ICOADS and High-Resolution Marine Meteorology and Oceanography

Project Background

As the result of a US project starting in 1981, available global surface marine data from the late 18th century to date have been assembled, quality controlled, and made widely available to the international research community in products of the Comprehensive Ocean Atmosphere Data Set (COADS). A new name, International COADS (ICOADS), was agreed in 2002 to recognize the multinational input to the blended observational database and other benefits gained from extensive international collaboration (e.g., Kent et al. 2006a, b), while maintaining continuity of identity with COADS, which has been widely used and referenced.

Synoptic marine meteorological observations from Voluntary Observing Ships (VOS), now managed under the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology, form a relatively consistent data foundation over the complete period of record. For recent decades we have augmented the VOS observations with measurements, some at high temporal sampling rates, from moored and drifting buoys, and with near-surface (i.e., from a depth of three meters or less) oceanographic profile temperatures from the Levitus World Ocean Atlas/Database (1874-1996).

The ICOADS observations and products have been periodically updated and enhanced, with the period of record now covering 1784-2005 (Release 2.3). The basic observational archive (213 million records) is augmented with simple derived monthly summary data products, metadata, and documentation—with centralized access provided via the project web portal (icoads.noaa.gov).

Recent Updates

• In 2005, Release 2.1 (Worley et al. 2005), which covered 1784-2002, was updated and extended for 1998-2004 (Release 2.2; 1784-2004). This included replacement of some Ocean Data Acquisition System (ODAS) data received via the Global Telecommunication System (GTS) with higher quality data:
a) Worldwide drifting buoy data from Canada's Marine Environmental Data Service (MEDS).
b) Tropical Pacific and Atlantic moored buoy data, for the TAO/TRITON and PIRATA arrays, from NOAA's Pacific Marine Environmental Laboratory (PMEL) and the Japan Agency for Marine-Earth Science and Technology (JAMSTEC).
c) US moored buoy and Coastal-Marine Automated Network (C-MAN) data from NOAA's National Data Buoy Center (NDBC).

• Release 2.2 was recently extended through 2005 using GTS data. Pending completion of a final processing step for ship metadata (discussed below), this will constitute Release 2.3 (1784-2005).

Figure 1 shows the platform type composition for the resulting 1980-2005 data, clearly illustrating recent sharp declines in VOS observation numbers beginning about 1990 (Kent et al. 2006c). Spatially, Figure 2 contrasts the platform type composition for July 1980 versus 2005.

Another key improvement for 1973-2005 is the association of WMO ship platform and instrument metadata (Kent et al. 2006d) with the reported observations. For the 1980-2005 period, Figure 3 shows the extent to which we were able to blend the metadata with individual ship reports; metadata for 2005 are in final preparation at the UK National Oceanography Centre, Southampton (NOCS).

Data and Product Access

A new ASCII-based International Maritime Meteorological Archive (IMMA) format for the ICOADS observations is now available, and also being advanced under JCOMM. This ASCII format includes flexible capabilities for attachments, including one for the ship metadata.

All the ICOADS individual observations and data products (simple gridded monthly summaries for a selection of observed and derived variables) are freely and openly available internationally, with access via the project web portal [icoads.noaa.gov].

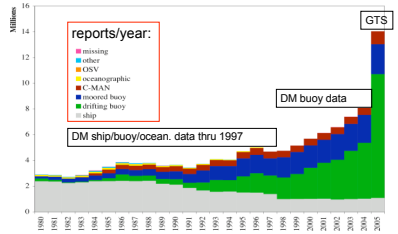

Figure 1. Annual number of marine reports stratified by observing platform type for 1980-2005 ("OSV" indicates ocean station vessels, and "C-MAN" indicates NDBC automated land–ocean boundary zone reports). Prior to 2005, the archive contains varying contributions of delayed-mode (DM) data as indicated, with only the period prior to 1998 currently including DM ship and oceanographic, as well as buoy, data.

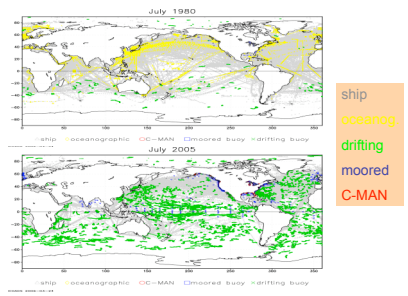

Figure 2. Spatial coverage, for July 1980 (upper) and 2005 (lower), broken down by observing platform type.

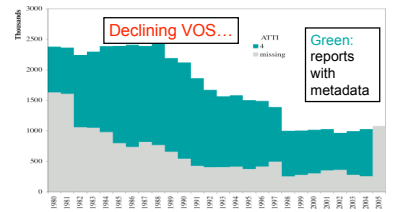

Figure 3. Annual number of ship reports for 1980-2005. Green (grey) indicates reports with (without) associated WMO ship platform and instrument metadata. The metadata are received in delayed-mode from WMO, and associated with the ICOADS reports by UK NOCS.

Acknowledgements

The original COADS project, and the continuing US contribution toward the new international database, ICOADS, is the result of a cooperative project between the National Oceanic and Atmospheric Administration (NOAA)—specifically its Earth System Research Laboratory (ESRL), its National Climatic Data Center (NCDC), and the Cooperative Institute for Research in Environmental Sciences (CIRES, conducted jointly with the University of Colorado)—and the National Science Foundation's National Center for Atmospheric Research (NCAR). The NOAA portion of ICOADS is partially funded by the NOAA Climate Program Office (CPO).

