2nd International Workshop on Advances in the Use of Historical Marine Climate Data (MARCDAT-II)

Meeting Report

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Executive Summary

MARCDAT-II brought together 60 participants from eight countries—including marine data users, and managers of marine data and products—for four days of talks, posters and discussions with the goal of setting priorities for the future development of marine climate data and products. Presentations highlighted progress on many fronts. In particular: improved data and metadata availability; improved understanding of uncertainty and bias in a wide range of important climate variables; improved techniques for dataset construction and improved understanding and characterisation of the marine environment resulting from analysis of these new datasets.

Several common themes emerged from the various discussions:

- The need for prioritisation of historical data for digitisation calls for inventories of available undigitised data to be developed.
- The need for the decline in the number of Voluntary Observing Ship (VOS) reports to be reversed, if possible. This requires the development of user requirements and adequacy assessments for marine climate data and the improvement of links with operational organisations and those designing the observing system.
- Metadata are key to the development of climate-quality products.
- It is important to avoid users having to access multiple data repositories wherever possible. Further links between related data sources (e.g. surface marine and sub-surface data) should be developed.
- Quality of climate products can be improved by the availability and intercomparison of at least 3 different products for each variable, each containing estimates of uncertainty.
- The blending of data from different sources requires full characterisation of each data source.
- The profile of the marine climate community needs to be raised and communication between users enhanced.

A comprehensive set of recommendations was developed and progress toward these goals will be tracked via the meeting website [http://icoads.noaa.gov/marcdat2/]

This report is intended as a record of presentations and discussions from the MARCDAT-II meeting, primarily for meeting participants. As such there may be inaccuracies in this report. If you feel there is information which needs correcting, or will be helpful to us in our endeavours, please contact us via the meeting website.

1. Strategy and goals

The four general Themes of the workshop were:

Theme 1: developing gridded data sets: combining/reconciling observations (includes understanding the observations, homogeneity, quality control and analysis issues)

Theme 2: quantifying data and analysis uncertainties (putting error bars on the data sets; includes bias and bias-correction uncertainties, random and sampling errors)

Theme 3: data base development and access (technical issues such as observation and metadata database construction, adding more data, documentation, data dissemination, etc)

Theme 4: use of marine data in climate research (defining data requirements, assessing what we know about climate variability and change)

The aim of the discussions during the plenary and breakout group sessions was to *set priorities for the future development of marine climate data and products over the next four years*. Specifically, the goals of this workshop were to:

- Review progress against the scientific and technical recommendations made at MARCDAT-I and CLIMAR-II (Brussels, 2003; http://icoads.noaa.gov/climar2/).
- Develop the timetable for enhancing *in situ* marine data bases, with a focus on the International Comprehensive Ocean-Atmosphere Data Set (ICOADS), taking account of plans for further digitization and improved processing of the basic observational data.
- Develop strategies for the creation of multi-decadal, homogeneous, gridded data sets for climate applications, identifying priorities for improvement amongst four groups of variables: (i) sea surface temperature (SST), marine air temperature (MAT) and humidity; (ii) sea ice concentration and extent; (iii) sea level pressure and winds and (iv) sub-surface ocean temperature and salinity, fluxes and clouds.
- Discuss methods for quantifying uncertainties in marine data and create a timetable for the assembly of a suite of gridded marine datasets with associated uncertainties.
- Consider how to define our future data requirements

Oral and poster presentations presented recent progress in these areas, with an opportunity for further information to be included in breakout group discussions. The meeting broke out into groups to explore these issues in greater depth as they relate to specific groups of variables: (i) SST, MAT and humidity; (ii) sea ice concentration and extent; (iii) sea level pressure and winds and (iv) sub-surface ocean temperature and salinity, fluxes and clouds. Theme 3, *data base development and access,* was discussed in the plenary, as this theme relates to all the variables. The aim and goals of these discussions were those of the workshop as a whole. Breakout groups then reported their discussions and draft plans to the workshop as a whole during a consolidation session at the end of the meeting.

2. Summary of presentations

2.1 Theme 1: developing gridded data sets

Chair: Alexey Kaplan; Rapporteur: Tara Ansell

Oral presentations described: (i) a reanalysis of the whole twentieth century driven by 6-hourly pressure observations and HadISST1[1]; (ii) correction of modern winds for changes in

[1] See Appendix I for a list of acronyms.

anemometer height; (iii) how to calculate flux climatologies minimizing sampling bias; (iv) a new combined land and ocean cloud-type product (ocean: 1950s-1990s, land: 1970s-1990s); (iv) the National Ice Center weekly (1972-2001) and biweekly (2002 onwards) sea ice concentration data set, which is more accurate than passive microwave retrievals; (v) how SST fields derived from combined buoy and ship observations are biased significantly cold relative to ship-only SST, so corrections need to be developed; (vi) the plans for the creation of the GHRSST-PP reanalysis of satellite and *in situ* SST at high spatial and temporal resolution, using state-of-the-art blending techniques and producing uncertainty estimates; (vii) how AVHRR Pathfinder data for 1985 onwards are more consistent than operational AVHRR, when both are compared to OI.v2 and HadSST2 and (viii) how the development of a 25km daily SST analysis demonstrates the ease with which fixed high-gradient structures in the Gulf Stream can be reproduced, but showing the necessity of good data coverage when attempting to capture propagating features.

Poster presentations described: (i) an analysis of rainfall estimates from VOS weather reports; (ii) the influence of waves on surface turbulent fluxes of momentum and latent and sensible heat suggesting that the global ocean effect is of order $5Wm^{-2}$; (iii) the quality control and analysis of 5 decades of temperature and salinity profiles from bathythermographs, conductivity-temperature-depth (CTD) sensors, moored buoys and Argo floats; (iv) a self-consistent approach to the combined estimation of temporal and spatial variability using a range of *in situ* and satellite datasets; (v) the use of Geographic Information System (GIS) techniques in reconstructing the routes and positions of ships in the CLIWOC period (1750-1854); (vi) issues surrounding the use of mean pressure differences to correct for wind trends when winds are unsteady; (vii) the Hadley Centre Global Subsurface Ocean Analysis (HadGOA) which is constructed with isotherms rather than depth as the vertical co-ordinate; (viii) the quality control of Argo profile data; (ix) the construction and analysis of a 100-year Arctic surface air temperature dataset from a combination of *in situ* and satellite observations; (x) progress in the development of the WMO Global Digital Sea Ice Data Bank (GDSIDB) including improved data availability and documentation; (xi) improved understanding and quality control of the surface humidity observations in ICOADS; (xii) a merged satellite and *in situ* daily SST product from April 2004 onwards from the Japan Meteorological Agency (JMA); and (xiii) a new historical SST dataset from the JMA: Centennial *in situ* Observation-Based Estimates of the variability of SSTs and marine meteorological variables (COBE-SST) as used in the Japanese Re-analysis Project (JRA25).

2.2 Theme 2: quantifying data and analysis uncertainties

Chair: Elizabeth Kent; Rapporteur: Philip Brohan

Oral presentations described: (i) uncertainties in passive microwave sea ice concentration due to atmospheric effects on retrievals at low concentration and emissivity effects at high concentrations; (ii) a 1 degree resolution day and night marine air temperature analysis corrected for platform height changes and daytime heating effects; (iii) an objective analysis of corrected *in situ* winds; (iv) how validation of (A)ATSR against buoys and AMSR-E gives random errors of 0.13K, 0.2K and 0.4K for (A)ATSR, buoys and AMSR-E respectively and (v) an illustration of the effects on uncertainties of different treatments of low frequency variability in historical SST reconstructions.

Poster presentations described: (i) an assessment of the uncertainties in VOS visual wave observations (1958-2002) including the effect of uncertainties on estimates of extreme waves; (ii) the estimation of ocean subsurface temperature trends at a range of depths from the World Ocean Database (WOD2000); (iii) the development of uncertainty estimates for VOS surface flux datasets including both measurement and sampling uncertainty; (iv) the comparison of latent heat fluxes from the Met Office HadGAM1 atmospheric model with the National Oceanography Centre, Southampton (NOCS) surface flux dataset; (v) the effect of airflow distortion on VOS wind speed measurements estimated using computational fluid dynamics (CFD) to assess possible biases for generic ship types; (vi) a new flexible gridded SST dataset (HadSST2) from 1850 onwards developed from ICOADS and including bias correction and uncertainty estimates; and (v) an assessment of bias in marine winds from VOS using buoy data as a comparison standard.

2.3 Theme 3: data base development and access

Chair: Takashi Yoshida; Rapporteur: Elanor Gowland

Oral presentations described: (i) ICOADS Release 2.2, which includes reprocessed data for 1998-2002 and the addition of data, and WMO Publication 47 metadata (in IMMA format only), through 2004; (ii) the availability of substantial new historical data sources, which an ICOADS team with limited resources are currently not able to blend; (iii) the achievements and future plans of the Climate Database Modernization Program (CDMP); (iv) efforts toward making high-resolution marine climate data from research vessels, which are not reported through regular WMO channels, available for ICOADS; (v) the effect of the decline in the numbers of reporting ships on the uncertainty in fields and timeseries of marine air temperature, for which ships are currently the only useable wide-ranging source and (vi) the need for resources to digitize the significant amount of early instrumental data in, e.g. the East India Company logbooks.

Poster presentations described: (i) an end-to-end data management (E2EDM) prototype project for JCOMM; (ii) an update of the progress of the Shipboard Automated Meteorological and Oceanographic System (SAMOS) Initiative; and (iii) a JCOMM Expert Team on Marine Climatology (ETMC) task which had made WMO information relating to marine data transmission codes and formats available on the web.

2.4 Theme 4: use of marine data in climate research

Chair: Chris Folland; Rapporteur: Craig Donlon

Oral presentations described: (i) COPES (Coordinated Observation and Prediction of the Earth System), a framework to coordinate existing WCRP core programmes and which highlighted the importance to this programme of ICOADS; (ii) the wide and expanding range of uses of marine data in climate research, the need to continue collecting and integrating these data according to the GCOS climate monitoring principles and to recover undigitised log book data, especially for 1914-18 and 1939-45; (iii) an analysis of a data set of waves and their associate uncertainties, partitioned between wind sea and swell, showing that variations in the two parameters are caused by different mechanisms and exhibit different trends; (iv) the use of marine data in paleoclimatic research as predictors in proxy reconstructions and also in verification of such reconstructions and model simulations; (v) the importance of intercomparison between analyses of different variables when assessing reconstructions for the last 200 years; (vi) the use at ECMWF of marine data, both as input for and verification of the Reanalysis and the use of Reanalysis output in turn as a verification for the data themselves and (vii) a blended data set (GDSIDB) of historical sea ice charts from seven countries/collections, which has been used to assess the variability of sea ice over the past five decades by means of robust statistics, due to the non-Gaussian nature of such variability.

Poster presentations described: (i) the evolution of British Navy terms for wind force including new wind speed equivalents for the period 1691 to 1820; (ii) the results of forcing a climate ocean model with heat fluxes from the NOCS ICOADS-based flux dataset which have been adjusted to be in global heat balance; (iii) how the skill of an ocean decadal prediction system could be improved through initialisation with ocean current estimates; (iv) the JCOMM Marine Climatological Summaries Scheme (MCSS); and (v) the sea ice component of the coupled climate model HadGEM1 illustrating improvements over the HadCM3 model sea ice formulation.

3. Breakout group and plenary discussions

Discussions from the 4 breakout groups and the plenary discussion are described in the following sections.

3.1 Breakout group 1 (SST, air temperature and humidity)

Chair: David Parker, Rapporteurs: Elanor Gowland, John Kennedy

Discussion subjects included the importance of, and difficulty of discovering, user requirements (temporal and spatial resolution, target and usable accuracy). Users include both climate researchers and those involved in a diverse range of research, for example in ecosystem research. It was noted that even if it were possible to generate a comprehensive list of users and their requirements, that both would change over time. Such a list would be highly desirable, but difficult to generate and maintain. It could be used to illustrate the adequacy of our current observations and products for a range of applications and users. Methods of identifying applications and users were discussed, including analysing data requests, which might also lead to an indication of dataset development needs, but no simple easy mechanism was obvious. It would be desirable to be able to discern the diurnal cycle.

The need for improved metrics for the performance of the observing system was stated. In addition to the number of observations it is necessary to know, for example, their spatial and temporal distributions, precision, and bias. The utility of feedback from assimilation, modelling and reanalysis for monitoring data, blacklisting ships and other platforms was stressed. It was noted that if ICOADS were produced in near real time it could be used to show the health of the *in situ* observing system, comparing sampling for the current month with past averages, perhaps using a "traffic-light" coding system for ease of use by managers. However it is dangerous to say the observing system is adequate without accompanying qualifying statements.

