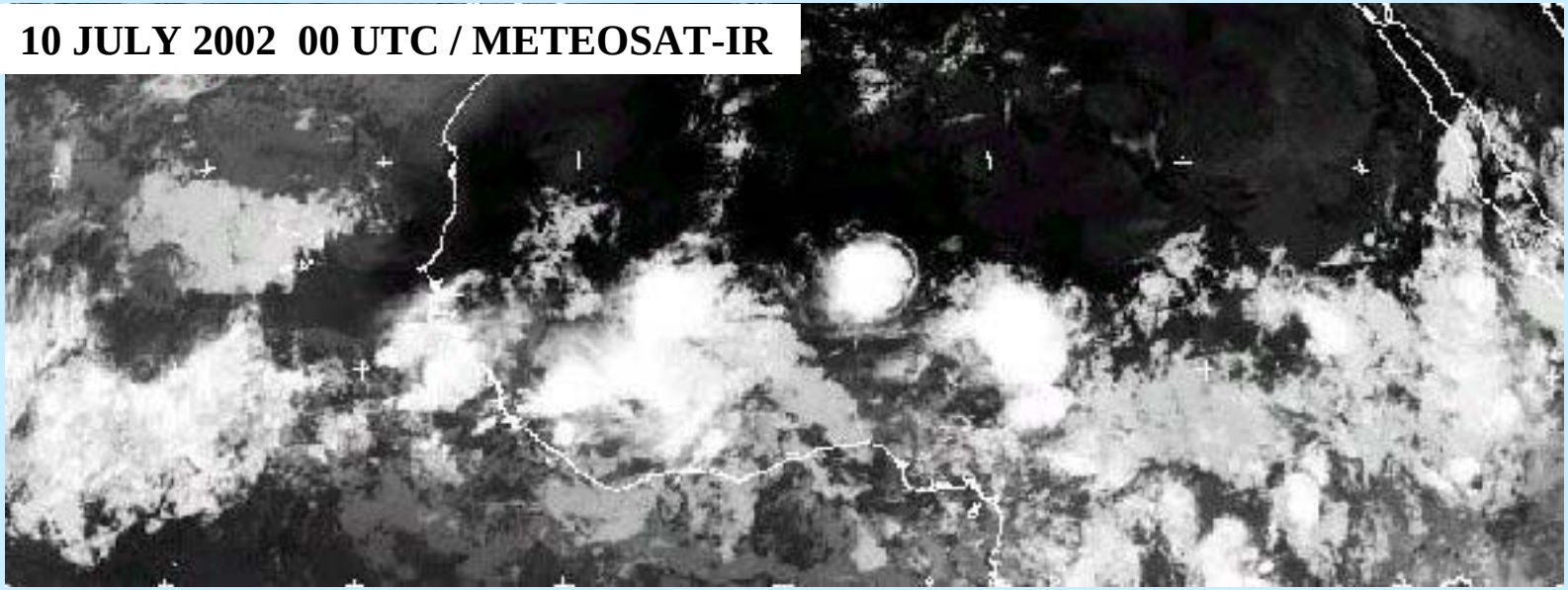
AMMA
Special Observation Periods



SCIENTIFIC OBJECTIVES OF AMMA/SOP

ATMOSPHERIC DYNAMICS

- **Dynamics of the monsoon**
  - monsoon onset (Saharan heat low vs. gulf of Guinea)
  - tropospheric jets (AEJ, TEJ, STWJ)
  - waves (3-5 and 6-9 days easterly waves), intraseasonal variability

- **Precipitating systems :**
  - from local Tstorm to large MCS, convective and stratiform
  - local and environmental controlling factors
  - evolution and propagation, coupling with monsoon dynamics

- **Water and energy budget (low to mid-troposphere):**
  - spatial variability, relationship with surface and atmospheric conditions
  - evolution during the monsoon onset, intraseasonal changes
  - verification of the performances of numerical and statistical models

SCIENTIFIC OBJECTIVES OF AMMA/SOP (cont 'd)

SURFACE CONDITIONS

- **Continent :**
  - coupling with precipitating systems
  - memory effect
  - dynamics of vegetation

- **Hydrology :**
  - spatial and temporal variability of rainfall
  - water fluxes and budgets at surface and subsurface
  - validation of coupled models (vegetation - hydrology)

- **Ocean :**
  - role of the Gulf of Guinea in controlling the monsoon flow
  - variability of oceanic circulation and budgets
  - role of Eastern tropical Atlantic ocean

SCIENTIFIC OBJECTIVES OF AMMA/SOP (cont 'd)

