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Reports of Meetings of Experts and Equivalent Bodies

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In this Series, entitled

Reports of Meetings of Experts and Equivalent Bodies, which was initiated in 1984 and which is published in English only, unless otherwise specified, the reports of the following meetings have already been issued:

1. Third Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans
2. Fourth Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans
3. Fourth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño' *(Also printed in Spanish)*
4. First Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources
5. First Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources
6. First Session of the Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
7. First Session of the Joint CCOP(SOPAC)-IOC Working Group on South Pacific Tectonics and Resources
8. First Session of the IODE Group of Experts on Marine Information Management
9. Tenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies in East Asian Tectonics and Resources
10. Sixth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
11. First Session of the IOC Consultative Group on Ocean Mapping ***(Also printed in French and Spanish)***
12. Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ships-of-Opportunity Programmes
13. Second Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
14. Third Session of the Group of Experts on Format Development
15. Eleventh Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
16. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
17. Seventh Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
18. Second Session of the IOC Group of Experts on Effects of Pollutants
19. Primera Reunión del Comité Editorial de la COI para la Carta Batimétrica Internacional del Mar Caribe y Parte del Océano Pacifico frente a Centroamérica ***(Spanish only)***
20. Third Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
21. Twelfth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
22. Second Session of the IODE Group of Experts on Marine Information Management
23. First Session of the IOC Group of Experts on Marine Geology and Geophysics in the Western Pacific
24. Second Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources ***(Also printed in French and Spanish)***
25. Third Session of the IOC Group of Experts on Effects of Pollutants
26. Eighth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
27. Eleventh Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans ***(Also printed in French)***
28. Second Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources
29. First Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
30. First Session of the IOCARIBE Group of Experts on Recruitment in Tropical Coastal Demersal Communities ***(Also printed in Spanish)***
31. Second IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
32. Thirteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asia Tectonics and Resources
33. Second Session of the IOC Task Team on the Global Sea-Level Observing System
34. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
35. Fourth Session of the IOC-UNEP-IMO Group of Experts on Effects of Pollutants
36. First Consultative Meeting on RNODCs and Climate Data Services
37. Second Joint IOC-WMO Meeting of Experts on IGOSS-IODE Data Flow
38. Fourth Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
39. Fourth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
40. Fourteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asian Tectonics and Resources
41. Third Session of the IOC Consultative Group on Ocean Mapping
42. Sixth Session of the Joint IOC-WMO-CCPS Working Group on the Investigations of 'El Niño' ***(Also printed in Spanish)***
43. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
44. Third Session of the IOC-UN(OALOS) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources
45. Ninth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
46. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico
47. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
48. Twelfth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans
49. Fifteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asian Tectonics and Resources
50. Third Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
51. First Session of the IOC Group of Experts on the Global Sea-Level Observing System
52. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean
53. First Session of the IOC Editorial Board for the International Chart of the Central Eastern Atlantic ***(Also printed in French)***
54. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico ***(Also printed in Spanish)***
55. Fifth Session of the IOC-UNEP-IMO Group of Experts on Effects of Pollutants
56. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
57. First Meeting of the IOC ***ad hoc*** Group of Experts on Ocean Mapping in the WESTPAC Area
58. Fourth Session of the IOC Consultative Group on Ocean Mapping
59. Second Session of the IOC-WMO/IGOSS Group of Experts on Operations and Technical Applications
60. Second Session of the IOC Group of Experts on the Global Sea-Level Observing System
61. UNEP-IOC-WMO Meeting of Experts on Long-Term Global Monitoring System of Coastal and Near-Shore Phenomena Related to Climate Change
62. Third Session of the IOC-FAO Group of Experts on the Programme of Ocean Science in Relation to Living Resources
63. Second Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
64. Joint Meeting of the Group of Experts on Pollutants and the Group of Experts on Methods, Standards and Intercalibration
65. First Meeting of the Working Group on Oceanographic Co-operation in the ROPME Sea Area
66. Fifth Session of the Editorial Board for the International Bathymetric and its Geological/Geophysical Series
67. Thirteenth Session of the IOC-IHO Joint Guiding Committee for the General Bathymetric Chart of the Oceans ***(Also printed in French)***
68. International Meeting of Scientific and Technical Experts on Climate Change and Oceans
69. UNEP-IOC-WMO-IUCN Meeting of Experts on a Long-Term Global Monitoring System
70. Fourth Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
71. ROPME-IOC Meeting of the Steering Committee on Oceanographic Co-operation in the ROPME Sea Area
72. Seventh Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño' ***(Spanish only)***
73. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico ***(Also printed in Spanish)***
74. UNEP-IOC-ASPEI Global Task Team on the Implications of Climate Change on Coral Reefs
75. Third Session of the IODE Group of Experts on Marine Information Management
76. Fifth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
77. ROPME-IOC Meeting of the Steering Committee for the Integrated Project Plan for the Coastal and Marine Environment of the ROPME Sea Area
78. Third Session of the IOC Group of Experts on the Global Sea-level Observing System
79. Third Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
80. Fourteenth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans
81. Fifth Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes

CONTINUED ON INSIDE OF BACK COVER

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TABLE OF CONTENTS

ANNEXES

I. Agenda

II. List of Participants

III. Terms of Reference

IV. Terms of Reference: CLIVAR Upper Ocean Panel

V. GCOS Organization, Strategy and Priorities

VI. Products and Users of the JMA Climate Service

VII. Users of WOCE Products

VIII. Sample Outlines of Applications from Observations

IX. NOAA's Ship of Opportunity XBT Programme

X. Specific Implementation Issues: Floats

XI. Sea Surface Temperature

XII. Ocean Requirements and Satellite Sensor Tables

XIII Satellite Altimetry and Sea Level

XIV Glossary of Acronyms and Special Terms

1. OPENING

The first session of the Ocean Observations Panel for Climate (OOPC) was held at the Rosenstiel School of Marine and Atmospheric Sciences (RSMAS), University of Miami, Florida, 25-27 March 1996. The meeting was hosted by Otis Brown, Dean of RSMAS and also chairman of the Joint Scientific and Technical Committee for the Global Ocean Observing System (J-GOOS). He welcomed the participants and explained that the OOPC was established to further the work of its predecessor, the Ocean Observing System Development Panel (OOSDP). That Panel's parent body was the Joint Scientific Committee (JSC) for the World Climate Research Programme (WCRP). J-GOOS, the JSC and the Joint Scientific and Technical Committee (JSTC) for the Global Climate Observing System (GCOS) all saw a need and agreed to co-sponsor the OOPC. Brown gave his view on how he expected the OOPC to function. His philosophy was to recruit good people, explain the goal and let them determine their own plan of action.

Neville Smith, Chairman OOPC, also welcomed the participants. All members except T. Yamagata were able to attend. Invited guests included R. Molinari, R. Reynolds, M. Lefebvre, O. Brown, E. Lindstrom, T. Manabe, and T. Spence. After the members and guests introduced themselves, Smith stated that a prime objective of this first meeting would be to scope out what the Panel should try to do, with milestones and dates wherever possible. The complete list of attendees is given in Annex II.

2. REVIEW AND ADOPTION OF THE AGENDA

Panel members were invited to comment on the provisional agenda. After brief discussion the Panel adopted the agenda as given in Annex I.

3. TERMS OF REFERENCE

Smith invited comments on the appropriateness of the present terms of reference (TOR) for the OOPC (see Annex III). Several recommendations resulted: (1) that JGOFS and CLIVAR should be added to WOCE and TOGA as sources for the OOPC to draw on [see para (ii)]; (2) that the words used in the OOSDP Final Report to describe the required observations (i. e., long-term, systematic, relevant to the global climate system, subject to continuing examination, cost-effective and routine) that distinguish between operational and research aims, should be reflected somehow in the TOR; and (3) that ocean circulation is seen to incorporate carbon.

4. BACKGROUND

4.1 OOSDP REPORT

Smith provided some of his perspectives of applications of the report in numerical weather prediction, climate assessment centers, ocean/climate model verification, and numerical ocean prediction. The report targets specific goals such as the production of surface fields, surface fluxes, upper ocean heat content and sea level change. Smith noted that many of these goals in the "To be implemented now" category are in fact on the agenda for this meeting (see Section 6). Smith also noted that the way we use models to add value/interpret observations has a significant impact on observing system design for specific products. SST analysis, for example, does not use models at all. Smith reviewed the philosophy behind the feasibility-impact diagrams and noted that recent developments were already cause for some changes, (e.g., upgrading of the impact of the altimeter based on the remarkable performance of TOPEX-POSEIDON).

4.2 WCRP PERSPECTIVE

Neville Smith informed the Panel of the WCRP interest in the OOPC. That interest resides mainly in the Climate Variability and Predictability (CLIVAR) Programme, although GEWEX's hydrological programme has some potential interest. CLIVAR has two numerical experiment groups: NEG-1 for the interannual component, i.e., CLIVAR GOALS, and NEG-2 for the decadal to century time scale component, i.e., CLIVAR DEC-CEN, and the anthropogenic climate change (ACC) component. Smith described some of the planned NEG-1 projects, among them intercomparisons of ocean model simulations forced by several different wind stress products. The aim is to gather together operational and/or experimental ocean analyses, intercompare their products and compare them against various high-quality analyses. The ultimate aim is to develop the best ocean analysis. Observations will be used to verify models and to determine the impact of initialization on forecast skill.

CLIVAR has also formed an Upper Ocean Panel (UOP). The question was initially posed as to whether both the UOP and the OOPC were needed. Smith, who attended the first UOP meeting, came away convinced the answer was yes. The UOP task is specific to prescribing the observational data needed to fulfil the scientific goals of CLIVAR. Initially, the UOP strategy will be to use the OOSDP design as the basis for developing a CLIVAR upper ocean observing system. It will pursue a strategy of organizing workshops to address required activities. The OOPC task is broader, requiring consideration of the intermediate and deep ocean as well as the upper layers, includes chemical and biological issues, and is aimed specifically at routine, long- term (operational) activities and products. Terms of Reference and membership of the UOP are in Annex IV.

4.3 GCOS PERSPECTIVE

Tom Spence, Director of the Joint Planning Office (JPO) for GCOS reviewed the past relationship with the OOSDP. The work of that Panel was important to GCOS in that it provided scientific rationale for requirements and priorities for the ocean component of GCOS as well as the climate module of GOOS. Spence took some time to relate GCOS to the greater international context (e.g., the Framework Convention on Climate Change, the World Climate Programme and its subsidiary bodies, the Intergovernmental Panel on Climate Change, etc.). Then, with a series of overhead transparencies (Annex V), Spence described the JSTC structure as well as the GCOS strategy, objectives, priorities relationships with other observing systems e.g., World Weather Watch (WWW), Global Atmosphere Watch (GAW), Global Terrestrial Observing System (GTOS) and GOOS and related them to the OOPC. He noted that GCOS will, on the basis of requirements and priorities, implement ocean observations in cooperation with GOOS and other implementation bodies. Proposals are being developed to have existing agencies enhance observations and where necessary take on some things that aren't currently being done. Spence declared that responsibility for sea ice observation planning had not been clearly established and suggested that the OOPC should assume responsibility.

Spence concluded his presentation by listing some suggested activities for the OOPC derived from the report of the fifth session of the JSTC:

(i) consider/describe useful products;
(ii) assign priorities: feasible and significant;
(iii) address the carbon issue: rivers, corals, etc.;
(iv) consider technical tradeoffs, for example:
    (a) for heat content: the Ship of Opportunity Programme (SOOP) vs the ALACE floats;
    (b) for SST Calibration: the Volunteer Observing Ship (VOS) vs Drifting Buoys;
(v) consider the WOCE approach for data quality assessment;
(vi) provide advice on implementation priorities for JSTC;
(vii) propose ways to increase interaction:
    (a) among GCOS groups
    (b) among others (e.g., CEOS);
(viii) be the eyes and ears for ocean issues for the JSTC.

5. USER NEEDS AND PRODUCTS OF THE OCEAN OBSERVING SYSTEM FOR CLIMATE (OOSC)

Clearly, if the OOPC is to effectively refine the plan for the OOSC developed by the OOSDP, it must devise a strategy for better defining user needs for the products of the OOSC and of the benefits to be obtained. To better understand the role of observations in existing operational systems, the Panel invited

Teruko Manabe to describe the Japan Meteorological Agency (JMA) system (Annex VI) and Eric Lindstrom to provide information on the analyses being undertaken of WOCE data and the uses it is expected to fulfil (Annex VII).

The El Nino Monitoring Centre of JMA publishes near-real- time descriptions of oceanographic and atmospheric conditions related to El Niño in its monthly ocean report. Ocean data are also assimilated in an operational ocean model. The JMA has a mature products and user-needs outlook; information is provided for the agricultural sector, ship routing, fisheries, socio-economic applications (e. g., merchandising), and to various government agencies for planning and policy decisions.

Smith described the efforts at the Bureau of Meteorology (BoM) in Australia. The BoM have several operational products which depend on oceanographic data, including SST analyses and subsurface ocean temperature analyses. The BoM Climate Analysis Section regularly use these products when formulating outlooks for climate in the Australian region. The emphasis is often on the 1-3 month time scales in which case it is important to have good systems for monitoring climate in near real time and for forecasting on these shorter time scales; these methods are often statistical and increasingly depend on oceanographic information. Sometimes these systems provide rainfall outlooks directly; in other cases it is necessary to add further interpretation of, e.g., a Southern Oscillation forecast. El Niño forecasts are important but are still treated with caution. These are sometimes based on “intuitive” interpretation of monitoring products, using historical experience, but more commonly now on coupled ocean-atmosphere predictions. BoM runs an intermediate coupled model routinely; its initialization is strongly constrained by subsurface ocean temperature data. In most cases it is the BoM Climate Analysis Section which is the “user”; it examines the various ocean products (some of them interpreted by coupled models) among other things, and formulates advice on likely short-term and long-term climate changes. In other cases ocean analyses such as SST are incorporated into systems which can be operated at the “farmer’s gate”; the “RAIN MAN” system is one of these, incorporating various ocean indices in its climate monitoring and prediction facilities.

John Field sketched the background of marine biogeochemical programmes sponsored by SCOR-IGBP. These include JGOFS, LOICZ, GLOBEC and the likely successor to JGOFS: Surface Ocean Lower Atmosphere Feedback (SOLAF). It is notable that GLOBEC plans to interact strongly with GOOS and has plans for development of new technology to make biological observations in conjunction with advanced modelling techniques, i.e., the Advanced Modelling and Observation System (AMOS). SOLAF is also planned to take advantage of new ocean observing technology.

JGOFS main users include the scientific community and climate modelers and forecasters. JGOFS and its successor programmes will need observation systems to support the development of detailed eddy-resolving models with greatly improved vertical resolution in order to model biological processes. Such models will need to assimilate data and be nested within coarser models. Key information required will include SST, chlorophyll and mixing depth in order to produce synoptic maps leading to predictions of primary production and, ultimately, new production. Field noted that when WOCE-JGOFS observations are completed towards the end of the century, the successor programmes, CLIVAR and SOLAF, only include plans to study the upper ocean for biogeochemical processes. The deep ocean is not included in present plans and may end up being neglected.

JGOFS time-series stations with monthly or better resolution of vertical profiles have proved essential for calibrating and validating biogeochemical ocean models. Field emphasized that these must be maintained and, if possible, expanded to regions with key processes that impact upon the ocean climate system.

It became clear from the discussions of the analyses being carried out at JMA and BoM, that existing ocean observations and products produced using the data are contributing both directly and indirectly to climate services, including ENSO predictions. There is, however, a need to tailor products to specific user groups and much remains to be done in this area. The Panel recognized that the willingness of most nations to implement an OOSC will depend somewhat on having the support of national user groups.

The chair urged that the Panel, in the absence of alternative methods, must bring the OOSC (the OOSDP plan) to the users and implementors and not wait for this to be done by others. The Panel decided that it would be useful to produce a number of relatively concise descriptions to illustrate the relationship between the OOSC observations and its products and successful climate-related applications. The favoured strategy was to select key observation-to-product "lines" and produce illustrative documents demonstrating the value of these "lines". The first two would be developed in the near future and would concern the prediction of ENSO events and the determination of global sea level change using satellite altimeters and tide gauges. An outline of these two OOSC applications is given in Annex VIII. A list of others to be developed before the next meeting of the OOPC is included in Section 8.1

6. SPECIFIC IMPLEMENTATION ISSUES,

6.1 THE PROPOSED SHIP OF OPPORTUNITY PROGRAMME (SOOP)

R. Molinari gave a presentation on NOAA'S Ship of Opportunity Programme. It is included as Annex IX. Some 17,000 XBT probes were deployed globally in 1995. Though the budget has been cut for probes for 1996, a lower price from SPARTON ($25 per unit vs $50 in the past) will make it possible to procure the same number this year.

Molinari hopes to supplement XBT data in regions of data voids with PALACE floats. He mentioned that WOCE has a proposal to deploy 150 floats ($10 - $12k per unit) in the Atlantic in 1997, some with salinity measuring capability (about $15k per unit). Molinari believes, that with a couple of more years of experience with the profiling floats, that it will be possible to specify the optimum mix of XBTs and PALACE floats,

Lindstrom informed the Panel that JMA (Japan) has a plan to make TRANSPAC XBT observations from 1997 in cooperation with NOAA of the (USA). Noting that the observing network undergoes changes, some of them large, some of them subtle, he urged the Panel to consider maintaining a running record of the state of the global observing system similar to what was done by the former CCCO Pacific Ocean Climate Studies Panel under the chairmanship of David Halpern for the Pacific Ocean.

Discussion on this subject brought out a number of SOOP issues for the OOPC to consider. These are capsulized below:

(i) There is a need to bolster poorly sampled XBT lines, before adding more lines.

(ii) WOCE requested some high-density Indian Ocean lines that are not implemented.

(iii) New technology: should we try to develop re-usable instruments à la the mechanical BT?

(iv) Can we make better use of existing ships? Met data? Biogeochemical data? Salinity data?

(v) Re-examine state of data available for upper ocean climatologies and the seasonal cycle.

(vi) Are the operational analyses making best use of SOOP data? Real time transmission is essential for this application.

(vii) Should OOPC leave to the CLIVAR UOP work on observation system simulation and experimentation, or be active in describing and undertaking needed experimentation?

