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REPORT OF THE 5TH MEETING OF CLIVAR ATLANTIC IMPLEMENTATION PANEL

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CLIVAR is a component of the World Climate Research Programme (WCRP), which was established by WMO and ICSU, and is carried out in association with IOC and SCOR. The scientific planning and development of CLIVAR is under the guidance of the JSC Scientific Steering Group for CLIVAR assisted by the CLIVAR International Project Office. The Joint Scientific Committee (JSC) is the main body of WMO-ICSU-IOC formulating overall WCRP scientific concepts.

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Table of contents

Action Items

1) Submit list of new members to the panel for input and submit final list to SSG

(*Visbeck and Boscolo*)

2) Get more information on the status of ongoing and future CO_2 observation in the Atlantic. Is CARINA the right contact for future observations?

(*Boscolo, Bates and Hood*)

3) Strengthen interaction with OOPC for sustained observations in the Atlantic

(*Visbeck and Boscolo*)

4) Inform the Panel on improved surface flux fields pilot study in the Atlantic Ocean funded by NOAA.

(*Yu, Weller and Boscolo*)

5) Express support for holding a reanalyses workshop sometime in 2004

(*Visbeck and Stammer*)

6) Explore the willingness/capability of Coriolis and/or AOML and others to take on more CLIVAR data streams and their connectivity to reanalysis efforts

(*Bourles, Koltermann, Stammer, Busalacchi and Johns)*

7) Further Develop panel's perspective on data management needs

(*Koltermann and others*)

8) Update the proposal of the workshop on Atlantic Climate Predictability by taking into account the comments and suggestions put forward at the panel session.

(Sutton and Kushnir)

9) Propose to the SSG the endorsement of the Atlantic Climate Predictability Workshop.

(*Visbeck and Boscolo*)

10) Encourage the timely submission of the SACOS workshop recommendations to the community.

(*Piola, Reason and Wainer)*

11) Review the SACOS recommendations and provide feedback

(*Wright, Marshall, Mauritzen and Johns*)

12) Liaise with WGOMD and WGCM on planning joint activities on observing system design in particular in the S. Atlantic region.

(*Piola, Wainer and Reason*)

13) Liaise with CLIVAR/CliC SO Panel for the review of the GOODHOPE proposal.

(*Marshall, Koltermann and Piola*)

14) Work together with the AMMA group on strengthening of the climate component of the AMMA project

(*Bourles, Kushnir, Schott and Reason*)

15) Encourage further planning for a Tropical Atlantic Climate Experiment (TACE) and the submission of a white paper including STC, ITCZ, "PIRATA + extensions"

(*Schott, Johns, Kushnir, Reason and Bourles)*

16) Review the initial plans for the TACE

(*Sutton, Hurrell and Wainer*)

17) Express concern about leadership within PIRATA

(*Visbeck and ICPO*)

18) Provide feedback to ASOF Chair on the endorsement letter submitted to CLIVAR.

(*Mauritzen and Visbeck*)

19) Liaise with ASOF on the issue of CLIVAR/CliC role in the Arctic Ocean.

(*Mauritzen, Dickson, Ryabinin and Koltermann*)

20) It was agreed to foster the cooperation between the Atlantic Panel and WGOMD in the field of model and data intercomparisons. While in the present phase of OMIP it will not be possible to provide all the products being envisaged by the observational community, it was found important to explore possibilities for designing a programme of coordinated model experiments (e.g. an OMIP-2 phase) focusing on ocean variability.

(*Boening, Sutton and Schott)*

21) Further develop the Metrics of Atlantic Climate Variability and provide the inputs to WGOMD for ocean model verification.

(*Delworth, Wright, Johns and Schott*)

22) Update the proposal of the THC workshop and ask SSG for endorsement.

(*Visbeck, Boening and Boscolo*)

23) Inform the Panel on the outcome of the EURESCO conference on Achieving Climate Predictability by using Paleoclimate Data: EuroConference on North Atlantic Climate Variability, S. Feliu (Barcelona) 11-16 October 2003.

(*Boscolo and Wainer)*

24) Explore the possibility of holding the next Atlantic Panel session before or after the CLIVAR conference in June 2004. Possible venue: Columbia University, New York USA. Explore topics for next meeting: CLIVAR and the Arctic Ocean, extratropical climate modes: NAO and Stratosphere, summer season.

(Visbeck and Boscolo)

1. Background

The CLIVAR Atlantic Implementation Panel is a part of the CLIVAR organization. The panel is in charge of implementing the CLIVAR science plan in the Atlantic sector. More specifically its Terms of Reference are:

1. To recommend and oversee the implementation of observations in the Atlantic Ocean sector, in order to meet the objectives outlined in CLIVAR's Science and Initial Implementation Plans, particularly with respect to the Principal Research Areas D1 (North Atlantic Oscillation), D2 (Tropical Atlantic Variability) and D3 (Atlantic Thermohaline Circulation).
2. To collaborate with the JSC/CLIVAR Working Group on Coupled Modelling and CLIVAR Working Group on Seasonal-to-Interannual Prediction, in order to design appropriate numerical experiments, and to be aware of requirements set by these groups for data sets needed to validate models.
3. To liaise with the relevant CLIVAR panels, in particular The CLIVAR Ocean Observation Panel and the PIRATA Steering Group, to ensure that best use is made of resources from the global and equatorial research programs.
4. To liaise with Ocean Observation Panel for Climate and other relevant groups to ensure that CLIVAR benefits from and contributes to observations in GOOS and GCOS.
5. To report to the CLIVAR SSG.

The members of the CLIVAR Atlantic Implementation Panel are:

M. Visbeck (Chair)	Lamont-Doherty Earth Observatory, Palisades, USA
A. Busalacchi	ESSIC, University of Maryland, USA
T. Delworth	GFDL-NOAA, Princeton, USA
J. Hurrell	NCAR, Boulder, USA
W. Johns	RSMAS, Miami, USA
K.-P. Koltermann	Bundesamt Seeschiffahrt Hydrographie, Hamburg, Germany
Y. Kushnir	Lamont-Doherty Earth Observatory, Palisades, USA
D. Marshall	Dept. Meteorology, Uni. Reading, UK
C. Mauritzen	Norwegian Meteorological Institute, Norway
A. Piola	Servício de Hidrografia Naval, Buenos Aires, Argentina
C. Reason	University of Cape Town, South Africa
F. Schott	Institut für Meereskunde, Kiel, Germany
R. Sutton	Centre for Global Atmospheric Modelling, Uni. Reading, UK
I. Wainer	University of São Paulo, São Paulo, Brazil
D. Wright	Bedford Inst. of Oceanography, Dartmouth Canada
ICPO Representative is:	
R. Boscolo	ICPO SOC Southampton UK and IIM-CSIC Vigo Spain

2. Opening Session (panel members only)

Martin Visbeck (Chair) welcomed the panel members (Appendix A) to the Citadel Conference Centre in Villefranche-sur-Mer for the 5th session of the annual CLIVAR Atlantic Implementation meeting. This meeting followed the AGU/EGS Joint Assembly held in Nice, France, on 7-11 April 2003. The CLIVAR Working Group on Ocean Models Development (WGOMD) also decided to hold its 4th session at the same time and in the same Conference Centre, therefore the two chairmen scheduled joint discussions for specific agenda items in order to facilitate and foster co-operation between the two groups. Finally Roberta Boscolo was thanked for her help in organizing the logistics of the meeting.

2.1 Review of the Agenda

Martin Visbeck presented the agenda of the meeting (Appendix B) anticipating the joint sessions with WGOMD during the presentation of “Ocean Reanalysis” by D. Stammer on day 1 and for a two hour discussion on crosscutting ocean model issues on day 2. F. Schott expressed concerned that the time allocated to the joint session on day 2 was not enough to deal properly with the scheduled discussion items and also suggested that a discussion item concerning the PIRATA status should be included in the present agenda. Y. Kushnir anticipated that during his presentation on tropical Atlantic issues he would give a summary of the US CLIVAR workshop on "Dynamics and Predictability of the Atlantic ITCZ System" held at IRI in September 2002.

2.2 Review of the Panel Membership

Martin Visbeck welcomed the new members of the Atlantic Panel: W. Johns, D. Marshall, C. Mauritzen and D. Wright and accepted the apologies from W. Johns who couldn't be present at his first meeting. He also reminded that the term for serving on the CLIVAR panel is 4 years with the possibility of extension in special circumstances. The panel members whose term finishes in 2003 (A. Busalacchi, T., Delworth, Y. Kushnir and F. Schott) were asked to say whether they wish to serve the panel for 2 more years or otherwise to suggest potential replacements.

All panel members were asked to suggest potential replacements to the outgoing members.

> **ACTION ITEM 1**. Submit list of new members to the panel for input and submit final list to SSG later in the year (*Visbeck and Boscolo*)

3. Introduction (open meeting)

Martin Visbeck welcomed the guests and observers (see Appendix A) to the 5th session of the CLIVAR Atlantic Implementation Panel. The terms of reference of the CLIVAR Atlantic Panel were reviewed and commented. The goals and strategy of this panel were summarized in four points:

- Describe and model coupled atmosphere-ocean-land interactions in the Atlantic sector, quantify their influences on and interaction with the regional and global climate system, and determine their predictability
- Assemble quantitative historical, proxy and real time data sets that may be used to test, improve and initialize models of coupled Atlantic climate variability
- Investigate the sensitivity of the ocean's meridional overturning circulation to changes in surface forcing
- Assess the likelihood of abrupt climate change

With respect to the three Principal Research Areas D1 (North Atlantic Oscillation), D2 (Tropical Atlantic Variability) and D3 (Atlantic Thermohaline Circulation) that the Atlantic Implementation Panel is asked to address, the emphasis is on the interactions with each other and/or other climate forcing including ENSO (El Nino / Southern Oscillation) and ACC (Anthropogenic Climate Change).

The CLIVAR Atlantic panel plays an important role in coordinating the large number of process studies / programs that address different aspects of the climate variability and predictability in the Atlantic sector, most of them not directly initiated under CLIVAR (www.clivar.org/organization/atlantic/IMPL/proc-stud.html). In addition to the coordinating role a high priority issue for CLIVAR as a whole is the design and implementation of a strategy on data integration and archiving which will allow global synthesis. For this reason it was decided that the special topic of this meeting was on a brainstorming session about data products, reanalysis, predictability and synthesis.

4. Report from the 24th WCRP Joint Scientific Committee session

Tony Busalacchi reported that the progress in the WCRP core activities was highlighted by the WMO Executive Council at its last session (June 2002). Of particular interest were the regional studies being undertaken in CLIVAR focusing on African climate variability, the variability of the American monsoon system (VAMOS) and the Asian-Australian monsoon. The Council stressed that attention should also be given to the applications and applicability of CLIVAR scientific results. The Council particularly recognized the achievements of the World Ocean Circulation Experiment (WOCE), which had now completed its final stage of synthesizing the measurements collected during the field programme (1990-1998) into a dynamically consistent view of the ocean circulation in the 1990s. The representative of the IOC emphasised that the Commission would continue to play an active role as co-sponsor of the WCRP. In particular IOC recognized the great value of the WOCE results and it was foreseen that the CLIVAR study would lead to understanding and forecasting of climate change on decadal time-scales.

The overall presentation of CLIVAR activities and progress, which included the issues related to the implementation of CLIVAR in the Atlantic sector, was well received at the 24th JSC meeting (March 2003). The CLIVAR highlights were summarized as follow:

- Contribution of CLIVAR for ocean observations: WOCE legacy, extension of a subset of the WOCE data centers and ocean Carbon coordination
- Cross panel activities emerging: AMMA (Atlantic-VACS) and GOODHOPE (Atlantic-SO)
- Planning of a Pacific Decadal Variability Study
- SALLJEX and VAMOS Project Office
- Strong support for atmosphere and ocean synthesis activities
- CLIVAR-GEWEX collaboration on CEOP Inter Monsoon Model Study
- SMIP assessment of seasonal forecast skill
- Potential links to START
- Advances towards an Indian Ocean Panel

Several issues and concerns related to CLIVAR were reported too:

- Transition of TAO from PMEL to NDBC. Ability to sustain ATLAS moorings in certain regions
- COOP-OOPC Coordination
- Southern Hemisphere observations
- Status of WCRP data management
- Status of WCRP surface flux coordination
- Need for WCRP visibility and support of AMMA
- WCRP progress on studies of sea level rise?
- J. Mitchell and A. Busalacchi recommendation that a Vice Chair (with experience in climate variability) be appointed to JSC/CLIVAR WGCM
- WCRP crosscut workshop on monsoon modelling?
- Recommendation of annual meeting of chairs and directors (6 months after the JSC meeting)

The WCRP Banner on Predictability was discussed at several levels within the CLIVAR organization. At the JSC session it was agreed that the concept of a Climate Observing Prediction Experiment (COPE) should be developed as a banner activity, comprising hindcasting from 1979-2009 and prediction to 2020 of coupled atmosphere, ocean, land and cryosphere (+biosphere etc…). The JSC was asked to list a set of themes, which will provide the foci for the WCRP projects. It was recommended that the remit of WGSIP should be extended to include decadal timescales. There was a general support for a "Modelling Council" to be established across all WCRP projects to cover climate system data assimilation and model initialization (Chair Shukla). In addition an "Observations Council" should be envisaged to cover WCRP data management issues including assimilation, synthesis and reanalysis. The existing WCRP projects were asked to establish the sunset dates in order to better support and coordinate with COPE.

