Dynamics-Aerosol-Chemistry-Cloud Interactions in West Africa (DACCIWA) – An Introduction

Peter Knippertz & the DACCIWA Team

Karlsruher Institut für Technologie

SEVENTH FRAMEWORK PROGRAMME

Outline

- **WHO is DACCIWA?**

  The 16 partners

- **WHY DACCIWA?**

  Motivation and background

- **WHAT is DACCIWA going to do?**

  Field campaign, modelling, data analysis, process understanding

- **HOW is DACCIWA organised?**

  Governance, workpackages, collaborations, timeline

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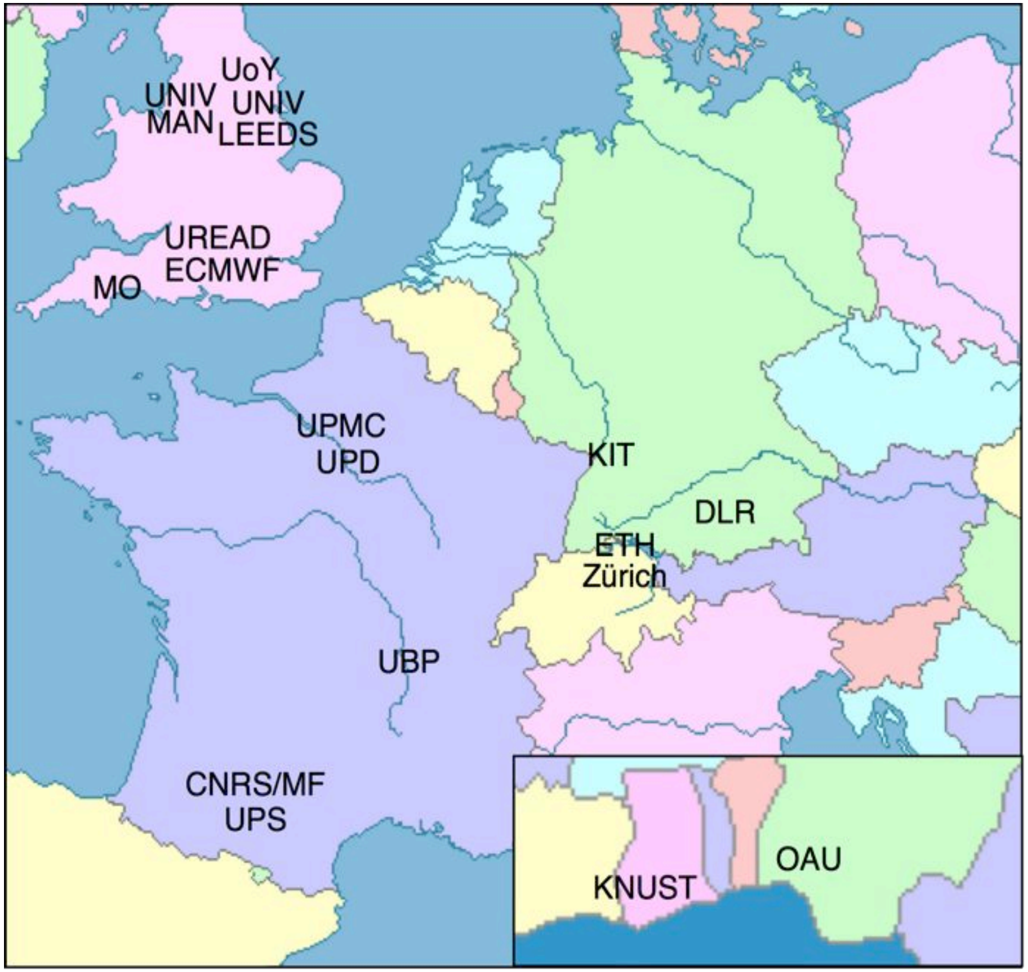
Who is DACCIWA?