(viii) The effectiveness of XBTs vs PALACE and SPALACE floats needs to be evaluated.

6.2 BUOYS AND FLOATS

Ed Harrison reviewed briefly the status of the TAO array in the tropical Pacific. Full deployment of the array, with about 70 moorings in place, was first accomplished in late 1994. Availability of ship resources to maintain full deployment of the array is a continuing concern. Because the array has been in full deployment for such a short time, it will be some time before a thorough assessment of the array's performance can be carried out, A first description of the SST and subsurface variability as seen by the array is available (Kessler *et al* 1996), and a first assessment of the variability of the winds is underway by PMEL staff. The impact of the array on the skill of ENSO forecasts will be a priority activity in the coming years. Because much forecasting is done at present with anomaly models (because of problems of "climate drift" in coupled ocean-atmosphere models), the array will have to be in place long enough to have a well defined climatology in order to give optimum support to forecast efforts. Forecast impact and array assessment activities will be carried out by a number of groups within the CLIVAR and the operational NOAA communities.

Walter Zenk described the various floats that are available today, to compete in the future with XBTs. His presentation is in Annex X.

6.3 SEA SURFACE TEMPERATURE (SST)

Reynolds reminded the Panel of the critical role of *in situ* SST observations for correcting satellite SST biases. These biases are negative and have magnitudes which can be quite large (4-5°C) during extreme aerosol events, with considerable spatial structure. They are always changing. At present, SSTs from VOS, drifters and moored buoys all play an important role in the preparation of the Reynold's SST analysis.

Reynolds discussed progress to date on the use of ATSR to measure SST. Key points are included here, but a more detailed report of his presentation is included in Annex XI. In principle, ATSR, because of its dual look, offers the opportunity to better correct for atmospheric effects compared to AVHRR. In a comparison study of ATSR SST and AVHRR SST, he found that there were regions where the difference between the two satellite retrievals was too large to be explained as the difference between the AVHRR bulk SST and the ATSR skin SST. Use of independent *in situ* data showed the ATSR retrievals were in error. The location and sign of the errors suggested they were due to cloud contamination in the ATSR retrievals. After correction of the satellite biases, analyses of large-space-scale SST anomaly patterns (> 10°) observed by either. satellite were similar although south of 45°S there were differences because of a lack of buoys to recalibrate the ATSR.

Reynolds indicated there is interest in obtaining SST with higher resolution in time than is possible from polar orbiting satellites. He suggested that SST retrievals from GOES were needed to improve the time resolution and to resolve the diurnal cycle,

Reynold's SST product from AVHRR relies on drifting buoys and VOS data for *in situ* calibration. The satellite operators make global corrections in response to instrument and/or atmospheric effects on SST measurements. However, the regional impacts of aerosols and other atmospheric effects require global *in situ* coverage to make corrections on the space/time scales of the variability. There are overlaps in VOS and drifting buoy coverage in some oceans. However, there are also data voids that should be filled by more buoys. The Reynolds analysis system could quality control and ingest other sources of data. A density of 2-3 observations per 10° square is desired. The OOPC could indicate where additional surface data are needed on, a high priority basis for satellite sensor calibration.

Smith presented statistics showing that the BoM SST analysis has no systematic bias with regard to any of the input data streams. He noted, as Reynolds on previous occasions that the rms differences between buoys and the final analysis, and ships and the final analysis are different: the ratio is typically 0.6°C to 1.0°, implying a buoy is 2 to 3 times more useful than a VOS measurement (this is somewhat smaller than results from Reynolds). If the VOS were equipped with hull-contact sensors, one might expect this comparison to be closer to unity.

R. Weller presented results from TOGA COARE. In this experiment every effort was made to resolve space/time variability in SST, Diurnal warming (up to 4°C in the upper 2m) and shallow, cool rain pools were observed, and, in low winds, the aircraft radiometric observations showed variability of several tenths to 1.0°C on several to 10s of km scales. To achieve a common SST product COARE had adopted the strategy of interpolating all measurements up from their observation depth to the surface. This is done using a simple mixed layer model driven by local flux observations, The small scale clouds associated with convection and spatial variability of SST observed during the experiment suggest limits to the ability of satellites to measure SST do exist.

Smith opened a discussion on how to improve SST products and on how to proceed. One clear recommendation would be to improve *in situ* observations south of 45°S where data density is sparse to zero. The OOPC could advise on where to put drifters to improve the SST product. Another is to improve the quality of existing SST observations by getting rid of the mix of bucket temperatures, ship intake temperatures etc., and moving toward hull-contact sensors. Weller showed two hull-contact sensor systems, one developed by W. Emery and one built at WHOI based on the U.K. design validated by Peter Taylor. The hull-contact sensors are straightforward and an obvious improvement. In conjunction with them, however, it would be desirable to see improved data communication within the VOS ships (i.e., wireless telemetry) and better near-real time communications links to send data (and meta data) back to shore.

Otis Brown added that with new ATSR-type sensors the satellite SST global product may improve to 0.4°C accuracy. He stressed that we need to maintain continuity of systems and tracking processing techniques. Such techniques may evolve for present operational products, but the ability to produce a consistent, climate record should be maintained.

Discussion led to the following conclusions:

(i) ATSR is potentially useful but a poor model is reducing its use;

(ii) GOES has significant potential, as yet untapped;

(iii) Hull-contact SST sensors have potentially a great impact;

(iv) A combined satellite and *in situ* climatology would seem to be the best option for the future (Brown did not believe this was the best option at present, for an end-to-end demonstration);

(v) Reynolds and Harrison proposed sub-sampling simulated SST data to try to determine the best *in situ* network (one problem with this is how to simulate atmospheric interference and calibration errors present in AVHRR in sampling of this);

(vi) For DBCP/CMM, provide maps of effective *in situ* data referenced against an ideal 1 per 700 or 800 km square: (a) Existing BUOY, SHIP, ALL; (b) 25%, 50%, 100% of SHIPS with hull-contact sensors, assuming error same as BUOY; and (c) an idealized situation where some SHIPS are improved to fill an "uncertainty" gap, and BUOY enhancement is proposed for other gaps. Smith will attempt this.

6.4 SPACE-BASED OBSERVATIONS PLANNING

6.4.1 The GCOS Plan

The session opened with the Chairman referring to the GCOS Plan for Space-Based Observations (GCOS Report No. 15), in particular to Table 4-1 and parts of Table 5-1 (See Annex XII) which may require revised input from the OOPC. It was also made clear that advice from the OOPC to the upcoming CEOS/GCOS Meeting in Seattle later in the week would be most appreciated.

6.4.2 Altimetry

A presentation by C. Le Provost highlighted recent results from the TOPEX/POSEIDON satellite altimetry mission. TOPEX has performed with a precision much better than expected - so precise, in fact, that sea level anomalies can be extracted from the data that appear to correspond with seasonal heat storage variations. This unexpected millimeter precision has made it necessary to review the entire calibration system, including the ground truth, in order to bring it to a level commensurate with that being demonstrated by the altimeter. With the door now open to the possibility of using the altimeter data for monitoring heat content, monitoring the global seasonal cycle, and monitoring sea level change, this new potential requires a revisit of the implied prioritization in the OOSDP report for the altimeter needs. A more complete summary of Le Provost's presentation is given in Annex XIII.

Le Provost made a plea to keep the Hawaii Sea Level Center open; he stressed it is essential for the TOPEX calibration. The continued collection of high-quality altimeter data allows shifting of altimeter observations toward impacts than those listed in the OOSDP Report. This applies to OOSDP Figures VIII. A.2-6 (sub-goal 2A) and VIII. A.2-8 (subgoal 2c) and to the situation for sub-goal 3a (Figure VIII.A.2-9) via impact on 2a.

Sea level change (goal 3c) observation depends on continuity of fast-delivery, *in situ* observations and it was agreed that this particular combination of *in situ* and space observations appears to make possible a product that retains the benefits of both the long *in situ* record and global coverage of the altimeter, in effect giving useful estimates of long-term change at large space scales. This conclusion has ramifications for the tide gauge network, implying a critical role for a set of fast response, referenced gauges.

M. Lefebvre and O. Brown emphasized the long lead time for development and implementation of space-based systems and the need for a clear picture of the *in situ* and modelling and assimilation components of an OOSC, in order to guide the space-based component. It was further made clear that while there are several 15-20cm accuracy altimeter missions approved, it is quite uncertain whether there will be a TOPEX/POSEIDON follow-up with better than 5cm accuracy. This illustrates the point made by Lefebvre, that it is a challenge to obtain a long-range commitment beyond the life of a single satellite.

6.4.3 Ocean colour

For ocean colour, Brown noted that we measure remotely what we can, not what we want. We therefore measure radiance and convert it. Understanding the diurnal cycle effect on radiance has been ignored in the past but it's important for producing climatologies. By way of example Brown used a CO_2 plot to illustrate the steps that one must go through to produce the final product from radiance observations. He would like to see OOPC worry about the modelling needed to get the needed end product.

Several satellite missions are approved and ocean surface radiance data will be collected, but there is a considerable need for research and demonstration of algorithms before it can be ascertained that these data can be used in operational monitoring of carbon sources and sinks. Brown stressed that the end-to-end construct has to be steered by someone or some entity - possibly OOPC. Spence agreed that with some cross fertilization OOPC could be the integrating entity.

6.5 INITIAL PRIORITIES FOR GOOS PRIORITIES AGREEMENT MEETING

Eric Lindstrom informed the Panel on the status of the draft background document developed for a proposed priorities agreement meeting. In 1995 I-GOOS set-up an *ad hoc* document on Initial Priorities for GOOS with the intention of presenting the document at a meeting to have been hosted by the U.S. in May 1996. The priorities meeting has now been postponed until 1997, which presents an opportunity to revisit the draft document. The document sets out the process of setting priorities (most important - least important), contains information on the parameters thought to be most important, and proposes a framework for the way forward. The meeting was to have been attended by invited high-level representatives of national agencies - individuals capable of making national commitments, who would review the priorities, specify their commitments and, through their national networks and procedures, assure their commitments to GOOS would be honored.

Needler added that he was a participant in the review process for the draft document. He believed the postponement was the result of a lack of consensus, in considering priorities, on whether to separate the things that are well planned from those that are not. The GOOS approach, to proceed with implementing all the modules along a single time front, clashes with strongly held views that it's important to get something committed to now in order to move GOOS ahead, which implies moving ahead on a priority basis with those modules that are ready.

Discussion of the document by the Panel centered on concern over the requirements and priorities for parameters that were not well supported by documentation and/or surveys at the international level. The climate module (through the OOSDP report) is the only one to be adequately specified. Progress on this module may be held up while other modules develop their plans. To avoid this, the Panel discussed the feasibility of holding priorities meetings on individual modules, suggested as a possible alternative by E. Lindstrom. Broad support for this concept was tempered by Alexiou's comment that Member States may well want other modules, e.g., Coastal Zone, to be developed earlier. Several members were of the opinion that the OOSC would be better presented using a selected number of champions, perhaps following the end-to-end model above, rather than as a complex integrated system as presented in the OOSDP report.

Recognizing the expense and organizational complexities of international programmes, and that nations have their own climate programmes for their own needs, the question of what is worthwhile putting into international programmes was discussed. The Panel reached a consensus view that documents for two to three applications/products should be developed, describing the procedure from end to end that is required to convert raw observational data to a product useful to society. These documents would be used to explain and "sell" concepts when approaching agencies for support. The objective would be to illustrate how the packages could be implemented and how they could be sustained for the long-term. Smith suggested that the following were candidate areas having an application/product that could be developed in this way and carried forward by a "champion":

(i) ENSO Monitoring and Prediction;
(ii) Ocean/climate model validation (for IPCC as a customer);
(iii) Monitoring the amplitude and spatial pattern of long-term sea level change,

7. TECHNOLOGY AND PRODUCTS OF FUTURE OBSERVING SYSTEMS

7.1 OCEAN INSTRUMENTATION

G. Griffiths gave a presentation on issues relating to technology development. The major driving forces for developing new technologies for ocean observations include:

(i) Lower unit costs - where the unit may be the instrument, a unit of data, or a section or programme;

(ii) Increased specification - particularly for research purposes;

(iii) Lower (or appropriate) specification - where instruments in transition from research to operational use can benefit from cost reduction by accepting lower specification;

(iv) Low deployment/lifetime costs - where users are increasingly considering the through-life costs associated with instrumentation;

(v) Dependable calibration - *In situ* instrumentation has an important role in maintaining the long-term integrity of data sets, e.g., through use as "transfer standards" across different space-based instruments:

(vi) Collaboration - In Europe, co-operation between science-base and industry is an important element in winning new funds for technology development;

There are two major interlinked issues in technology development relevant to GOOS. First, lead time, from technology research through use in oceanographic research to operational use, may be 5-10 + years. This may be shortened by moving from development through to operational use, This may be of advantage in attracting industry involvement through better market definition. Second, GOOS is perceived in many quarters to be a large-scale customer for ocean instrumentation and for new developments. To capitalise on this interest, OOPC may want to indicate where technology development efforts could best be focussed for GOOS climate requirements. This could be done through technology "boxes" in the applications brochure.

Significant effort is being applied to developing autonomous ocean monitoring systems, from moored profilers (by Frye at WHOI), to banks of autonomous miniature one-shot profilers (by Guinard, Société Bretonne d'Instrumentation Océanographique) and autonomous vehicles (Autosub by Southampton Oceanography Centre, Ocean Voyager by Florida Atlantic University, etc.).

New sensor technologies are being applied to measure biogeochemical parameters such as nitrate concentration, e.g., *in situ,* flow injection chemical analysis (MBARI osmotic nitrate sensor, MERMAID and CARIOCA consortia in Europe). Efforts to make existing technologies robust and reliable and to import technology from the non-marine sector are also being pursued, e.g., SeaSense Link initiative in the U.K.

7.2 HIGH-LATITUDE CIRCULATION AND THE CARBON CYCLE

P. Haugan gave a presentation on the high-latitude circulation and its influence on the ocean carbon cycle. The high-latitude areas provide a link between the upper ocean and the deep ocean. Decadal and even inter-annual variability in the high-latitude ocean may be easier to detect at depth than near the surface because of the high variability in near surface conditions. An example of recent warming in the Norwegian Sea, linked to reduced convection in the Greenland Sea has been demonstrated by Osterhus and Gammelsrod (1996, submitted). The importance of maintaining deep ocean time series in order to detect climate change and variability and assess the state of the ocean cannot be overstated. For high-latitude, surface-energy fluxes, estimates of oceanic heat advection have recently been used to select suitable paramaterizations of the sensible, latent and radiative heat fluxes in the Nordic Seas (Simonsen & Haugan, 1996). Thus we are now at a stage where inter-annual variations driven by SST and atmospheric parameters can be elucidated for the high-latitude seas as well.

For oceanic uptake of atmospheric CO_2, as well as for redistribution (transport) of carbon in both the pre-industrial and present ocean, it can be argued that section data, including accurate estimates of the net water transport, are presently the most feasible route towards reliable assessment of carbon fluxes. This is backed by high-latitude estimates by Lundberg & Haugan (1996), as well as results from JGOFS-WOCE data. Further for the carbon cycle, first attempts at determining the geographical distribution of carbon runoff from land are being reported (Haugan *et al,* 1996, submitted). They demonstrate that this component is non-negligible for assessments of the global redistribution of carbon by the ocean.

Reliable data for the climatological hydrological cycle, including runoff from land, and the organic and inorganic carbon content of the runoff, are needed. In particular, the presently used global water balance (Baumgartner & Reichel, 1975) is quite old; revised. balanced climatologies of runoff are important for several aspects of ocean climate. This is not covered by existing initiatives and may need to be addressed by OOPC, perhaps in combination with sea ice.

Haugan's presentation triggered a discussion on the proven importance of time series stations and the difficulty with funding them on a secure long-term basis. The funding for the few ocean stations (e. g., off Hawaii, Bermuda, Norway, Canary Islands, etc.) that are still operating seems to be in constant jeopardy even though their value for climate variability studies is unquestioned. Weather ships have been deemed to be too costly (of the order of $2 million/year) by nations that have funded them in the past. Any solution would have to lie with new technology. It was decided that this issue was critical enough for the OOPC to undertake some action now to examine the design issues of a time series network and to maintain continuity of the threatened valuable records. The first immediate step would be a workshop to (i) review the benefits gained from weather ship data, (ii) to review technological advances to improve the cost/benefit ratio, (iii) review progress from JGOFS time series and (iv) come up with recommendations on siting/type of stations we should have for the OOSC, taking into consideration CLIVAR intentions. Field, Haugan, Zenk, Harrison and Weller agreed to organize the workshop around March 1996.

8. AN OOPC WORK STRATEGY

The OOPC considered in some detail both its long-term and near-term objectives and the actions that must be undertaken to meet them. These objectives and action items are summarized here as elements of a work plan for the OOPC.

8.1 PREPARE END-TO-END ILLUSTRATIVE EXAMPLES

As discussed in agenda item 5, it was decided to provide descriptions of various applications of an OOSC, of the benefits to be obtained and the end-to-end process that connects observations from the observing system with the user of its products. The applications initially to be addressed and Panel members primarily responsible for the description are:

(i) ENSO forecasting/monitoring and the use of XBT and TAO observations -- N. Smith;

(ii) determination of long-term sea level change using precision altimeters and tide gauges -- C. Le Provost;

(iii) marine data for improved climatologies and contributing to a better understanding of air-sea coupling (in the manner of COADS) -- R. Weller;

(iv) either the carbon cycle, climatology or a well-cared-for data set including times series to determine how carbon is partitioned -- J. Field;

(v) example of long-term interior ocean fluctuations provided by North Atlantic overturning and water mass formation -- G. Needler, P. Haugan;

(vi) the rationale for technology development and its importance for an OOSC -- G. Griffiths.

8.2 COMMISSION SPECIAL SUBJECT REPORTS AND WORKSHOPS

The OOSDP found it useful to commission a number of reports when an expanded treatment of particular subjects was considered important for the design of an OOSC. The OOPC decided that a continuation of this practice would be of great benefit to its work. Initial candidates for OOPC background papers are:

(i) Thermal sampling in the North Pacific, e.g., review of achievements arising from the TRANSPAC program and lessons learned in sampling and climate change detection -- G. Meyers, K. Hanawa to be approached, target of 2nd half of 1997.