In addition, strengthened links between WCRP and IGBP-phase II were encouraged and a WCRP Surface Flux Task Group was formed. Among the discussion items the most relevant to the Atlantic Panel were:

- Potential Arctic Ocean gap between CLIVAR, CliC and ASOF
- Potential links between SPARC and CLIVAR/Atlantic on Northern Annular Mode science

5. Overview of ICPO status and activities

Howard Cattle, the new director of the International CLIVAR Project Office, reported on the recent developments and status of the ICPO. Howard Cattle, formerly at the Met Office, took up the Director's post on 1st August 2002 after John Gould's retirement. Katy Hill joined the office in November 2002, replacing Daniela Turk who left in June 2002. Katy took over the responsibilities on CLIVAR Pacific and Carbon links. Katherine Bouton who was in charge of the web and data management, left the office at the end 2002. The current staffing level is 5.5 full-time equivalent with staff geographically dispersed. The responsibilities and locations are as follows:

- Howard Cattle (SOC, UK) - Director; CLIVAR Scientific Steering Group (100%)
- Roberta Boscolo (Vigo, ES) - CLIVAR Atlantic and Variability of the African Climate System (VACS) (50%)
- Carlos Ereño (Buenos Aires, AR) - Variability of the American Monsoon Systems (VAMOS) (50%)

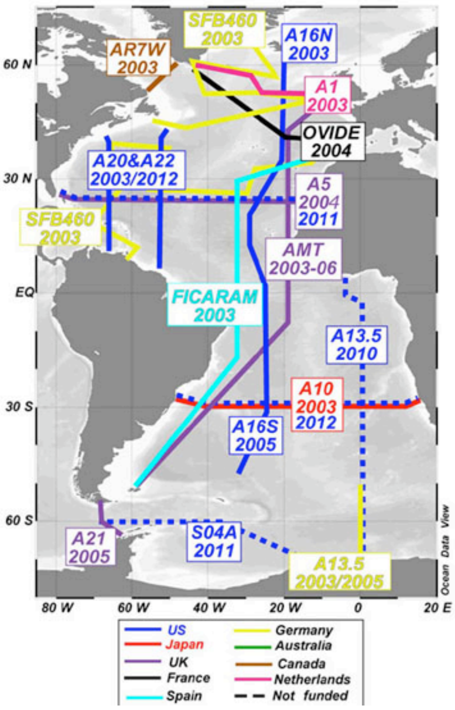
- Sandy Grapes (SOC, UK) - Secretary and administration (100%)
- Katy Hill (SOC, UK) - CLIVAR Pacific, Data Management and Carbon links (100%)
- Michael Sparrow (Bejing, CHINA) Southern Ocean Panel (20%)
- Andreas Villwock (Kiel, DE) Working Group on Seasonal to Interannual Prediction (WGSIP), Working Group on Coupled Modelling (WGCM), Working Group on Ocean Model Development (WGOMD), PAGES/CLIVAR Working Group, CLIVAR Exchanges, CLIVAR Web (75%)
- Zhongwei Yan (SOC, UK) - Asian-Australian Monsoon Panel and Expert Team on Climate Change Detection (100%)

In addition Valery Detemmerman from the WCRP Joint Planning Staff (WMO Geneva) is involved in and supports ICPO activities.

The ICPO staff is proactive in maintaining the links with panels and working groups helping with the related issues and in developing new activities especially in relation to workshops and meetings. ICPO develops and maintains several outreach initiatives like the website (www.clivar.org), CLIVAR Exchanges Newsletter, meeting reports, posters etc… Some current key activities involve developing links with other WCRP projects (GEWEX, CliC), IGBP and IOC, and designing CLIVAR data management and information activities, particularly through the CLIVAR remit to the WOCE DACs. The ICPO typically produces about 20 reports per and 4 issues of CLIVAR exchanges per year. Due to the growing interest within the community, the size of the Newsletter has increased up to 40-60 pages with about 1700 subscribers per issue. However funding cuts are putting the future of Exchanges under discussion. Such a situation may result in the contributed papers being published on the web only. Maintaining a reasonable level of funding under such a tight financial climate is one of the challenges that ICPO has to face for the incoming years. Another challenge consists of developing a comprehensive data and information management structure for CLIVAR for real time and delayed mode data for atmosphere, oceans and land.

6. CO_2 activities and plans in the Atlantic

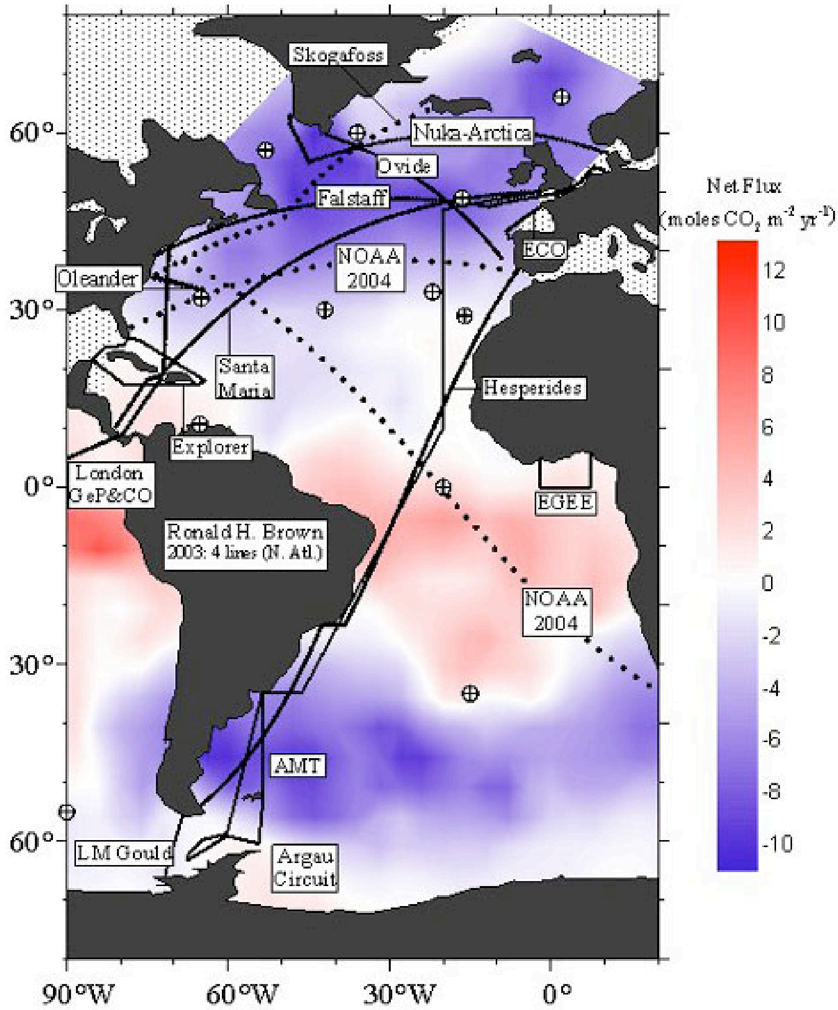
Nick Bates was invited to inform the panel on the status of the ongoing activities and future plans for carbon measurements in the Atlantic.



Cruise	Country / Status/freq.	Contact for Carbon	CTD/ O2/ Nuts.	LADCP	DIC	pCO2 (disc)	DOC / DON	TAlk	pH	pCO2 (UW)	CFC	He/Tr	Trace Metals	C14	C13	Last Update
A02 / SFB460 2003	Germany Funded	Wallace	✓	-	✓	-	✓	✓	✓	✓	✓	-	-	-	✓	Apr 03 edit?
A03(05) 2004	UK Funded	Watson / Smethie (pending)	✓	✓	✓	-	✓	✓	-	-	✓	✓	-	-	-	May 03 edit?
A7 (formerly AR7E) 2003	Netherlands Funded;7 per year for next 5 years	deBaar / Van Aken	✓	-	✓	✓	✓	✓	-	✓	-	-	✓	-	-	Jan 03 edit?
AR7W 2003	Canada Funded	Jones / Azetsu-Scott / Kepkay	✓	-	✓	-	✓	✓	-	-	✓	-	-	-	-	May 03 edit?
A10 Oct - Nov 2003	Japan Funded; 5-10 yrs	Murata / Key / Watanabe	✓	✓	✓	-	-	✓	✓	✓	✓	-	-	✓	✓	Jan 03 edit?
A13.5 south of 45S Nov 2002 - Jan 2003	Germany Funded; 3 yrs	Hoppema	✓	-	✓	✓	-	-	-	✓	-	✓	✓	-	-	Jan 03 edit?
A13.5 2009	USA Planned; 10 yrs	Feely	✓	✓	✓	-	✓	✓	-	-	✓	✓	-	-	-	Jan 03 edit?
A16N April-June 2003	USA Funded; 10 yrs	Feely	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓ surface	✓	Apr 03 edit?
A16S 2005 Austral Summer	USA Funded; 10 yrs	Feely	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Jan 03 edit?
A20 Sept - Oct 2003	USA Funded; 5 yrs	Feely	✓	✓	✓	-	✓	✓	-	-	✓	✓	-	✓ surface	-	Apr 03 edit?
A22 Oct - Nov 2003	USA Funded; 5 yrs	Feely	✓	✓	✓	-	✓	✓	-	-	✓	✓	-	✓ surface	-	Apr 03 edit?
OVIDE 2004	Spain / France Funded; 2 yrs	A. Rios/F. Perez	✓	✓	-	-	-	✓	✓	✓	✓	-	-	-	-	Jan 03 edit?
FICARAM 2003	Spain Funded; 2 / yr	A. Rios	✓	✓	-	-	-	✓	✓	✓	-	-	-	-	-	Jan 03 edit?
Atlantic Meridional Transect 2003	UK Funded; 2 /yr	Lefevre	✓	-	✓	-	-	✓	-	✓	-	-	-	-	-	Jan 03 edit?

Figure 1. Repeat hydrography and Carbon observations plans in the Atlantic (http://ioc.unesco.org/ioccp/hydAtlM.htm)

The CARbon dioxide IN the Atlantic Ocean (CARINA) programme provides information exchange and supports cooperation between groups, which measure CO_2 in the Atlantic Ocean. CARINA is formed by 19 partners (groups) belonging to 12 countries. CARINA keeps a collection of all CO_2 data collected in the Atlantic and includes new data as soon as possible. In addition it helps with data quality control and the format for the final storage in a CO_2 data centre (CDIAC). The current inventory lists 136843 bottle samples (83 cruises) and 350000 surface values of fCO_2 (56 cruises). The CARINA webpage (www.ifm.uni-kiel.de/fb/fb2/research/carina) allows downloading all the available datasets (password protected) and displays the cruise-tracks to visualize coverage. In addition it serves as a communication centre for the partners by listing upcoming cruises, allowing cross-check of data etc…



Vessel	Ports	Dates of Operation	Frequency of Repeat	Measurements	Chief Scientist	Last Updated
Nuka Arctica	Aalborg, Denmark - Nuuk, West Greenland	2001-2001	Monthly	Surface pCO2, SST, salinity, atm. pCO2, atm. pressure, wind speed; SAMI CO2	T. Johannessen / Norway	Jan 03 edit?
Falstaff	UK and Germany to America	2001-2001	Six-week round-trip	Underway pCO2, SST, TCO2, alkalinity, C13, Nutrients, Chlorophyll, POC, PLOC	D. Wallace / Germany	Jan 03 edit?
Santa Maria	Portsmouth, UK - Windward Islands	2001-2001	35 day round trips	Wind speed, wind direction, air temperature, air isotopes, air pCO2, seawater pCO2, SST, S, nitrate, phosphate, silicate	A. Watson / UK	Jan 03 edit?
Hesperides	Cartagena, Spain -Rio de Janeiro - Ushuaia	2001-2003	2 / year	Underway pCO2, salinity, SST, fluorescence	A. Rios / Spain	Jan 03 edit?
Atlantic Meridional Transect	UK - Falkland Islands	1995 - 2000 / 2002 - 2006	1 round-trip per year	physical, biological, chemical	C. Robinson / UK	Jan 03 edit?
Oleander	Norfolk - Bermuda	planned for May 2003 start	100 / year	pCO2, SST, salinity, atm.pCO2, atm. pressure, wind speed	N. Bates / Bermuda	Jan 03 edit?
Skogafoss	Norfolk - Reykjavik	planned for April 2003 start	12 / year	pCO2, SST, salinity, atm.pCO2, atm. pressure, wind speed	R. Wanninkhof / USA	Jan 03 edit?
NOAA 2004	New York - Cape Town S.Africa	planned for 2004	6 / year	pCO2, SST, salinity, atm.pCO2, atm. pressure, wind speed	R. Wanninkhof / USA	Jan 03 edit?
NOAA 2004 (was Nuevo Leon)	Miami - Spain	planned for 2004	8 / year	pCO2, SST, salinity, atm.pCO2, atm. pressure, wind speed	Millero / Wanninkhof / USA	Jan 03 edit?
Contship London / GeP&CO	Le Havre - New York - Panama - Tahiti - Auckland - Noumea	1999-2002	3 month round trips	SST, salinity, Chlorophyll, atm. pressure, phytoplankton pigments, TCO2, Alk, nutrients, plans for surface pCO2	Y. Dandonneau / France	Jan 03 edit?
ECO project / Car Carrier L'Audace	Vigo - St Nazaire (France)	2002-2005	2 transects per week	Underway pCO2, salinity, SST, atm. CO2, atm pressure, wind speed, chlorophyll, fluorescence, O2, pH, Alk, discrete samples of O2 and nutrients every 2 weeks.	A. Rios / Spain	Jan 03 edit?
Argau Project / IRIZAR	Buenos Aires - Antarctica	2000 -	2-4 times / year	underway pCO2, SST, salinity, chlorophyll, atm. pCO2, atm. pressure, wind speed, biological samples	A. Poisson / France and D. Ruiz / Argentina	Jan 03 edit?
Drake Passage Time Series / LM Gould	Punta Arenas Chile - Palmer Station Antarctica	2002 -	20 times / year	underway pCO2, SST, salinity, chlorophyll, atm. pCO2, atm. pressure, wind speed	T. Takahashi / C. Sweeney / USA	Jan 03 edit?
RV Ron Brown	Atlantic and Pacific / Random lines	1991 -	random	underway pCO2, SST, salinity, atm. pCO2, atm. pressure, wind speed	R. Wanninkhof / USA	Jan 03 edit?
EGEE	Gulf of Guinea	2003-2005	3 / year	discrete DIC, TAlk	B.Bourles / France	Jan 03 edit?

Figure 2. Underway pCO2 measurements plans in the Atlantic (http://ioc.unesco.org/ioccp/UWAtlM.htm)

The US Repeat Hydrography Program (http://ushydro.ucsd.edu/) was established in support of the objectives of the US Carbon Cycle Program and US CLIVAR. The program main objectives are:

- Data for model calibration and validation
- Carbon system studies: changes in anthropogenic carbon inventory, transport of carbon, oxygen and nutrients and large scale natural, anthropogenic variability of biogeochemical properties
- Heat and freshwater storage and flux studies: divergence of transport-surface fluxes, transport of heat and salt, storage of heat and freshwater, globally changing inventories of heat and freshwater
- Deep and shallow water mass and ventilation studies: changes in subduction and formation rates, effective spreading rates, pathways of ventilation, rates of dilution, water mass ages
- Calibration of autonomous sensors: Argo salinity, biogeochemical moorings and floats, relationship between sensors and other properties.