The decline in the number of observations from VOS was noted, and also that the VOS Climate Project (VOSClim) was designed to supplement, not replace, the VOS. The need for a wide range of observing platforms (VOS, moored buoys, drifters, satellites) was noted as each has strengths and weaknesses in terms of sampling and the ability to measure the required range of parameters. The need for the broad spatial sampling provided by traditional VOS, including manual observations of clouds and waves, was noted and should be stressed to National Meteorological Services and to JCOMM. Automatic Weather Systems (AWS) on ships provide large data volumes, useful for many purposes, but do not provide a wide spatial coverage. Often the parts of the report requiring manual input are missing from AWS observations. The need to follow the GCOS monitoring principles was noted.

The requirement for validation and comparison data was discussed. These can either be from specialised platforms (aircraft, research vessels or buoys) giving local comparisons or provided by generating datasets of co-located observations from, for example, ICOADS.

Satellite data and *in situ* data are needed as input to reanalyses. The problems polar orbiting satellites have in cloudy regions can be at least partially addressed with multiple geostationary satellites because their more frequent sampling enhances the number of cloud-free views of the ocean surface. There is a problem with the inhomogeneity of datasets using satellites after the 1980s, due to the transition from coarse resolution *in situ* analyses to the higher resolution analyses supported by satellite data.

The need to revisit which parameters are extracted from GTS buoy messages was discussed. Possibly, significant numbers of additional humidity observations could be rescued going back several years. (Breakout group 3 were also interested in extracting additional instrument metadata from the buoy observations). It was noted that the original observation is now stored as part of the IMMA format.

The digitisation of data from specific time periods was thought necessary to improve certain data products. An example is the requirement for more data from the 1900 to 1920 for all areas except the North Atlantic to improve the datasets required to understand interdecadal variability and climate change.

A variety of metadata is needed to accompany both gridded products and individual observations. For gridded products metadata includes the processing applied to the original data and the methodology used to construct the dataset. For individual observations measurement method and height metadata is required for bias adjustments to be made. It was thought that the importance of metadata availability should be stressed to those in charge of the operational observing network, both internationally and within National Meteorological Services. Metadata for the ships is collected through the WMO, but is not regularly supplied by all countries contributing ship observations. An international database for ODAS (Ocean Data Acquisition Systems, i.e., moored and drifting buoys and platforms) has been set up by JCOMM but needs to be populated with new and historical information.

It is important that more data centres start to produce datasets in near real time. Ideally three independent analyses are required to make intercomparisons which should also be made in near real time. The results of the regular intercomparisons should be made freely available.

3.2 Breakout group 2 (Sea ice)

Chair: Nick Rayner, Rapporteur: Harry Stern

The goals for the sea ice discussion group were for sea ice datasets which could be used to force atmospheric models, for datasets with accompanying uncertainty estimates and for datasets useful for research including climate change and trend analysis.

Requirements are for a homogeneous, multi-decadal record. Data must be stable over time and consistent across the different satellites that make up the record. More research is needed to understand and reconcile data from ice charts and from passive microwave sensors. Variables of interest are: sea ice concentration and extent; ice thickness; ice drift; ice albedo; ice type (e.g. smooth or ridged, landfast); mean weighted thickness of level ice; ice thickness at coastal stations; and possibly sub-daily ice motion; lead formation and small-scale strain rates. Snow-related measurements are also important, for example the snow depth on sea ice; the insulating properties of snow and its effect on ice growth rate. It is important to quantify uncertainty at every grid point and pixel and to perform comprehensive and regular intercomparisons of different data sources (e.g. charts and satellite) and products.

Requirements for sea ice data are stated in the GCOS Implementation Plan (GCOS-92), and in reports by Sea Ice Mass Budget of the Arctic (SIMBA). The finest spatial resolution required was thought to be 1/3˚. Data are also required for validation of processes in ice models, for example deformation and sea ice rheology and upward looking sonar (ULS) and submarine data are needed for validation of ice thickness datasets. National Operations Ice Information requirements are listed in Appendix B of JCOMM Meeting Report No. 28 of the Expert Team on Sea Ice.

Methods of quantifying bias were discussed. The difference between the various passive microwave algorithms should be studied and understood. Sea ice charts provide semi-independent information. There is also a need to define the uncertainty on bias correction and the sampling error. Accuracy requirements are not well defined and errors are different for different sea ice concentrations. For example ice concentrations of 50-60% are rarely observed, so have large uncertainties. But the difference between 50% and 60% concentration is less important than the difference between 96% and 98% concentrations. The identification of open water is important. It was noted that the error distribution will be non-symmetric as concentration is capped at 100%.

The definition of the ice edge is problematic (15% concentration? 30% concentration?), as is the definition of its uncertainty. One method might be to assign an uncertainty to each ice concentration value then produce an ensemble of ice edges as concentration values are varied within their error range. The ice edge from satellites may be smeared out compared to that from ice charts.

The passive microwave sea ice record was discussed in detail. It was noted that the "weather flag" in the microwave data could be wrong and that it is difficult to capture the uncertainty in a single flag or error estimate, especially near the ice edge. It would be helpful to break down the contributions of different causes to the uncertainty estimate. Some passive microwave data have coastal contamination with sea ice along all coasts, others have been cleaned up. The hole at the poles is larger for SMMR than for SSM/I and this hole needs to be filled consistently. Causes of error in passive microwave ice concentration are from: atmospheric processes (wind, water vapour and cloud); ice/snow emissivity; mixing of footprints/sidelobes (depends on concentration gradient) and sensor noise. Different algorithms have different responses to water vapour but in general an increase in water vapour inflates the ice concentration, with less inflation at high ice concentration, more inflation at low ice concentration. It might be possible to blend algorithms to combine best properties depending on ice concentration and/or proximity to ice edge. Sensor noise is on the order of 1-2% ice concentration according to pre-launch instrument calibration work. Comparison with SAR near 100% ice concentration shows the biases and standard deviations of differences of the various algorithms are ± few %. There is a need for very high-resolution imagery (~1m) to resolve melt ponds. Information on the melt onset data is available from SAR and passive microwave and NSIDC has a dataset of dates of melt onset. Higher errors should be assigned to ice concentration from passive microwave during the melt season. Errors in passive microwave ice concentration are higher at low to intermediate ice concentration than at high concentrations due to the larger signal at high ice concentration caused by emissivity contrast between ice and open water. The availability of validation information from thousands of miles of ship tracks and from ice stations such as NP-33 was discussed.

Further validation could come from ship data collected as part of Antarctic Sea ice Processes and Climate (ASPeCt). The difficulty of comparing ship and satellite data and the representativeness of ship measurements and 25 km pixels were discussed. The error characteristics of passive microwave sea ice concentration could be different from the Arctic due to differences in sea ice properties between the hemispheres.

John Stark and Soren Anderson will re-process SSM/I 1987-present using corrected brightness temperatures from Frank Wentz that account for inter-satellite differences. They will make water vapour corrections etc., and come up with improved sea ice concentration.

ICESat measures the freeboard of ice (the laser does not penetrate the ice) so the retrieval of ice thickness requires knowledge of the reference level (e.g. from SAR). So far no good large-scale estimates of ice thickness have come from ICESat. The Radar altimeter penetrates the snow and results in different measures of freeboard. The need for a replacement for the failed CryoSat mission to measure ice thickness was stressed.

The relation between ice age and ice thickness was discussed, illustrated by an animation. There were large extents of old (10+ years) ice in the Arctic prior to 1989, which a high Arctic Oscillation then largely flushed out through Fram Strait, leaving younger thinner ice in the Arctic. A smaller Beaufort Gyre brings back ice to the coast within 3-4 years (where it melts in summer) rather than 10 years when the Beaufort Gyre is bigger. Even though the Arctic Oscillation returned to near-normal levels by mid 1990s, sea ice has not recovered. It was thought that ice age could explain over 50% of the variance in ice extent.

The availability of historical ice charts was discussed. The Walsh sea ice dataset was produced before some Norwegian charts became available so there is the potential to enhance the early record. There are further ice charts at DMI which have not yet been digitised. There is an NSIDC effort to convert NIC e00 chart files to the EASE grid for the period 1995 to 2004. Antarctic charts currently digitally available include: NIC 1973-present and Russian 1971. Earlier data in atlases (1957-1969) could be digitised, but there are no individual charts. Log books are also available but significant effort is required to extract useful information. The British Antarctic Survey or Scott Polar Research Institute may have additional information and the ASPeCt project is collecting ship data. There are accuracy/consistency considerations, and different analysts may have different interpretations.

There is a need to reconcile early chart data with later charts that use remote sensing imagery. Vinje and the Environmental Working Group Arctic Atlases on CD-ROM documentation define ice extent for the charts, and that could be used as a guide.

3.3 Breakout group 3 (Pressure and winds)

Chair Gil Compo, Rapporteurs Rob Allan, Julie Jones

Important issues for this group included: the need for more data for specific periods and locations; the availability of metadata to allow the identification and removal of data bias; the definition of user requirements and the possibility of improved feedback on data quality from, for example, the reanalyses.

Key was the requirement to extend the record focussing on important and data sparse regions and periods. Priorities will vary with application and time scales, for example for synoptic applications extra data from the North Pacific would be helpful, for longer time periods the focus would shift to the Central and South Pacific.

Important datasets yet to be digitised, or if digitised to be blended into ICOADS include: CLIWOC (requires incorporation into ICOADS); 5.7k UK Navy logbooks for the WWII period (require digitisation); US Merchant Marine 1910-1913 (to be digitised by CDMP); Dutch ship data currently being catalogued; Hudson Bay ship logs 1700 to 1860 (require digitisation); and at least 25 million undigitised observations in UK National Archive. Periods that would benefit from improved data coverage include 1936-48, 1911-20, and the whole 19th Century. Figure 7 in Worley et al. (*International Journal of Climatology*; 2005) shows the status of a variety of important historical candidates for blending.

For prioritisation to be effective it is necessary to catalogue the data available. The minimum required would be a metadata record for each data source containing start and end date, route/region, parameters available and sampling information. Once cataloguing is complete prioritisation can proceed. It was noted that partial digitisation of logbooks was undesirable; data near coasts are not a high priority in themselves, but are vital for geopositioning of the early ship voyages. Once a logbook has been partially digitised it becomes very unlikely that the undigitised parts will ever be recovered. Imaging and indexing of logbooks prior to digitisation may alleviate this problem. It was noted that the digitisation of complete logbooks was easier for the instrumental period (after 1854) rather than the pre-instrumental, more descriptive, records.

Large amounts of untapped wind speed data exist in the US Maury Collection (1784-1863), which were not translated from descriptive terms into physical units. The CLIWOC dictionary should be useful for this purpose, however adjustments in the dictionary may be required (including for any data in the future digitized prior to 1750) as the terms used continually evolved. There is a need for improved communication between researchers using the pre- and early-instrumental data and those using the later-instrumental record. Further digitisation of the post-CLIWOC period was supported along with resources to include the data fully in ICOADS. It was noted that additional terrestrial pressure data was also a priority. Digitisation activities often have a national or local perspective, but international priorities should also be taken into account.

The group was also exercised by the identification and correction of data bias. One example, only partially resolved, is the low pressure bias in the US Maury dataset within ICOADS in the 1850s. The historical reliability of position is around 15-30 miles (once away from land), while the 0.1 degree precision reported in some historical data represents about 6 miles. In contrast, there was a strong feeling that increasing the precision in the modern ship code to at least 0.01 degrees was extremely desirable. There is also a need to characterise airflow distortion. The eventual goal is for a long time record of homogenous winds and pressures that are consistent with each other. A strategy for the inclusion of bias information and adjustments in the full time record of ICOADS is required.

Observation method and height metadata were important to the group. The digitisation of ship metadata by CDMP was welcomed and the need for metadata records going back as far as possible in time was stressed. It was thought important that metadata on buoy anemometer heights should be extracted from the buoy report by ICOADS which is not currently done. Other metadata that could be improved in ICOADS includes information on wind speed measurement method; possibilities for improving such information should be investigated. The possibility of including anemometer height (and other metadata) in the ship (or IMMT logbook) code should also be investigated, however this could take many years to implement internationally.

It was noted that feedback from reanalyses such as ERA70 could be used for improved QC and bias correction in ICOADS. Problems such as poor data quality, track rejections etc. could be used to develop better datasets in the future. Biases derived for recent data by ECMWF could be compared with those derived independently. Although the withholding of data is an important requirement for validation, reanalysis efforts tend to assimilate all suitable available data.

