DRAFT White Paper and Meeting Report

<u>(not for circulation)</u>

Global Eulerian Observatories (GEO) International Science Team

2nd Meeting, Honolulu, 16-18 February 2002

White Paper version 1 December 2002

Introduction

In response to the growing need and demand for an ocean observing system that encompasses both lagrangian and eulerian in-situ observations, CLIVAR and GOOS (through their COOP and OOPC bodies) as well as POGO requested the initiation of an international timeseries project that is global in scope and that will complement the already much advanced ARGO project of a profiling float network around the globe.

To take on this charge, an international science team was created under the sponsorship of the above organizations. At its first meeting in May 2001 this team defined a timeseries pilot project, called Global Eulerian Observatories Pilot Project (GEO-PP). The project will work towards the implementation of a preliminary global array of long-term multi-disciplinary timeseries observatories over a 5-year period. The ideal mode of implementation for timeseries is via autonomous technologies (moorings, gliders, etc) and this is the long-term goal, including real-time data telemetry. As an interim approach, ship-based repeat occupations will however also be included as long as relevant modes of variability are resolved (see section ...).

This document describes the GEO-PP and the role and activities of the associated International Science Team (GEO-IST). It is designed as an evolving document that is updated and refined regularly, adding new information, new sites, new developments and decisions. The most current document can be found on the GEO website www.oceanpartners.org/geo.

Rationale

The science community, policy makers, and society need an observing system for the global ocean, climate and ecosystem in order to detect changes, to describe/quantify them, to understand/explain them and to develop a capability to predict them.

The World Ocean Circulation Experiment (WOCE) of the WCRP had demonstrated that global observations of the ocean state are possible and feasible, but had focussed on the mean state.

The overall ocean observing system needed now should provide a global 4-D description of the oceanic variables of climatic and societal relevance. Fixed-point timeseries provide a unique 2-D cut through this space (time and depth) for many variables at selected locations, resolving a wide range of temporal variability and sampling the water column from the surface to the bottom. Thus they complement very well other components of the observing system.

Due to the size and weight of many of the sensors, timeseries currently are the only approach for observing multidisciplinary variability.They are also uniquely suited for sampling critical or adverse regions and periods (e.g straits, boundary currents, boundary layers, ice-covered some observation types that require a timeseries or mooring approach, and some users of such data.

Application fields of timeseries data

Ocean timeseries data collected at representative or critical locations are required in many fields of earth science research, observation and prediction. These include

- observations and study of variability in the earth system and the interactions between the subsystems (atmosphere, ocean, solid earth, land, cryosphere)
- role of the ocean in climate: physical and biogeochemical ocean processes of climate variability and change, e.g. heat transports and CO_2 sequestration
- health of the ocean
- detection of changes and events in the ocean (physical, biological, pollution, climatic, seismic,etc)
- operational uses (assimilation, short-term prediction, climate forecasting, e.g. ENSO)
- development and validation of numerical models and of forecasting tools
- ground-truthing/calibration of remote sensing and autonomous instrumentation (e.g. floats)

Ocean processes and data types that require a timeseries or mooring approach:

Certain types of ocean processes and physical/biogeochemical variables naturally lend themselves for observations in a timeseries or moored mode e.g.by requiring high-frequency observations, or strictly require such an approach, at least based on existing technologies, e.g in strong current regimes. These include

- variables relevant to processes operating mainly in the time-depth dimensions (e.g. water mass formation, biogeochemical processes like productivity in the upper layer and vertical carbon export)
- linkage between biological, chemical and physical/climatic parameters (many variables)
- velocities, mass transports and other integral properties (e.g. heat content) at fixed places, e.g. in/across boundary currents
- flows and conditions in straits, passages, overflows, choke points
- surface meteorology, incl. flux referencing data and wave spectra
- CO_2 concentrations and air-sea CO_2 fluxes (need to resolve short time variability: diurnal, seasonal, interannual...)
- ecosystem productivity and variability, incl. zooplankton and fish abundance
- water column carbon flux and particle export
- ocean bottom processes and events: seismic, geodetic, electromagnetic, bottom pressure signals, tsunamis
- benthic community structure changes

In addition there may be purely instrumental reasons and needs for mooring approaches, like in the case of heavy sensors such as in-situ analyzers, sound sources, and others.

