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

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ABSTRACTS

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

Theme 1: oral

Toward the SST Climate Data Record from Space

Kenneth S. Casey, Andrew D. Barton (NOAA/NODC)
Edward J. Kearns (U Miami/RSMAS)
Richard W. Reynolds (NOAA/NCDC)

To meet the need for a high resolution sea surface temperature (SST) climate data record, an improved, 20-year long data set based on NOAA Advanced Very High Resolution Radiometer (AVHRR) observations and an enhanced Pathfinder algorithm has been developed by the NOAA National Oceanographic Data Center and the University of Miami Rosenstiel School of Marine and Atmospheric Science. This gridded data set implements numerous improvements over previously available global AVHRR-based SST data sets, including a finer spatial resolution, better use of ice masks in quality level determinations, and greater inclusion of coastal and inland waters. Validation studies demonstrating the progress being made in developing this rigorous single-sensor SST climate data record from space will be presented. Remaining steps, such as the development of accurate error estimates, will be discussed in the context of creating a Pathfinder climate record suitable as the baseline input to the GODAE High Resolution SST (GHRSST) reanalysis program. The GHRSST reanalysis efforts seeks to blend multiple satellite sensor observations into an accurate, temporally stable, globally complete, and high resolution SST data set with quantified uncertainties.

Theme 1: oral

Feasibility of a 100 year reanalysis using only surface pressure data

Gilbert P. Compo, Jeffrey S. Whitaker, and Prashant D. Sardeshmukh
NOAA-CIRES Climate Diagnostics Center

Climate variability and global change studies are increasingly focused on understanding and predicting regional changes of daily weather statistics. Assessing the evidence for such variations over the last hundred years requires a daily tropospheric circulation dataset. The only available data for the early 20th century are error-ridden hand-drawn maps of the mean sea level pressure field over the northern hemisphere. Modern data assimilation systems have the potential to improve upon these maps, but prior to 1948, there are few digitized upper-air sounding observations available for such a reanalysis. We investigate the possibility that the quantity of newly recovered surface pressure observations is sufficient to generate a useful reanalysis of at least the lower tropospheric circulation back to 1900. Surprisingly, we find that with an ensemble data assimilation system, one should be able to produce high-quality reanalyses of even the upper troposphere using only surface pressure observations. The errors of such upper-air circulation reanalyses would be comparable to the 2 day errors of current operational weather forecasts. Progress towards producing a 100 year reanalysis dataset will be reported.

Theme 1: oral

The Global Ocean Data Assimilation Experiment (GODAE) High Resolution Sea Surface Temperature Pilot Project (GHRSST-PP) Reanalysis program

Craig Donlon[1] and Kenneth Casey[2]
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[2] NOAA National Oceanographic Data Center, Silver Spring MD, USA

The GHRSST-PP is currently implementing a distributed near real time processing and dissemination service providing high-quality, high resolution combined field sea surface temperature (SST) and sea ice (SI) data sets. Both Observational (L2P, ideally available in near-real-time (NRT) within 6 hours of acquisition) and analysis (L4 available at 6, 12 and/or 24 hour intervals) data products are provided. In addition, a comprehensive match-up database (containing co-located satellite and in situ observations) and high-resolution diagnostic data sets (HR-DDS) are generated. The latter products for the basic data quality are validation resources on which the GHRSST-PP data products will be judged.

Recognising the limitations of a near real-time system, the GHRSST-PP international Science Team initiated a GHRSST-PP Re-analysis project (RAN) that is tasked with providing climate data record (CDR) standard combined SST and SI data products that can take advantage of both GHRSST-PP and other delayed mode data. Delayed mode in the RAN context means up to a 12 month delay from data acquisition. In this framework, the RAN allows GHRSST-PP data that have been re-analysed and controlled to a higher-standard of quality to enter the re-analysis effort together with observations that were never used in the NRT system due to timelines criteria.

This presentation will review the plans, status and challenges facing the GHRSST-PP RAN project in terms of properly blending satellite and in situ observations from a variety of sources, establishing uncertainty estimates and melding the historical satellite and in situ record with the current generation of satellite observations.

Theme 1: oral

Extending the U.S. National Ice Center's Sea Ice Climatology

Florence Fetterer[1], Charles Fowler[2], Todd Arbetter[1], Walter Meier[1] and Towanda Street[3]

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2. Colorado Center for Astrodynamics Research, University of Colorado, Boulder, Colorado
3. National Ice Center, Suitland, MD

The U.S. National Ice Center (NIC), a joint NOAA, DoD, and Coast Guard operational analysis and forecasting center, has published weekly or biweekly charts depicting Arctic and Antarctic sea ice conditions since 1972. These are produced using all available in-situ, remotely sensed, and model data sources. They are generated primarily for mission planning and safety of navigation and are delivered in near real-time to NIC customers in picture (gif) or GIS vector formats via the World Wide Web (http://www.natice.noaa.gov). In 2000, NIC released all 1972-1994 Arctic ice analyses in digital format as part of the U.S./Russia Environmental Working Group Sea Ice Atlas on CD-ROM. This product has enjoyed exceptional popularity with researchers in part because operational ice charts offer better accuracy for total concentration and for ice edge location than is available from more commonly used passive microwave satellite data. We are now engaged in updating the digital chart series as well as the climatological products (probability of occurrence, median ice extent, minimum ice extent, maximum ice extent) to cover the period 1972-2004. This involves addressing inconsistencies in the series due both to human factors (such as different analysts creating the charts) and to other factors such as changes in the electronic format over time. Software has been developed to translate NIC files in ArcInfo output formats or WMO SIGRID (Sea Ice Grid) formats into a gridded format used by researchers (Equal Area Scalable Earth, or EASE-Grid). Operational charts are the basis for the bias correction applied to passive microwave data to achieve sea ice concentration homogeneity in the Hadley Centre sea ice and sea surface temperature data set (HadISST1). This is but one reason to keep a "researcher's version" of the NIC chart series available and up-to-date. We hope to encourage broader use of NIC products by publishing work that illustrates how NIC charts may be used to validate model results.

Theme 1: oral

New strategy for the development of global gridded climatologies of air-sea turbulent fluxes based on probability distributions

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The aim of this paper is to overcome a sampling problem in the development of surface flux fields. Sampling uncertainties, being inhomogeneous in space and time, strongly affect the accuracy of the gridded air-sea flux fields in different ocean areas. Direct averaging of flux-related variables and fluxes for the further development of the gridded climatological fields results in sampling biases, which are quite large in the areas of poor sampling and high synoptic variability of fluxes. We suggest a new approach for the development of flux climatologies. This approach is based on the use of probability density functions for the averaging of fluxes within particular boxes and time periods (e.g. months, seasons). We use the probability density function (PDF), which belongs to the family of the so-called double-exponential distributions and is very effective for the description of the distributions of turbulent fluxes of sensible and latent heat. This PDF allows us to effectively account for the extreme flux values and synoptic variance even if the sampling is poor. Moreover, application of this method to the relatively large areas helps to quantify the energy balances of different ocean basins. We use in our analysis voluntary observing ship (VOS) data form ICOADS (International Comprehensive Ocean-Atmosphere Data Set) and different reanalyses (ERA-40 and NCEP/NCAR) for the period from 1948 to 2004. On the basis of different data we build up double-exponential PDFs for the 2-degree boxes and derive new climatological flux fields and their variability. Our estimates are very close to the widely used climatologies (e.g. SOC) in well sampled regions, but exhibit significant differences in the areas of poor sampling, showing more realistic climatological values, less affected by the sampling uncertainties. Different applications of the method proposed are presented. In particular, we show the possibility of its use for the derivation of variability patterns and the reduction of the imbalances associated with sampling uncertainties in highly variable ocean regions.

Theme 1: oral

Biases in Modern in situ SST Measurements

John Kennedy
Hadley Centre for Climate Prediction and Research, Met Office, U.K.

There exist systematic differences between sea surface temperatures measured by drifting buoys and moored buoys and between these and the various methods employed by the Voluntary Observing Ships. Changes in the proportions of observations taken by each of these methods can lead to time-varying biases in large scale averages of SST and therefore to misestimates of recent global trends. Using metadata from ICOADS and WMO publication 47 the relative biases due to bucket measurements and engine room intake measurements from ships are evaluated and compared with the measurements from drifting buoys. Between 1970 and 2004 the proportion of observations in ICOADS that comes from drifting buoys has risen from 0% to over 60%. Because drifting buoys on average report cooler SSTs than ships this increase in relative numbers implies that we may be underestimating the recent warming of the ocean's surface.

Theme 1: oral

A Daily Analysis for Sea Surface Temperature

Richard W. Reynolds (NOAA, NESDIS, NCDC)
Kenneth S. Casey (NOAA, NESDIS, NODC)
Thomas M. Smith (NOAA, NESDIS, NCDC)

A weekly optimum interpolation (OI) sea surface temperature (SST) analysis has been produced at the National Oceanic and Atmospheric Administration since 1993. The analysis is produced on a one degree spatial grid from November 1981 to present and uses bias corrected Advanced Very High Resolution Radiometer (AVHRR) infrared satellite retrievals and in situ SST observations from ships and buoys. The analysis been widely used for weather and climate monitoring and forecasting.

