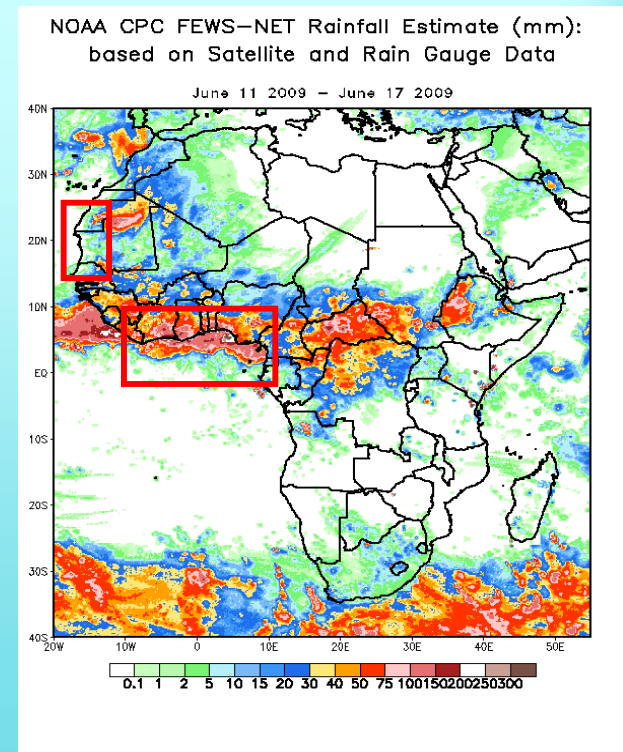


On research and capacity building related to physical oceanography and climate in West Africa

(by Bernard BOURLES,
with inputs by Augustus VOGEL)

- General scientific context
- Research programs and observations
- Capacity building
- Perspectives



- General scientific context:

- Oceanic conditions in the eastern tropical Atlantic (and the Gulf of Guinea) and regional climate

International AMMA, TACE/CLIVAR & PIRATA programs

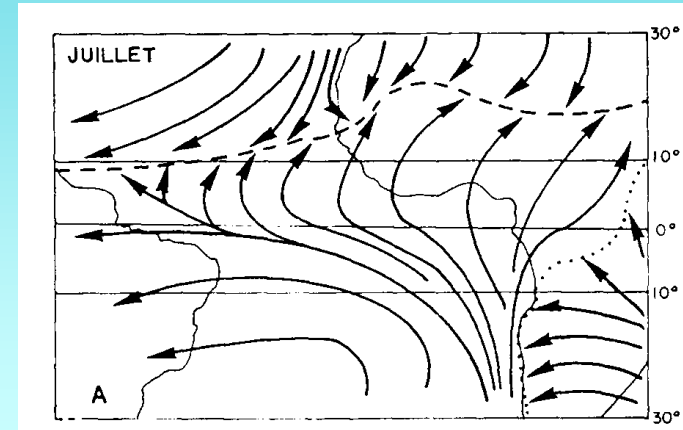
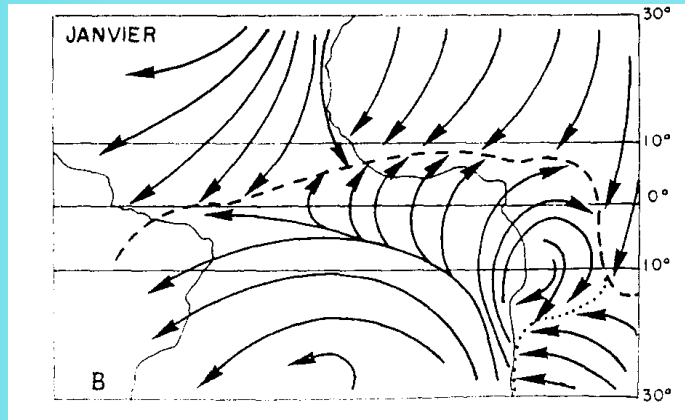
- Coastal upwelling variability and fisheries

Regional PROPAO program

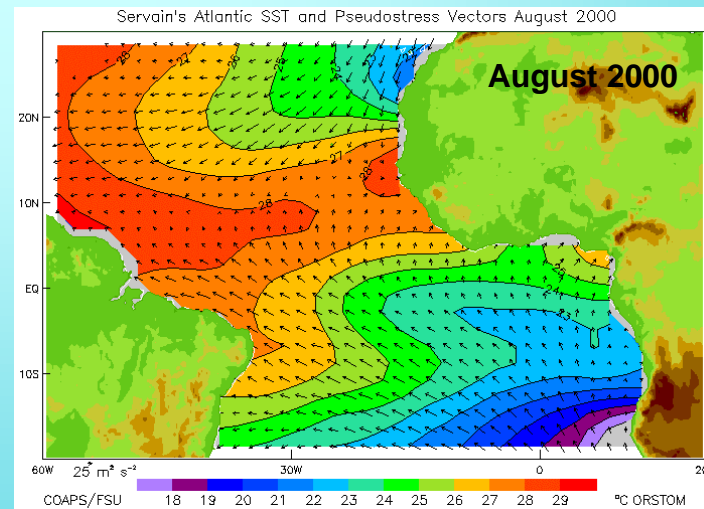
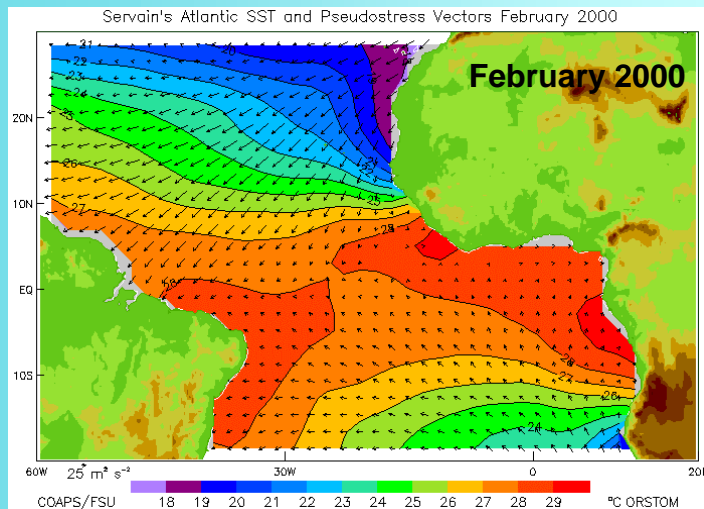
Climate changes \Leftrightarrow sea level rise and coastal erosion

Follow on programs...

Oceanic conditions in the eastern tropical Atlantic (and the Gulf of Guinea) and regional climate

