Newsletter
January – March, 2020

International Centre on Space Technologies for Natural and Cultural Heritage under the Auspices of UNESCO
# CONTENTS

( January–March, 2020 )

## Special Focus

2. HIST Governing Board Convenes 8th Session in Beijing

3. HIST Convenes 2020 Annual Work Meeting

4. HIST Holds Workshop on Monitoring and Protection of World Heritage Sites in Beijing

## HIST Bases

5. Vertical Take-off and Landing Fixed Wing UAV Aerial Photo Mapping and its Application in the Dongzhao Archaeology Site

6. Digital Reconstruction and Application of Lushan Mountain, a World Heritage Site of Cultural Landscape

9. "Living" Map Assisted Epidemic Prevention and Control scientifically

## AIR News

10. AIR, University of Macau Establish Joint Lab of Aerospace Information

12. AIR Research Results Win 2019 National Science and Technology Award

## UNESCO News

12. Multi-agency report highlights increasing signs and impacts of climate change in atmosphere, land and oceans

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HIST Convenes 2020 Annual Meeting

HIST held the 2020 annual meeting in Beijing on the afternoon of January 6. The meeting was presided over by Academician Guo Huadong, Director of HIST.

The annual meeting summarized the work in 2019 and put forward the priorities for 2020. In 2019, HIST devoted itself to building interdisciplinary subject of space archaeology, promoted the publication of Introduction to Space Archaeology, and carried out cooperation in research projects such as space-based remote sensing monitoring in Bagan, Myanmar, and Jiuzhaigou, China, around the whole-chain global governance system for world heritage sites. To strengthen the development of network, Nanchang Base, the fourth after Zhengzhou, Harbin and Hengyang Bases, was established, forming an academic arrangement of “pivotal center with a large network.” In 2020, HIST will continue to bolster the development of space archaeology and the whole-chain governance system, focus on research projects such as Sri Lanka’s elephant habitat, accomplish relevant tasks in the third round of Asia-Pacific periodic reports for world heritage sites, and prepare for its side event and exhibitions of the 44th session of the World Heritage Committee. Zhengzhou, Harbin, Hengyang and Nanchang Bases respectively reported on the progress of scientific research, exchange & cooperation, and platform construction in 2019, and put forward the work plan for 2020.

The HIST Secretariat introduced the draft *HIST Workstation Management Measures* that specify the application qualifications and procedures, as well as business management and other regulations for workstation, soliciting opinions and suggestions. Applicants for Xiamen Base, Wuhu, Changsha and Tengchong Workstations made application reports respectively. Academician Guo Huadong commented on application reports, and delegates offered constructive suggestions on the reports.

After the report session, delegates conducted in-depth discussions on work arrangements, implementation measures, and coordination and cooperation between HIST headquarters and its bases during the period of Phase II. Representatives from the bases said that they will continue to conduct more research in the specialized fields and make new contributions to the monitoring, protection and management of heritage sites using space information technology.

Finally, HIST Director Guo Huadong recognized the achievements made by HIST and its Bases in 2019 and made arrangements for major tasks for 2020 in his concluding speech. He called for more emphasis on preparing the side event and exhibitions of the 44th session of the World Heritage Committee, updating the *Remote Sensing Atlas for World Heritage Sites (China)*, making natural and cultural heritage maps along the Belt and Road route, refining 20 classic heritage maps, and producing publicity materials for HIST and its Bases. In 2020, HIST will continue to carry out research on the application of space technology to the protection of world heritage sites along the Belt and Road route, further sharpen HIST’s core competitive edge, and strive to become an internationally renowned institution in this field.

The meeting summed up the achievements in 2019, pointed out the direction in 2020, analyzed opportunities and challenges faced by HIST, and strengthened the exchanges and cooperation between HIST headquarters and its bases and between all bases, gaining a good momentum of win-win cooperation.