The desirability of a "one stop shop" for climate data was stated. It was thought that this could be explored, for example through JCOMM. Possibly information flow could be improved with a web forum.

Breakout group 3 discussed progress against those past requirements of MARCDAT-I and CLIMAR-II relevant to surface pressure and winds (see Appendix II). Areas where progress had been made included: HadSLP is now updated in near-real-time; the inclusion of a wind expert on the MSLP working group; the availability of a catalogue of pressure products; work has started on a pressure databank for all (both marine and land) pressure measurements under AOPC/OOPC; the availability of a high-resolution wind analysis for the North Atlantic 1958-1997 from the Meteorological Service of Canada; the availability of WMO Pub. 47 metadata alongside ICOADS reports; the development of improved reanalysis techniques to generate long time record datasets and the improved availability of datasets including uncertainties. Areas requiring further effort include: the development of datasets going back to 1950 by FSU; the need for improved adjustment techniques for visual and anemometer winds; the application of these improved adjustment techniques to ICOADS; the need for more pressure observations to improve historical MSLP analyses; the availability of historical and current ODAS metadata in the JCOMM metadatabase; the need for daily and now subdaily pressure analyses; the need for unique buoy identifiers (no reuse of buoy IDs); improved communication with proxy data community.

3.4 Breakout group 4 (Sub-surface ocean temperature and salinity, fluxes and clouds)

Chair: Sergey Gulev, Rapporteurs: Tara Ansell, Matt Palmer, Stephen Warren

3.4.1 Sub-surface ocean data and currents

It was thought that a multi-variate approach to data analysis would be beneficial. For example subsurface temperature information, including from ocean analyses, forecasts and reanalyses, could be used to improve SST and provide information on near surface temperature gradients needed to reconcile information from ships (buckets, engine intakes and hull sensors) and buoys at a variety of depths with skin measurements from space. This could lead to improvement in other surface variables, such as salinity, as well.

There is a need for an inventory of all available surface data, this has been started by ENACT (Enhanced ocean data assimilation and climate prediction). There is the potential to digitise Japanese profile data and subsurface data recovery efforts are a priority.

It is important to compare estimates of upper ocean heat content to surface flux estimates, the IMET mooring should help with this. The use of synthetic salinity (from the T/S relationship) should be investigated to increase the amount of salinity information available.

For gridded products the user requirement identified was for information on a 1-2˚ grid, surface to 700m and monthly. There was a need for clear and open documentation of gridding techniques, such as those being developed as part of the HadGOA project. The development of uncertainty estimates is vital, both for the input data and output products. It was noted that for subsurface data the measurement uncertainty tends to be small, but large errors come from sampling and representativeness. It was thought that at future meetings it might be desirable to have more input from those developing subsurface databases and QC methods.

For information on currents, the priority was to investigate new sources of data and to exploit existing sources better. Some information comes from the ships log of speed through the water/speed over land but not always the full current vector. Some data are collected by the Global Ocean Surface Underway Data Pilot Project (GOSUD) but improved documentation is required. Ocean Surface Current Analyses - Real Time (OSCAR) provides some information in the tropical Pacific. Validation data and uncertainty estimates are required for current data and products.

3.4.2 Waves

A review of observational manuals was recommended, first an inventory of international instructions, then a review of visual instructions. It may not be possible to standardise, but we should work to understand differences. Wave summaries should be included in ICOADS. The need for a subset of very high quality data was discussed. The importance of metadata was stressed; the errors are thought to mainly arise from how the measurements are taken. For example it has been estimated that around 40% of wave observations made on ships where anemometers are present may be wind based, hindcast estimates. There is a need for further analysis of the visual wave estimates, including the effects of ship motion; day, night; new moon, full moon; etc. There is also a need for better analysis techniques.

New type of wave information may come from VOS based estimates of directional wave spectra (with low accuracy, but high frequency - e.g. every second). Every ship has a radar (usually 2) and this can be used to extract wave spectra. Some Russian and German ships are making these measurements and there is a pilot project at GKSS to analyse the data. A further source of information may come from laser range finders installed on some oil platforms.

3.4.3 Fluxes

Metadata are key to improving surface flux estimates from VOS. WMO Pub. 47 metadata for individual ship call signs (and ship names) are currently available back to 1973, and becoming available back to 1955. However, linkage to individual ship reports will become more difficult prior to the advent of telecommunicated data around 1966, as logbook data may lack the call sign. Research is needed both to identify biases in the basic meteorological observations (winds, SST, air temperature, humidity, pressure) that depend on measurement method, and on how to apply corrections to observations without measurement method information. More work is needed to improve the VOS metadata from Pub. 47, and to integrate the new information from the digitised editions prior to 1973. In the absence of call signs, it may be possible to derive metadata and hence corrections based on analysis of Pub. 47 by country or to derive metadata from the data itself (for example wind distributions for visual and anemometer winds have different characteristics). We may need to attribute confidence levels to the actual metadata, and hence uncertainty estimates to the bias corrections. Supplementary information, such as that from instruction manuals is also important.

In common with all the groups the importance of regular intercomparisons and uncertainty estimates for gridded data were stressed. There is an issue with the application of flux parameterisations derived from research vessel data to data from VOS. For example the Coare3.0 algorithm requires either skin temperature, or a time record of meteorological variables to estimate the variation of temperature with depth in the surface layer. As this information is not available, other parameterisations are used. It would be desirable if a parameterisation suitable for use with VOS data could be derived from the most modern flux measurements.

It may be necessary to investigate flexible gridding techniques, gridding only at resolutions supported by the data. The development of blended flux products using *in situ*, satellite and model output cannot be done effectively until each data source is characterised with random and bias uncertainties.

3.4.4 Clouds

Of primary concern was the move to automated systems on VOS and the resulting decrease in the number of cloud observations. Even when automated systems have the ability to accept manual input of cloud (and wave) information, these parameters are often missing. It is vital to demonstrate how important the *in situ* observations are for cloud datasets and we need to feedback information on how we use the observations to the observers. The cloud record is remarkably consistent; there have been no coding changes since 1949. It is important not to change the coding now.

An important recommendation is the future incorporation of information from the Extended Edited Cloud Report Archive (EECRA) into ICOADS. It is desirable to have all the information gathered together; which will make more information available to those analysing the cloud information. There is an ongoing need for ship-based cloud products. It is important to use information on all the characteristics of the cloud when deriving uncertainty estimates. A dataset of high-quality Ocean Weather Station (OWS) cloud estimates would be useful for quantifying uncertainty and bias in cloud observations. Validation data are needed for cloud base height.

3.5 Plenary discussion on data base development and access

How can we better support database development e.g. ICOADS?

Inventory needed of available data sources (hard copy, imaged, and digitized). Science requirements (e.g., reanalysis) should drive the priorities. This small group can't set the specific priorities. Regional and national priorities will factor in.

An important consideration is the keying of complete logbooks spanning entire voyages in key regions and periods.

The period 1901-1920 or possibly -1930? may be a rising priority, especially for regions outside the North Atlantic.

Recommendation: Need inventory of available data sources (hard copy, imaged and digitised) to guide the prioritisation process.

How can we accelerate the inclusion of new and improved data into ICOADS?

More digital data are available, and CDMP is rescuing and digitizing additional international sources. These need to be incorporated into ICOADS.

Partnerships to prepare IMMA data (good idea, volunteers?).

It is important to study and evaluate original format before converting to IMMA. The ICOADS project has Fortran software available to make transition to IMMA easier.

It is essential to evaluate result for accuracy and problems. It would be helpful for procedures or templates to be developed by the experienced ICOADS group to check accuracy of conversions.

ICOADS is developed by a small group, more money is needed to increase activity which should come both from the US Government and the international community. Scientists interested in development of ICOADS could be encouraged to develop projects. GHRSST may provide a model for these actions.

Recommendation: Create tools and guidance ('roadmap'), considering the GHRSST model, for implementing translation into IMMA format.

How can we improve international recognition leading to formal international connection and enhanced support from the US and International centers?

International co-operation should be developed with the JCOMM Expert Teams, the WMO Commission for Climatology (CCl), GEOS, and national in kind programs (e.g. US IOOS, others?).

We have not presented a unified front as the marine climate community. We could advertise our existence with perhaps a webpage, beyond the ICOADS webpage.

Reports of the MARCDAT-II meeting are to appear in *CLIVAR Exchanges*, the *Bulletin of the American Meteorological Society* and the *WCRP Working Group on Surface Fluxes Newsletter*.

Mechanisms to better integrate operational data collection with the marine climate community and their datasets should be investigated. These could involve CLIVAR, JCOMM and CCl, perhaps through the Expert Team on Climate Change Detection, Monitoring and Indices.

How important is near real-time data delivery for the ICOADS observations ?

At least monthly updates are required, based, at minimum, on real time (GTS) data. Products will be needed a few days after the end of each month.

The importance of QC feedback noted.

The scope could be broadened to include results in JCOMM Electronic Products Bulletin.

However we must not forget the importance of delayed mode data (e.g., ship logbook IMMT data, which are presently only included through 1997 in ICOADS) and metadata.

Recommendation: Emphasize the importance of near-real-time data delivery and QC feedback. Explore the inclusion of analysis products, incorporating both near-real-time and historical data, in the JCOMM Electronic Products Bulletin.

What is the best strategy to keep the research community informed about advances in marine databases?

Is the ICOADS portal (icoads.noaa.gov) sufficient?

Additional portals: sea ice, satellite, subsurface, analyses/reanalyses, intercomparisons, new Live Access Servers (LAS)?

Online fora using wiki technology could be developed, also a mailing list, or tutorial by technical experts to advise new users.

The JCOMMOPS website portal (www.jcommops.org) provides information on most real time products, and links to other websites.

NASA has DAC network, but underfunded. Recommend that NASA continue to support DACs.

Recommendation: ICOADS portal by itself isn't sufficient for all requirements. Other mechanisms including JCOMM should be explored. However, the new icoads.noaa.gov URL could provide an umbrella web domain for linkages, etc.

How can we improve acquisition of science quality data?

Possible sources of high quality data are: research vessels, moored buoys, Argo, OceanSITES.

Recommendation: Cataloguing of existing science-quality is key.

How can climate proxy data be used more?

What are the advantages of creating an integrated collection, versus stand alone?

Should they be integrated with *in situ* based collections?

Recommendation??: go back to EuroClivar document and see what we can do.

How can attain better integration of sea ice, subsurface, and surface databases?

Additional near-surface data should be incorporated from WOD into ICOADS (included presently only through 1996). GHRSST taps the highest profile temperatures from GTS, and this, and well as possible incorporation of sea surface salinity (SSS), should be explored. A request has been made to fit Argo floats with thermistors to measure surface temperature as the pumped systems are switched off at 8 m and there is the potential for other parameters to be measured.

ETMC may also undertake some related tasks towards improved integration of data from the three domains.

Consider the use of dynamically linked web portals.

Integration of databases may come from application of the data. WOCE may be a mode for this activity, however significant resources and money were required.

Existing standards may prove critical for storage, discovery, and interoperability of metadata. Recommendation: Considering available resources, initially handle data integration through web technologies and standard metadata and catalogue services to promote easy discovery and data access.

Consider feasibility of operationally stripping out top-level near-SST profile measurement from GTS, perhaps in collaboration with GHRSST-PP.

What data qualities help define the priority for historical data work (both digitization and database preparation)?

Data sparse: periods such as WWI and WWII, and regions such as the Southern Ocean.

Reanalyses (1850-present): set priorities moving backwards.

For the pre-instrumental period the North Atlantic is important, for the instrumental period the priority areas are outside the North Atlantic.

What are good mechanisms to capture and use user feedback to improve ICOADS?

Simple questionnaire. Send out to community. Collate information collected and put into summary document for program managers.

Recommend that IMMA software be created to read and write new attachments? These attachments could be used to provide corrections and flags. The question of integration of the information held in the various attachments can be made later. An example would be the proposed EECRA cloud attachment.

Recommendation: Need both user survey, and methods to capture the feedbacks and bias assessments (e.g., IMMA attachments) that can be provided by users and applications such as reanalyses.

What is the future role of the basic MSG/ICOADS in relationship to climate quality products?

E.g. HadISST, bias adjusted fields from NOC S

ICOADS should continue to provide monthly summaries, as many papers are still based on these. Stopping production would badly undercut user community. However, there is a need for communication between ICOADS and user community in that some datasets are corrected. Needed: DISCLAIMER: 'SST data before 1940 are not corrected for biases.' Similarly for winds: although corrections are not known yet, users need to understand the shortcomings of the uncorrected data.