A higher resolution version of the OI analysis is produced on a 0.25-degree spatial grid using in situ and AVHRR satellite data. The results show that the gradient features in the analysis have been improved even in regions with sparse AVHRR data due to cloud cover. This implies that many SST features evolve slowly in time. The daily OI analysis includes a weekly correction of satellite biases. Thus, the analysis is useful for climate studies and for users requiring higher resolution such as those wishing to compute air-sea fluxes. After the new analysis has been carefully tested and evaluated, an additional version would be computed using microwave data from the Tropical Rainfall Measuring Mission (TRMM) Microwave Imager (TMI) and AMSR-E. Because the microwave and infrared retrieval methods are different, the bias errors from the two different sources are independent and combining them reduces the bias of the combined product.

Theme 1: oral

Trends in Marine Winds Adjusted for Changes in Observation Method, 1970 - 2002

Bridget R. Thomas[1], Elizabeth C. Kent[2] and Val R. Swail[3]

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Wind speeds from ship reports archived in the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) show an increasing trend in global wind speeds over the past several decades. Previous work has suggested that for the period 1950 to the mid 1980's the apparent wind trends could be explained by the shift over time from visually estimated to anemometer measured wind speeds combined with an increase in mean anemometer height. ICOADS contains flags which indicate whether winds were measured using an anemometer or derived from visual estimates of sea state. Anemometer height information is part of the metadata found in the World Meteorological Organisation (WMO) Publication No. 47 "List of Selected, Supplementary and Auxiliary Ships". It should be possible therefore to apply corrections to the wind speed data in ICOADS which account for changes in observational methods and for changing measurement heights to reveal physical changes in the winds.

Individual measured wind speeds were adjusted for anemometer height to a 10 metre reference level using individual anemometer heights for each observation from the metadata, from 1970 onwards. Mean anemometer heights increased over the past 3 decades from near 20 m to near 30 m. Visually estimated wind speeds were adjusted for biases in the Beaufort wind scale that relates the wind speed to the sea state. Monthly scalar wind statistics for 5 degree latitude x 5 degree longitude grid boxes show that the change in scalar wind speeds from 1970 to 2002 is only partially explained by the changes in observational practice. The remaining trends vary by ocean basin and latitude but typically show an increase in mean wind speed. Other potential causes of spurious trends are investigated.

Theme 1: oral

Data sets for cloud cover and cloud types over the global ocean

Stephen Warren (University of Washington)
Carole Hahn (University of Arizona)

Synoptic weather reports from COADS were processed, edited, and rewritten to provide a dataset of individual observations of clouds, the "Extended Edited Cloud Reports Archive" (EECRA). Information about cloud amounts, types, and height, including the present weather, was extracted from each report to produce a shortened report designed for cloud analyses. Cases of "sky obscured" were interpreted by reference to the present-weather code (fog, rain, snow, thunderstorm). Amounts are given for low, middle and high clouds, either as directly reported or inferred, both overlapped and non-overlapped. In addition, the relative lunar illuminance and the solar zenith angle are given, providing information that can be used to minimize the "night-detection bias." Pressure, wind, temperature, and humidity are included to facilitate correlations of these variables with clouds. Reports that do not contain cloud information (e.g. buoys) are excluded. The ocean part of the EECRA now contains 74 million ship observations over 46 years (1952-1997). We are using it to produce an updated and revised version of our gridded (5x5 degrees) cloud climatology, including seasonal mean amounts and diurnal cycles for nine cloud types. For this analysis we excluded the ship reports from some "card decks." One of these, the Historic Sea Surface Temperature (HSST) deck, is large; it contributes a significant fraction of COADS reports prior to 1961. It was rejected because it does not contain cloud-type information and, for unknown reasons, appears to be biased low in total cloud cover. Preliminary analyses of interannual variations show the expected correlations of clouds with indices such as ENSO and NAM. Low-cloud base height is positively correlated with sea-surface temperature. Regional trends for night-time cloud cover correlate well with the corresponding daytime trends. The global average trend is slightly positive, and disagrees with ISCCP's global cloud trend, for reasons that are now becoming understood.

Theme 1: poster

Improved Rainfall Estimates from Voluntary Observing Ships

David I. Berry

National Oceanography Centre, Southampton, UK

Precipitation over the global oceans forms an important component of the global water cycle and heat budget, transporting vast amounts of energy and moisture many miles from its source. This heat and moisture is then released by precipitation, warming the atmosphere and freshening the ocean surface. This freshening influences the density of the surface waters, which in turn influences the strength of the overturning circulation.

There are few in-situ measurements of precipitation over the ocean. We must therefore rely on either estimates based on descriptive observations of the weather made by Voluntary Observing Ships (VOS) or from satellite estimates such as those contained within the Global Precipitation Climatology Project (GPCP) data sets. The estimates from ship observations of the weather are based on a method developed using data from a handful of coastal stations, and may give biased results outside of the region in which the method was developed. However, the ship based estimates have the advantage of providing a long time series, extending back to at least the 1960s and possibly earlier. The ship observations should also be consistent over time due to their descriptive nature. In contrast, the satellite estimates have the potential to give more accurate estimates, however, they only extend back to 1979 and may contain inhomogeneities due to changing platforms.

Recent satellite observations and ship data will be used to increase the accuracy of the ship based estimates by developing a new parameterisation for the ship observations. New estimates of the precipitation, based on the ship observations, will then be presented.

Theme 1: poster

Wave Influences on Surface Turbulent Fluxes

Mark A. Bourassa

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A new surface turbulent flux model is applied to determine the influences of waves on surface fluxes of momentum, sensible heat, and latent heat. The new model has been shown to be accurate over a wide range of wind and wave conditions, and is unique in that it considers changes due to swell as well as wind waves. It can also account for changes in the direction of stress due to swell. Initial tests results suggest that the global (over water) bias in turbulent heat fluxes due to not considering waves is roughly $5Wm^{-2}$. Regional differences in these biases will be discussed. The influences of waves in this first study are assessed with NWP and satellite data to estimate the value of a similar study with in situ data. Historical fields based on in situ data have relatively coarse temporal resolution compared to satellite and NWP fields. The influences of temporal averaging are examined as part of this study to determine the value of considering wave-related modifications to surface turbulent fluxes in historical flux fields. The in situ based FSU3 wind and flux fields have been developed with the consideration of including wave influences in the objective analysis.

Theme 1: poster

Multi-decadal oceanographic quality control and analyses

Bruce Ingleby, Hadley Centre for Climate Prediction and Research, Met Office, U.K>

The EU supported ENACT project (ENhanced ocean data assimilation and ClimaTe prediction) involved ten partner institutes from six European countries.

Over six million temperature and salinity profiles from 1956 to 2001 were quality controlled using a new, automated QC system. All types of temperature-salinity profiles - bathythermographs, CTDs, moored buoys and ARGO floats - were processed. Various diagnostics and displays were developed in order to validate and tune the system. There are checks of internal consistency of both ship tracks and individual profiles (spike and stability checks), a correction for XBT fall-rates and optional superobbing of buoy data. Then there is a comparison with prior (background) estimates of the T and S values. Bayesian probability theory is used to calculate the Probability of Gross Error in individual values, both by direct comparison with the background and comparing differences from background with those from other nearby observations.

Global, 3D analyses of temperature and salinity were produced using a variety of analysis techniques and at several European institutes. They used a common set of surface fluxes (from ERA40), quality controlled in situ temperature and salinity profiles (1958 onwards) and/or satellite altimeter sea surface height anomalies (1993 onwards). Overall global ocean temperatures have increased over the last four decades, but with long-period fluctuations superposed. The agreement between the different analysis systems suggests that temperatures in most parts of the world are reasonably well constrained by the available data. In contrast, salinity shows much more variability between the different analyses.

Theme 1: poster

Self-consistent approach to estimating long-term and interannual variability with combined spatial scales in historical data sets

A. Kaplan, LDEO of Columbia University, New York, USA

An iterative procedure is developed to obtain gridded reconstructions of climate fields whose variability on long and interannual scales is consistent with the data and whose error on the variety of spatial scales can be adequately represented by an ensemble of possible realizations. The procedure combines spatial scales in covariance estimates using a sequence of optimal interpolation solutions. It achieves the consistency with the data for the estimates of the long-term variability in seasonal cycle and in spatial covariance by iterations similar to Expectation-Maximization technique. The method is applied to the analysis of sea surface temperatures.

Theme 1: poster

The use of GIS in reconstructing old ship routes

Frits B. Koek, KNMI, The Netherlands

In 2003 the EU project CLIWOC was successfully completed with the delivery of an impressive final report and an even more impressive data set. CLIWOC contains data from old ship logbooks (1750-1854) that needed a range of corrections and adjustments before they could be used for further research. One of the problems was the so-called 'shifting prime meridian'. The current prime meridian (Greenwich) was only accepted internationally in 1884, during an international conference in Washington. Before that time, a wide range of alternatives were used. In CLIWOC not less than 646 different prime meridians were identified. Another problem was the inaccuracy of the determination of the ships' positions. Although sailing around the globe, the precision of the ships' navigation was not high. Many ships travelled along the coast, to keep in touch with the land, but increasingly more ships went on the high seas without any point of reference along their route at all. Small daily inaccuracies in estimating their positions increased the error towards the end of their voyage. Not knowing exactly where they were, captains continued on their method of dead reckoning, even if they might end over land on their navigational charts. During the CLIWOC project, a methodology was developed to deal with these problems, making use of GIS software (i.e. ArcMap). This methodology will be presented at the workshop.

Theme 1: poster

Problems of using mean pressure differences for the correction of trends in wind speed.

