surface ocean solas lower atmosphere study

Report for the year 2018 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 2018 – Jan-Feb 2019*
- Part 2: *reporting on planned activities for 2019/2020 and 2021.*

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;
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 2018 to Jan/Feb 2019

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: Ratios of greenhouse gas emissions observed over the Yellow Sea and the East China Sea
Text: Greenhouse gases are pervasively produced by human activities and the Asian continent has become the largest source of anthropogenic pollutants. In order to explore the factors that affected the distribution of the greenhouse gases over the East China Seas, we determined carbon dioxide (CO_2), methane (CH_4), carbon monoxide (CO), and nitrous oxide (N_2O) over the East China Sea (ECSs, i.e. the Yellow Sea and East China Sea) in spring of 2017 using a continuous observation system. The spatial variations of these gases were very similar. The ratios of the mole fraction enhancements between every pair of trace gases downwind of the source areas showed that the distributions of these trace gases over the ECSs in the spring were mainly caused by the emissions from Eastern China. The much higher enhancement ratio of $\Delta CO/\Delta CO_2$ and the lower ratio of $\Delta CH_4/\Delta CO$ observed in the air parcels from big cities indicated high CO emission from the cities. The ratios of the averages in the air coming from the Northern sector (Russia) were on average closer to the Marine Boundary Layer (MBL), and the air that stayed over the Yellow Sea and the

East China Sea was a mixture of emissions from wide regional areas.

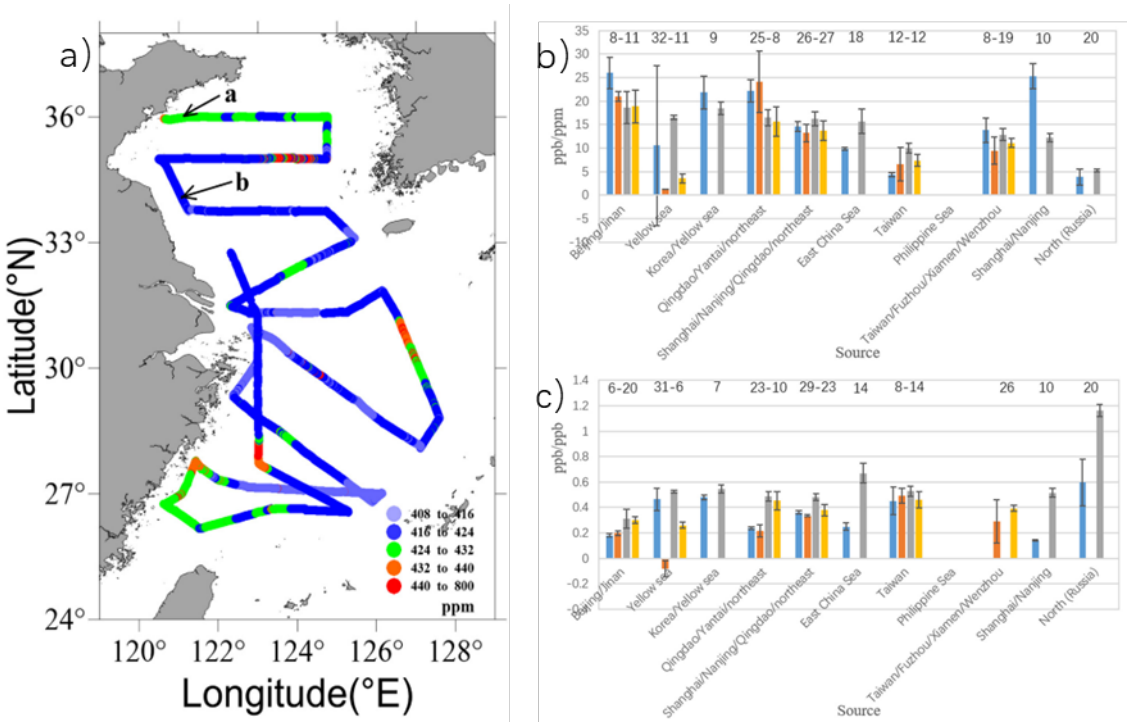

Figure: a) Spatial distribution of CO_2 mole fraction. b) The enhancement ratios of $\Delta CO/\Delta CO_2$ downwind different source areas. c) The enhancement ratios of $\Delta CH_4/\Delta CO$ downwind different source areas.