The schedule and measurements of the US Repeat Hydrography program can be viewed at the program website. Figure 1 shows the overall international plans for repeat hydrography in the Atlantic.

Numerous ship of opportunity programs are currently operating in the Atlantic Ocean providing the possibility of determining air-sea fluxes of CO_2 on basin and seasonal timescales. Current US efforts are two new NOAA funded proposals towards the implementation of a sustained ocean pCO_2 observing network in order to quantify fluxes in North Atlantic in support of the Global Carbon Program and to fill in observational holes elsewhere (>30°S). The programs implement underway systems on research ships, Antarctic supply vessels and VOS ships on high-density XBT lines. Figure 2 shows all the ongoing pCO_2 measurements in the Atlantic.

> **ACTION ITEM 2**. Obtain more information on the status of ongoing and future CO_2 observation in the Atlantic. Is CARINA the right contact for future observations? (*Boscolo, Bates and Hood*)

7. Updates on the Atlantic Observational network

Roberta Boscolo went through the various elements of the observational system currently in place or planned/funded in the Atlantic sector. Up-to-date information and details on observational activities are available at http://www.clivar.org/organization/atlantic/IMPL/. Particular attention was given to the new observations that will be performed within the funded projects ASOF (http://asof.npolar.no/) and RAPID (http://www.nerc.ac.uk/funding/thematics/rcc/). Together with other enhanced regional observations funded by France, Canada, Germany, Norway and The Netherlands, the ASOF and RAPID projects will help to maintain an almost adequate sustained monitoring of the MOC in the North Atlantic. The South Atlantic needs more attention but plans are developing as result of the SACOS workshop (see section 13). In general the global arrays like drifters, subsurface floats, sea-level network, XBT, surface marine network all show a similar picture: good coverage of the North Atlantic and poor coverage in the South Atlantic. Such an observational system represents roughly 70% of the CLIVAR initial implementation plan in the Atlantic sector. It was suggested that a closer interaction with OOPC would help to address the sustainability of some process-study observations and several issues related to global network operators.

> **ACTION ITEM 3**. Strengthen interaction with OOPC for sustained observations in the Atlantic. (*Visbeck and Boscolo*)

There are several process studies relevant to CLIVAR in the Atlantic sector but not under direct CLIVAR funding. The Atlantic panel plays an important role in coordinating those activities and helps avoid duplication.

> **ACTION ITEM 4**. Inform the Panel on the improved surface flux fields pilot study in the Atlantic Ocean funded by NOAA. (*Yu, Weller and Boscolo*)

8. Ocean reanalysis and data assimilation

The Atlantic panel met jointly with the WGOMD for a short session on ocean reanalysis and data assimilation. D. Stammer reported on methods for rigorous data assimilation. Amongst other efforts like GODAE (Global Ocean Data Assimilation Experiment) and Mercator, representing the French contribution to GODAE, Stammer highlighted the ECCO ("Estimating the Circulation and Climate of the Ocean") project. ECCO is a consortium between scientists at JPL, MIT and SIO. It is funded under the National Oceanic Partnership Program (NOPP) with funding provided by the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), and the Office of Naval Research (ONR). The first phase of ECCO ends in 2004.

The ECCO Consortium uses rigorous global ocean state estimation methods to produce dynamically consistent time-varying model/data syntheses over the 10+ year period from 1992 to present as the basis for studies of a variety of scientific problems. Rigorous estimation methods are computationally demanding. However, they are essential in obtaining dynamically self-consistent estimates useful for understanding the physics of the time-evolving ocean and its interaction with the atmosphere by exploiting the information contained in ocean and satellite data. ECCO estimates are based on the MIT general circulation model (Marshall et al., 1997), which employs advanced mixed layer physics and an eddy parameterization scheme. Ongoing efforts of the ECCO Consortium consist in producing two sustained near global ocean estimates: (1) A near-real-time product on a nominal 1^o horizontal grid telescoping to $1/3^o$ toward the equator with 46 levels assimilating altimetric sea surface height and *in situ* temperature profiles using a Kalman filter-smoother, (2) A product assimilating all available data on a 1^o-horizontal grid with 20 levels using an adjoint model. Both estimates are forced by daily heat and freshwater fluxes and twice-daily wind stress fields. The results from those two products are available to the public and are distributed through the internet. They can be accessed via the consortium's data server (http://www.ecco-group.org/data_server.html).

Model output comprises weekly to monthly averages of the full model state, twice-daily sea surface height and bottom pressure fields, as well as the surface forcing fields that are part of the estimated solution. Other fields or additional diagnostics can be made available upon request. See http://www.ecco-group.org for details. A release and full documentation of both forward and adjoint ECCO codes is available at http://mitgcm.org/sealion. Applications of ECCO products are manifold and include: ocean dynamics, parameter testing, surface fluxes/bio-geochemistry estimation and initialisation of coupled models. Some of the remaining issues in the context of ocean data assimilation are:

- Improving prior process and error statistics
- Improving model and resolution
- Extending the control space to include model error
- Extending the estimation period
- What data are required?
- Where can all required input fields be obtained?
- Sustained support: man and computer power

Two Workshops are currently being planned which are mainly focussing on ocean reanalysis but will also address atmospheric reanalysis and coupled efforts. The first one is a NSF-ONR sponsored US Workshop on "Progress and Prospects of Data Assimilation in Ocean Research" to be held in Williamburg, VA, Sept. 9-11, 2003. The goals of this planning workshop are to:

- Assess the state of the art in data assimilation and discuss what new research will be required to realize the full potential of data assimilation and new observational methods for sciences and operational purposes.
- Summarize the status of major national ocean data assimilation efforts and enumerate their impact in the U.S.
- Review remaining challenges and discuss benefits from addressing them for science and operational assimilation efforts.
- Identify potential mechanisms for providing long-term funding support for sustained assimilation efforts, for advancements in data assimilation approaches, and for expansions of applications.
- Develop mechanisms for interactions between research-oriented efforts and those at the operational centres.
- Discuss needs for educating, training and retaining scientists involved in data assimilation for both research and operations.

The second workshop is an international CLIVAR Workshop on Ocean Reanalyses with the following objectives:

- Review the status of ongoing and planned ocean synthesis (reanalysis) efforts
- Establish the requirements for ocean state estimation and reanalysis in climate research within the remit of CLIVAR,
- Promote the use of existing reanalyses,
- Review the synergy between ocean and atmospheric reanalysis activities with specific focus on improving surface flux fields
- review coupled ocean-atmosphere model synthesis in support of climate prediction.

The outcome of the workshop includes: a summary of the status of ongoing efforts in the ocean and atmosphere and their results; an overview of requirements for ocean reanalyses for a range of climate research activities; a strategy to develop sustained syntheses of satellite and *in-situ* observations of the ocean suitable to support climate research and a strategy to bring ocean and atmosphere syntheses into a coupled reanalysis that conserves key properties. The meeting will be open to the community but limited in size. The anticipated number of attendees: 50-80. The meeting will consist of plenary sessions with invited talks followed by working sessions in which discussions will be held that focus on addressing the meeting's outcomes.

The following topics are envisaged:
The requirements for Ocean Reanalyses

- Ocean synthesis requirements, benefits and strategies
- Status of atmospheric reanalyses
- Data assimilation approaches
- Data and model requirements
- Computational and infrastructure requirements
- Missing parts

Summary of ongoing activities in the ocean (e.g.: ENACT, ECCO, Mercator, GODAE, etc….)
Fluxes from Atmospheric reanalyses (e.g. ECMWF (ERA-40), NCEP, DAO, SURFA)
Applications of reanalysis efforts:

- Improving Ocean-Atmosphere fluxes
- Defining ocean variability
- Estimating ocean mixing
- Quantifying seasonal to interannual variations
- Anthropogenic change
- Sea level rise

Ocean observing system for CLIVAR:

- Observations from *in situ* and VOS platforms (availability and identified gaps).
- Satellite observation needs.
- Data flow, QC and archiving.
- Requirements over and above those specified by GOOS/GCOS

Uncertainties and biases:

- Estimating data surface flux errors
- Estimating model errors
- Estimating uncertainties in syntheses
- Dealing with biases in models and surface fluxes
- Sensitivity to model physics
- Identification of deficient model physics.

Challenges for the future

- Coupled reanalysis approaches
- What new approaches might there be to estimation procedures.
- Resolution and non-linearities
- Required observing and data delivery systems
- Manpower and infrastructure needs.

The proposal for the international workshop will be presented to the CLIVAR SSG for endorsement. The venue of this meeting is currently under discussion.

The participants felt that the topic of ocean reanalysis and data assimilation are of increasing importance. Experience for the atmospheric reanalysis have documented the value of such an endeavour. Systematic intercomparison of reanalysis, models and climatology will be a useful tool for the assessment of the basin status and variability. Both panels welcomed the planned international workshop as an important cornerstone for a comprehensive assessment and future planning.

> **ACTION ITEM 5**. Express support for holding a reanalyses workshop sometime 2004. (*Visbeck and Stammer*)

9. Coriolis: a component of the French approach to monitor and forecast ocean behaviour

Bernard Bourles kindly took the task of presenting the French approach to data acquisition and management: the Coriolis project. Ocean climate research and operational programs need to estimate the global 4-D ocean state in order to better understand climate-related changes and processes, and to forecast the ocean state on daily to seasonal timescales. For setting up of such a system the French research agencies put together the following components:

- Sea-surface observations from satellites
- *In-situ* measurements from ships, moored or drifting autonomous systems
- Assimilation of *in situ* and satellite data in an ocean circulation model

There are always several problems with the *in situ* data:

- They are generally collected by different teams around the world with rather little coordination among them and mainly not rapidly available to the community (>2 yr)
- For the (quasi) real-time ocean data (drifters, moorings, VOS etc…) access is not always easy. Data are generally available on GTS but with various quality codes and/or criteria. Thus a quality check is recommended before their utilization in scientific or assimilation studies.

Coriolis is the project-component that addresses the need to ease access to the *in situ* ocean data. It is a pilot project (2000-2005) supported by a multi-institutes effort (CNES, CNRS, IFRTP, IRD, METEOFRANCE, SHOM, IFREMER) that aims to define the necessary structure to provide a sustainable service to operational ocean models after 2005.

Coriolis is the French contribution to a global *in situ* observing system (with focus on Atlantic) and in particular to Argo. Its first tasks are:

- To set up an operational *in situ* data center
- To organize the systematic data collection (both real-time and delayed-mode) of *in situ* measurements necessary for operational oceanography
- To develop and improve the technology (instrumentation, sensor accuracy etc…) necessary for operational oceanography

The French scientific community is actively involved in developing Coriolis. A scientific advisory group provides expertise in measurements techniques, data processing and data analysis as well as ensures that Coriolis is integrated in scientific programs at national and international levels such as Argo, CLIVAR, GODAE, GOSUD….

Within the Coriolis project, France will deploy several hundreds of floats mainly in the Atlantic and Indian Ocean and will provide together with the US GODAE centre in Monterey, a centralized homogeneous access to Argo data acquired all over the world. The national Argo data centres will validate the data for the floats they deployed according to standardized procedures for quality control in real-time and delayed mode. Coriolis will provide a rapid and secure way to access the data from a unique portal and an efficient exchange of data and metadata based on internet (http://www.coriolis.eu.org/ and http://www.usgodae.fnmoc.navy.mil/).

Currently Coriolis receives data from: floats (PROVOR and APEX), surface drifters (MeteoFrance surface drifters, CMOD buoys), moorings (PIRATA array) and real-time data from ships (XBT, XCTD, CTD, thermosalinographs, ADCP current-meters). After a quality control (within 24 hours), the data are distributed on GTS and internet (FTP, www) with a standard format. Additional products are also provided like T and S gridded fields and estimation of sensor drifts. For the Argo floats the information provided on FTP are Metadata (general information on the float), profiles (original data and best available with quality flag), trajectory and technical info in NetCdf format. The Coriolis web site has several visualization tools: global display of platforms, temperature and salinity in the area, float trajectories, statistics on data and its evolution. It also provides tools for choosing subsets/formats: temporal, geographical, drift-level criteria, full or interpolated resolutions, submerged or surface or total displacements, parameters, format etc…Coriolis aims to extend the database to a more global coverage in collaboration with other institutes and programs like Ocean time-series and GHRSST-PP. Also, according to the needs of operational models, it is envisaged dealing in the future with biogeochemical types of data.

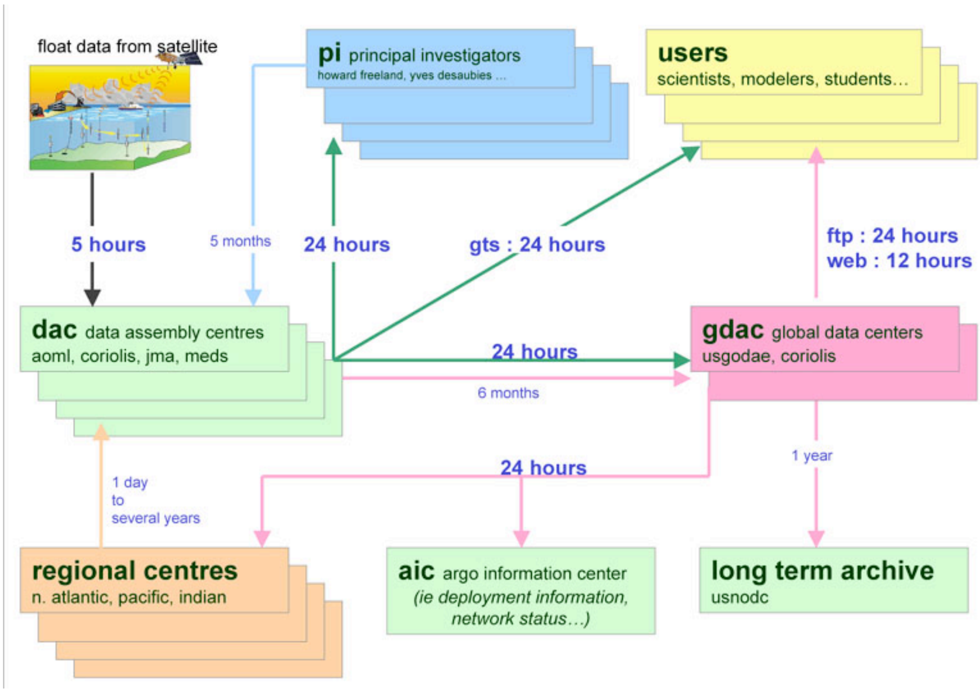


Figure 3. Schematic of the ARGO data flow

It was recognised that Coriolis is a model of a data centre that serves both the operational and research communities. Its unified format approach to data from whatever sensor and station makes easy access for the users.