Ralf Lindau

Marine wind reports from merchant ships provide valuable information about the climate trends over the world ocean during the last century. However, spurious trends in the data may affect the true climate signal. In this situation, pressure reports are a suitable mean to calibrate the wind data. However, the appropriate method to derive pressure gradients from ship data is controversial. The use of spatial gradients of the monthly mean pressure field is actually adequate to calibrate the vector mean wind. But for many applications the scalar wind trend is the crucial parameter. If mean pressure differences shall be used also for the correction of the scalar wind it has to be assured that the wind steadiness, which is defined by the ratio of scalar and vector wind, is constant throughout the years. If this inherent assumption of mean pressure methods holds true is tested by ship observations in the North Atlantic.

Theme 1: poster

The Hadley Centre Global Subsurface Ocean Analysis (HadGOA)

Matt Palmer, Tara Ansell and Simon Tett
Hadley Centre for Climate Prediction and Research, Met Office, U.K.

HadGOA is a project to develop an ocean subsurface analysis and climatology product designed for model validation and evaluation of historical ocean variability. The project is currently in the preliminary stages, so our focus has been on the scientific strategy and clarifying user requirements. The product is based on quality-controlled observational data from ENACT (Enhanced Ocean Data Assimilation and Climate Prediction) and is planned to incorporate near real-time updates by its completion. The HadGOA analyses will be made freely available for use by the climate research community.

One of the driving forces behind this project is the community's need for an alternative to the NODC (National Oceanographic Data Center, USA) analyses. Some of the key advantages of our analyses will be: (i) averaging of properties on isotherms and/or isopycnals; (ii) a rigorous quality control procedure; and (iii) error estimates of derived quantities. The gridding and interpolation algorithms used by HadGOA will be clear and open-source. This will enable observation-model comparisons to be performed in the most meaningful way. The potential difficulties of model comparisons with the NODC products have been documented in Gregory et al [2004].

The first stage of the project will concentrate on evaluation of the historical ocean heat content. Isotherms will be used as the vertical coordinate in order to utilise all the available temperature data. This approach has the advantage over a more traditional z-level analysis of removing some of the influence of changes in ocean dynamics on variations in heat content.

Theme 1: poster

Quality Control of non-recoverable CTD's from the ARGO programme

Rebecca McCreadie[a], Lesley Rickards[a], Juan Brown[a], Brian King[b]

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(presented by Jon Turton, Met Office)

Traditionally CTD's are recovered after every profile, usually with bottle samples taken at various depths during the profile for calibration purposes. This ship based method of deployment has generated a considerable high quality global database. However, in recent years with improved technology large numbers of free-floating CTD's have begun to be deployed (e.g. the Argo Project). Such instruments are not destined for recovery and are designed to profile for up to 5 years. During this period sensors could reasonably be expected to drift and traditional calibration methods are not feasible. Consequently, this mode of operation presents a formidable challenge in ensuring that the resulting data is accurate. The production of a high quality dataset from such instruments is studied and results are presented, with particular reference to data collected in the southern Indian Ocean and South Atlantic.

Theme 1: poster

Arctic Surface Air Temperatures for the Past 100 Years: Analysis and Reconstruction of an Integrated Data Set

Ignatius Rigor, Harry Stern, and Axel Schweiger

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Accurate fields of Arctic surface air temperature (SAT) are needed for climate studies, but a robust gridded data set of SAT of sufficient length is not available over the entire Arctic. The ACIA (2004) report exhibits a "data void" over the Arctic Ocean. The SAT data sets with wide spatial coverage over the Arctic Ocean begin in 1979 with buoy observations and satellite-derived surface temperatures. There are discrepancies between the *in situ* and satellite-derived data sets, e.g. the satellite estimates of trends show cooling over the Arctic during winter where the *in situ* estimates show warming. We propose to produce authoritative SAT data sets covering the Arctic Ocean from 1901 to present, which will be used to better understand Arctic climate change.

We plan to address these questions:
- How do we reconcile and explain the differences between the *in situ* observations and the satellite-derived estimates of SAT?
- How does Arctic SAT vary on multi-decadal time scales? Are changes in Arctic SAT related to large-scale modes of variability (e.g. Arctic Oscillation) over the longer record?
- Are the increases in Arctic SAT the primary driver of decreases in sea ice extent?
- Do Global Climate Models correctly represent SAT variability over the Arctic Ocean?

Our research will be organized as follows:
- Collect all available data sets on Arctic SAT, and reconcile the differences between *in situ* observations, reanalysis, and satellites. Filter and bias-adjust as appropriate.
- Produce ARCSS-SAT: an objectively analyzed, gridded field of SAT with error variances established through careful cross-validation, resulting in a "best estimate" field of SAT that minimizes the errors and biases in the original input data sets.
- Use standard statistical techniques such as EOF analysis of the resulting ARCSS-SAT to understand the primary modes of variability of Arctic SAT.
- Produce ARCSS-SAT-REC: a reconstructed gridded field of SAT from 1901 to present, using long-term records from "super-stations" and EOF reconstruction techniques. Blend with the Jones et al. (1999) data set to produce a century-long global data set with a high quality representation of the Arctic Ocean. Conduct a careful error analysis on the reconstructed fields to provide error bars that vary in time and space to guide future climate analysis on this data set.

Theme 1: poster

Advances in sea-ice data sets for XX century within the WMO GDSIDB project

Vasily Smolyanitsky, AARI of Roshydromet, St-.Petersburg, Russia
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An attempt is undertaken to give a possibly fuller description of historical ice charts of the XX century submitted in a digital form by national ice services, and to show special features of applying various statistical parameters to assess long-term and large-scale variability of ice conditions of the Arctic region. We estimate historical ice charts as the optimal information product to assess the XX century variability of the Arctic ice cover from the aspects of temporal duration, accuracy, harmony (i.e. presence of insignificant changes in compilation technique), as well as spatial coverage of Arctic regions. Other types of the ice information under condition of their individual use - satellite data (e.g. SSMR-SSM/I-AMSR), coastal station, shipborne, proxy from fauna/flora, folklore, etc. are characterized by less duration, accuracy, or less spatial coverage.

The largest archive of 5-10 days ice charts of XX century in the WMO standard format SIGRID is presently available within the framework of WMO project "Global Digital Sea Ice Data Bank" - GDSIDB (http://www.aari.ru/gdsidb and http://nsidc.org/noaa/gdsidb). The project includes charts from Canada (since 1962), Russia (since 1950), the USA (since 1972), the Baltic services (since 1961), Japan (since 1970), etc., giving the information on distribution of the sea ice total and partial concentrations and stages of development of the Arctic seas and Basin, total number of archived units being of 10,000 order. Extension of the project is scheduled before IPY 2007/2008 both back in time to 1930s and to last annual intervals (2004-2006s).

Climatic processing may be carried out on separate charts collection or on the fused data sources the latter are more optimal for large-scale phenomena. Such a blended GDSIDB dataset was initially developed in 2003 and integrated on a monthly basis and on a 15x15 geographical minutes grid the sea ice total concentration data from various ice services since 1950 up to 1998. Elimination of gaps equal to ~1/2 was provided in the first version by means of monthly climatology and in the next versions with more advanced means like estimates typical for each year from the point of atmospheric processes.

Theme 1: poster

Investigating the role of surface water vapour content in recent climate change: creation of a new global surface humidity dataset

Katharine Willett, Climatic Research Unit, University of East Anglia
Phil Jones, Climatic Research Unit, University of East Anglia
Peter Thorne, Hadley Centre, Met Office
Nathan Gillett, Climatic Research Unit, University of East Anglia

The quantification of recent changes in the content of water vapour, which plays a key role in the climate system, would be an invaluable tool to aid in our understanding of changes to the climate system. We aim to further previous work on observational water vapour changes which has considered either a small subset, primarily land-based, of the available data or made no attempt to homogenise raw data to account for non-climatic effects.

We will produce a comprehensive gridded global product of monthly mean surface vapour pressure changes from the early 1970's. Marine humidity data from ICOADS (buoys and ships) will be combined with land data from Integrated Surface Hourly NCDC dataset. This will be made widely available.

This is a first attempt at utilising humidity data from ICOADS and so this project explores largely unknown territory. We will employ techniques already set in place with ICOADS dataset work but address the problems more specific to humidity data quality in the marine environment:

- Data density (spatial and temporal)
- Sampling errors and systematic changes in practice over time
- Instrumental errors (wet-bulb drying / freezing / poor ventilation / daytime temperature bias / salt or fresh water)
- Systematic changes over time (deck height / no. of buoys / no. of ships)

Finally, the combined global gridded product will be used for trend and timeseries analysis and model (HadGEM) comparison. This poster focuses on the marine component of this project. It outlines: the results from an in-depth study of ICOADS humidity data; the implications for dataset development; and outlines our future plans.

Theme 1: poster

Merged satellite and in-situ data Global Daily SST

Toshiyuki Sakurai, Yukio Kurihara and Tsurane Kuragano
Japan Meteorological Agency

(Presented by Takashi Yoshida)

A new daily high resolution global sea surface temperature (SST) analysis, Merged satellite and in-situ data Global Daily Sea Surface Temperature (MGDSST), has been in operation since April 2004. It is based on the satellite remote sensing SSTs derived from AVHRRs (Advanced Very High Resolution Radiometers) and AMSR-E (Advanced Microwave Scanning Radiometer-EOS) and in-situ observations used as the ground truth. Advantages of infrared and microwave sensors are high spatial resolution and more frequent data acquisition through clouds, respectively. Satellite-derived SST fields are decomposed into two temporal components (long (> 53 days) and short (< 53 days)) and three spatial components (large (>580km), middle (>143km) and small (<143km)). After adjustment to the ground truth and optimal interpolation for each component, they are summed up into a single analyzed SST field. This multi-components optimal interpolation method is conceived to provide better representation of both small scale ocean structure and large scale ocean phenomena. A comparison with moored and drift buoy observations shows RMS error and bias between 30S and 30N are 0.5 and +0.02 C respectively, 0.86 and +0.14 C between 30N-60N, and 0.61 and +0.03 C between 60S-30S.