The conference brought together 60-odd people including HIST’s director and deputy director, and secretary-general and deputy secretary-general; heads of all departments; all members of the Digital Heritage Office and the Secretariat; and representatives from all bases and research institutes that intend to apply for a base or workstation.
HIST convened the 8th session of its Governing Board on 7 January 2020 in Beijing, China. Mr. Zhuang Yan from International Cooperation Bureau of Chinese Academy of Sciences (CAS) moderated the meeting. In his opening remarks, Mr. Zhuang emphasized that CAS will continue to support the sound development of HIST.

HIST’s Annual Report of 2019 and Biennial Work Plan for 2020-2021 were discussed and approved by the Governing Board. In 2019, HIST made excellent progress especially in mobilizing CAS resources for HIST activities. It also contributed its efforts to facilitate Sri Lanka, Myanmar and other UNESCO member states to monitor their world heritage sites, which were highly appreciated and have attracted international attention and interest. In the coming biennium, it will continue to strengthen its abilities to apply space technologies in the identification, conservation, management and sustainable development of UNESCO-designated sites. It will also organize a side event and an exhibition during the 44th session of World Heritage Committee, and participate in the 3rd Cycle of Periodic Reporting of World Heritage sites in Asia and the Pacific region.

Progress reports of 4 HIST Bases and DBAR-Heritage Working Group were also presented during the meeting. HIST Board members appreciated the rapid development and active contribution of 4 HIST bases and expressed satisfaction over their progress. It was acknowledged that DBAR also provides a very good platform for HIST to extend its work beyond UNESCO World Heritage sites.

Thorough discussions were held on collaborative research on UN SDG 11.4 and other relative SDGs. The Board also recommended that HIST explore collaborations with ICOMOS, UNESCO Beijing office, Delft University of Technology and other organizations.

In his concluding remarks, Acad. Prof. Guo Huadong expressed his appreciation to the Board, secretariat and HIST bases for their valuable contributions and excellent suggestions. He expressed hope that HIST will become better and better with their guidance and advice. He said that HIST will rise to the challenge and take full advantage of the growing awareness of governments about the importance of using space information technology in monitoring world heritages. UNESCO need more contributions from HIST and HIST will work hard to meet pressing needs of UNESCO and its member states.

HIST’s deputy directors, staff members at HIST secretariat, representatives of research teams and HIST’s bases joined the meeting as observers.
HIST Holds Workshop on Monitoring and Protection of World Heritage Sites in Beijing

HIST held a workshop on the monitoring and protection of world heritage sites in Beijing on the morning of January 6, 2020. The workshop, themed “monitoring and protection of world heritage sites,” discussed new developments, ideas, and technologies in the field of heritage protection and facilitated academic exchanges in the natural and cultural heritage. Academician Guo Huadong, Director of HIST, delivered a welcoming speech. Research Fellow Wang Xinyuan, Deputy Director of HIST, presided over the meeting.

In his speech, Academician Guo said that experts and representatives from China and beyond are welcome to attend the seminar. Since its inception in 2011, HIST has been committed to using space information technology to help monitor and protect world heritage sites. It has assisted Sri Lanka, Cambodia, and other developing countries in preserving their heritage sites. At the 44th World Heritage Conference held in 2020 HIST will hold parallel conferences and exhibitions on the application of space technology to world heritage sites to showcase the application of science and technology in heritage conservation.

In adopting space information technology for monitoring and protection of heritage sites, Prof. Rosa Lasaponara, Senior Research Fellow of the National Research Council of Italy, introduced the great value of big data to the application of digital earth, and analyzed the opportunities and challenges of big earth data for heritage protection through cases. Prof. Dang Anrong of Tsinghua University’s School of Architecture focused on the case of using space information technology to monitor the Yulin section of the Ming Great Wall, highlighting the importance of space information technology to the protection of the Great Wall. Research Fellow Chen Fulong, Deputy Director of HIST, briefed over the demand for space technology for the sustainable development of national heritage sites along the Belt and Road route, focusing on the environmental monitoring in the China-Pakistan Economic Corridor, the accurate monitoring and impact assessment of typical heritage sites, and the cases of Bagan in Myanmar and Angkor Wat in Cambodia.