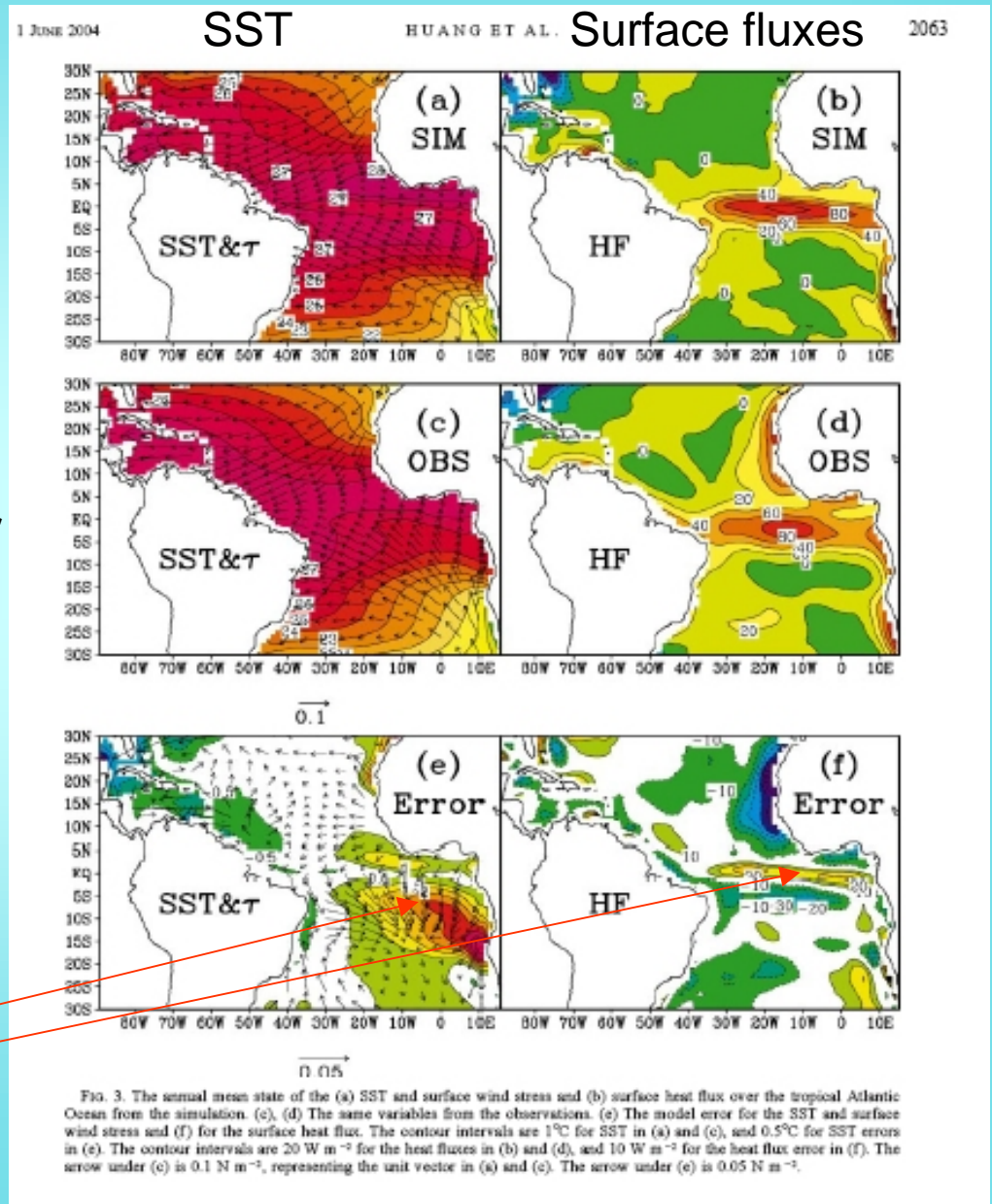


Northward penetration of moist air from the Gulf of Guinea up to the Sahelian domain with strong influence on the WAM (development and intensity).



High sea surface temperature variability (and thus fluxes variability) in this particular area ! (cold tongue, equatorial and coastal upwellings)

The Gulf of Guinea is very badly simulated in numerical models...



-Pb with fluxes;
(eg wind stress, local air-sea interaction, convective heating over land of S. America and W. Africa)

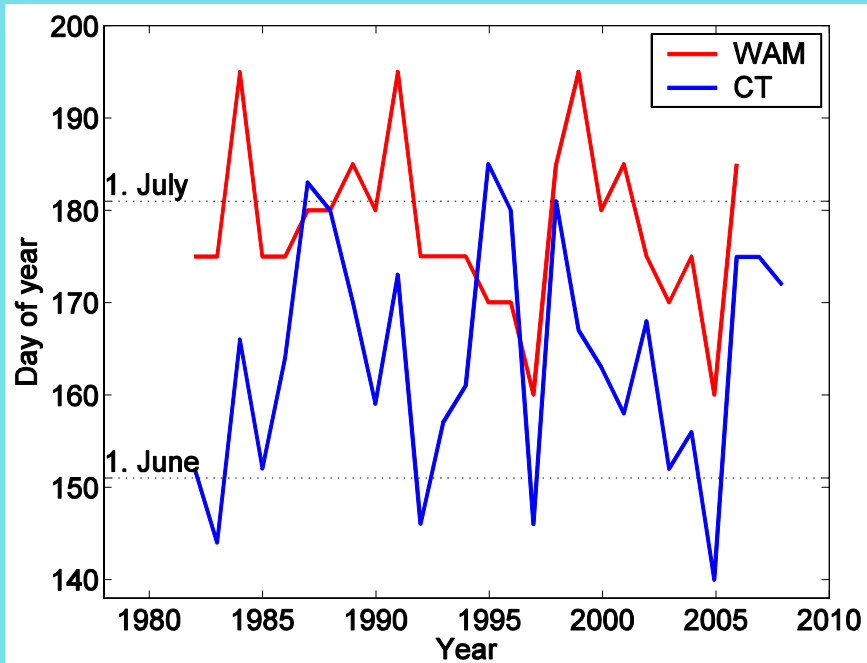
-Pb with mixing processes;

- Pb with horizontal advection
+ interactions with subsurface

Pb mostly in the GG...

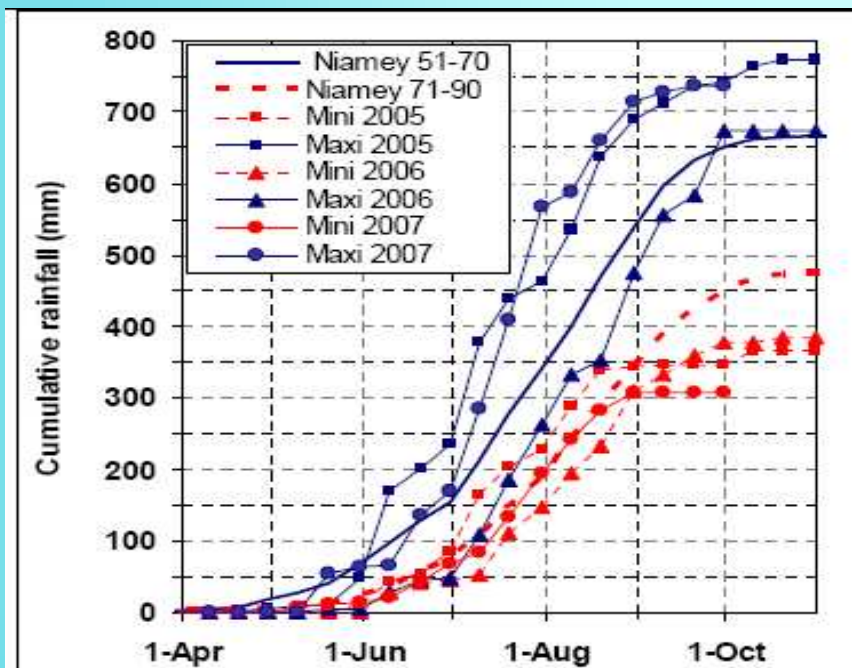
-Pb with impacts of oceanic waves;

Link between the Cold Tongue and the West African Monsoon



Onset date for the WAM (from Fontaine and Louvet, 2006; obtained using the GPCP data set) and onset date for the ACT (from Caniaux et al., 2010).

From Brandt et al., 2010.



Difference of Cumulative rainfall in Niger (Niamey) in :

- 2005 (early WAM and ACT, cold event)
- 2006 (late WAM and ACT, warm event)
- 2007 (intermediate situation).