Theme 1: poster

Operational use of newly analyzed historical SST data for Climate monitoring (COBE-SST) at Japan Meteorological Agency

Ikuo Yoshikawa, Shoji Hirahara, Kazuyoshi Fukuda*, Takanori Mastumoto, Masayoshi Ishii** and Tadashi Ando
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**Japan Agency for Marine-Earth Science and Technology

(Presented by Takashi Yoshida)

Japan Meteorological Agency has prepared a newly analyzed historical sea surface temperature (SST) dataset, which will be operationally updated and utilized for climate monitoring from March 2006. This new SST dataset is a part of the gridded datasets so called 'Centenial in-situ Observation-Based Estimates of the variability of SSTs and marine meteorological variables (COBE)'. The COBE-SST dataset is analyzed globally with optimum interpolation technique with longitude and latitude resolutions of 1 x 1 degree using historical data from ICOADS and KOBE Collection datasets. General characteristics of the datasets are reported in Ishii et al. (2005). The COBE-SST dataset is already used as an ocean boundary condition of an atmospheric numerical model in the Japanese Re-analysis Project (JRA25) which is now going on and will be completed until the end of 2005. This reanalyzed data will also updated operationally as a part of JMA Climate Data Assimilation System for the atmosphere.

The operationally updated COBE-SST will be utilized as follows.
(I) Monitoring equatorial Pacific SSTs and El Niño/ La Niña evolutions.
(ii) Input of the Ocean Data Assimilation System (ODAS) in JMA.
(iii) Input of the JMA Climate Data Assimilation System (JCDAS).
(iv) Monitoring decadal change in the global ocean, such as Pacific Decadal Oscillation (PDO).

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 2: oral

Error assessment of satellite passive microwave ice concentration retrieval

Soren Andersen and Rasmus Tonboe, Danish Meteorological Institute

More than 30 years of near-continuous, global coverage satellite passive microwave observations are used to derive sea ice parameters such as ice concentration. The data are assimilated in NWP and ocean models and used in climate monitoring studies. However there are still unresolved and significant error sources that are only gradually becoming better understood. In particular we see three types of errors that can be attributed to different physical processes: 1) The use of microwave data at different frequencies and resolution, i.e. the mixing of different footprints; 2) atmospheric emission, scattering and absorption; 3) variable ice surface emissivity. While the atmospheric influences, with the exception of clouds, are now relatively well described, an elusive class of errors is introduced by surface emissivity variations caused by physical variations in the layered system of snow and ice. During summer the fundamental problem is due to melt water on top of the ice but even in winter emissivity variations can result in significant errors (up to 20 %) in ice concentration estimates. These errors are propagated to ice area calculations.

The presentation will give a summary of the error sources encountered in passive microwave retrievals of sea ice parameters and the methods that can be used to compensate them. It will also outline the present understanding of snow and ice emissivities and discuss the related errors in retrievals.

Theme 2: oral

Understanding and Improving Marine Air Temperatures

David I. Berry and Elizabeth C. Kent

National Oceanography Centre, Southampton, UK.

It is well known that marine air temperatures often contain biases due to solar heating of the sensor environment and this has resulted in daytime air temperatures being excluded from climate analyses. Unbiased air temperatures are also required if wind speeds are to be height adjusted using a stability-dependent correction or to apply corrections to bucket-derived sea surface temperatures for the effects of heat exchange. The analysis of bias and uncertainty in marine air temperature is difficult as we have relatively few reliable air temperature measurements.

A variety of approaches have been used in the analysis of bias and uncertainty in marine air temperature: an analytical model of the heating errors has been developed; the exposure of the instruments and its effect on data quality has been assessed using the VOSClim dataset; the effects of measurement method have been assessed using metadata from World Meteorological Organisation Publication No. 47; and analyses using both reanalyses and forecast model air temperature comparisons have been performed. Recent results of analysis of errors in ICOADS air temperatures will be presented showing improvements to the quality of air temperatures and demonstrating that biases have been reduced.

Theme 2: oral

Spatial Variability of Random Error and Biases in the FSU3 Winds

Mark A. Bourassa and Shawn R. Smith

The new FSU3 wind climatology will be introduced and briefly described. The spatial patterns of random errors and biases are examined for the FSU3 wind product. The biases are assessed in comparison to satellite observations, and are small for most areas. Differences are largely due to the smoothing required in the in situ product. An objective technique has been developed to determine uncertainty (random errors) as a function of sampling and observational error, as well and the functional used in the variational method. This technique can be applied to any objectively gridded product for which sampling and observational errors can be estimated for all the input data. This technique will be briefly described. In the near future, this technique will be extended to all fields in an in situ based flux product. The influences of sampling and observational errors are compared. This detailed error analysis will be of great use to users of the FSU3 gridded product.

Theme 2: oral

Cross Validation of the COBE Products

Masayoshi Ishii (FRCGC/JAMSTEC) and Yoshikazu Fukuda (JMA)

Objective analysis of marine-meteorological variables, COBE, has been made and the outputs are used in a Japanese atmospheric re-analysis and a historical analysis of ocean temperature and salinity. The COBE products show a nice performance in the above projects. The observational data have a little noise intrinsically due to the large thermal inertia of the oceans and ample moisture there, rather than those on land. However, many quality control procedures have to be applied to the observations in order to obtain an analysis satisfactory to climate studies. To estimate accuracy of objective analysis using such observations, cross validation is applied to COBE products. Here, let the objective analysis for example in the1990s be true, "pseudo-analyses" are made using data of the 1990s distributing similarly to those in the other decades, and finally differences between the true and pseudo-analyses are discussed. The result of cross validation provides a measure of reliability of the objective analyses for each decades. Analysis errors have been estimated by the framework of optimal interpolation and are stored in the COBE data base. The error is purely theoretical, and therefore it should be verified by the cross validation. Also, it could be clarified by the cross validation how the data distribution affects quality of the analysis. Moreover, it gives us an answer if either optimal interpolation or reconstruction produces a better analysis under the condition of sparse data distribution.

ABSTRACT WITHDRAWN

Theme 2: oral

Validation of AATSR sea surface temperatures with in situ observations

Anne O'Carroll, Met Office, U.K.

The Advanced Along Track Scanning Radiometer (AATSR) was launched upon ENVISAT in March 2002. AATSR top of atmosphere brightness temperatures and skin sea surface temperatures (SSTs) at 10 arc minute spatial resolution have been received at the Met Office in near-real time since August 2002. Various processing have been performed on these data to convert from skin to sub-skin (bulk) SST and to model and recognise diurnal warming effects on these observations. In addition ATSR-1 and 2 SSTs have also been processed back to 1992 providing a 15 year dataset of precision SSTs.(A)ATSR SST observations have been validated against global in situ buoy SST observations on a weekly basis since August 2002. Results from these comparisons will be presented, along side results from comparisons of (A)ATSR SSTs with other satellite SSTs. A three-way comparison between AATSR, buoy, and AMSR-E SSTs will be presented, enabling errors for each observation type to be evaluated.

Theme 2: oral

Error Estimates for Historical Surface Temperature: The Influence of Spatial Scales on Sampling Error

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Several estimates of SST and merged land-sea temperature error have been computed using different methods. Here several of these methods are compared for the average-temperature error, with emphasis on comparing Folland et al. (2001) and Smith and Reynolds (2004, 2005). For these two studies, the largest differences in error estimates are in sampling error, due to the spatial scales used for analyses. The error estimates due to bias-adjustment uncertainty are more similar.

In the Smith and Reynolds analyses, the low- and high-frequency variations are separately analyzed. First the low-frequency (interdecadal) variations are analyzed using a combination of averaging and smoothing of anomalies over 10º-15º spatially and 15 years temporally. Then the high-frequency variations are analyzed by fitting data (minus the low-frequency analysis) to a set of large-scale spatial modes. It is assumed that these modes can be computed for high-frequency variations using high-density observations from the recent period. Low-frequency variations can have periods much longer than the recent period, so they are analyzed using the simpler methods. Without adequate sampling for the simpler methods, the low-frequency anomaly damps to zero and its associated error is large. This is the case for many regions before 1950. In Folland et al. large-scale spatial modes are used to analyze both the low- and high-frequency variations. Because these modes have large scales, much less sampling is needed to resolve the low-frequency variations, and a smaller overall sampling error is estimated. However, it is not clear that these modes adequately span the all low-frequency variations, so they may not resolve some variations in those frequencies. For the late 19th and early 20th century, this difference can change the error by a factor of 2. These differences and their implications are discussed.

Theme 2: poster

Overview of the uncertainties inherent in visual wave data available from VOS

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Visual observations provide the longest records of wind wave estimates worldwide starting from 1870 onwards. However, the accuracy of these data is questionable due to different errors inherent in the visual data. These errors result from the observational accuracy, different visual observing practices, coding systems and sampling inhomogeneity, affecting the development of the gridded fields. Using ICOADS collection of visual wave data for the period 1870-2002 we quantified most of uncertainties and developed the comprehensive assessment of the accuracy of visual wave data. Analysis included different statistical procedures for the estimation of random and systematic errors and involved the use of the alternative information, such as buoys, model data and questionnaires distributed among ship officers. In our presentation we give global quantitative estimates of different types of uncertainties in mean wave parameters as well as in the wave statistics, including occurrences of the extreme wind waves.