ATMOSPHERIC CHEMISTRY

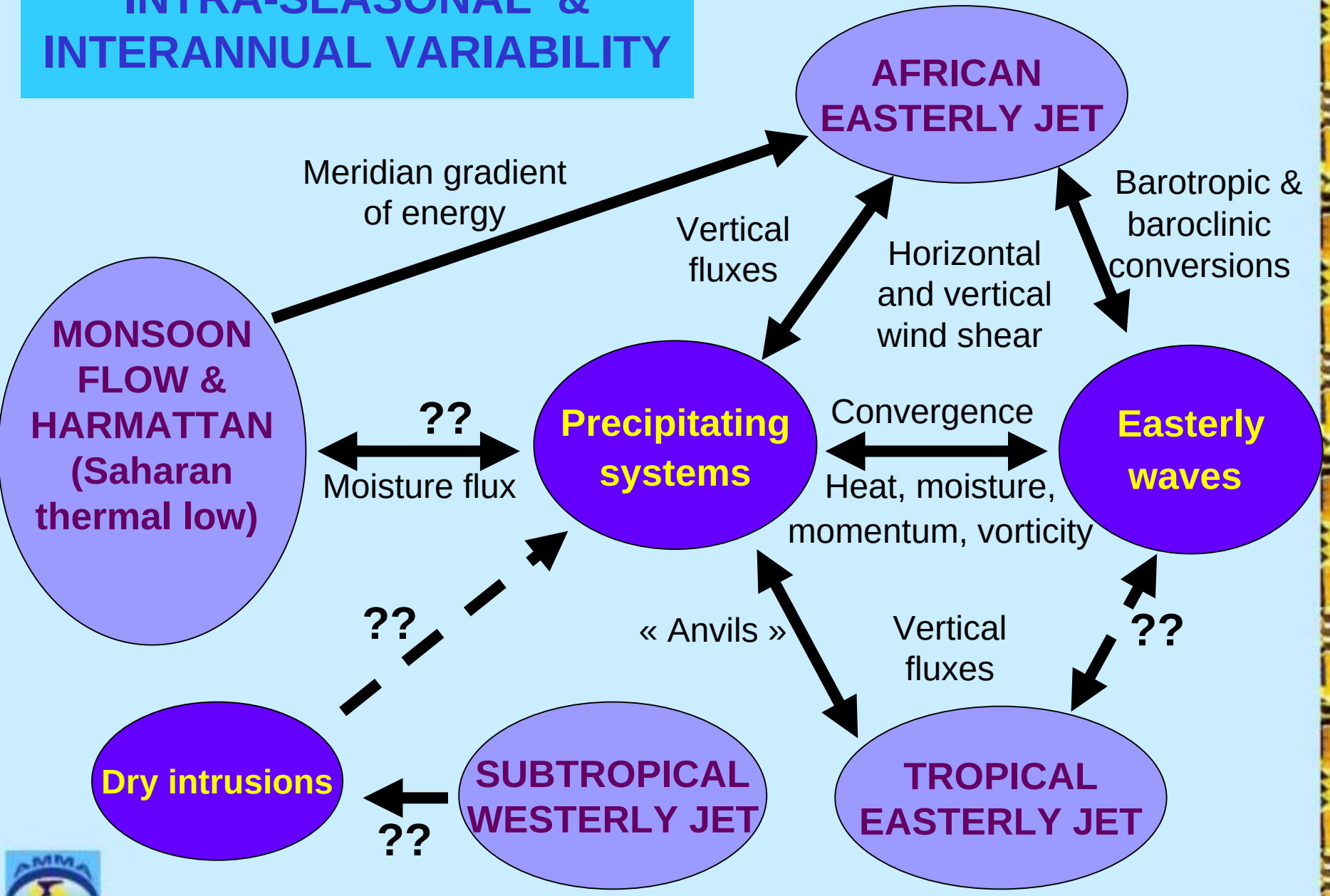
- **Emissions and deposits :**
  - inventory of chemical species, spatial and temporal variability
  - relation with surface conditions (vegetation, humidity, …)
  - natural vs. biomass burning vs. fuel burning

- **Role of clouds :**
  - low-level inflow and upper-level outflow of trace gases
  - chemistry in presence of liquid water and ice, HO_X budget
  - role of lightning in NO_X budget

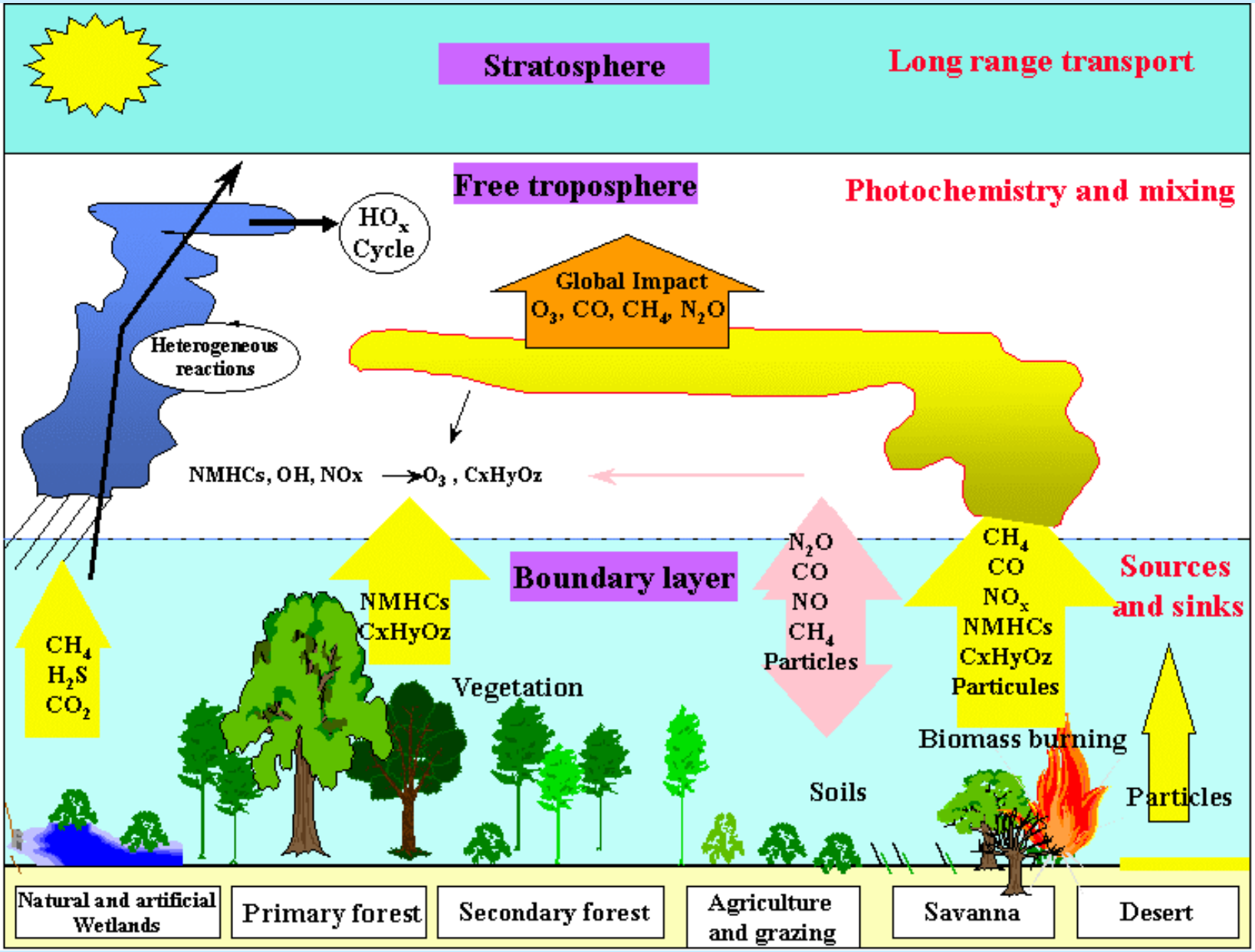
- **Aerosol :**
  - spatial and temporal variability of natural and anthropic emissions
  - horizontal and vertical fluxes
  - direct and indirect (through clouds) radiative effects