GERMANY
– Karlsruher Institute für Technologie (KIT)
– Deutsches Zentrum für Luft- und Raumfahrt (DLR)

UNITED KINGDOM
– University of Leeds (UNIVLEEDS)
– University of York (UoY)
– The University of Reading (UREAD)
– The University of Manchester (UNIVMAN)
– Met Office (MO)
– European Centre for Medium-Range Weather Forecasts (ECMWF)

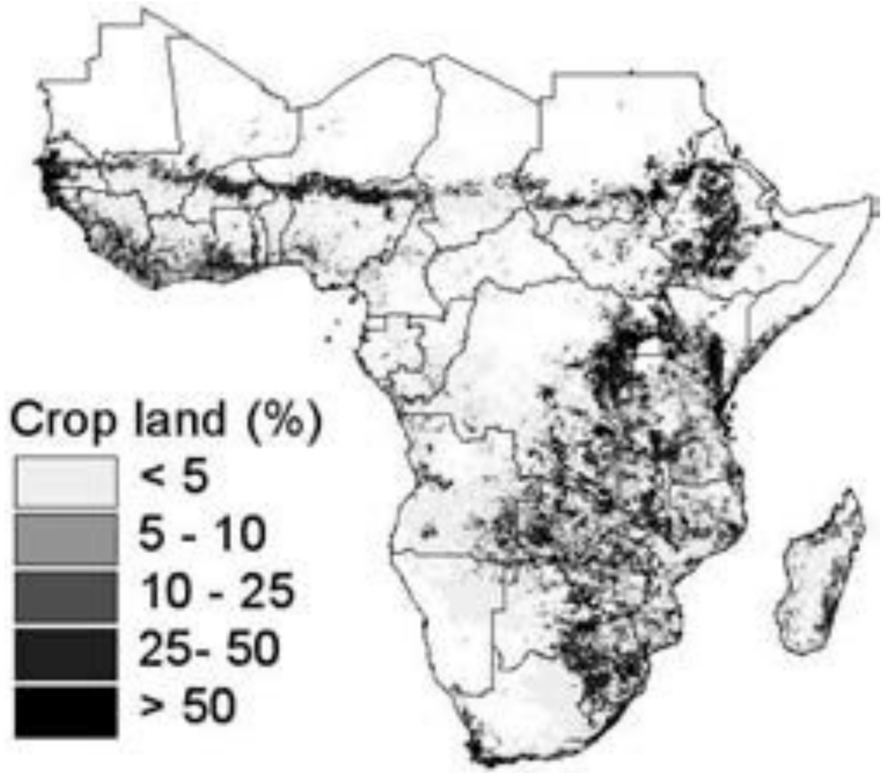
FRANCE
– Université Paul Sabatier (UPS)
– Université Pierre et Marie Curie (UPMC)
– Université Blaise Pascale (UBP)
– Université Paris Diderot (UPD)
– Centre National de Récherche Scientifique (CNRS) with Météo France (MF)