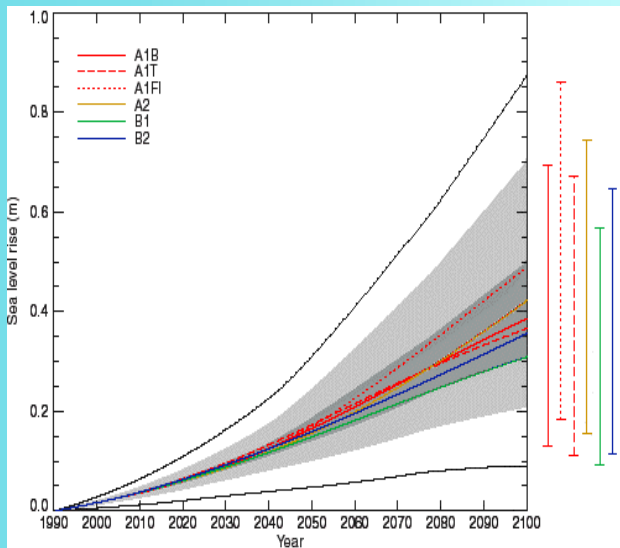
From Lebel et al., 2009

Climate changes \Leftrightarrow sea level rise and coastal erosion



*Cotonou,
December 2009
(Photos: C.Duos, IRD)*

About 30m/year
in some locations
along the northern
coasts of the GG



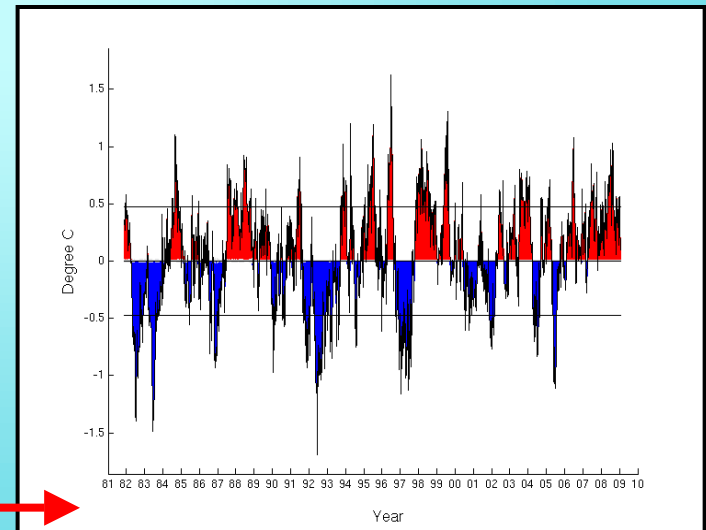
Source: GIEC, 2007



Sea level rise



and (to check)
potential rise of
sea upper
layer temperature
in the GG



Source: pers.com. B.Johns, 2009 via Reynolds.

Potential impacts of 1m sea level rise along the GG northern coast:



Present level

Ghana

Togo

Benin

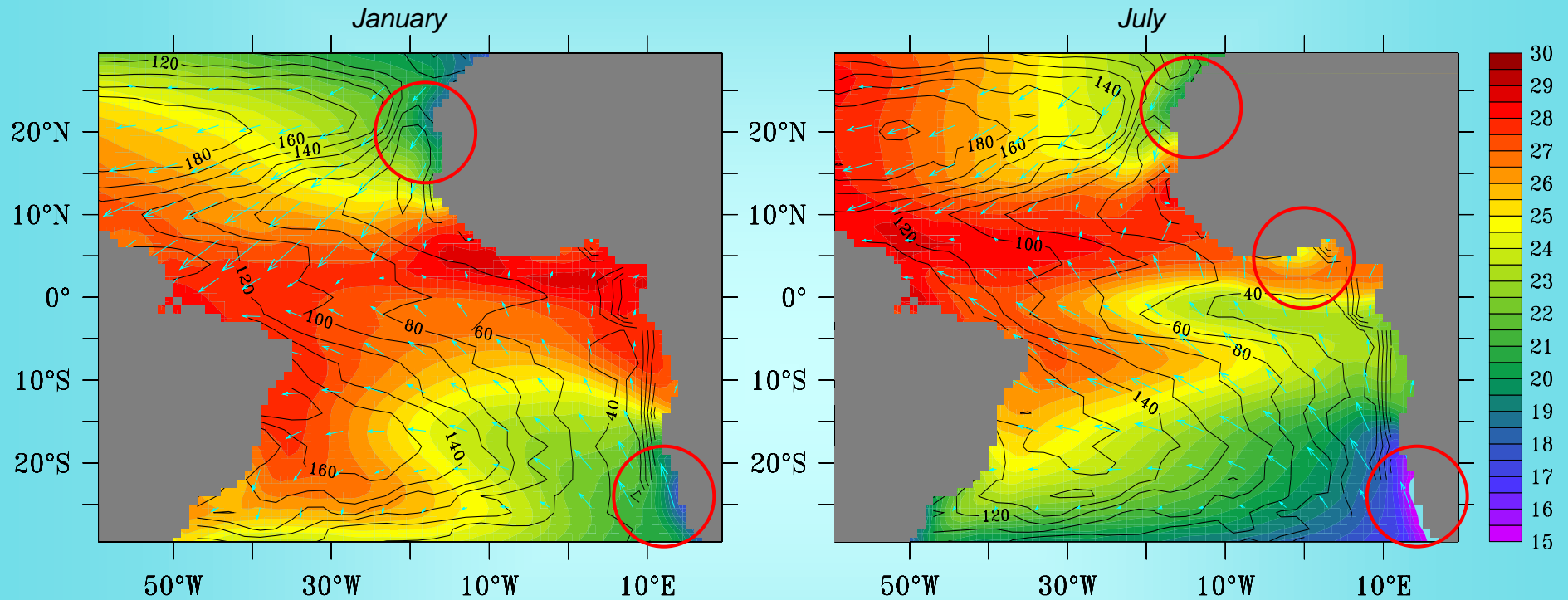
Nigeria



Present level
+ 1 meter

*Most of the population + economy (ports = 70% of funding resources)
+ agriculture (salt in the groundwater naps) + flooding during rainy season ⇔ health.*

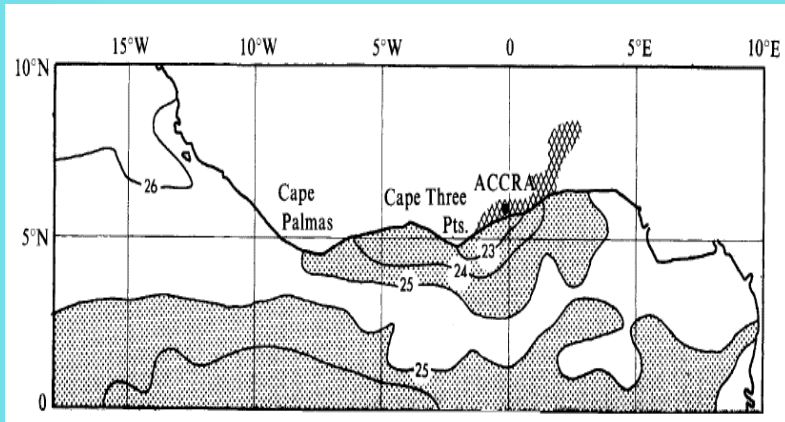
Coastal upwellings along African coasts



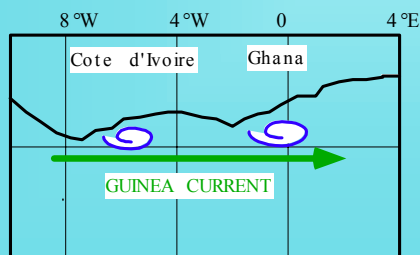
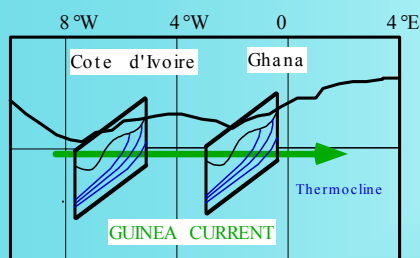
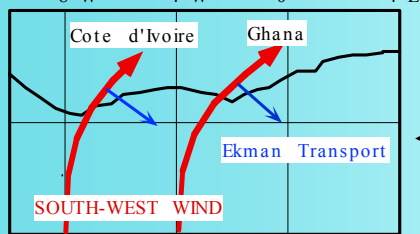
Mean Reynolds SST (°C), TAOSTA D20 contours (m), ERS wind stress (N/m²)

Upwellings = main resource zones for fishing activities...

