Zhan L., Zhang J., Li Y., Liu J, 2017. Spatial Variability and Factors Influencing the Air-Sea N<sub>2</sub>O Flux in the Bering Sea, Chukchi Sea and Chukchi Abyssal Plain. *Atmosphere*, 8(4), <https://doi.org/10.3390/atmos8040065>.
10. Fu J. P., Wang B, Chen Y, Ma Q. W., 2017. The influence of continental air masses on the aerosols and nutrients deposition over the western North Pacific, *Atmospheric Environment*, 172, doi: 10.1016/j.atmosenv.2017.10.041.
11. Fang, Z., Yang, W., Chen, M., & Ma, H., 2017. Source and fate of dissolved black carbon in the western south china sea during the southwest monsoon prevailing season. *Journal of Geophysical Research Biogeosciences*, 122(11), 2817–2830.

*For journal articles please follow the format:*

*Author list (surname and initials, one space but no full stops between initials), year of publication,*

*article title, full title of journal (italics), volume, page numbers, DOI.*

**4. Did you engage any stakeholders/societal partners/external research users in order to co-produce knowledge in 2017? If yes, who? How did you engage?**

## **PART 2 - Planned activities for 2018/2019 and 2020**

### **1. Planned major field studies and collaborative laboratory and modelling studies, national and international (incl. all information possible, dates, locations, teams, work, etc.).**

- There will be a spring cruise to the South China Sea, Luzon Strait and Northwest Pacific conducted by R/V TAN KAH KEE in 2018. This cruise will study the material exchange between South China Sea (SCS) and West Pacific. Other cruises to the Southern South China Sea basin, the Yellow Sea and Bohai Sea will be conducted by R/V TAN KAH KEE and R/V Dongfanghong 2 in 2018, which will benefit data accumulation. These cruises will be supported by NSFC Open Research Cruise, which is funded by Shiptime Sharing Project of NSFC. (Theme 1)
- It is confirmed that there will be a cruise to the Northwest Pacific conducted in April by R/V TAN KAH KEE in 2019. This cruise will study the biogeochemical responses to an eddy in the upper ocean with high resolution investigation. This cruise will be supported by NSFC. (Theme 1)
- Field sampling: Surface seawater and aerosol sampling campaign from South China Sea (January 2018, May 2018 and August 2018) (Theme 3)
- Field experiment: Bio-degradation and photo-degradation of atmospheric dissolved organic matter (precipitation and aerosol water soluble organic carbon) from South China Sea (August 2018) (Theme 3)
- Two SOLAS cruises will be conducted in summer and winter of 2018 on the Yellow Sea and East China Sea to study the distributions, air-sea fluxes and biogeochemical cycles of trace gases (i.e. CH<sub>4</sub>, N<sub>2</sub>O, DMS, CO<sub>2</sub>, CO, Halogens) in the atmosphere and the seawater. (Theme 1)

### **2. Events like conferences, workshops, meetings, schools, capacity building etc. (incl. all information possible).**

A SOLAS themed session is confirmed to be held at the 4<sup>th</sup> Xiamen Symposium on Marine Environmental Sciences (XMAS-IV, <http://mel.xmu.edu.cn/conference/4xmas>), January 6-9, 2019, Xiamen, China

### **3. Funded national and international projects / activities underway.**

CHOICE-C (Carbon cycling in China Seas-budget, controls and ocean acidification) project was renewed by the MOST of China for another 5 years from January 2015 to December 2019. This renewed project is termed as CHOICE-C II with a budget of 25 million CNY. Through comparative study of carbon cycling in River-Dominated-Ocean-Margins (RioMars, the northern South China Sea shelf being a case) and the Ocean-Dominated-Ocean-Margin (OceMars, the South China Sea basin being a case), CHOICE-C II is focusing on the carbon cycle in South China Sea in terms of its budget, controls and global implications. (Theme 1)

National Key Research and Development Program: Biogeochemical processes and climate effect of marine biogenic trace gases in the east marginal seas of China. Leading PI: Gui-Peng Yang. Institution: Ocean University of China. Budget: 25.86 million CNY. Research Duration: 5 years

(2016.7-2021.6). (Theme 2)

Major National scientific Research Program: Atmospheric deposition and its impact on marine primary production and nitrogen cycle (2013-2018), leading PI: Huiwang Gao. (Theme 3)

NSFC innovative research group: Nitrogen cycle under global change (2018-2023), Leading PI: Shuh-Ji Kao from Xiamen University, budget 10.5 million CNY. (Theme 1)

NSFC program: Utilizing ultrahigh resolution mass spectrometry and molecular markers to characterize the molecular composition and fate of atmospheric dissolved organic carbon in the South China Sea (2018-2020), Leading PI: Hongyan Bao from Xiamen University (Theme 3)

NSFC general program: Effects of multiphase reactions for atmospheric organic acid on deposition ice nucleation efficiency of particles (2018-2021), leading PI: Bingbing Wang from Xiamen University (Theme 3)

**4. Plans / ideas for future projects, programmes, proposals national or international etc. (please indicate the funding agencies and potential submission dates).**

- Proposal on co-limitation and utilization of major and micro/trace nutrients & export production in the West Philippine Sea will be submitted in March, 2018 to the Joint China-German Research Projects which is funded by the German Research Foundation and the National Natural Science Foundation of China.

**5. Engagements with other international projects, organisations, programmes etc.**

**Comments**