In using science and technology to restore cultural relics, Prof. Hou Miaole of Beijing University of Civil Engineering and Architecture introduced the definition, advantages, challenges and research progress of virtual restoration, explained the five major functions of the virtual restoration system for cultural relics, and analyzed the cases of Dazu Rock Carvings Thousand-Handed Bodhisattva and Terracotta Warriors.

In the field of urban heritage and sustainable development, Ana Rodgers, a professor with Delft University of Technology in the Netherlands, briefed over causes, categories and value types of urban heritage protection, analyzed ancient and modern buildings of Curaçao Island on Willemstad, and illustrated the evolution of urban heritage protection in the Netherlands.

In protecting agricultural heritage sites, Prof. Min Qingwen, Research Fellow at the Institute of Geographic Sciences and Natural Resources Research of the Chinese Academy of Sciences, introduced the origin and distribution of the Globally Important Agricultural Heritage Systems (GIAHS) and China’s
Recently HIST Zhengzhou base purchased a vertical take-off and landing fixed-wing unmanned space data acquisition system. The system contains fixed wing vertical take-off and landing flight platform, multi-rotor flight platform, orthophoto camera, tilt photography camera, multi-spectral camera, terrain data processing system and the control point acquisition device. The system passed the acceptance test of HIST Zhengzhou Base on January 16, 2020.

On April 8, 2020, HIST Zhengzhou Base used this system to carry out a flight experiment at the Dongzhao archaeological site in Zhengzhou, and acquired many data of the site, such the orthographies, oblique aerial photography and multi-spectral image.

A variety of image data obtained by the system can be used for site mapping, 3D model construction and interpretation of site features. In particular, the system has a big advantage in the protection and research of large-scale cultural heritage such as the Great Wall, Beijing-Hangzhou grand canal.
Digital Reconstruction and Application of Lushan Mountain, a World Heritage Site with Outstanding Cultural Landscape

From March 2016 to December 2019, supported by National Science and Technology Support Program and Guided by Prof. Fang Chaoyang, HIST Nanchang Base, Jiangxi Provincial Basic Geography Center and Jiangxi PuShi Technology Co., Ltd., cooperated and successfully completed the data collection and processing of the Lushan Mountain, World Cultural Landscape. This work has successfully built a achievements database on cultural heritage digitization and tourism resource informatization, providing support for the protection and utilization of Lushan Mountain.

It is based on the cooperation between HIST Nanchang Base, Jiangxi Provincial Basic Geography Center and Jiangxi PuShi Technology Co., Ltd. for more than 4 years. It used digitalization methods of cultural heritage such as surveying and mapping, satellite remote sensing, digital photography, digital video shooting, 360-degree panoramic view, and environmental objects photography, digital recording, graphic & digital scanning and interview records, collected and organized basic geographic data, cultural and tourism resource information and 3D modeling data of Lushan Mountain, etc., completed the Lushan Mountain East Forest Temple and Bailudong Academy The high-resolution real-world 3D modeling of Heguling Street and other areas and the DEM+DOM terrain modeling of the full coverage of the Lushan Mountain Natural Reserve, and established the Lushan Mountain digital reconstruction and virtual experience system together with tourism information and scientific investigation data.
Related technologies have been applied to city-wide tourism electronic map platform in Yingtan, smart tourism platform for Gaobei Town, smart scenic platforms for Fairy Lake and Yihuang Baoji Temple, Jiangxi Provincial Tourism Geographic Information System, Online Pavilion for Jiangxi Provincial Surveying and Mapping Geographic Information Application Results and Maps, Digital Jiujiang Tourism Geographic Information System, Land and Resources Multimedia 3D Display System of Land and Resources Bureau of Shangrao Municipal Government. And it has organized relevant training courses for the society for three consecutive years.