- **Upper troposphere - lower stratosphere :**
  - upward and downward mass fluxes (deep convection)
  - chemical characteristics

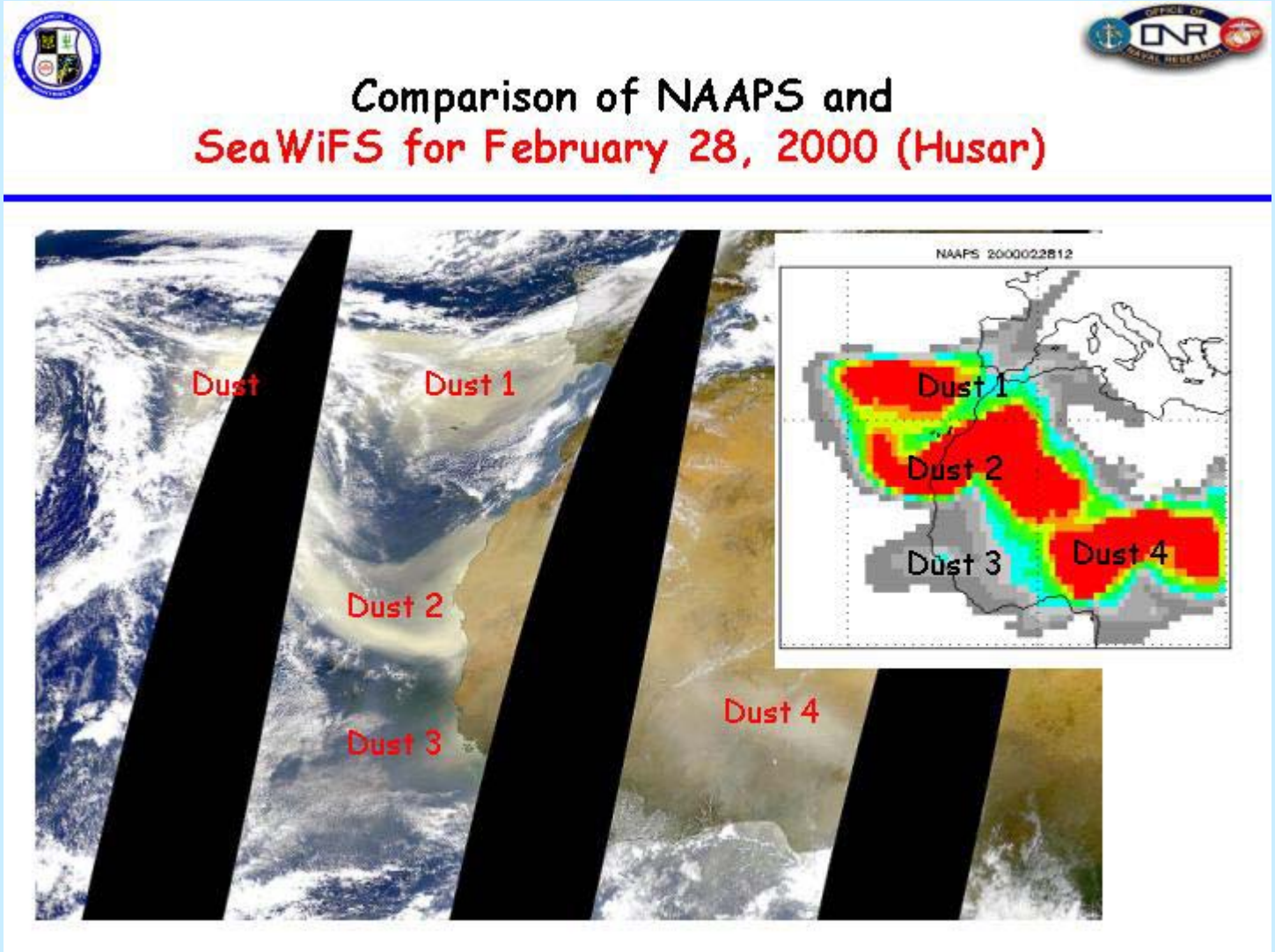
INTRA-SEASONAL & INTERANNUAL VARIABILITY