COASTAL UPWELLING IN THE GULF OF GUINEA



Mean SST (1850-1970) in August. Hashed areas for SST < 25°C (From Bakun, 1978).



-Two upwelling seasons:

- Main upwelling season from June to September;
- Minor upwelling season from January to March.

-A remarkable characteristic:

- No evident correlations between wind forcing and coastal temperature during the major upwelling season

Potential regional climate impact?

(impact on meridional surface temperature gradient)

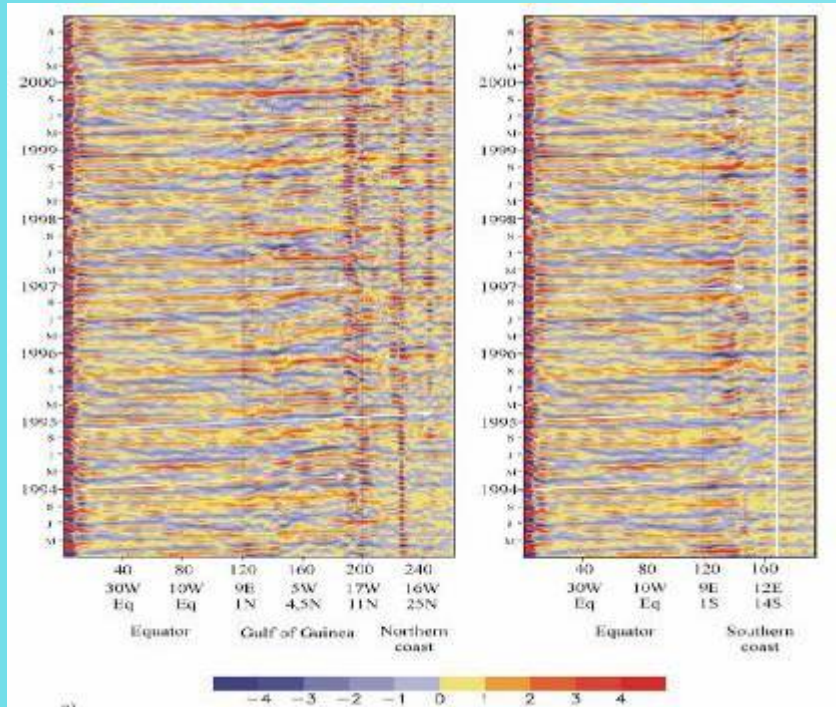
=> Alternative mechanisms have been suggested:

- Local wind stress and regional wind curl
(*but not for both seasons!*).
- Guinea Current may influence upwelling
- Cape effect (*no; may contribute to maxima*)
- Strong evidence of remote forcing by trapped Kelvin waves

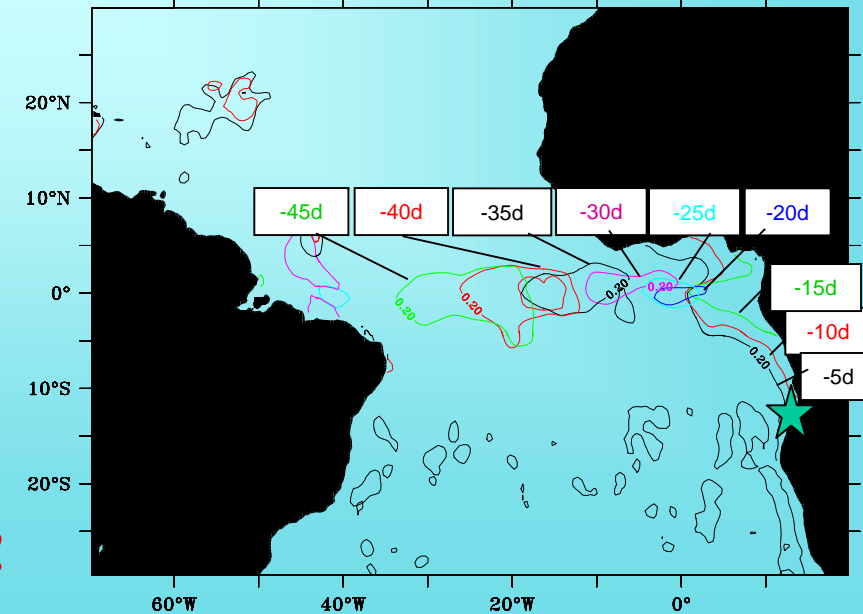
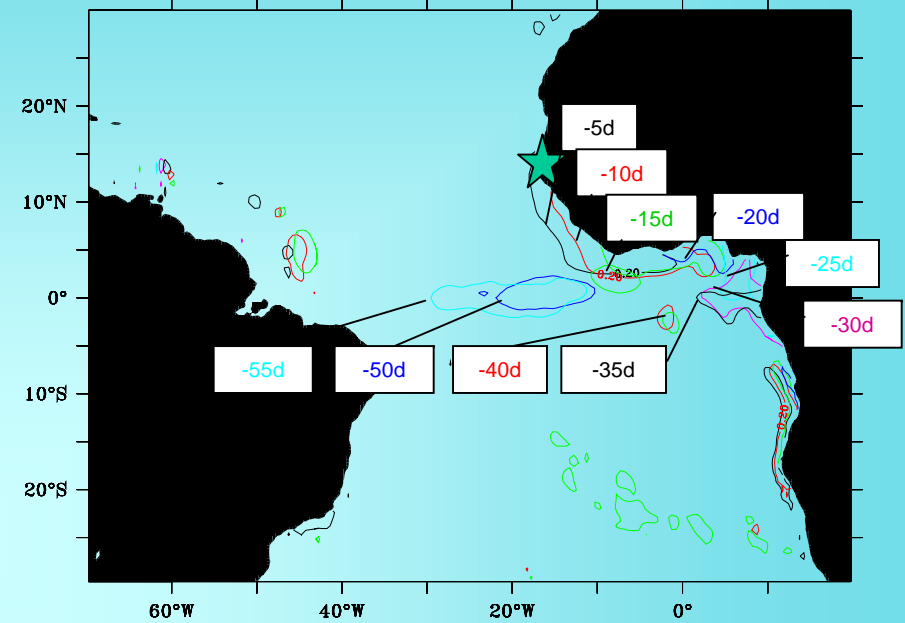
New regional analysis and data needed!