Fig 1 White Deer Cave Academy

Fig 2 Donglin Temple

Fig 3 Stone Tablet Garden for Mao Zedong's Poetry

Fig 4 CULING street

Fig 5 3D Image of Lulin Lake by Real View in Lushan Mountain scenic area
Fig 6 A series of achievements of tilt 3D model

Fig 7 Lushan Mountain Three-dimensional Display Experience Platform

Fig 8 Three-channel VR/AR Experience Environment Consisting of "Solid Model, Stereo Electronic Sand Table and Panoramic Large Screen"
“Living” Map Assisted Epidemic Prevention and Control scientifically

During the epidemic prevention and control period, people not only pay attention to the changes in numbers every day, but also care about the epidemic map updated in real-time manner. Where does the virus come from and go? what is its current spatial distribution and scope of transmission?

During the epidemic prevention and control period, Li Meifang, head of big data analysis at Nanchang CDC’s new crown pneumonia prevention and control emergency command center, a Specially-appointed Researcher at School of Geography and Environment, Jiangxi Normal University(JXNU), and a postdoctoral of Dartmouth College in the United States, have been working hard to draw a “living” epidemic map. With the help of the powerful spatial analysis technology in geographic information science, she enabled the mobile signaling data to be displayed on the map, endowed the coordinate numbers with the connotation of the spatial distribution of epidemic situation and individual activity track, etc.; she also explored the correlation between them, compared the coincidence of tracks among different individuals, and analyzed the correlation between seemingly independent spatial individuals (or objects) to simulate real individual activities and epidemic situation, so as to study the source of case infection and epidemic situation trend, and provide inputs into decision-making process in scientific and accurate prevention and control.

In today’s digital era, geographic information technology has penetrated into all aspects of people’s lives, not only to help prevent and control the epidemic. In our province, there are many such cases.

The amount of wetland is an important part of the assessment index of ecological civilization construction. Aiming at the problem of how to realize the quantitative and accurate calculation of Wetland Reserve, Fang Chaoyang, executive deputy director of Key Laboratory of the Ministry of Education of the Poyang Lake Wetland and Watershed, JXNU, and member of the Governing Board of HIST Nanchang Base, led the team to develop the intelligent wetland platform, monitor the occupancy and compensation of wetland by using
satellite remote sensing, and achieve the fine management with a “map”.

In addition, Fang also focused on “smart tourism”. The epidemic prevention and control smart travel platform integrates electronic appointment verification, crowd flow and body temperature monitoring, virtual experience of scenic spots, intelligent tour guide service and epidemic emergency response plan to strengthen epidemic prevention and control management. This employs geographic information technology, such as virtual intelligent tour guides based on geographic location services, which not only reduces the risk of cross-infection between tour guides and tourists, but also allows tourists to establish their own tour records. Fang Chaoyang said, many tourist attractions and scenic spots in the province have built such platforms to provide tourists with intelligent information services while also assisting in epidemic prevention and control.

Lin Hui, academician of the International Eurasian Academy of Sciences, dean of the School of Geography and Environment of JXNU, and director of HIST Nanchang Base, said that the “living” map not only brings all kinds of conveniences, but also gives us a new way of thinking- use the “big map” to realize the refined management of the government. From personnel positioning to mobile phone maps, vehicle navigation, to big data applications in various fields of economy and society, the geographic information service industry is expected to prosper. The application of “living” maps is particularly significant in the prevention and control of epidemics.

The original text is visible: [link]

The Joint Laboratory of Aerospace Information was established by the Aerospace Information Research Institute (AIR) under the Chinese Academy of Sciences (CAS) together with the University of Macau (UM) on January 9 in Macao. WU Yirong, Director General of AIR, and Song Yonghua, rector of UM, signed a cooperation agreement on behalf of both institutes.