Theme 2: poster

Estimating Ocean Subsurface Temperature Trends

D.E. Harrison & Mark Carson

We have identified the 1x1 degree grid boxes in WOD2000 in which there are at least five observations per decade for at least four of the last five decades, and examined trends over the period 1955-2000 for 500m, 300m, 100m and nominal surface depths. We have also examined the running 20-year trends. This approach is taken in order to avoid as many intermediate data analysis procedures as possible, and to see the resulting spatial patterns of trends. We find there is considerable spatial structure to both the 50year and 20year trends, and we find many regions in the ocean over which the 20year trends substantially change sign over the analysis period. Filtering these results for only the boxes with 90% significant trends reduces the box to box variability and identifies a few regions with very clear trend signals. Unfortunately the data coverage under our sampling criterion is quite limited. Even at 300m, well over 75% of the ocean is not adequately sampled. The challenge of estimating uncertainty of basin scale long term trends is considerable.

Theme 2: poster

Uncertainty in Surface Turbulent Fluxes

Elizabeth C. Kent and David I. Berry

National Oceanography Centre, Southampton, UK

Marine meteorological reports from Voluntary Observing Ships (VOS) such as those in the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) can be used to produce estimates of air-sea heat exchange. Although surface flux climatologies derived from VOS reports typically contain annual-mean global heat flux imbalances of order 30 Wm^{-2} they are an important resource. For example VOS fluxes are good enough to reveal errors in Reanalysis turbulent flux estimates which contain large regional biases despite being in global balance.

To use the VOS fluxes effectively it is important to estimate their uncertainty. There are known biases and random errors in the reports and sampling errors can be large in some regions. All of these sources of uncertainty and bias have the potential to vary over both space and time. Estimates of the uncertainty in surface flux estimates from ICOADS will be presented along with an assessment of the most important contributions to the overall uncertainty.

Theme 2: poster

Differences between Met Office and SOC latent heat fluxes in areas prone to tropical cyclones.

M.E. McCulloch, A. Hines and I. Culverwell.
Hadley Centre for Climate Prediction and Research, Met Office, U.K.

Air-sea heat flux climatologies derived from the Met Office's global Numerical Weather Prediction (NWP) model, were compared with fluxes derived at the Southampton Oceanography Centre (SOC) from ship data. The NWP latent heat fluxes appear to show a greater ocean heat loss in areas, and seasons, with tropical cyclones. Various explanations for this are investigated, including a possible tropical-hurricane fair-weather bias in the SOC fluxes.

Theme 2: poster

Assessing the effect of airflow distortion on VOS wind speed measurements

Ben I. Moat[1], Margaret J. Yelland[1], Elizabeth C. Kent[1] and Anthony F. Molland[2]

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Wind speed measurements obtained from ship-mounted anemometers are biased by the distortion of the airflow around the ship's hull and superstructure. Past studies have used computational fluid dynamics (CFD) to simulate the airflow over individual research ships. Due to the variation in shape and size of the several thousand ships participating in the Voluntary Observing Ship (VOS) project it would be impractical to study the airflow around each ship in this way. Therefore, simulation of the mean airflow over a typical, or generic, tanker/bulk carrier/general cargo ship has been examined.

The results show the modelled wind speed bias is highly dependent upon the anemometer location. The wind speed bias at particular locations also varies with the relative wind direction, i.e. the angle of the ship to the wind. Wind speed biases for various anemometer positions are presented for bow-on and beam-on flows. A method to estimate the airflow distortion for VOS wind speed reports will be presented.

The metadata required to apply the method to VOS wind speed reports, such as ship type and size, have been available in the World Meteorological Organisation Publication No. 47 metadata since 2000. A statistical comparison of wind speed reports from different types of ship will be presented and the results interpreted using the results of the airflow studies.

Theme 2: poster

Improved analyses of changes and uncertainties in sea surface temperature measured *in situ* since the mid-nineteenth century: the HadSST2 data set

N.A. Rayner, P. Brohan, D.E. Parker, C.K. Folland, J. Kennedy, M. Vanicek, T. Ansell and S.F.B. Tett

Met Office Hadley Centre for Climate Prediction and Research, U.K.

A new flexible gridded dataset of sea surface temperature (SST) since 1850 is presented and its uncertainties quantified. This analysis (HadSST2) is based on data contained within the recently created ICOADS data base and so is superior in geographical coverage to previous datasets and has smaller uncertainties. Issues arising when analysing a data base of observations measured from very different platforms and drawn from many different countries with different measurement practices are introduced. Improved bias corrections are applied to the data to account for changes in measurement conditions through time. A detailed analysis of uncertainties in these corrections is included by exploring assumptions made in their construction and producing multiple versions using a Monte Carlo method. An assessment of total uncertainty in each gridded average is obtained by combining these bias correction related uncertainties with those arising from measurement errors and under-sampling of intra-grid box variability. These are calculated by partitioning the variance in grid box averages between real and spurious variability. From month to month in individual grid boxes, sampling uncertainties tend to be most important (except in certain regions), but on large scale averages bias correction uncertainties are more dominant owing to their correlation between grid boxes. Changes in large-scale SST through time are assessed by two methods. The linear warming between 1850 and 2004 was 0.52±0.19ºC (95% confidence interval) for the Globe, 0.59±0.20ºC for the Northern Hemisphere and 0.46±0.29ºC for the Southern Hemisphere. Decadally filtered differences for these regions over this period were 0.67±0.04°C, 0.71±0.06°C and 0.64±0.07°C.

Theme 2: poster

An Assessment of Bias in Marine Winds, Using Co-located Ships and Buoys

Bridget R. Thomas[1], Elizabeth C. Kent[2] and Val R. Swail[3]

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Ships and moored buoys both provide important information on the marine wind field. Ship reports are widely distributed over the ocean but are of varying quality. Moored buoys typically provide good quality wind speed data but are geographically limited. Some inhomogeneities between ship and buoy wind reports are due to factors (such as different anemometer heights) whose effects can be computed theoretically and compensated for. Other factors such as air flow distortion and differences in averaging technique are less well understood, and not easily predicted from theory.

This study attempts to identify these less well understood factors and to quantify them using statistical techniques. It is an extension of an earlier study which was based on International Comprehensive Ocean-Atmosphere Data Set (ICOADS) ship data and Canadian buoy data during 1980-1995. ICOADS ship reports are co-located with Canadian and US buoy reports for the longer period 1975-2002. Including more recent data in the analysis allows the use of an extended metadata format in World Meteorological Organisation (WMO) Publication No. 47 "List of Selected, Supplementary and Auxiliary Ships", which gives more information about individual ships, including vessel type and dimensions. The co-located ship and buoy dataset, including metadata, allows a quantification of sources of bias and uncertainty in the wind data including: differences between traditional ship reports and those from automated weather observing systems onboard ships; differences due to the observing practices of different countries; visually estimated wind day/night differences; differences in reported winds from ahead compared to winds from astern; and the effects of air flow distortion. Better understanding and quantification of these effects will in the future allow for improved adjustment methods to homogenize marine winds.

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

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Theme 3: oral

The Climate Database Modernization Program's Marine Data Rescue Activities

Joe D. Elms

The primary goal of the Climate Database Modernization Program (CDMP) is to digitize and preserve NOAA's historical climate and environmental data and to make them easily accessible via the Internet. CDMP is supporting 50 different NOAA tasks including several marine projects which involve locating, imaging, and keying marine records. Current projects include imaging and keying the pre-1912 merchant marine logbooks in the National Climatic Data Center (NCDC) archives, and logbooks collected during the World War I and II era but not previously keyed or imaged. In addition, CDMP actively supports keying projects involving current incoming marine data from Voluntary Observing Ships (VOS) logbooks and U.S. Navy ships. These data are directly ingested into national and international databases.

Additional marine rescue activities include imaging logbooks held at the National Archives and Records Administration (NARA). These include lightships off the U.S. coast and in the Great Lakes, the Simultaneous Ship Observations (1875-1902), and any other collections we can identify.

Based on a lead from a European colleague on the CLIWOC project, CDMP has located some early French ship observations on microfilm in the U.S. Library of Congress. CDMP is in the process of obtaining copies of these data, which originally came from the French archives, so they can be imaged and keyed. In addition, CDMP is working in conjunction with UK collaborators in an effort to locate resources to image the marine logbooks in the British Archives and eventually transfer those images to CDMP for keying.

CDMP is also working with the Meteorological Service of Canada to key some of their previously un-keyed logbooks from their VOS program. All CDMP marine tasks will be discussed in some detail under the "Database Development and Access" theme at MARCDAT-II.

Theme 3: oral

VOSClim

Elizabeth C. Kent[1], Sarah North[2], Scott D. Woodruff[3] and David I. Berry[1]

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2 - Met Office, Exeter, UK

3 - NOAA/ESRL, Boulder CO, USA

The World Meteorological Organisation / Intergovernmental Oceanographic Commission Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) Voluntary Observing Ships (VOS) Climate Project (VOSClim) aims to produce a high-quality dataset using a subset of VOS. VOSClim has been running since 2001 and has collected meteorological reports and metadata from over 100 ships. The VOSClim observations are co-located with Met Office forecast model output and these ship/model pairs are being used to assess the quality of the data. The VOSClim dataset contains additional parameters designed to assist quality assessment of the data, and which are available in delayed-mode. The VOSClim dataset will be used to understand and correct biases in ship data, both for VOSClim and for the wider VOS.

