The VOS Climate Project

UK Met. Office

Introduction

Final preparations for the Voluntary Observing Ships (VOS) Climate Project are now complete, and initial recruitment of participating ships has begun.
The following article provides an overview of the objectives of the project, its status, and how it is intended to operate.

Background

The project is a natural extension of the earlier Voluntary Special Observing Programme for the North Atlantic (VSOP –NA)[1], which demonstrated that the quality of observed measurements depends significantly upon the types of instruments used, their exposures, and the observing practices of shipboard personnel. It made a number of substantive recommendations in these areas aimed at providing ship observations of a quality appropriate to global climate studies.

Objectives

Whilst VOS observations continue to be an essential ingredient for numerical weather prediction, there is a growing need for higher quality data from the observing fleet. Specifically, recent trends, such as the increasing availability of data from satellite sensors and the increased concern with regard to climate analysis and prediction, are making further demands on the quality of ship observations.

The project aims to provide a high-quality subset of marine meteorological data, available in both real time and in delayed mode, which can be used for:

·Satellite ground truth verification

An important role for accurate VOS data is the detection of biases in remotely sensed satellite data due to instrument calibration changes or changing atmospheric transmission conditions. Ship and buoy observations can, for example, be used to detect and correct biases in satellite data caused by varying atmospheric aerosol loading due to volcanic eruptions. Without such real time bias corrections, errors can occur in satellite-derived data. Consequently, for satellite verification purposes, there is an established need for a dataset of accurate ship observations with known error characteristics.

Climate Change Studies

Data from observing ships are increasingly being used for climate change studies, e.g., to quantify global changes of sea-surface and marine air temperature. However, the detection of climate trends is only practicable if, as far as is possible, observational biases owing to the changing methods of observation are corrected. Sea temperature data, for example, have different bias errors, depending on whether temperatures were obtained using wooden, rubber or canvas buckets, or using engine room intake thermometers. It is therefore important to clearly document the observing practices that are being used on board ships.

Climate Research and Climate Prediction

Increasingly, coupled numerical models of the atmosphere and ocean are being used for climate research and climate change prediction. The simulated air-sea fluxes of heat, water and momentum must therefore be shown to be realistic if there is to be confidence in model predictions. Accordingly, model predictions of near surface meteorological variables (air temperature, humidity, sea-surface temperature (SST), etc.) need to be verified against high-quality in situ observations from buoys and specially selected voluntary observing ships.

In addition to the above, the project will provide a reference data set that can be used to assess

the quality of data received from the rest of the voluntary observing fleet.

Ship selection and recruitment

Ship recruitment is a critical component of the project, and it is hoped that the ships selected will provide more or less global coverage in both space and time. To this end, ships which make frequent and regular ocean crossings, as well as ships sailing in the southern ocean, Antarctic supply vessels and research ships, have been identified as potential recruits. Where feasible it has also been decided that ships engaged in the Ship of Opportunity Programme and the Automated Shipboard Aerological Programme should be recruited.

A relatively small target of ~200 ships has been set for recruitment to the project, and provisional lists of participating ships have been prepared by Australia, Canada, France, Germany, India, Japan, Poland, UK and USA. Several other countries are also potential project participants, and it is anticipated that the target number of ships should be achieved.

The UK is aiming to recruit approximately 30 observing ships to the project, with emphasis being given to those ships which routinely return to the UK, have a good observing record, and are preferably fitted with hull sensors and the Royal Netherlands Meteorological Institute's TurboWin software. The selected vessels will be drawn from those operating

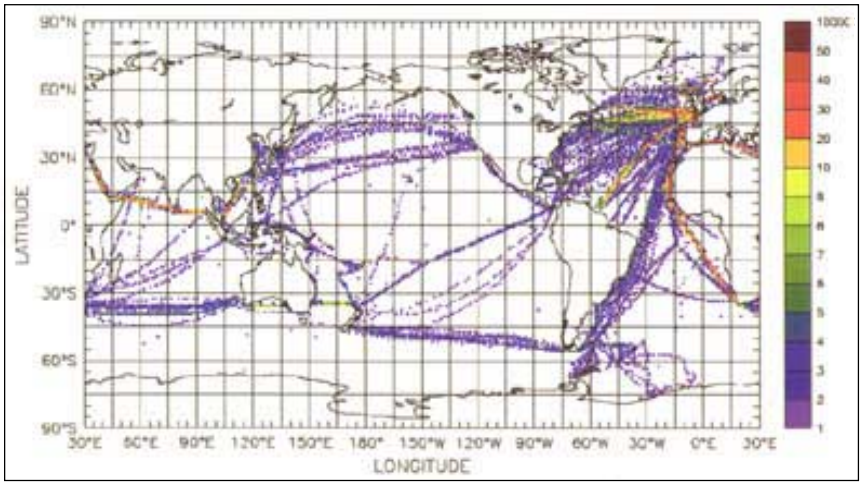

Figure 1 - Extent of coverage anticipated from UK voluntary observing ships participating in the VOS Climate Project. (Courtesy of Southampton Oceanography Centre.)

both on world-wide and near continental voyages and will include some research vessels providing observations in data sparse areas. Figure 1 shows the extent of coverage expected from UK voluntary observing ships, whilst Figure 2 indicates the projected global coverage.