GCOS climate monitoring principals mandate the continued production until a full replacement is available.

Recommendation: Continue to produce ICOADS MSG summaries. Important benchmark. More documentation and cautions needed, but presented in a positive way.

How can we upgrade the QA/QC for ICOADS observations?

Existing trimming is OK for some applications, should be continued.

Users with expertise can apply their own QC and provide IMMA attachments for wider use.

Desirable to develop methods beyond climatological trimming, for example adaptive techniques, buddy checks, winsorization.

A multi-variable approach to QA/QC should be developed.

The dynamic computation of statistics should be considered.

Metadata or a website about tools, techniques, information, processes, methods used to create data and metadata would be useful. Should we go further and develop additional attachments to hold bias corrected data and QC information?

Recommendation: Keep existing ICOADS QC intact. Try to collect some of the external QC information. Work towards dynamic generation of summaries, possibly using different QC schemes.

How to improve availability of metadata?

Recommendation: WMO Pub 47 should be developed into a consistent metadatabase.

4. Consolidated Recommendations

4.1 Inventories and digitisation priorities

1) Digitisation and other data recovery initiatives should take account of the needs of the marine climate community in prioritising activities.

2) It is recommended that logbook recovery and keying continue for both the pre-instrumental and instrumental periods.

3) The development of data inventories (for hard copy, imaged and digitised sources) and assessments of user requirements are essential to guide the prioritisation process. An International Catalogue of imaged and hardcopy logbooks and data collections not yet incorporated into ICOADS should be initiated within the next 2 years. The catalogue should include as a minimum information on ship routes, start date, position, measurements taken, sampling information and the end date. One immediate need is for an inventory of pre-instrumental and early instrumental (1840s onwards) observations, see for example icoads.noaa.gov/reclaim/ .

4) Within the next four years a community discussion should be held to prioritize future digitization efforts. It is recommended that an important consideration be the keying of complete voyages from logbooks including data within prioritized areas and times. The imaging and keying of partial voyages can result in incomplete metadata, make utilizing keyed data difficult (e.g., track checking, QC) and complicate future keying; and therefore is not recommended.

5) Any digitisation project should attempt to identify resources to ensure: 1) the full translation of descriptive terms into quantitative measures where appropriate; 2) the inclusion of all available metadata; and 3) incorporation of any digitised data into marine datasets such as ICOADS is achieved.

6) Subsurface data recovery should be raised as a priority with data reclamation projects. An inventory of available subsurface data, both digitised and undigitised started under the ENACT project should be further developed.

7) An inventory of research vessel and other research quality observations should also? be developed.

Further information

Possible data sources for digitisation or incorporation into ICOADS include: at least 25 million ship data from UK archives, possibly extending past the mid C19th; Hudson Bay ship logs 1700 to 1860s; Russian Antarctic sea ice atlas containing statistics for sea ice for 1950s and 1960s; sea ice information for the Atlantic Arctic for late C19th and early C20th from undigitised Danish ice charts; research quality data from ships and buoys including 2.1 million Russian research vessel data not yet in ICOADS; CLIWOC data not yet in ICOADS. (See also Figure 7 in Worley et al, 2005, International Journal of Climatology).

User requirements identified include: enhancement of the data records for reanalyses (1850 to present), World War II, World War I, and the regions of the North Pacific, Southern Ocean, South Atlantic, South Pacific and Southern Indian Ocean; to enhance data for the pre-instrumental (e.g. expanding CLIWOC) period by keying data for the North Atlantic from 1690s and instrumental data (1790's) for the Southern Hemisphere; interdecadal climate change analysis could be improved by extra data for the period 1900 – 1920 for all areas apart from North Atlantic.

4.2 User requirements, measurement standards and adequacy assessments

8) It is vital to halt and preferably reverse the decline in the number of VOS reports and their spatial and temporal coverage in line with the GCOS climate monitoring principles. To achieve this it is necessary to improve links with e.g. JCOMM, GCOS, WCRP, CCl and the WMO Commission for Basic Systems (CBS).

9) Mechanisms to better integrate operational data collection with the marine climate community and their datasets should be investigated. These could involve CLIVAR, JCOMM and CCl, perhaps through the Expert Team on Climate Change Detection, Monitoring and Indices.

10) A set of user requirements for the marine climate observing system, including for non-physical subsurface parameters, should be developed within the next 2 years. Once developed the user requirements should be regularly reviewed.

11) The adequacy of the marine climate observing system should be regularly assessed against these user requirements. An important step would be the near-real time availability of ICOADS.

12) More interaction with users is highly desirable. Current users can be identified using ICOADS data requests which may also help to identify ICOADS development needs.

13) The importance of reports of visual estimates of cloud and wave properties (including manual supplements to otherwise automatic reports) should be stressed to marine observers. Observers should be encouraged to make full reports including visual observations of clouds (including types and heights), weather codes, visual winds (where appropriate), waves and visibility. It is essential that the present codes and observing practices be maintained, particularly for cloud reports.

14) All suitable VOS ships should be recruited to VOSClim.

15) Links with organisations developing recommendations on standards for VOS and buoy observations should be improved. Guides to climatological practices should be strengthened to foster marine climate-quality observations, traceable to absolute standards.

16) An increased effort should be made to report back to observers through national programs and through JCOMM the importance of marine observations and information on how the observations are being used.

17) As the low accuracy of ship position hinders comparisons, particularly with satellite data, it is recommended that future ship position reporting accuracy be upgraded from 0.1 to 0.01 or higher.

4.3 Individual Observations, ICOADS and Other Databases

18) Users can benefit from having all available data and metadata of a given type brought together into a single, easily accessible and secure, archive; it is recommended that this approach be continued or adopted, to the maximum extent feasible, for the following broad data categories:
    (a) Surface marine meteorological data and metadata (e.g., ICOADS).
    (b) Subsurface oceanographic data and metadata (e.g., WOD).
    (c) Ice extent data sets and associated uncertainties and metadata (e.g., GDSIDB). It would be useful for all sources of ice thickness to be listed together in one place.

19) CLIWOC data should be fully blended into ICOADS in the next two years. CLIWOC has created an extensive dataset of pre-instrumental wind estimates and made progress in translating 'descriptive wind estimates' into Beaufort equivalent wind speeds. It is recommended that over the next 4 years, pre-instrumental data continue to be carefully converted to wind measurements, including translating US Maury text wind terms.

20) The added value from delayed-mode data as compared to real-time data should be assessed. Changes in data characteristics of ICOADS in 1997/98 due to the reliance on GTS ship reports after 1997 are apparent. It is important to determine if these changes are due to ICOADS quality control procedures, to the addition of delayed mode data, or to both factors.

21) The integration of appropriate datasets into ICOADS should be accomplished using IMMA attachments to provide ancillary information. Priorities for integration should include: information for the interpretation of cloud information including the solar elevation and the relative lunar illuminance from the Extended Edited Cloud Reports Archive (EECRA); and meteorological reports from research vessels.

22) Improve integration of sea ice, subsurface, and surface databases, initially using web technologies and standard metadata and catalogue services to promote easy discovery and data access.

23) Consider the feasibility of operationally stripping out top-level near-SST profile measurements from GTS for ICOADS, possibly with GHRSST-PP.

24) ICOADS should investigate the requirements for, and feasibility of, decoding extra information from GTS and delayed-mode archives of buoy observations including: humidity; additional wave parameters; and buoy anemometer height and type. Other sources of additional information, for example for humidity observations only available as relative humidity, should also be investigated.

25) NWP centers, data assimilation and reanalysis projects, and other users are encouraged to flag marine data problems (e.g., track-check rejections, and ship 'black' lists) and make these QC results readily available for access by data providers, ICOADS, and other interested groups. The desired feedback results may already be produced in many of these areas, but the reverse linkages and access mechanisms are not yet adequate. The approach taken by the AOPC/OOPC Surface Pressure Working Group, who are developing a new data format for their pressure data base that includes fields/flags for analysis error, could be used as a model.

26) The real-time data collection centres should keep original copies of the GTS data stream (e.g., such as NOAA/NCEP is doing by attaching original FM 13 and FM 18 messages to BUFR). A comparison of GTS receipts at these collection centers should be made.

27) A complete set of subdaily pressure observations around the globe with a focus on 1850 to present (instrumental period) should be constructed within the next 2 years.

28) Within the next 3 years, specific data collections (e.g., VOSClim and RVs) should be specifically identified within ICOADS as being useful for validation.

29) A dataset of ocean surface and subsurface currents for tropical oceans should be developed. Interaction with the OSCAR program could be a good step towards this goal.

30) A high quality subset of wave information should be developed.

31) All available wave parameters should be used to improve the consistency and quality assurance of wave datasets.

32) Gaps in the (A)ATSR data 1991-date need to be plugged. The record should be complete by 2008/09 save for one month.

33) The role of IMMA attachments for incorporating quality control, bias, metadata and other non-standard information into ICOADS should be expanded. Tools and documentation should be developed to guide users in the conversion of datasets into IMMA format. GHRSST may be considered as a model for this.

34) The possibility of improving links with sources and users of proxy data should be investigated, using the EuroClivar document as initial guidance.

35) Need both user survey, and methods to capture the feedbacks and bias assessments (e.g., IMMA attachments) that can be provided by users and applications such as reanalyses.

4.4 Metadata

36) The need for observing method and instrumentation metadata is key to all marine climate activities. Improvements are needed to both historical and operational metadata availability and to links between the metadata and data.

37) It is highly desirable that the possibility of resolving ambiguities in historical wind measurement method metadata using alternative historical data sources be investigated.

38) The possibility of including or enhancing the metadata (for example, anemometer and thermometer height and SST depth) in the real time and delayed mode transmission formats should be investigated.

39) ICOADS should decode metadata available in buoy reports, in particular anemometer height and type.

40) The ODAS metadata bank should be populated with both historical and contemporary metadata, including the necessary metadata rescue efforts.

41) An inventory of national and international (e.g., WMO) marine observation and code manuals should be developed, and rare historical publications should be imaged and made available on-line if possible (continuing JCOMM, JMA, and CDMP efforts in this area).

42) A summary of available observing instructions for visual observations should be made including observational practice and code changes.

43) Noting that large variations ship draft occur, the possibility of extracting information on loading-level from ships' logbooks should be investigated to supplement the information available for VOSClim reports.

44) Observational metadata are vital for the calculation of high quality surface fluxes. Methods to improve and extend metadata should be investigated including the development of an improved and consistent metadatabase from WMO Publication No. 47 and its extension using other documentary sources.

45) Methods of obtaining metadata for the historical record should be investigated, for example, using country information, national observing instructions, Lloyds register, and published historical ship descriptions.

4.5 Analysis of Bias and Uncertainty and the need for validation data

46) Within the next two years the feasibility of incorporating bias and other homogeneity corrections into ICOADS and other datasets should be explored.

47) A web site should be created for collecting and distributing tools, techniques, and information used in bias correction, homogenization, and uncertainty estimates in order that biases, other data quality problems, and techniques for correcting them are fully communicated to the scientific community. This would serve as data base for bias corrections methodology. The utility of a users web forum or mailing list should be considered.

48) Buoys have a global average SST bias but we should also make an effort to adjust the data for regional changes in measurement method. Kent and Kaplan (*2006: Journal of Atmospheric and Oceanic Technology*) bucket correction method could be extended to full global dataset.

49) Bias in MAT should be investigated including: using optimal blending techniques to de-bias and incorporate historical day-MAT; reassessment of questionable MATs since 1979 in the tropical South Pacific; the use of time-slice difference analysis to highlight pattern of trends.

50) Investigate the use of empirical orthogonal function analyses as one way of diagnosing biases in SST, MAT and humidity.

51) Intercomparisons in a local area between different data sources can show strengths / weaknesses / biases (e.g. aircraft, ship, buoy; or between different historical decks).

52) The random uncertainties for bias corrected and uncorrected surface fluxes should be calculated and compared.

53) Further investigation is required to characterise air flow distortion over ships.

54) Further investigation of pressure bias in the US Maury collection is required.

55) Further investigation of adjustments required to both visual and anemometer winds are required. Adjusted gridded wind datasets should be developed using the results of these studies.

56) Reference humidity measurements are needed.

57) It is recommended that ice thickness distribution and snow depth on sea ice be measured throughout the Arctic and Antarctic sea ice.