(ii) Precision altimeter and *in situ* observations for the determination of long-term sea level change -- C. Le Provost, by early 1997;

(iii) Time series stations: physics, chemistry and long-term change. To be based on a workshop in March-April 1997, presently being scoped out -- J. Field to lead with E. Harrison, W. Zenk, R. Weller and P. Haugan.

8.3 UPDATE REVISED PRIORITIES FOR THE OOSC

The OOPC decided that it would not be useful to issue a revised design of the full OOSC more frequently than every 3-4 years. However, revisions on key issues where changes from the OOSDP design are required would be provided as needed. An example of the latter is the changing role of tide gauges for long-term sea level change measurement as a result of the unexpected precision of TOPEX-POSEIDON.

8.4 ADVISE IMPLEMENTATION GROUPS

The implementation of the OOSC has been hampered by lack of detail on the OOSDP report, lack of advice in a form that can be readily understood by agencies, as well as a scarcity of resources. The OOPC proposed an on-going programme of direct interactions with whatever groups are involved in implementation. Some examples:

(i) For SST, advise WMO and DBCP on distribution of *in situ* observations from hull-mounted sensors and drifters, based on where OOPC believes enhanced *in situ* sampling is warranted; and space agencies, e.g., on ATSR (Along Track Scanning Radiometer) and GOES (Geostationary) satellite sensors.

(ii) For the Ship of Opportunity (SOOP) Implementation Plan, at present, OOPC is not in a position to provide more detailed advice than is in the OOSDP report. Until further information is available guidance will be limited essentially to "As you were, " for the low density lines but with emphasis to maintain long-term, time-series tracks. Use the report of 8.2(a) and the CLIVAR UOP to provide more specific guidance. G. Needler was requested to participate in the SOOP MC meeting in May in Toulouse on behalf of the OOPC.

(iii) For satellites, OOPC should continue to advise on critical remote sensing needs for the OOSC, taking into account proposed schedules.

8.5 PARTICIPATE IN AND INITIATE PROJECTS TO REFINE THE OOSC

The OOPC will encourage the use of OSEs and OSSEs to refine the design of the OOSC and occasionally initiate/participate in the work as appropriate. Reynolds and Harrison agreed to conduct some observing system experiments to investigate the actual *in situ* requirement for calibrating AVHRR, using ocean model simulations.

8.6 MAINTAIN LIAISON WITH RELATED RESEARCH PROGRAMMES

The OOPC will maintain close interaction with programmes of the IGBP (e.g., JGOFS, GLOBEC, LOICZ); the WCRP (e. g., WOCE, GEWEX and CLIVAR - particularly the CLIVAR-UOP and the DecCen planners); and the IPCC process.

8.7 DEVELOP SCHEDULE FOR IMPLEMENTATION AND ACTIONS

The OOPC will develop a schedule of its activities based on the schedule of agencies with which it must interact and on the actions agreed to elsewhere in this report.

8.8 CONSIDERATION OF PROGRAMME SCOPE

In the future the OOPC will consider the scope of its activities; for example, the need to address the interaction of coastal regimes with the open ocean, shorter time scales than the OOSDP (perhaps biweekly), sea-ice, the observation of significant shelf edge flows, and the hydrological cycle.

8.9 PROVIDE INPUT TO PRIORITIES AGREEMENT MEETING

The OOPC will need to provide input to the Priorities Agreement Meeting (initially proposed by the U.S) when the scope and timing and host of that meeting becomes clear. Needler to coordinate action.

8.10 DRIVE TECHNOLOGY DEVELOPMENT

The OOPC will consider ways to drive the development of ocean technology for the OOSC. One way of doing this is suggested in section 7.

8.11 FURTHER DEVELOP MODELLING AND ASSIMILATION ASPECTS

Modelling and data assimilation aspects of the OOSC will bean agenda item for the next meeting.

9. VENUE AND DATE OF NEXT MEETING

John Field offered to host the next meeting of OOPC in Capetown, South Africa, during the first week of February 1997. The Panel accepted the invitation on a provisional basis depending on a determination of the estimated costs. Alexiou and Field will look into costs.

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ANNEX I

AGENDA

1. OPENING

2. REVIEW AND ADOPTION OF THE AGENDA

3. TERMS OF REFERENCE

4. BACKGROUND

   4.1 OOSDP REPORT
   4.2 WCRP PERSPECTIVE
   4.3 GCOS PERSPECTIVE

5. USER NEEDS AND PRODUCTS OF THE OCEAN OBSERVING SYSTEM FOR CLIMATE (OOSC)

6. SPECIFIC IMPLEMENTATION ISSUES

   6.1 THE PROPOSED SHIP OF OPPORTUNITY PROGRAMME (SOOP)
   6.2 BUOYS AND FLOATS
   6.3 SEA SURFACE TEMPERATURE (SST)
   6.4 SPACE-BASED OBSERVATIONS PLANNING

      6.4.1 The GCOS Plan
      6.4.2 Altimetry
      6.4.3 Ocean Colour

7. TECHNOLOGY AND PRODUCTS OF FUTURE OBSERVING SYSTEMS

   7.1 OCEAN INSTRUMENTATION
   7.2 HIGH-LATITUDE CIRCULATION AND THE CARBON CYCLE

8. AN OOPC WORK STRATEGY

   8.1 PREPARE END-TO-END ILLUSTRATIVE EXAMPLES
   8.2 COMMISSION SPECIAL SUBJECT REPORTS AND WORKSHOPS
   8.3 UPDATE REVISED PRIORITIES FOR THE OOSC
   6.4 ADVISE IMPLEMENTATION GROUPS
   8.5 PARTICIPATE IN AND INITIATE PROJECTS TO REFINE THE OOSC
   8.6 MAINTAIN LIAISON WITH RELATED RESEARCH PROGRAMMES
   8.7 DEVELOP SCHEDULE FOR IMPLEMENTATION AND ACTIONS
   8.8 CONSIDERATION OF PROGRAMME SCOPE
   8.9 PROVIDE INPUT TO PRIORITIES AGREEMENT MEETING
   8.10 DRIVE TECHNOLOGY DEVELOPMENT
   8.11 FURTHER DEVELOP MODELLING AND ASSIMILATION ASPECTS

9. VENUE AND DATE OF NEXT MEETING

10. REFERENCES

ANNEX II

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ANNEX III

TERMS OF REFERENCE

OCEAN OBSERVATIONS PANEL FOR CLIMATE

Recognizing the need for scientific and technical advice and guidance for the common module of the Global Climate Observing System (GCOS) and the Global Ocean Observing System (GOOS), and the need for liaison and co-ordination between these operational observing systems (e. g., systematic, long-term, global climate observations) and those of climate research (e. g., limited-life, hypothesis-validating observations), J-GOOS, JSTC for GCOS and JSC for the WCRP hereby establish an Ocean Observations Panel for Climate with the following terms of reference.

(i) To evaluate, modify and update, as necessary, the design of the observing system for the common module of GOOS and GCOS whose goals are:

to monitor, describe and understand the physical and biogeochemical processes that determine ocean circulation and its influence on the carbon cycle as well as the effects of the ocean on seasonal to multi-decadal climate change,

to provide the information needed for climate prediction.

(ii) To provide a procedural plan and prioritization for an integrated set of requirements consistent with the observing system design criteria and in a form that enables timely and effective implementation. This will entail drawing from findings of WOCE, TOGA, JGOFS, and CLIVAR, and particularly close interaction with the CLIVAR Upper Ocean Panel (UOP).

(iii) To liaise and provide advice, assesment and feedback to other panels in task groups of GCOS, GOOS and WCRP, as requested, concerning ocean observing for climate in order to ensure that the designs and implementation schedules are consistent and mutually supportive.

(iv) To establish the necessary links with scientific and technical groups to ensure that they are cognizant of, and can take advantage of the recommended system, and that, in turn, the Panel can benefit from research and technical advances.

(v) To carry out agreed assignments from and to report regularly to the JSTC, J-GOOS and the JSC for the WCRP.

ANNEX IV

TERMS OF REFERENCE

CLIVAR UPPER OCEAN PANEL

1. To assess and evaluate the effectiveness of the observing system by examining actual data flow and related products of the CLIVAR research programmes, in particular data assimilation products and, as appropriate, operational products, and to provide advice on optimal observing strategies compatible with the resources available.

2. To determine observational requirements for experimental and operational ENSO prediction systems, develop strategies for ameliorating any deficiencies, and determine appropriate levels of redundancy within the upper ocean measurement system by taking into account other information sources such as wind stress and sea surface temperature estimates.

3. To evolve an implementation strategy for an upper ocean observing system based on a mix of physical variables, (temperature, salinity, sea level and velocity) and measurement platforms to meet the scientific requirements of CLIVAR in light of existing and new technologies and the emerging operational observing systems of GOOS/GCOS.

4. To advise the CLIVAR SSG on the status of upper ocean observing system and related products and to liaise with the CLIVAR NEGS, CLIVAR/GCOS TAO Implementation Panel, WOCE Synthesis and Modelling Working Group and WOCE DPC as appropriate.

5. To liaise with GOOS/GCOS and, in particular the Ocean Observations Panel for Climate (OOPC) in regard to operational and quasi-operational systems and products.

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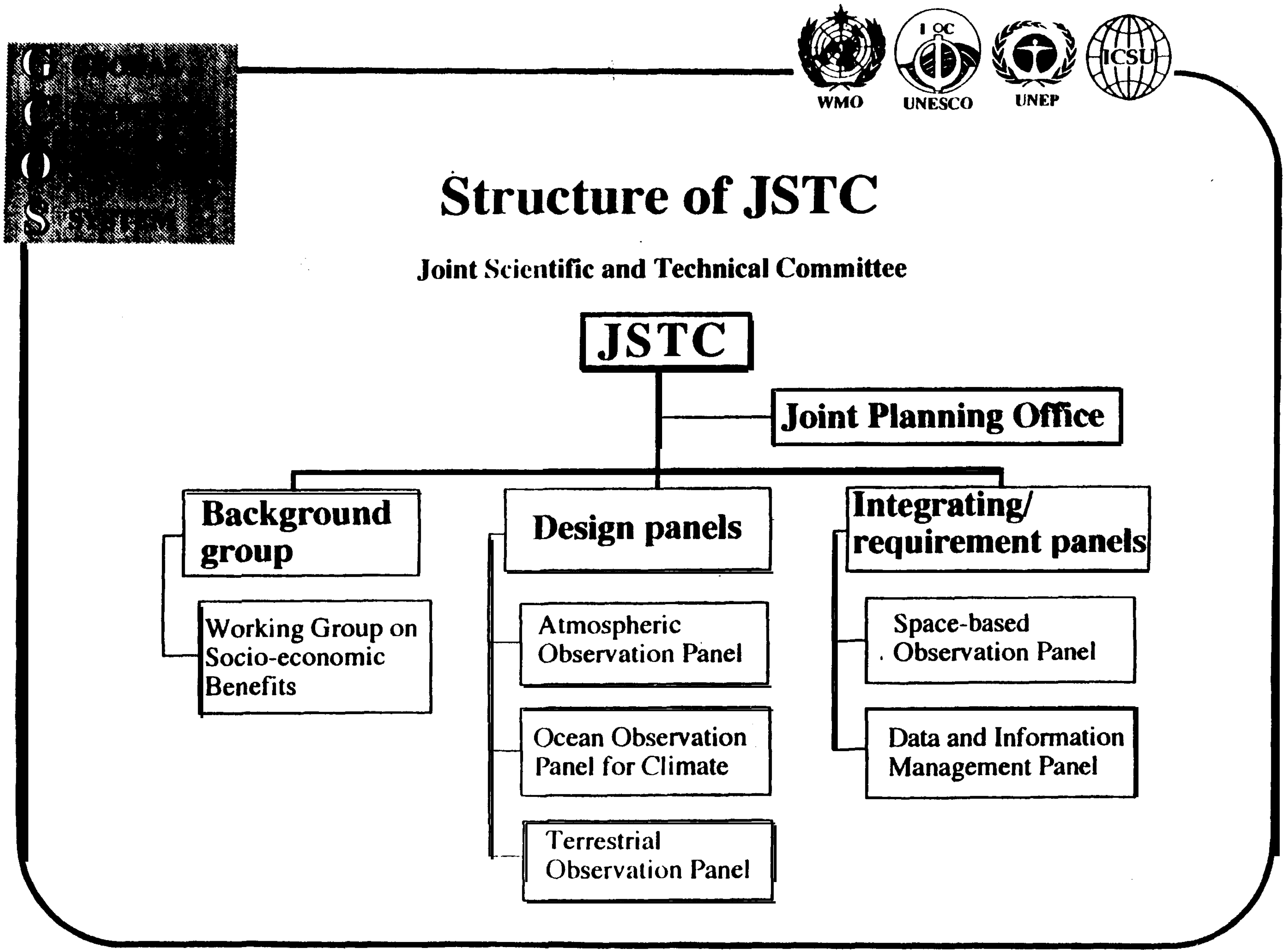
ANNEX V

GCOS ORGANIZATION, STRATEGY AND PRIORITIES


WMO
UNESCO
UNEP
ICSU
Structure of JSTC
Joint Scientific and Technical Committee
JSTC
Joint Planning Office
Background group
Working Group on Socio-economic Benefits
Design panels
Atmospheric Observation Panel
Ocean Observation Panel for Climate
Terrestrial Observation Panel
Integrating/ requirement panels
Space-based Observation Panel
Data and Information Management Panel

Joint Scientific & Technical Committee (JSTC)

Chairman:

Professor John Townshend	**(USA)**

Vice-chairmen:

Dr. Lennart Bengtsson	**(Germany)**
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Members:

Dr. Ekundayo Balogun	**(Nigeria)**
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Prof. John Harries	**(UK)**
Dr. Neville Smith	**{Australia)**
Mr. Gregory Withee	**(USA)**

Joint Planning Office:

Dr. Thomas Spence	**(USA)**

WMO UNESCO UNEP ICSU

THE GCOS STRATEGY

Specific Objectives

Objective 1 Design an effective operational climate observing system

Objective 2 Establish, coordinate and manage the Initial Operational System by integrating and enhancing existing components

Objective 3 Develop new components to provide a comprehensive and responsive system to meet future needs.

WMO UNESCO UNEP ICSU

FUNDAMENTAL SCIENTIFIC PRIORITIES

- Seasonal-to-interannual climate prediction
- The earliest possible detection of climate trends and climate change due to human activities
- Reduction of the major uncertainties in longer-term climate prediction

GLOBAL CLIMATE OBSERVING SYSTEM

WMO UNESCO (IOC) UNEP ICSU

RELATIONSHIP BETWEEN OBSERVING SYSTEMS

	ATMOSPHERE		LAND	OCEANS
	WWW	**GAW**	**GTOS**	**GOOS**
GCOS	CLIMATE		CLIMATE	CLIMATE
	Weather	Air Pollution Ozone	Land Degradation Pollution Biodiversity Sustainablity of Managed Systems Anthropogenic Impacts on Natural Systems	Marine Services Coastal Zone Management Ocean Health Living Marine Resources

ANNEX VI

PRODUCTS AND USERS OF THE JMA CLIMATE SERVICE

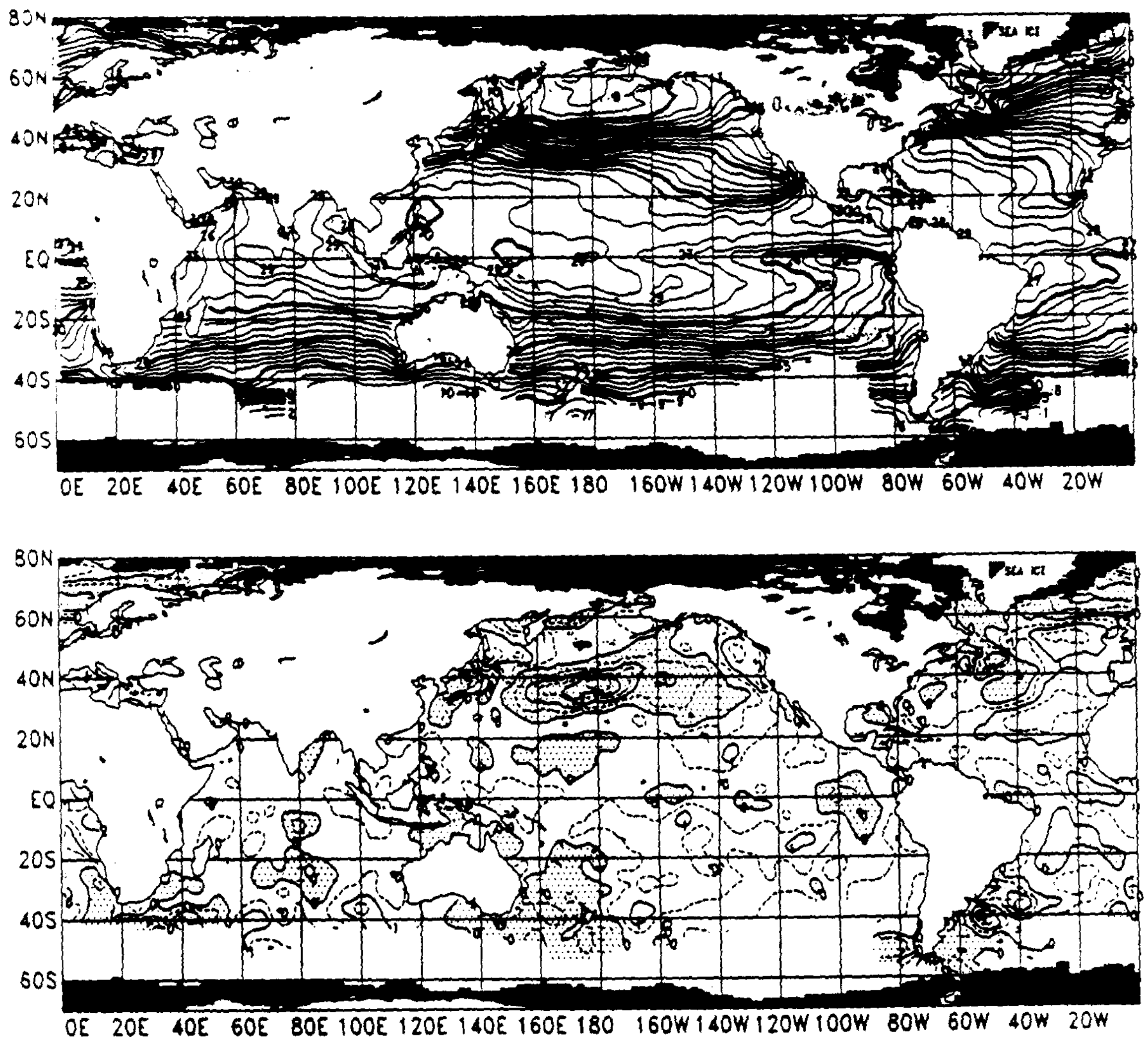
(Teruko Manabe)

The Japan Meteorological Agency (JMA) has been operationally providing oceanographic information such as SST (Figure 1), subsurface temperature (Figure 2), sea level (Figure 3) and surface current (Figure 4) for the global ocean, especially for the western north Pacific for about fifty years and has been acting as the Specialized Oceanographic Centre for the Pacific of the IGOSS Data Processing and Services System (IDPSS).