Citation: Liu, Y., Zhou, L., Tans, P. P., Zang, K., Cheng, S., 2018, Ratios of greenhouse gas emissions observed over the Yellow Sea and the East China Sea. *Science of the Total Environment*, 633, 1022-1031, doi: 10.1016/j.scitotenv.2018.03.250.

Title: Source of reactive nitrogen in marine aerosol over the Northwest Pacific Ocean in spring
Text: Atmospheric deposition of long-range transport of anthropogenic reactive nitrogen (Nr, mainly comprised of NHx, NOy and water-soluble organic nitrogen, WSON) from continents may have profound impact on marine biogeochemistry. Despite the importance of off-continent dispersion and Nr interactions at the atmosphere–ocean boundary, our knowledge of the sources of various nitrogen species in the atmosphere over the open ocean remains limited due to insufficient observations. We conducted two cruises in the spring of 2014 and 2015 from the coast of China through the East China seas (ECSs, i.e. the Yellow Sea and East China Sea) to the open ocean (i.e. the Northwest Pacific Ocean, NWPO). Aerosol NO_3^-, NH_4^+ and WSON decreased logarithmically with distance from the shore, reflecting strong anthropogenic emission sources in China. Obviously, marine DON emissions should be considered in model and field assessments of net atmospheric WSON deposition in the open ocean. This study contributes information on parallel isotopic marine DON composition and aerosol Nr datasets, but more research is required to explore complex Nr sources and deposition processes in order to advance our understanding of anthropogenic influences on the marine nitrogen cycle and nitrogen exchange at land–ocean and atmosphere–ocean interfaces.

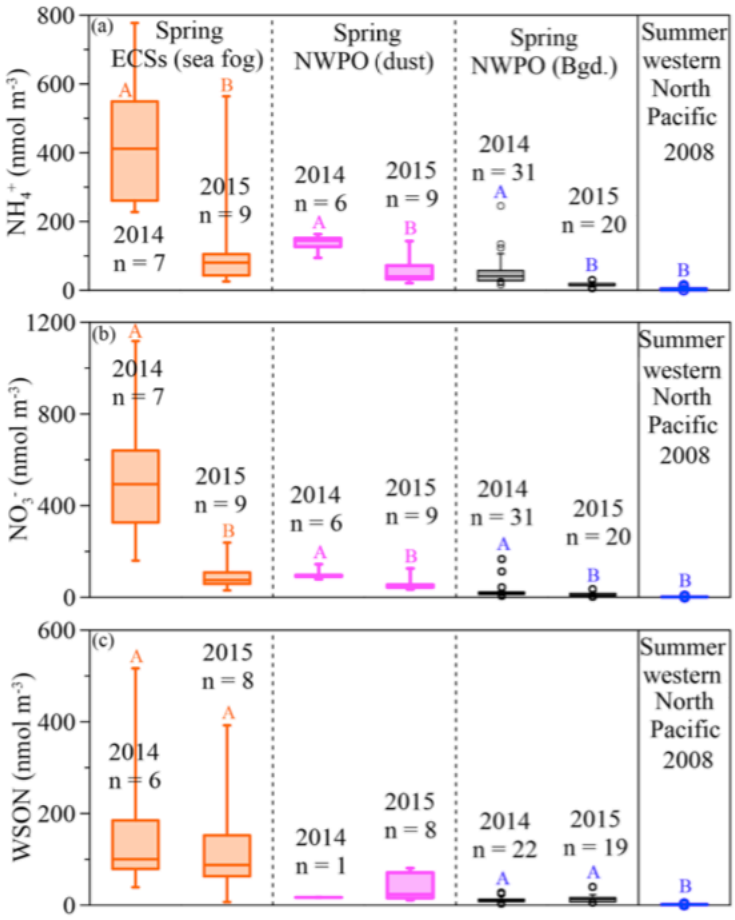

Figure: Box plots for spring concentrations of aerosol NH_4^+ (a), NO_3^- (b) and WSON (c) in the ECSs and NWPO.

