World Meteorological Organization

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WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)

FOURTH INTERNATIONAL WORKSHOP ON THE ADVANCES IN THE USE OF HISTORICAL MARINE CLIMATE DATA (MARCDAT-4)

2016

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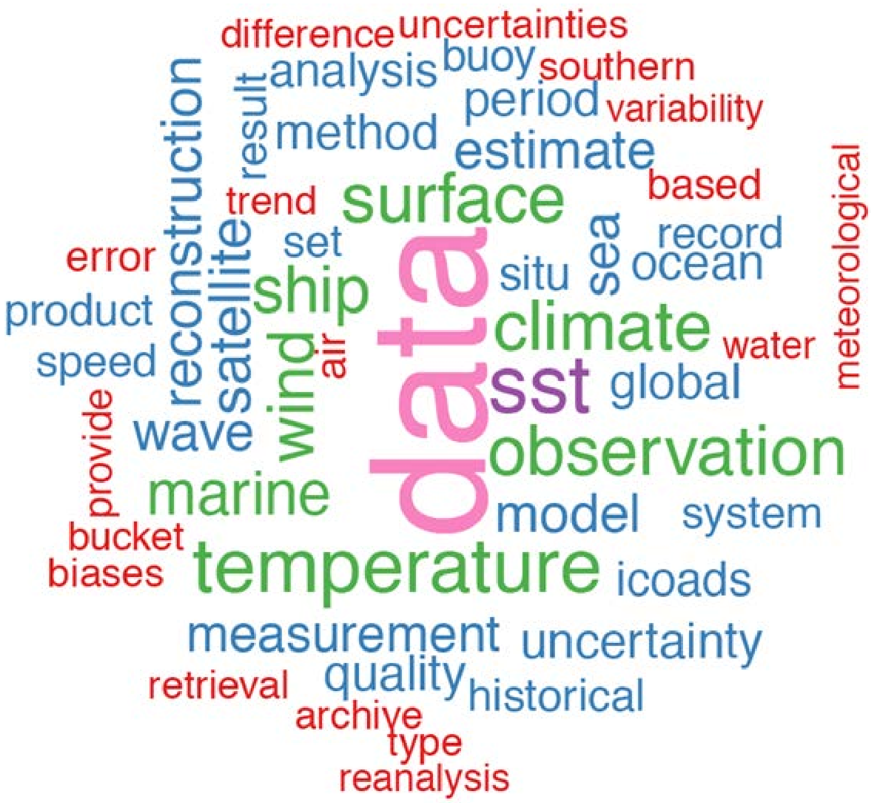
FOURTH INTERNATIONAL WORKSHOP ON THE ADVANCES IN THE USE OF HISTORICAL MARINE CLIMATE DATA (MARCDAT-4) - SUMMARY PUBLICATION



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NOTES

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EXECUTIVE SUMMARY

The Fourth International Workshop on the Advances in the Use of Historical Marine Climate Data (MARCDAT-4) met at the UK National Oceanography Centre, UK, from the 18th to 22nd July 2016. This meeting bought together 51 participants, including two remote, to discuss recent advances in the use of historical marine climate data and, in particular, the International Comprehensive Ocean-Atmosphere Data Set (ICOADS).
The goals of the meeting were twofold:

1. To share and discuss recent advances on the use of historical marine climate data, including: improved understanding of the error characteristics of the data; how the observing system is evolving and the use of satellite data; how best to analyze and extract maximum information from the marine climate data; and how the analyzed products are used.

2. Discuss current issues in the use and provision of marine climate data and as a community make recommendations back to the providers of the data and those collecting the observations.

To meet this end the meeting was organized around seven broad themes, with recent advances and research presented, and three breakout sessions where current issues were discussed. The themes were:

1. Data homogenization
2. Quantification and estimation of uncertainty
3. Integrating In-situ and satellite data sources
4. Reconstructing past-climates (methods)
5. Reconstructing past climates (products)
6. Reconstructing past climates (applications)
7. Data management, recovery and processing

The book of abstracts, and a selection of the presentations, can be found on the meeting website: http://icoads.noaa.gov/marcdat4/

The breakout sessions were organized into two plenary sessions and a third session with three parallel discussions.