The joint lab is built to promote the development of aerospace information technologies in line with the development of smart city. The collaboration activities will include cooperative research, academic exchanges, and joint projects in order to strengthen the construction of Guangdong-Hong Kong-Macao Greater Bay Area and the development of the China’s Belt and Road Initiative.

Song addressed that over the past two decades since Macao returned to China, UM has received great support from the central government in the establishment of state key laboratories and research centers as well as in industry-academia collaboration. The relevant research fields have been highly recognized by the central and Macao SAR governments. He hopes that this joint lab will further advance scientific research and the training of professionals on both sides.

Wu hopes that this collaboration opportunity will encourage more young professionals to devote themselves to related research fields. As a gift, AIR presented UM with the “Atlas of Remote Sensing for the Twentieth Anniversary of Macao’s Return to China”.

After the ceremony, Wu gave a lecture titled “Aerospace Information: A Natural Big Data Framework”, introducing what constitutes aerospace information and the cutting-edging technologies in the field. He focused on the concept of aerospace information as a carrier of big data, related technologies and its related industry applications. The talk attracted many faculty members and students.
The both sides sign a cooperation agreement.

The nameplate-unveiling ceremony.

WU Yirong delivers an academic report.

The AIR delegation visits the Library of the UM and presents books, journals, and remote sensing atlas as gifts.
AIR Research Results Win 2019 National Science and Technology Award

At the annual ceremony of the National Science and Technology Award held on January 10, 2020 in Beijing, the Aerospace Information Research Institute (AIR) under the Chinese Academy of Sciences (CAS) won three prizes for the National Science and Technology Progress Award in 2019, including a first and a second prize as the first research unit, and a second prize as the second research unit.

The National Science and Technology Award is the highest award of China in the field. It is divided into five types: the National Preeminent Science and Technology Award, the National Natural Science Award, the National Technological Invention Award, the National Science and Technology Progress Award and the China International Science and Technology Cooperation Award.

Previously, AIR has won a second prize for the 2018 National Technological Invention Award, two second prizes for the National Science and Technology Progress Award as the first research unit and the third research unit respectively.

Multi-agency report highlights increasing signs and impacts of climate change in atmosphere, land and oceans

New York / Geneva, 10 March 2020 - The tell-tale physical signs of climate change such as increasing land and ocean heat, accelerating sea level rise and melting ice are highlighted in a new report compiled by the World Meteorological Organization and an extensive network of partners. It documents impacts of weather and climate events on socio-economic development, human health, migration and displacement, food security and land and marine ecosystems.

The WMO Statement on the State of the Global Climate in 2019 includes input from national meteorological and hydrological services, leading international experts, scientific institutions and United Nations agencies. The flagship report provides authoritative information for policy makers on the need for Climate Action.

The report confirms information in a provisional statement issued at the UN Climate Change Conference in December that 2019 was the second warmest year in the instrumental record. 2015-2019 are the five warmest years on record, and 2010-2019 the warmest decade on record. Since the 1980s, each successive decade has been warmer than any preceding decade since 1850.

2019 ended with a global average temperature of 1.1°C above estimated pre-industrial levels, second only to the record set in 2016, when a very strong El Niño event contributed to an increased global mean temperature atop the overall warming trend.

“We are currently way off track to meeting either the 1.5°C or 2°C targets that the Paris Agreement calls for,” said United
Nations Secretary-General Antonio Guterres in a foreword. “This report outlines the latest science and illustrates the urgency for far-reaching climate action. It brings together data from across the fields of climate science and lists the potential future impacts of climate change – from health and economic consequences to decreased food security and increased displacement,” he said.

The report was launched at a press conference given by the UN Secretary-General and WMO Secretary-General Petteri Taalas at UN headquarters on 10 March.