These preliminary maps showing the potential route coverage of the proposed project ships have been prepared by Southampton Oceanography Centre, who have been actively involved in setting up the project. Such maps will assist in planning national recruitment and will also allow the selective targeting of obvious data sparse areas as recruitment proceeds.

Data Assembly Centre

Data collected during the project will undergo quality control (QC) and be archived by a Data Assembly Centre (DAC). The National Climatic Data Center, NOAA, USA, has agreed to perform this role which requires them to merge the real-time observation reports with the delayed mode reports, eliminate any duplicates, and compile a complete project data set which will be available to users.

The DAC will also create and maintain a relational database so that the information on instrument types, exposure and observing practice can be automatically associated with each observation. The database will also be freely accessible to registered users.

Real Time Monitoring Centre

The project will require real time monitoring of the observational data and comparison with model fields. To this end, the Met Office (which already undertakes such monitoring of ship observations on a routine basis), has agreed to act

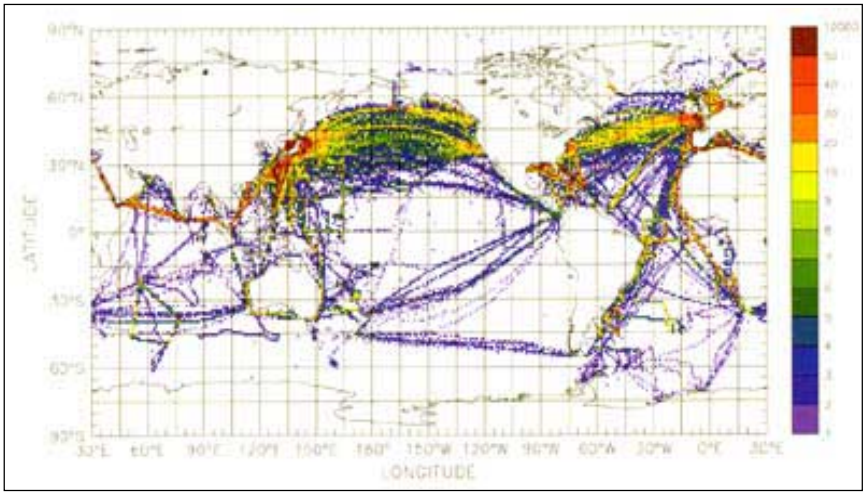

Figure 2 – Project global coverage of ships taking part in the VOS Climate Project [(drawn from raw reports from the Global Telecommunication System (GTS) using data from November 1999 to October 2000), downloaded from http://www.cdc.noaa.gov/ncep_obs/]

as Real Time Monitoring Centre (RTMC) for the project.

Priority will be given to the following six parameters: wind direction and speed; sea level pressure; sea-surface temperature; air temperature; and humidity. The Met Office will monitor these variables for all project ships and forward the resultant statistics to the DAC for inclusion on a dedicated project Web site.

Statistics on the 'fit 'of the observed variables to the numerical weather prediction Global Model's background forecasts will be used to produce lists of 'suspect' ships, i.e., ships will be flagged as suspect if the mean and standard deviations of their observation-minus-background (o-b) values meet certain agreed criteria. Lists of flagged ships will be forwarded by the RTMC to the DAC each month, and to participating countries on a weekly and monthly basis. As ships'call signs are subject to change when there are changes in registry, it will be necessary for the RTMC to regularly check call signs to ensure the correct ships are being monitored.

Any project ships identified as having submitted suspect observations will be followed up by the Port Met. Officer networks as quickly as possible, and the results of any corrective action taken thereafter notified to the DAC.

In addition to the monitoring function, the RTMC will extract the six observed variables for each project ship received in real time from the Global Telecommunication System (GTS) and associate them with the co-located model field values. The resultant data sets will then be transferred on a regular basis to the Data Assembly Centre.

Instruments

Although relevant, the quality of ships observing instruments has less effect upon the quality of data than their use and exposure. It will therefore be essential for the project to ensure that observing instruments, their physical exposure, and the associated observing practices confirm to high standards and that up-to-date instrument records are maintained and catalogued.