ATMOSPHERIC CHEMISTRY OVER WEST-AFRICA

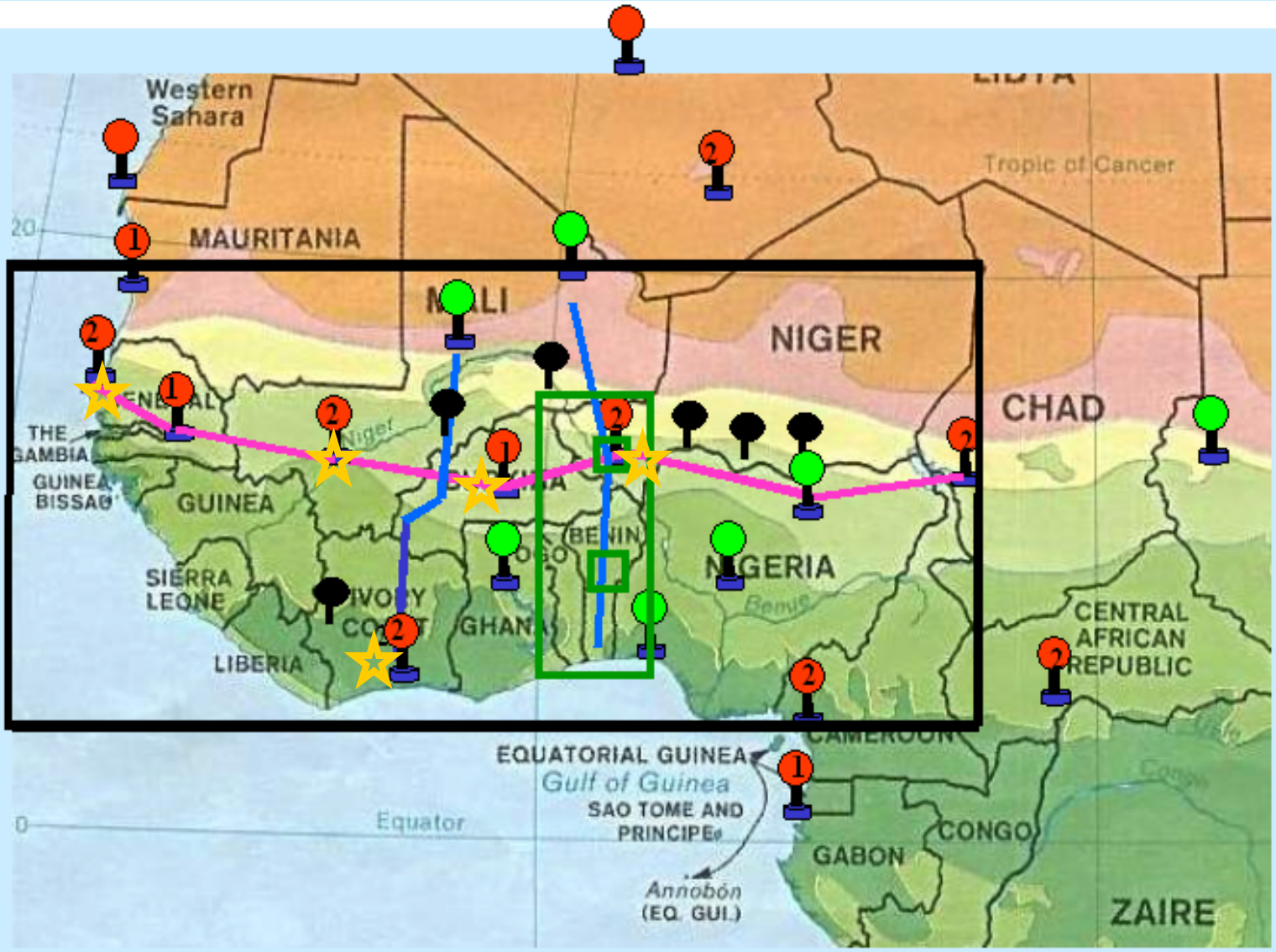


AEROSOL FROM SAHARA AND WEST-AFRICA



From http://www.nrlmry.navy.mil/aerosol/Case_studies/20000226_sahara/

THE WEST-AFRICAN NETWORK

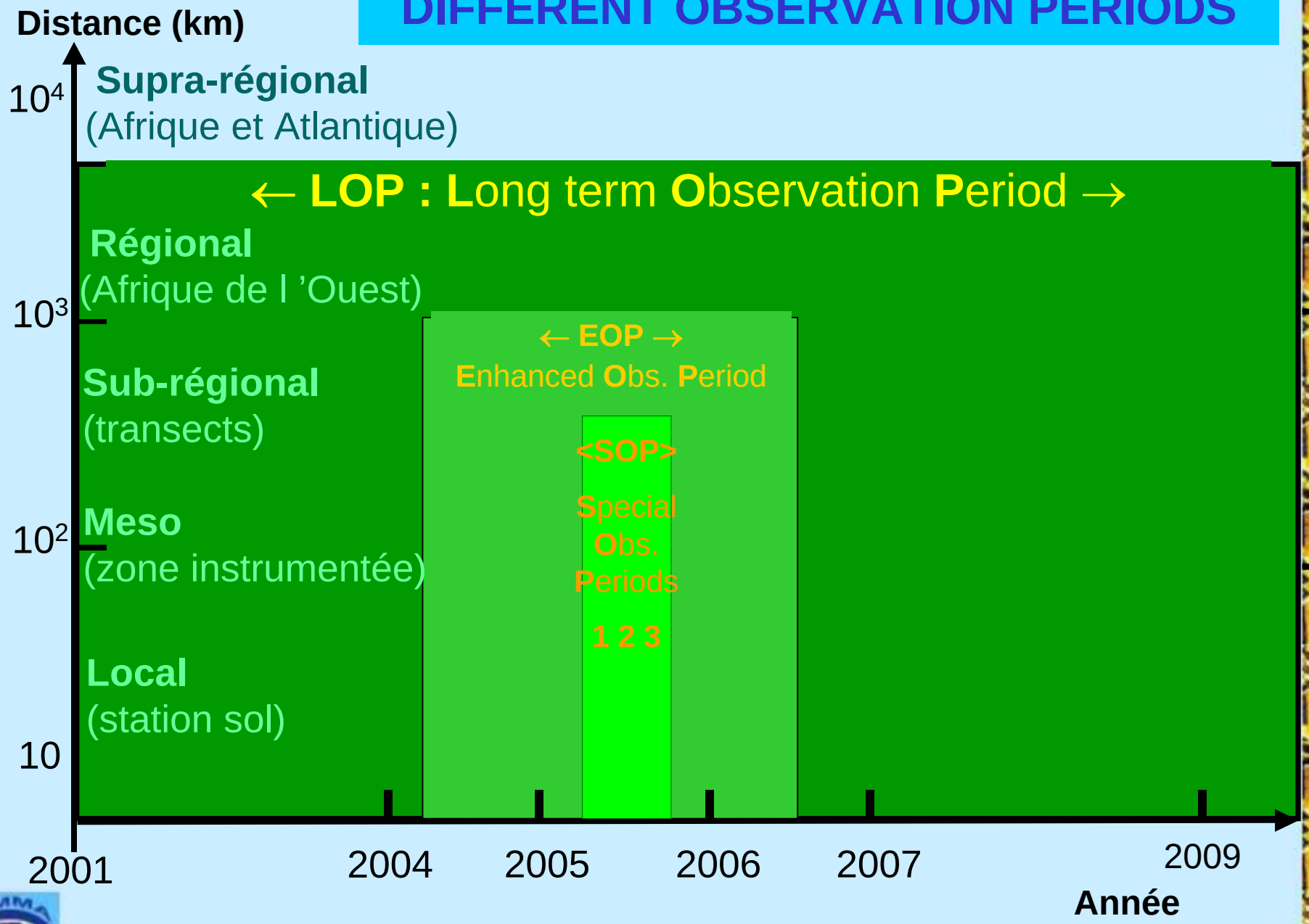


Zonal transect
Meridional transects
CATCH Windows
Regional domain
Soundings reported on GTS
Soundings not reported on GTS
PIBAL (Wind) on GTS

: « operational » radars

[+ IDAF, AERONET networks]

DIFFERENT OBSERVATION PERIODS



Long-term Observation Period (LOP)

inter-annual and decadal variability

- *To collect, homogenize and distribute historical data*
- *To promote new observations, maintain and coordinate existing facilities 2002-2010*

(meridian and zonal transects, local / mesoscale / regional → most sites exist but they have to be maintained)

Enhanced Observation Period (EOP)

Two rainy seasons & interseason 2004-2005-2006

- *To observe the seasonal cycle along the transects (surface and atmosphere) ➔ Effect of the « surface memory »*
- *To document the chemical species and aerosols (inventory, fluxes, evolution)*

(sites for satellite validation, improvement of the radiosounding network, international observing networks (IDAF, AERONET, …)

Special Observation Periods (SOP)

Rainy season 2005 (incl. Intensive Observations Periods : few days)

SOP_1 : Monsoon onset (~ 15 May - 1 July)

SOP_2 : Monsoon Maximum (~ 1 July - 15 August)

SOP_3 : Monsoon (~ 15 August - 15 September)

Required observations during the SOP

Additional soundings

- High-frequency (up to 4-8/day) and GTS-reporting RS **(➔**LOP, EOP)
- « Driftsondes » NCAR / ICARUSS (+ CNES stratospheric balloons ?)
- Dropsondes from FR/Falcon
- Constant level balloons from the Gulf of Guinea (or inland)
- Enhanced O3-soundings + stratospheric balloons for chemistry
- UHF / VHF/ RASS wind profiler ? GPS geodesic stations ?

Airborne measurements

- Low to mid-troposphere : in-situ dynamics, thermodynamics, radiation, chemistry ➔ FR/ATR