Citation: Luo, L., Kao, S. J., Bao, H., Xiao, H., Yao, X., Gao, H., Li, J., Lu, Y., 2018, Source of reactive nitrogen in marine aerosol over the Northwest Pacific Ocean in spring. *Atmospheric Chemistry and Physics*, 18, 6207-6222.

Title: Variations in the phytoplankton community due to dust additions in eutrophication, LNLC and HNLC oceanic zones

Text: Dust deposition can bring nutrients and trace elements to the upper ocean and affect phytoplankton growth and community structure. We conducted a comparative study using on-board microcosm experiments amended with varying amounts of dust in the East China Sea (eutrophic zone), the subtropical gyre (Low-Nutrient and Low-Chlorophyll zone, LNLC), and the Kuroshio-Oyashio transition region (High-Nutrient and Low-Chlorophyll zone, HNLC) of the Northwest Pacific Ocean. The additions of dust supplied a considerable amount of nitrogen and negligible phosphorus relative to the seawater, contributing to the increases in chlorophyll a and the shifts towards larger cells of phytoplankton with increasing dust additions. In the experiments conducted in LNLC and HNLC zones, micro-sized phytoplankton benefited most from dust additions, while in eutrophic zone, the primary beneficiary was the nano-sized phytoplankton. The relative abundance of diatoms (RAD) increased substantially with increases in the N: P ratio until the ratio approached the Redfield ratio, and then decreased gradually as the N: P ratio increased. This was ascribed to the lower sensitivity of dinoflagellates to nutrient shortage. Overall, our results suggested that the overwhelming input of N relative to P by dust deposition might cause significant ecological impacts by altering the N: P ratio of varying trophic seawaters.