Ideally, it is recommended that ships taking part in the project should have the following instrumentation and facilities:

- Accurate and well-exposed thermometers with precision to 0.1 °C;
- Sea surface temperature measuring instruments from hull contact sensors;
- Permanently-mounted, well-exposed anemometers to 0.1 m s $^{-1}$ precision;
- Precision marine barometers to 0.1 hPa precision, preferably connected to a static head; and
- Electronic logbook facility, to include true wind computation, QC checks and updated encoding in the revised code forms required by the project.

It is recognized, however, that common instrumentation is unlikely to be achieved. For instance, UK observing ships traditionally

estimate the wind speed and direction from the sea state and are not provided with calibrated anemometers.

Regular checks upon the serviceability and calibration of instruments by Port Met. Officers will be essential to the project, e.g., calibration of temperature sensors can be performed using a water bath, and it is possible to calibrate some types of wind speed sensor by mechanically rotating the propeller.

Inter-comparison of instruments is a difficult and time-consuming task; it is possible to compare typical samples of each type or source of manufacture, but often variations between members of the same type are greater than between different instruments. This problem will be addressed by inter-comparison of the observations of the VOS climate subset with large-scale model fields, or with neighbouring ships at sea. At a later stage in the project development, it is expected that consideration will be given to enhancing or upgrading participating ship instrumentation as necessary, in line with VSOP –NA recommendations.

Metadata

To achieve the accuracy required by the project, it will be essential to have comprehensive information about the type and location of meteorological instruments. This will include information of the date of any changes to instruments and details of their exposures supported by digital imagery. Details of such 'metadata ' will be stored in a master index of ships which will be developed as a supplement to, but separate from, the main WMO ship catalogue (International List of Voluntary Observing Ships WMO –No.47.) The catalogue will be continuously updated and made available through the Data Assembly Centre. It will contain details of the instrument locations for each ship in an agreed format, together with details of the results of inspections performed by Port Met. Officers.

Port Met. Officer involvement

The Port Met. Officer networks of participating countries will be essential for the project's success, as close liaison with ships' masters, observing officers and ship owners will be needed. PMOs will, in the first instance, visit individual ships to explain the project to observers and to assess their likely commitment to the project. They will also record details of the exposure of the observing instruments, noting any permanent structural features which might affect the observation, e.g., water outfalls, airflow obstructions, air-conditioning vents, etc., and the relevant ship specifications. In addition to detailed written descriptions, the location of instruments will be marked on simple arrangement drawings and supported by photographs in digital format.

Final selection of ships will take note of existing instrumentation and exposure, past performance, and the general impression gained by the Port Met. Officers. Difficulties may arise where a ship is well equipped for one parameter but not another, e.g., no anemometer, but mounting a hull sensor for sea-surface temperature. The value of the ship's contribution will be assessed in terms of the importance of the parameters which are acceptable.

The information obtained by PMOs for selected ships will be forwarded to the Data Assembly Centre for compilation of the metadata catalogue. PMOs will also explain the use of new coding requirements and new logbooks (electronic or hard copy) being developed for the project. Later visits will be needed to check that instrument exposure has not changed and to discuss any problems with observers. These observer 'contact'visits will be extremely important in maintaining the interest of the observers and the impetus of the project.

Ship survey and inspection forms

Special ship recruitment and inspection report forms are being designed for the project and will be made available in French, Russian and Spanish versions. The forms, together with associated instructions, will be downloadable from the new project Web site and will be suitable for use in both hard copy and electronic format.

Immediately following recruitment to the project, Port Met. Officers will complete the initial ship survey report form. Each recruiting country's PMOs will conduct

follow-up ship inspection visits when project ships are visiting their home ports, as far as possible on a quarterly basis (the current UK practice). Some ships not on regular trades may also need to be inspected by their participating (i.e. non-recruiting) countries, and care will be needed to ensure there is no duplication of inspections. In order to establish a complete metadata and inspection history for each ship, the completed inspection reports will be submitted to the DAC via e-mail.

Observation codes

To ensure that the project provides timely and complete information and that no reports from participating ships are lost, data will be submitted in both real time and delayed mode. Although real time observations will continue to be transmitted in the Ships' International Meteorological Code (FM13 –XI), the delayed mode observations will be augmented by additional code groups. These extra codes are essential to the success of the project and comprise details specific to each ship. (Refer to Ship Parameters chart).

Originally, the intention had been to require these additional code groups in both real time and delayed mode. However, proposals to modify the ship code were not supported by WMO because of their long-term ambition to phase out the use of such alphanumeric codes in favour of new table-driven codes (e.g. BUFR[2] and CREX[3] codes).

Recognizing that it would be impractical to re-train observers to use complex new code forms in time for the start of the project, it was decided that the additional code groups were not absolutely essential in real time, provided that the expected delay in the non-real time data delivery did not exceed 6 –12 months.