> **ACTION ITEM 6**. Explore the willingness/capability of Coriolis and/or AOML (others?) to take on more CLIVAR data streams and their connectivity to reanalysis efforts. (*Bourles, Koltermann, Stammer, Busalacchi and Johns)*

10. CLIVAR Data/Products Needs and Requirements

To assess the large-scale description of the recent or present Earth System we have come to use and rely on comprehensive datasets. A large number has been produced in the last decades. The way to describe the ocean or atmosphere has moved from the paper (atlas) towards digitally available gridded data sets. This implies an immediate availability, and the opportunity to tailor products to one´s needs. It also invites combining different datasets.
Peter Koltermann addressed the topic of coherent and consistent (hopefully) global datasets, assuming that they have a temporal and spatial resolution adequate to describe the features relevant for climate issues. A nice "portal" is the NCAR/CAS site (http://www.cgd.ucar.edu/cas/). The CPC/NCEP site /(http://www.cpc.ncep.noaa.gov/) is also very much up-to-date but very much focussed on the Pacific.

Data-sets can be designed either as a classical climatology (Levitus´WOA94), being a static description of a mean state and its variance (base period), or as a continuing description of a parameter set with time (time slices of fixed period) such as Levitus´ WOD01. They might also be a dynamic description, where for given time slices the end is open. This we find in a number of satellite products, such as the TP/ERS altimeter server of R. Leben at UCAR. There are a number of real-time "machines" that produce the above type of datasets "on the fly", such as either FOAM for the North Atlantic, the Re-Analysis work of NCEP or ERA40 or data collectors such as Coriolis. They have different levels of complexity, or product status.

Based on the preliminary ideas presented at the last SSG Meeting, there are few observations that lie beyond the scope of the initial strategy or come between the "regional/application centers" and the

"Science/Model/Data Assimilation Activities" levels. As users are inclined to put their own observations into a temporal or spatial perspective, they become used to accessing data sets freely available. We can find single parameter data sets, other with derived quantities, and a few with error estimates. More advanced are multi-parameter, some model-derived (see Appendix C). Going through the climate "compartments", those data-sets for the atmosphere are the most advanced, and readily available. The ocean ones are mostly static, some are dynamical such as WHOI/HydroBase, but there is plenty of room for improvements both in resolution, parameters and product level.

And in doing so we realise that they are:

- for a given limited, non-congruent time period
- with different spatial and temporal resolutions
- for land or ocean only, or only regional
- or in the worst undocumented or obsolete.

Usage, checked by going through references, is of course by scientific merit. But to some (and maybe to a large extent) usage is also influenced by availability which in turn keeps outdated products alive. In some cases we run here into the consequences of WMO Resolution 40: no live access is permitted.

The common issues of this excursion into the realm of level III products with relevance to CLIVAR and its own data stream are:

- Who ensures continuity of datasets, products? Hurrell´s NAO index ends in February 2002. The CRU SST data set is only 1856-1998
- How do we encourage "better procedures"? such as adequate, maybe common resolution, increasing meta data , or common reference periods.
- In general: How do we get periods covered by these data sets closer to present day observations. If there is a 10 years hiatus between observing and the available level III products we have a credibility problem for climate monitoring?

Even when and if assimilation machines will be routine, and effective these questions of continuity and availability will still be there.

> **ACTION ITEM 7**. Further Develop panel's perspective on data management needs. (*Koltermann and others*)

11. Atlantic ITCZ dynamics and predictability

As described by Yochana Kashnir, the Atlantic ITCZ annual migration determines the seasonal distribution of rainfall in densly populated regions and its interannual variability directly affects water resources, agriculture and health there. The ITCZ also dynamically interacts with remote regions through global teleconnection patterns.

During Boreal spring the SST in the Tropical Atlantic (TA) is warm with a weak gradient and there is a strong surface wind convergence with overall weak marine convection. This results in intense rainfalls in NE Brazil, onset of the African monsoon and intensified dust in the Sahel. The ENSO state, the previous winter NAO and the previous summer S. Atlantic atmospheric circulation can all influence this pattern. During Boreal summer the SST is overall colder with strong gradients. The strong marine convection is then positioned furthest from the equator. This results in intense rainfall and dust in the Sahel, tropical storm activity and rainfall in northern S. America. This pattern can be influenced by the previous ENSO state, S. Atlantic circulation and upstream land conditions.

During Boreal spring 33% of the interannual rainfall variability is explained by variations in the western TA core of the ITCZ. Rainfall is weaker and the ITCZ is shifted northward when the Northern Tropical Atlantic (NTA) is warmer than normal. The change is strongest when at that time the Southern Tropical Atlantic (STA) is colder than normal. A cross-equatorial wind anomaly is associated with the changes in convection, which is hypothesized to cause a positive local air-sea feedback. In Boreal summer, 23% of interannual rainfall variability is explained by variations in the TA core of the ITCZ, primarily in the east. Rainfall is stronger than normal and the ITCZ is shifted southward when the region of the Atlantic cold tongue is warmer than normal. The surface wind anomaly is converging towards the anomalously warm water in a pattern akin to El Niño. Subsurface oceanic data indicate that the SST anomaly is associated with a deeper than normal thermocline. The Atlantic warm events are far less persistent and frequent than ENSO.

An Atlantic ITCZ workshop sponsored by US CLIVAR was organized at IRI, Palisade USA, on 18-20 September 2002. The workshop helped to identify the community interested in pursuing ITCZ studies with expertise in the disciplines of large-scale tropical meteorology and oceanography, convection, land surface interactions, climate predictions and climate impacts and applications; and to identify and update the participants about programmatic linkages national and international. The participants were invited to identify and prioritise the one-few areas/issues offering best opportunity to improve understanding of tropical Atlantic climate and its predictability, and contribute to improve predictions. Presentations were related to the following themes:

- Impacts and emerging applications
- Challenges in TA climate predictions
- The TA climate system

Discussion groups were formed to identify and prioritize outstanding issues and to recommend actions to advance understanding and predictions. The workshop highlighted the significant progress achieved in crucial climate applications research. In particular:

- Health and climate in West Africa: M. Thomson showed the correlation of dust with outbreak of meningitis and linked the dust with warm SST in the Gulf of Guinea (GG). Early prediction of GG SST will induce early distribution of immunization against meningitis and a significant reduction in mortality rates.
- Reducing risk by forecast-dependent water resources management in NE Brazil: U. Lall showed how predictions of streamflows based on SST in key regions (ENSO, TA) up to 6 months in advance are input to reservoir optimization models to derive projections of amounts and cost of water. Customers pay for needed water amount with guarantee of supply.

There is a substantial potential predictability in the TA region but actual predictions remain a problem. Global coupled models in particular, display large biases in simulating the climate of the TA compared to other regions (figure 4). Statistical schemes to predict the anomalies in the Atlantic marine ITCZ location and strength have limited success. The difficulties appear to emerge from the sensitivity of the Atlantic marine ITCZ intensity and location to relatively small changes in surface and upper air conditions and the unique blend between local and external mechanisms that affect these conditions. Models do not capture the cold season anomaly in eg. east Atlantic. They perform better in the northern subtropics, though the range of prediction is small, and do well in the southern subtropics.

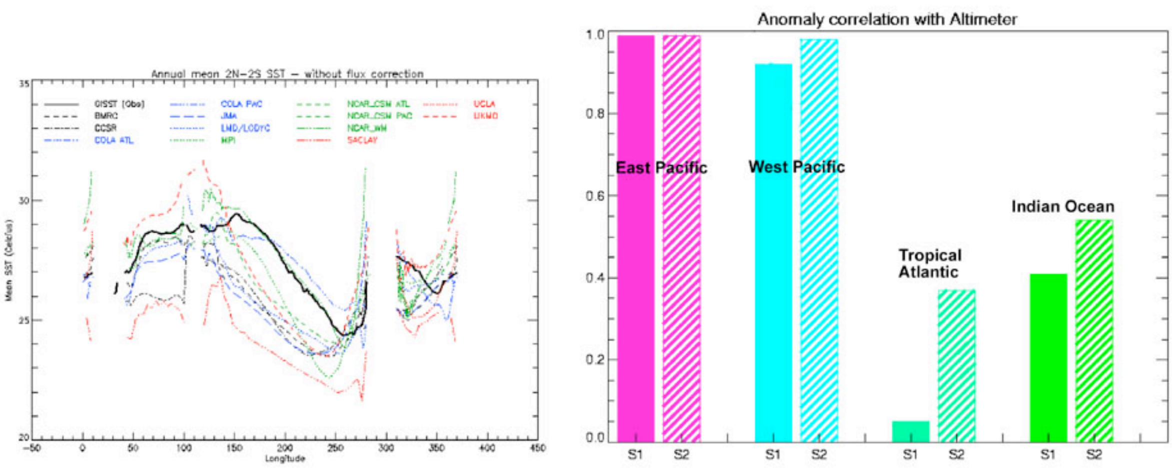


Figure 4. Climate Model Biases. Left: coupled model systematic error in equatorial SST simulations. Right: in situ data assimilation at ECMWF (S1 and S2 systems), anomaly correlation to altimeter observations (T. Stockdale).

Bad SST prediction results in large error in TA ITCZ rainfall. Critical issues are:

- Understanding the mechanisms & relative roles of local atmosphere-ocean interaction, adjacent land effects, and remote influences from other ocean basins (e.g., ENSO, NAO) in determining the position and intensity of the ITCZ throughout the year, with particular emphasis on the seasons when maximum societal impact is experienced , i.e., boreal spring and boreal summer.
- Overcoming model biases and developing modeling strategies (atmosphere, ocean, and land-surface interactions) to study the dynamics of, and accurately simulate, and predict, the seasonal and interannual variability of the ITCZ and its regional impacts.
- Defining sustained observations & field programs in support of improved, reliable monitoring and prediction of ITCZ variability and its regional influences.

Finally Yochanan Kushnir put forward some ideas on future CLIVAR activities that would help to focus on ITCZ issues:

- Identify ways to address model discrepancies and biases (diagnostic studies, model experiments, & field campaigns)
- Establish links to the prediction centers and "climate forum" activities
- Continue to create opportunities for meeting to exchange research results and facilitate discussions
- Establish and maintain links to other related CLIVAR programs, in particular those under VAMOS, VACS (AMMA), CLIVAR Pacific (Pan-American), and emerging South Atlantic initiative.
- Move to give this subject wider international scope

12. Atlantic Predictability Workshop Proposal

Rowan Sutton submitted to the panel a preliminary plan developed together with Y. Kushnir for holding a CLIVAR workshop on Atlantic Predictability. Efforts to improve climate prediction are at the heart of CLIVAR. In TOGA, and in the first phase of CLIVAR, much attention was focused on the problem of forecasting ENSO and its climate impacts, particularly those in the Indo-Pacific region. Rather less attention has been addressed to forecasting the climate of the Atlantic region, although a number of centres do now routinely issue seasonal forecasts for aspects of Atlantic climate. Recent years have also seen considerable research progress in understanding the causes and predictability of Atlantic climate variability. This progress has been discussed at various meetings, but there is a need to ensure that the progress in understanding is translated into progress in climate prediction. This need was recognised at the CLIVAR workshop on Tropical Atlantic Variability held in Paris in Summer 2001, where a specific recommendation was made for a workshop on Atlantic Predictability, to bring together the research and operational forecasting communities. This draft proposal is a response to that recommendation.

The aims of the workshop are proposed as follow:

- To provide an up to date assessment of the state of knowledge concerning the predictability of climate in the Atlantic Sector, with particular emphasis on the role of the Atlantic Ocean.
- To improve communication between operational prediction centres and forums and the research community.
- To identify gaps in knowledge, and in observing systems, required for the further development of systems for forecasting Atlantic Sector climate.
- To recommend priorities for future research, observational programmes and development of prediction systems.

The topics to cover should be: (A) Ongoing prediction activities: reports from operational centres and climate fora including the communication with communities of users (IRI, ECMWF, NCEP, INPE, UK Met Office, Meteo-France, and summaries of regional forum activities; (B) Predictability of Atlantic Sector climate: state of the research and assessment of future prospects:

- Seasonal Timescales
  - Theoretical framework for analysis of predictability
  - Predictability of the upper Atlantic Ocean & its influence on climate
  - Predictability of the ENSO influence on the Atlantic sector

- Predictability of climate on continents surrounding Atlantic basin: West Africa, South America, North America and Europe
  - Impact of land surface processes on predictability of Atlantic sector climate
  - Predictability of Atlantic hurricane activity
  - Predictability of socio-economic impacts (water, health, food…)

- Decadal timescales & climate change
  - Predictability of the Atlantic thermohaline circulation & its effects on climate
  - Predictability of the Atlantic sector response to greenhouse gas forcing

The structure of the meeting needs further discussion, it should be decided whether to have solicited talks only or to consider an open call for papers. If the latter, it will still be appropriate to have a number of solicited talks on key topics. Solicited speakers should be asked to provide: a) an overview of what is known; b) an assessment of the key outstanding issues; c) a written summary (white paper) of their subject area. The venue is Reading, UK, 19-23 April 2004.

The panel welcomed the proposal and made some suggestions on the workshop format and scientific committee.