“Given that greenhouse gas levels continue to increase, the warming will continue. A recent decadal forecast indicates that a new annual global temperature record is likely in the next five years. It is a matter of time,” said WMO Secretary-General Taalas.

“We just had the warmest January on record. Winter was unseasonably mild in many parts of the northern hemisphere. Smoke and pollutants from damaging fires in Australia circumnavigated the globe, causing a spike in CO₂ emissions. Reported record temperatures in Antarctica were accompanied by large-scale ice melt and the fracturing of a glacier which will have repercussions for sea level rise,” said Mr Taalas.

“Temperature is one indicator of ongoing climate change. Changes in the global distribution of rainfall have had a major impact on several countries. Sea levels are rising at an increasing pace, largely due to the thermal expansion of sea water as well as melting of the largest glaciers, like in Greenland and Antarctica. This is exposing coastal areas and islands to a greater risk of flooding and the submersion of low-lying areas,” said Mr Taalas.

**Oceans**

**Marine heatwaves**: More than 90% of the excess energy accumulating in the climate system as a result of increased concentrations of greenhouse gases goes into the ocean. In 2019, ocean heat content down to a depth of 2 kilometers exceeded the previous record highs set in 2018.

**Ocean warming** has widespread impacts on the climate system and contributes more than 30% of sea level rise through thermal expansion of sea water. It is altering ocean currents and indirectly altering storm tracks and melting floating ice shelves. Together with ocean acidification and deoxygenation, ocean warming can lead to dramatic changes in marine ecosystems. In 2019, the ocean experienced on average nearly 2 months of unusually warm temperatures. At least 84% of the ocean experienced at least one marine heatwave.

**Ocean Acidification**: In the decade 2009-2018, the ocean absorbed around 23% of annual CO₂ emissions, cushioning the impacts of climate change but increasing ocean acidity. The change of pH reduces the ability of marine organisms such as mussels, crustacean and corals to calcify, affecting marine life, growth and reproduction.

**Ocean Deoxygenation**: both observations and models indicate that oxygen is declining in the open and coastal oceans, including estuaries and semi-enclosed seas. Since the middle of the last century, there has been an estimated 1%-2% decrease (77 billion–145 billion tons) in the global ocean oxygen inventory.
Marine Ecosystems: Deoxygenation alongside ocean warming and acidification is now seen as a major threat to ocean ecosystems and the wellbeing of people that depend on them. Coral reefs are projected to decline to 10%-30% of former cover at 1.5°C warming, and to less than 1% at 2°C warming. Sea level has risen throughout the satellite altimetry record (since 1993), but the rate has increased over that time, mainly due to melting of ice sheets on Greenland and Antarctica. In 2019, the global mean sea level reached its highest value on the record. Ice: The continued long-term decline of Arctic sea ice was confirmed in 2019. The September monthly average extent (usually the lowest of the year) was the third lowest on record with the daily minimum extent tied for second lowest. Until 2016, Antarctic sea ice extent had shown a small long-term increase. In late 2016 this was interrupted by a sudden drop in extent to extreme low values. Since then, Antarctic sea-ice extent has remained at relatively low levels. The Greenland ice sheet has recorded nine of the 10 lowest surface mass balance years in the last 13 years. And 2019 was the 7th lowest on record. In terms of total mass balance, Greenland lost about 260 Gt of ice per year over the period 2002-2016, with a maximum of 458 Gt in 2011/12. The loss in 2019 was 329 Gt, well above the average. Glaciers: Preliminary results from the World Glacier Monitoring Service indicate that 2018/19 was the 32nd consecutive year of negative mass balance for selected reference glaciers. Eight out of the ten most negative mass balance years were recorded since 2010.