To enable the international exchange of the extended observation reports in delayed mode, a revised version of the International Maritime Meteorological Tape Code (IMMT) has also been developed for the project.

Paper and electronic logbooks

Observations will be recorded for delayed mode submission using either hard copy or electronic logbooks. In order to collect and process the additional delayed mode observation data in hard copy format it will be necessary to either implement new logbooks (or logsheets), or to modify existing ones. Similarly, new versions of electronic logbook software programs (e.g. TurboWin, SEAS 2000 etc.) are being developed to incorporate the additional delayed mode data. The logbooks (or logsheets) will need to be collected on a regular basis by Port Met.Officers, who will also download the electronic log files.

The use of software programs such as TurboWin will greatly simplify the collection of delayed mode data required by the project, as they will electronically record the observations in the revised IMMT format at source. This avoids the need for observations to be manually digitised following receipt at participating national meteorological services, which is presently the case for paper logbooks. For that reason, it is hoped to equip the majority of UK ships participating in the project with such software, either loaded into dedicated 'notebook' computers or, if acceptable, loaded into one of the ships' computers.

Data Transmission

Observational and instrumentation data submitted by project ships will be subjected to various procedures and relayed via a number of centres before it eventually reaches the Data Assembly Center. A simplified flow diagram

Ship parameters		
Code 1	**ss**	Instantaneous ship's speed in knots at time of observation
Code 2	**DD**	Ship's heading in tens of degrees true
Code 3	**LL**	Maximum height in metres of deck cargo above summer maximum load line
Code 4	**hh**	Departure of summer maximum load line from actual sea level (m)
Wind		
Code 5	**ff**	Relative speed in knots or m s^{-1} (in conformity with wind code indicator)
Code 6	**DD**	Relative wind direction in tens of degrees (00 to 36) off the bow.

showing the data will be routed is given in Figure 3.

The national meteorological services participating in the project will apply minimum QC procedures to the digitised observations in the revised IMMT format. The digital data sets will then be forwarded to the two Global Collecting Centres (GCCs) for the WMO Marine Climatological Summaries Scheme (located in Hamburg in Germany and in Bracknell in the UK). The GCCs will thereafter apply their normal QC and related procedures and forward the data to the Data Assembly Centre in IMMT format (using an appropriate medium, or via the Internet) with a minimum delay.

The Met Office, in its capacity as the RTMC, will also transfer datasets of the real time reports and associated model field values to the Data Assembly Centre. As this data will be transmitted in BUFR code (which is now regarded as the preferred standard for the international distribution of weather data) decoding software will be needed in order that the DAC can merge the received real time and delayed mode reports and compile a complete project data set.

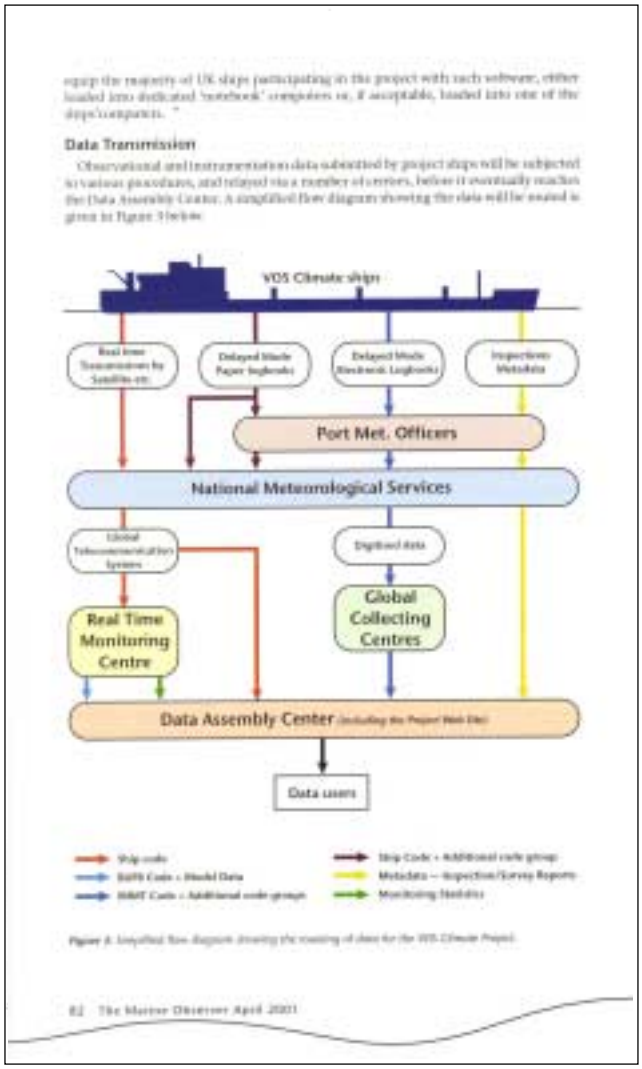

Figure 3 - Simplified flow diagram showing the routeing of data for the VOS Climate Project.