58) The limiting factor in the accuracy of emissivity modelling is the correct specification of the configuration of the snow cover and sea ice. It is recommended that concurrent

measurements of sea ice and snow microphysical parameters and *in situ* radiometric measurements be made as part of IPY.

59) The significance of sensor drift in the passive microwave sea ice record should be considered along with algorithm tie point emissivity drift from physical causes. The need to carefully study overlap periods is noted.

4.6 Analysis and Intercomparison of non-gridded datasets

60) Diurnal cycles of SST must be reliably estimated, for example, through GHRSST-PP.

61) MAT observations should be calibrated against a reference dataset of radiometric and interferometric instruments. However, these devices do not work in rainy conditions.

62) ETSI should continue its work on investigating ice thickness using remote sensing. Stage of development may be used for estimating ice thickness, especially in the marginal ice zone. This information is available for the second half of the C20th. There is evidence that duration of ice existence (age if ice) may also be used as a proxy for ice thickness.

63) Cloud parameters observed by OWS should be compared with other cloud datasets and products.

64) It would be timely to re-visit the development of parameterisations of shortwave radiation from co-located cloud observations and solar radiation measurements.

65) The applicability of flux parameterisations derived from research quality data to routine observations requires investigation.

66) The usefulness of a variety of new sources of wave information should be investigated. Possible sources include standard ship radar estimates of wave spectra (e.g. German and Russian research vessels), ship motion information or data from laser range finders.

67) The wind-wave and stress-wave relationship should be further investigated.

68) The usefulness of ocean profile information, from a variety of sources, to improve surface variables, especially SST should be investigated.

69) Further develop global and regional estimates of upper heat content and explore their application in hurricane research.

4.7 Gridded datasets:

70) Continue to produce ICOADS MSG summaries as an important benchmark in climate research.. It is necessary to improve documentation and provide cautions, presented in a positive way, to enable best use of the data.

71) The existing ICOADS QC should be kept intact. Collect alternative QC information and make available with IMMA attachments. Work towards dynamic generation of summaries, possibly using different QC schemes.

72) All gridded datasets should contain estimates of random and bias uncertainty and error co-variances. Where data corrections have been applied the data uncertainties should be re-evaluated.

73) Gridded datasets should include metadata describing the processing done on the original data and the gridding procedures.

74) Some estimate of the resolution (rather than grid-spacing) should be included in data products. The use of variable grid-spacing should be investigated.

75) A range of interpolated gridded products are needed to verify existing products. For global climate monitoring, we need 3 or more independently analysed datasets. Reasons for differences between analyses still require investigation. Comparisons between analyses should uncover errors but need not result in uniformity, only a better estimate of structural uncertainty.

76) The development of multi-variate products for intercomparison should be encouraged, including surface flux and subsurface products.

77) A more integrated approach should be adopted to the evaluation of heat and freshwater budgets, incorporating information from surface fluxes, SST, subsurface and sea ice observations.

78) Data centres should produce and compare datasets in near real-time for both single variable and multivariate analyses to evaluate biases in gridded products. Monitoring statistics and results need to be published and be freely available.

79) To allow the independent validation of gridded products, it should be considered whether some sources of data should be withheld from particular analyses.

80) The resolution of each product should be accounted for in any intercomparisons.

81) SST analyses should be compared, including by using them to force the same models. An ensemble of bias corrections could also be used to assess these corrections following Folland (2005; *International Journal of Climatology*).

82) We need to review techniques for optimal analysis of local-scale as well as large-scale SST variations and for ascribing error-bars. It is accepted that error estimates and effective resolution will vary temporally and geographically. HadISST2 will need these optimal analyses for input to future reanalyses and CLIVAR Climate of the 20th Century simulations. Tropical SST maxima, and gradients round them, are particularly important.

83) Analyses made without using full-period modes to reconstruct early SST and MAT should assess the resulting uncertainty early in the record.

84) The existing ICOADS QC should be kept intact but enhanced with external QC information where possible. It is desirable to eventually generate summaries dynamically, with the possibility of using different QC schemes.

85) It is highly desirable that in addition quality assurance procedures beyond climatology-based approaches are used, for example using near-neighbour or model forecast comparisons. For some parameters it would be desirable to use multivariate QA to determine rejections.

86) We note the need for satellite as well as *in situ* observations for re-analyses, but clouds can cause problems for satellites. GHRSST-PP reanalysis project 1981-present will use AVHRR as a basic input, (A)ATSR as a reference and buoys as a backup truth.

87) The development of blended products requires improved characterisation of data (uncertainties and biases point-by-point) in order to blend data from a variety of sources (e.g. VOS, moored buoys, drifting buoys, platforms, NWP and satellites).

88) (A)ATSR data should be used in a version of HadISST and of similar products as a reference for *in situ* observations.

89) The priority for humidity is to produce initial datasets which will form the basis for further research.

90) Sea-ice data should be used in the gridding of SST to produce a full dataset. Also minimum SSTs may be -1.9˚C in Antarctic oceans due to higher salinity. Presence of sea ice may have a greater effect on the MAT.

91) A combined data set of ice thickness information should be created with uncertainty estimates.

92) Intercomparisons between historical and recent chart sea ice data sets, along with passive microwave derived fields, using many different algorithms should be made. Additional satellite derived information and marine *in situ* data could be used as validation data.

93) Useful indications of structural uncertainties in ice data sets can be derived from comparisons between ice concentration retrievals using many different algorithms. These uncertainties can be attributed to different causes with the aid of radiative transfer modelling in the case of atmospheric effects and comparison of detailed operational charts may be used to evaluate errors due to emissivity changes. Uncertainties in operational ice charts depend on data collection periods and natural variability of ice processes in each region and errors connected with processing methods. WMO publication No. 574 provides description of data processing techniques. In general, we note that in all cases ice concentration variability distribution is non-Gaussian, so robust statistics should be used to estimate uncertainties.

94) All available cloud parameters should be used in the derivation of uncertainty estimates for gridded cloud cover datasets.

95) The development of uncertainty estimates for subsurface data (profile data and products) should be a priority including error bars on derived time series. Validation data for subsurface datasets is required.

96) The possibility of including wave summaries as ICOADS products should be investigated.

97) Climate indices, for example heat content, should be calculated from subsurface data following the recommendations of the CCl/CLIVAR Expert Team on Climate Change Detection, Monitoring and Indices.

Specific dataset requirements

The requirements for specific datasets are noted including: the WCRP Strategic Framework: Coordinated Observation and Prediction of the Earth System (COPES) needs blended SST products; current model validation requires sea ice data set resolution of at least 1/3 degree spatially and monthly mean; high spatial and temporal (subdaily) resolution wind and pressure gridded fields (including ERA 70 (1940-2010) in the next 5 years; Subdaily Northern Hemisphere SLP (1850-2009) in the next 4 years; 20th Century reanalysis in the next 4 years; the extension and improvement of products like HadSLP, ERSLP, and KaplanSLP in the next 4 years).

4.8 Links, Visibility and Wider Data Dissemination:

98) The possibility of closer interaction with projects such as GOSUD and GTSPP should be investigated.

99) The potential for the provision of *in situ* flux estimates to the WCRP SURFA project or other intercomparison efforts should be investigated.

100) Explore the inclusion of analysis products in the JCOMM Electronic Products Bulletin, incorporating both near-real-time and historical data and information on advances in marine datasets.

101) We must ensure adequate links with a range of organisations including: JCOMM and their various Expert Teams, WMO CBS and CCl; AOPC/OOPC and their working groups on pressure and SST and sea ice; WCRP Working Group on Surface Fluxes (WGSF) and Observations and Assimilation Panel (WOAP); CLIVAR Global Synthesis and Observations Panel (GSOP) and the Joint CCl/CLIVAR Expert Team for Climate Change Detection Monitoring and Indices (ETCCDMI).

102) Improve international recognition with a view to formal international connection and enhanced support from the US and international centers. A report of the MARCDAT-II meeting should be published in one or more high-visibility publications (e.g. CLIVAR Exchanges, Bulletin of the American Meteorological Society).

103) Emphasize the importance of near-real-time data delivery and QC feedback. Explore the inclusion of analysis products, incorporating both near-real-time and historical data, in the JCOMM Electronic Products Bulletin.

104) ICOADS portal alone isn't sufficient for all requirements. Other mechanisms including JCOMM should be explored. It is noted that the new icoads.noaa.gov URL could provide umbrella web domain for linkages, etc.

105) CLIMAR-III should be held as a self-funding meeting in 2007.

5. Summary

The meeting goal of *setting priorities for the future development of marine climate data and products over the next four years* was in the main addressed.

Significant progress had been achieved toward addressing the recommendations of the previous workshops (see Appendix II). Areas where progress had been made included: large volumes of historical data recovered; improved measurement method metadata availability for ships; development of a variety of new data products, many containing uncertainty information; improved data access and formats; blending of SST and sea ice data; However several areas showed little progress, in particular there was need to: improve bias adjustments for several variables; begin regular intercomparisons of data products; develop target accuracies for marine climate variables and assess the adequacy of the observing system against those targets; and improve data set visibility and links to complementary sources of climate data.

Activities required to enhance marine datasets were identified. The development of inventories indicating the availability or potential availability of data, whether undigitised, imaged or digitised, as candidates for digitisation or inclusion into ICOADS was thought to be key. These inventories would guide the prioritisation of data recovery activities, but more work is required to identify scientific data priorities for analyses on a variety of timescales. The definition of user requirements and regular assessments of observations against those requirements is necessary to ensure future data availability. Improved links with observers, managers of operational and climate observing systems, national data collectors, international bodies, NWP and reanalysis centres were all thought to be important to increase the quality and quantity of marine climate data. Integration of datasets (for example of enhanced cloud information, data from research vessels or historical digitised sources) into ICOADS is a priority. The need for single repositories for particular data sources, for example ICOADS for surface marine meteorology, WOD for ocean profiles, GDSIDB for ice, was highlighted, along with the importance of effective linking of these, and other, datasets. Improved QC was a priority for many, but it was agreed to keep the ICOADS QC intact and to encourage users to develop procedures which could lead to information being added to ICOADS as IMMA attachments. Metadata should also be closely linked to the relevant data in a similar way.

Outstanding needs for the development of multi-decadal climate quality datasets were also discussed, among other priorities recommended by the different breakout groups:

• The breakout group for SST, air temperature and humidity identified a range of priorities. These included: the advantages of strengthened links to and feedback from modelling, reanalysis and data assimilation activities; improved characterisation of all *in situ* and satellite data sources to aid the generation of blended products; digitisation of data from the early C19th; additional validation and comparison data from a variety of sources; for datasets available in near real time; for the recovery of humidity data from buoys; and for observation metadata to allow improved bias adjustments.

• For pressure and winds the priorities were for data cataloguing and digitisation activities, particularly of whole voyages, the development of wind speed equivalents for early descriptive wind reports, for observation method and height metadata for ships and buoys. Improved homogenisation techniques for winds are required including the quantification of bias in visual winds and that due to airflow distortion. Improved interaction with reanalysis activities has the potential to lead to improved QC and bias correction.

• Sea ice development priorities included: the need for a multi-variate approach going beyond sea ice concentration and extent to include parameters such as ice thickness, ice albedo, ice drift and ice type; the quantification of bias and uncertainty in these parameters; the blending of the *in situ* ice chart and passive microwave records into climate datasets; digitisation of all available historical ice charts and measurements; the need for more research and validation measurements.

• The breakout group for subsurface ocean data, waves, fluxes and clouds were keen to promote a multi-variate approach to dataset development, particularly for ocean, SST and flux data and including heat budget approaches. Metadata availability was key, as was the exploitation of measurements such as radar waves, electromagnetic-log currents. The automation of VOS had led to a reduction in visual cloud and wave observations beyond the general decline in ship report numbers, which is significantly impacting on dataset quality.

All groups were concerned that the identification of users, user requirements and assessments of data adequacy should proceed without delay. The observed decline in VOS report numbers was seen as a threat to the development of long term homogeneous climate datasets.

The need for more resources for ICOADS was highlighted to enable the development of near-real-time update capabilities, the incorporation of new datasets and delayed mode data, the continued development of the successful IMMA format, improvements to data accessibility and the web portal and links to other organisations.

It was agreed that good progress had been made toward the quantification of data uncertainty and the development of gridded datasets with associated uncertainty estimates. More research is needed however, and ocean profile and sea ice data were seen as needing the most work. Data biases and homogeneity are still a problem, for example biases in some Maury Collection pressure data; there are spurious trends in modern visual wind data and biases in post-WWII SST; we need to rehabilitate daytime air temperatures and questionable air temperatures in the Tropical South Pacific in the 1970s. Satellite sensor drift needs to be identified and corrected. All gridded datasets should contain estimates of random and bias uncertainty, resolution and error-covariance.