> **ACTION ITEM 8**. Update the proposal of the workshop on Atlantic Climate Predictability by taking into account the comments and suggestions put forward at the panel session. *(Sutton and Kushnir)*
>
> **ACTION ITEM 9**. Propose to the SSG the endorsement of the Atlantic Climate Predictability Workshop. (*Visbeck and Boscolo*)

13. Report on the SACOS workshop and observations planned

The South Atlantic Climate Observing System (SACOS) workshop was held in Angra dos Reis (Brazil) on February 6-8, 2003 under the sponsorship of CLIVAR, OOPC and IAI. The objectives of the workshop were:

- Provide an overview of the scientific understanding of the influence of the South Atlantic (SA) Ocean on the regional and global climate
- Discuss existing and identify new elements for a SA observing system required for a more complete understanding of the climate system in regional and global scales
- Integrate the region’s diagnostic, modelling and observational communities and to develop joint actions and principles for a long-term observing strategy
- Identify potential funding sources and associated operational partners

More specifically the operational goals focused on:

- Social and economic regional impacts of climate change and climate prediction
- National commitments and plans for research and operational observations
- Data management activities, including historical data
- Development of multinational action plan

More information on the structure of the workshop can be found at:
http://www.labmon.io.usp.br/web_edmo/SACOS/SACOS.html

Alberto Piola summarized the science issues that were discussed at the workshop:

- The SA plays a role in determining the Meridional Overturning Circulation (MOC). In particular it:
  - Influences the variability of the upper layer interbasin exchange and the meridional heat and freshwater fluxes
  - Contributes to intense water mass transformations and short-circuits in the MOC
  - Influences the variability and stability of global MOC

- In terms of the air-sea interaction, and variability from seasonal to decadal time scales:

- The SA plays a role in shaping the meridional and zonal SST gradients on the Tropical Atlantic through ocean atmosphere interactions and subsurface oceanic pathways (STCs)
- The SST variability in the south-eastern (south-western) SA has direct impact on precipitation over Africa (S. America)
- Several coupled ocean-atmosphere modes of variability require further investigation

- In terms of the impacts on the regional and global climate:
  - SST anomalies over the SW Atlantic (confluence region) seem to have an impact on cyclogenesis, rainfall and temperature variability over southeastern South America and southwestern Africa
  - The Gulf of Guinea is a major source of moisture for the West African monsoon. The influence of SST variability in this region needs further investigation. Processes influencing SST variability in this region should be better understood.
  - Rainfall over northeast Brazil is better correlated with Tropical South Atlantic (TSA) anomalies (roughly between 20W-5E and 20W-5S) than with Tropical North Atlantic (TNA) anomalies in the preceding seasons. The TSA anomalies appear also to be more predictable than those over TNA
  - Warm and cold events, originating as equatorial Kelvin waves forced by trade wind anomalies in the western Atlantic, have a significant impact on regional fisheries and southern Africa rainfall. Activities in this region should be coordinated with proposed PIRATA southern extension

ACTION ITEM 10. Encourage the timely submission of the SACOS workshop recommendations to the community (*Piola, Reason and Wainer)*

ACTION ITEM 11. Review the SACOS recommendations and provide feedback (*Wright, Marshall, Mauritzen and Johns*)

One of the main concerns highlighted at the workshop was the SA sparse observation network that limits the improvements on the understanding of the SA impact on climate. The southeast and southwest regions of the SA are the gateways for entrainment of upper layer water from neighbouring oceans and for their modification through mixing and water mass conversions. Time series transport measurements and regional modelling are necessary in these regions. As table 1 shows the estimates of the SA meridional heat flux near 30°S are very spread. To better understand the role of the SA on the MOC it is necessary to reduce the uncertainty on the meridional heat flux through the subtropical band.

Lat (°S)	Heat Flux (PW)	Method	Source
32	0.66 – 0.88	Inverse	Fu (1981)
30	0.69	Air-sea fluxes	Hastenrath (1982)
32	0.16 – 0.68	Direct	Bennett (1978)
32.5	0.63	Numerical Model	Donners (pers. comm. 2003)
32	0.4	Direct	Bryan (1962)
30	0.39	Air-sea fluxes	Bunker (1980)
30	0.38	Air-sea fluxes	Hsiung (1985)
30	0.3	Inverse	MacDonald & Wunsch (1996) Ganachaud & Wunsch (2000)
30	0.29	Numerical Model	Marchesiello et al. (1998)
30	0.26	Numerical Model	Matano (pers. comm. 2003)
32	0.24	Inverse	Rintoul (1991)
30	0.22	Direct	McDonagh and King (2003)
30	0.19	Numerical Model	Matano & Philander (1993)
30	-0.23	Inverse	De las Heras & Schlitzer (1999)

Table 1. Estimates of South Atlantic meridional heat flux near 30°S

The SST anomalies in the SA influence South American and African climate on several timescales, and have predictable components. These SST anomalies may arise primarily from coupled air-sea interactions or be forced primarily by the atmosphere. Though the tropical Atlantic is covered by the PIRATA array, additional observations in the tropical-subtropical region appear to be necessary in order to monitor the area of extra-tropical upwelling and the bifurcation of the SEC are also suggested (Figure 5). Diagnostic studies from observations and numerical simulations shows that there is a combined pattern of SST and SLP variability in the Central South Atlantic that explains the largest fraction of variance. North-south transects through the subtropical high (around 10°W) are also suggested.

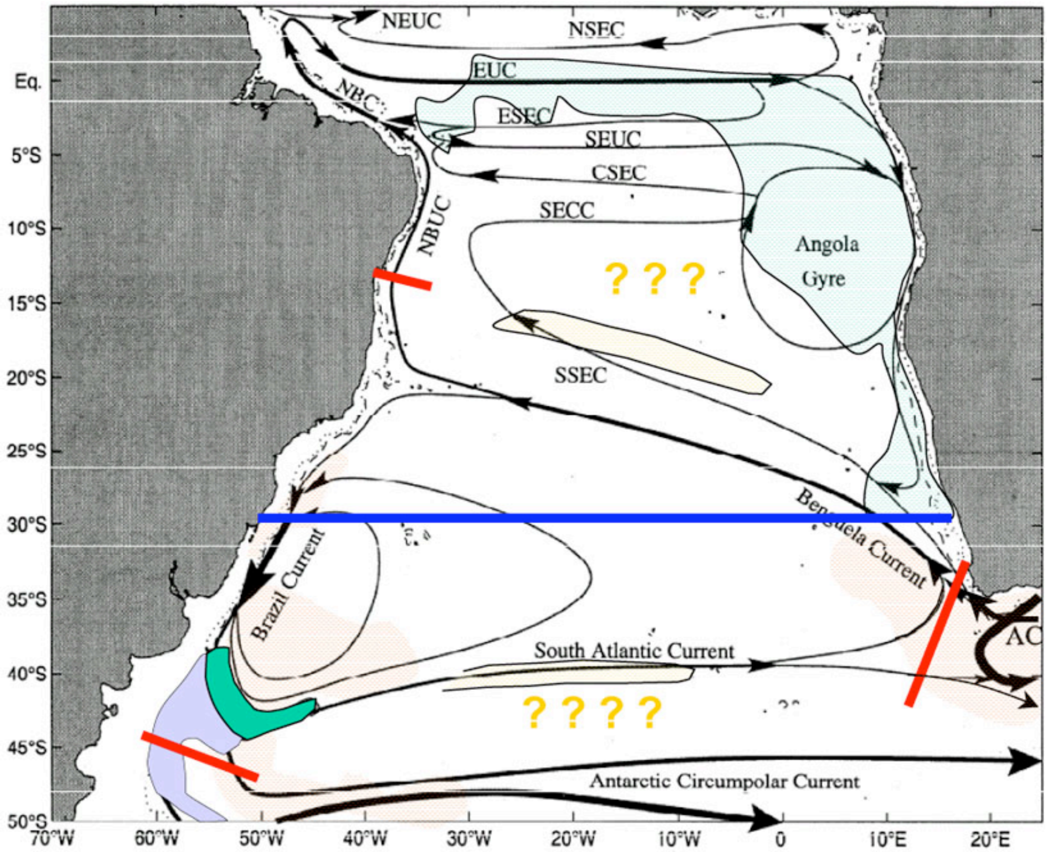


Figure 5. Proposed sustained measurements in South Atlantic. Red lines represent time series stations. Blue line indicate long-term monitoring of heat transport at 30°S. Yellow ? indicate region of air-sea fluxes measurements.

> **ACTION ITEM 12**. Liaise with WGOMD and WGCM on planning joint activities on observing system design in particular in the S. Atlantic region (*Piola, Wainer and Reason*)

14. Updates on Pirata SE Extension ASSTEX and GoodHope Projects

Chris Reason reported on observational initiatives in southeastern Atlantic:

14.1 PIRATA SE Extension

Rainfall impacts during warm and cold events, including those on Angola/Benguela fisheries and the fact that those events are an oceanographic phenomenon with relatively long lead times, suggests that better monitoring of the tropical SE Atlantic region is important and could have significant societal benefits. Monitoring of warm events upstream (and the PIRATA array) could provide an early warning forecast system that could be beneficial to both agriculture and fisheries. Due to the lack of data in the region, a SE PIRATA extension is also justified to monitor and study the interannual and intraseasonal variability of ocean dynamics and ocean atmosphere interaction of the region and the impact on Fisheries and rainfall of the region. Mooring around 5S-8E and 10S-11E could provide the missing link between the equatorial mode of variability in the Atlantic and ocean variability of Angola. There is also indication that tropical Southeast Atlantic is important for the ITCZ or could precondition SST conditions during the early rainy season (April May) of West Africa.

The PIRATA-SEE project would involve the participation of several institutions from Angola, Namibia and South Africa charged with the logistics, operation, and deployment of two ATLAS buoys in the tropical waters off the Angola Current and north of the Benguela Current. The PIRATA SEE committee is seeking support from BCLME (Benguela Current Large Marine Ecosystem) a 5-year project (2003-7) of the World Bank GEF. A feasibility study is underway as requested by BCLME for motivating the funding with submission in October 2003.

14.2 The Agulhas South Atlantic Thermohaline Transport Experiment - ASTTEX

Mass and thermohaline fluxes and their connection to global climate are still the subject of controversy. At a number of locations around the world, inter-ocean transport variability and the contrast in water mass properties between adjacent oceans can be large, with a potentially significant effect on the global climate.□ The Agulhas Retroflection region is a location of strong and variable inter-ocean transport, where warm, salt-enriched waters from the South Indian ocean enter the South Atlantic.□The Agulhas Retroflection region as part of the warm water route is the only possible source for waters warm and saline enough to maintain the observed balance in□the Atlantic thermocline, a balance which preconditions it for the formation of North Atlantic Deep water (NADW). The ASTTEX (http://gyre.umeoce.maine.edu/ASTTEX/) science goal is to provide a quantitative, multi-year Eulerian measurement of the strengths and characteristic scales of Agulhas-South Atlantic (ASA) mass and thermohaline fluxes at mesoscale resolution. The core of the ASTTEX field component is a 24-month deployment of sixteen moorings. The moored array consists of twelve pressure sensor-equipped inverted echo sounders (PIES) three near-bottom current meters (CM), and one validation mooring with six recording conductivity- temperature (CT) sensors. All of the moorings are deployed along a Topex-Poseidon/Jason satellite altimeter groundtrack. The mooring deployment was completed on January 16, 2003. ASTTEX also includes the large-scale analysis of regional sea surface height (SSH) anomaly fields during the field portion of the experiment as well as a long-term (12-year) analysis of Agulhas eddies in the SSH record (1992-2004).□This component, provides a large-scale, low-frequency context for the experiment.□The SSH fields are to be derived from Topex-Poseidon and Jason-1 altimeter data.

14.3 GOODHOPE

The South Africa – Antarctica chokepoint transect is the most natural location for:

- Southern Ocean monitoring. While intense and periodic monitoring of the other two SO chokepoints (Drake and Tasman sections) has been effective for a number of years, a regular monitoring line between South Africa and Antarctica is currently not occupied.
- Helping to fill major gaps remaining in our understanding of the ACC
- Better understanding and long-term monitoring of the inflow of Indian waters into the Atlantic Ocean. This will help to close the oceanic heat and salt budgets and measure the influence of this region on local and global-scale atmospheric dynamics and variability.

The survey will be performed principally along the SR2 line from Cape Town to the German Antarctic Base station.

The advantages of this line are:

- It follows the TOPEX/POSEIDON-JASON1 altimeters flight path.
- The southernmost fraction of this line (south of 50ºS) has already been sampled for a number of years by moorings deployed during the WECCON project.
- The northern boundary of the intended monitoring line overlaps with the ASTTEX programme thus linking the Southern Ocean dataset with that collected in the southern Benguela region.
- Two PIE moorings have already been deployed along this line and the data collected during the monitoring programme will further support the PIE data set. In addition, it is envisaged a further 2 PIE moorings will be deployed along this line in the next 2 years further supporting the dataset.

- The intended monitoring line lies in close proximity to the annual "ferry service" of the SA Agulhas from Cape Town to the German Antarctic base Neumayer. It is expected that no more than one extra day will be required to accommodate this line.

ACTION ITEM 13. Liaise with CLIVAR/CliC SO Panel for the review of the GOOD HOPE proposal. (*Marshall, Koltermann and Piola*)

Several Argo floats are being deployed in Agulhas Current, return current and frontal regions upstream of Prince Edward Islands. Deployments are performed by research students of UCT on board of SA Agulhas during supply cruises to Antarctica, Gough and Merion Islands. UK provided the floats in March 2003 cruise.

15. The AMMA Project and its oceanographic component EGEE

Bernard Bourles gave a comprehensive overview of the scientific issues related to the West African Monsoon and the AMMA plans to address them.

The interannual and interdecadal variability of the West African monsoon (WAM) is well documented and has motivated many research efforts in recent decades. However there are still fundamental gaps in our knowledge of the coupled atmosphere-land-ocean system at least partly arising from lack of appropriate observational datasets. The monitoring system for the WAM and its variability is inadequate with many gaps in the standard routine network and lack of routine monitoring of some key variables; while the next generation of satellites will help, the research that will enable this still needs to be done. The dramatic change from wet conditions in the 50s and 60s to much drier conditions in the 70s, 80s and 90s over the whole region represents one of the strongest inter-decadal signals on the planet in the 20th century. Superimposed on this, marked interannual variations in recent decades have resulted in extremely dry years with devastating environmental and socio-economic consequences. The reasons for such variability are still uncertain meanwhile the rainfall deficit has raised important issues related to sustainability, land degradation, and food and water security in the region. Dynamical models used for prediction suffer from large systematic errors in the West African and tropical Atlantic regions; current models have problems simulating fundamental characteristics of rainfall such as the diurnal, seasonal and annual cycles. West Africa is also an important source region for natural and anthropogenic emissions of precursors to key greenhouse forcing agents (e.g. ozone, aerosols). For example, biomass burning in savanna and forest ecosystems over Africa contributes around 20% of the global biomass burning. Long-range transport of trace gases out of West Africa also has important implications for the global oxidizing capacity of the atmosphere (which controls the level of many greenhouse gases), global climate change and the transport of key constituents (e.g. water vapour, ozone depleting substances) into the stratosphere.