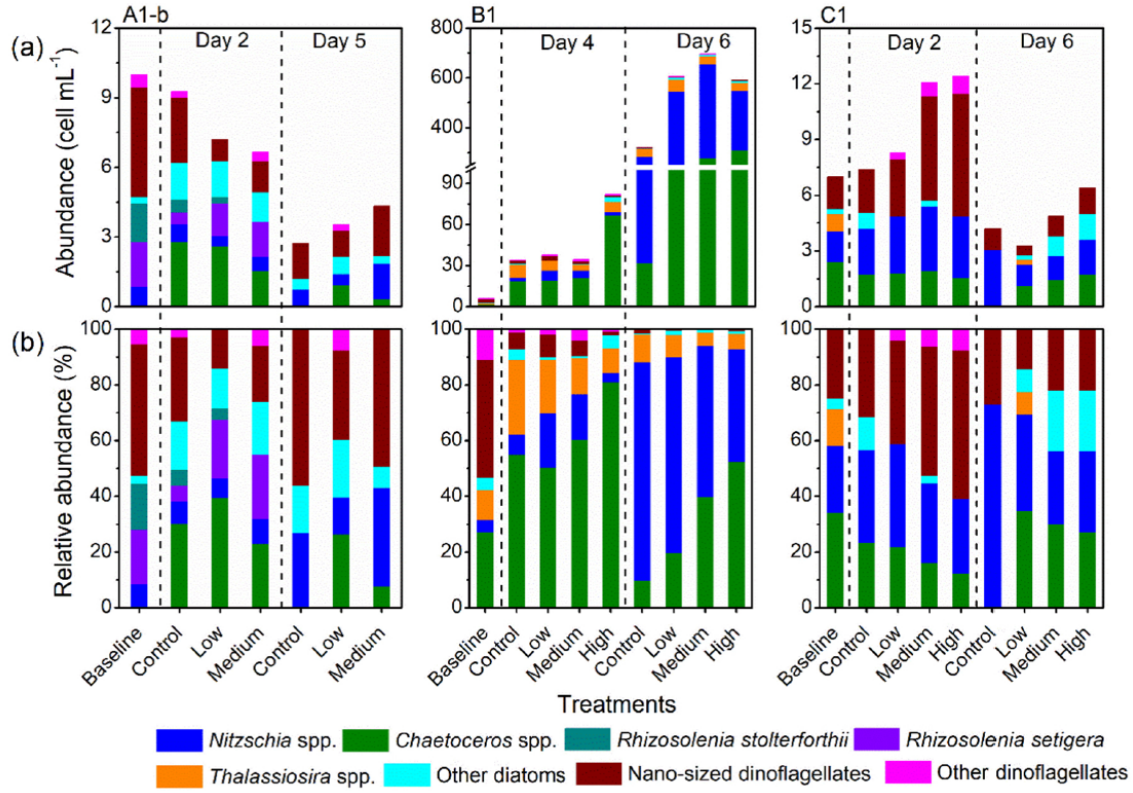

Figure: (a) Abundance of large size phytoplankton and (b) their contributions to the total abundance, with different amounts of dust added during the incubation experiments conducted in LNLC (A1-b), HNLC (B1) and eutrophic zone (C1).

Citation: Zhang, C., Yao, X., Chen, Y., Chu, Q., Yu, Y., Shi, J., Gao, H., 2019, Variations in the phytoplankton community due to dust additions in eutrophication, LNLC and HNLC oceanic zones. *Science of the Total Environment*, doi: 10.1016/j.scitotenv.2019.02.068.

Title: Analysis of the co-existence of long-range transport biomass burning and dust in the subtropical West Pacific region

Text: Biomass burning and wind-blown dust has been well investigated during the past decade regarding their impacts on environment, but their co-existence hasn't been recognized because they usually occur in different locations and episodes. However, we reveal the unique co-existence condition that dust from the Taklamakan and Gobi Desert (TGD) and biomass burning from Peninsular Southeast Asia (PSEA) can reach to the West Pacific region simultaneously in boreal spring. The upper level trough at 700 hPa along east coast of China favours the large scale subsidence of TGD dust while it travels southeastwards, and drives the PSEA biomass burning plume carried by the westerlies at 3–5 km to descend rapidly to around 1.5 km and mix with dust around southeast China Mainland and Taiwan Island. As compared to the monthly averages in March and April, surface observations suggested that concentrations of PM_{10}, $PM_{2.5}$, O_3, and CO were 69%, 37%, 20%, and 18% higher respectively during the 10 identified co-existence events. Co-existence also lowers the surface O_3, NOx, and SO_2 by 4–5% due to the heterogeneous chemistry between biomass burning and mineral dust as indicated by model simulations. These results provide new insights into the atmospheric deposition to the west Pacific.