Regarding the impact of El Niño on Japan, JMA established the El Niño Monitoring Centre in April 1992. The function of the Centre is to collect and analyze oceanographic data and to disseminate information on El Niño/La Niná events. Based on *in situ* data circulated on the GTS, those from various Japanese agencies and satellites (GMS, NOAA, TOPEX/POSEIDON), the Centre makes various products, disseminates them by radio facsimile and publishes the "Monthly Ocean Report" which includes nearly real-time descriptions of the oceanographic and atmospheric conditions related to El Niño events as well as anomalies (Figure 5). The Centre developed its ocean data assimilation system and began to use it operationally in February 1995. Several products such as variation of ocean heat content appear in the report (Figure 6). Aiming at operational prediction of ENSO, the El Niño Monitoring Centre is developing a coupled ocean-atmosphere general circulation model (CGCM). Furthermore, JMA regularly publishes "Monitoring of Global Warming and Ozone Depletion" and "Reports on Recent Climate Change in the World" for public dissemination. These publications include oceanographic information such as SST trends and the role of the ocean in CO_2 variation, as well as weather/climate information.

Important uses of JMA's information on oceanic conditions are for ships routing and fisheries. The Agriculture Sector also seeks long-term weather forecasts for planning; JMA's oceanographic data help meet this socio-economic need. JMA also provides climate information, including oceanographic information, to other governmental agencies to help them achieve their missions.

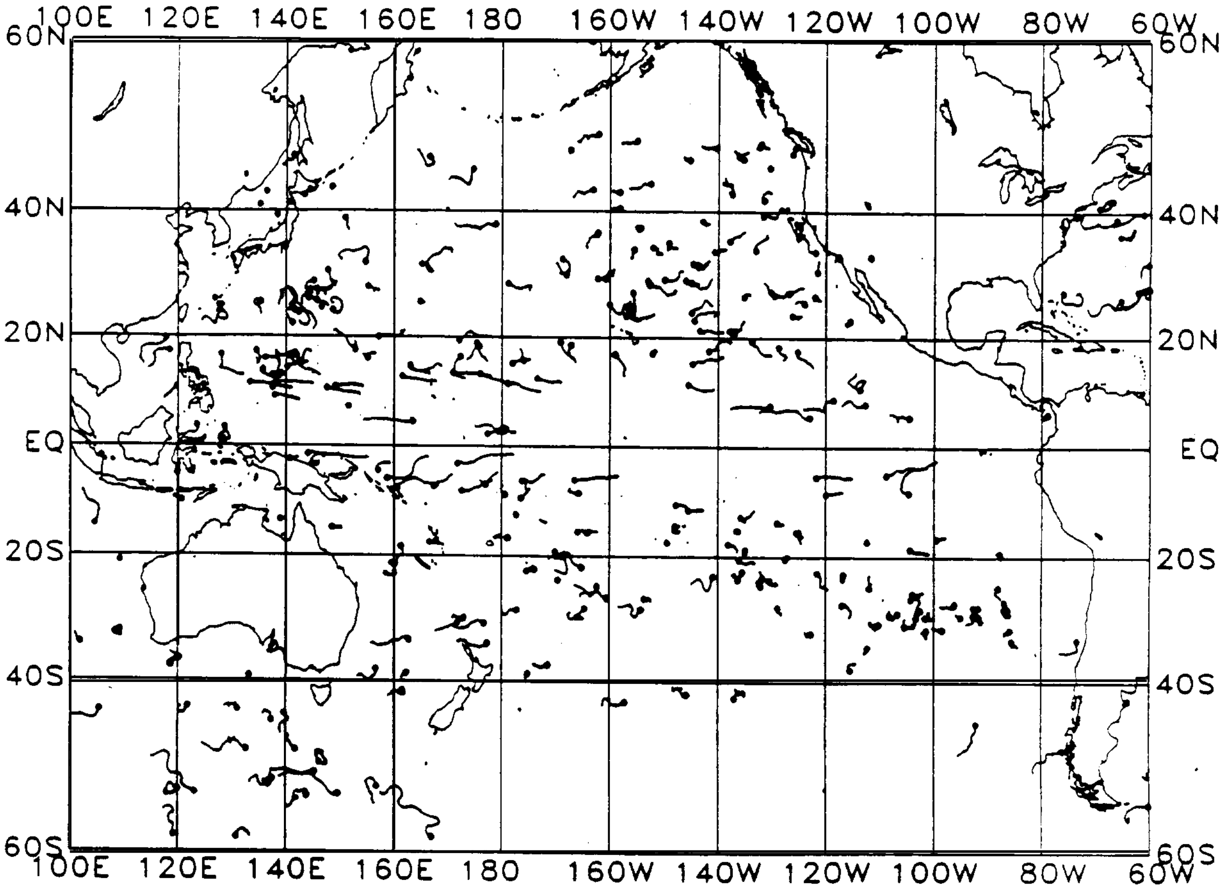
SST Anomalies in the Global Ocean



第6図　全球月平均海面水温図（上）及び偏差図（下）（1995年 7月）

Figure 1 Monthly mean sea surface temperature over the global ocean (top) and anomalies (bottom) for JUL 1995. Anomalies are computed from the JMA climatology (1961~1990) (Marine Department of JMA, 1991, Climatic charts of sea surface temperatures of the western North Pacific and the global ocean). Contour interval is 1°C (top) and additional anomaly contours of ±0.5°C are shown as broken lines. Negative anomalies are spotted. Maximum coverage of sea ice is shaded. Data sources for sea ice are U.S. National Ice Center (polar regions) and JMA (the Sea of Okhotsk).

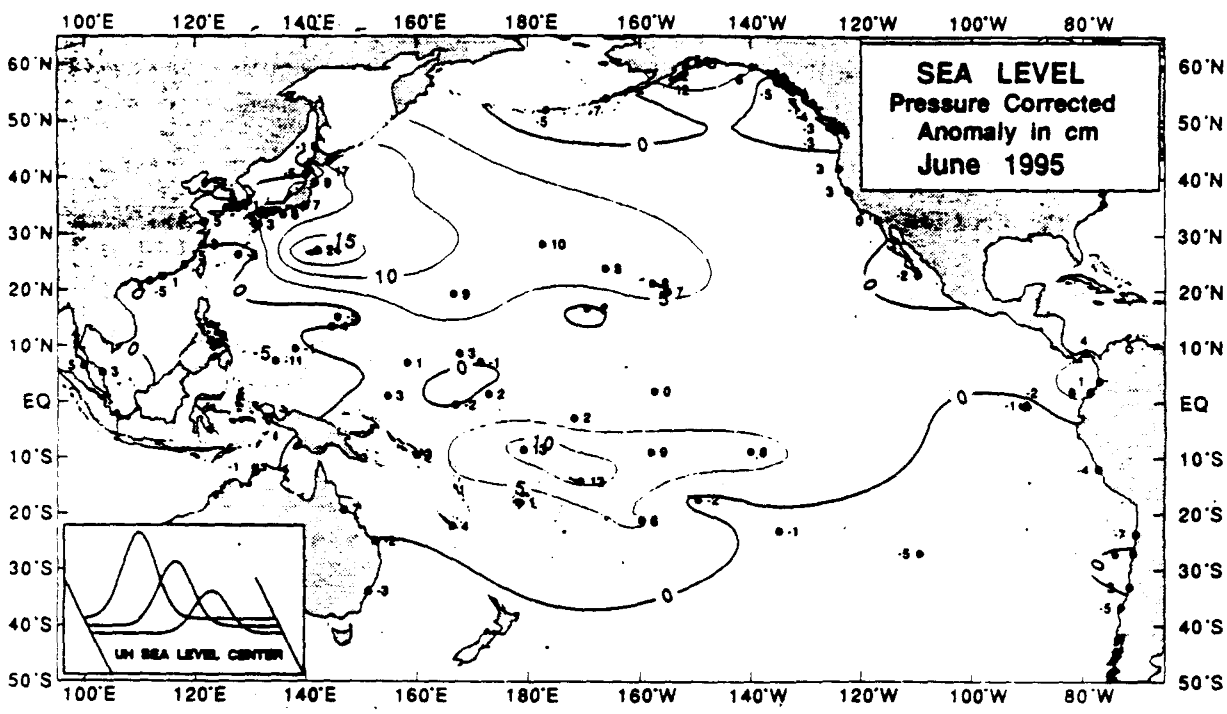
Movements of Drifting Buoys



第10図　太平洋ブイ流跡図(1995年 7月)

Figure 2 Movements of drifting buoys in the Pacific Ocean during JUL 1995. Each track is for one buoy. Small circles represent last positions for the month.

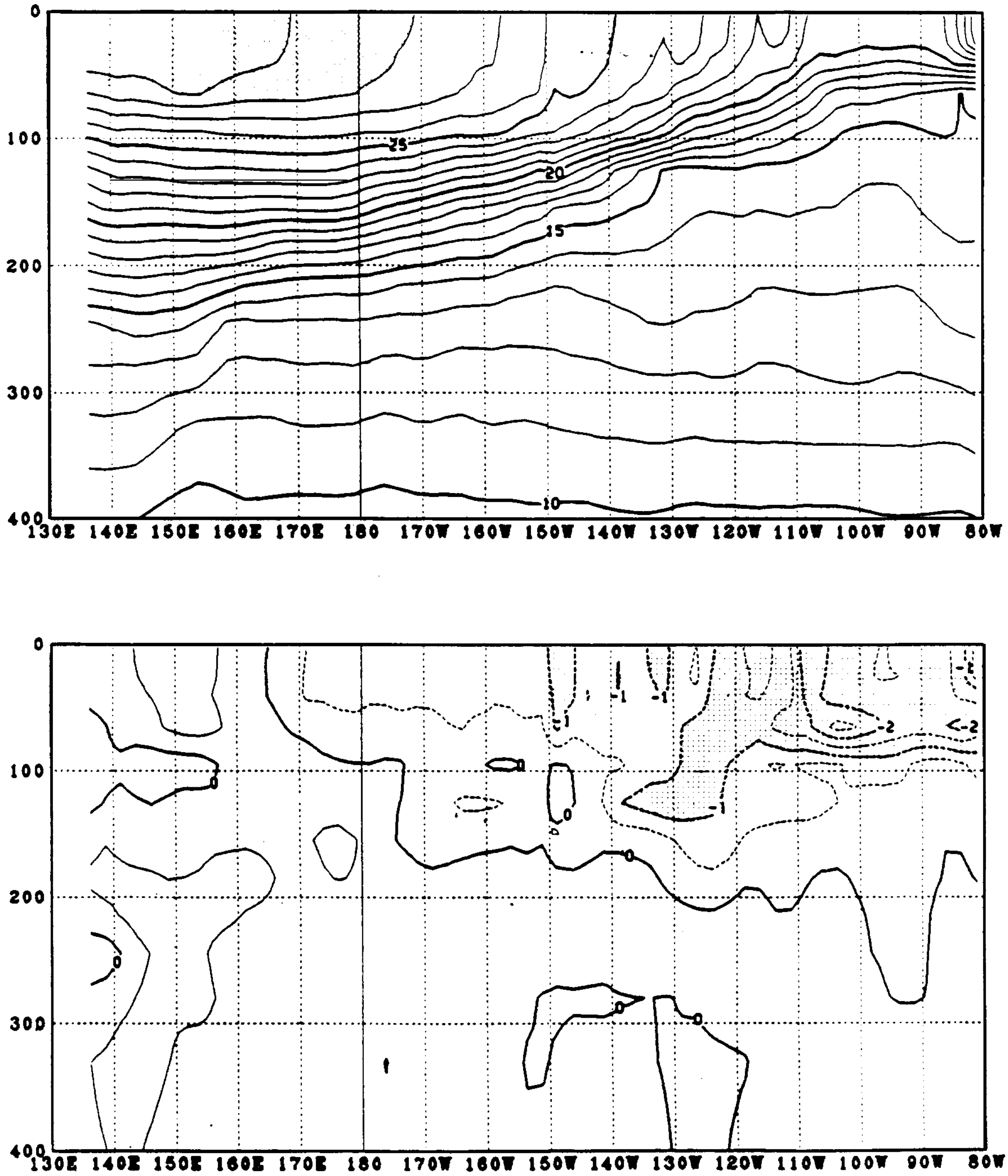
Anomalies of Sea Level



第11図　太平洋海面水位偏差図（ 1995年 6月 ）

Figure 3 Monthly sea level anomalies for JUN 1995 obtained from mean sea level (1975–1986) adjusted for atmospheric pressure.
This figure is prepared by the SOC of ISLP–PAC, Dept. of Oceanography, Univ. of Hawaii.

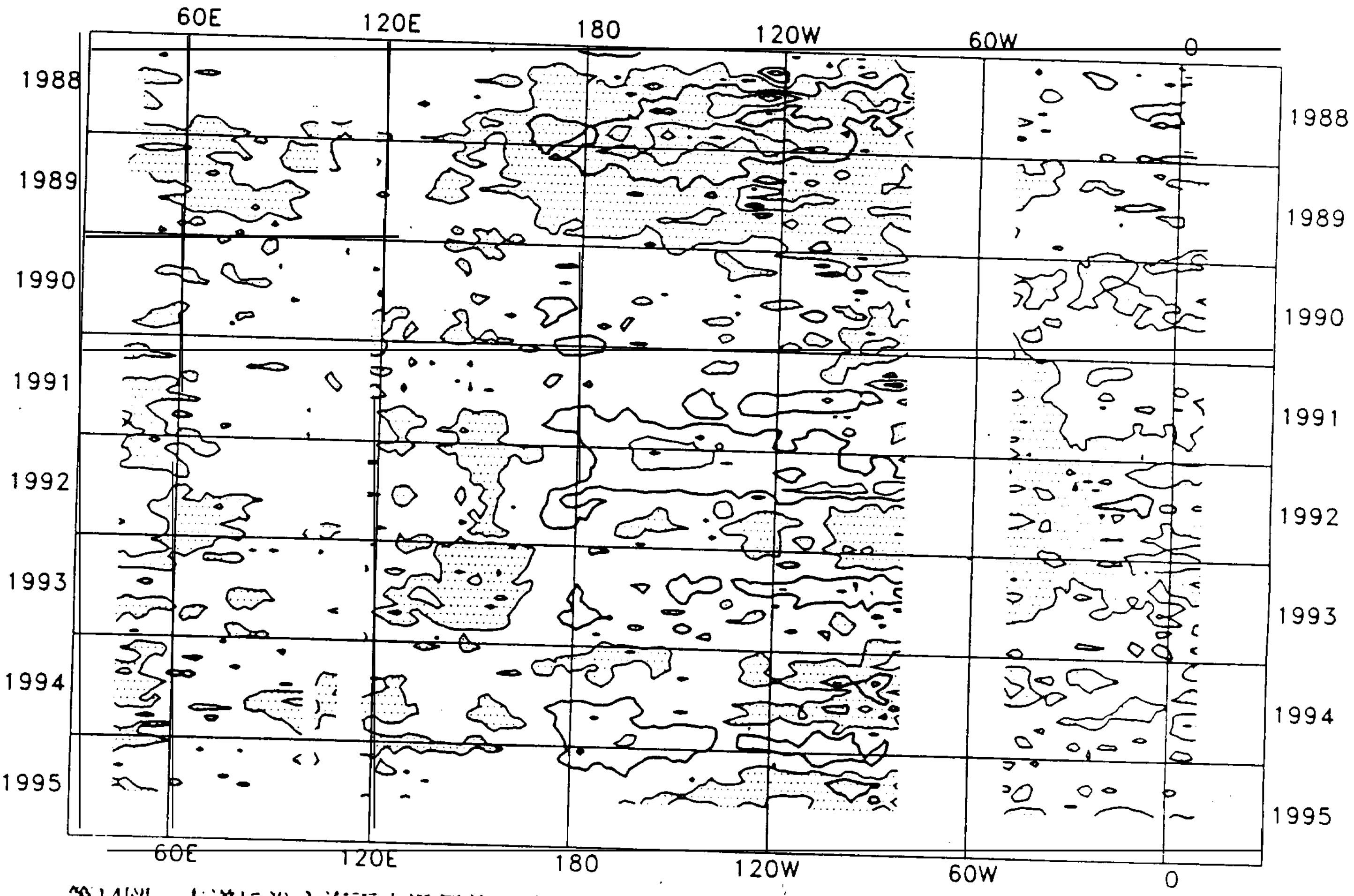
Depth-Longitude Section of Equatorial Temperature and Anomalies



第9図　太平洋赤道に沿う表層水温（上）及び偏差（下）の深度－経度断面図（1995年 7月）

Figure 4 Depth−longitude sections of temperature (top) and anomalies (bottom) along the equator in the Pacific Ocean for JUL 1995. Data are derived from the Ocean Data Assimilation System of JMA. Contour interval is 1° C (top) and 0.5° C (bottom). Values greater than 28° C in top panel are shaded. In bottom panel values greater than 1° C are shaded and values less than −1° C are spotted. Anomalies are computed from 1987−1994 base period means.