- low to mid-troposphere: airborne Doppler radar, water vapour lidar ➔*P3 (NOAA, NRL/NCAR)*
- low to mid-troposphere: chemistry ➔ UK/BAe-146
- Upper troposphere: dropsondes, cloud lidar+radar, (Doppler lidar) ➔ FR/ Falcon *(+ DE/Falcon ?)*
- Upper troposphere: chemistry, radiation, microphysics ➔ UK/ Egrett *(+ EU/Geophysica ?)*

Required observations during the SOP

Ground-based radars

- Reliable observations with « operational » radars + archives
- X-band polarimetric Doppler radar near Djougou (Benin) ➔CATCH
- C-band polarimetric Doppler radar (French CETP/RONSARD)
- + Another [S-band] polarimetric Doppler radar

  ➔ *Dynamics and microphysics of Tstorms and MCS*
- Lightning detection network

Surface measurements

- Raingauges (Djougou ➔CATCH ; Niamey ➔HAPEX-EPSAT)
- Vegetation, water budget (existing + …)
- Sensible and latent heat fluxes (Météo-France, CEH Wallingford)
- Chemical emissions and deposits (IDAF network + LA instrumented van)
- Aerosol optical properties (AERONET network + …)

Special Observing Period - SOP 1 : Monsoon Onset / 15 May - 30 June 2005

The main objective is to study the <u>coupled system " Saharan thermal low / monsoon flow / African Easterly Jet "</u> , its interactions with the surface characteristics and emissions.

An important point concerns the evolution during the <u>" monsoon jump "</u>, i.e. the sudden northward displacement of the intertropical convergence zone (ITCZ) between mid-June and early July

Special Observing Period - SOP 1 : Monsoon Onset / 15 May - 30 June 2005

SOP_1.1 " Low to mid-troposphere energy budget, evolution, spatial variability "

•(i) the structure and evolution of the atmospheric boundary layer before the arrival of the monsoon flow, then in presence of the monsoon and tropospheric jets,

•(ii) the quantification of the energy budgets (heat, humidity, momentum).

•" extended CATCH window ", i.e. a meridional cross-section [Cotonou (6.38°N, 2.34°E) – Parakou (9.36°N, 2.61°E) –Niamey (13.52°N, 2.12°E) - Gao (16.25°N, 0.00°)] where enhanced radiosoundings will be conducted.