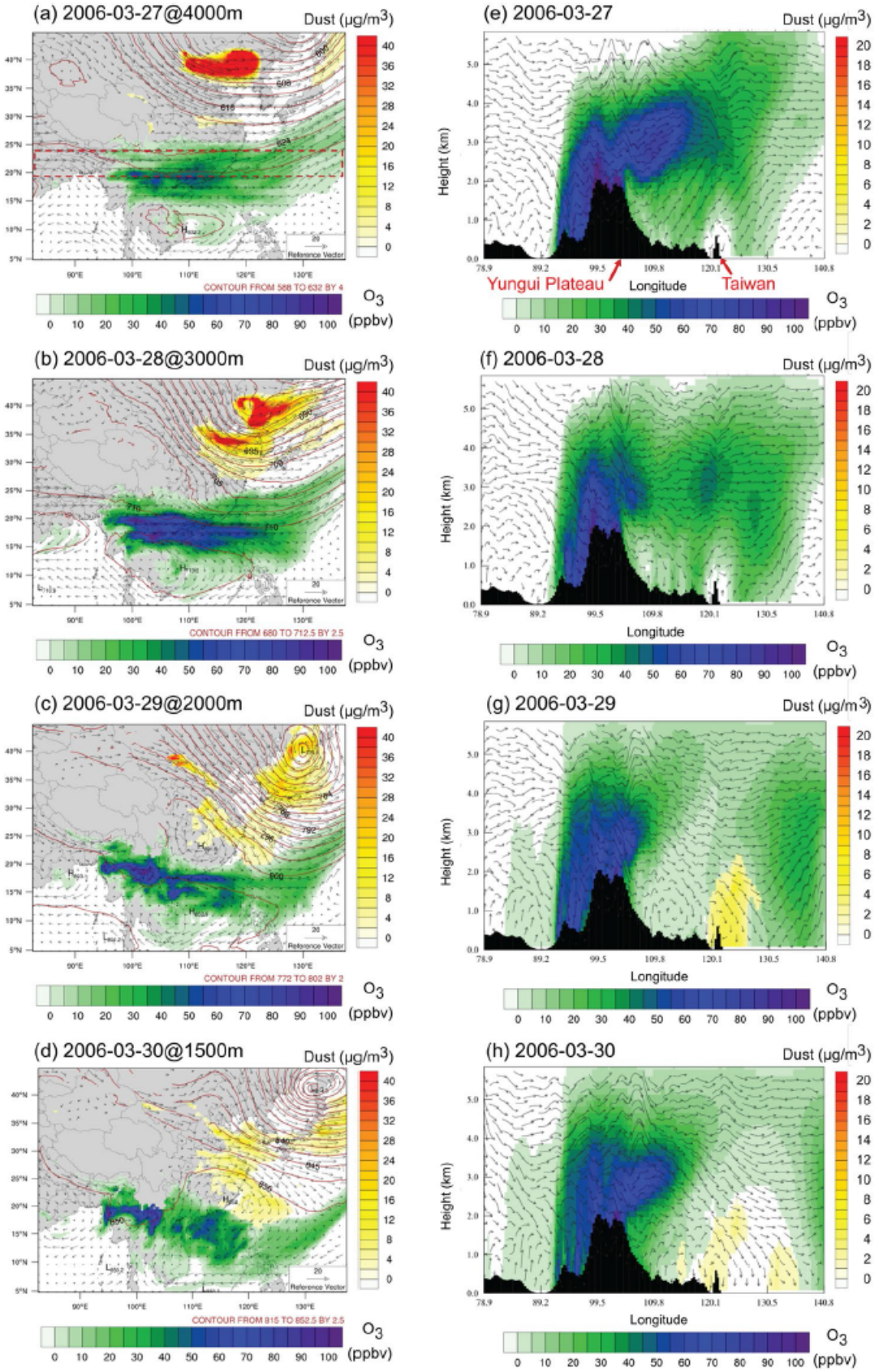

Figure: Spatial distributions of wind vector, pressure contour, dust concentration, and biomass burning O_3 concentration on (a) Mar. 27 at 4000 m; (b) Mar. 28 at 3000 m; (c) Mar. 29 at 2000 m; and (d) Mar. 30 at 1500 m above sea level; Zonal average (19°N-24°N, along the red dashed box in (a)) cross section distributions of wind vector, dust concentration, and biomass burning O_3 concentration on (e) Mar. 27; (f) Mar. 28; (g) Mar. 29; and (h) Mar. 30.

Citation: Dong, X., Fu, J. S., Huang, K., Lin, N. H., Wang, S. H., Yang, C. E., 2018, Analysis of the

co-existence of long-range transport biomass burning and dust in the subtropical West Pacific region. *Scientific Reports*, 8(1), 8962, doi: 10.1038/s41598-018-27129-2.

Title: The influence of terrestrial transport on visibility and aerosol properties over the coastal East China Sea

Text: Air pollutants from East Asia continent can affect the physico-chemical and optical properties of marine aerosols under seasonal winds. We investigated the change of visibility and haze frequency from 1974 to 2017 over the coastal East China Sea (ECS), and reconstructed the light extinction coefficients according to the chemical compositions of $PM_{2.5}$ samples collected at Huaniao Island in the ECS. The annual average visibility significantly decreased from over 25 km in the early 1970s to <18 km in recent 4 years. The occurrence of daily maximum haze frequency was approximately 3-h later with respect to land sites, which could be explained by the diffusion of air pollutants from nearby cities to the coastal ECS as well as the formation of secondary aerosols enhanced by photochemical reactions around noon. Meanwhile, anthropogenic chloride transported from the land could increase the concentration of Cl^- in marine aerosol, which may weaken the Cl^- depletion phenomenon over coastal ECS and even induced considerable Cl^- enrichment during the severe haze event. The largest contributor to the light extinction was $(NH_4)_2SO_4$ followed by NH_4NO_3 and OM in almost all seasons. Especially in winter and spring, $(NH_4)_2SO_4$ accounted for 45% and 52% of total light extinction, respectively.