This meeting report contains a summary of those sessions:

1) Homogenisation, biases and uncertainty
2) Experiences of using climate data
3) Breakout 3:
    a. Designing an SST Inter-comparison
    b. The Ocean Observing System
    c. Approaches to storing and using ICOADS (and marine climate data)

The main recommendations focused: on maintaining the climate observing system, including continuity of observations and observance of the GCOS climate monitoring principles; improving the provision of observational metadata for both historical and contemporary observations; improved documentation of the underlying datasets and formats.

Dr David Berry
Chair, MARCDAT-4 Organizing Committee

1 BREAKOUT 1: HOMOGENISATION, BIASES AND UNCERTAINTY

During the first breakout session the meeting split into two groups to discuss homogenization, biases and uncertainty, with the first group focusing on temperature observations and the second more generally on marine climate data.

Both groups discussed the use of statistical and physics based approaches to the homogenization of data. The land community typically use comparison with neighboring stations that have a similar climate signal. The marine community tends to use physics-based approaches to correct for known inhomogeneities, biases and problems with the data. These include, inter alia, the bucket model of Folland and Parker (1995)[1] , to correct for heat loss, adjusting the observations to a common reference height and waves for buoy tilt.

The marine community directly uses available platform and instrumental metadata. For the land community metadata, for example on station moves or changes and the instrumentation, is important to make break dates more precise and for the validation of the results, while a direct use is still rare. Whilst noting that some progress has been made with respect to metadata since the CLIMAR-IV meeting participants commented that there are still large gaps in the marine metadata record, particular for historical buoy records. For many cases this is often missing or incomplete, with the buoy metadata described as abysmal multiple times and by multiple people during the meeting. Land station metadata is often available nationally, but unfortunately not shared internationally, which requires a common format.

Both groups discussed the need to raise awareness of the importance of homogenization with observing network operators, users of climate data, stakeholders and funders. For example, the meeting noted that new wave buoys (hull and/or sensor) were being deployed without adequate testing and comparison with existing systems. WMO requires that changes made to land stations should be accompanied by several years of parallel measurements, but this is unfortunately not always possible or done. The meeting also noted that whilst climate data is fundamental to all of climate science it is often difficult to fund the homogenisation and reprocessing of historical climate data needed to ensure a stable climate record without artificial steps and trends. Other topics discussed were that some users, including in the published scientific literature, were taking climate data from operational sources and archives that had not been homogenised and drawing incorrect conclusions about trends. Other users need access to the unadjusted data. At all stages it is important to maintain traceability of the data, the ability to identify what level of homogenisation have been applied and to link back to the original source.

Potential actions range from: reminding the network operators of the importance of testing any new system (platform and sensor) alongside existing systems, as highlighted in the GCOS climate monitoring principles; encouraging the community to adopt a common vocabulary for describing the level of processing and homogenisation applied to environmental observations and for data providers to use this vocabulary when serving the data; and providing guidance documentation alongside the observations describing what homogenisation has been applied to the data and whether the data is the most appropriate for a particular use.

New approaches to homogenisation were discussed. These included: the use of performing buddy checks and performing comparisons to gridded / spatially interpolated fields based on nearby observations; the use of reanalysis model feedback archives; multivariate approaches, e.g. wind / waves or air temperature / humidity; pairwise comparison based on ICOADS decks or other clustering; Many of these are still in their infancy and require further work to develop. The new decomposition correction methods for land stations may also be useful for marine data.

[1] Folland, C.K., and D.E. Parker, 1995: Correction of instrumental biases in historical sea surface temperature data. Q.J.R. Meteorol. Soc., 121, 319-367.

Overall, the MARCDAT-4 meeting recommended:

1) to aid climate studies data providers, and buoy data providers in particular, work with the JCOMM Observations Programme Area and subsidiary teams and panels to identify the metadata needs, both contemporary and historic, and to provide this metadata to the JCOMM in situ Observations Programme Support Centre (JCOMMOPS) for inclusion in the proposed metadata database.