•**PRIORITY EQUIPMENTS :**

- **F/ATR with flight level dynamic and thermodynamic measurements, dropsondes**
- **NRL/P3 with flight level measurements, remote sensing (LEANDRE 2, ASTRAIA-ELDORA), dropsondes**

•OPTIONAL EQUIPMENTS :

- DLR/Falcon with WIND Doppler lidar
- Constant level balloons released from the coast
- Radiosoundings, constant level balloons and/or Aeroclippers released from the coast or from a research vessel in the gulf of Guinea
- UHF-RASS and/or VHF wind profiler
- Ground-based Doppler lidar

Special Observing Period - SOP 1 : Monsoon Onset / 15 May - 30 June 2005

SOP_1.2 " Vegetation and water budget "

•Studies concerning vegetation come mostly under the auspices of EOP and LOP (e.g. German IMPETUS program coordinated with the French CATCH program over the Ouémé river basin in Benin).

•The need for additional, enhanced or specific measurements during the SOP will be discussed with the groups in charge of these medium- or long-term surveys.

• Spaceborne remote sensing measurements will bring a lot of information, but these data must be validated through comparisons with local, ground-based or airborne, observations.

•**PRIORITY EQUIPMENTS:**

- **Stations for (sensible and latent heat, radiation) flux measurements**
- **Stations for soil humidity and vegetation measurements (→ LOP-EOP)**

•OPTIONAL EQUIPMENTS:

- F/ATR or NRL/P3 for airborne remote sensing of surface humidity?

Special Observing Period - SOP 1 : Monsoon Onset / 15 May - 30 June 2005

SOP_1.3 " Chemistry of the low and mid-troposphere "

•In parallel with the evaluation of the energy budget (SOP_1.2), it is necessary to quantify concentrations and fluxes of trace gases at surface (including emission and deposition) and in the atmosphere, and to compare the results before and after the arrival of the monsoon flow.

•Active networks in West Africa, such as IDAF and AERONET, which are mostly considered in the EOP and LOP frameworks, will provide information on the atmospheric contents.

•**PRIORITY EQUIPMENTS**

- **Stations for the measurement of surface emissions of trace gases and aerosols (e.g. IDAF, AERONET → LOP-EOP, optical counters, impacters, TEOM)**
- **Instrumented van from Laboratoire d'Aérologie**
- **F/ATR with flight-level measurements of CO, O_3, NO_X, COV**
- **Enhanced ozone soundings**

Special Observing Period - SOP 2 : Monsoon Maximum / 1 July - 14 August 2005

The main goal is to document the structure, evolution, propagation, impact and control of the West African <u>mesoscale precipitating systems</u>.

→ EOP

- **Secured network of radiosoundings and integrated humidity measurements, assimilated in weather prediction models ;**
- **Observations from operational geostationary and polar-orbiting meteorological + atmospheric chemistry satellites ;**
- **Network of « operational » meteorological radars over West Africa (Dakar, Bamako/Ouagadougou, Niamey, Abidjan, Cotonou)**

Special Observing Period - SOP 2 : Monsoon Maximum / 1 July - 14 August 2005

SOP_2.1 "Tropospheric water budget and surface conditions"

- Mass and energy budget in a 100-km radius ***Instrumented Zone (IZ)*** : near Djougou (Benin → CATCH) or near Niamey (Niger → HAPEX 1°x1°)
- Precipitation efficiency
- Relations between atmospheric and surface conditions

- **PRIORITY EQUIPMENTS**
  - **≥2 C- or S-band polarimetric Doppler radars**
  - **Raingauges network, surface humidity and hydrological measurements**
  - **Surface fluxes (sensible & latent heat, radiation) measurements**
  - **Enhanced radiosoundings and/or dropsondes (F/Falcon)**
  - **Pre-and post-storm thermodynamic and chemical measurements (F/ATR)**
- OPTIONAL EQUIPMENTS:
  - UHF / VHF/ RASS wind profiler
  - NRL/P3 with ELDORA Doppler radar and LEANDRE lidar
  - DE/Falcon with WIND Doppler lidar
  - Ground-based Doppler lidar
  - F/ Falcon with cloud radar + lidar, radiative and microphysical measurements

Special Observing Period - SOP 2 : Monsoon Maximum / 1 July - 14 August 2005

SOP_2.2 " Propagation and evolution of precipitating systems , interactions with synoptic scales "

•Instrumented aircraft will allow studies that will complement the budgets determined from ground-based observations in the IZ.

•The large scale structure, interactions with the environment, propagation and evolution of the long-lived convective perturbations will be investigated.

•**PRIORITY EQUIPMENTS**

- **F/Falcon with dropsondes**
- **NRL/P3 with ELDORA-ASTRAIA Doppler radar and LEANDRE water vapor lidar**
- **Driftsondes (NCAR/ICARUSS or CNES)**

•OPTIONAL EQUIPMENTS:

- DLR/Falcon with WIND Doppler lidar
- Second aircraft with Doppler radar (NOAA/P3 ?)

Special Observing Period - SOP 2 : Monsoon Maximum / 1 July - 14 August 2005

SOP_2.3a " Budget of ozone and HO_X radicals in relation with precipitating systems "

•The main objective is to quantify the tropospheric budgets of HO_X and O_3 in presence of convective precipitation, in the IZ as a first priority.

•**PRIORITY EQUIPMENTS**

- **UK/BAe for airborne chemical measurements in the low and mid-troposphere**
- **F/Falcon for chemical measurements in the upper troposphere (O_3/CO : MOZAIC analyzers, NO_X : MONA, COV : cartridge or cylinder, radicals HO_X HCHO CH_3CHO : SAMU mass spectrometer), or DLR/Falcon with its own chemical device**
- **F/ATR with chemical measurements in the boundary layer and low troposphere**
- **Ozone soundings**
- **Lightning detection (optionally: 2D or 3D localization)**
- **Enhanced surface measurements of trace gases emissions**
- **Coordinated ground-based or airborne Doppler radar observations**

Special Observing Period - SOP 2 : Monsoon Maximum / 1 July - 14 August 2005

***SOP_2.3b** " Characterization of the tropical tropopause layer (TTL) "*

•The objective is here to measure the chemical components in the TTL zone between 13 and 17 km altitude, above the strongest convective outflow and below the thermal tropopause.