Links between equatorial and coastal waves in satellite SSH

Intraseasonal SLA (T/P) from Polo et al (2008)



Lag correlations (0.2 contours) between T/P SLA (*) and SLA in the whole basin

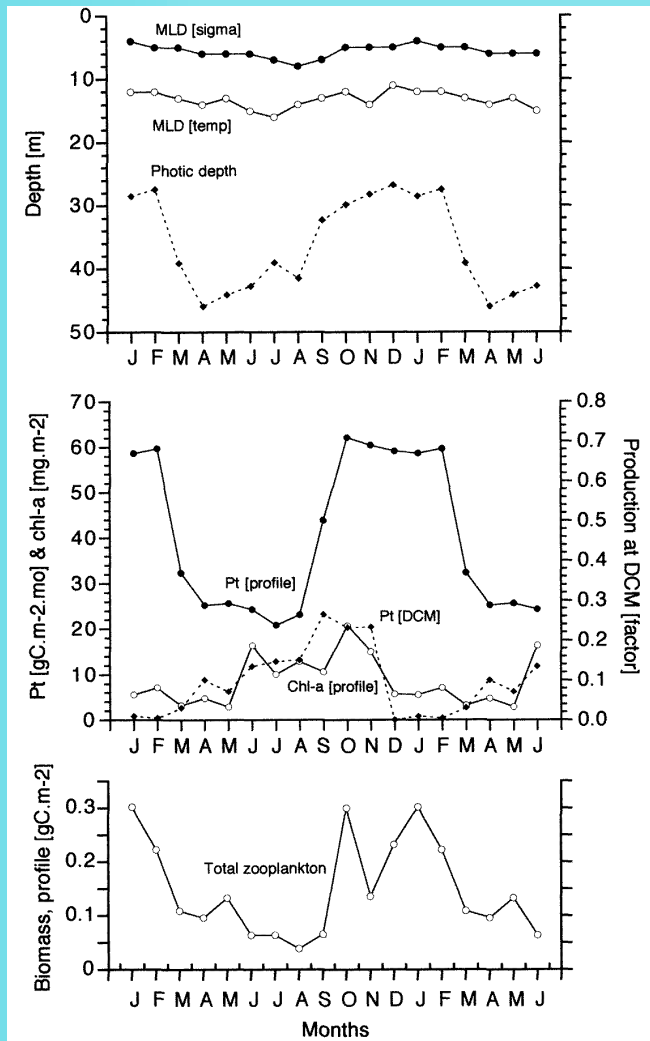


Kelvin Wave :

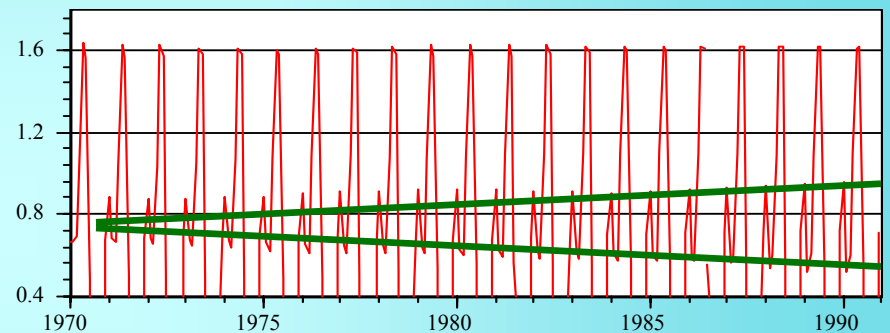
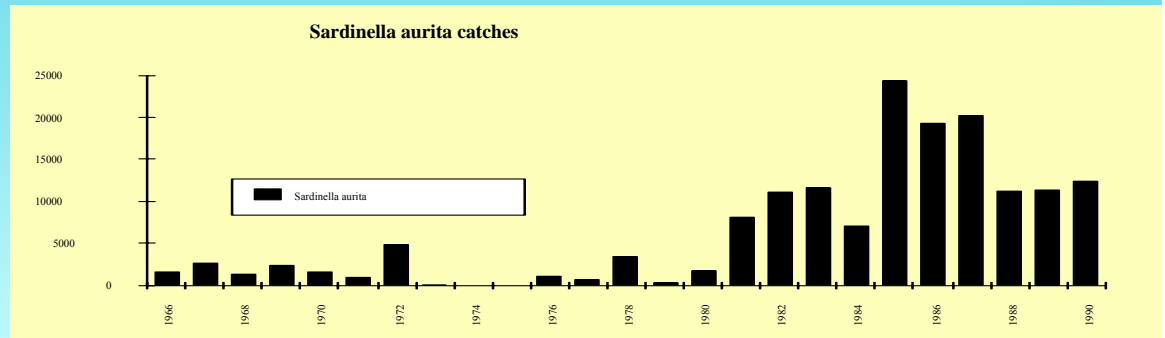
- propagate from western equator to 12°N and S at the african coasts
- ~2 months period, $v \in [1.5, 2.1]$ m/s
- remote forcing in the coastal upwelling areas

⇒ Observations needed over the whole basin and along the coasts!

Coastal upwelling variability and fisheries



Characteristic seasonal cycles of monthly averaged mixed layer and photic depths, surface chlorophyll and rate of primary production, integrated and at the DCM. From Longhurst (1998).

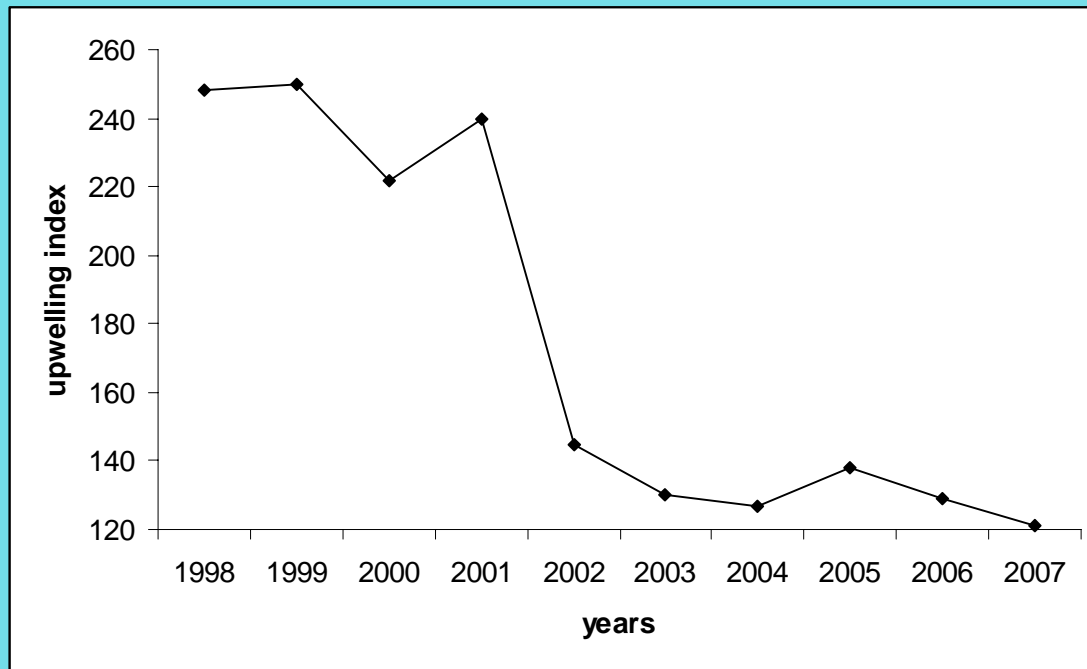


Evolution of *Sardinella* catch and sea surface temperature anomalies off Côte d'Ivoire from 1970 to 1990 ;

Augmentation of catches simultaneous to the augmentation of the coastal winter upwelling amplitude off Côte d'Ivoire (source: Claude Roy, IRD).

(trend suggesting an increase of the minor winter upwelling amplitude). To be confirmed!

Note about fisheries: difficult now to estimate real impact of climate / over-catching activities!



• Annual upwelling index is calculated from 1998 to 2007 between 8°W-5°E and 4°N-5°N.

(Sum of the differences between a threshold SST of 26°C (Arfi et al., 1991) and the lowest temperature of the week. This sum is multiplied by the total number of weeks of the cold season. It indicates the intensity of the coastal upwelling)

- strong decrease from 2002 (50%).
- 1998 to 2001 have been cooler than the years 2002 to 2007 during boreal summer and along the coasts

Low index during 2002-2007 is related with:

From Ali E.K. et al., 2010

- 1- the duration of the coastal upwelling (2004 case)
- 2- the weakness of the cooling (2002 case)
- 3- and the combination of both parameters (2003 case)

To be confirmed + impact on primary production!