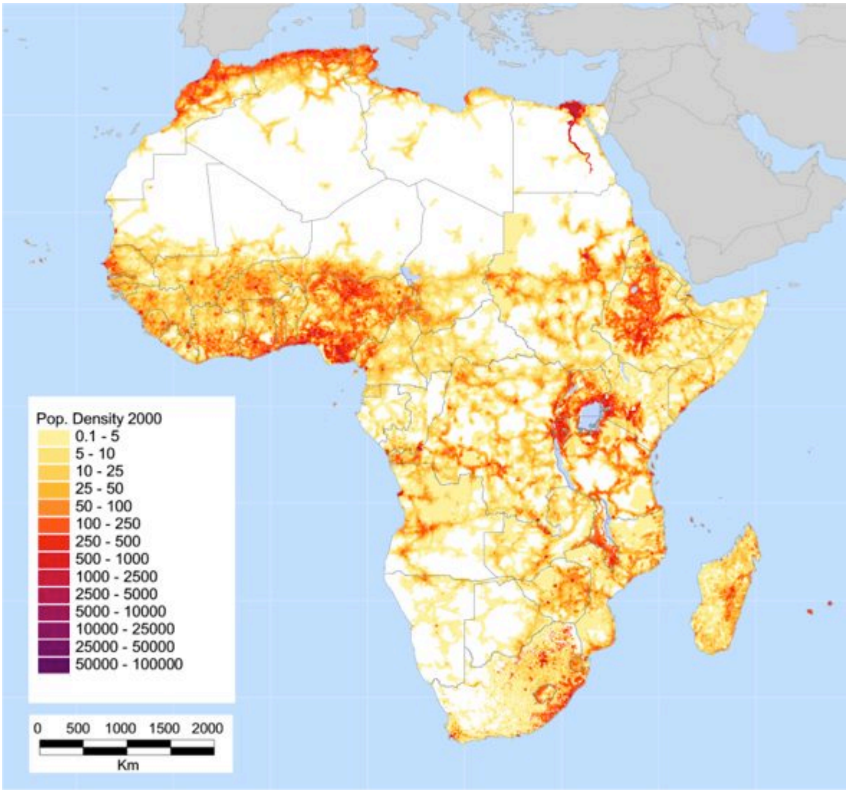
SWITZERLAND
– Eidgenössische Technische Hochschule Zürich (ETH Zurich)

WEST AFRICA
– Kwame Nkrumah University of Science and Technology (KNUST)
– Obafemi Awolowo University (OAU)

Why DACCIWA?