All agreed that the definition of our future data requirements was long overdue but no firm plans for assessments have yet been made. Recommendations have been drafted to try to ensure that this is addressed in the short term by the group.

Summaries of the MARCDAT-II meeting have appeared in *CLIVAR Exchanges* and the WCRP Working Group on Surface Fluxes Newsletter and are anticipated shortly in the *Bulletin of the American Meteorological Society*.

Appendix I: Acronyms

Acronym	*Meaning*
(A)ATSR	(Advanced) Along Track Scanning Radiometer
AMSR-E	Advanced Microwave Scanning Radiometer for EOS
AOPC	GCOS/WCRP Atmospheric Observation Panel for Climate
ASPeCt	Antarctic Sea ice Processes and Climate
AVHRR	Advanced Very High Resolution Radiometer
AWS	Automatic Weather System
BUFR	Binary Universal Form for the Representation of meteorological data
CCl	WMO Commission for Climatology
CDMP	NOAA Climate Database Modernization Program
CFD	Computational Fluid Dynamics
CLIMAR	JCOMM Workshop on Advances in Marine Climatology
CLIVAR	Climate Variability and Predictability Project
CLIWOC	Climatological Database for the World's Ocean 1750-1854
COBE-SST	Centennial in-situ Observation-Based Estimates - SST (JMA)
COPES	WCRP Coordinated Observation and Prediction of the Earth System Framework
CryoSat	European Space Agency Ice Mission Satellite
CTD	Conductivity/Temperature/Depth
DAC	Data Acquisition Center
DMI	Danish Meteorological Institute
E2EDM	End to End Data Management
EASE	Equal-Area Scalable Earth
ECMWF	European Centre for Medium Range Weather Forecasts
EECRA	Extended Edited Cloud Report Archive
EMULATE	European and North Atlantic daily to MULtidecadal climATE variability
ENACT	Enhanced ocean data assimilation and climate prediction
ENVISAT	European Space Agency Environmental Satellite
EOS	Earth Observing System
ERA70	Planned ECMWF 70-year Reanalysis
ERS	European Remote-sensing Satellite
ERSLP	Extended Reconstructed Sea Level Pressure
ETCCDMI	Expert Team on Climate Change Detection, Monitoring and Indices
ETMC	JCOMM Expert Team on Marine Climatology
ETSI	JCOMM Expert Team on Sea Ice
ETWS	JCOMM Expert Team on Wind Waves and Storm Surges
FM 13 or 18	Ship or buoy transmission code
FSU	Florida State University
GCOS	Global Climate Observing System
GDSIDB	Global Digital Sea Ice Data Bank
GEOS	Global Earth Observation System
GHRSST-PP	GODAE (Global Data Assimilation Experiment) High Resolution SST Pilot Project
GOOS	Global Ocean Observing System
GOSUD	Global Ocean Surface Underway Data Pilot Project
GSOP	CLIVAR Global Synthesis and Observations Panel
GTS	Global Telecommunication System
GTSPP	Global Temperature-Salinity Profile Program

Acronym	*Meaning*
HadCM3	Hadley Centre Coupled Model, version 3
HadGAM1	Hadley Centre Global Atmospheric Model
HadGEM1	Hadley Centre Global Environmental Model
HadGOA	Hadley Centre Global Subsurface Ocean Analysis
HadISST1	Hadley Centre Global sea Ice Coverage and Sea Surface Temperature data (1870-present)
HadSLP	Hadley Centre Sea Level Pressure dataset
HadSST2	Hadley Centre SST dataset
ICESat	Ice, Cloud,and land Elevation Satellite
ICOADS	International Comprehensive Ocean-Atmosphere Data Set
IMET	Woods Hole Improved Meteorology system
IMMA	International Maritime Meteorological Archive format
IMMT	International Maritime Meteorological Tape Format
IOC	Intergovernmental Oceanographic Commission
IOOS	US Integrated Ocean Observing System
IPY	International Polar Year
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
JCOMMOPS	JCOMM in situ Observing Platform Support Centre
JMA	Japan Meteorological Agency
JRA25	Japanese 25-year Reanalysis Project
KNMI	Royal Netherlands Meteorological Institute
LAS	Live Access Server
MARCDAT	International Workshop on Advances in the Use of Historical Marine Climate Data
MAT	Marine Air Temperature
MCSS	Marine Climatological Summaries Scheme
MSG	ICOADS Monthly Summary Groups
MSLP	Mean sea level pressure
NASA	National Aeronautics and Space Administration
NCEP	National Centers for Environmental Prediction
NIC	US National Ice Center
NIC e00	GIS interchange format ice information files
NOAA	US National Oceanic and Atmospheric Administration
NOCS	National Oceanography Centre, Southampton
NP-33	Central Arctic Drifting Ice Station
NSIDC	US National Snow and Ice Data Center
NWP	Numerical Weather Prediction
OceanSITES	OCEAN Sustained Interdisciplinary Timeseries Environment Observation System
ODAS	Ocean Data Acquisition System
OOPC	GCOS/GOOS/WCRP Ocean Observations Panel for Climate
OOPC	Ocean Observations Panel for Climate
OSCAR	Ocean Surface Current Analyses
OWS	Ocean Weather Ship/Station
Pub. 47	International List of Selected, Supplementary and Auxiliary Ships, WMO Publication No. 47
RV	Research Vessel
SAMOS	Shipboard Automated Meteorological and Oceanographic System Initiative
SAR	Synthetic Aperture Radar
SIMBA	Sea Ice Mass Budget of the Arctic
SMMR	Scanning Multichannel Microwave Radiometer
SSM/I	Special Sensor Microwave/Imager
SSS	Sea Surface Salinity

Acronym	*Meaning*
SST	sea surface temperature
SURFA	Surface Flux Analysis Project
ULS	Upward Looking Sonar
VOS	Voluntary Observing Ships
VOSClim	JCOMM VOS Climate Project
WCRP	World Climate Research Program
WGSF	WCRP Working Group on Surface Fluxes
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WOD2000	World Ocean Database 2000

Appendix II: Tracked Recommendations from Previous Meetings

Recommendation	Status	Carried forward?
A1	More work needed	4.6
A2	Close to completion	
A3	More work needed	4.6
A4	More work needed	4.5
A5	Withdrawn	
A6	Withdrawn	
A7	Ongoing	
A8	Ongoing	
A9	Significantly improved data available	
A10	Ongoing	
A11		?
A12		?
A13	More work needed	Through GCOS SST/SI WG
A14	Ongoing	
A15	Ongoing	
B1	Ongoing	
B2	Completed	
B3	Completed	
B4	Ongoing	
B5	More work needed	4.5
B6	More work needed	4.5
B7	More work needed	
B8	More work needed	4.5
B9	Ongoing	4.1
B10	More work needed	4.4
B11	Completed	
B12	Ongoing	
B13	Ongoing	
B14	Ongoing	
C1	More work needed	4.1
C2	Ongoing	
C3	Ongoing	
C4	More work needed	4.7
C5	Ongoing	
C6	More work needed	4.3
C7	More work needed	4.3
C8	Ongoing	
D1	Ongoing	
D2	Ongoing	
D3	More work needed	4.2

Recommendation	Status	Carried forward?
D4	More work needed	4.2
D5	More work needed	4.2
D6	More work needed	4.7
D7		?
D8	Not done	4.7
E1	Ongoing	
E2	More work needed	4.4
E3	More work needed	4.4
E4		?
E5	More work needed	4.4
E6		4.2
E7	More work needed	
E8	More work needed	4.3
E9	More work needed	4.5
F1		?
F2		4.8
F3	Ongoing	
F4	Ongoing	
F5	More work needed	4.3
F6		?
F7	Completed	
F8	Ongoing	4.8

Recommendations from MARCDAT-I, Boulder 2002.

A. SST and Surface Temperature Working Group

A1 Re-examine the historic bias corrections to SST, especially for the late 1930s through the end of the 1940s.
Status: Good progress
Notes: There are two published correction schemes for historic bias in SST (Folland C.K. and Parker D.E, 1995: Correction of Instrumental Biases in Historical Sea Surface Temperature Data, Quarterly J. Royal Met. Society, 121, 319-367 and Smith, T.M. and R.W. Reynolds, 2002: Bias corrections for historical sea surface temperatures based on marine air temperatures, J. Climate, 15, 73-87). These corrections need to be reassessed whenever substantial updates are made to the SST datasets. The Folland and Parker (1995) correction was developed using the Met Office Marine Databank and required updating for use with ICOADS. The Hadley Centre have adapted the corrections to ICOADS (N.A. Rayner, P. Brohan, D.E. Parker, C.K. Folland, J.J. Kennedy, M. Vanicek, T. Ansell and S.F.B. Tett, 2005: Improved analyses of changes and uncertainties in sea surface temperature measured *in situ* since the mid-nineteenth century, accepted by J. Climate). They also plan to engage in a more in-depth examination, aimed at determining whether or not corrections are required post-1941. 3 papers published looking at biases post 1973 (Kent, E.C., and P.K. Taylor, 2006: Towards Estimating Climatic Trends in SST, Part 1: Methods of Measurement. Journal of Atmospheric and Oceanic Technology, 23(3), 464-475; Kent, E.C., and P.G. Challenor, 2006: Towards Estimating Climatic Trends in SST, Part 2: Random Errors. Journal of Atmospheric and Oceanic Technology, 23(3), 476-486; Kent, E.C., and A. Kaplan, 2005: Towards Estimating Climatic Trends in SST, Part 3: Systematic Biases. Journal of Atmospheric and Oceanic Technology, 23(3), 487-500).

A2 All the metadata in the issues of WMO Publication No. 47 (International List of Selected, Supplementary and Auxiliary Ships) should be digitized.
Status: Good progress
Notes: Imaging of the available published editions and supplements for 1955-72 has been completed (16 PDF volumes, http://icoads.noaa.gov/metadata/), under NOAA's Climate Database Modernization Program, and digitization of the metadata for that period is underway and planned for completion in 2006. (See also E1.)

A3 Biases in recent night marine air temperature (NMAT) data should be evaluated, and NMAT interpolation techniques should be re-assessed.
Status: Good progress
Notes: NMAT biases have reassessed (Rayner, N.A., D.E. Parker, E.B. Horton, C.K. Folland, L.V. Alexander, D.P. Rowell, E.C. Kent and A. Kaplan, 2003: Global Analyses of SST, Sea Ice and Night Marine Air Temperature Since the Late 19th Century, J. Geophysical Res. 108(D14), 4407, DOI:10.1029/2002JD002670) and improved interpolation schemes tested (Folland C.K., Salinger M.J., Jiang,

N. and N. Rayner. Trends and Variations in South Pacific Island and Ocean Surface Temperature. J. Climate, 16, 2859-2874).

A4 Use geostationary satellite and moored buoy data to analyse the diurnal cycle of SST, particularly in the tropical west Pacific warm pool.
Status: Some progress
Notes: Results of analyses of a combination of AVHRR and TMI data have been published: Gentemann, C., C.J. Donlon, A. Stuart-Menteth, F.J. Wentz, 2003: Diurnal Signals in Satellite Sea Surface Temperature Measurements. Geophysical Research Letters , 30(3), 1140-1143 and Stuart-Menteth A.C., I.S. Robinson, P.G. Challenor 2003: A global study of diurnal warming using satellite-derived sea surface temperature, J. Geophysical Res. 108(C5): art. no. 3155 MAY 22 2003. Use of GOES geostationary data may be problematic due to calibration problems.

A5 It is recommended that the Voluntary Observing Ship Climate (VOSClim) Project be extended, or a parallel project be initiated, to include buoys.
Status: Withdrawn
Notes: At CLIMAR-II it was decided to withdraw this recommendation.

A6 Commence regular comparisons of the quality control (QC) procedures for SST. For these, common *in situ* input data should be used.
Status: Withdrawn
Notes: One motivation for this was the relative annual cycle seen in SST anomalies of data sets produced by NOAA and those produced by the Hadley Centre. This arose mainly because of the use of daily anomalies in the QC and gridding of the Hadley Centre data sets. The daily climatology was interpolated from the monthly climatology in a non-conservative way, leading to an enhanced annual cycle in the aggregated monthly anomalies (see N.A. Rayner, P. Brohan, D.E. Parker, C.K. Folland, J.J. Kennedy, M. Vanicek, T. Ansell and S.F.B. Tett, 2005: Improved analyses of changes and uncertainties in sea surface temperature measured *in situ* since the mid-nineteenth century, accepted by J. Climate). This has been improved in the latest Hadley Centre analysis.