An overview of the VOSClim project will be presented, along with recent results from the analysis of the dataset, and plans for making the data available. Workshop participants are encouraged to consider and discuss the potential for scientific exploitation of the VOSClim project and dataset during the breakout sessions.

Theme 3: oral

Marine Climatology from Research Vessels

Shawn R. Smith[1], Scott D. Woodruff[2], and Steve Worley[3]

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Technological advances on research vessels are making it possible to collect and transmit higher volumes of marine meteorological and near-surface ocean data. Many research vessels are equipped with shipboard automated meteorological and oceanographic systems (SAMOS) that record atmospheric and ocean surface conditions (e.g., sea temperature and salinity) on temporal frequencies of ≤15 minutes. The increased volume of data from research vessels provides challenges and opportunities for the marine climate community. Presently, research vessel data make up only a small fraction of, and frequently are not reported in a manner so they can be readily included in, ICOADS.

We will present a research vessel comparison between observations that currently are available in ICOADS and SAMOS data. Variations in spatial coverage will be discussed and the improved resolution of SAMOS data highlighted. In addition, we will describe a collaborative effort between the ICOADS project and the Florida State University research vessel surface meteorological data center to develop methods to sub-sample SAMOS data for inclusion in ICOADS. Development of a new attachment for the International Maritime Meteorological Archive (IMMA) format will be proposed to facilitate archival of data collected from SAMOS and other automated instrumentation (e.g., research moorings).

By illustrating the added value of the high-resolution data, and proposing strategies for improved archival and availability of research quality observations, we hope to stimulate discussion in the research community to make better use of these high-quality observations. The role of research vessels as platforms for advanced measuring systems (e.g., direct flux measurements, infrared sea surface temperatures, underway CO_2) will also be discussed.

Theme 3: oral

Climatic data from the 'pre-instrumental' period: potential and possibilities

Dennis Wheeler (University of Sunderland SR1 3PZ, UK)
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For many climatologists the instrumental period begins sometime in the mid-nineteenth century. This is not, however, to conclude that instrumental (or other) data do not exist for earlier periods. In this respect naval logbooks, of which there are more the 100,000 in the UK from before 1850, are of particular significance. The EU-funded CLIWOC project, which covered the period 1750 to 1850, has shown that non-instrumental logbook data can be put to good use and, indeed, there is the possibility of procuring pressure field reconstructions from such data. Whilst it is true to state that most logbook climate information from before 1850 is of this non-instrumental type (wind force, wind direction and weather descriptions) it does not follow that instrumental data are absent, and one source is of particular importance in this respect: the logbooks of ships of the English East India Company (EEIC). In contrast to Royal Navy ships, most of whom did not commit barometric or temperature readings to paper until the 1830s, from as early as the 1790s officers of the EEIC used pre-printed logbook sheets that included specific spaces for air temperature and pressure. Given also that as many as six such vessels a year would negotiate the oceans between England, India and China, with observations being made at noon every day, there is represented here a notable volume of climatic data with a significant geographic range and time span (the Company ceased activity in 1833). Most of the logbooks have survived and are held in the British Library (St. Pancras). Although the sailings were highly seasonal and timed to take advantage of the annual rhythm of air flow in the Indian Ocean, these data have much potential but have yet to be digitised for any more than a small number of 4000 logbooks that are held in BL. This presentation describes the character, origin and nature of these data and is made with a view to opening discussions with colleagues to determine the potential for integrating them into existing, more recent, data sets.

Theme 3: oral

ICOADS: Plans and Prospects for Improvements

Scott D. Woodruff [1], Steven J. Worley [2], and Richard W. Reynolds [3]

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Plans for improvements in the observations, metadata, and products of the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) fall under four primary efforts: (1) Regular extensions (aiming toward annual and potentially monthly) based on real-time (GTS) data. (2) Blending new data sources—both historical and contemporary—to augment the current (1784-2002) archive. (3) Integrating meteorological observations with ship (1955-) and eventually buoy metadata. (4) Completing transition to, and collaborations with data providers on, a new observational format (IMMA).

These development activities will add value to ICOADS and grow its relevance to international research projects and climate assessments. The large number of data sources, the many complex formats, and the changes in the observing systems and recording practices require careful work to improve the basic archive collection—a resource-intensive process. With current US support limited, future prospects to move forward will be discussed.

Theme 3: oral

INVITED PRESENTATION
ICOADS: Data, Products, and Access

Steven J. Worley[1], Scott D. Woodruff [2], Zaihua Ji [1], Richard W. Reynolds [3]

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The International Comprehensive Ocean-Atmosphere Data Set (ICOADS) is the world's largest archive of marine data, currently spanning 1784-2002 at Release 2.1. The basic observational data archive (185 million records) is augmented with simple derived monthly data products, metadata, and documentation. ICOADS has a centralized information portal at the project website (icoads.noaa.gov). Here, all services from the three cooperating US partners are cohesively organized and users can choose from and are linked to a variety of data access methods.

An update on new data access features, formats, and metadata at the ICOADS portal will be provided along with the current status of Release 2.2 (~1998-2004 update), which is planned for completion by the time of the workshop. Future plans for data access will also be described.

Theme 3: poster

JCOMM End-to-End Data Management (E2EDM) prototype project.

Elanor Gowland, Met Office

The JCOMM Expert Team on Data Management Practices (ETDMP) set-up a number of pilot projects as a result of their first meeting (Oostende, Belgium, September 2003). One of these projects was the development of the E2EDM Prototype, the remit includes; building and demonstrating a prototype system which can undertake real-time data fusion from distributed sources into sample products of interest to JCOMM users (covering both oceanography and marine meteorology).

The JCOMM E2EDM Strategy defines the overall vision of the end-to-end data management process and contains the general proposals and decisions on various (technological, institutional and other) aspects of the E2EDM establishment including the measures which are necessary for the E2EDM design and implementation.

The objectives of E2EDM are:

(i) to ensure the quality, completeness and comparability of operational and delayed marine data collected from different sources, as well as of forecast, analysis and climate products generated by various organizations and groups;

(ii) to organize the full and continuous marine data and information cycle from data collection to product generation;

(iii) to provide the timely delivery of marine data and products to meet scientific, forecasting, industrial and environmental needs. E2EDM should not replace, but build on the existing infrastructure of marine data acquisition and management, e.g. the infrastructure developed under major national and international programmes of such agencies as IOC, WMO, ICSU, GOOS, etc.

The basic principles of the JCOMM E2EDM Strategy were considered by ETDMP-1 session and the appropriate document was distributed among IODE management bodies and JCOMM DMCG (Data Management Co-ordination Group). This document is available on the ETDMP E2EDM home page: http://data.oceaninfo.ru/e2edm/index.html

Theme 3: poster

Progress of the Shipboard Automated Meteorological and Oceanographic System (SAMOS) Initiative

Shawn R. Smith

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An ongoing initiative will be described which aims to improve the quality of observations collected in-situ by shipboard automated meteorological and oceanographic systems (SAMOS) on research and merchant vessels. Goals of the initiative include improving the accuracy, calibration and inter-calibration, access to, and archival of quality-assured, high-resolution (sampling rates typically <15 min) surface meteorological and near-surface oceanographic data from SAMOS. In 2004, a data assembly center (DAC) was established at the Florida State University to coordinate the collection, quality assurance, distribution, and permanent archival of SAMOS observations. An update of the center's activities will be provided, including status of data exchange and metadata standards, data accuracy targets, data quality evaluation, and archival. Progress of the 2005 pilot project to establish daily electronic exchange of data and metadata between research vessels and the FSU DAC will be described. Current shipboard partners include the Woods Hole Oceanographic Institution and the Scripps Institution of Oceanography.

Several of the recommendations from CLIMAR-II will be addressed, including those related to data availability and climate monitoring. In addition to improving SAMOS data access, the SAMOS initiative is working towards a handbook of "best practices" for marine meteorological measurements. The status of the handbook will be described, including contributions by the WCRP Working Group on Surface Fluxes. In addition, progress on a portable, state-of-the-art flux instrumentation suite will be presented. The portable suite is expected to improve the understanding of SAMOS accuracies through onboard, at-sea comparison with the SAMOS deployed on individual vessels. Finally, ongoing interaction with user communities to design suitable products for research and operational activities will be described along with the status of international collaborations between the SAMOS initiative, GOSUD, VOSClim, and international climate programs (e.g., CLIVAR).

Theme 3: poster

Making documentation relating to the marine codes and formats available on the web

Takashi Yoshida
Japan Meteorological Agency

In the long history of marine observation and data accumulation, the marine codes and formats have been changed several times. In order to make the correct interpretation of observational data contained in the long term archive, which were sensitive to the codes and formats used their exchange, it is valuable to make documentation relating to the marine codes and format easily available. As one of the tasks of JCOMM Expert Team on Marine Climatology, history of the marine ship code and format was made available on the web. The original documentation including all final reports of the sessions of WMO technical commissions such as CMM and CSM/CBS relating to the codes and formats was made available on the web, in addition. The task will be expanded to other marine codes such as those for buoy data and sub-surface profiles.