Why DACCIWA? Southern West Africa

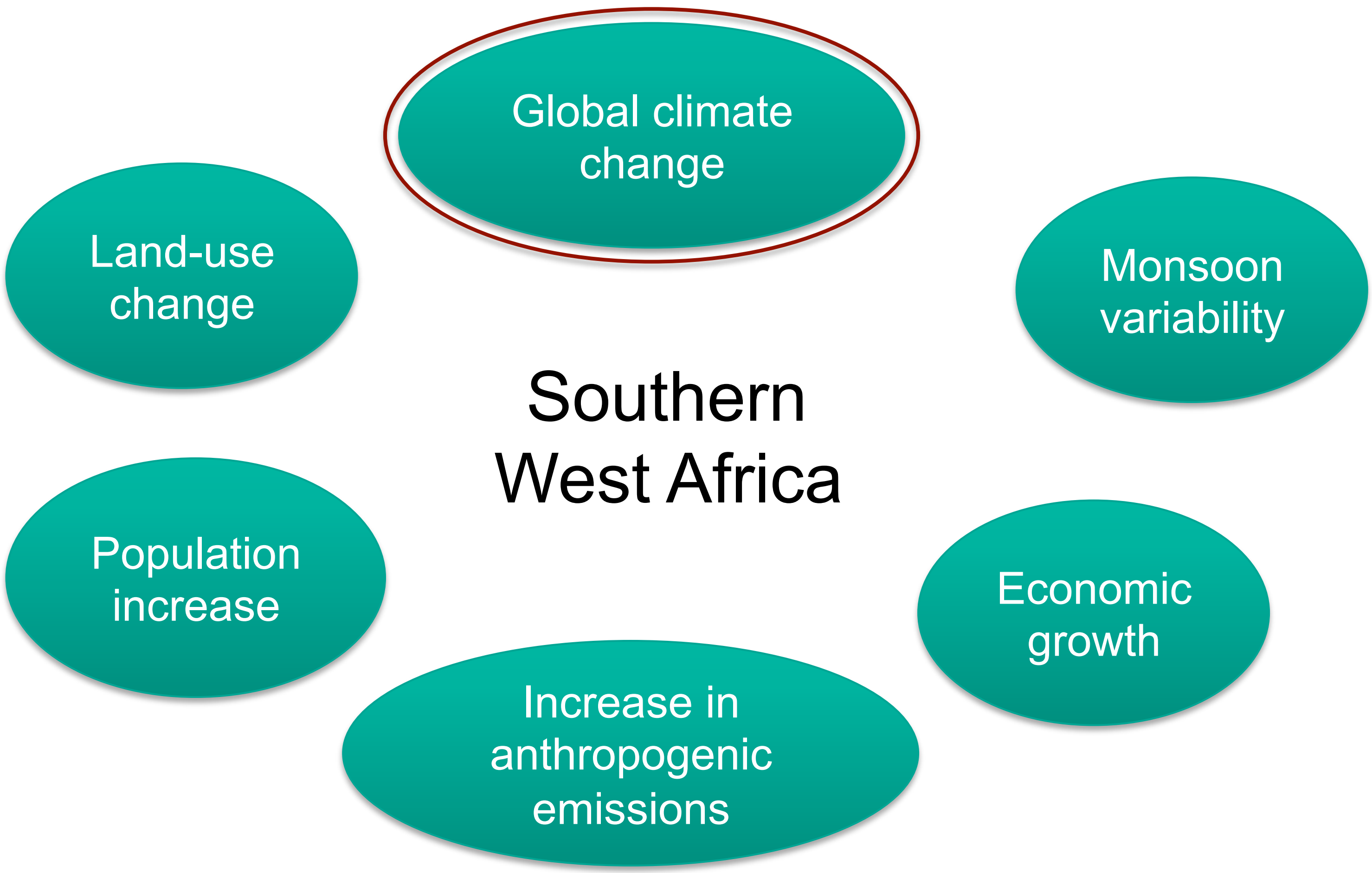




Source: You, Wood, and Wood-Sichra (2009).

Why DACCIWA? Background and Motivation

West Africa is a region affected by multiple stresses on food, water and health



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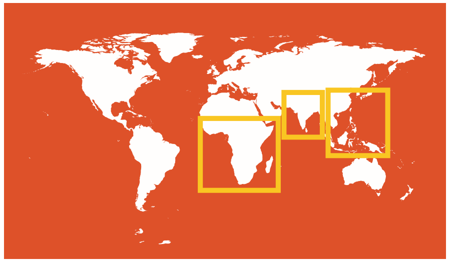
Why DACCIWA? Climate Change