A7 Collate NOAA Pathfinder satellite SSTs for inland seas and large lakes.
Status: Good Progress
Notes: Inland seas and lake temperatures have been calculated and included in the recent NODC/RSMAS Pathfinder SST Version 5.0 reprocessing (http://www.nodc.noaa.gov/sog/pathfinder4km). However, these data should be treated skeptically until validation studies have been performed. The Pathfinder algorithms and quality flagging procedures were not originally designed for small, inland, freshwater bodies, and no *in situ* matchup data from these areas are included in the calculation of the algorithm coefficients. Work at the University of Edinburgh has shown that open-ocean retrievals of SST from infra-red satellite measurements are not adequate for lake temperature, due to large spatial gradients in the water temperature leading to clearing of false clouds (John Marsham, 2003: Lake temperatures - thermal remote sensing and assimilation into a lake model, PhD Thesis, Institute for Meteorology, University of Edinburgh, 2003).

A8 Develop sub-monthly analyses of SST since 1950.
Status: Good progress
Notes: The Met Office routinely produces pentad (5-day) SST fields and has a flexible system to grid SST on any spatial and temporal resolution. Daily analyses on a 1° grid for 1901-2001 are documented in Ishii, M., Shouji, A., Sugimoto, S., and Matsumoto, T., 2005: Objective analyses of sea surface temperature and marine meteorological variables for the 20th century using ICOADS and the Kobe collection, Intl. J. Climatol, 25, 865-879. High resolution daily analyses for 2005 onwards are being produced by the GODAE High Resolution SST Pilot Project.

A9 The Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) Expert Team on Sea Ice (ETSI) should provide recommendations on the blending of sea-ice data and on the interpretation of microwave observations of sea-ice. This will provide much-needed information on variations in sea ice thickness.
Status: Good progress
Notes: First version of the blended GDSIDB Arctic sea ice total concentration data set for 1950-1998 was constructed in December 2002. Dataset is based on four sets of 5-10 days ice charts from the WMO Global Digital Sea Ice Data Bank. The fifth set is monthly Northern Polar Region total concentration dataset for1901-1997, also called John Walsh dataset. All five datasets were reprojected to the same temporal monthly scale (mid-month) and to the same 15 by 15 minutes grid. Population of the grid was carried out by means of substitution values by the most representative which were chosen according to the zones of responsibility of the national service. Cases of no-information were populated by monthly robust means. So far, constructed "blended GDSIDB Arctic sea ice total concentration data set for 1950 -1998" may be thought as the most informative factual data and is proposed as a source of WMO norms on sea ice for 1950-1998 period. Further progress is anticipated in changing general climatic values to typical ones and involving some regional data sets presently absent in blended data set. NCDC also produce SST analyses incorporating sea-ice information.

A10 It is desirable that the ETSI should provide an inventory of historical sea ice data for the Southern Ocean.
Status: In progress
Notes: ETSI-I agreed "to develop blended sea ice variables for global climate analysis and to prepare historical sea ice data information for the Southern Ocean" during the inter-sessional period. Status report will be available by ETSI-II (Autumn 2004).

A11 The use of satellite SSTs in relationships between SST and sea ice concentration should be re-assessed owing to possible contamination of these SSTs by the sea-ice. Improved sea-ice data and relationships should be incorporated into SST analyses.
Status: Good progress
Notes: Project funded by Hadley Centre and carried out at University of Edinburgh has used ATSR-2 brightness temperatures to develop an improved retrieval in polar regions. A demonstration data set of SST values on a daily 1 km grid for two days per month throughout 1999 has been produced. This will be taken forward when resources are available.

A12 Cloud-clearing techniques for satellite-based infrared SSTs should be compared.
Status: Some progress
Notes: A NOAA-funded project has developed a new Bayesian cloud detection algorithm for GOES. The GOES Bayesian cloud mask is running in parallel with the operational threshold-based scheme. Individual uncertainty estimates can be assigned to every single SST retrieval.

A13 Regular comparisons of SST analyses should commence.
Status: Little progress
Notes: Some informal comparisons made at the Hadley Centre

A14 All SST analyses need to include gridded fields of analysis error including bias correction error. Error covariances are also needed.
Status: Good progress
Notes: Several analyses including ERSST.v2 (Smith, T.M., and R.W. Reynolds, 2004: Improved Extended Reconstruction of SST (1854-1997), Journal of Climate, 17, 2466-2477) and HadSST2 (N.A. Rayner, P. Brohan, D.E. Parker, C.K. Folland, J.J. Kennedy, M. Vanicek, T. Ansell and S.F.B. Tett, 2005: Improved analyses of changes and uncertainties in sea surface temperature measured *in situ* since the mid-nineteenth century, accepted by J. Climate) now have accompanying error estimates and covariances.

A15 Create monthly and sub-monthly blended SST/sea-ice products. Estimates of errors, and indications of sources of data, should be included in the product.
Status: Good progress
Notes: ERSST.v2 (http://www.ncdc.noaa.gov/oa/climate/research/sst/sst.html) incorporates sea ice concentration to improve high-latitude SST and includes error estimates. The Hadley Centre plans to develop HadISST2, which will contain error estimates.

B. Surface Pressure and Wind Working Group

B1 The Hadley Centre global monthly MSLP data set HadSLP should be updated.
Status: Ongoing
Notes: A new version of HadSLP (1850-2004) is now complete (HadSLP2p) and is updated in near-real-time (HadSLPr). A paper (Allan and Ansell, 2005) is in preparation, to be submitted to J. Climate by the 12th of August 2005. HadSLP2p/r are seen as interim products and a selective release to around eight research groups around the world was made for testing and evaluation of these products. The final version will be released in February 2006.

B2 The Terms of Reference of the GCOS MSLP Working Group should be expanded to include surface winds.
Status: Amended
Notes: At CLIMAR2 SLP Working Group Meeting it was decided to amend this recommendations to "The GCOS MSLP Working Group should be expanded to include a specialist in surface winds."

B3 A catalogue of available pressure products should be developed.
Status: Available
Notes: On the AOPC/OOPC Surface Pressure Working Group web page (http://www.cdc.noaa.gov/Pressure/).

B4 Florida State University will have a non-global (Pacific & Indian Oceans) data set of surface wind and MSLP, fluxes, and related variables from 1950 onwards.
Status: Limited progress
Notes: 2° wind products are available for the Tropical Pacific from 1961 and the Tropical Indian Ocean from 1970: http://www.coaps.fsu.edu/. Research to extend to pressure and flux products on a 1-degree grid and prior to 1978 is ongoing.

B5 Appropriate techniques for the adjustment of both estimated and measured wind speed observations should be investigated and applied.
Status: In progress
Notes: Investigation in progress (e.g. Thomas, B.R., E.C. Kent and V.R. Swail, 2005: Methods to Homogenize Wind Speeds from Ships and Buoys Int. J. Climatology (CLIMAR-II Special Issue), 25(7), 979-995, DOI: 10.1002/joc.1176) and analysis of recent wind observations using all available metadata is underway.

B6 Monthly wind statistics for 1854 to date should be computed using the adjusted estimated and measured winds.
Status: No progress
Notes: No progress at the moment but is still an important piece of work.

B7 The Meteorological Service of Canada has created a high-resolution analysis of winds over the North Atlantic for 1958-1997. The use of historical daily MSLP fields to backdate this analysis should be investigated.
Status: In progress
Notes: Feasibility study being performed by Oceanweather under contract to Environment Canada. More information should be available by the end of April 2004.

B8 Biases from the US Maury Collection pressure data set should be investigated.
Status: Completed for Hadley Centre needs
Notes: Hadley Centre made approximate adjustment (Ansell et al., 2005).

B9 More observations on pressure are needed to improve historical MSLP analyses.
Status: Ongoing
Notes: See AOPC/OOPC Surface Pressure Working Group web page (http://www.cdc.noaa.gov/Pressure/).

B10 The new JCOMM metadata base for moored and drifting buoys, and other ODAS (eg, offshore platforms), should be populated with current and historical data.
Status: Ongoing
Notes: See item E, 3.

B11 Merged ICOADS and WMO Publication No. 47 data 1980-97 should be made available.
Status: Completed
Notes: See item E, 5.

B12 Improved monthly (and daily if possible) surface pressure for land stations should be made available for blended land-marine analysis.
Status: Ongoing
Notes: Progress for Atlantic/European sector as part of EMULATE. A new Northern Hemisphere reconstruction of daily MSLP, building on EMULATE, is planned.

B13 Improved Reanalysis techniques, currently being developed, should be used to produce a combined daily MSLP and surface wind product for as much of the world as possible back to the late 19th Century.
Status: In progress
Notes: A pilot reanalysis for 1938 - 1948 is underway as part of the Historical Reanalysis Project. 4 times daily tropospheric fields (surface to 250 hPa) are planned to be complete by September 2006. 2 papers on the project are either in press (http://www.cdc.noaa.gov/people/gilbert.p.compo/Whitakeretal2004.pdf) or under review (http://www.cdc.noaa.gov/people/gilbert.p.compo/Compoetal2005.pdf).
The proposed GCOS daily and subdaily database of surface and sea level pressure marine and land observations is currently being assembled with the tentative title of the International Surface Pressure Dataset.

B14 For all gridded data sets, error estimates of wind and pressures should include grid box uncertainties and error covariance structures.
Status: In progress
Notes: This has been done for EMULATE daily pressures (Ansell et al., 2005) and for global monthly pressure fields (Allan and Ansell, 2005).

C. Technical Issues Working Group

C1 Data that add the most information to the existing database should be given priority for digitisation.
Status: Ongoing
Notes: Taking place within e.g. ICOADS, CLIWOC and EMULATE.

C2 The research community should have access to preliminary data. Identification and documentation should clearly distinguish final from interim products, and advise users of potential duplication and lack of QC in the interim products.
Status: Ongoing
Notes: ICOADS now offers data for 1998-2002 from a new "real-time" archive, and is beginning to offer supplementary (add-on) datasets in standard formats: http://dss.ucar.edu/datasets/ds530.0/. Further work is needed on the identification and documentation issues.

C3 Use a new, fully documented format for interim and newly-digitised data.
Status: Ongoing
Notes: A new ascii IMMA format is now offered by ICOADS, by the CLIWOC project for 1750-1854 European ship logbook data, and helping to meet requirements of the VOSClim project. IMMA format documentation is available here: http://icoads.noaa.gov/e-doc/imma/. The JCOMM Expert Team on Marine Climatology agreed at its first session (Gdynia, Poland, 7-10 July 2004) to publicize the format more widely (e.g., through a JCOMM technical report) and to continue to be involved in its evolution and development. More information can be found on:http://icoads.noaa.gov/etmc/, document 4.1)

C4 Continue development and application of new QC techniques and utilization of metadata.
Status: Some QC progress
Notes: Preliminary work has been done on an "adaptive" QC for SST, which shows promise for other variables. The resulting SST 2-degree monthly summaries can be accessed from this webpage: http://dss.ucar.edu/pub/coads/forms/msg/msga.form.html. The resulting QC flags have also been merged into IMMA format for 1784-1997.

C5 Continue wide distribution of all data in appropriate formats, and share software to access and analyse the data. Data should be available freely, e.g. over the Internet, or at a minimum cost for media.
Status: Ongoing
Notes: ICOADS data freely available from on-line sources, or at cost of reproduction on other media. All Hadley Centre data sets now freely available (no licence required) from http://www.hadobs.org.

C6 The real-time data collection centres should keep original copies of the GTS data stream. A comparison of GTS receipts at these collection centers should be made.
Status: Ongoing
Notes: NCEP's BUFR format preserves the original message strings. NCDC is also translating NOAAPort GTS data into the IMMA format with attached original message strings. Some preliminary comparisons have been completed between these sources, and this work continues.

C7 Incorporating modern high quality, high temporal resolution data into ICOADS.
Status: Ongoing
Notes: As of October 2005, FSU has defined a procedure, in collaboration with the ICOADS group, to create hourly sub-samples from higher temporal resolution meteorological reports collected on research vessels. The subsampled data will be provided to ICOADS in the IMMA format using a newly designed supplemental record. The supplement will provide multiple navigation, meteorological, and near surface ocean measurements from research vessels, and accommodates multiple measurements for a single parameter (e.g., 2 air temps. from port and starboard sensors). The supplement also contains an uncertainty measure for each parameter. A set of rules has been established to select from the multiple values in the supplement to populate the core of the IMMA ICOADS record. Once a few more minor bugs are worked out, all original one-minute sampled meteorological reports collected by FSU during the World Ocean Circulation Experiment will be provided to ICOADS. The procedure will be used as part of an ongoing effort to place additional research vessel records into ICOADS.