Project promotion literature and logo

Draft literature to promote the project, and an associated logo for the project have been developed. The logo will, in due course, appear on a plaque that will be presented to participating ships. The promotional literature will include a small explanatory brochure that will be made available to participating shipping companies and officers, and will be available in multi-lingual format. As the project unfolds, observers will inevitably have questions about why the additional observations are needed and about how they will be used. The brochure will therefore address these points, and a copy of the brochure is included at the end of this article.

Project Web Site

The primary means of information exchange for the project will be via a dedicated Web site which will be both developed and maintained by the DAC, with contribu-

tions to be made by both participants and users. Information to be made available through the Web site will include:

- metadata catalogue of participating ships;
- regular project update reports;
- monitoring and data application results;
- project newsletter for participating ships;
- data catalogues;
- links to other relevant Web sites;
- project focal points and other relevant contact details;
- the project document and other publications; and
- any other information relevant to the project.

Access to the ship metadata catalogue will be via the ship name, call sign or IMO number, which will then allow selection of any required subsets of ships' instruments, etc. This catalogue will also allow access to ship status reports, with links to the observational data and monitoring reports.

The project data (observations, metadata, real time monitoring data and the additional observational data) will also have a direct access through the Web site for ftp download. Similarly, ship survey and inspection forms (including instructions for their completion) will be available from the Web site for download. Some password protection to guard against abuse and to safeguard potentially sensitive information is anticipated.

Project newsletter

A project newsletter is also considered to be an essential component of the project, providing a means of informing and communicating with participating ships as well as among meteorological services, data centres, users and other participants. It is hoped that it will help to maintain interest and enthusiasm among observers, regularly informing them of the status of the project in general, and of their own specific contributions.

The newsletter will contain information, reports and statistics on participating ships together with information drawn from all participants, including the Port Met. Officers, participating ship operators, the RTMC, the DAC and the ships' crews themselves whenever possible. It will be issued biannually and edited by the WMO Secretariat. It will be made available on the project Web site in a suitable format to allow downloading by participating operators for printing and distribution to ships.

The future benefits

The potential benefits of the project are clear. For the shipping industry, it will encourage the development of new marine meteorological systems, which will result in improved marine weather forecasts and real time weather information for operational purposes. Moreover, the improved quality of ship observational data will help us to better understand the large-scale weather changes associated with climate change.

The success of this ambitious project will therefore depend upon the close involvement and co-operation of the national meteorological services, the Port Met. Officer networks and, of course, the ships' voluntary observers. It will require careful management if it is to achieve the aim of developing into a long-term, operational programme. ⚓

References

Voluntary Observing Ships (VOS) Climate Subset Project (VOSCLIM)Project Document. JCOMM Technical Report No 5 – WMO/TD No.1010
Final report of the VOS Climate Project. .Second Project Meeting, Asheville N.C.,USA,30 October-1 November 2000
[1] See *The Mariner Observer,* January 1992, 24
[2] Binary Universal Form for the Representation of meteor logical data (FM94 –XI Ext.BUFR)
[3] Character form for the Representation and EXchange of data (FM95 –XI Ext.CREX.

Editors Note:

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VOS Climate (VOSClim) Project

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World Meteorological Organization

Why do we want the VOS Climate (VOSClim) Project?

The main purpose of the Voluntary Observing Ship (VOS) Climate (VOSClim) Project is to provide a high quality set of marine meteorological observations and detailed information on how the data were obtained. Such observations are of great value to operational marine forecasting. Furthermore, climate studies rely on the increased accuracy of good observations. Improved climate models, better ground truth for checking satellite observations, and a more accurate high-quality marine dataset, will be possible with the cooperation of international ship participants.

For the VOSClim Project we are asking port meteorological officers to collect extra information about the selected VOS. Why do we want that information? What will it be used for? Here are answers to some of the questions you may have.

Q: *As a ship's officer how will it change the way I take observations?*

A: Hardly at all. If you use an electronic logbook or coding system (e.g. "Turbowin") you will be issued with an upgraded version; if you fill in logbooks you will be asked to report the relative wind speed, direction and ship's speed and head at the time of the observation. In return, you will benefit from enhanced support from the port meteorological officers and you will be able to learn more about the various ways in which your observations are used.