•This region is characterized by important interactions between troposphere and stratosphere which must be correctly understood to provide a reliable lower boundary condition for stratospheric chemistry.

•**PRIORITY EQUIPMENTS**

- **UK/Egrett and/or M55-Geophysica for dynamic, microphysical, radiative and chemical measurements in the TTL**
- **F/Falcon and/or DLR/Falcon for in situ and/or remote sensing measurements in the upper troposphere**
- **Stratospheric balloons**

Special Observing Period - SOP 2 : Monsoon Maximum / 1 July - 14 August 2005

SOP_2.4 "Aerosols, clouds and radiative effects "

•Spaceborne and ground-based observations of aerosols, clouds and their radiative effects must be validated by in situ and remote sensing observations.

•Another objective concerns the influence of precipitating systems on raising low-level mineral and organic, natural and anthropic aerosols.

•It is necessary to measure concentration and type of aerosols, in relation with the microphysical and radiative properties of clouds, and precipitation.

•It will also be important to conduct in situ and remote sensing observations in the ice clouds of the upper troposphere.

•**PRIORITY EQUIPMENTS**

- **Surface stations measuring the integrated atmospheric content of aerosol and humidity**
- **F/ATR with flight-level aerosol, microphysical and radiative measurements**
- **F/Falcon with RALI, in situ microphysical and radiative measurements**

•OPTIONAL EQUIPMENTS :

- UK/Egrett and/or M55-Geophysica with thermodynamic, microphysical, radiative measurements in the TTL
- F/ATR with aerosol lidar

Special Observing Period - SOP 3 : Late Monsoon and Impact / 15 Aug - 15 Sep 2005

- The goal is to study the large scale influence of the West African monsoon, particularly toward the tropical Atlantic ocean.
- During SOP_3, the instrumented aircraft will be based in Dakar, Senegal and/or in Sal, Cape Verde.
- *This phase of the AMMA/SOP could eventually be coupled with a US experimental program over central and western tropical Atlantic.*

Special Observing Period - SOP 3 : Late Monsoon and Impact / 15 Aug - 15 Sep 2005

SOP_3.1 "Convective systems and tropical cyclogenesis "

•During SOP_3, the instrumented aircraft will be based in Dakar, Senegal .

•The goal is to study the transformation of the meso- to synoptic scale perturbations passing from the West African continent to the warm waters of the tropical eastern Atlantic, and the influence of environmental conditions, particularly the presence of dry saharan air in the mid-troposphere

•**PRIORITY EQUIPMENTS**

- **F/Falcon with dropsondes**
- **NRL/P3 with ASTRAIA-ELDORA Doppler radar, LEANDRE water vapor lidar, and flight-level measurements**
- **F/ATR for flight-level measurements**
- **Driftsondes**

•*COORDINATED OBSERVATIONS :*

- *US research program over central and western Atlantic*

Special Observing Period - SOP 3 : Late Monsoon and Impact / 15 Aug - 15 Sep 2005

SOP_3.2 "Long distance export "

•Intensive and detailed documentation of the West African " plume " (trace gases , mineral and organic aerosols, …) toward tropical Atlantic, carried by the tropospheric easterly flow, will be conducted

•Another phenomenon during the late monsson period concerns cross-hemispheric mass transfer toward West Africa and the contribution of emissions from southern Africa where biomass burning begins

•**PRIORITY EQUIPMENTS**

- **F/ATR for in situ aerosol, radiative and microphysical measurements, aerosol lidar (if compatible with other lidar requirements)**
- **Chemical measurements with UK/BAe , F/Falcon and DLR/Falcon**