Linkages to High-resolution Marine Meteorology and Oceanography

ICOADS is already linked to a limited extent with high-resolution marine and oceanographic (e.g., Levitus) data. Some TAO and PIRATA moorings have transitioned from hourly to high-resolution 10-minute average data. In view of data volume considerations, we sub-sampled the data used for Release 2.2 to achieve better agreement with other buoy datasets (the complete data, however, can be made available separately).

In the future, we plan to blend data extracted from the archive maintained by the Research Vessel Surface Meteorology Data Center (RVSMDC) at Florida State University. These high-resolution data have been sub-sampled to maintain a reasonable measure of diurnal atmospheric variability, using the RVSMDC quality controls (Figure 4). Including the RVSMDC data will enhance ICOADS coverage outside of the normal shipping lanes, and the increased data frequency will help resolve the diurnal and semi-diurnal cycles over the ocean. Meanwhile the RVSMDC data are being made available separately from the main archive as an Auxiliary dataset (in our standard IMMA format with ICOADS QC flags), together with other Auxiliary datasets such as as indicated in Figure 5.

In keeping with JCOMM goals to further operationalize and integrate the marine and ocean data domains, we hope to explore additional ways, as resources permit, that ICOADS might evolve to include more high-resolution marine and near-surface ocean data (e.g., sea surface salinity). These may include:
- Building upon the successful RVSMDC effort with connections to the GOSUD and SAMOS datastreams.
- Tapping into oceanographic (GTS) datastreams in near-real-time to obtain key elements such as near surface temperature and salinity.
- Development of new IMMA format attachments (see Data and Product Access box) as required to make readily available these new data and metadata.

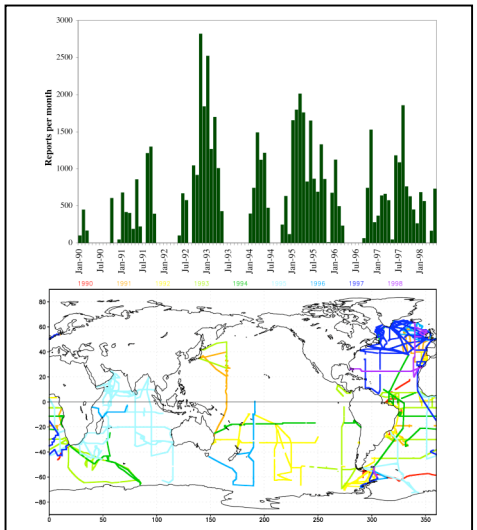

Figure 4. RVSMDC data: The upper panel shows the temporal distribution (reports per month, 1990-98), and the lower panel shows the spatial distribution stratified by year 1990-98 (colors).

Future Plans

In addition to the RVSMDC data, a large number of new or improved candidate datasets are available to augment the coverage or quality of ICOADS; examples, with the emphasis on historical ship data collections, are shown in Figure 5. Adding these collections has progressed slowly because processing and blending requires more staff resources than currently available.

Other beneficial improvements to ICOADS, which are also limited by scarce resources, are:
a) Regular updates based on GTS data, aiming initially for annual extensions.
b) Digitization and blending of untapped logbook data from the UK and other archives (Figure 5).
c) Blending of additional ship metadata (1955-72), and future availability of ODAS metadata.
d) Generation of climate-quality surface fields and uncertainties from ICOADS using the best knowledge for bias adjustments to variables.

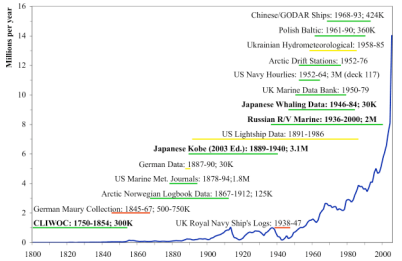

Figure 5. The time periods of candidate datasets to be blended into ICOADS are spanned by horizontal colored lines: green candidates are fully digitized and may need format translation and QC work, yellow are partially digitized, and red are in the planning stages for digitization. Each dataset is appended with the date range and approximate number of observations, if known. Four Auxiliary datasets (i.e., in ICOADS format, but offered separately from the main archive) are listed in bold face. The solid curve shows the number of reports in Release 2.3. This is an update through 2005 of Figure 7 from Worley et al. (2005).

Recent ICOADS and related publications

Kent, E., S. Woodruff, N. Rayner, C. Folland, D. Parker, and T. Yoshida, 2006a: Report on the 2nd International Workshop on Advances in the Use of Historical Marine Climate Data. *CLIVAR Exchanges*, No. 36 (Vol. 11, No. 1, January 2006), 29-30.
Kent, E., S. Woodruff, N. Rayner, T. Arbetter, C. Folland, F. Koek, D. Parker, R. Reynolds, R. Saunders, V. Smolyanitsky, S. Worley, and T. Yoshida, 2006b: Second International Workshop on Advances in the Use of Historical Marine Climate Data. (Submitted to *Bull. Amer. Meteor. Soc.*)
Kent, E.C., D.I. Berry, S.D. Woodruff, and P.K. Taylor, 2006c: Voluntary Observing Ships: A vital observing system in decline. (Submitted to *CLIVAR Exchanges*.)
Kent, E.C., S.D. Woodruff and D.I. Berry, 2006d: MOW Publication No. 47 metadata and an assessment of observation heights in ICOADS. (Accepted for *J. Atmos. Oceanic Technol.*)
Woodruff, S.D., H.F. Diaz, S.J. Worley, R.W. Reynolds, and S.J. Lubker, 2005: Early ship observational data and ICOADS. *Climatic Change*, **73**, 169-194.
Worley, S.J., S.D. Woodruff, R.W. Reynolds, S.J. Lubker, and N. Lott, 2005: ICOADS Release 2.1 data and products. *Int. J. Climatol.*, **25**, 823-842.

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For ICOADS data and metadata visit the project web portal: icoads.noaa.gov