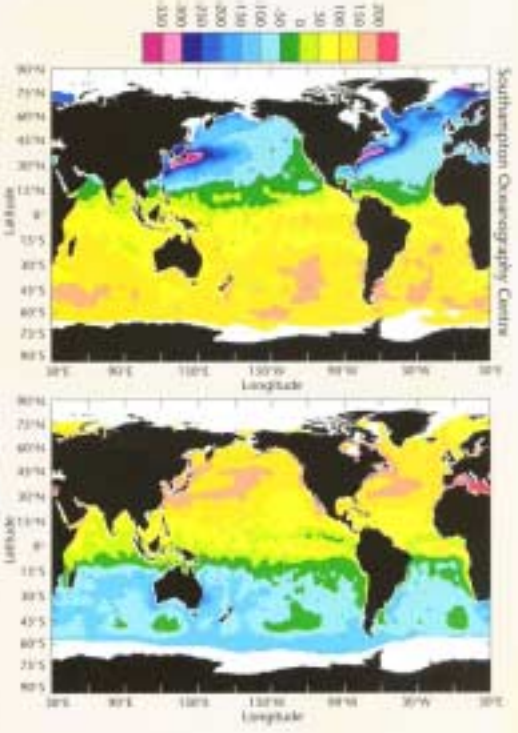
Q: *What do you mean when you say the ships observations will be used to study the climate?*

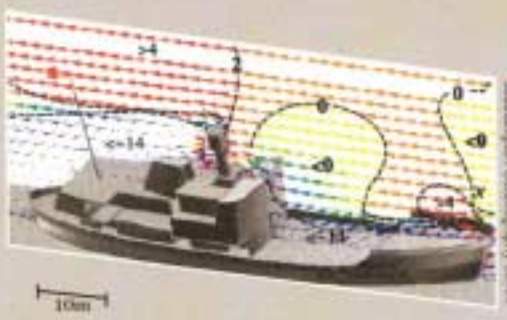
A: The map on the right shows the transfer of heat between the ocean and the atmosphere for an average month of January.

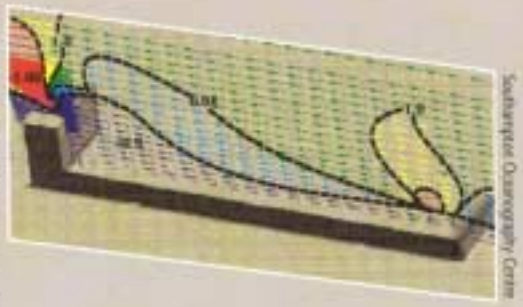
In the northern hemisphere it is winter and the blue colours (top map) show that the ocean is loosing large amounts of heat to the atmosphere — especially over the Gulf Stream and the Kuroshio.

The bottom map is for the month of July. Now the northern hemisphere oceans are being warmed and the cooling is occurring in the southern oceans where the sea ice has spread out from Antarctica.

We could only draw these maps because of the millions of observations which have been taken by merchant ships in the past. Nowadays we obtain information from satellites and computer models, but ship data are as important as ever. In fact we need really good ship observations to check the models and calibrate the satellites. That is the aim of the VOSClim Project. Better observations really will make a difference!







Q: *Why do you want to know the dimensions of the ship and the position of the anemometer?*

A: The ship disturbs the airflow. The anemometer will not measure the true value that the wind would have if the ship were not there. Using computer models we can calculate the flow around the ships and find out how big this error is. Or we can place a model of the ship in a wind tunnel and measure the error for different wind directions.

The plot below is for an anemometer on the port yardarm of the main mast of the ship in the computer model. The winds are speeded up over the wheelhouse except when the wind is from astern (or from the starboard beam when the anemometer is in the wake of the mast).

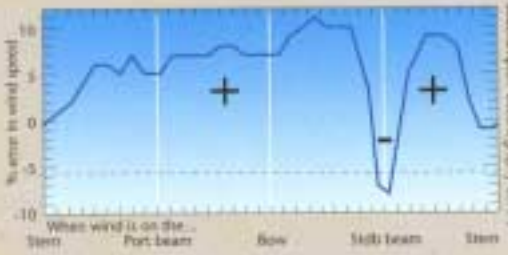
The example above is taken from a research ship which has been used for special experiments. We cannot hope to study each VOSClim ship in great detail but if we know the main dimensions of the ship we can use simple models, like the "tanker" beside it, to estimate how much the wind speed is likely to change for a typical anemometer position on a merchant ship.