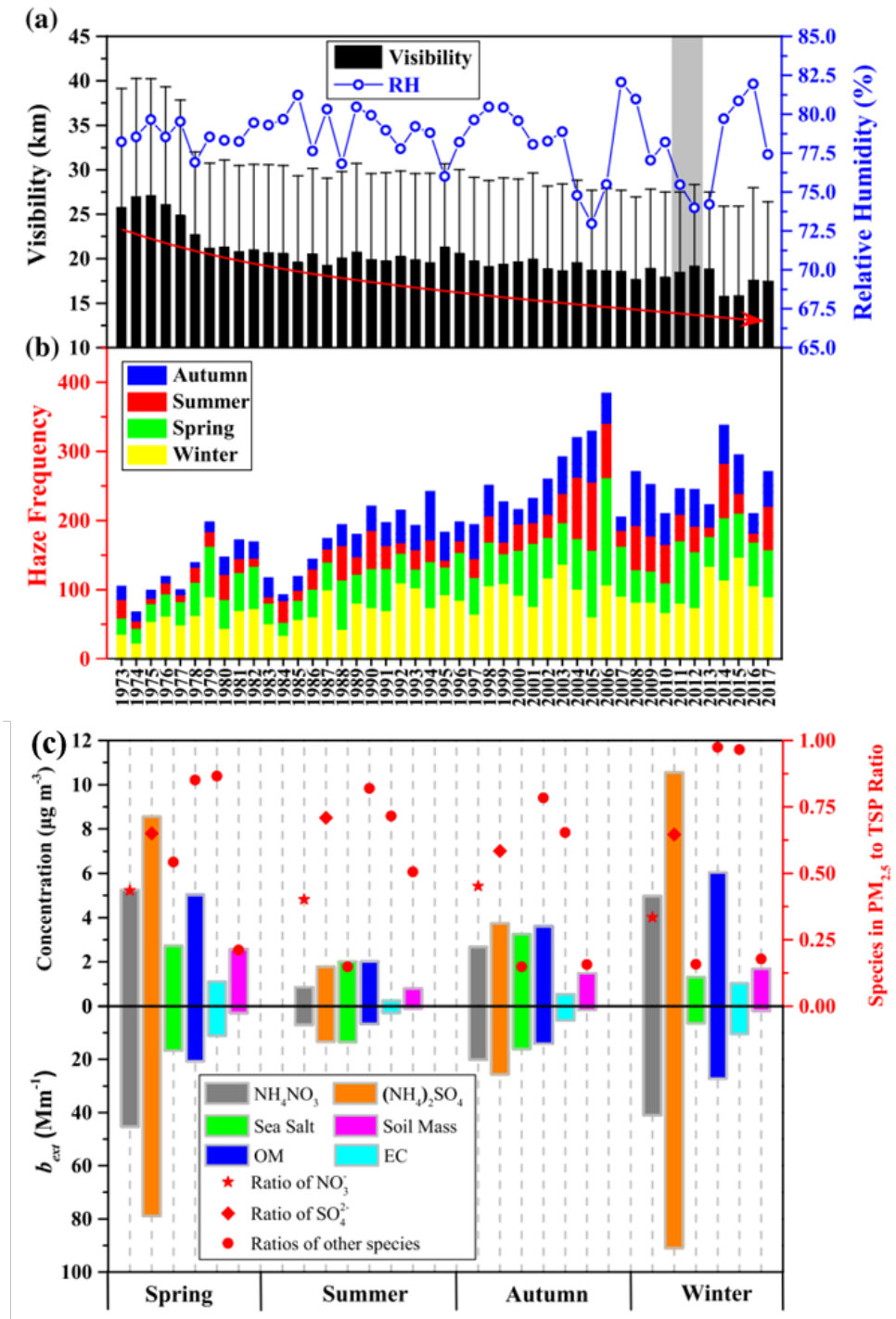

Figure: (a) Variation of annual average visibility and relative humidity over the coastal ECS from 1973 to 2017 (b) Haze frequency in different years and seasons. (c) Seasonal variation of $PM_{2.5}$ components concentration and light extinction coefficient (b_{ext}).