Users (real-time and delayed-mode):

Timeseries data are useful for a wide range of users, and once data are available publicly and in real-time, the applications and user-base are likely to expand. The likely users expected at present are

- research and development community (incl. testbed applications, model development)
- climate policy makers, signatories of conventions (e.g.IPCC)
- weather, ocean, and climate forecasters (short and long-term, maritime commerce offshore industry, search and rescue)
- desaster warning and mitigation agencies (seismic, tsunami, harmful blooms,...)
- fisheries (fishing community and resource managers)
- Outreach and education agencies
- remote sensing community (for ground-truth)
- national security community

Definition and Criteria for timeseries sites in the system

The global eulerian observatories system will be multidisciplinary in nature, providing physical, meteorological,chemical, biological and geophysical timeseries observations.

The data will be publicly available as soon as received and quality-controlled by the owner/operator, or by a data acquisition center performing this taskon his behalf.

An international Science Team provides guidance, coordination, outreach, and oversight for the implementation, data management and capacity building

A number of criteria have been agreed upon, which need to be fulfilled by a site in order to qualify for being part of the system:

Defining criteria:

1) Sustained in-situ observations at fixed geographic locations of ocean/climate related quantities at a sampling rate high enough to unambiguously resolve the signals of interest. Sustained means a plan/committment for longer than one project/proposal period and intention to pursue funding from "observing system programs" when available. Therfore: Wherever possible, the observations should be achieved with autonomous instrumentation, in a moored or virtually moored mode. Where/while this option is not available (certain variables, logistical constraints, etc), ship-occupied timeseries may qualify an alternate approach, if at least seasonal variability can be resolved. The rationale for this mooring-based goal is that only in this mode can high temporal resolution be achieved, which is critical for various observations or events (diurnal cycle, convection, blooms, seismic, etc). Also, only this way can the long-term goal of unattended operation over many years be approached or remote glider-based methods be explored.

2) Transport sections using whatever technique are included in choke points and major boundary current systems (moorings, gliders, ship ADCP, tomography, etc)

3) Coastal timeseries are included when they are instrumented to have multidisciplinary impact on the global observing system and if they are not part of a national coastal buoy network.

4) Any implemented site fulfilling the criteria will become part of the system but has to deliver its data into the system and to demonstrate successful operation and value after 5 years.

5) Real-time data telemetry of operational variables will be pursued, i.e every effort will be made if it is technically feasible and/or if there are operational users. The rationale for this requirement is: a) Monitoring of instrument functioning (essential for targetting uninterrupted timeseries); b) Some endusers may have requirement for real-time data (ocean forecasting, real-time assimilation, politicians to demonstrate Kyoto monitoring obligations). c) Helpful for outreach and publicity (online public information about ocean state and changes, ability to feed news about events to media), the TAO array is a good example. d)verification and validation, e) event-driven sampling

6) Data should be made public in near real-time for real-time data or as soon as processed and post-calibrated for other data; certain quality control standards, data formats, and data centers need to be established

The pilot project

The initial implementation of the Global Ocean Timeseries Observatory System consists of all operating sites and those planned to be established within 5 years, subject to evaluation in terms of the qualifying criteria by the Science Team. This is the Initial Timeseries Observing System . It was initiated in mid-2001.

During the pilot phase the international Science Team and those that deploy and maintain the sites will undertake the following activities:

- Identify gaps in the system and encourage filling them

- Develop new technology for sensors and moorings

- Address implementation of the more challenging sites of critical importance, including multi-community and multi-national efforts

- Identify products and end users and establish routine provision of data from the sites to users

- Make a convincing case for a timeseries observatory system (to the public, policy makers, funding agencies)

- Capacity building, enabling participation in the observatory system

- Review all operating sites in year 5. Accept the proven ones into the longer-term system.