Time-Longitude Section of SST Anomalies



第14図　赤道に沿う海面水温偏差の時間ー経度断面図

Figure 5: Time-longitude section of SST anomalies along the Equator (2°N-2°S) computed from the JMA climatology (1961-1990). Contour inverval is 1°C, with thick contour lines at +1°C and -1°C. Negative anomalies are spotted.

Time-Longitude Section of Ocean Heat Content & Anomalies (6°N)

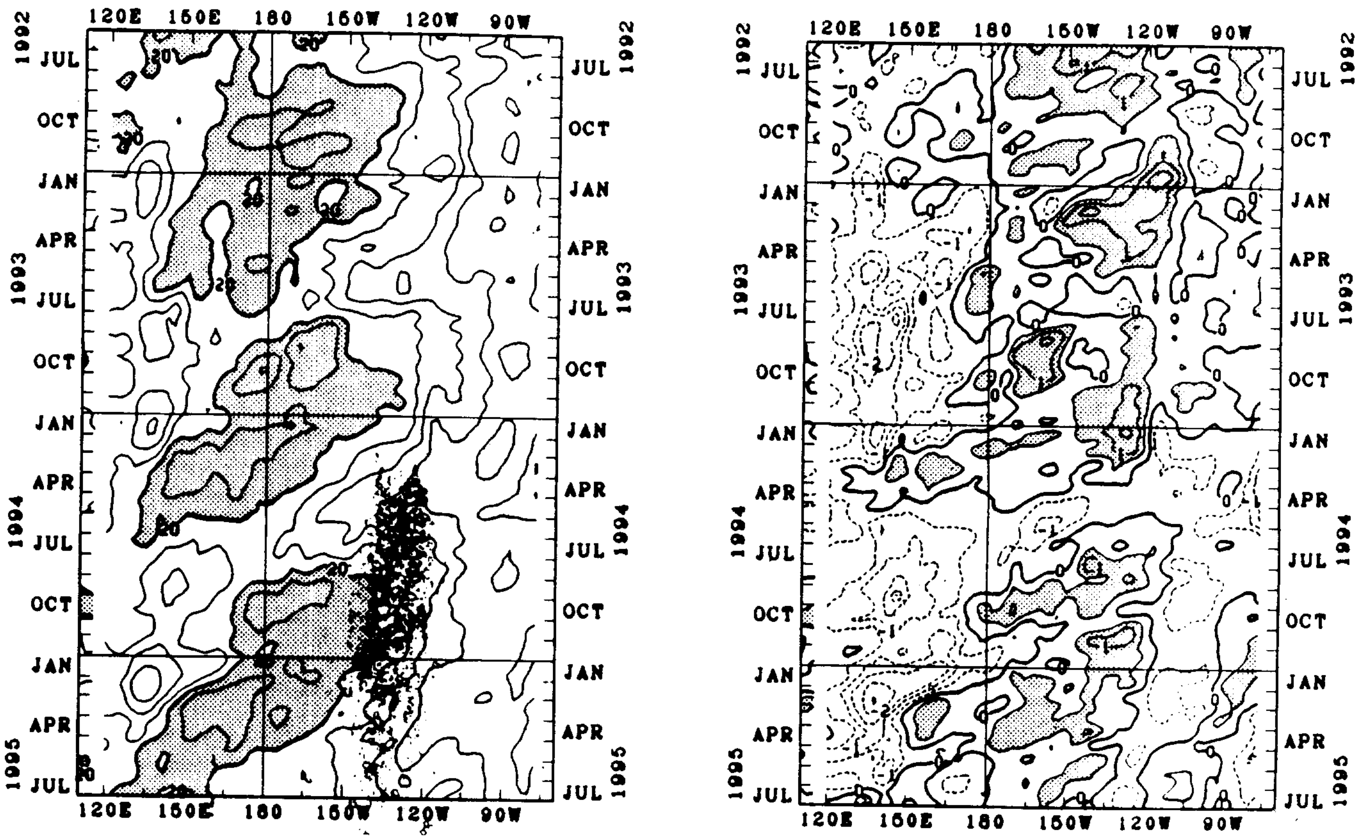


Figure 6: Time-longitude sections of ocean heat content in the upper 260m along 6° N (left) and anomalies (right) in the Pacific Ocean. Data are derived from an Ocean Data Assimilation System of JMA. Contour interval is 1° C (left) and 0.5° C (right). Values in the left panel are greater than 20° C are shaded and values less than 16° C are spotted. Dashed contours in right panel indicate negative anomalies. Anomalies are computed from 1987-1994 based period means.

ANNEX VII

USERS OF WOCE PRODUCTS
(Eric Lindstrom)

Users of WOCE products were defined for OOPC within the framework of WOCE Goals. Goal 1 is to develop models useful for predicting climate change and to collect the data necessary to test them. Goal 2 is to determine the representativeness of the specific WOCE data sets for the long-term behaviour of the ocean, and to find methods for determining long-term changes in the ocean circulation. These imply a primary market for WOCE data and information in the oceanographic and climatology scientific communities. The overall scheme for WOCE data flow (Fig. 1) incorporates data flow into a WOCE Data Resource that is used by investigators in the production of scientific analyses and syntheses. The WOCE Data Resource encompasses a number of activities (Fig. 2), particularly data assembly for individual measurement types. The WOCE Data Products Committee (DPC) chaired by E. Lindstrom, has oversight of the WOCE Data Resource and has recently drafted a plan to advance toward data-based products in support of WOCE synthesis. Figure 3 gives one perspective of the overall intention of the DPC plan and a characterization of intended users of the products.

The essence of the DPC proposal (Fig. 4) is for Data Assembly Centres to work toward production of a “variable-based” data set from the measurement types held by the facilities. This will be a more useful product for the modelling and analysis community. This product would serve as one starting point for scientific-based analysis, interpretation, modelling and synthesis in WOCE. The final products of such analyses will serve the climate modelling community and provide the baseline state of the oceans for the 1990s.

A Schematic of WOCE Data Flow

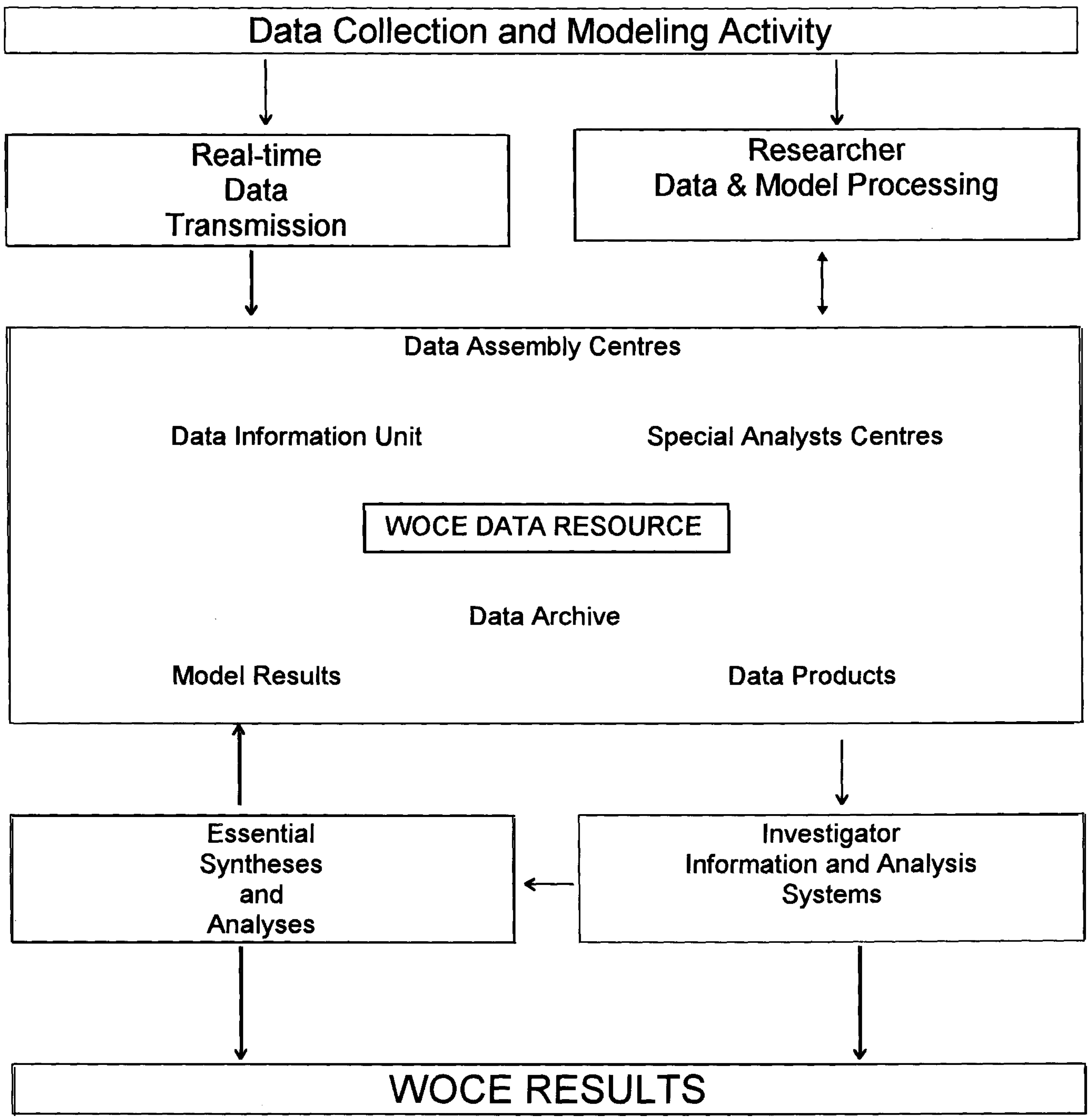


Figure 1

ELEMENTS OF THE WOCE DATA AND INFORMATION SYSTEM
(Thirteen primary data streams)

1 METADATA AND PROGRAM INFORMATION	
Data Information Unit	UDEL, USA
2 HYDROGRAPHIC PROGRAM	
WHP Office	WHOI, USA
WHP Special Analysis Center	BSH+, FRG
3 SURFACE DRIFTERS	
Global Drifter Center	AOML, USA
Archive	MEDS, CAN
4 UPPER OCEAN THERMAL DATA	
Data assembly (GTS)	MEDS, CAN
Data assembly (Delayed mode)	NODC, USA
Regional Quality Control Centers	
Atlantic	AOML, USA
Pacific	SIO, USA
Indian	CSIRO, AUS
Global UOT Data Centre	IFREMER, FR
5 SEA LEVEL	
- Fast Delivery	UH, USA
- Archive	BODC, UK
6 SUBSURFACE FLOATS	WHOI, USA
7 MOORED MEASUREMENTS	OSU, USA
8 SURFACE METEOROLOGY/AIR SEA FLUX	FSU, USA
9 SURFACE SALINITY	IFREMER, FR
10 SATELLITE ALTIMETRY AND SST	JPL, USA
11 BATHYMETRY	NGDC, USA
12 ADCP (to be established)	JODC, Japan
13 MODEL RESULTS AND DERIVED PRODUCTS	Not established
WOCE DATA ARCHIVE	WDC-A, USA

Eric Lindstrom, WOCE Data Products Committee

Figure 2

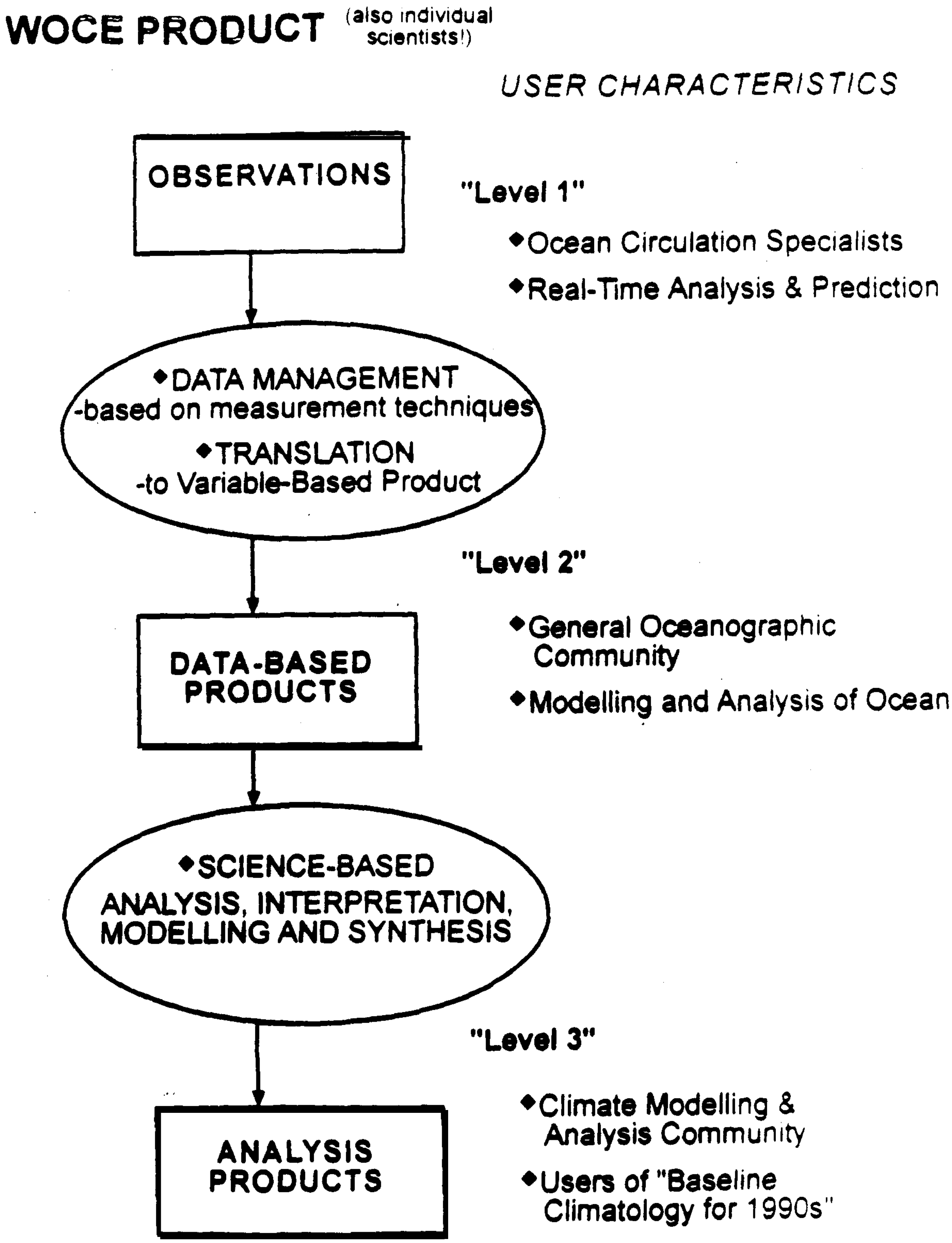

WOCE PRODUCT (also individual scientists!)
USER CHARACTERISTICS
OBSERVATIONS
"Level 1"
◆Ocean Circulation Specialists
◆Real-Time Analysis & Prediction
◆DATA MANAGEMENT
-based on measurement techniques
◆TRANSLATION
-to Variable-Based Product
"Level 2"
DATA-BASED PRODUCTS
◆General Oceanographic Community
◆Modelling and Analysis of Ocean
◆SCIENCE-BASED
ANALYSIS, INTERPRETATION, MODELLING AND SYNTHESIS
"Level 3"
ANALYSIS PRODUCTS
◆Climate Modelling & Analysis Community
◆Users of "Baseline Climatology for 1990s"

Figure 3

Conceptual path toward a comprehensive data set: "data derived products".

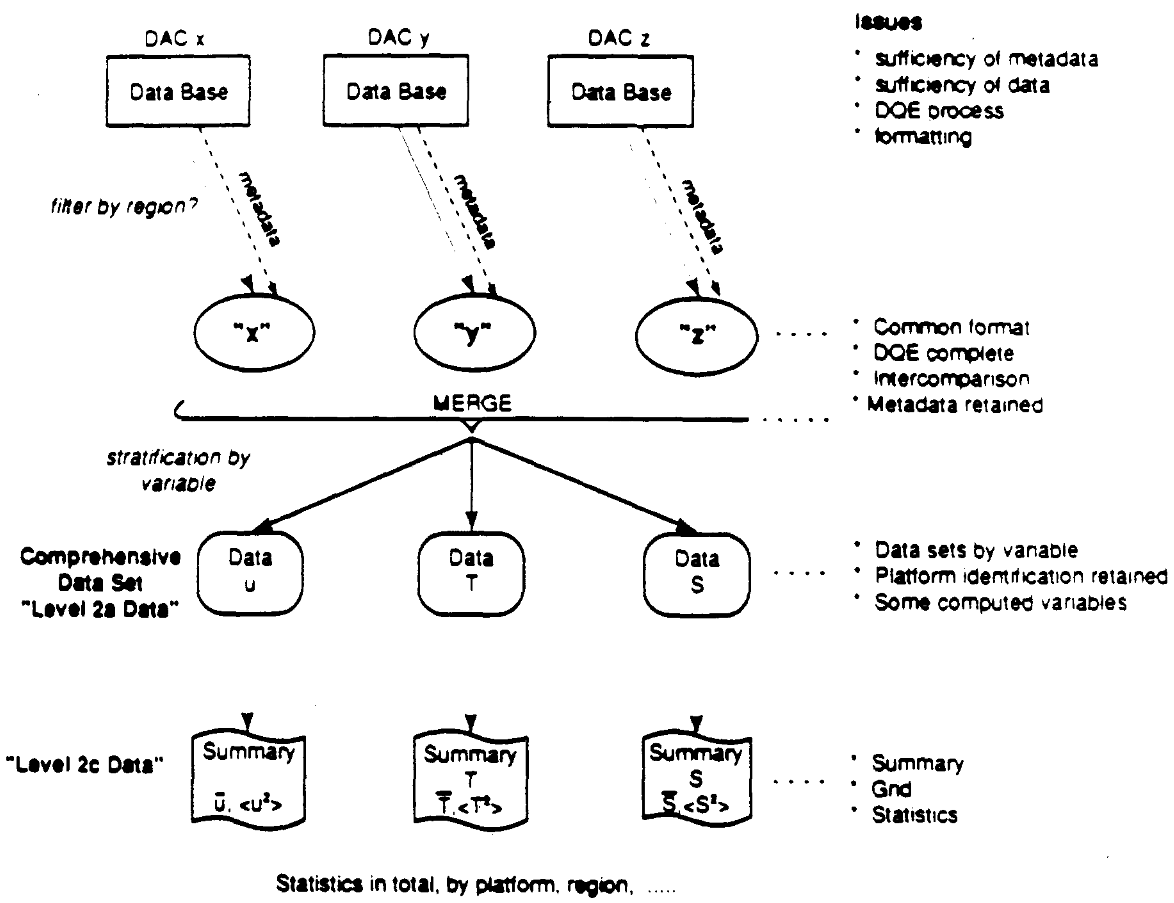


Figure 4

ANNEX VIII

SAMPLE OUTLINES OF APPLICATIONS FROM OBSERVATIONS

I. ENSO MONITORING

Application:

El Nino monitoring and prediction: (the role of *in situ* ocean thermal data)

Target Users:

* National climate services
* International climate monitoring
* Agricultural sectors.