4°

Turn Down the Heat

Climate Extremes, Regional Impacts, and the Case for Resilience

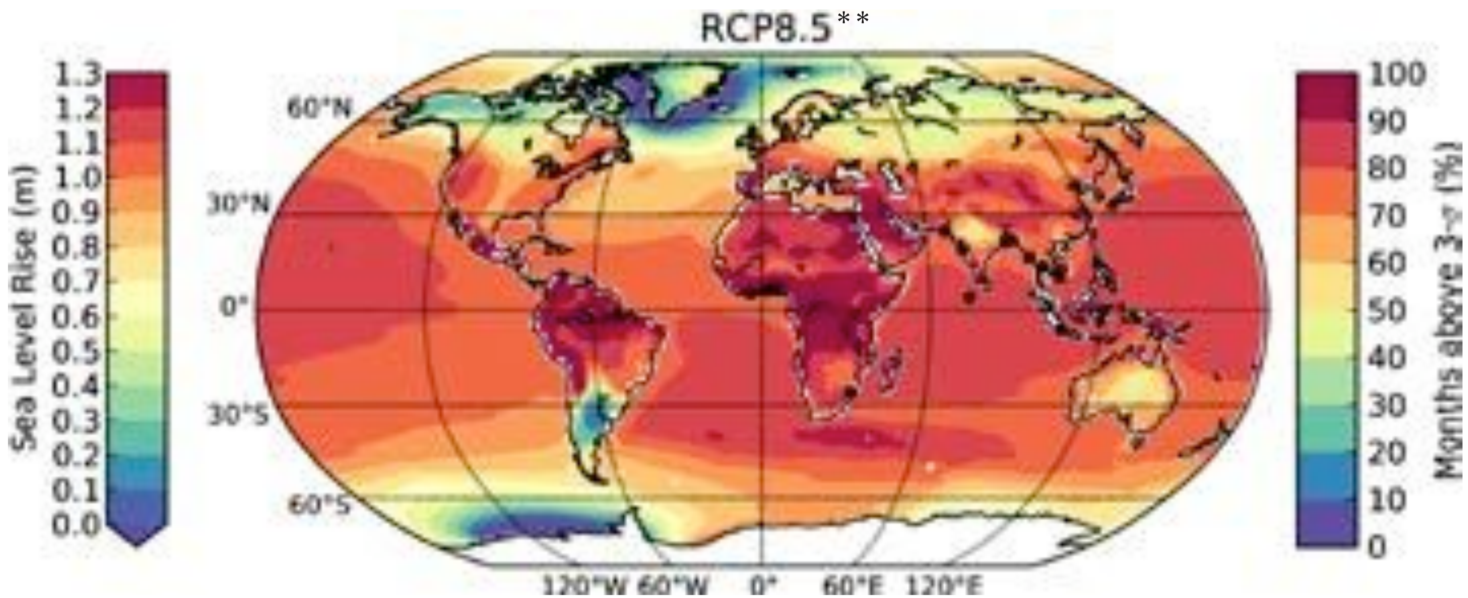


THE WORLD BANK

June 2013

A Report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics

Why DACCIWA? Change in Heat Waves

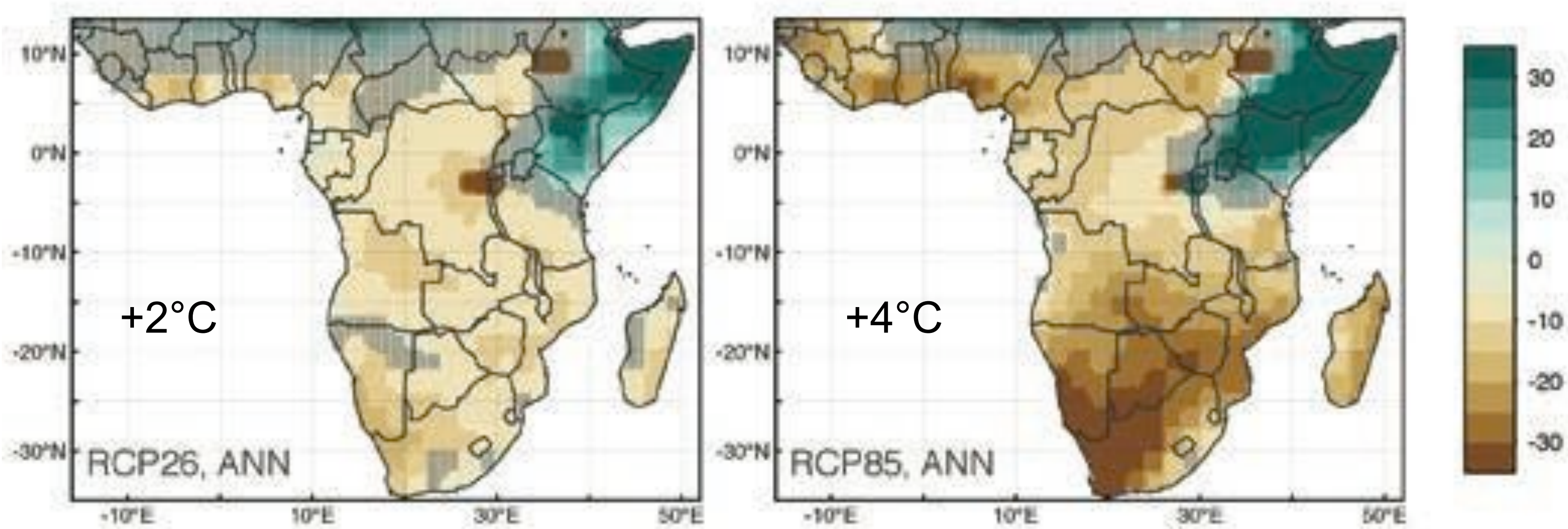


World Bank Report, 2013

Large likelihood of unprecedented summer heat in 4° warmer world!