Citation: Wang, B., Chen, Y., Zhou, S., Li, H., Wang, F., Yang, T., 2018, The influence of terrestrial transport on visibility and aerosol properties over the coastal East China Sea. *Science of the Total Environment*, 649, 652-660, doi: 10.1016/j.scitotenv.2018.08.312.

2. Activities/main accomplishments in 2018 (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**

- Cruise studying on marine biogenic reactive gases in the Yellow Sea and East China Sea was conducted during the summer of 2018 (Theme 1-5).

- Atmospheric chemistry and marine ecology were investigated on Huaniao Island during March 31- May 9 and October 23-November 22, 2018 (Theme 3-5).

- A SOLAS cruise campaign was conducted from June 26 to July 17 of 2018 to the Yellow Sea and East China Sea to study the distributions, air-sea fluxes and biogeochemical cycles of trace gases (i.e. CH_4, N_2O, DMS, CO_2, CO, Halogens) in the atmosphere and the seawater. (Theme 1)

- The material exchange between South China Sea (SCS) and West Pacific were investigated based on large-scale observations of a cruise conducted onboard R/V TAN KAH KEE during June 12- July 10, 2018. Parameters related to the air-sea 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 Aug. 1-12, 2018 to the South East Asia Time-series Station (SEATS) in the SCS. This cruise aimed to understand how monsoonal forcing controls biogeochemical cycles in the SCS. This cruise was supported by the Fundamental Research Funds for the Central Universities. (Theme 1)

- **Model and data intercomparisons**

The modelling of marine biogenic DMS emissions and reactions using WRF-CMAQ (Theme 5)

- **Projects**

National Key Research and Development Program: Vertical Observation of Aerosol Particles and Their Characteristics at Single Particle Level within Marine Boundary Layer at Coastal Areas (2018-2021), leading PI: Bingbing Wang from Xiamen University (Theme 4)

NSFC Innovative Research Group: Nitrogen Cycle under Global Change (2018-2023), leading PI: Shuh-Ji Kao from Xiamen University (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)

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. 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 (2016-2021), leading PI: Gui-Peng Yang from Ocean University of China (Theme 2)

- **Infrastructure**

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 completed its first trial voyage at the end of December, 2018.

- **International interactions and collaborations**

In October 2018, Prof. Zhiyu Liu and Dr. Jinyu Yang attended a workshop in Kiel, which was related to establish an international research lab working on a time-series observation in the North Atlantic Ocean. This prospective International Lab is a significant initiative towards integrated ocean-atmosphere observations and experiments, which is a central theme of international

programs such as SOLAS. This International Lab would also be an exciting platform for fruitful international collaborations that MEL/XMU is looking forward to.

- **Workshop organized**

From 6 to 9 January 2019, the 4th Xiamen Symposium on Marine Environmental Sciences (XMAS-IV) with the theme of 'The Changing Ocean Environment: From a Multidisciplinary Perspective' took place in Xiamen, China. The symposium consists of 33 sessions covering physical oceanography, marine biogeochemistry, biological oceanography, and marine ecotoxicology along with workshops for emerging topics in marine environmental sciences. A SOLAS Session C4 entitled "Surface Ocean and Lower Atmosphere Study—Air-Sea interactions and their climatic and environmental impacts" was included. In this session, the SOLAS scientific community exchanged new ideas and discussed the latest achievements in our understanding of the key biogeochemical-physical interactions and feedbacks between the ocean and the atmosphere, and of how this coupled system affects and is affected by climate and environmental change. Studies focusing on atmosphere-ocean exchange of climate active gases, atmospheric deposition, chemical transformations of gases and particles, interactions between anthropogenic pollution with marine emissions, feedbacks from ocean ecosystems and impacts to environments and climate were presented in particular.

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

The 7th Xiamen University Ocean Sciences Open House was held on November 4, 2018, Zhou-Long-Quan Building, Xiang'An Campus, Xiamen University, China.