The post-pilot phase (subsequent 5 years) will include the following activities:

- Complete the deployment of the global array using the new capabilities developed and based on the reviews carried out

- Add new proposed sites for a trial phase.

- Work toward a transition to operational status

The Science Team

Terms of reference:

1) Define an initial set of locations for a global array of long-term time series stations for multi-disciplinary observations at the sea surface, in the ocean, and on the sea bottom

2) Develop the rationale for establishing and maintaining each element of the array, including recommended and minimum required measurements

3) While initially building on existing PI-driven sites or continuing previous/existing timeseries, carry out a critical review of these and identify gaps in the network and synergy between programs (e.g. CLIVAR and DEOS)

4) Continually review the set of locations in the light of new requirements, insights or interests of participants and program

5) Consider resources, logistics, data delivery (real-time, delayed-mode)

6) Coordinate the implementation

7) Coordinate data transmission/formats/streams/management

8) Liase with complementary programs (ARGO, ocean assimilation/prediction, interdisciplinary groups, etc) and ensure integration into the overall observing system

9) Consider funding mechanisms for sustained observations, and work, with help of the sponsoring and supporting bodies, towards national committments for supporting sites

Membership:

Bob Weller, WHOI, USA (Co-Chair)
Uwe Send; IfM Kiel, Germany (Co-Chair)

Philip Boyd, New Zealand
Ed Boyle, MIT, USA
Francisco Chavez , MBARI, USA

Dave Karl, SOEST, USA
Tony Knap, Bermuda Station
Yoshihumi Kuroda, JAMSTEC, Japan
Richard Lampitt, SOC; UK
Joao Lorenzetti, INPE, Brazil
Roger Lukas, SOEST, USA
Mike McPhaden, PMEL,USA
Liliane Merlivat, LODYC, France
Rodrigo Nunez, SHOA, Chile
John Orcutt, SIO, USA
Svein Osterhus, Bergen Univ., Norway
Bronte Tilbrook, CSIRO, Australia

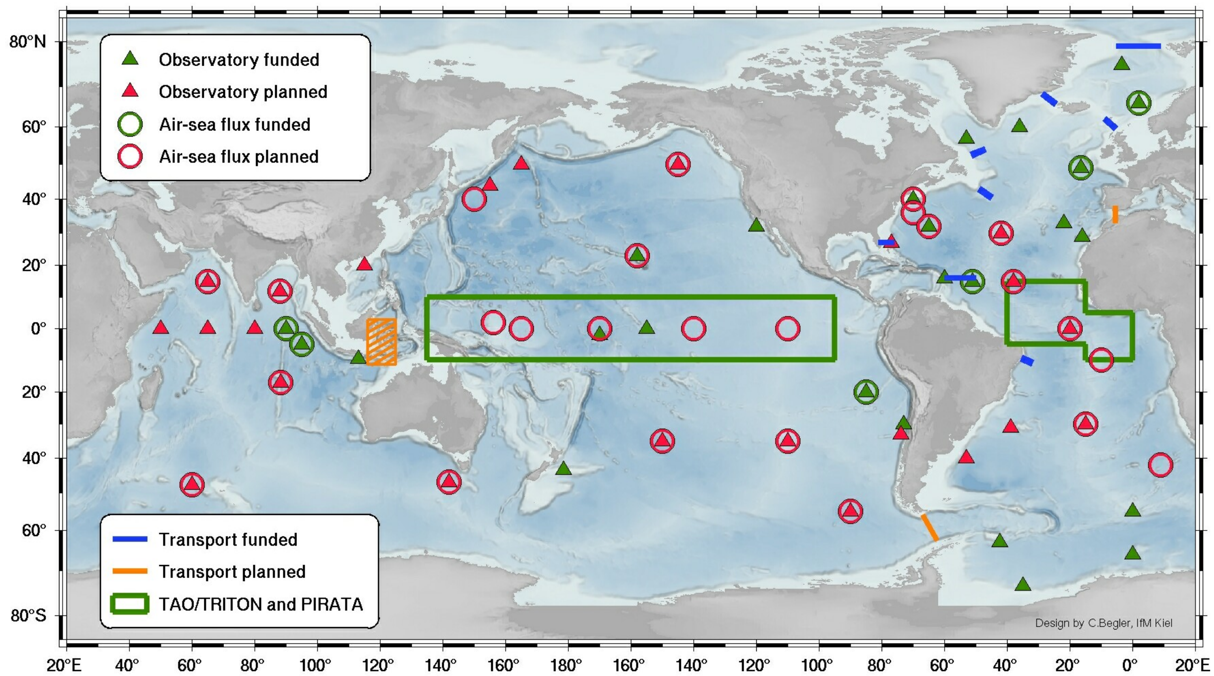
Examples from existing or past timeseries observations