More generally the WAM is a system where scale interactions between convection (moist convection in the ITCZ, dry convection in the transverse circulation of the thermal depression), easterly waves, the African Easterly Jet (AEJ) and moisture flux convergence in low-levels are predominant. The main known and unknown interactions between the various dynamical features are summarized in Figure 6. Studying these scale interactions, requires us to investigate the dynamics of the continental water cycle - the variability of the convective systems and of the associated rain events plays an essential role in this dynamics, which, in turn, feeds back to the atmosphere - and of the surface conditions themselves. As a matter of fact surface conditions are a key forcing factor of the WAM. They are characterized by a marked interannual variability (sea surface temperature and seasonal cycle of the vegetation) and long-term trends (degradation of the vegetation, warming of the tropical oceans in the southern hemisphere) which are hardly known.

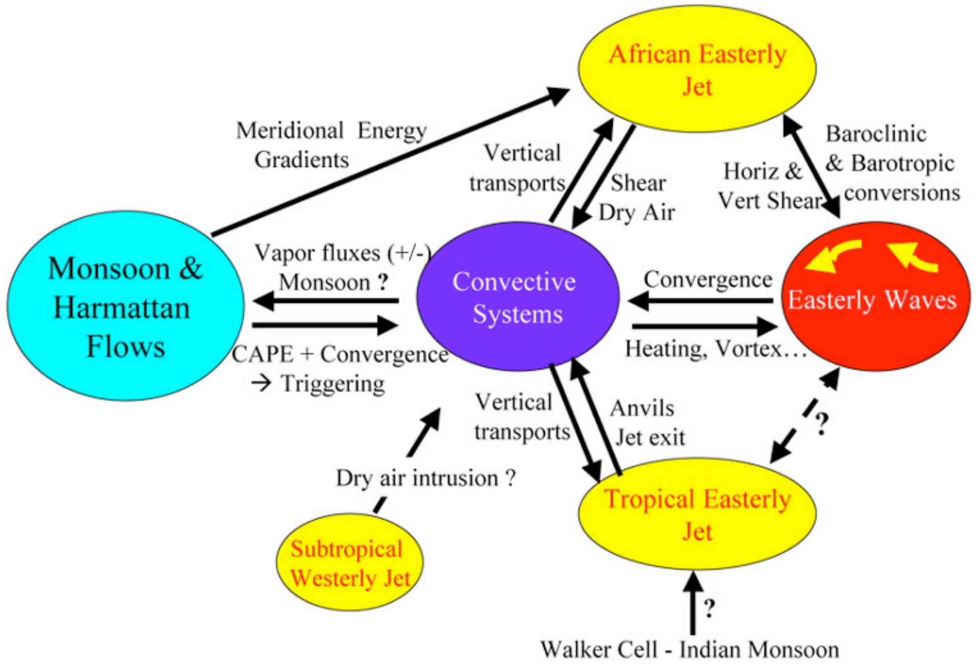


Figure 6. Intra-seasonal scales and interannual variability.

In 2000 the French community selected the WAM as a major research topic with the support of the French agencies (CNES, CNRS/INSU, IRD, MeteoFrance). They identify:

- A need for coordination and re-enforcement among the observational and modeling activities over WAM (CATCH, IMPETUS, JET2000, PROMISE)
- A need for specific and coordinated efforts on the numerous coming satellite missions (research and operational) presenting a strong interest for WAM (clouds, aerosols, chemistry, hydrology)
- A need to re-enforce collaborations between countries and disciplines given the favorable international context: CLIVAR-VACS, GEWEX (GHP, GCSS…), EU programs (WAMP, PROMISE …)

In 2001 the French proposal was submitted at the international community (White book) and in 2002 numerous researchers and agencies from African countries, USA and Europe declared their strong will to get involved. After several meetings AMMA (http://medias.obs-mip.fr/amma/index.en.html) was established. The project obtained the endorsement of CLIVAR and GEWEX in 2003. AMMA main goals are:

- To provide an improved description and understanding of the WAM, water cycle, variability and associated scale interactions
- To improve our understanding of the atmospheric chemistry and aerosols over WA and its global impact
- To identify & implement an integrated observing strategy in WA, needed to support research and prediction (medium-range, seasonal and climate scale)
- To develop & test the long term monitoring of surface & atmosphere (combining satellite and surface networks)
- To implement a strategy to use weather and climate observations and modeling/assimilation outputs for applications (health, food security, water resources)
- To develop training/education activities for African countries

To achieve these aims AMMA proposes a multidisciplinary approach to the study of the WAM. AMMA will link observations, data analysis and modeling on a wide range of space and time scales. The project will address the following interacting science areas: Monsoon dynamics and scale interactions, continental water cycle, aerosols, atmospheric chemistry, food, water and health. The observation strategy will thus associate operational observations (great attention will be paid to collecting and archiving historical datasets in close collaboration with African countries) with long term observations concentrated in a sub-regional window

and obtained from various ongoing research projects (CATCH, IMPETUS, INTEO, GLOWA-Volta, AERONET, IDAF). In addition, intensive multi-disciplinary observations will be performed during specific periods, focusing on the understanding of key processes. The utility of bringing in additional observations for the future will be tested using modeling and assimilation systems. Recommendations for future optimal networks will result, an important demand of African services and regional agencies.
AMMA is planned to be a multi-year project and will involve 3 observing periods:

- The Long term Observing Period (LOP) is concerned with data of two types. First, there are a number of unarchived observations that have been obtained during the past 50 years that would benefit studies on interannual-to-decadal variability of the WAM. These include rainfall and data describing land cover changes. Secondly, supplementary long term observations will be promoted to document and analyse the strong interannual variability of the WAM.
- The Enhanced Observing Period (EOP) is designed to serve as a link between the LOP and the SOP. Its main objective is to document over a climatic transect the annual cycle of the surface conditions and of the atmospheric state variables at convective-to-synoptic spatial scales. The EOP will be of 2-3 year duration, and hopefully longer.
- The Special Observing Period (SOP) will focus on detailed observations of specific processes at various key stages of the rainy season during three periods in 2006: (i) monsoon onset, (ii) peak monsoon and (iii) late monsoon

The northward penetration of moist air from the Gulf of Guinea up to the Sahelian domain, strongly conditions the WAM. For this reason the French community proposed an oceanographic component associated to AMMA. The EGEE (Ocean Circulation Study in the Gulf of Guinea and its variability) is a program that studies the oceanic parameters and circulation and their variability in the upper layers of the Eastern Tropical Atlantic through in situ and satellite data, and numerical models and experiments. The main goal of EGEE is the comprehension of the oceanic processes that control the energy exchanges at the ocean-atmosphere interface in the GG, and particularly the sea surface temperature (SST) and its variability, from seasonal to interannual time-scales. EGEE main components are:

- Analysis and validation of SST fields (comparison of SST climatology, satellite products and in situ measurements): representativity of fluxes at the ocean-atmosphere interface.
- Analysis of processes responsible for SST, SSS and mixed layer variability: joint analysis of hydrology, currents, tracers, measurements, satellite products and numerical models
- Analysis of the boundary layer variability: a) determination of parameters responsible for the discrepancy between numerical results and observations; b) high resolution modelisation of the mixed layer.
- Specific oceanographic cruises (EGEE cruises) and validated transits:
  - Operational cruises twice a year in GG for three consecutive years (during AMMA EOP) running through the PIRATA mooring sites and repeat sections at 10°W. Measurements: SST, SSS, meteo parameters, currents, S, T, O_2 in the upper 1000m, biogeochemical parameters (nutrients, CO_2) and surface drifter deployments (SVP, PROVOR).
  - Specific cruises planned in 2006. SOP-1 (May – July) in the GG during the monsoon onset (surface to bottom oceanic measurements and additional atmospheric and interface measurements). SOP-3 (end August – September) in the eastern tropical Atlantic during the late monsoon and the eastern tropical Atlantic export; off Dakar and across the Guinea Dome, and repetition of the 10°W section.
- Implementation of a meteorological station at Sao Tome Island (0-6E): extension towards the east of the GG of meteorological measurements available along the equator via the PIRATA network, associated with a tide-gauge already maintained by IRD and LEGOS.

EGEE will naturally link with CLIVAR (TAV), Argo (CORIOLIS), GOOS (PIRATA, VOS, XBT), GODAE (MERCATOR) and US projects (*Field study of the Atlantic Cold Tongue*, by J. Carton et al.; *Effects of atmospheric forcing, upper ocean teleconnections and feedbacks on TA SST variability*, by S. Garzoli et al.; *Dynamics of the Atlantic Marine ITCZ complex*, by K. Kushnir et al.). At the last AMMA International meeting (Nice, April 10-11) a working group (J. Carton, B. Bourles, G. Caniaux, S. Garzoli …) was established with the task of defining oceanic studies and field cruises for the "International Science Plan of

AMMA" (in preparation). There exists the proposal to have simultaneous US-French cruises in northern TA and in the GG during SOP-1 and SOP-3.

16. Tropical Atlantic Observations linked to AMMA

Martin Visbeck noted that AMMA has been endorsed by CLIVAR with a recommendation that the "ocean component" be strengthened. This is really the climate component of AMMA, and the Atlantic panel should ensure that this activity goes beyond the SOP period. A letter from Chris Thorncroft (VACS co-Chair) directed to the Atlantic panel was distributed among the present members. There, Chris Thorncroft informed the panel of a recent informal meeting in Miami between the AMMA representatives and international oceanographers that built upon the dialogue already begun in France that resulted in the EGEE proposal. Chris Thorncroft requests that the Atlantic Panel encourages the activity started in Miami. This is an exciting opportunity for scientists working in TA to collaborate with scientists working on WAM in order to address a major societal need and strengthen the interaction between CLIVAR Atlantic and VACS panels.

> **ACTION ITEM 14**. Work together with the AMMA group on strengthening of the climate component of the AMMA project (*Bourles, Kushnir, Schott and Reason*)

Fritz Schott presented some preliminary plans for a Tropical Atlantic Climate Experiment that would link to the AMMA study. As seen in section 11 (figure 4) all the climate models exhibit a systematic error in the equatorial SST: the predicted SST on eastern tropical zone tends to be too warm. The study of the Tropical/Subtropical Cells (STCs) might help to improve the forecast of TA climate. Results of numerical simulations show considerable differences in the mean pathways that connect the subduction areas with the upwelling areas on the equator. In the Southern Hemisphere observational and modelling evidence suggest that western boundary processes play an important role in the northward transport of subducted water. A significant portion of this water may upwell either along the equator or in the region of surface divergence associated with the ITCZ a few degrees north of the equator. Waters subducted in the Northern Hemisphere may be transported southward along the path of the North Equatorial Current. Some enter the western boundary and become entrained in the North Equatorial Counter Current/ North Equatorial Under Current system of zonal currents. Specific topics regarding the STC dynamics are the effect of subduction variability vs. equatorial Ekman divergence on the STCs and the relation between the variability of the North Brazilian Under Current, the equatorial upwelling and the SST. Results of coupled model experiments for a stronger than average STC (EUC, NBUC, equatorial upwelling and Trade winds stronger) show a cooler equatorial SST and less precipitation in ITCZ area. The opposite results for a weaker STC.

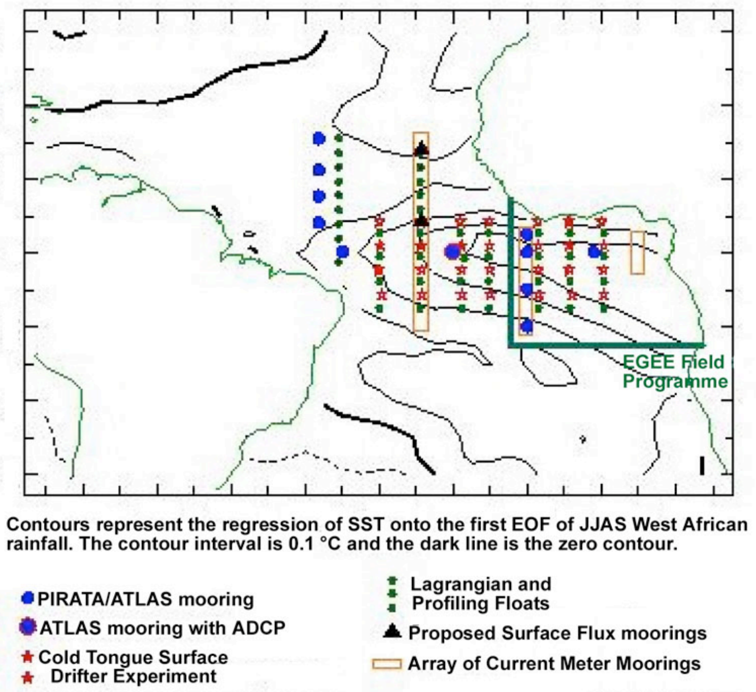


Figure 7. Preliminary plan of fieldwork suggested to study ocean's role in tropical Atlantic Climate variability and to be part of the climate element of AMMA

During the German CLIVAR project "Tropical-subtropical interactions" (http://www.ifm.uni-kiel.de/allgemein/research/projects/clivar/ta/array.html) a set of observations were made as repeat sections at 35W, 5S, 11S and a moored array was deployed off Brazil near 11S. The data show the North Brazil Undercurrent (NBUC) already well developed at 11S, with about 25 Sv flowing northward in the upper 1000m, i.e., the SEC bifurcation is located well south of 11S. While the NBUC was located over the shelf edge, large cruise-to-cruise differences were found in the location and strength of the North Atlantic Deep Water (NADW) core at both latitudes. The moored array data showed large deep variance at about 70 days period that appears to be responsible for the NADW transport variations.

Following on the funded and planed proposals of new observations in the TA and given the development of ITCZ and WAM dynamics studies the international community of oceanographers interested in the STC studies proposed to develop an ocean component of AMMA. The main topics to study are:

- Role of advection for SST anomalies: westward extension of EGEE
- Ocean mechanisms determining predictability for SST and land precipitation anomalies.