3. Top 5 publications in 2018 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.

1. Liu, Q., Guo, X.H., Yin, Z.Q., Zhou, K.B., Roberts, E.G., Dai, M.H., 2018, Carbon fluxes in the China Seas: An overview and perspective. *Science China-Earth Sciences*, 61(11), 1564-1582.
2. Jiang, Y., Lin, T., Wu, Z., Li, Y., Li, Z., Guo, Z., Yao, X., 2018, Seasonal atmospheric deposition and air–sea gas exchange of polycyclic aromatic hydrocarbons over the Yangtze River Estuary, East China Sea: Implications for source–sink processes. *Atmospheric Environment*, 178, 31-40, doi:10.1016/j.atmosenv.2018.01.031.
3. Dong, X., Fu, J. S., Huang, K., Lin, N. H., Wang, S. H., Yang, C. E., 2018, Analysis of the Co-existence of Long-range Transport Biomass Burning and Dust in the Subtropical West Pacific Region. *Scientific Reports*, 8(1), 8962, doi:10.1038/s41598-018-27129-2.
4. Wang, B., Chen, Y., Zhou, S., Li, H., Wang, F., Yang, T., 2018, The influence of terrestrial transport on visibility and aerosol properties over the coastal East China Sea. *Science of the Total Environment*, 649, 652-660, doi:10.1016/j.scitotenv.2018.08.312.
5. Sun, M.-S., Zhang, G.-L., Ma, X., Cao, X. -P., Mao, X.-Y., Li, J., Ye, W.-W., Liu, S.-M., 2018, Dissolved Methane in the East China Sea: distribution, seasonal variation and emission. *Marine Chemistry,* 202, 12-26, doi: 10.1016/j.marchem.2018.03.001.

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 2018? If yes, who? How did you engage?

PART 2 - Planned activities for 2019/2020 and 2021

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

- Two SOLAS cruises will be conducted in fall and winter of 2019 to the Yellow Sea and East China Sea to study the distributions, air-sea fluxes and biogeochemical cycles of trace gases (i.e. CH_4, N_2O, DMS, CO_2, CO, Halogens) in the atmosphere and the seawater. (Theme 1)

- A spring cruise to the Northwest Pacific is being conducted by R/V TAN KAH KEE in March-April, 2019. This cruise is studying the biogeochemical responses to an eddy in the upper ocean with high resolution investigation. This cruise is supported by NSFC.
- It is confirmed that there will be a cruise to the Northwest Pacific conducted in April by R/V TAN KAH KEE in 2019. It will be the 1st GEOTRACES-China Cruise.
- There will be a winter cruise to the Northwest Pacific conducted by R/V TAN KAH KEE under Carbon-FE project from the end of 2019 to January of 2020, which aims to examine carbon fixation and export, or the biological bump in general, regulated by differently sourced nutrients including macronutrients (i.e., N, P, Si) and micronutrients (e.g., Fe).

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

- The 4th Global Ocean Acidification Observing Network (GOA-ON) International Workshop will be held at Hangzhou, April 14-17, 2019.
- More than 20 scientists and students from China will attend the SOLAS Open Science Conference 2019 held in Sapporo Hokkaido, Japan, April 21-25, 2019.

3. Funded national and international projects / activities underway.

- NSFC program: CARBON Fixation and Export in the oligotrophic ocean (Carbon-FE) (2019-2023), leading PI: Minhan Dai from Xiamen University (Theme 1)

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

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

Prof. Minhan Dai engage in REgional Carbon Cycle Assessment and Processes-2 (RECCAP2) which is an activity of the Global Carbon Project with a number of partners. The objectives of RECCAP2 are: 1) to quantify anthropogenic greenhouse gas emissions, 2) to develop robust observation-based estimates of changes in carbon storage and greenhouse gas emissions and sinks by the oceans and terrestrial ecosystems, distinguishing whenever possible anthropogenic vs. natural fluxes and their driving processes, 3) to gain science-based evidence of the response of marine and terrestrial regional GHG (CO_2, CH_4, N_2O) budgets to climate change and direct anthropogenic drivers. To address these objectives, RECCAP2 will design and perform a set of global syntheses and regional GHG budgets of all lands and oceans, and explore mechanisms by which to deliver regular updates of these regional assessments based on scientific evidence, considering uncertainties, understanding of drivers, and retrospective analysis of recent trends. RECCAP2 is expected to accomplish most of the work over 2019-2020 with publication of all papers by 2021.

Comments