Benefits:

* Agriculture: improved planting/harvesting strategies.
* Local, national forewarning of changed likelihood of extreme conditions (government policy, insurance and energy industries).
* Scientific community.

N.B. The users here are the services; for each of the benefits listed above it was suggested that the end-to-end brochure would contain a suitable figure.

OOPC Strategy:

I. Observation Network:

(a) TAO Array
(b) XBT Network
(c) Communications

[aside: wind stress, SST, Altimeter, in situ tide guages]
Figure showing the platforms

2. The Level-2 Parameters:

Merged estimates of tropical Pacific thermal structure (Use figure with observation location superimposed; could use NCEP or BMRC; or JMA N. Pacific/ 137°E sections.

3. Initialization of coupled models

(a) Ocean Models
(b) Coupled model constraints (figure from BoM

4. Model Forecast

NCEP forecast or from Experimental Bulletin?

5. Demonstration of how (2)-(4) are further developed for practical applications.

(a) "map discussion"
(b) SST forecast -> AGCM -> rainfall simulation

6. Issues

(a) Multivariate dependency on data (CLIVAR investigating)
(b) Model, data errors
(c) Translation of model forecast into something useful

II. SEA LEVEL MONITORING

Application: Monitoring the amplitude and spatial pattern of long-term sea level change.

There is widespread concern and interest with the problem of climate change and, in particular, that associated with anthropogenically induced climate effects. Monitoring this effect has depended on careful analysis of in-situ tide guage data; this analysis is made difficult by the mixed quality of the data, the lack of precision referencing, and lack of spatial context. The altimeter, on the other hand, has provided only a very short record but is able to provide global spatial resolution of sea level changes and at an accuracy suited to detecting long-term change, albeit with some apparent trend/bias.

By combining these two observation techniques, we can provide a product that retains the benefits of both the long-term in-situ record and global coverage of the altimeter, in effect giving useful global estimates of long-term changes at large space scales.

Targeted Users:

* The intergovernmental climate change assessment process (IPCC)
* National climate change/sea-level rise evaluation (regional plus local)
* National, international policy makers

Benefits:

* More effective policy for response to/mitigation of sea level rise associated with greenhouse effect;
* Better quantification of regional natural variability;
* Validation of models for "prediction" of climate change.

Strategy:

1. The Observation Network

(a) Precision altimetry (TOPEX-POSEIDON-type) (figure)
(b) High-quality in-situ network of guages (fast response) (figure)
(c) Position referencing (e.g., DORIS) (figure)

2. The Level-II Parameters

(a) Altimeter: 4-5 mm/yr estimates, with global coverage (figure)
(b) Gauges: O-1 mm/year estimates, local sites (figure)
(c) DORIS: reduced bias/uncertainty =...

3. Merging 1 and 2 (above)

Global estimates with bias and uncertainty of from *in- situ* network but with spatial coverage and resolution of altimeter. (figure).

4. Issues

* The optimal network of in-situ guages has to be determined.

* In a system like TP, timely communications between the guage network and the altimeter processing centre are required (e.g., the WOCE fast-response network).

* Continuity of altimeter missions: a combination of past analyses and *in situ* data could be used to fill gaps, but at what point does the gap become too long?

* Determine optimal subset of gauges for merge: eliminate redundancy, poor quality.

* Determine DORIS sites for referencing, taking account of above.

* Intercomparison with coupled climate models to determine optimal design.

ANNEX IX

NOAA'S SHIP OF OPPORTUNITY XBT PROGRAMME

by Robert Molinari

The International WOCE and TOGA programmes established requirements for upper ocean temperature data obtained from commercial vessels, i.e., Ships of Opportunity (SOOP) and Volunteer Observing Ships (VOS). The nominal WOCE network (which also includes the TOGA grid) is given in Figure 1. Three types of sampling are given: low density sampling along all the lines includes monthly coverage with four XBT launches per day (about 90 nautical miles spacing from a typical merchant ship); high density sampling includes seasonal coverage with 50 km spacing in the interior and 10-30 km spacing along the boundaries and across high gradient regions; and frequently sampled lines including 18 transects per year along a particular transect. Sampling requirements were derived from earlier studies of the statistical variability of the tropical upper ocean thermal field in the Pacific.

NOAA's VOS programme supports VOS lines in all three oceans. Real-time sampling (i. e., temperature profiles are transmitted via satellite in real-time) for 1995 is shown in Figure 2. Approximately 17,000 probes were deployed globally. Similar probe deployments are planned for 1996. Although it's an "operational" programme, support for the purchase of probes comes from a research component of NOAA: the Office of Global programmes. Salaries for the operational aspects of the programme, until now, have come from the National Ocean Service (i.e., operational dollars). However, shortly the salary support will be transferred to the Ocean and Atmosphere Research line of NOAA (i. e., research dollars).

The Office of Global programmes also supports an Upper Ocean Thermal Centre at AOML. The objectives of the centre are to: (i) perform the operational requirements to maintain the global VOS grid; (ii) quality control delayed mode data; (iii) generate products from the real and delayed mode data; (iv) identify climatically important upper ocean signals; (v) perform numerical model validation studies with the data and (vi) develop cost-effective sampling strategies for climatically important signals. To date, the major emphasis of the Centre has been on Atlantic Ocean issues with studies on all six of the elements just listed. The efforts in the Pacific and Indian Oceans have been primarily operational.

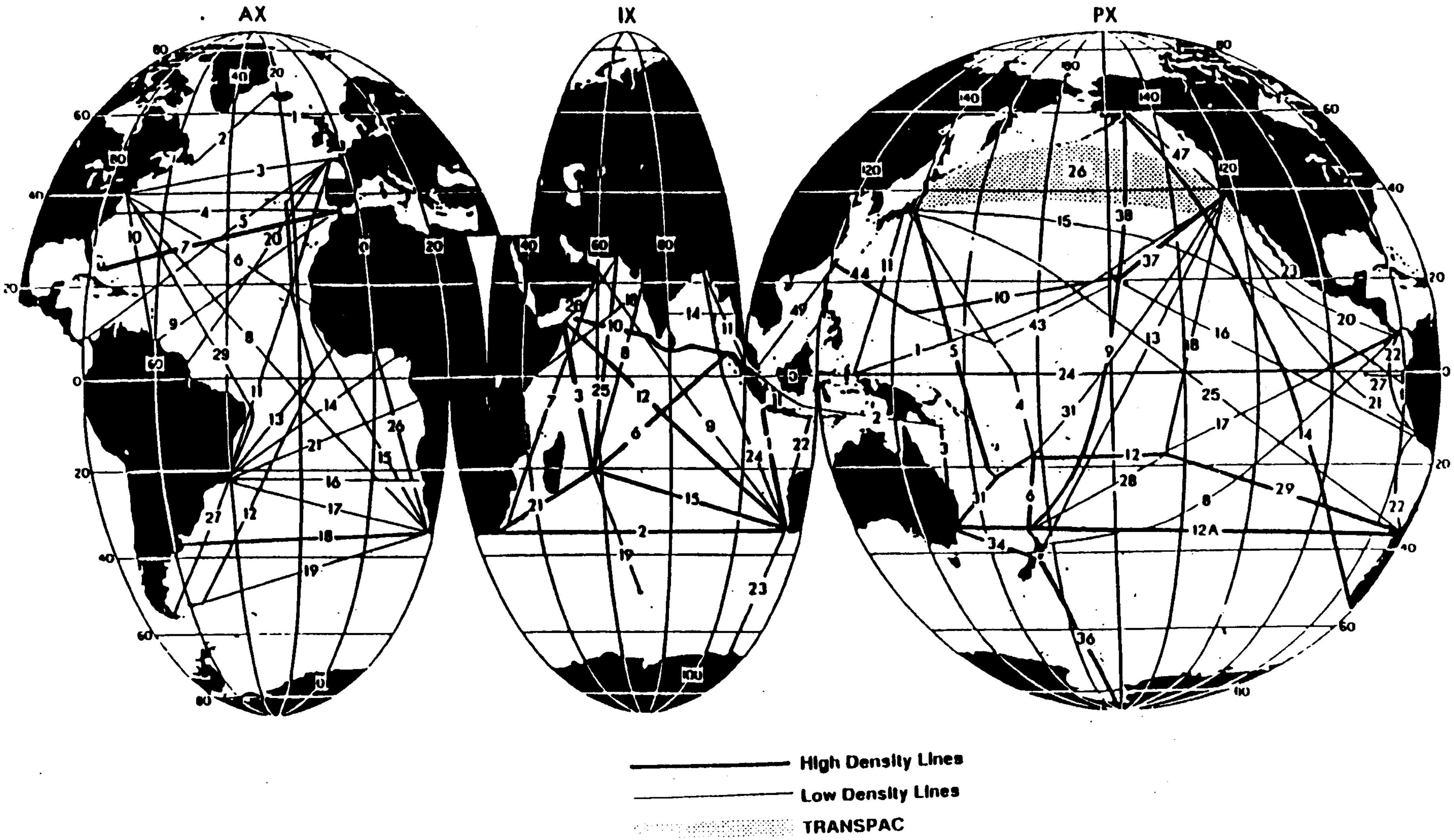


Figure 1: The WOCE XBT Grid. Numbers on the sections represent line designators

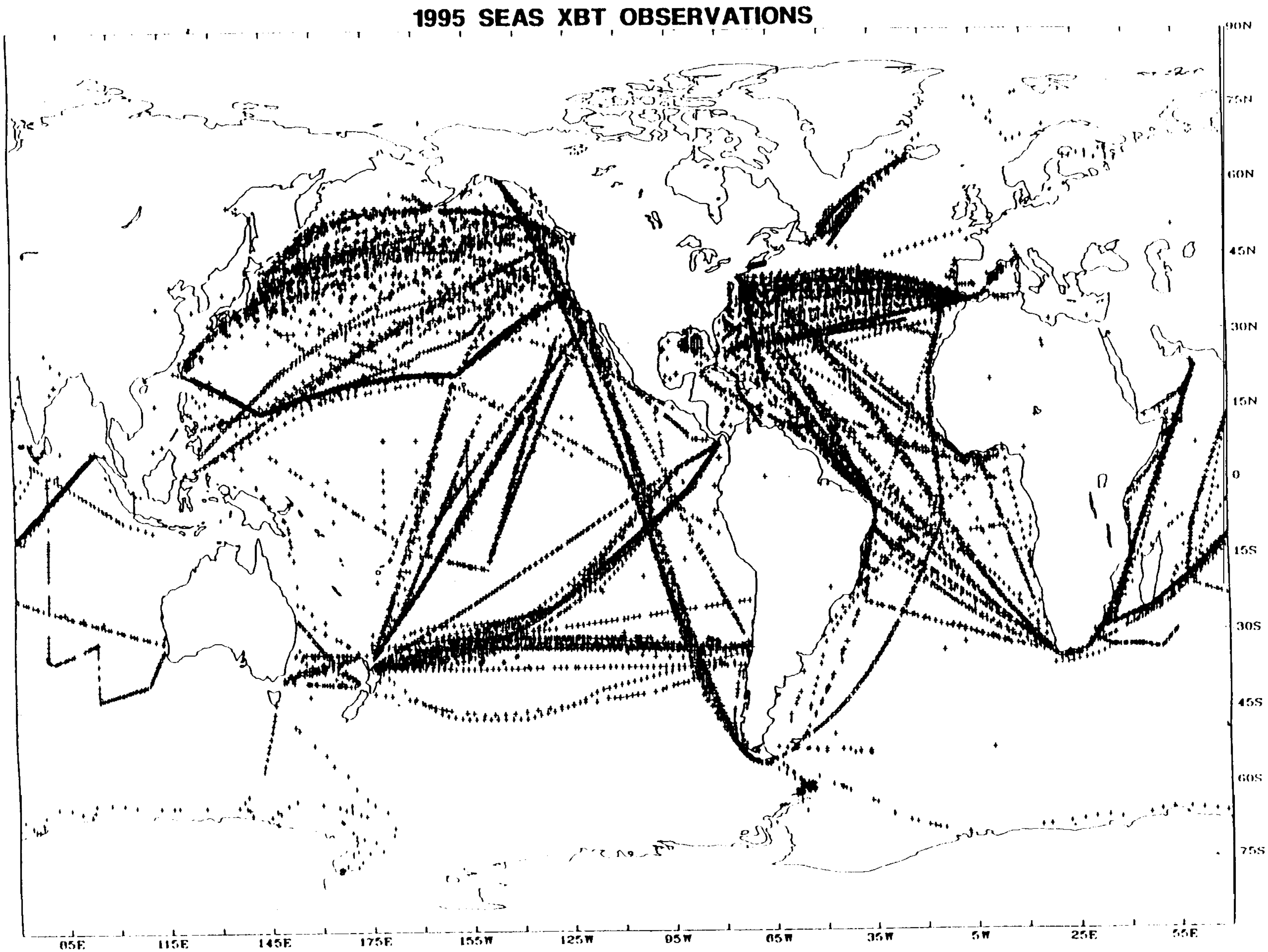


Figure 2: NOAA XBT Observations during 1995

ANNEX X

SPECIFIC IMPLEMENTATION ISSUES: FLOATS

by Walter Zenk, Institut fuer Meereskunde Kiel

Floats are the' only instruments capable of directly measuring in-situ ocean currents over large areas and for long times. The past five years have seen a tremendous increase of applications of neutrally buoyant floats in ocean science. The call for in-situ Lagrangian observations on a global scale was initiated by the WOCE Implementation Plan (WCRP 11/12, 1988) requesting a coverage of 5 float years in every 500 x 500 km2 region of the oceans. With the advent of WOCE many float prototypes have been turned into commercial products. We estimate that by the end of the WOCE observational phase about 1000 floats will have been sent on their missions.

Since the early days of Swallow and SOFAR floats, today a variety of float types are available for scientific and operational applications. Depending on different needs one can distinguish between floats with capabilities for acoustic tracking and those instruments that can cycle between predetermined depths and the surface. The majority of the first type, RAFOS floats, are designed for mission length of up to two years collecting time-of-arrival signals from an array of moored acoustic generators. Ranges of over 3000 km have been obtained depending on sound propagation conditions in the region under investigation. The second species - mostly the Autonomous Lagrangian Circulation Explorer - has no record of its underwater drift between regular returns to the sea surface. While at the surface, ALACE floats report only their present location and may transmit optionally temperature and salinity profiles (ALACE, PALACE, SPALACE).

Table 1 gives a compressed overview on key properties of active and passive floats together with a hybrid type, i.e. the French MARVOR. In comparing basic float types insonification costs for underwater tracking need to be considered. The network of sound generator moorings, necessary for RAFOS floats, can be shared among participating institutions/agencies/nations as the WOCE example in the South Atlantic has successfully demonstrated (Fig. 1). The costs of one deep-sea sound source mooring corresponds to at least ten RAFOS floats.

The nature of low-cost, one-time RAFOS floats allows only two parameter profiles during the beginning and the end of their mission. Only up-profiles have a near real-time potential which makes them less suitable for upper ocean thermal observations. The strength of RAFOS floats lies in their in-situ, eddy- resolving, roving-current meter capabilities.

In large regions of the Pacific and the Southern Ocean the WOCE fleet of ALACEs has delivered an amazing amount of new information on circulation patterns at mid-depth ranges. The majority of WOCE floats in the South Atlantic consist of RAFOS floats. Fig. 2 shows a subset of trajectories collected by IfM Kiel.

In the future we expect, that the trend towards profiling facilities of cycling floats will continue. Improved deployment strategies and equipment. will be necessary for float launches from ships of opportunity at full speed. Devices for delayed in-situ release of floats are presently under construction. They will enable float observations at smaller-scale regions such as passages and channels. While waiting for their mission starts these floats will be temporarily fixed on the sea bottom (Float Park).

Abbreviations:

ALACE	Autonomous Lagrangian Circulation Explorer
ALFOS	Combination of ALACE and RAFOS
IfM	Institut fuer Meereskunde
IFREMER	Institut Français de Recherche pour l'Exploitation de la Mer
MARVOR	Hybrid active and passive float named after Bretonian word for seahorse ,
PALACE	Profiling Autonomous Lagrangian Circulation Explorer
RAFOS	SOFAR spelled backwards or Ranging and Fixing of Sound
RSMAS	Rosenstiel School of Marine and Atmospheric Sciences
SIO	Scripps Institution of Oceanography
SIVOR	Passive version of MARVOR
SOFAR	Sound Fixing and Ranging
SPALACE	Profiling Lagrangian Circulation Explorer with temperature and salinity observing facilities
URI	University of Rhode Island
UW	University of Washington
WCRP	World Climate Research Program
WHOI	Woods Hole Oceanographic institution

Selected references:

Davis, R. E., D.C. Webb, L.A. Regier und J. Dufour (1992): The Autonomous Lagrangian Circulation Explorer (ALACE). J. Atm.
Oc. Techn., 9, 264-285.

Konig, H. and W. Zenk (1992): Principles of RAFOS technology at the Institut fur Meereskunde Kiel. Ber. Inst. f. Meereskunde Kiel, Nr. 222, 99 S.