The proposed field program includes (see figure 7):

- long-term observing period (>5yrs) with meridional arrays of moored stations, 2 flux stations, isopycnic floats (RAFOS) and drifters, Argo profiling floats, XBT lines and satellite observations
- enhanced observing period (2005-7) with repeat ship survey of cold tongue and marine ITCZ
- special observing period (2006) similar to what EGEE proposes with mixing experiments on cold tongue physics

ACTION ITEM 15. Encourage further planning for a Tropical Atlantic Climate Experiment (TACE) and the submission of a white paper including STC, ITCZ, "PIRATA + extensions" (*Schott, Johns, Kushnir, Reason and Bourles)*

ACTION ITEM 16. Review the initial plans for the TACE (*Sutton, Hurrell and Wainer*)

Some discussion on the PIRATA moorings followed the TACE presentation and a question arose on the need for the PIRATA array in the context of TACE whether at its actual level or reduced/enhanced. The

Atlantic panel was concerned with the PIRATA moorings survival following some recent controversial discussion at the last PIRATA meeting.

> **ACTION ITEM 17**. Express concern about leadership within PIRATA (*Visbeck and ICPO*)

17. Update on ASOF progress

Information on the ASOF study can be found at http://asof.npolar.no/. There has been few changes at the organizational level: the ISSG remains with its overall coordination role but regional tasks are now planned by groups with the practical expertise to do so, with a numerical modelling group serving them all. Roberta Boscolo was recruited as project scientist in September 2002, working for 50% of her time. ASOF-East has been funded mainly by EU Framework 5 (3 years starting from Dec. 2002) while ASOF-West is receiving support from NOAA, NSF and ONR. The elements of the ASOF freshwater array are partly in place, the data haven't been analysed yet but there has been an analysis of proxy measure of freshwater flux from the AR7W WHP line by I. Yashayaev. The offshore density gradient in the 0-150m layer from Labrador Shelf to the Central Labrador Sea has progressively steepened with the NAO over the past 4 decades (equivalent to a 20% increase in southward transport) largely through freshening of shelf and upper-slope waters. Bob Dickson gave further evidence on the rational of the ASOF study: as the Earth is warming a warmer atmosphere will carry more water vapour because of the exponential increase of vapour pressure with temperature. An enhanced water cycle will change the distribution of salinity in the upper ocean hence a program for monitoring salinity changes is needed. He showed that between Station W (39N – 70W) and Bermuda the Salinity Maximum Water formed in the subtropical gyre at the Atlantic E-P maximum has increased its salinity over the same 40-year period of the freshening in the Labrador Sea. The change in salinity is not confined to the North Atlantic, the Atlantic surface tropics / subtropics and Mediterranean Overflow Water is getting saltier while DSOW, LSW, AAIW and NEADW are getting fresher. The same symmetrical pattern of change, freshening intermediate waters from high North and South latitudes and more-saline upper ocean at low latitudes has been shown for the Pacific and Indian oceans too. This is a new evidence of the expected multi-decadal increase in the global water cycle. While there is no evidence yet if any sustained change in the MOC it is expected. It is therefore important that the observational array that ASOF is putting in place is adequate, simultaneous and lasts for a decade or two.

Bob Dickson also submitted to the panel a request for CLIVAR endorsement of ASOF (see APPENDIX D).

> **ACTION ITEM 18**. Provide feedback to ASOF Chair on the endorsement letter submitted to CLIVAR. (*Mauritzen and Visbeck*)

18. WCRP focus on Arctic, Cryosphere and Climate, links to CLIVAR Atlantic

About 10 years ago the WCRP launched a project called the "Arctic Climate System Study (ACSYS)". ACSYS has provided progress in understanding the interactions between the Arctic Ocean circulation, ice cover and the hydrological cycle thus giving scientific basis for an accurate representation of Arctic processes in global models. The ACSYS legacy is its data sets and the products resulting from a long-term regional monitoring programme (available at http://acsys.npolar.no/). ACSYS will celebrate its end in 2003 with a final science conference "The ACSYS decade and Beyond" in November at St. Petersburg, Russia (see programme at http://acsys.npolar.no/meetings/final/conf.htm). The CLIVAR Atlantic panel is invited to attend.

"Climate and Cryosphere (CliC)" is a new WCRP project resulting from a WCRP's request to initiate a global project on the climate and cryosphere (endorsed by JSC in 2000). The science and coordination plan for CliC has been developed by an international task group of the JSC for WCRP/ACSYS SSG. The 1st draft of the implementation plan is available at the CliC web site (http://clic.npolar.no/) and the CliC Project Office is co-located in Tromso, Norway with the ACSYS Project Office. CliC's principal goal is to assess and quantify the impacts of climatic variability and change on components of the cryosphere, and their consequences for the climate system, and to determine the stability of the global cryosphere. The specific objectives are:

- Enhance the observation & monitoring of the cryosphere in support of process studies, model

evaluation and change detection
- Improve understanding of the physical processes and feedbacks through which the cryosphere interacts with other components of the climate system
- Improve the representation of cryospheric processes in models to reduce uncertainties in simulation of climate and predictions of climate change

Reductions in Arctic sea ice cover observed during the passive microwave era (1978-present) exemplified by the record ice loss in September 2002 are part of a larger pattern of Arctic change including increases in surface air temperature, permafrost degradation, increased river discharge to the Arctic Ocean and changes in ocean structure which may have feedbacks on the global climate system. The ice thickness in the American sector of the Arctic shows an apparent 40% decrease between 1960's and 1990's and continuing thinning by 10cm per year during the 1990s. CliC key scientific questions can summarized as:
- Contribution of glaciers, ice caps and ice sheets to changes in global sea level (rise) on decadal-century timescales (and water resources)
- Changes in frozen ground regimes on decadal-century timescales and their global and economic consequences (e.g. water management)
- Nature of changes in ice (mass balance) in both polar regions in response to climate change
- Contribution to studies of abrupt climatic changes resulting from regime changes in ice shelf-ocean and sea ice-ocean interactions that impact on the ocean thermohaline circulation
- Cryospheric data as indicators in the climate system

Potential additions includes: the role of intensified release of carbon-containing gases into the atmosphere in the course of frozen ground thawing; joint role of snow cover and vegetation in carbon exchange; geocryology + hydrology + biogeochemistry; joint with CLIVAR – carbon exchanges between polar oceans and atmosphere.

Several modeling activities initiated within ACSYS will continue with CliC in particular, in the field of model intercomparison projects. Also there are several observational activities that will be implemented in the future both in situ and satellite. Among the ongoing observational network it is worth mentioning the International Arctic Buoy Programme (IABP http://IABP.apl.washington.edu/). CliC is already interacting with CLIVAR through the joint CLIVAR/CliC Southern Ocean Panel, which had its first session in March 2002, however there are several issues that CliC would benefit through a joint work with CLIVAR Atlantic. Some potential areas of interaction are:
- CliC is more land-based than ACSYS, joint address of Arctic hydrography
- Recognition of ASOF role - common planning needed;
- Arctic System Re-analysis, AO re-analysis with inclusion of sea-ice – the only way to understand past variations
- ACSYS/CliC has useful data: ADIS => DISC
- Data sets: SCICEX, IPSs, historical, ARDB
- Ocean R-A: past ice reconnaissance data, CRYOSAT; snow;
- Carbon: Arctic Coastal Dynamics + ?
- Modelling: AO, sea ice, ice sheets, snow, hydrology of cold climates (river run-off through permafrost);
- Sea Level Rise (CLIVAR, CliC, GLOSS of GOOS, …);

ACTION ITEM 19. Liaise with ASOF on the issue of CLIVAR/CliC role in the Arctic Ocean. (*Mauritzen, Dickson, Ryabinin and Koltermann*)

19 Joint Session with WGOMD

The participants were welcomed by the chairmen of both groups, Martin Visbeck (Atlantic) and Claus Boening (WGOMD) who gave short introductions about the tasks of the individual panels. It was emphasised that the aim of this joint session was to exchange information about the common working areas and interest; specifically the Atlantic panel was asked to provide inputs on metrics and indices of climate variability in the Atlantic sector to be used for model-model and model-data intercomparison studies. The Atlantic panel expressed interest in access to output from model experiments (e.g. OMIP) for intercomparison with observations. The initial focus was to identify metrics jointly and develop model experiments to explore the responses and sensitivity of the Meridional Overturning Circulation (MOC).

19.1 Summary of OMIP status and plans

A.-M. Treguier gave a short progress report on the P-OMIP (Pilot Ocean Model Intercomparison Project) study. The goal of the P-OMIP is to demonstrate the feasibility and merit of a coordinated investigation of global ocean-ice model performance. WGOMD has formulated and agreed on a protocol, (basically following the example of a previous German 'mini-OMIP' between two ocean models: MOM and HOPE); P-OMIP involves a 100-year integration period and forcing by a global flux dataset based on refined ECMWF re-analysis products.

During the past year, the Pilot study took place with 6 modelling groups participating. Since a number of experiments have been completed very recently, some more analysis of the results is still required. Because of some incompatibilities, e.g. with the surface flux formulations in various coupled systems, not all groups applied the forcing protocol strictly. 3 groups followed the protocol strictly, 3 with some modifications. It was decided that some modest, but well documented modifications to the protocol should be allowed in order to allow sufficient participation. For a full OMIP additional resources would be required to perform common analysis. Potential options, including funding have to be explored.

As the WGCM (Working Group on Coupled Modelling) recommended, the OMIP study will be coordinated with activities within CMIP and AMIP in preparation for the next assessment of the IPCC. This means that the demonstration phase of OMIP has to be completed by early 2004. The results of this first OMIP phase should be assessed and reviewed during a workshop planned back-to-back to the next meeting of WGOMD in Spring 2004.

19.2 Summary of CMIP THC response studies ("water hosing experiments")

S. Griffies gave an overview on this subproject of the Coupled Model Intercomparison Project (CMIP). The aim is to establish a benchmark for the sensitivity of the Thermohaline Circulation (THC) to an imposed surface freshwater flux. The motivation is the broad spread of MOC scenarios as highlighted in the IPCC TAR 2001. The design is to apply a surface flux of 0.1 Sv in total, uniformly distributed over the Atlantic between 50°N and 70°N, for a period of 100 years, starting from a control state. This additional flux is a net addition of freshwater to the ocean; it is not compensated for by removal elsewhere. After 100 years, the imposed water flux will be switched off, and the experiment continued to run, so that any recovery can also be investigated.

Experiments like the 'water hosing' experiment of CMIP are difficult to conduct with ocean-only models. The usual restoring boundary condition on surface salinity overly damps the salinity anomaly and misrepresents the sensitivity of the oceanic circulation. Flux boundary conditions for salinity seem a more natural choice. Combined with restoring conditions for SST mixed boundary conditions are realized. This is the case whenever SST is relaxed to a fixed reference temperature, for instance by using bulk formulae for the latent and sensible heat fluxes where a prescribed air temperature enters. Mixed boundary conditions are known to result in a much too sensitive system where small changes in salinity result in massive changes in the thermohaline circulation (Bryan, 1986; Rahmstorf, 1995; Lohmann et al.,1996). The sensitivity results from the positive salinity advection feedback: Warm and saline water that is carried northward by the thermohaline circulation is cooled in high latitudes, leading to enhanced sinking. The replacement of the sinking water strengthens the thermohaline circulation. In the climate system, the negative temperature advection feedback counteracts the salinity advection feedback. The heat released by the ocean warms the atmosphere and reduces the density gain in the poleward branch of the thermohaline circulation. This feedback is suppressed with prescribed air temperatures in ocean models. Simple atmospheric models have been used to overcome these difficulties (e.g. Rahmstorf, 1995; Lohmann et al., 1996) but are no options for experiments which aim at a close simulation of the observed ocean state and its temporal development. The suggestion of splitting the salinity in two components where one is restored to reference surface salinities while the other integrates the anomalous surface fluxes is under investigation.

19.3 Data sets for testing models, particularly with respect to the MOC

The MOC is believed to be the most important aspect of North Atlantic (NA) ocean circulation for climate variability. At the last Atlantic panel meeting (Bermuda July 2002), Dr. Wright was charged with the task of compiling a list of MOC observables to be passed to the ocean modelling community (WGOMD) including

- those that help to assess the model representation of processes believed to be critical for the dynamics of MOC variability
- observed decadal-interdecadal changes in quantities that are influenced by the MOC
- ongoing or planned observations that may allow quantitative assessments of the present state and future changes in the MOC

Dr. Wright began his presentation by emphasizing that the NA cannot be decoupled from the Arctic and that the THC cannot be decoupled from the wind-driven circulation. He assumed that the ocean models will be run with specified forcing from reanalysis products so that the models at least have a chance to reproduce the observations. Mean properties, statistics of variability and qualitative behaviour should also be reproduced by coupled models but they should not generally be expected to reproduce specific events.

Although the primary interest is in observations that will test the variability seen in models, the "mean" state strongly influences this variability. A model that has reasonable variability but has an incorrect base state cannot be trusted outside of the range of conditions over which it has been tested. Major pathways and mean transport estimates have been identified based on an eclectic data set that includes:

- Current meter moorings
- Cable data
- Drifters (shallow and deep)
- Hydrography and Tracers
    - Point snapshots and time series
    - Detailed correlation analyses
    - Diagnostic Calculations
    - Inverse Calculations

Recent work on data assimilative models promises both new results and estimates of uncertainties.

Direct observations of MOC variability are very limited and there is considerable uncertainty about how the observations that are available should be compared to model results. Observations of the effects of MOC variations may have to be used in lieu of direct observations in order to provide meaningful comparisons with model results. The final 'shopping-list' that Dr Wright came up with to intercompare ocean models with observations had the following elements:

- The mean overturning circulation
- Basin scale changes in water mass properties
- Spatial and temporal variation of tracers
- Variations in sea ice and relation to SST
- Variations in SST
- Variations in major gyre transports (Curry and McCartney)
- Variations in upper ocean shelf-slope transports (analogues to Curry and McCartney)
- Variations in Florida Current transport
- Variation in transport through A5/AR1 section (24°N)
- Variations in transport through A2/AR19 section (Grand Bank to England)
- Qualitative and quantitative response to the Great Salinity Anomaly(ies)
- Production and drainage of Labrador Sea Water and deeper water masses
- "Drainage" of Greenland Sea deep water

He noted that it might also be possible to derive useful information from long-term sea level observations by looking for long-term basin-scale changes in the east-west and north-south tilts, but it is not clear whether or not a reliable estimate of variations can be extracted from the available observations. Additional items that were identified as desirable were sections across 10°N (MOVE/GAGE), 10°S and 30°S. He noted that his list of available observations was biased towards the North Atlantic and that this was partly due to less information being available for the South Atlantic but also reflected his limited knowledge of South Atlantic studies. He will be requesting input from other panel members to help fill some of the gaps.