2) that JCOMM, and its parent bodies, remind network operators of the needs of the climate community, the GCOS climate monitoring principles and for any changes to the observing system to be assessed for their impact on the climate record, including the evaluation of new systems co-located with existing systems.

3) that the community and JCOMM continue to promote and coordinate reference networks to support inter-comparisons of essential climate and ocean variables, e.g. OceanSITES, field campaigns with different sensors / platforms co-located.

4) that a common syntax to describe processing levels, including homogenisation, is adopted by the marine climate data community and that the community works with others, e.g. land / satellite, to harmonize across domains and observing systems. And that data at a various processing levels is made available.

5) that new approaches be developed, including those based on multivariate techniques, for statistical homogenisation and quality control.

6) that the community, together with JCOMM and its parent bodies, push to raise awareness of the importance of homogenisation and reprocessing of the climate archives with funders and stakeholders at the national level.

2 BREAKOUT 2: EXPERIENCES OF USING CLIMATE DATA

The second breakout session split into two groups, both discussing their experiences of using climate data and identifying what does or does not work. The discussions ranged from data access and discovery issues to improving the formats used and sharing informal knowledge gained through experience.

On data access and discovery, the inability to easily identify and access complementary coastal and island station data from the land archives was noted as a major issue. This is in part due to a lack of an integrated terrestrial observation archive. It was noted that there are multiple sources for climate data, often with considerable overlap and that this could be confusing for the non-expert user. Services and websites, such as the NCAR Climate Data Guide and the KNMI Data Explorer, are helpful for addressing this. Some participants reporting using only reanalysis model output in preference to the observations due to the ease of use and user interfaces for the reanalysis data archives.

Improving the interoperability and discoverability was noted as being fundamental to improving access to the observations that underpin the marine climate record. This would require discovery metadata to be enhanced (or created if non existent), the use of standard variable names and a common vocabulary. This would in turn enable distributed services to access data from different sources in a coherent manner and allow the identification of overlaps between different data sources. In this context it is also desirable to provide information on how to translate values to standard variables, e.g. 2m temperature, 10m wind, or provide such products with uncertainty attached. The different levels of data processing should be indicated along with the data in order to enable traceability and reprocessing of uncertainties.

The data formats, and in particular IMMA, were noted as being a barrier to entry and using marine climate data. Whilst good for distribution, archival and preservation of the data, the IMMA format was reported to be slow to access and difficult to search for specific records within the dataset. Similarly, the documentation describing the IMMA format and ICOADS data were found to be difficult to use and required a level of prior knowledge. It was noted that a simple user guide to ICOADS was needed. Many science users had a preference for other formats, such as CF compliant NetCDF, and that a better user interface to access the ICOADS data would be desirable. It was also noted that downstream users have a requirement for ASCII delimited data formats, e.g. csv. Online reprocessing tools, such as sub-setting and gridding data, would make a huge difference if funding was not an issue. Similarly, improving the data models used to describe the observations and data formats would make a large difference to the community.

In terms of improvements to ICOADS, improved quality control, the ability to link to the image of the original logbook and the provision of uncertainty alongside the individual observations were all noted as significant improvements that could be made. The loss of most ship callsigns (since late 2007, owing to commercial and security concerns) was noted as a big issue, both for the quality control and black listing of data and for the association of metadata with the observations. The importance of having all the information required to use the observations, such as the metadata, in one place was highlighted. Many users required improved timeliness for marine climate data and metadata, with the data often required within a few days of the end of a month. The big delays with the provision of the WMO Publication 47 metadata were noted as problematic, with the data available from the WMO website several years out of date. Real time and / or near real time observations that were consistent with the climate record were desirable, analogous to the Intermediate Climate Data Records produced by the Earth observing and satellite community. The idea of a common syntax for describing the level of processing applied to the data was raised again.