TOWARD

Regional research programs and observations

Preliminary remarks:

- 1) Many African laboratories dedicated to oceanography often too isolated and with few people, weak background in physical oceanography, very weak material means or funding
= > Strong need of regional collaborations/partnership & capacity building
- 2) Several international activities programs the Gulf of Guinea :
e.g.
 - ODINAFRICA (Ocean Data and Information Network for Africa)
 - GCLME (Guinea Current Large Marine Ecosystem)
(but no, or very few, applied research)

A few laboratories also involved in:

 - AMMA (*African Monsoon Multidisciplinary Analysis*), and its oceanographic component (*EGEE in France*).
 - PIRATA (*Prediction and Research Moored Array in the Tropical Atlantic*) mostly through participation to cruises, local helps for clearances in EEZ and ports...
- 3) Very few measurements maintained at long term or very isolated; to our knowledge, no dedicated monitoring of the coastal erosion (but recently in Ghana, with support of US; see below).
- 4) Still strong reticence to share data (in a few laboratories...) !!!

1) ODINAFRICA (& GLOSS) :

=> strong contribution to the monitoring of a coastal network of tide gauges!



- A total of 22 sea level stations have been installed/upgraded during ODINAFRICA-III program

-The maintenance of the equipment after the end of ODINAFRICA III is not clearly planned

-Serious concern about the installation planned at Casablanca and the maintenance at: Nouaktchott, Port Sonara, Pointe Noire (and also Djibouti).

(the Proudman Oceanographic Laboratory in UK cannot ensure them anymore).

2) the Regional Program of Physical Oceanography in West Africa (Gulf of Guinea; 2007-2010); PROPAO:

Program funded by French FSP-RIPIECISA through IRD and carried out by: Benin (CRHOB), Nigeria (NIOMR), Togo (CGILE), Ghana (DOF) Côte d'Ivoire (LAPA & CRO) and France (IRD/Legos).

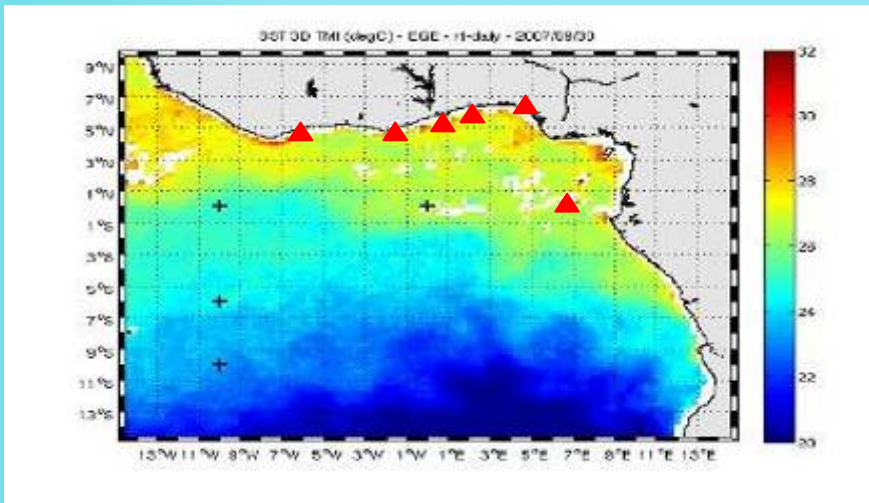
Main goals :

- Continuity of measurements activities, research and training initiated in the frame of EGEE / AMMA, in coastal countries of the northern Gulf of Guinea (Nigeria, Benin, Togo, Ghana and Cote d'Ivoire).
- To set up a network of regional measurements and build a regional coastal data bank; (before PROPAO, measurements of SST and SSS in the Gulf of Guinea were only from Bucket System and a few Tide Gauges)
- Monitoring and analysis of coastal upwelling regime and understand the coastal environment.

PROPAO NETWORK ALONG THE COAST:



- Autonomous thermometers :



Deployments:

Cotonou, Bénin: July 2005

Las Rolas, São Tome: September 2006

Kpémé, Togo: October 2006

Sassandra, RCI: February 2008

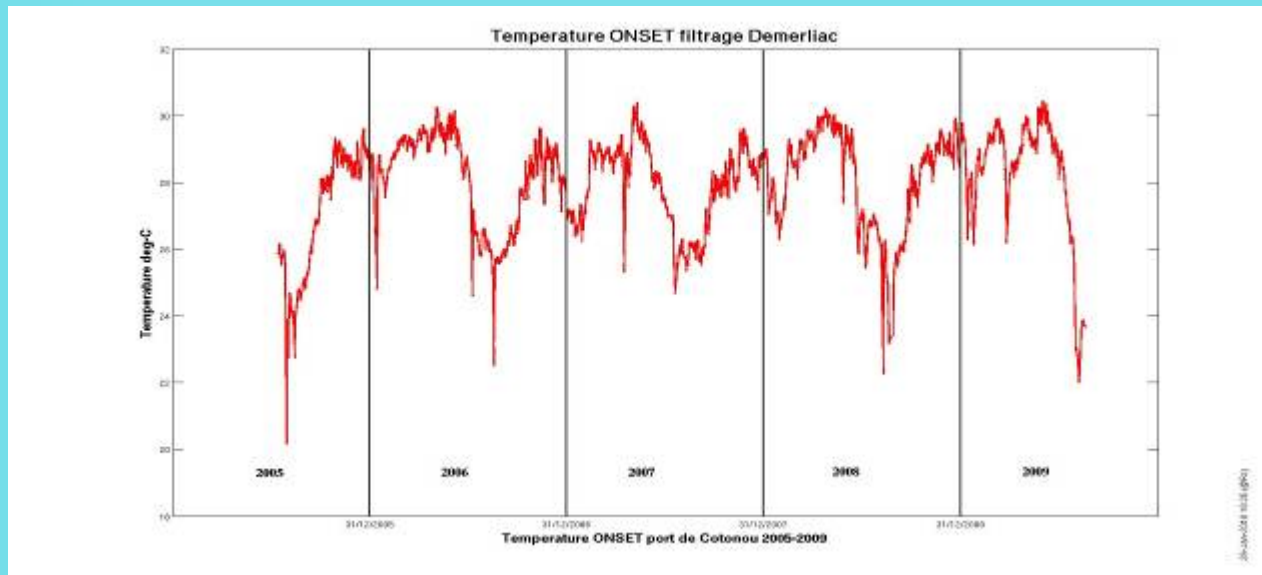
Lagos, Nigeria: March 2008

Takoradi, Ghana: May 2008

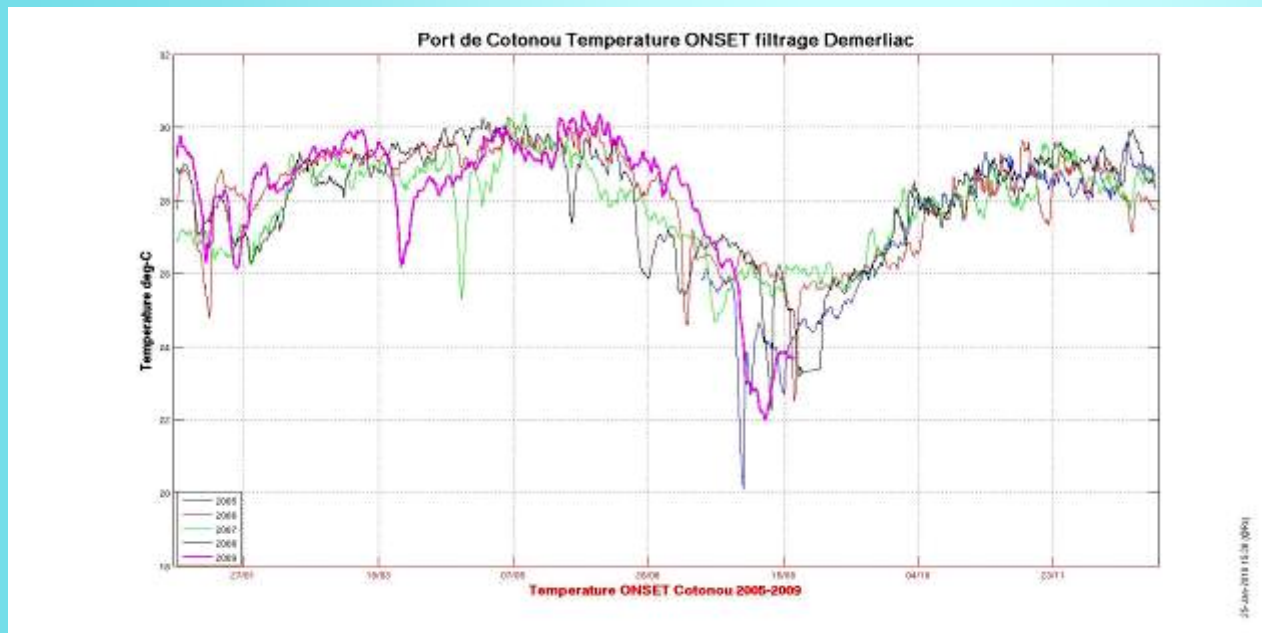
- ⇒ **time series of SST gathered (every 1 hour)**
- ⇒ **first analysis and comparisons with historical data**
- ⇒ **calibration process developed (achieved for the 5 years time series in Benin)**
- ⇒ **fully autonomous network in 2010 (maintenance, data validation, sensor calibration will be fully ensured in Benin for the whole region)**

Enough sensors provided for several years...

4 years of SST measurements at Cotonou:



SST variability; interannual & intraseasonal:



2 upwelling seasons

In spring:

- 2008 warm year

In summer:

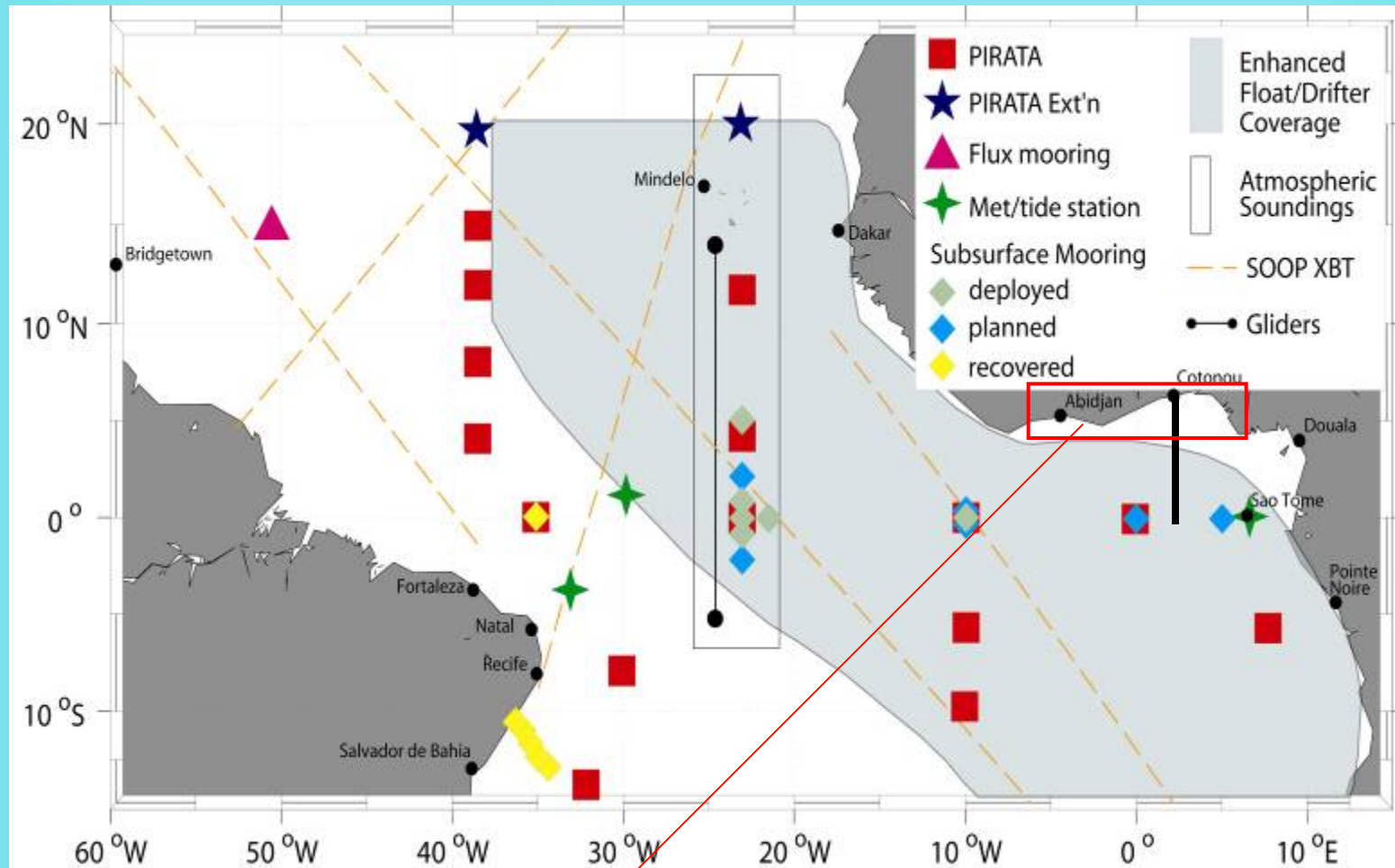
- 2005: cold year

- 2007: warm year

- 2008: late cooling

Evidence of short duration events with large SST amplitude...

PROPAO could become an African contribution to the TACE – PIRATA – EGEE/AMMA observing network



PROPAO Ripiecsa Ocean coastal network

Other works in the framework of PROPAAO:

- Study of the processes responsible for the coastal upwelling in the northern of the Gulf of Guinea, (PhD thesis in Abidjan; 2nde year)

- Analysis of the influence of the tropical Atlantic SST on regional climate, as seen from numerical studies with the Modèle Atmosphérique Régional -MAR- (*2 different simulations are running with different SST products & other forcing conditions, work done at LAPA/Univ.of Cocody, Abidjan*)

- Organization of one regional Colloquium at Cotonou in November 2009 about « Research and formation in Oceanography in West African Universities »,
 - => GOAL: -communication & collaboration between regional capacity building programs
 - regional collaborations between observation programs
 - get easier their visibility (+ share students/courses)
 - => recommandations about capacity building, observation systems, & collaborations...
 - => decision taken for yearly « workshops » for data acquisition and treatment & courses (e.g.: ADCP or CTD data treatment ; analysis of data/products; communications of courses for local universities teachers ; online courses & formations...)

- + Capacity building => launching of a new Master 2 dedicated to « physical oceanography and applications » in Cotonou/BENIN !

The Regional Master 2 of Physical Oceanography and Applications (RMPOA) :

- **Launched in September 2008, thanks to IRD support & funding**
- **Established in collaboration between University of Abomey-Calavi/Cotonou (International Chair of Mathematical Physics and Applications; CIPMA, UNESCO Chaire => with UNESCO recognition) and University Paul Sabatier of Toulouse, and IRD (LEGOS, Toulouse & Cotonou).**

Additional support by the oil company TOTAL from sept.2009 (funding & access to engineering companies for training periods).