He concluded that there is a need to discuss what observations should be compared with what models and what should be expected from the models. The webpage: http://www.clivar.org/organization/atlantic/IMPL/index.htm was mentioned as an outstanding example for the present observational database and future projects in CLIVAR Atlantic. With respect to the Tropical Atlantic variability (TAV) a new website is available under http://www.knmi.nl/~hazelege/tameet/tameetmod.html for intercomparisons with model results for tropical Atlantic circulation. This website provides links to data from ocean models that will participate in a "low profile" model intercomparison for tropical Atlantic circulation as decided during the ad hoc group addressing Tropical Atlantic Variability meeting, in August 2002 in Kiel. The focus will be on robust features in the models despite their differences in configuration. Especially the seasonal cycle of the different current branches is of interest. In addition the data will be used for comparison with hydrographic data. It was agreed to foster cooperation between the Atlantic Panel and WGOMD in the field of model and data intercomparisons. While in the present phase of OMIP it will not be possible to provide all the products being envisaged by the observational community, it was found important to explore possibilities for designing a programme of coordinated model experiments (e.g. an OMIP-2 phase) focusing on ocean variability.

> **ACTION ITEM 20**. Encourage joint activities on model-data intercomparison with WGOMD (*Boening, Sutton and Schott*)

At the last Atlantic meeting T. Delworth was asked to lead a subgroup formed by Atlantic panel members to provide inputs to WGOMD on metrics and indices of climate variability in the Atlantic sector for model-model and model-data intercomparison studies and detection of climate change. The initial focus is on the MOC and basin-scale water mass properties as the most important oceanic features. The purposes of the model experiments are:

- Investigate the mechanism responsible for MOC variability and MOC response to forced changes, including issues of MOC stability, in a variety of (coupled and uncoupled) models
- Evaluate the extent to which MOC behaviour in a variety of models is likely to be realistic/unrealistic
- Identify key model requirements for realistic/adequate simulation of MOC variability and change (the appropriate definition of "realistic/adequate" will depend on specific purpose)
- Identify the degree to which variability in water mass properties are consistent between different models and how this variability compares with that seen in reality

A draft of primary and secondary metrics have been proposed:

Primary Metrics	**Ocean-only Models with Climatological Forcing**	**Ocean-only Models with (preferably) Identical Interannual Forcing**	**Coupled Models**
1) MOC at 26.5N (potentially also 30S, 10S, 10N, 48N)	YES (time-mean only)	YES (time-mean and time series)	YES (time-mean and time series)
2) Heat and freshwater transports as a function of latitude and time (monthly resolution)	YES (climatological seasonal cycle)	YES (climatological seasonal cycle and interannual variations)	YES (climatological seasonal cycle and interannual variations)
3) Curry and McCartney baroclinic transport index (store integrated potential energy anomalies separately)	YES (time-mean only)	YES (time-mean and time series)	YES (time-mean and time series)

4) SST gradient between North and South Atlantic	MAYBE, but caution is warranted if there is any SST restoring	YES (time-mean and time series; caution if there is SST restoring)	YES (time-mean and time series)
5) Heat and freshwater transports through key passages: a) Canadian Archipelago (if resolved), b) Iceland-Faroer-Scotland, c) Denmark Strait and d) Florida Strait	YES (time-mean only)	YES (time-mean and time series)	YES (time-mean and time series)
6) Model analogue for Bermuda hydrographic time series	NO	YES	YES

Secondary Metrics	**Ocean-only Models with Climatological Forcing**	**Ocean-only Models with (preferably) Identical Interannual Forcing**	**Coupled Models**
1) Heat and freshwater transports through additional key passages, such as Gibraltar	YES (time-mean only)	YES (time-mean and time series)	YES (time-mean and time series)
2) Upstream "heat" or deep Greenland Sea waters overflowing the Iceland-Faroer-Scotland sills	YES (climatological seasonal cycle)	YES (climatological seasonal cycle and interannual variations)	YES (climatological seasonal cycle and interannual variations)
3) T, S, and volume of Labrador Sea water	YES (time-mean only)	YES (time-mean and time series)	YES (time-mean and time series)
4) Measure of Gulf Stream position	YES (time-mean only)	YES (time-mean and time series)	YES (time-mean and time series)

Potential model experiments proposed:
a. Sensitivity to horizontal resolution of processes relevant for MOC variability and change. One such experiment could focus on the dependence on resolution of signal propagation along the western boundary. The first task is to agree on an experimental design that could sensibly be applied with a range of models.
b. Adjustment of models to surface perturbations. One such experiment is already underway; there is an existing CMIP project to examine the response of coupled models to imposed freshwater forcings, and to CO2 increases. Another potential experiment be the response of models to perturbations associated with stronger or weaker NAO states, or to altered NAO spatial structures.

> **ACTION ITEM 21** Further develop the Metrics of Atlantic Climate Variability and provide the inputs to WGOMD for ocean models verifications (*Delworth, Wright, Johns and Schott*)

19.4 CLIVAR Workshop on North Atlantic Thermohaline Circulation Variability
A workshop on 'North Atlantic Thermohaline Circulation Variability' which will be held 13-16 September 2004 in Kiel Germany is being organized under the auspices of the International CLIVAR Project by the Atlantic Implementation Panel, the Working Group on Ocean Model Development, and the Special Research Programme on the "Dynamics of Thermohaline Circulation Variability" (SFB 460) at the Institute for Marine Research (IfM) of Kiel University. The organising committee is co-chaired by Claus Boening (Institut für Meereskunde, Kiel, Germany) and Martin Visbeck (Lamont-Doherty Earth Observatory, Palisades, USA).

The workshop intends to bring together expertise from observations, theory and modelling, to discuss recent advances and outstanding problems in our understanding of the mechanisms of deep water formation and circulation in the subpolar North Atlantic, their relation to large-scale thermohaline circulation variability and impact on the uptake anthropogenic trace gases. Its aims are two fold: 1) To take stock of our understanding and best estimates of the present and future state of the Atlantic Thermohaline Circulation and 2) To guide implementation plans by assessing the capabilities and future needs of THC observing and synthesis systems to detect low-frequency changes or trends.

Particular themes are:

- What is known about the key processes governing NADW formation and its variability?
- What are the main characteristics and mechanisms of interannual, decadal, and interdecadal variability in water mass formation, deep current systems, ocean-atmosphere fluxes, and large-scale transports?
- What is the effect of this variability on the sequestration of anthropogenic trace gases?
- How well are the observed behaviours captured in present ocean and climate models, and what are the main requirements for improvements?
- What are the elements of an efficient observation system for the Atlantic THC, what are the research needs to improve its design?

Further details will be distributed at a later stage.

During the discussion inclusion of an atmospheric topic in the list of themes was suggested, e.g. Interaction of NAO and THC variability.

> **ACTION ITEM 22**. Update the proposal of the THC workshop and ask SSG for endorsement. (*Visbeck, Boening and Boscolo*)

19.5 Open Science CLIVAR Conference

The co-chair of the CLIVAR SSG, A. Busalacchi, gave an overview on the scope and format of the first international CLIVAR Science Conference, to be held, 21-25 June 2004 in Baltimore, USA. The conference will review the first phase of CLIVAR and feature:

- Overviews prepared by expert teams
- Invited presentations and discussion forums
- Contributed poster presentations (with special emphasis on young scientists' participation).

Contributions are solicited on research topics will include, but not be limited to:

- **Advances in understanding elements of the climate system:** Seasonal-to-interannual variability especially ENSO, monsoon systems, decadal (and longer) variability, and anthropogenic climate change
- **Looking into the past:** Analysis of paleoclimate records; reanalyses
- **New approaches to climate prediction:** Modelling, data assimilation, and validation
- **Improvements to the observing system**
- **Climate applications:** Who are our customers? What products and Information do they need?

More information can be found at the conference web site (http://www.clivar2004.org).

The preliminary programme is almost complete and will be released shortly. Busalacchi recommended that the panels work together with the designated speakers on the preparation of the presentations. It is envisaged that a special issue of the Journal of Climate will be prepared containing the main conference papers.

20. Additional Future activities and Next meeting

M. Visbeck brought to the attention of the panel the upcoming EURESCO Conference on "Achieving Climate Predictability Using Paleoclimate Data" as an opportunity to establish links with the paleo community and initiate activities in paleomodelling. The conference will be held in San Feliu de Guixols, Spain on 11-16 October 2003 co-chaired by Thomas Stoker and Martin Visbeck with co-sponsorship from IGBP/PAGES and WCRP/CLIVAR. Invited speakers and final programme can be found at: http://www.esf.org/euresco/03/lc03170).

ACTION ITEM 23. Inform the Panel on the outcome of the EURESCO conference on Achieving Climate Predictability by using Paleoclimate Data: EuroConference on North Atlantic Climate Variability, S. Feliu (Barcelona) 11-16 October 2003. (*Boscolo and Wainer)*

M. Visbeck suggested to have the next panel meeting in US attached to the CLIVAR conference.

ACTION ITEM 24. Explore the possibility of holding next Atlantic Panel session before or after the CLIVAR conference in June 2004. Possible venue: Columbia University, New York USA. Explore topics for next meeting: CLIVAR and the Arctic Ocean, extratropical climate modes: NAO and stratosphere, summer season. *(Visbeck and Boscolo)*

APPENDIX A: List of Attendees

Panel Members		
Busalacchi Tony	ESSIC, Maryland, USA	tonyb@essic.umd.edu
Delworth Tom	GFDL, Princeton, USA	td@gfdl.gov
Hurrell Jim	NCAR, Boulder, USA	jhurrell@ucar.edu
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Wainer Ilana	Uni. Sao Paolo, BR	wainer@usp.br
Wright Dan	BIO, Dartmouth, CA	WrightDG@mar.dfo-mpo.gc.ca
Guests and Observers		
Bates Nick	BBSR, Bermuda	nick@bbsr.edu
Bourles Bernard	IRD, Brest, FR	Bernard.Bourles@ird.fr
Dickson Bob	CEFAS, Lowestoft, UK	r.r.dickson@cefas.co.uk
Ryabinin Vladimir	JPS/WCRP, Geneva CH	Ryabinin_V@gateway.wmo.ch
Stammer Detlef	SIO, La Jolla, USA	dstammer@ucsd.edu
Todd Jim	NOAA-OGP, USA	james.todd@noaa.gov
ICPO		
Boscolo Roberta	IIM-CSIC, Vigo Spain	rbos@iim.csic.es
Cattle Howard	SOC, Southampton UK	hyc@soc.soton.ac.uk

APPENDIX B: Agenda

Venue: Salle Academie, the Citadel Conference Centre

Day 1: Sunday 13th April

9:00 - 9:50 Panel Session (panel members and ICPO only)

- Welcome Remarks
- Review of Agenda *(Visbeck)*
- Review of the Action Items from last meeting *(Visbeck)*
- Review of the Membership *(Visbeck)*

10:00 Introduction (Open meeting)

- Welcome *(Visbeck)*
- Meeting Arrangements *(Visbeck and Boscolo)*

10:15 Feedback from WCRP/JSC (*Busalacchi*)
10:35 Update on CLIVAR/ICPO activities *(Cattle)*
11:00 Coffee break
11:20 Update on CO2 observations in the Atlantic (*Bates*)
11:45 CLIVAR activities in the Atlantic: current and future (*Boscolo*)

- Observing system
- CLIVAR core programs
- CLIVAR related programs

12:50 Lunch
14:00 – 15:30 CLIVAR Data / Products / Atmosphere-Ocean reanalysis

- Ocean reanalysis (D. Stammer)
- Coriolis/Mercator (B. Boules)
- Data needs “strawman” (P. Koltermann)

15:30 Coffee Break
16:00-16:15 Panel Discussion on “data requirements”
16:15 - 17:30 CLIVAR - Predictability / Synthesis

- Atlantic ITCZ dynamics and predictability and input from ECMWF for needs in tropical Alantic (Kushnir)
- Proposal for CLIVAR predictability workshop (Sutton)

17:30 Panel Discussion on “connection to prediction / synthesis efforts”
18:15 Adjourn
19.00 Panel Dinner

Day 2: Monday 14th April

9:00 Follow up of South Atlantic Climate Observing System (SACOS) Workshop *(Piola)*
9:40 Update on African activities: PIRATA SE extension, ASSTEX - Agulhas rings, GOOD HOPE - proposal SE Atlantic and ARGO deployments (*Reason*)
10:05 Update on AMMA and EGEE (*Bourles, Kushnir*)
10:30 Coffee Break
11:00 Developments on plans for an STC-TAV study (*Schott*)
11:20 Discussion on TAV / S. Atlantic activities
11:40 Update on ASOF (*Dickson*)
12:05 Update on WCRP/CliC and links with Atlantic (*Ryabinin*)
12:30 Lunch
13:30 - 15:30 Joint session with WGOMD on crosscutting ocean model issues.

- Introductory remarks about the tasks and activities of the Atlantic panel (*Visbeck*)
- same for WGOMD (*Boening*)
- summary of OMIP status and plans (*Treguier*)
- summary of CMIP THC response studies ('water hosing exps.') (*Griffies*)
- data sets for testing models, particularly with respect to the THC (*Wright*)
- Metrics of Atlantic Climate Variability (*Delworth*)

- CLIVAR workshop on THC variability (*Visbeck*)

15:45 Coffee Break
16:10 CLIVAR Conference in June 2004 *(Busalacchi)*
16:30 End of open panel session
16:30 - 18:00 Discussion on Panel Business (panel members and ICPO only)

- Discussion of what was presented
- Letter writing / endorsements
- Future meetings (workshops etc...)
- Next Panel meeting
- Action items

18:00 Adjourn