C8 There should be a mirror data site for the new ICOADS database.
Status: Ongoing
Notes: As a first step in this direction, mirroring arrangements were developed between NOAA/CDC and NCAR. The focus of this initial mirroring was on the ICOADS website and metadata (hosted at CDC). In addition, NCEP Real-Time (NRT) observations, which serve as an interim update to ICOADS, are being mirrored, since these data have only been preserved at CDC. Longer-range work is needed to ensure that all major ICOADS data and products are, at minimum, fully duplicated at separate formal archive locations, and actively mirrored if this becomes more feasible.

Recommendations from CLIMAR-II, Brussels 2003.

D. Climate Monitoring

D1 All observations should be taken following the GCOS Climate Monitoring Principles, remembering that any distinction between "operational" and "climate" observations is artificial.
Status: Ongoing

Notes: This philosophy is being pressed widely on the operational agencies.

D2 Because remotely sensed data are an important part of the climate record, it is recommended that the continuity and overlap of satellite missions should be planned in line with the GCOS Climate Monitoring Principles.

Status: Ongoing

Notes: This philosophy is being pressed widely on the operational agencies, including through a letter from the Chair of the World Climate Research Programme Joint Scientific Committee Prof Peter Lemke to the Intergovernmental Group on Earth Observations and the Committee for Earth Observation Satellites. Money is likely to be a constraint.

D3 It is important that we improve dialogue between Numerical Weather Prediction, climate and data-generation communities, through for example the GCOS Panels. Some CLIMAR-II participants should attend the JCOMM Products Workshop (OCEAN OPS04) (Toulouse, 10-15 May 2004) to broaden its scope.

Status: Some progress

Notes: Several CLIMAR-II attendees attended the OCEAN OPS04 Workshop (http://www.meteo.fr/marine/oceanops04/). Other meetings attended included the UK Met Office User Forum for Observations, Met Office, Exeter, May 2004. Considerable debate on the application of Reanalyses to climate is ongoing through the US Climate Change Science Program Synthesis Product on Temperature Trends in the Lower Atmosphere. This was developed further at the Workshop on Understanding Vertical Profiles of Temperature Trends held at the Met Office, Exeter, UK, 13-17 Sept 2004. A JCOMM Ship Observations Team meeting (SOT-III) took place in Brest 7-12 March 2005.

D4 To ensure the extension of adequate climate observations into the future, it is necessary to define target accuracies for fields of each of the basic meteorological variables (SST, MAT, SLP, humidity, wind speed and direction, waves, cloud cover) and for their combination into flux fields (sensible heat, latent heat, longwave radiation, shortwave radiation, precipitation, atmospheric moisture, momentum). The adequacy of the observations collected, as measured against these requirements, should be regularly assessed. The Second Adequacy Report on the GCOS (GCOS, 2003) has already given an overall assessment, but the Statements of Guidance (SOG) on observing requirements for climate need to be completed and regularly updated through the GCOS Panels.

Status: Some progress

Notes: AOPC-X (April 2004) requested that the SOGs on Monitoring Climate Change and Monitoring Climate Variability reviewed at this session be provided to CCl for further review by appropriate CCl Expert Teams (ETs) and individuals, and subsequently be submitted through these ETs to the CBS ET-ODRRGOS. It noted that CCl was in the process of developing additional SOGs for climate applications and agreed that it should review these as appropriate as part of the process of submitting them to the ET-ODRRGOS. The Panel further recommended that formal ownership of these SOGs reside within the CCl structure.

D5 Recommendations for standards in instrument location, mast design, stability.

Status: Some progress

Notes: Frank Bradley, Chris Fairall, and Shawn Smith are drafting a handbook outlining the best procedures and practices for marine meteorological measurement on research vessels. The handbook focuses on practices that will ensure one's ability to calculate accurate turbulent air-sea fluxes. A first draft of the handbook was completed by the end of 2005 and the content will be reviewed at the 1st Joint GOSUD/SAMOS workshop in May 2006. Developing the handbook is a priority of the SAMOS initiative and the WCRP Working Group on Surface Fluxes.

D6 Develop, through JCOMM and its Expert Team on Marine Climatology (ETMC), a list of appropriate climate indices for winds, waves and SLP. Indices are a logical update in technology to marine meteorological summaries under the Marine Climatological Summaries Scheme (MCSS). Development of climate indices should be done in liaison with the WMO/CLIVAR/CCl Expert Team on Climate Change Detection and Indices, and with the GCOS Panels.

Status: Ongoing

Notes: AOPC-X (April 2004) reiterated the value of establishing an open Web site presenting a selected group of climate indices and requested the Chairman (Mike Manton) to liaise with the UK Met Office (Chris Folland) to complete this initiative. ETMC discussed the existing MCSS scheme at its first session (Gdynia, Poland, 7-10 July 2004), but agreed that the development of useful climatic indices might need different aspects of expertise than were available on the ETMC-it encouraged the Task Team on Ocean Product Development to consider this issue.

D7 The Global Ocean Observing System (GOOS) should support extra spectral ocean wave measurements at existing sites in the Southern Ocean and tropics.

Status:

Notes:

D8 Investigate the inclusion of wave information in ICOADS summaries.

Status: Not done

Notes: Recommended again at MARCDAT-II

E. Metadata and Homogenisation

Metadata

E1 Digital availability of the entire record of the WMO ship catalogue (Publication No.47; 1955-), in a format suitable for use in association with both operational and climate data, should be made a priority. Editions for 1955-72 and 2005 are not yet available in digital form.

Status: Good progress

Notes: WMO Pub. No. 47 is now available in machine-readable form for the full period 1973 to the end of 2004 (as of July 2004). Editions for 1955-72 have been imaged by NOAA's Climate Database Modernization Program (CDMP) and await digitisation in 2005. More information can be found on: http://icoads.noaa.gov/etmc/ (modern metadata: document 5.1; historical metadata: document 5.3)

E2 Observing practice literature, both national and international, is an import ant aspect of climate metadata. Two of the more important decisions recorded in this literature were the historical WMO/Commission for Marine Meteorology (CMM) decisions which improved VOS data and the Marine Climatological Summaries Scheme (MCSS). To document the evolution of observing practice, a procedure for identifying, archiving and distributing this type of metadata should be developed. The archive should be updated through JCOMM and its ETMC, without destroying the older entries, when observational practice is updated. Eventually, the archive could also link to the results of instrument validations and comparison studies.

Status: Some progress

Notes: The ETMC have investigated whether all versions of the WMO Manual on Codes (WMO-No. 306) and information on IMMT formats documenting the history of the marine ship codes and exchange formats are available. More information onhttp://icoads.noaa.gov/etmc/, document 4.2. Many relevant documents have now been scanned by JMA, and through additional efforts by the NOAA Climate Database Modernization Program (CDMP), made available as searchable PDFs at this location: http://goos.kishou.go.jp/ws/ETMC/code_task/ (availability from CDMP is also planned).

E3 An archive of metadata for moored and drifting buoys, and other ODAS (e.g. offshore platforms), should be filled by Members, with WMO coordination, as soon as possible with information on both current and historical deployments.

Status: Ongoing

Notes: A web based buoy metadata collection scheme is being developed at JCOMMOPS thanks to EGOS funding. Developments started in January 2004. Implementation is planned for early 2005 to mid-2005. Collected metadata will be publicly available and submitted to the JCOMM ODAS metadata database. The database will be hosted in China (see JCOMMOPS website for more details: http://w4.jcommops.org/cgi-bin/WebObjects/JCOMMOPS)

E4 If possible, a given buoy should have a unique identifier. The re-use of identifiers (buoy numbers) for different buoys can cause erroneous application of metadata. If buoy numbers must be reused, the metadata should include sufficient features (e.g., timestamps) so that they can be correctly applied.

Status:

Notes:

E5 Metadata, including information on homogeneity adjustments applied, should be clearly linked to data.

Status: Some progress

Notes: A subset of Publication No. 47 metadata has been linked to ICOADS individual ship reports for the period 1973 to 2004 using the metadata attachment to the IMMA format.

Homogenisation

E6 It remains essential to acquire data from independent platforms (e.g. VOS, buoys, research vessels, satellites), to allow independent validation and homogenisation of records. The important VOSClim data validation and improvement project should be continued.

Status: Ongoing

Notes: The decline in the numbers of observations from VOS was highlighted at the 3rd meeting of the JCOMM Ship Observations Team and will be the subject of a poster at the JCOMM Scientific Conference, Operational oceanography and marine meteorology for the 21st century, 15-17 September 2005 and at the JCOMM-II 19-27 September 2005, both in Halifax, Canada. See also D2.

E7 There is a need to investigate the best way of applying wind homogenization techniques in the absence of adequate metadata.

Status:

Notes:

E8 Proxy data (e.g. coral-based SST estimates) should be carefully matched with instrumental data,

following the GCOS Climate Monitoring Principles. Error-adjusted annual fields may help in this process.
Status:
Notes:

E9 Continue efforts to make QC of data more consistent and effective, including documenting and homogenising the methods used as much as possible.
Status:
Notes:

F. Uncertainties, Data Availability and Future Workshops

Uncertainties
F1 Consider forming a working group on uncertainties in climate data and analyses. This should include all climate data, not just marine, and the group could appropriately work with, and report to, the GCOS Panels and IPCC.
Status:
Notes: The IPCC held a workshop on Uncertainty and Risk in Maynooth, Ireland 11-13 May 2004. This included predictions as well as observational analyses. See http://ipcc-wg1.ucar.edu/meeting/URW/.

Data Availability
F2 We need to simplify and accelerate data access to users, especially new comers to the field. There should be a "route map" to the best available data. JCOMM should work with the GCOS Panels and appropriate research groups to identify operational, and experimental, integrated climate information products and put them on their web portal.
Status:
Notes:

F3 The successful International Marine Meteorological Archive (IMMA) format developed under the ETMC should continue to be used.
Status: Some progress
Notes: ICOADS Release 2.1 (1784-2002) data have been converted into the IMMA format, and updated data through 2004 are anticipated for availability by late 2005.

F4 Widening access to high quality research vessel data and metadata.
Status: Substantial progress
Notes: In addition to efforts listed above to subsample WOCE research vessel data for ICOADS, the Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative is completing a successful pilot data project in 2005. The pilot project consisted of two research vessels from the Woods Hole Oceanographic Institution transmitting a full suite one-minute averaged navigation, meteorological, and near-surface ocean data from a vessel at sea directly to the SAMOS data center at FSU. The data transmissions occur on a daily basis via email and have been ongoing since June 2005. Once the data arrive at FSU, they are reformatted, blended with vessel specific metadata, and automatically evaluated for data quality. Preliminary files are made available to the public, via the web (http://samos.coaps.fsu.edu), within 5 minutes of receipt of the email at FSU. A process for developing research quality data files is under development and the recruitment of additional research vessels is underway. Continued collaboration with the Global Ocean Surface Underway Data (GOSUD) project is planned, including the 1st Joint GOSUD/SAMOS Workshop in Spring 2005.

F5 Investigate the inclusion of relative humidity (RH) data into ICOADS when RH is the only available moisture parameter.
Status: Ongoing
Notes: Background on the problem is that TAO buoys and some research vessels (R/V; ref. item C, 7), e.g., report RH, but existing ICOADS observational formats lack a field to directly store RH (other than as supplemental data). As a preliminary fix, steps are now being taken in translations of TAO and R/V data into IMMA format to convert RH into dew point temperature. Revisions to the new IMMA format might be a better way to handle this problem (and also possibly include additional data or metadata specific to buoys) in the future. Humidity at the surface as well as aloft was one of the themes of the Workshop on Understanding Vertical Profiles of Temperature Trends held at the Met Office, Exeter, UK, 13-17 Sept 2004.

F6 Consider developing links to sources of coastal and island data.
Status:
Notes:

Future Workshops
F7 A sequel to the Boulder workshop should be held in 1-2 years time.
Status: Completed

Notes: MARCDAT-II was held at the Met Office, Exeter, UK, 17-20 October 2005.

F8 CLIMAR-III should be held in 2007.
Status: Ongoing
Notes: JCOMM-II endorsed the recommendation of the first Session of the JCOMM Expert Team on Marine Climatology (Gdynia, Poland, 7-10 July 2004) for a self-funding workshop, CLIMAR-III, to be held in 2007,