The meeting noted that there was a need for improved documentation of ICOADS and that is was hard to associate known problems with the observations. For example, there are known problems with ICOADS deck 732 (Russian Marine Met. Data Set; MORMET) but this information is not recorded in the IMMA format. Similarly, the supplemental data attachment from ICOADS typically contains the original data prior to conversion to IMMA and often contains extra information that is not encoded in IMMA. The description of these attachments can be found in the ICOADS 'transpec' documents for some individual decks (mostly associated with relatively recent translations) in ICOADS but this is poorly indexed and difficult to associate with the data by non-expert users. The meeting noted that there is a lot of informal expert knowledge in the community based on experience of using the data but that there are no mechanisms of forums for currently sharing this information. The production of an ICOADS user guide and document series was proposed as one possible solution. Another would be the development of an online Marine Climate Data users group although it was questioned whether there was the critical mass required to make this a success. The production of a community factsheet on different datasets available and the suitability for potential uses was also suggested.

A large variety of software is used within the community to access marine climate data, ranging from compiled languages, such as Fortran and C, to interpreted languages such as Python and analysis environments such as Matlab and R. It was noted that there is a desire to share many of the solutions for accessing climate data through open source collaboration tools but that there were barriers to doing so due to internal policies and security requirements in many of the institutes developing and using the software. The need for clear information on the reference and licensing of software and data products was highlighted.

There is a community wide need for further training and capacity building in the use of marine climate data and the meeting welcomed the initiatives being undertaken by the JCOMM CMOC/China in the west pacific region. Projects and funding to bring together, and improve communication between, dataset developers and the users of those datasets would be a big advance for community. The ESA CCI was given as an example where this has worked well.

Overall, the meeting recommended:

1) better documentation for climate data, and in particular ICOADS, be developed. Examples include: a beginners guide to ICOADS; a FAQs document / webpage; a forum / online user group or mailing list. The documentation needs to be searchable, updateable, comprehensive documentation (PDF, website, Wiki).

2) more frequent updates to ICOADS be made, in both near real time and delayed mode. This will require good version control and the near real time processing and for the processing applied to the near real time updates to be consistent with that applied to the delayed mode data;

3) capacity building and training resources be developed, including: examples; case-studies; and cookbooks (e.g. OceanTeacher);

4) the methods for distributing ICOADS observations continue to be improved, with augmented abilities to subset and serve ICOADS in commonly used formats, such as NetCDF and delimited ASCII;

5) improved quality control methods be developed and shared within the community;

6) the use of collaborative software tools and shared code repositories be encouraged within the community as a mechanism for sharing code and best practices;

7) the discoverability of climate data be improved, both through improving online guides such as the NCAR climate Data guide and KNMI Climate Explorer and through improved discovery metadata provision and dissemination.

3 BREAKOUT 3

The third breakout session split into three groups: the first discussing the design of SST inter-comparisons; the second discussed the ocean observing system, what new observations would be desirable, how to integrate observations from new technologies (e.g. gliders, bio-Argo etc) into the existing climate archives, and how to preserve and enhance the existing observing networks; and the third discussed different approaches to storing and using the ICOADS data.

Designing an SST Inter-comparison;

The first group discussed the need for an inter-comparison of SST datasets, how to design and implement such an inter-comparison and the resulting outputs. Whilst the majority of SST datasets show similar changes in the global mean anomaly over the past 150 years there are notable difference, in both regional values and for particular periods in time. In order to give confidence in our knowledge of climate variability over the past 150 years and an improved understanding of the impacts of choices made during dataset construction a comprehensive inter-comparison is needed.

One approach would be a CMIP like controlled inter-comparison, with a common source dataset selected at a particular time (e.g. ICOADS release 3.0) and all participants producing a set of specified outputs (parameters) in a common format. The products would then be compared based on an agreed set of diagnostics covering all steps of the processing. This would cover a range of scales and applications, e.g.: long-term trends; regional patterns; stability; gradients etc.
As part of the comparison, user validation of the datasets would be useful but require strong engagement by the users. This would help understand the relative strengths and weaknesses of a particular set of methods and their impact in different application areas. For example, does a particular method give a good representation of the large scale variability but do a poor job of representing local variability or vice versa?