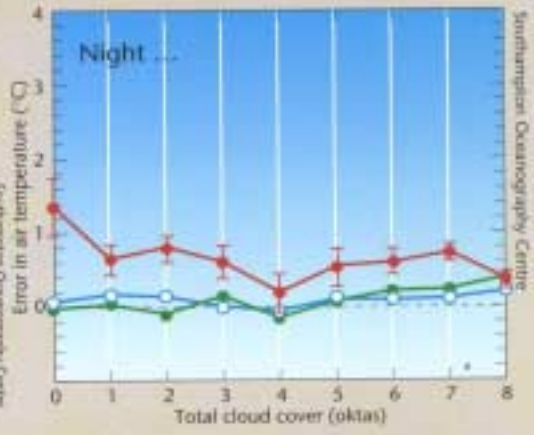
This is the airflow over a very simplified model of a tanker or bulk ore carrier. It was generated from a computer model. Among other factors, the airflow over the wheelhouse depends on the distance between the main deck and the wheelhouse top — one of the dimensions that you are being asked to specify for the VOSClim Project.

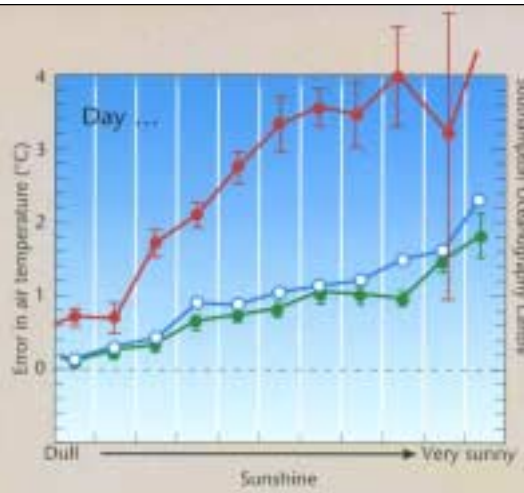
Q: *Why do you want to know the type of instrument used to measure air temperature and where it is situated?*

A: Let us taken an example. The graph below shows the average error in air temperature measurement for thermometer screens on different ships. The different lines show how well the screen was situated (green = good, blue = moderate, red = bad).

At night, the badly exposed screens were, on average, half to one degree too warm. The other screens gave good readings. Now look what happened during the day (above right). In sunny conditions, all the screens tend to







read too warm. For screens with good or moderate exposure, the over-heating is reasonably uniform and we can devise a correction. The screens with bad exposure read much too high — several degrees — and there are big differences between different screens. We cannot correct these errors but it is important that we know about them.

Q: *Why is it important to know the method of sea surface temperature determination?*

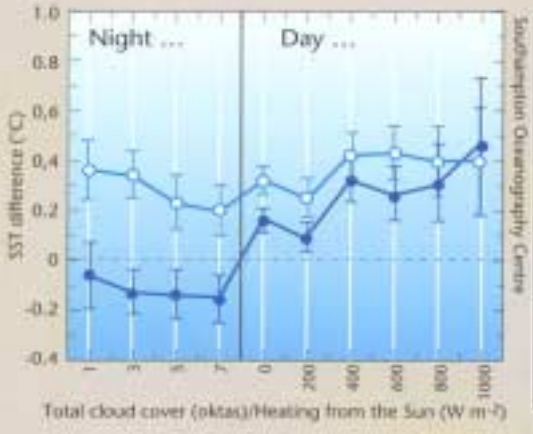
A: The value of the sea surface temperature (SST) depends to some extent on how it is measured. An increasing number of ships are being fitted with thermometers that are fastened to the inside skin of the hull (called hull contact sensors). Provided that they are kept in calibration, we believe that these instruments give the most accurate SST values. The plot (below left) shows the average difference between SST values from engine room intake (ERI) thermometers and those from hull contact sensors (light blue line).

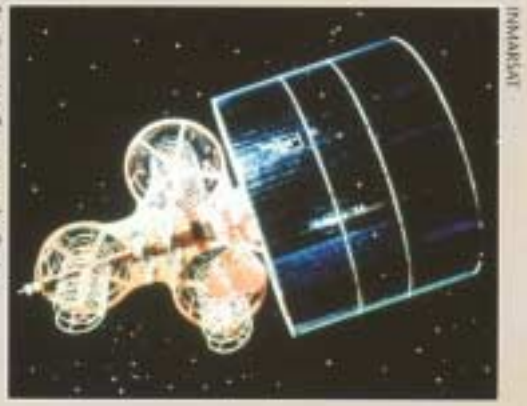
For both day and night, the ERI values are warmer by about 0.3 to 0.4°C. Bucket readings are close to, or slightly colder than, the hull contact readings at night. However during daytime, the bucket readings tend to become warmer if the Sun is shining.