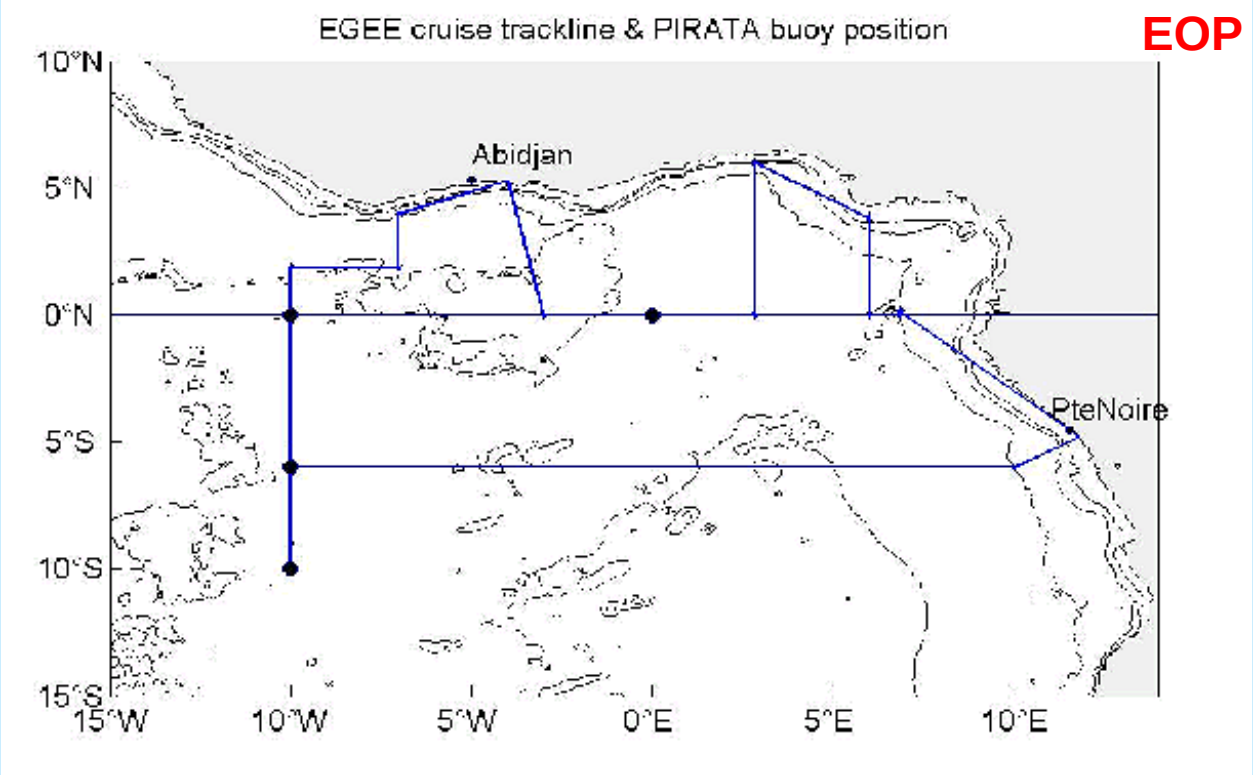
•*COORDINATED OBSERVATIONS :*

- *US research program over central and/or western Atlantic*

Special Observing Period : oceanographic campaign EGEE

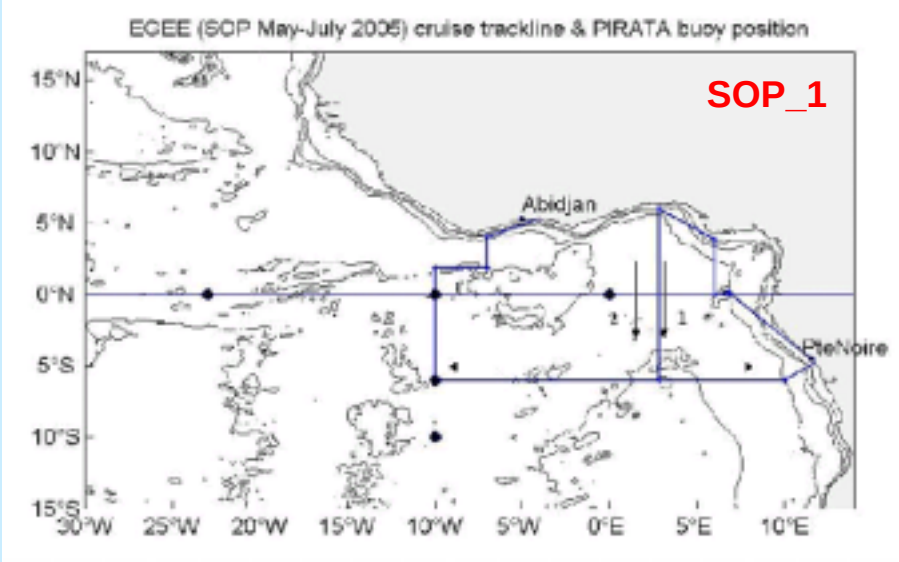
OBJECTIVE: Study the oceanic circulation and its variability in the upper layers of the Gulf of Guinea and Eastern tropical Atlantic, during cruises (oceanic + atmospheric measurements) in relation with :

- ***PIRATA : network of buoys in the tropical Atlantic***
- ***ARGO/CORIOLIS : surface drifters and subsurface drifting buoys***

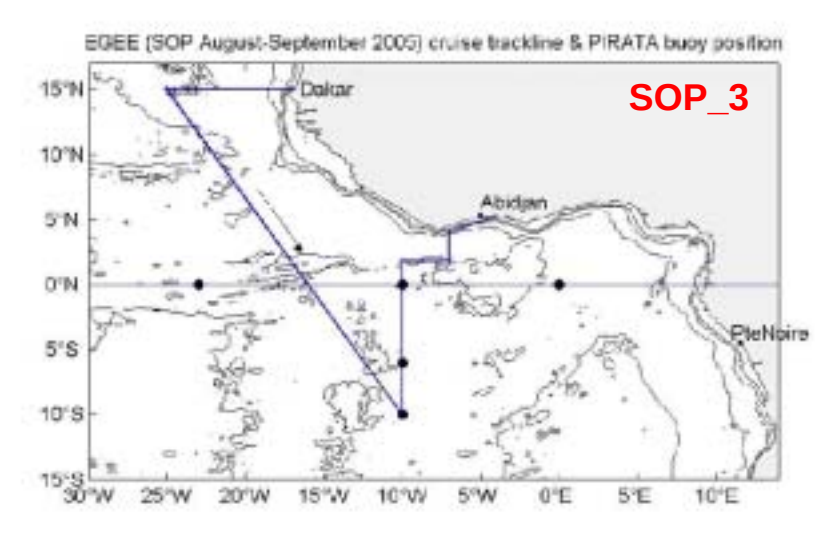


Special Observing Period : oceanographic campaign EGEE

SOP_1 cruise: *in the Gulf of Guinea during the « monsoon onset »*



SOP_3 cruise: *off Dakar and across the Guinea dome during the « late monsoon »*



Special Observing Period : the « dry SOP » (winter 2005-2006)

Two sources of aerosol in Africa : mineral (mostly from Sahara) and organic (from biomass and fossil fuel burning). This SOP is aimed at:

- determining the physical, chemical and radiative characteristics of this « mixture », and their evolution during the transport;
- quantifying the natural and anthropic sources of aerosol during the dry season
- validating the spaceborne observations from the « Aqua train » (AQUA + CALIPSO + CLOUDSAT + PARASOL)

- **PRIORITY EQUIPMENTS**
  - **Surface stations for aerosol measurements (incl. AERONET, IDAF + LA instrumented van)**
  - **Aerosol lidar**
  - **F/ATR with flight-level aerosol, microphysical and radiative measurements**

+ Satellite observations, numerical modelling