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

Theme 4: oral

Climate variability in statistical characteristics of surface wind waves from the VOS data

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We analyse changes in the statistical characteristics of ocean waves derived from the ICOADS collection of visual VOS observations for the period 1870-2002. Analysis is performed for the mean wave parameters (sea, swell, SWH heights and periods) as well as for the wave statistics, first of all extreme wave heights. For more than centennial period from 1870 onwards we analysed homogenized time series of SWH along the major ship routes in the World Ocean. We found positive trends in SWH over the North Pacific with a maximum of 8-10 cm/decade in the northeast Pacific. In the North Atlantic and other basins significant upward changes (up to 14 cm/decade) are observed only for the last five decades and not for centennial-scale records. Long-term tendencies in extreme SWH of 5% and 1% occurrences were quantified in the North Atlantic and North Pacific where they show secular changes. For the last 5 decades data allow for the separate analysis of characteristics of sea and swell. This analysis was performed in terms of linear trends and leading modes of interannual variability (EOFs) for the major wave statistics, including extreme seas and swells. On the basis of comparison with buoy and WAM data we quantified the uncertainties in estimation of interannual variability in wind wave characteristics. Finally we quantified the accuracy requirements for the development of the gridded products of long-term wind wave statistics.

Theme 4: oral

The WCRP strategic framework 2005-2015: Coordinated Observation and Prediction of the Earth System (COPES)

Peter Lemke (AWI), David Carson (WMO) and members of JSC for WCRP (presented by Sergey Gulev (IORAS))

COPES (Coordinated Observation and Prediction of the Earth System) is a strategic framework of WCRP launched in response to the present requirements of international climate research. Being tentatively planned for 2005-2015, COPES has the aim to facilitate analysis and prediction of Earth system variability and change for use in an increasing range of practical applications of direct relevance, benefit and value to society. COPES will provide the unifying context and agenda for the wide range of climate science coordinated by, and performed through, WCRP core projects (CLIVAR, GEWEX, CLIC, SPARC), and other activities, and for demonstrating their relevance to society. Specific, time-limited objectives will be identified and set annually by the Joint Scientific Committee (JSC) for the WCRP. An initial list of such topics, considered as first priority activities, includes: seasonal prediction, monsoons, and sea-level rise. The necessary activity to achieve these objectives will, in general, be performed through the continuing WCRP projects. In the talk the structure, goals, and basic organizations of COPES will be presented.

Theme 4: oral

Comparison of numerical climate model simulations with historical climate data

[1]Julie M. Jones, [2]I. Fischer-Bruns, [1]Hans von Storch, [3]Fidel Gonzalez-Rouco, [1]Eduardo Zorita, [1]Martin Widmann

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Quantitative estimates of natural climate variability are essential for assessing the human influence on climate. These estimates are derived from palaeoclimatic proxy data, such as tree rings and ice cores, historical and long instrumental data, and simulations using numerical climate models. Consistency tests between simulated and empirical climate estimates can reduce uncertainties, and contribute to the validation and improvement of climate models. Comparison of empirical and simulated climates can also be used to test climate hypotheses derived from both data types.

For example, an analysis has been undertaken of mid-latitude storm activity in simulations with the ECHO-G GCM: two historical multicentennial simulations, a control simulation, and three climate change simulations (Fischer-Bruns et al. 2005). In the climate change simulations there are parallel trends between the two variables. However, in contrast to what may be expected, during the pre-industrial period temperature and storm track activity are mostly decoupled. Marine historical data may allow investigation of these findings.

Fischer-Bruns, I., H. von Storch, J. F. González-Rouco and E. Zorita, 2005. Modelling the variability of midlatitude storm activity on decadal to century time scales. *Climate Dynamics*, accepted.

Theme 4: oral

Climate of the last two centuries: Constraints from the instrumental data and paleoproxies

A. Kaplan

Data collections of the International Comprehensive Ocean Atmosphere Data Set pushes compilations of marine observations from the ship reports back to pre-1800s. The 19th century exhibits dramatic changes in the marine data availability, from on the order of 1000 reports per year in the first two decades to a quarter of million reports per year at the close of the century. The reduced space objective analysis technique is used to reconstruct near-global fields of sea surface and air temperatures, sea level pressure, surface winds, humidity, and cloudiness with spatial resolution of 4 degrees and monthly temporal resolution for the 19th and 20th centuries. The quality of reconstructions changes significantly with the amount of available data. The reconstructions are compared with each other, with satellite-based data sets covering last one or two decades, with the climate variability inferred from land station measurements, and with historical chronologies of prominent climatic events, like El Nino. Instrumental reconstructions are intercompared with the networks of paleoclimatic proxies. Differences between the trends and dominant covariance patterns derived from the paleo and instrumental data for the 19th vs 20th centuries are discussed. Attempts are made to distinguish between secular changes in the data quality and changes in the variability patterns.

Theme 4: oral

INVITED PRESENTATION
The use of marine surface data in climate research

David E Parker (1)

(1) Met Office, Exeter, United Kingdom

We review the various uses of marine surface data in climate research. Key applications are in climate monitoring, empirical studies of ocean-atmosphere interaction, forcing of atmospheric general circulation models, boundary conditions for model-based reanalyses of the atmosphere, and validation of coupled atmosphere-ocean general circulation models.

Marine surface (and subsurface) data are vital for climate monitoring because the ocean covers about 70% of the globe and its thermal capacity vastly exceeds that of the atmosphere and the continental surface soil. In addition, marine surface temperature data provide an important cross-check on coastal and island surface air temperatures; trends in the past century are largely consistent and, where they diverge, can be explained either by known changes of mid-latitude atmospheric circulation or by non-standard instrumental exposure at tropical land stations before the mid-20th century.

Empirical studies of ocean-atmosphere interaction include estimates of air-sea fluxes, vital for the validation of coupled models and the diagnosis of interannual to multidecadal atmosphere-ocean interactions, feedbacks and fluctuations. These studies can in particular lead to more skilful prediction of phenomena such as the El Niño – Southern Oscillation, the North Atlantic Oscillation on interannual time-scales, as well as longer-term variations such as the Interdecadal Pacific Oscillation and the Atlantic Multidecadal Oscillation. For this, subsurface ocean data are also essential.

Atmospheric general circulation models constrained by historical sea surface temperatures and natural and anthropogenic forcings are a useful tool in climate change detection and attribution. Their simulated continental-scale land surface air temperatures have been used to validate the bias corrections applied to historical sea surface temperatures.

Model-based reanalyses of the atmosphere require geographically-complete, unbiased historical sea surface temperatures and observations of atmospheric pressure. Given adequate quality control and bias-adjustment, air temperatures, humidity and winds over the oceans can also greatly enhance these reanalyses. Hitherto, reanalyses have been limited to the past 60 years when radiosonde (and, later, satellite) data have been available, but the development of longer reanalyses, based solely on surface data, is presented elsewhere in this workshop. A future prospect is for joint atmosphere-ocean reanalyses, when subsurface ocean data have been sufficiently developed. These reanalyses will extend the current use of sea surface temperature in the validation of coupled atmosphere-ocean models.

Theme 4: oral

Atmospheric Reanalysis - A User and Provider of Marine Climate Data

Adrian Simmons
European Centre for Medium-Range Weather Forecasts

Atmospheric reanalysis is both a user and a provider of marine climate data. It is a user because it typically has a key requirement for separately produced analyses of sea-surface temperature and sea-ice distribution spanning the several past decades it covers. It processes past synoptic meteorological observations over the ocean surface, especially of pressure and wind. It may also make use of observations of ocean-wave conditions, and if coupled in the future with ocean analysis will become a user of sub-surface marine data. Atmospheric reanalysis is a provider because it produces a complete climatology of marine meteorological and ocean-wave conditions, and a comprehensive set of air-sea fluxes of momentum, latent and sensible heat, radiation and fresh water. These fluxes are needed to drive the ocean models used to simulate decadal variations and to produce ocean initial conditions for use in the development and calibration of monthly and seasonal forecasting systems. Atmospheric reanalysis also provides feedback on the quality of the marine observations it assimilates.

In this presentation, several examples will be drawn from the ERA-40 reanalysis for the period from September 1957 to August 2002 to illustrate the importance and use of marine data for reanalysis. Some of the problems experienced both in the use of data and in the quality of the products provided will be discussed. Recent progress in data assimilation and plans for future atmospheric reanalysis will be presented.

Theme 4: oral

Development of the Arctic Ocean statistical parameters describing variability of ice conditions

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Present report provides a review of the special features of the Arctic sea ice variability for the 20th century assessed on a basis of statistical analysis of historical sea ice charts. Spatial statistical analysis is based on information from the WMO project the "Global Digital Sea Ice Data Bank" (GDSIDB) for 1950-1998 period, while analysis of temporal variability is based both on GDSIDB data and sea ice index information for the Eurasian (from 1900s) and Canadian (from 1968) Arctic from the Russian and Canadian national ice services.

Analysis of relationship between statistics, assessed on a basis of GDSIDB data, and special features of ice conditions provides possibility to choose optimal statistical parameters for describing ice variability within certain areas of the Arctic Ocean in general and in time. It is shown that abnormal types of distribution functions like U, I, J-formed are predominant for sea ice total and partial concentrations and may be used for general classification schemes of sea ice conditions.

Estimation of sea ice temporal variability on a basis of GDSIDB data in a form of linear trend gives a typical picture of a negative trend from 1950 to ~2000; however transition to either sub-periods, or to space (individual seas and smaller areas) or to spectral transform gives a more sophisticated picture varying both in time, season and space. Typical features include alternation of -/+ signs of linear trend, heterogeneity and similar alternation for 10-60-years period oscillations' amplitude sign and phases. Analysis of sea ice index data shows that maximum decrease of ice extent evaluated in linear term was noted during the first part of XX century (1900-1945) for Eurasian sub-region including Greenland, Barents and Kara Seas, whereas for the second part of the century (1946-2003) magnitude of linear trend estimated for the same region is several times less. Level of significance for the linear trend for sub-region including Laptev, Eastern-Siberian and Chukcha Seas (1933-2003) is close to zero. Canadian Artic ice index (1968-2004) is in general characterized by a negative trend, however with 95% probability both negative and positive signs of the trend are quite possible. Wavelet analysis of the ice index data for Eurasian and Canadian Arctic reveal the similar superposition of quasi-periodical oscillations of about 10, 20 and 50-60 years. The greatest contribution to the variability of the Western sub-region of Eurasian Arctic is from the 50-60-years cycle. Its magnitude as well as the influence of the 20-years cycle diminishes while transiting to the Eastern sub-region of Eurasian Arctic or Canadian Arctic. A general conclusion may drawn that the cycles of about 10, 20 and 50-60 years were predominant in the long-term changes of the ice extent of the Eurasian Arctic and Canadian Arctic during the last century and occurred against the background negative linear trends with magnitudes different in space and time.