Ollitrault, M., G. Loaec and C. Dumortier (1994): MARVOR: A multi-cycle RAFOS float. Sea Techn., 35, 39-44.

Rossby, T., D. Dorson and J. Fontaine (1986): The RAFOS System. J. Atm. Oc. Techn., 3, 672-679.

Swallow, J.C. (1955): A neutral-buoyancy float for measuring deep currents. Deep-Sea Res., 3, 74-81.

Konig, H., K. Schultz Tokos and W. Zenk (1991): MAFOS - a simple tool for monitoring the performance of RAFOS sound sources in the ocean. J. Atm. Oc. Techn., 8, 669-676.

Table 1: Float Essentials

Table 1: Float Essentials

Needs	Eddy resolving Underwater tracking		Large-scale no UW tracking
	max. 2 profiles	cyclic profilers	
Types	RAFOS (SOFAR) (SIVOR)	MARVOR (ALFOS)	ALACE (S)PALACE
Mission (typical)	< 2 y	< 5 y/50 cycles	
Costs (RAFOS units)	1	4-5	2-3
Number in WOCE estimated	200	100	> 500
Insoni-fication	yes, shared between France, Germany, USA (South Atlantic)		no
Future trend	Float park (delayed missions)	(?)	more profiling capabilities
Primary users	**URI, IfM, RSMAS WHOI, UW**	IFREMER	SIO and numerous others

Status: End of 1995

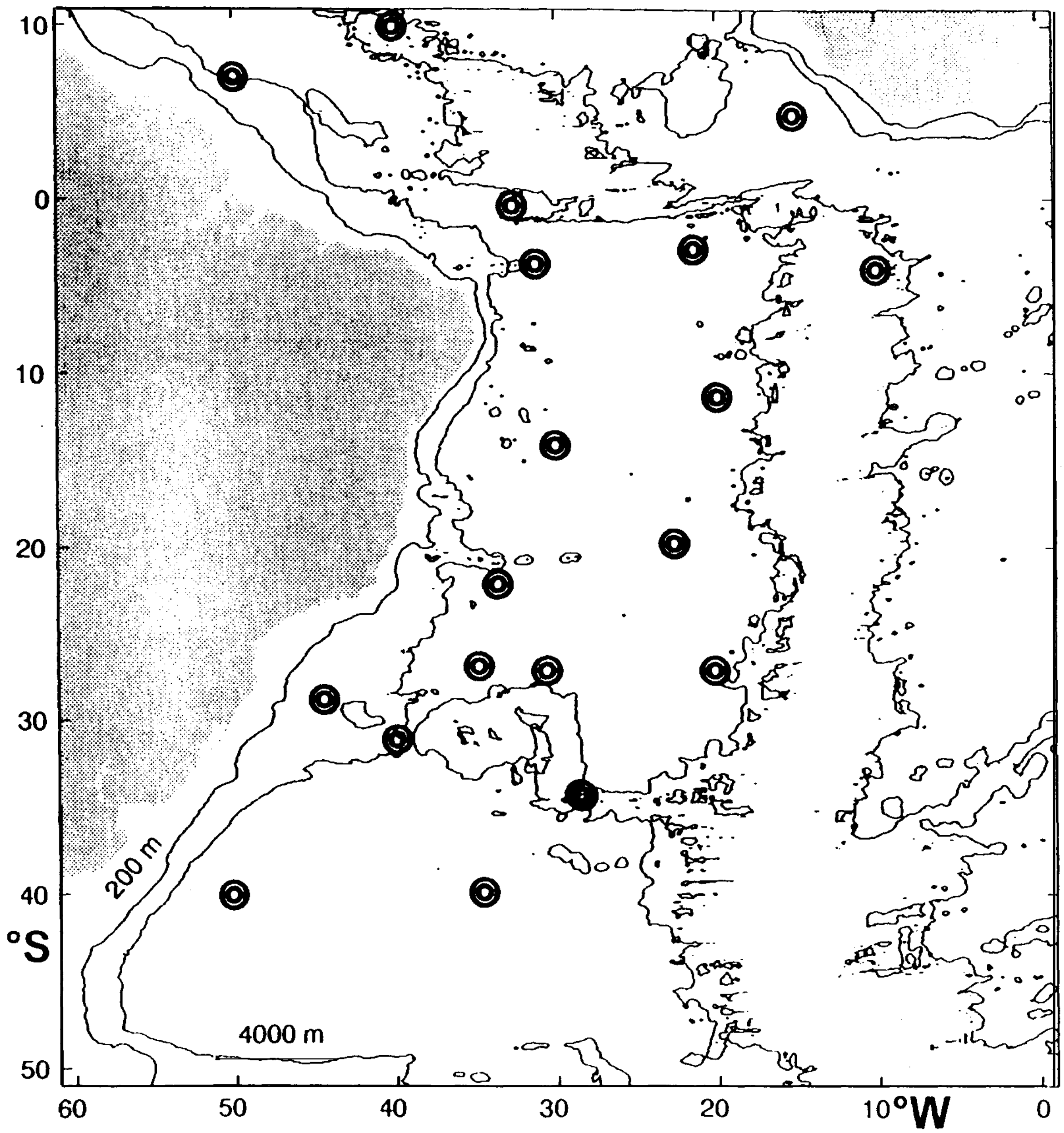


Figure 1: Distribution of shared moorings in the South Atlantic carrying RAFOS signal generators. A few of these moorings were additionally used as platforms for self-recording current meters. RAFOS sources were provided by IFREMER Brest, IfM Kiel and WHOI.
Status: early 1996

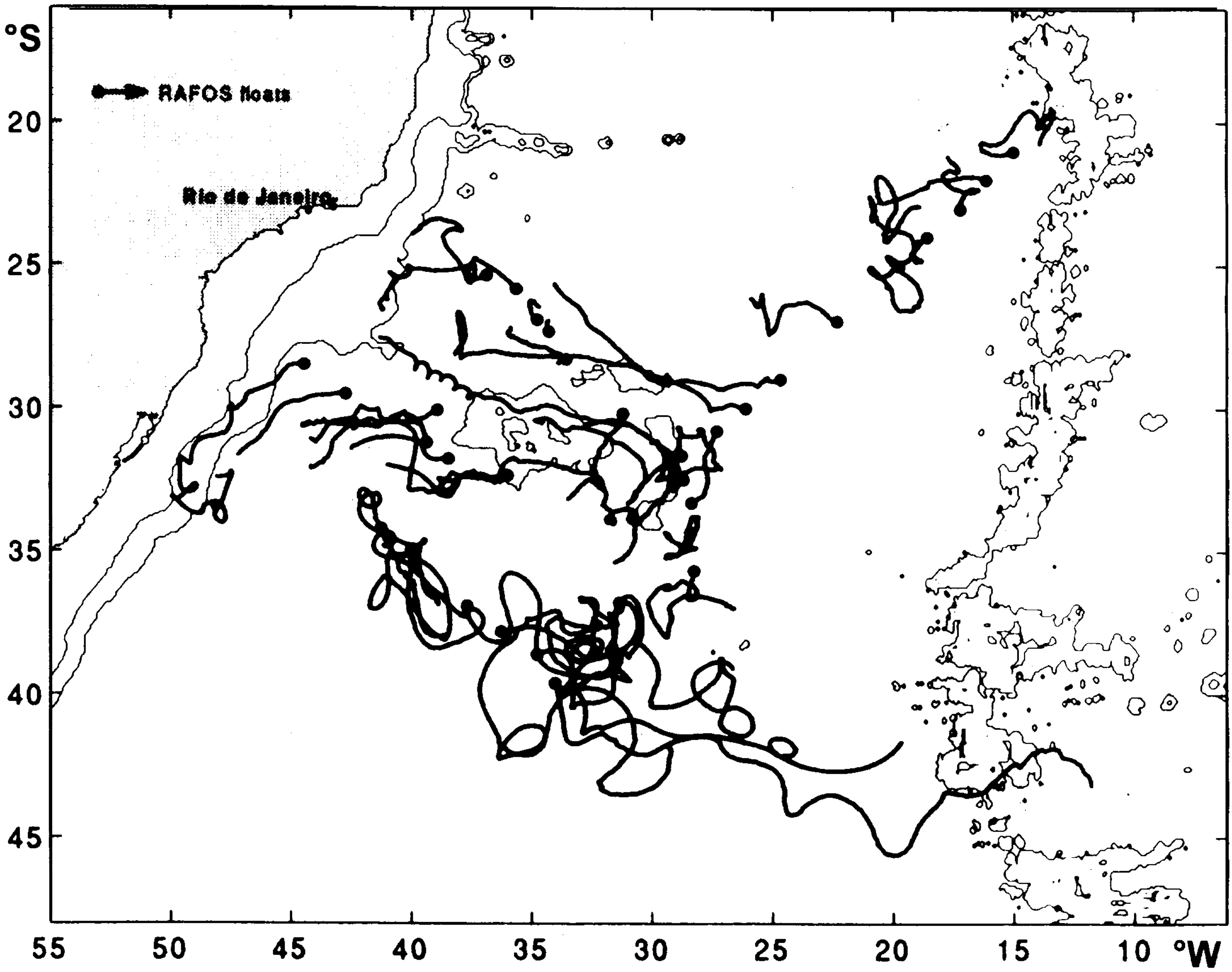


Figure 2: Example of RAFOS trajectories from the South Atlantic.

The displayed data subset was collected from the depth level of the Antarctic Intermediate Water (~900m depth) by IfM Kiel between 1992 and 1995. Mission lengths varied between several months and 1 1/2 years. Further float data were collected in the same region by IFREMER and WHOI

ANNEX XI

COMPARISON OF ATSR AND AVHRR SST RETRIEVALS

Richard W. Reynolds

A sea surface temperature (SST) analysis is routinely produced at the NOAA National Center for Environmental Prediction (NCEP) using in situ and satellite SST data. The satellite data are derived from a multichannel retrieval algorithm using the AVHRR instrument. The algorithm is tuned by comparisons to buoys. This procedure effectively converts the skin satellite SST (observed by the satellite) to a bulk SST (observed by the buoy). Because the AVHRR algorithm is only tuned periodically and is not a function of location, some satellite biases may remain. In the NCEP analysis, the first step is to correct any satellite biases using the in situ data on scales of 12° or larger. Then, the bias-corrected satellite data and the in situ data are analyzed using optimum interpolation.

The use of additional satellite data could improve the spatial and temporal resolution of the analysis, The ATSR instrument on ERS-1 allows a dual look at the sea surface. The dual look has a potential to reduce sensitivity to cloud and aerosol contamination of the retrievals. Elimination of this contamination, which reduces the SST value, has been one of the most difficult obstacles in producing accurate SST retrievals. In contrast to AVHRR, the ATSR algorithm is designed to directly produce a skin SST retrieval.

To compare the retrievals, the period of TOGA-COARE (October 1992 through February 1993) was selected because of the availability of additional in-situ data. Analyses were produced using either the AVHRR or the ATSR data. It was anticipated that any differences between skin and bulk retrievals could be corrected by the analysis procedures. The averages of the daily daytime and nighttime differences between ATSR and AVHRR retrievals were computed. The nighttime and daytime differences were similar so only the nighttime differences are shown in Figure XI. 1. The shaded areas in the figure show regions where the ATSR retrievals are more than 1°C colder than the AVHRR retrievals. The largest of these regions is in the tropical western Pacific.

To determine if these differences are reasonable, SSTs were obtained from the IMET buoy at 1.8°S and 156°N. The average diurnal bulk and skin SST from the buoy is shown in Figure X1.2 The bulk SSTs were directly measured at 0.45m. The skin SSTs were modeled from measured heat and momentum fluxes and the bulk SSTs. These computed skin SSTS were also verified against direct skin measurements from nearby ships and planes. The results show the skin and bulk temperatures were relatively constant during the night with the skin temperatures being approximately 0.3°C colder than the bulk. At this location the nighttime ATSR data were 1.8°C colder than the AVHRR. Compared to the buoy, the AVHRR were data 0.2°C warmer than the bulk SSTs. Thus, the ATSR data were too cold. The differences in Figure XI. 1 show that regions where the ATSR is over 0.5°C colder than the AVHRR tend to be regions with persistent cloud cover, e. g,, the ITCZ region in the Atlantic and eastern Pacific between roughly 5°N and 15°N.

The NCEP analysis using the ATSR data could not completely correct for the ATSR retrieval biases because the spatial scales were smaller than the 12° spatial scales used for the bias correction. These scales are limited by the availability of the in situ data and can only be decreased by increasing the temporal averaging period. In addition no correction of the ATSR retrievals was possible south of roughly 45°S because of a lack of in-situ data there. The ATSR retrievals will not be used in the NCEP analysis until the biases can be corrected. These results have been communicated to the ATSR scientists who are working on the bias problem.

*IMET: Improved Meteorological Measurements for Buoys and Ships

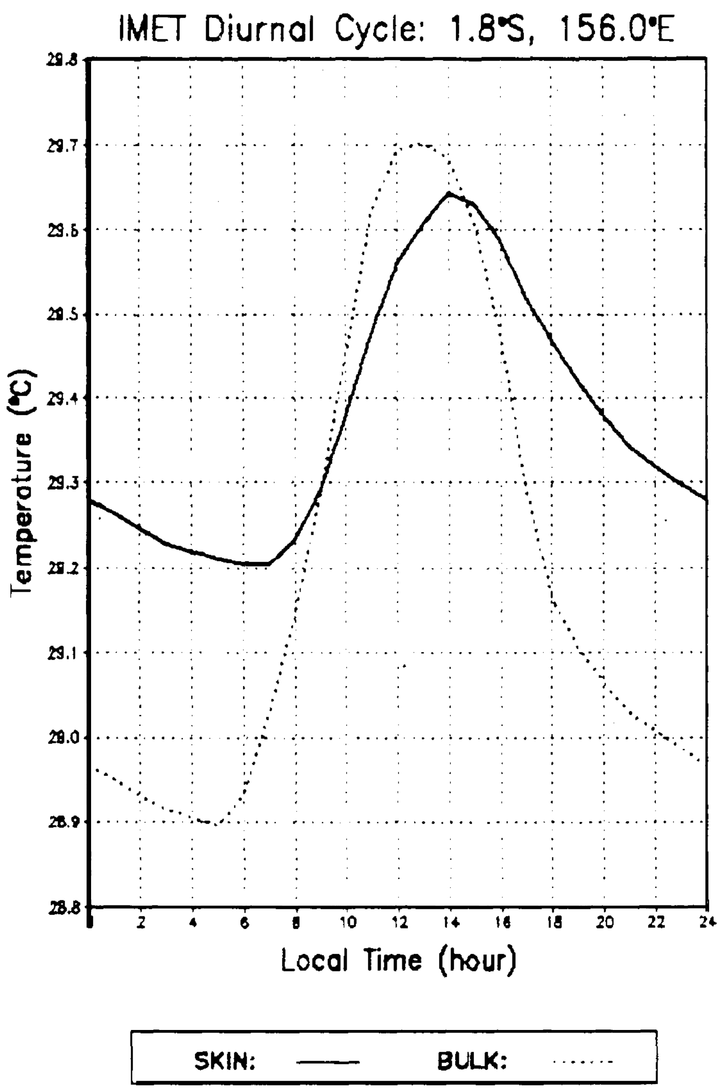


Figure XI.1 Average of the daily difference between the night-time ATSR and the night-time AVHRR SST retrievals for October 5, 1992 to February 28, 1993. The sign of the difference is ATSR minus AVHRR. The contour interval is 0.5°C with negative contours dashed; differences less than -1°C are shaded.

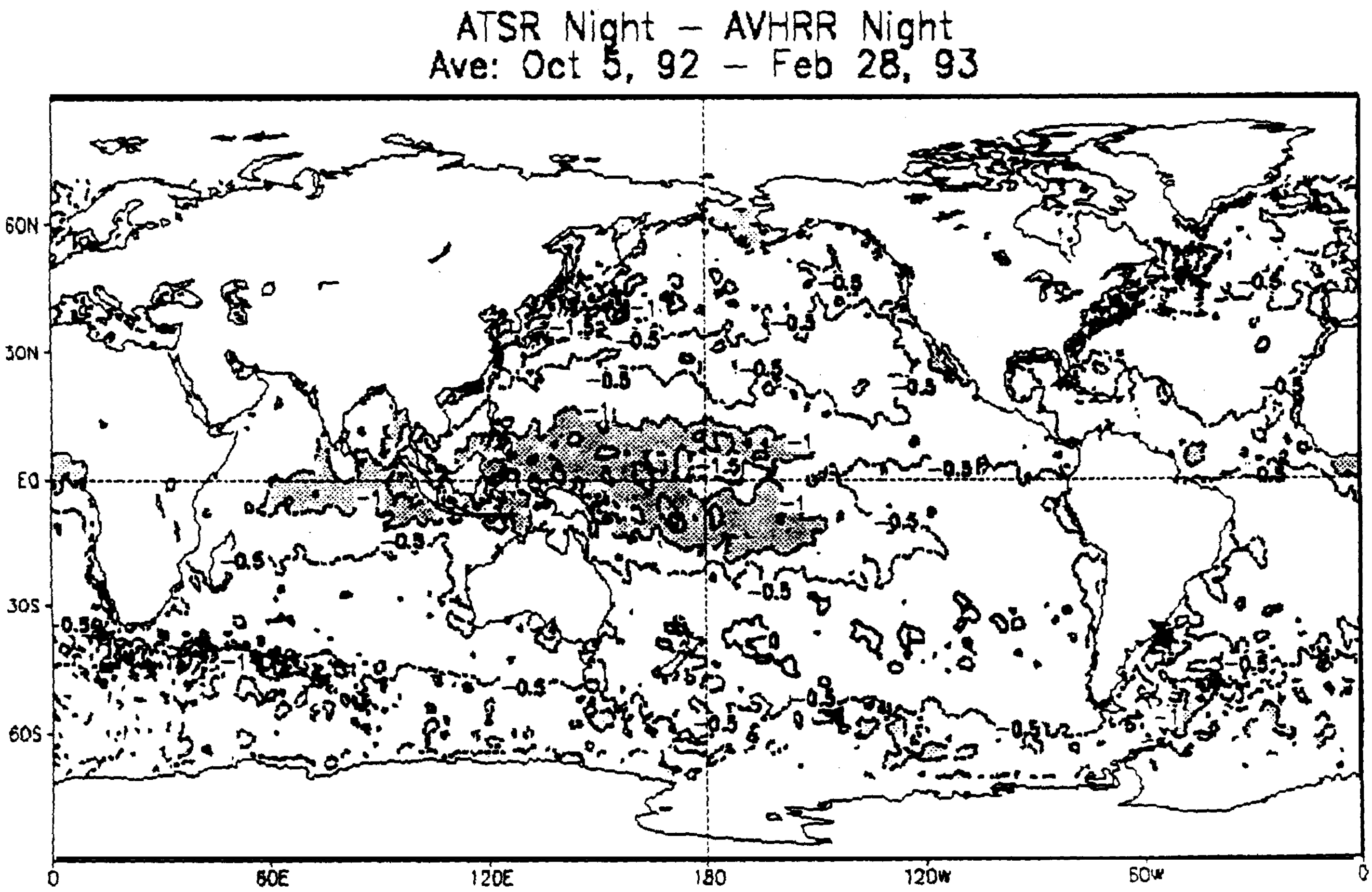


Figure XI.2 Average diurnal cycle of skin and bulk SST at the IMET moored buoy at 1.8°C and 156°E for the period October 22, 1992 to March 3, 1993.