Other approaches to validation discussed included: benchmarking; cross validation (withholding data); and use of independent datasets. Each approach has its own set of strengths and weaknesses. Benchmarking has the benefit of known errors and being controllable but it can be hard to represent the true error structure and biases found in the observations and over tuning needs to be avoided. Cross validation has the benefit of knowing the values reported at a given location but we don't know the 'truth' and the errors are unknown. The uncertainty in the withheld data also needs to be taken into account. High quality independent data can be used for validation but these only exist for the last few decades, diminishing in quality and quantity going backwards in time.

The current status of SST datasets and their generation were discussed, including what could be done immediately in terms of an inter comparison. Initially, comparison of data selection criteria and quality control flags would be relatively simple to do. Similarly, gathering diagnostics already produced and comparing between datasets would be straight-forward. Examples include global and hemispheric averages, bias adjustment fields, internal variability etc. These could be extended with building an observation – analysis statistic analogous to that produced for reanalysis. When developing new diagnostics the user needs need to be taken into account.

The group discussed further the steps in developing a benchmarking process for SST datasets and what needs to be considered when performing any inter comparison. The general progression for the generation of pseudo data to use in a benchmarking process is: pristine data ☐ downscaling step ☐ sub sam
☐ output data. Care needs to be taken at each step to ensure the different processes leading to errors and uncertainties can be represented and for the resulting data to be plausible compared to the observations. Benchmarking at every step of the generation of the SST dataset would be useful. Items to consider include: what definition of SST is being used; satellite vs in situ; point vs areal mean; grid resolution vs feature resolution; climatological periods; decomposition of uncertainties etc.

The Ocean Observing System;

The evolution of the observing system and technologies were discussed, noting that many new platforms (gliders, autonomous surface vehicles etc) and devices / sensor packages (wave radars, optical disdromters) were being developed and deployed. As part of the process many of the existing systems are being automated, such as the move from manual VOS observations to automatic weather stations. This is having an impact on the availability and reporting of a significant number of ECVs over the oceans. Examples include a reducing number of humidity, cloud cover, and present weather observations in recent years. The meeting noted that there is a need to ensure that the JCOMM community is aware of concerns that new automation is impacting on the climate observing system and takes action and pushes for more multivariate Automatic Weather Systems (AWS) be deployed over pressure-only or other constrained-parameter AWS.

New sensors and observations that would make a difference to participants were discussed. Profile measurements of the temperature in the upper 10s of meters from drifting buoys would have a big impact on satellite calibration / validation and air-sea interaction studies. There is a requirement for more biological in situ measurements, particularly in optically complex and coastal waters. There is also a requirement for better / more cloud observations. Both of these requirements come from the ocean color and biological communities. The need for the (further) development of a climate reference networks over the oceans were discussed – this would need to cover multiple ECVs / EOVs.

The management of new technologies, both introduction and data, were discussed. Issues of concern were the introduction of new technologies without rigorous testing alongside and comparison with existing systems. It was unclear who does this, when and where for the climate community. There needs to be an increased dialog between the operational and climate communities. The data management and flow to climate users was discussed, it was unclear who manages the data from these new technologies and whether they end up in the climate archives (e.g. WOD, ICOADS). Data volumes may be an issue due to the higher resolution and frequency of the data from these systems. New technology for interoperability and integration across domains and archives is needed, e.g. for a distributed in situ to in situ match-ups service.

Overall, the MARCDAT-4 meeting recommended:

1) that AWS on VOS should be multivariate (not just pressure) and that network operators should be encouraged to deploy more multivariate AWSs.

2) that there are expanded efforts to develop, and validate adequately for observational homogeneity with visual observations, new automated systems for cloud cover, visibility, waves etc.

3) that there is increased formal communication across JCOMM programme areas to ensure marine climate requirements are not lost in decisions made on the observing system development and data management practices.

4) that the use of thermistor chains / profilers on drifting buoys be increased to support ongoing satellite validation and air-sea interaction studies.