Theme 4: poster

The Evolution of British Navy Wind Force Terms and New Wind Speed Equivalents, 1691-1820

Michael Chenoweth

Wind force descriptors and equated wind speeds are examined using two independent records made in the late 18th and early 19th centuries. A comparison of these records with the modern Beaufort Wind Force Scale and its associated wind speeds indicates that estimated wind speeds are too high if the modern wind force descriptors are uncritically accepted in the older data. The evolution of wind force descriptors by the British Royal Navy from 1690-1820 reveals an almost constant evolution in the frequency and usage of individual descriptors. The mid-1750s mark the beginning of the evolution of wind force descriptors from the older usage into a newer "proto-Beaufort" wind force scale. The earlier usage was coarser than that of the early 19th century, due to both fewer commonly used terms and less frequent observations. The time for obsolete terms to vanish and to be replaced by new terms normally took place in two to three decades. New wind speed equivalents are produced for both ~1700 and ~1815. It is hypothesized that the evolution in the design of ships' sails and yards (as part of the design changes in ships as a whole) drove the changes in wind force descriptors because the ships became more sensitive "wind probes" and finer distinction could be made in lighter winds. The applicability of this study to objectively identify and classify historical tropical cyclones is described.

Theme 4: poster

The use of NOCS heat fluxes in a standalone climate ocean model

I Culverwell and H Banks
Hadley Centre for Climate Prediction and Research, Met Office, U.K.

The National Oceanography Centre, Southampton, (NOCS) have recently (2003) developed an ocean heat flux climatology which is globally, annually balanced to within $2W/m^2$. This climatology is based on the COADS dataset, corrected for biases in the ship reports. The resulting fluxes are variationally adjusted to improve their match to various hydrographic estimates of ocean heat transport. This poster describes the use of these fluxes in the standalone version of the NEMO ocean climate model, a tripolar ocean model developed at LODYC, Paris. It describes the preliminary results of driving a low resolution (2 degree) global model with the NOCS fluxes. It also compares these runs to those produced when the same ocean model is driven by surface fluxes from two other climatologies: an AGCM and NWP reanalyses. This comparison allows the accuracy of each climatology to be investigated, as well as providing an estimate of the sensitivity of ocean model integrations to the uncertainty in surface forcings.

Theme 4: poster

Initialising ocean currents for multi-annual climate forecasts

Stephen Cusack, Doug Smith and James Murphy
Hadley Centre for Climate Prediction and Research, Met Office, U.K.

The Hadley Centre has developed a system to forecast climate on annual to decadal timescales. This decadal climate prediction system has been designed to capture skill arising from both the initial conditions and boundary forcing of the climate system. The specification of the changes in the boundary forcing of the climate system is based upon techniques employed in models used for climate change studies. The specification of the initial conditions of the atmosphere are taken from analyses produced by ECMWF, whereas those for the ocean are created from measurements of temperature and salinity.

The initialisation process has been developed to use estimates of ocean currents, in addition to temperature and salinity. Such estimates are based upon analyses of ocean temperatures and salinity, together with satellite altimetry and atmospheric wind forcing datasets. A description of the method used to initialise ocean currents in climate forecasts will be presented.

Hindcast tests have been done to assess the impact of this development on forecast accuracy at lead times of up to 4 years. Such tests comprise forecast ensembles of seven members starting from 16 different start dates spanning 1994 to 2001. Results from these tests will be presented.

Theme 4: poster

Marine Climatological Summaries Scheme.

Elanor Gowland, Met Office

The Marine Climatological Summaries Scheme was proposed at the third session of the WMO Commission on Marine Meteorology (the fore-runner to JCOMM, the Joint IOC / WMO Commission for Oceanography and Marine Meteorology) in 1960, and adopted by the fourth congress in 1963. The objective was to establish a joint effort of all maritime nations in the preparation and publication of climatological statistics and charts for the oceans.

Summaries are prepared in both tabular and chart form, and normally include air and sea surface temperature, dew-point temperature, visibility, weather, wind direction and speed, atmospheric pressure, clouds and waves.

The publication Meteorology for Mariners includes the text:
"To this end certain member countries of the World Meteorological Organization have accepted responsibility for specific ocean areas. They have agreed to act as collecting centres for surface marine observations of all nations made within their areas from 1961 onwards and to prepare routine climatological summaries for a number of selected representative areas within their areas of responsibility. In this way the groundwork has been laid for the eventual preparation, when sufficient data have been accumulated, of a marine section of in the 'World Climatic Atlas,' planned by WMO. The area for which the United Kingdom has accepted responsibility is the North Atlantic north of 20º N and east of 50º W excluding the Mediterranean and Baltic Seas."

The JCOMM Expert Team on Marine Climatology is currently investigating the extent to which the MCSS charts are produced and used throughout the world. I propose this meeting looks at the usefulness of these charts, compared to other similar gridded data sets that are currently produced, and provides feedback to the ETMC on the production of these charts (should they be provided, could they be adapted, etc).

Theme 4: poster

Long-term variation of winter SST field in the Northern Hemisphere

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2. Department of Marine Science and Technology, Tokai University, Shizuoka, Japan

Using ship observation data archived in the COADS and the Kobe Collection, we investigate long-term variation of winter SST field in the Northern Hemisphere, with special reference to multidecadal time scale. After so-called Bucket Correction, winter (January through March) means of SST are calculated on the 4° (latitude) × 10° (longitude) box for the period of 86 years from 1912 through 1997.

An empirical orthogonal function (EOF) analysis is applied to the detrended SST anomaly fields in both the North Atlantic and the North Pacific. It is found that the 60-to-80-year variations exit in both the oceans as Mode 1 in the North Atlantic and Mode 3 in the North Pacific. The spatial distributions show that one polarity covers most of the North Atlantic, but does the central part of the North Pacific surrounding by the opposite polarity. These variations in both oceans temporally correlate well. That is, both time series take the maximum in the mid 1940s and the minimums in the early 1910s and 1970s. Further, from the early 1990s, both time series are in increasing trends. It is also found that these detected long-term variations well resemble the Atlantic Multidecadal Oscillation (AMO) in both spatial and temporal characteristics. That is, SST variation with the time scale of 60 to 80 years is considered to be the phenomenon having the hemispheric scale in space.

Theme 4: poster

The sea ice component of the coupled climate model HadGEM1

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HadGEM1 is a new coupled climate model developed at the Met Office's Hadley Centre. The sea ice model used in HadGEM1 is more sophisticated than that used in our previous climate model (HadCM3). We describe the improvements to the sea ice sub-model and evaluate the simulation of the mean sea ice state and variability against observational gridded datasets.

The geographical ice extent generally agrees well with observations, especially in winter, with the exception of the model winter ice being more extensive in the North Pacific. The seasonal cycle of total ice area in both hemispheres is in reasonable agreement with observations in phase and amplitude but always somewhat too large. The distribution of ice depth in the Arctic compares well with observations, with the deepest ice banked up against the north Greenland coast and the Canadian Archipelago. The ice circulation patterns are well captured in the model, but the model ice speeds are faster than observations suggest. Winter ice concentration in the Northern Hemisphere displays a realistic response to forcing from the North Atlantic Oscillation.

Theme 4: poster

The SST Long-Term Trend Features In North Atlantic Currents

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New numerical iterative procedure was developed to approximate and smooth climate temperature series. The advantages of this non-linear approach with respect to traditional techniques (linear, polynomial trends or moving average) are flexibility in description of low and medium-range oscillations and insensitivity to outliers. It was found that the SST trends for sites located along Gulf Stream (GS) have a common feature in the second half of last century: a decreasing branch in the forties and fifties, which transit to an increasing tendency since the sixties or seventies. SST minimum attained in late fifties is attributed to the GS part close to Eastern US coast. SST trend in Caribbean GS South branch has minimum in early sixties. In midst of North Atlantic, near to Azores, SST minimum position was moved to the late sixties. When GS reaches Western Europe coast SST minimum is shifted to the middle of seventies. Therefore, it was revealed that the SST non-linear trend phase moves along GS path. Similar results were obtained for cold Labrador currents and outflows from Arctic Mediterranean (AM, comprises Arctic Ocean and Nordic Seas). But, in contrast to above the outflow SST minimums are reached in time interval between late eighties and middle nineties. This phase delay with account to GS trends may be explained by observed reduction in Atlantic water northward inflow in AM started in sixties and partly recovered only in early nineties (Hansen and Osterhus, 2001). Re-circulation mechanism in AM, which feed a southward outflow to North Atlantic, and regulates heat accumulation and storage in Arctic Ocean, is other reason to explain above feature. Moreover, re-circulation weakening and Atlantic inflow strengthening in eighties and nineties were among possible factors of rapid warming in Arctic. Above features can also explain considerable phase delay in SST trend for southward outflow sites with account to GS trend phases.