- **Responsibilities: Norbert Hounkonnou (Pr., CIPMA/Benin), Nick Hall (Pr., UPS/France) & Bernard Boulès (Dr., IRD/Benin & France)**

- Student Population:

10 students (5 Benin, 2 Togo, 3 Nigeria) (2008-2009)

11 students (3 Benin, 2 Togo, 2 Nigeria, 2 Cameroon, 1 Cote d'Ivoire) (2009-2010)

(courses provided in english & french)

- **Collaborations with other African Universities in progress (University of Lagos/Nigeria, Cocody-Abidjan/Côte d'Ivoire, Accra/Ghana, Dakar/Senegal & CapeTown/South Africa).**

New Regional Master of Physical Oceanography and Applications in Benin:



United Nations
Educational, Scientific and
Cultural Organization



INTERNATIONAL CHAIR IN MATHEMATICAL PHYSICS AND APPLICATIONS (ICMPA)
UNESCO CHAIR IN MATHEMATICAL PHYSICS AND APPLICATIONS

established in 2006 at the University of Abomey-Calavi (Republic of Benin)



UNITWIN/UNESCO Chairs – Twinning networks and university networks

University of Abomey-Calavi

MULTI-UNIVERSITY MASTER'S DEGREE AND DOCTORAL TRAINING PROGRAMME IN PHYSICAL OCEANOGRAPHY AND APPLICATIONS

Considering the needs of capacity building in environmental sciences, climate and coastal environment, a regional master in “Physical Oceanography and Applications” is being organized by the International Chair of Mathematical Physics and Applications (ICMPA-UNESCO Chair) of the University of Abomey-Calavi at the Faculty of Sciences and Technology, involving the following universities, research institute and organizations:

Intergovernmental Oceanographic Commission (IOC) of UNESCO	Paul Sabatier University (France)	University of Abomey-Calavi (Benin)	Institut de Recherche pour le Développement (France)	Total (France)
<p>Mr Justin Ahanhanzo, Coordinator and Team Leader, Intergovernmental Oceanographic Commission of UNESCO (IOC/UNESCO) UNESCO, 1 Rue Miollis, 75732 Paris Cedex 15, France Tel: +33 1 45 68 36 41 Fax: +33 1 45 68 58 10/12/13 E-mail: j.ahanhanzo@unesco.org http://ioc.unesco.org</p>	<p>Prof. Nicholas Hall, Laboratoire d'Études en Géophysique et Océanographie Spatiales (LEGOS), 18 Avenue Edouard Belin, 31401 Toulouse cedex 9, France Tel: +33 5 61 33 29 19 Fax: +33 5 61 25 32 05 E-mail: Nick.Hall@legos.obs-mip.fr</p>	<p>Prof. Mahouton Norbert Houkonnou, International Chair of Mathematical Physics and Applications (ICMPA- UNESCO Chair), 072 B.P. 50 Cotonou, Republic of Benin. Tel: +229-21 38 61 27/ +229 95 06 26 89 Fax: +229-21 31 31 38 E-mail: norbert_houkonnou@cipma.net or houkonnou1@yahoo.fr</p>	<p>Dr Bernard Bourles, Laboratoire d'Études en Géophysique et Océanographie Spatiales (LEGOS) Centre de Recherches Halieutiques et Océanologiques du Bénin (CRHOB), Représentation IRD de Cotonou, 08 BP 841 Cotonou, Republic of Benin Tel: +229 21 30 03 54 / + 229 90 08 94 56 Fax: +229 21 30 88 60 E-mail: bernard.bourles@ird.fr</p>	<p>Mme Valérie Quiniou-Ramus TOTAL S.A. DGER/TDO/TEC/GEO – 21E09, Tour Coupole, 2, Place Jean Millier La Défense 6 - Cedex 45 92078 Paris La Défense, France Tel: +33 1 47 44 44 83 Fax: +33 1 47 44 49 48 E-mail: Valerie.Quiniou@total.com</p>

Official languages: English and French. English is the preferred choice, though, given the international attendance

Master 2 in Oceanography = Unique Opportunity

- **This is the only Master dedicated to physical oceanography and applications in West Africa (with emphasis on climate, coastal environment etc. & specific topics for the Gulf of Guinea).**
- **Unique opportunity for high quality education in Physical Oceanography for the Region.**
- **Opportunities for training onboard oceanographic vessel during one day sea trips (PIRATA cruises), to observe new scientific instruments/equipments and to be involved in real time data visualization & treatment (VM-ADCP, CTD, T/S graph).**
- **Training periods with scientific issues in the frame of PROPAO & AMMA/TACE-CLIVAR/PIRATA => potential for PhD & continuation of these analysis by regional scientists**

Other capacity building actions in West Africa by USA:

(inputs by Augustus Vogel, Maritime Partner Liaison,
Office of Naval Research, US Navy)

Almost the same motivations & goals than PROPAO
in Ghana, Nigeria & Gabon:

a) Deployment of drifting buoys: (supported by NOAA-AOML)

- Deployments from 2008-present (100 global drifters & 15 Argo floats)
- Deployments by multiple countries: United States (US Navy), Ghana (15 global drifters- in progress), Gabon (3 Argo floats), Nigeria (deployments pending)



b) Training workshops: (supported by NOAA-OAR, AOML)

- 3-5 workshops on deployment or data analysis
 - Ghana (2008; 40 participants)
 - Nigeria (2009; 36 participants)
 - Gabon and Senegal (planned and funded- 2010)
- Workshop foci
 - Deployment
 - Access to Argo and drifter data
 - Basic data analysis
 - Basic physical oceanography
 - Introduction to programming tools (Matlab-like programs)



c) Institutional development:

- Primary support to the University of Ghana

Participation by scientists and students
from the Nigerian Institute of Oceanographic and Marine Research

- Funding

3 year ONR grant to the University of Ghana

Support funding from US Naval Forces Europe and Africa

- 3-step program:

- Introduction of parties

- Implementation of research projects with technical support
from US and European Scientists

-Independent Research

Program will transition from step 2-3 in 2010-11



c) Institutional development (continuation):

- Supporting Institutions

WHOI, UNH, UNESCO-IHE, WWF, USC, UCSD,
Digital Globe, US Department of State

- Lines of effort:

1) **Coastal processes:**

Understanding of basic processes in Ghana, Historical erosion, Current erosion

2) **Analysis of anthropogenic activity in coastal zone:**

Illegal fishing, Oil spills, Coastal development

3) **Technical training support:**

- In situ survey and measurement of coastal zone (dGPS, ground-penetrating radar, video monitoring of short-term processes, near-shore bathymetry)

- Modeling (DELFT-3D)

- Remote sensing and aerial imagery applications (Computer lab to analyze satellite imagery, aerial imagery, and micro-UAVs)



CONCLUSIONS & PERSPECTIVES (1)

Continuity of research in oceanography beyond 2010 is critical for the region as a result of:

- analysis and monitoring of oceanic conditions (temperature, salinity, sea level, currents, winds, nutrients...)
- the influence of the surface oceanic variations on regional precipitations ;

=> Masters and PhD degrees + regional programs NEEDED :

+ **PROPAO** is a 3 years program (2007-2010), that has to be considered as an initialization of scientific capacity building and improved observation & research actions for the WA region.

Strong needs of supports for such initiatives.

(ie, topics, supervisors & grants for PhDs, fundings for the M2 & PhD formation, collaborations for supporting the regional partners and coastal network development...)

CONCLUSIONS & PERSPECTIVES (2)

=> Need to initiate urgent actions about:

- **Impact studies of oceanic conditions on climatic changes, resources and coastal erosion (sea level rise) associated to the present climatic changes.....very important to the economic, social and political stability of countries in the region.**
- **Maintaining and developing the present coastal measurements networks (principally the SST & tide gauges...).**
- **Ocean resources...**

=>

-Close collaborations between the few actions of capacity building by France & USA, and also by Germany, South Africa or others, have to be established as much as possible

(eg, yearly « workshops » for students/researchers/teachers of the regional universities; these workshops could be organized in cooperation, and dedicated to data treatment&validation etc...)



MANY THANKS FOR YOUR ATTENTION