to be included from brochure

Status of the global system

The following map and tables reflect the sites that are currently operating or funded (green on map), or where plans/intentions exist that the Science Team considers sufficiently concrete to give a realistic chance of implementation during the pilot phase (red). The map and tables distinguish air-sea flux reference sites, transport sites (boundary currents, passages/throughflows, long sections), and more general observatories where any collection of physical and/or biogeochemical variables may be observed.

The map and tables will be updated in January 2003 to reflect recent addition like the ASOF program and others.



Initial Atlantic Ocean Sites
OB: Observatory, FL: Air-Sea Flux reference site, TR: transport site

OB	FL	TR	Lat / Long	Status	Remarks
x			75N 3.5W	operating (AWI)	Greenland Sea, physical
x	x		66N 2E	operating (Norway)	OWS M, Norwegian Sea, physical, meteorology, biogeochemical
x			60N 36W	funded (EU)	CIS, Central Irminger Sea, physical, biogeochemical
x			57N 53W	operating (BIO, IfMK)	Bravo, Labrador Sea, physical, CO2
x	x		49N 16.5W	funded (EU)	PAP, Porcupine Abyssal Plain, meteorol., physical, biogeochemical
x	x		40N 70W	partially funded (WHOI)	Station W, meteorology, physical
	x		36N 70W	recommended	Gulf Stream extension flux reference
x	x		30N 42W	planned (DEOS)	North Atlantic DEOS, geophysics, meteorol., physical, biogeochemical
x			33N 22W	operating (IfMK)	K276, Azores Front/Madeira Abyss. Plain, physical/biogeochem.
x	x		32N 65W	observatory operating (US)	BATS/Station S/BTM, physical, meteorology, biogeochemical
x			29N 16W	funded, partially operating (EU)	ESTOC, Canary Islands, physical, meteorology, biogeochemical
x			27N 77W	planned (RSMAS)	Abaco, physical
x			16N 60W	operating (IfMK)	CLIVAR/MOVE western site, physical
x	x		15N 51W	operating (WHOI, IfMK)	NTAS and MOVE eastern site, meteorology, physical
x			0N 20W	recommended	biogeochemical sensors on existing PIRATA mooring
	x		10S 10W	recommended	flux reference on existing PIRATA mooring
x			31S 39W	planned (WHOI, IfMK)	VEMA channel, physical
x	x		35S 15W	recommended (DEOS)	South Atlantic DEOS, geophysics, meteorol., physical, biogeochemical
x			40S 53W	recommended (Brazil/Argentina)	Malvinas Confluence, physical
		x	78.5N 9E-5W	operating (Norway, Germany)	Fram Strait, physical, ice
		x	68-66N 29-24W	operating (Iceland, IfMK)	Denmark Strait overflow
		x	64-59N 3-9W	operating (Norw.,Faroer,Scotland)	Iceland-Scotland overflow, 3 sections, physical
		x	53N 50-53W	operating (IfMK)	Labrador Sea export
		x	44 —41N 45-49W	operating (BIO, IfMK)	Grand Banks boundary current
		x	36N 5.5W	planned (EU)	Gibraltar transport
		x	27N 77-81W	operating (RSMAS)	Florida strait transport
		x	16N 50-	operating (IfMK)	CLIVAR/MOVE deep transport