ANNEX XII

OCEAN REQUIREMENTS AND SATELLITE SENSOR TABLES
From GCOS Report 15

TABLE 4-1

VARIABLE	SCALE	RESOLUTION	FREQUENCY	ACCURACY	COMMENTS
SEA SURFACE TEMPERATURE	Tropics Global	200 km 200–500 km	15 day monthly	0.3 - 0.5 K 0.1 K bias	Seasonal forecast Climate monitoring
SURFACE WIND	Global ocean	100 km	12 hr	2 m/s	
SURFACE TOPOGRAPHY	Global ocean	100 km	10 days	5 cm	
SEA-ICE EXTENT	Polar ocean	30 km	1 day	2 - 5 %	
BIOMASS	Global ocean	to be determined	to be determined	to be determined	

Observing System Requirements Inferred from the Ocean Observation System Development Panel Report

No.	Variable	Instrument Acronym	Instrument Type	Class	Comments
3	OCEAN-AIR BOUNDARY				
3.1	Sea Surface Temperature	See 2.4			
3.2	Ocean Surface Wind Vectors	ASCAT	Microwave Scatterometer	F(P)	As part of an integrated observing system; continuity in doubt
		NSCAT; Sea-Winds	Microwave Scatterometer	C(P)	As part of an integrated observing system; continuity in doubt
		AMI	Microwave Scatterometer	P	As part of an integrated observing system; continuity in doubt; performance limitations
3.3	Ocean Surface Wind Speed	SSM/I	Microwave Scanning Radiometer	C	Performance limitations
		ALT; SSALT-2 (on TOPEX/POSEIDON; TPFO)	Radar Altimeter	C(P)	Performance limitations
		RA; RA-2; etc. (on ERS/ENVISAT)	Radar Altimeter	P	As part of an integrated observing system; continuity and performance limitations
		GEOSAT FO-1,-2	Radar Altimeter	P(P)	Performance limitations; continuity in doubt
		MIMR	Microwave Imaging Radiometer	P(P)	Performance limitations; continuity in doubt
3.4	Ocean Wave Height	ALT; SSALT-2 (on TOPEX/POSEIDON; TPFO)	Radar Altimeter	C(P)	As part of an integrated observing system; continuity in doubt
		RA, RA-2, etc	Radar Altimeter	P	As part of an integrated observing system; continuity in doubt
		GEOSAT FO-1,-2	Radar Altimeter	P(P)	As part of an integrated observing system; continuity in doubt
3.5	Atmospheric Surface Pressure				

No.	Variable	Instrument Acronym	Instrument Type	Class	Comments
2	OCEAN CHARACTERISTICS				
2.1	Upper Ocean Biomass	Sea WiFS MODIS	VIS Radiometer Multi-channel Imager	F(P)	Performance and consistency to be confirmed
		OCTS/GLI POLDER	VIS/IR Imager NIR/Visible Radiometer	P	Performance and continuity to be confirmed
2.2	Ocean Surface Topography	ALT; SSALT-2 (on TOPEX/POSEIDON; TPFO)	Radar Altimeter System	F(P)	As part of an integrated system; continuity in doubt
		RA; RA-2 (on ERS/ENVISAT)	Radar Altimeter System	P	As part of an integrated system; continuity in doubt
		GEOSAT FO-1,-2	Radar Altimeter System	P(P)	As part of an integrated system; continuity in doubt
2.3	Sea Ice Cover	SSM/I	Microwave Imaging Radiometer	F	
		AVHRR-2;-3	Multi-channel VIS/IR Radiometer	C	Performance limitations
		MODIS	Multi-channel Imager	C(P)	Performance to be confirmed; continuity in doubt
		ATSR-1,-2; AATSR	Dual Path IR Radiometer	P	Performance limitations; continuity in doubt
		MIMR	Microwave Scanning Radiometer	P(P)	Continuity in doubt
2.4	Sea Surface Temperature	MODIS	Multi-channel Imager	F(P)	Performance to be confirmed; continuity in doubt
		ATSR-1,-2; AATSR	Dual Path NIR/IR Radiometer	F(P)	Continuity in doubt
		AVHRR-2,-3	Multi-channel VIS/IR Radiometer	C	Performance limitations
		AIRS	Infrared Sounder	C(P)	Low resolution; continuity in doubt
		IASI	Infrared Sounder	C(P)	Low resolution; continuity in doubt
		OCTS/GLI	VIS/IR Imager	P	Performance to be confirmed; continuity in doubt
2.5	Sea Surface Salinity				
2.6	Geoid				

ANNEX XIII

SATELLITE ALTIMETRY AND SEA LEVEL

by Christian Le Provost

The France-US altimetric satellite TOPEX-POSEIDON (TP) has been supplying every ten days, since October 1992, a quasi-global measure of the sea surface topography (from 66°S to 66°N) with an along-track accuracy of the order to 3-4 cm. This unprecedented accuracy makes possible the extraction of much new information on the ocean circulation, gyre scale variabilities, ocean tides, low frequency wave dynamics, the patterns of global seasonal cycle, and global to regional mean sea level variations. Many results obtained to date from the mission have been published in two special issues of the Journal of Geophysical Research (Vol. 99, No. C12, 1994; Vol. 100. C 12, 1995). An overview of these results allows to consolidate or enhance the potential usefulness of satellite altimetry within a global ocean observing system, by reference to the OOSDP report.

Season to Interannual Variabilities

A major feature of the global variability spectrum is an increase of variance at the annual period for wave lengths ranging from 500 to 10,000 km (Wunsch and Stammer, 1995). A hemispheric asymmetry is observed in this annual cycle (Cheney *et al,* 1994; Minster *et al.* 1995): mean sea level annual variation in the Northern Hemisphere is twice that in the Southern Hemisphere. This asymmetry is consistent with the greater seasonal changes of oceanic heat content in the Northern Hemisphere. This new observation opens the way for a better understanding of the global air-sea flux exchanges. Minster *et al* 1995, for example, clearly pointed out a phase lag of two months between the maximum of the SST and the maximum of the sea surface height, at mid latitudes, due to the mixed-layer deepening processes. At smaller scales, typical annual signals are observed in many areas, e.g., the seasonal cycle of the Northern Equatorial Counter Current in the Atlantic and the Pacific, and of the monsoons in the Indian Ocean.

One important finding of the analysis of this three-year set of observations is that the interannual variability can be of the same order as the seasonal signals: the steric effect appears lower in 1993, interannual variations in the Indian Ocean appear to be large, as in the Pacific Ocean, spring 1995 is characterized by an abnormal increase of the mean sea level in the east Atlantic Ocean.

TP covered more than half of the series of El Nino events during the period 1991-1995 which mostly involved the tropical Pacific Ocean and the Indian Ocean. A combination of TP and ***in situ*** observations from the Tropical Ocean Global Atmosphere-Tropical Atmosphere Ocean moorings and drifting buoys has allowed comprehensive studies of these El Nino events (Busalacchi *et al,* **1994).** Investigations on the complexity of the tropical Indo-Pacific system has shown that the equatorial Kelvin waves do not necessarily reach the eastern coasts, revealing the role of local wind forcing. Boulanger and Menkes (1995) did not find any evidence of Rossby wave reflection at the western boundary to terminate the 1992-1993 warm event, as theory suggests.

Sub Seasonal Variabilities

The large scale variability at intraseasonal time scales is difficult to study from observations, because of the presence of mesoscale eddy variability. TP observations revealed for the first time the geographic distribution of this large scale intraseasonal variability, and its barotropic nature, as a forced response to wind (Fu and Davidson, 1995).

Heat Storage

As stated above, TP data will help to understand the global air-sea heat flux exchanges. In this perspective, White and Tai (1995) have investigated the potential of mixing XBT and TP data, from 30° S to 60° N, over the period 1993 and 1994. They checked the agreement between TP dynamic height and XBT heat storage anomalies: the correlation is of the order of 0.5 to 0.8, with slopes of regression ranging from 0.05 to 0.15 10^{-9} W-s/m²/cm. TP estimates of heat storage are less precise than those computed from XBTs, but White and Tai suggest that when combined with XBTs, their regular coverage allows to reach the error level of $\pm$ 2 W/m². This is half that achieved by XBT sampling and exactly that specified as the goal of WOCE. Then the observed rate of change in the upper ocean heat storage anomalies thus computed becomes statistically significant.

Validation of Ocean Circulation Models

Over the recent years, numerical models of general ocean circulation have significantly improved, due to the increasing power of the computers which allows higher and higher resolution. **The TP data has been shown to be very useful for validation of this kind of model.** One illustration was given recently by Fu and Smith (1996), with three years of TP and a high resolution simulation of the world ocean circulation (1/5° resolution, i.e., 31,5 km at the equator, 22.2 km at mid-latitudes, and 6.5 km at the highest latitudes) forced by 85-95 ECMWF wind fields, surface heat flux climatologies from Barnier *et al* (1995), and nudged surface salinity from Levitus seasonal climatologies.

The model results agree rather well with altimeter data, for the different classes of variability: the general geographical patterns of the sea level variability at the mesoscale, intraseasonal seasonal and interannual. The eddy activity in the main western boundary currents and Antarctic Circumpolar Current is in reasonable agreement, but the model fails to simulate the Gulf Stream and Kuroshio extensions, and, more globally, the correct level of variance, by a factor of 2. When smoothing the data at larger scales (600 km x 300 km) and at the seasonal cycle, the agreement is good (however, here also with weaker activity in the model) for steric hemispheric oscillations, the Indian Ocean monsoon, the North Equatorial Undercurrent, and upwellings along the South American, and African coasts. At the subseasonal frequencies, the large-scale variability associated to the barotropic response of the ocean to high frequency wind forcing, observed by Fu and Davidson (1995) in the TP data (see above) is well reproduced in the model,

The observed discrepancies between the TP data and the model results are not well understood (need for even more resolution, adequacy of the parameterizations, quality of the ocean-atmosphere fluxes?). **Assimilation of the TP data into models has shown promising improvements** (Blayo *et al* **1995): this is actually a field of intensive research.**

Global Mean Sea Level

The long-term rate of sea level rise, 1.8 mm/y at the century scale, has been up till now estimated from the Permanent Service for Mean Sea Level (PSMSL) archive, based on all the existing tide gauge measurements collected since the middle of the last century. However, it is recognized that the data set is not very well suited for this estimate. Moreover, the mean sea level is not rising everywhere at the same rate and thus the tide gauge network is not adequate for global monitoring. **The remarkable accuracy and precision of TP data indicate that the evolution of the mean sea level and its geographical distribution may be observable by this system.** Estimates based on three years of TP data indicate a global mean sea level rise at a rate of 4 to 6 mm/y (Nerem, 1995; Minster *et al*, 1995), A map giving the geographic distribution of this rate of sea level change has been produced by Nerem (1995): it has been estimated from a least- square fit of a linear trend plus annual and semi-annual harmonics to the first three years of TP data. Because of the short duration of the record, these results are dominated by the interannual variabilities, mainly the El Nino events. It is thus impossible to attribute these results to possible global warming. However, the patter displayed in this map appears to be coherent in space and time with the sea surface temperature rise during the same period. This correlation between sea level and SST signals are encouraging, indicating that oceanographic interannual variations are being observed.

The goal of observing with satellite altimetry the long-term evolution of the mean sea level remains extremely challenging. One major question is to control the possible drift of the system. A number of independent calibration experiments indicate for example that a drift may actually exist in the above mentioned TP estimate, of the order of 2 mm/y, which leads to a revised sea level rise of 2 to 4 mm/y over the last three years. This clearly underscores the need for external systems of calibration of the accuracy of the altimeter systems. This is even more necessary on the very long-term, in order to ensure the links between the successive altimeter missions, especially if these missions have no overlap. The global sea level network settled for TOGA and WOCE has been shown to be able to play this role (Mitchum, 1994). A series of altimetric satellite missions of the class of precision of TP, with a calibration relying on a tide gauge network, located in the same reference frame as the altimetric system, telemetering the data in quasi-real time, could be the more efficient way to monitor on the long-term the evolution of the mean sea level at the global scale.

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ANNEX XIV

GLOSSARY OF ACRONYMS AND SPECIAL TERMS

ACC	Antarctic Circumpolar Current
ALACE	Autonomous Lagrangian Circulation Explorer (float)
ATSR	Along-Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
BOM	Bureau of Meteorology
BT	Bathythermograph
CCCO	Comité Coordinator sobre la Capa de Ozono
CEOS	Committee on Earth Observation Satellites
CLIVAR	Cimate Variability and Predictability Programme
CMM	Commision for Marine Meteorology
COADS	Comprehensive Atmosphere Data Sets
COARE	Coupled Ocean-Atmosphere Response Experiment
DBCP	Data Buoy Cooperation Panel
ENSO	El Nino Southern Oscillation
GAW	Global Atmosphere Watch
GCOS	Global Climate Observing System
GEWEX	Global Energy and Water Cycle Experiment
GLOBEC	Global Ocean Ecosystems Dynamics
GOOS	Global Ocean observing System
GTOS	Global Terrestrial Observing System
IGBP	International Geosphere-Biosphere Programme
IPCC	Intergovernmental Panel on Climate Change
JGOFS	Joint Global Ocean Fluxes Study
JMA	Japan Meteorological Agency
JPO	Joint Planning Office
JSC	Joint Scientific Panel (of the WCRP)
JSTC	Joint Scientific and Technical Committee for GCOS
LOICZ	Land-Ocean Interaction in the Coastal Zone
MBARI	Monterey Bay Aquarium Research Institute
NEG	Numerical Experiment Group
NOAA	National Oceanic and Atmospheric Administration (USA)
OOPC	Ocean Observations Panel for Climate
OOSC	Ocean Observing System for Climate
OOSDP	Ocean Oberving System Development Panel
OOSE	Observing System Simulation Experiment
OSE	Observing System Experiment
PALACE	Profiling ALACE Floats
PMEL	Pacific Marine Environmental Laboratory
RSMAS	Rosenstiel School of Marine and Atmospheric Sciences
SCOR	Scientific Committee on Oceanic Research
SOLAF	Surface Ocean Lower Atmosphere Feedback
SOOP	Ship of Opportunity Programme
SPALACE	Profiling Lagrangian Circulation Explorer with temperature and salinity observing facilities
TOPEX	Ocean Topography Experiment
TOR	Terms of Reference

UOP	Upper Ocean Panel (of CLIVAR)
VOS	Vessel of Opportunity
WCRP	World Climate Research Programme
WHOI	Woods Hole Oceanographic Programme
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WWW	World Weather Watch (of WMO)
XBT	Expendable BT

82. Second Meeting of the UNEP-IOC-ASPEI Global Task Team on the Implications of climate Change on Coral Reefs
83. Seventh Session of the JSC Ocean Observing System Development Panel
84. Fourth Session of the IODE Group of Experts on Marine Information Management
85. Sixth Session of the IOC Editorial Board for the International Bathymetric chart of the Mediterranean and its Geological/Geophysical Series
86. Fourth Session of the Joint IOC-JGOFS Panel on Carbon Dioxide
87. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Pacific
88. Eighth Session of the JSC Ocean Observing System Development Panel
89. Ninth Session of the JSC Ocean Observing System Development Panel
90. Sixth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
91. First Session of the IOC-FAO Group of Experts on OSLR for the IOCINCWIO Region
92. Fifth Session of the Joint IOC-JGOFS CO_2 Advisory Panel Meeting
93. Tenth Session of the JSC Ocean Observing System Development Panel
94. First Session of the Joint CMM-IGOSS-IODE Sub-group on Ocean Satellites and Remote Sensing
95. Third Session of the IOC Editorial Board for the International Chart of the Western Indian Ocean
96. Fourth Session of the IOC Group of Experts on the Global Sea Level Observing System
97. Joint Meeting of GEMSI and GEEP Core Groups
98. First Session of the Joint Scientific and Technical Committee for Global Ocean Observing System
99. Second International Meeting of Scientific and Technical Experts on Climate Change and the Oceans
100. First Meeting of the Officers of the Editorial Board for the International Bathymetric Chart of the Western Pacific
101. Fifth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico
102. Second Session of the Joint Scientific and Technical Committee for Global Ocean Observing System
103. Fifteenth Session of the Joint IOC-IHO Committee for the General Bathymetric Chart of the Oceans
104. Fifth Session of the IOC Consultative Group on Ocean Mapping
105. Fifth Session of the IODE Group of Experts on Marine Information Management
106. IOC-NOAA *Ad hoc* Consultation on Marine Biodiversity
107. Sixth Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
108. Third Session of the Health of the Oceans (HOTO) Panel of the Joint Scientific and Technical Committee for GOOS
109. Second Session of the Strategy Subcommittee (SSC) of the IOC-WMO-UNEP Intergovernmental Committee for the Global Ocean Observing System
110. Third Session of the Joint Scientific and Technical Committee for Global Ocean Observing System
111. First Session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for climate