Q: *But what about satellites. Nowadays don't they tell you everything you need to know?*

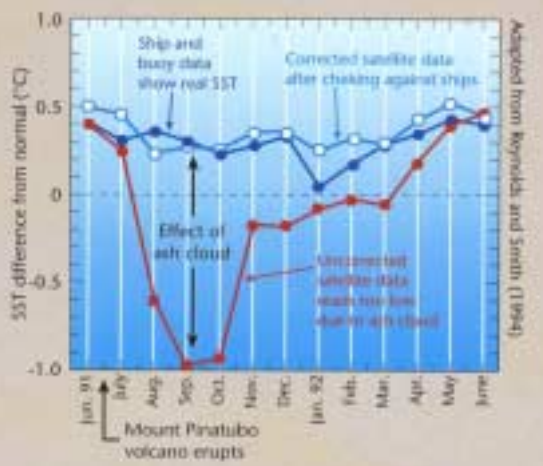
A: NO! For example, for about 20 years satellite data have been used to determine the SST over the globe, but when the Mount Pinatubo volcano erupted in June 1991 large quantities of ash were thrown high into the atmosphere. This ash cloud circled the tropics and caused the satellite sensors to report that the tropical SST was suddenly about 1°C colder than usual but the ships and buoys showed that really the SST was about 0.5°C warmer than usual! The graph (next page, above right) shows that it took a whole year for the satellite readings to return to the correct value. So satellite data are always checked against ship and drifting buoy data and corrected, as necessary, before they are used.

There are other problems with satellite data. Satellites may not measure storm force winds correctly. Some instruments cannot see through clouds or do not provide values close to the sea surface.





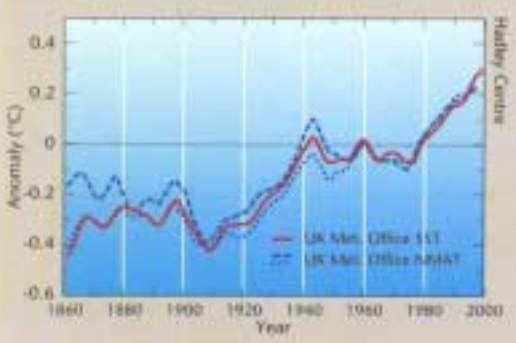
Mount Pinatubo erupts



Despite all the advances made in space technology, we still need good data from merchant ships!

Q: But *how much does it all really matter?*

A: Very much! As an example, the graph below shows the changes in global SST and night-time marine air temperature (NMAT) since 1860. Compared to the period between 1960 to 1990, in earlier years both the air and the sea were colder by a few tenths degree centigrade. In more recent years, warmer air and sea temperatures have been observed. These changes, detected in the weather reports from VOS, suggest that rapid global warming is occurring perhaps due to changes in the atmosphere caused by man. As a result, many countries have agreed to limit the release of gases like carbon dioxide into the atmosphere. Some countries have taken measures which have a direct impact on the everyday lives of their citizens — taxes on power consumption for example. In other countries, there remain doubts as to the degree of warming. After all, the changes are relatively small and the graph could only be plotted after making significant corrections to the data. To really understand these changes, it is important that, in the future, we obtain data of the highest accuracy — the VOSClim Project will help in this.



Remember, if the predictions are correct, rising sea level could be catastrophic for some island States. Storms of increasing frequency and strength would be associated with high winds and more frequent damaging floods. Your observations will help us tell to what extent this is already happening. In fact, we urgently need to understand the climate better. We need high quality data. We are asking you to help!

Q: *I have been making marine weather observations for many years. Why are they particularly important now?*

A: We have described how the marine weather observations from the past are providing vital information on the world's climate and have highlighted the present increases in global temperatures. With improving understanding of the weather, more data from satellites, and improved computer models to help in weather

Drought Monitoring Centre (DMC), Nairobi

forecasting, there is now an emphasis on obtaining ever higher quality measurements over the ocean. The ships in the VOSClim Project have been chosen as the ships which we believe can provide the high quality reports which we need.

Q: *Will the way we make weather observations change in the future?*

A: Better instrumentation has already been successfully tested on research ships and prototype systems are being installed on a few VOS. But these instruments are very expensive. Once the VOSClim Project has demonstrated the value of a chosen high quality subset of the VOS, the possibility of equipping them with advanced instrumentation will be much higher.

Q: *So are there any direct benefits to the shipping industry?*

A: The VOSClim Project will help in the development of future marine meteorological systems which are expected not only to produce better marine weather forecasts, but also to give ships much more comprehensive real-time weather information for operational purposes. By participating in the VOSClim Project, the shipping industry will also be helping mankind face one of its greatest challenges — the large-scale weather changes associated with changing climate.

Meteorological instrument on research ship

Brian Pascal/Southampton Oceanography Centre

For more information:
Please ask your port meteorological officer
or
visit the VOSClim Web site at
http://www.ncdc.noaa.gov/VOSClim.html.