Approaches to storing and using ICOADS (and marine climate data);

The experiences and approaches to using the raw ICOADS IMMA data were discussed. A variety of solutions were used, from using the original IMMA data to reformatted delimited ASCII files and through to NetCDF files and relational databases. In every case, the importance of being able to trace the processed data back to the original IMMA files was noted. It was also noted that many users, particularly outside of the marine climate research community, required data in easy to use formats such as csv files for subsets of the full record, and also that NCAR is already supporting some of these requirements for “spreadsheet” friendly formats through their sub-setting interface. A renewal of the IMMA format was discussed, noting that a transition to a delimited format, rather than fixed width, may aid the processing and use of ICOADS by many users. Similarly, the provision of the data in NetCDF format would help others (as has been funded recently by NCEI for work during 2016-17; ref. Eric Freeman’s presentation). In both cases, the use of standard variable names and a controlled vocabulary would be essential and that this would need to be in coordination with other existing bodies (e.g. WMO, IODE, IOC, IHO). Any future development of ICOADS and the provision of climate data should be compatible with the JCOMM Marine Climate Data System (MCDS) and interoperable with other web services (e.g. WIS, ODP, WMS/WFS etc).

It was recognized that users of marine climate data came from a wide variety of professions, including legal, agricultural and fisheries and that a user guide was required for both the expert and non-expert users. It was also noted that it would be useful to have a flow chart showing the decision tree for selecting which data to be used (e.g. unprocessed raw data, homogenised observations, gridded products etc) and where to find that data. It was noted that there were a number of community developed software solutions for accessing the data and that the developers of these were willing to share the software. It would be useful to link to this software from the ICOADS website and for a test suite of IMMA records to be made available for testing the software against. The operational and services communities have also developed tools for visualizing and accessing the data and it would also be beneficial to link to these where appropriate.

The MARCDAT-4 meeting recommended:

1) that the IMMA format be renewed, possible transitioning to delimited ASCII format for archival

2) that standard names and a common vocabulary be developed and used by the marine climate data community and that these be adopted by ICOADS. This would be in coordination with other international coordinating bodies (e.g. WMO, IODE, IOC, IHO)

3) that a comprehensive user guide and manual for ICOADS be developed, targeted at non-expert and expert users.

4) that the community develop on online resource for deciding / recommending what data to use for different purposes based on the characteristics of the data required (original, vs, homogenised vs gridded). This would be targeted at the non-expert user could take the form of a flow chart or decision tree.

5) that the ICOADS website, and websites for other climate archives, be augmented with links to community developed software.

6) that ICOADS provide a test suite of ICOADS records for testing and validating software against.

7) that any solution developed for disseminating climate data, and in particular ICOADS, should be interoperable with the MCDS and other systems. This would be through the provision of discovery metadata and the use of standard names and units.

ANNEX I

ORGANISING COMMITTEE

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Mr Scott Woodruff	CIRES / University of Colorado

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The venue, local support and the provision of refreshments have been provided by the UK National Oceanography Centre. The organizing committee have been funded by their home institutions.

ANNEX II

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ANNEX III

PAST MEETINGS

Proceedings and outcomes from past (and related) meetings can be found via the following webpages:

International Workshop on the Advances in the Use of Historical Marine Climate Data (Community led)

MARCDAT-3 (2011): http://icoads.noaa.gov/marcdat3/
MARCDAT-2 (2005): http://icoads.noaa.gov/marcdat2/
MARCDAT-1 (2002): http://icoads.noaa.gov/advances/workshop_plan.htm

JCOMM Workshop on Advances in Marine Climatology (JCOMM led)

CLIMAR-4 (2014): http://icoads.noaa.gov/climar4/
CLIMAR-3 (2008): http://icoads.noaa.gov/climar3/
CLIMAR-2 (2003): http://icoads.noaa.gov/climar2/
CLIMAR-1 (1999): ftp://ftp.wmo.int/Documents/PublicWeb/amp/mmop/documents/JCOMM-TR/J-TR-10-CLIMAR-99/START.htm

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