Climate-related Impacts

The report devotes an extensive section to weather and climate impacts on human health, food security, migration, ecosystems and marine life. This is based on input from a wide variety of United Nations partners. (See in Editor’s note for full list)

High impact events

Tropical cyclones: Tropical cyclone activity globally in 2019 was above average. The Northern Hemisphere had 72 tropical cyclones. The 2018-19 Southern Hemisphere season was also above average, with 27 cyclones. Tropical Cyclone Idai made landfall in Mozambique on 15 March as one of the strongest known on the east coast of Africa, resulting in many casualties and widespread devastation. Idai contributed to the complete destruction of close to 780 000 ha of crops in Malawi, Mozambique, and Zimbabwe, further undermining a precarious food security situation in the region. The cyclone also resulted in at least 50 905 displaced persons in Zimbabwe, 53 237 in southern Malawi and 77 019 in Mozambique. One of the year’s most intense tropical cyclones was Dorian, which made landfall with category 5 intensity in the Bahamas. The destruction was worsened as it was exceptionally slow-moving and remained near-stationary for about 24 hours. Typhoon Hagibis made landfall west of Tokyo on 12 October, causing severe flooding.

Adapted from WMO Press release on the WMO Statement on the State of the Global Climate in 2019.

Notes for Editors

National Meteorological and Hydrological Services, WMO Regional Climate Centres and dozens of scientific experts contributed to this report. United Nations Agencies: Information has been supplied by the Food and Agriculture Organization of the United Nations (FAO); the Intergovernmental Oceanographic Commission of UNESCO (IOC/UNESCO), the International Maritime Organization; the International Organization for Migration (IOM), the International Organization for Migration for Refugees (UNHCR), the United Nations Office for Disaster Risk Reduction, the United Nations High Commissioner for Refugees (UNHCR), the UN Conference on Trade and Development, World Food Programme and World Health Organization.

Data Centres: Global Precipitation Climatology Centre (GPCC); Met Office Hadley Centre; National Oceanic and Atmospheric Administration National Centres for Environmental Information (NOAA NCEI); European Centre for Medium-range Weather Forecasts (ECMWF) and Copernicus Climate Change Service (C3S); National Aeronautics and Space Administration Goddard Institute for Space Studies (NASA GISS); Japan Meteorological Agency (JMA); WMO Global Atmospheric Watch (GAW); NOAA National Ocean Data Center (NODC); National Snow and Ice Data Center (NSIDC); Mauna Loa Observatory; the Blue Carbon Initiative; Hong Kong Observatory; Pan-Arctic Regional Climate Outlook Forum (PARCOF); European Space Agency (ESA) Climate Change Initiative (CCI); Copernicus Marine Environmental Monitoring Service (CMEMS); Archiving, Validation and Interpretation of Satellite Oceanographic data (AVISO); the Polar Portal; Department of Physical Oceanography, Woods Hole Oceanographic Institution; Arctic and Antarctic Research Institute (AARI); Mercator Ocean; Global Ocean Oxygen Network (GO2NE); Global Ocean Acidification Observing Network (GOA-ON); Ocean and Sea Ice Satellite Application Facility (OSISAF) of European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT); Australian Bureau of Meteorology; Commonwealth Scientific and Industrial Research Organisation (CSIRO) Oceans and Atmosphere.

Climate Change Initiative (CCI); Copernicus Marine Environmental Monitoring Service (CMEMS); Archiving, Validation and Interpretation of Satellite Oceanographic data (AVISO); the Polar Portal; Department of Physical Oceanography, Woods Hole Oceanographic Institution; Arctic and Antarctic Research Institute (AARI); Mercator Ocean; Global Ocean Oxygen Network (GO2NE); Global Ocean Acidification Observing Network (GOA-ON); Ocean and Sea Ice Satellite Application Facility (OSISAF) of European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT); Australian Bureau of Meteorology; Commonwealth Scientific and Industrial Research Organisation (CSIRO) Oceans and Atmosphere.

Full details of all the contributors are available in the Statement on the State of the Climate 2019.

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