		x	9-13S 33-36W	operating (IfMK)	CLIVAR upper transport

Initial Pacific Ocean Sites

OB	FL	TR	Lat/Long	Status	Remarks
x	x		50N 145W	recommended	PAPA, meteorology; physical, biogeochemical
x			50N 165E	planned (JAMSTEC)	Northwest Pacific, biogeochemical, physical
x			44N 155E	planned (JAMSTEC)	KNOT, Northwest Pacific, biogeochemical, physical
	x		40N 150E	recommended	Kuroshio Extension, meteorology
x			32N 120W	operating (MBARI)	MBARI deep biogeochemical mooring
x	x		23N 158W	observatory operating (SOEST)	HOT, meteorology; physical, biogeochemical
x			20N 115E	planned (Taiwan)	South China Sea
	x		2N 156E	recommended	Warm Pool flux reference on existing TAO/TRITON mooring
x	x		0N 165E	recommended	flux & biogeochemical sensors on existing TAO/TRITON mooring
x	x		0N 145W	observatory operating (MBARI)	flux & biogeochemical sensors on existing TAO/TRITON mooring
	x		0N 170W	recommended	flux reference on existing TAO/TRITON mooring
	x		0N 110W	recommended	flux reference on existing TAO/TRITON mooring
x	x		20S 85W	operating (WHOI)	Stratocumulus deck off Peru, meteorology; physical
x			30S 73W	operating (Chile)	deep water off Chile, physical
x			33S 74W	planned (Chile)	200nm off Chile, physical
x	x		40S 115W	planned (DEOS)	South Pacific DEOS, geophysics, meteorol., physical, biogeochem.
x	x		35S 150W	planned (DEOS)	South Pacific DEOS, geophysics, meteorol., physical, biogeochem.

Initial Indian Ocean Sites

OB	FL	TR	Lat / Long	Status	Remarks
x	x		15N 65E	recommended	Arabian Sea, meteorology; physical, biogeochemical
x	x		12N 88E	recommended	Bay of Bengal, meteorology; physical, biogeochemical
x	x		0N 90E	planned (JAMSTEC)	TRITON north, meteorology; physical
x			0N 50E	recommended	Indian Ocean monsoon array, physical, meteorology
x			0N 65E	recommended	Indian Ocean monsoon array, physical, meteorology
x			0N 80E	recommended	Indian Ocean monsoon array, physical,

x	x		5S 95E	planned (JAMSTEC)	TRITON south, meteorology; physical
x			9.5S 113E	operating (Indonesia, Germany)	south of Indonesia, biogeochemical
x	x		25S 97E	planned (DEOS)	Indian Ocean DEOS, geophysics, physical, meteorol., biogeochem.
x	x		47.7S 60E	recommended	KERFIX follow-on, physical, meteorology, biogeochemistry
		x	3N-12S 116-125E	planned (LDEO, SIO)	Indonesian throughflow, several locations, physical

Initial Southern Ocean Sites

OB	FL	TR	Lat / Long	Status	Remarks
	x		42S 9E	recommended	SW of Cape Town, meteorology
x			55S 0E	operating (AWI, Norway)	Weddell Sea, physical, several moorings
x			63S 42.5W	operating (LDEO)	Weddell Sea, bottom water, physical, several moorings
x			66S 0W	operating (Norway, AWI)	Maud Rise/Weddell Sea, physical, several moorings
x			73.5S 35W	funded (Norway/UK)	southern Weddell Sea, ISW overflow, physical, 2 moorings
x	x		55S 90W	recommended	AAIW formation region, meteorology, physical, CO_2
x	x		47 S 142 E	planned (CSIRO, WHOI)	south of Tasmania, meteorology, physical, biogeochemical
x			43.5S 178.5E	operating (New Zealand)	off New Zealand, physical, biogeochemical, CO_2, 2 moorings
		x	56-62S 70-63W	planned (UK and WHOI)	Drake Passage transport

APPENDIX A: Detailed presentation of all sites