This is due to low natural variations in the deep tropics.

Why DACCIWA? Aridity Change



World Bank Report, 2013

Risk of increased aridity, even in 2° warmer world!

➔ Yield reduction, shift of ecosystem boundaries (also due to CO_2)
➔ Impacts on food security, poverty reduction, health, economic growth

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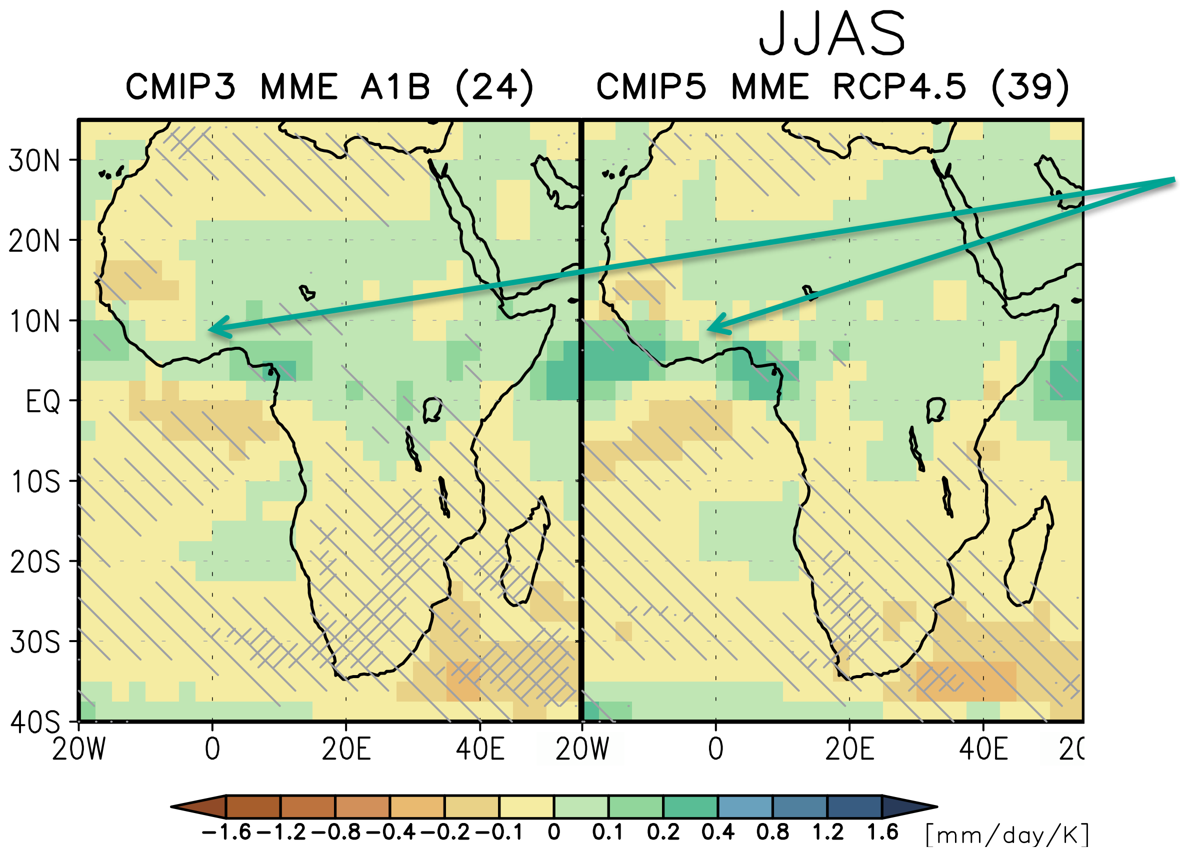
Why DACCIWA? Precipitation Change



Multi-model mean shows slight increase

No hatching indicates low confidence

Draft of IPCC Report, 2013

Models struggle to realistically reproduce the West African monsoon (WAM)

Why DACCIWA? Background and Motivation

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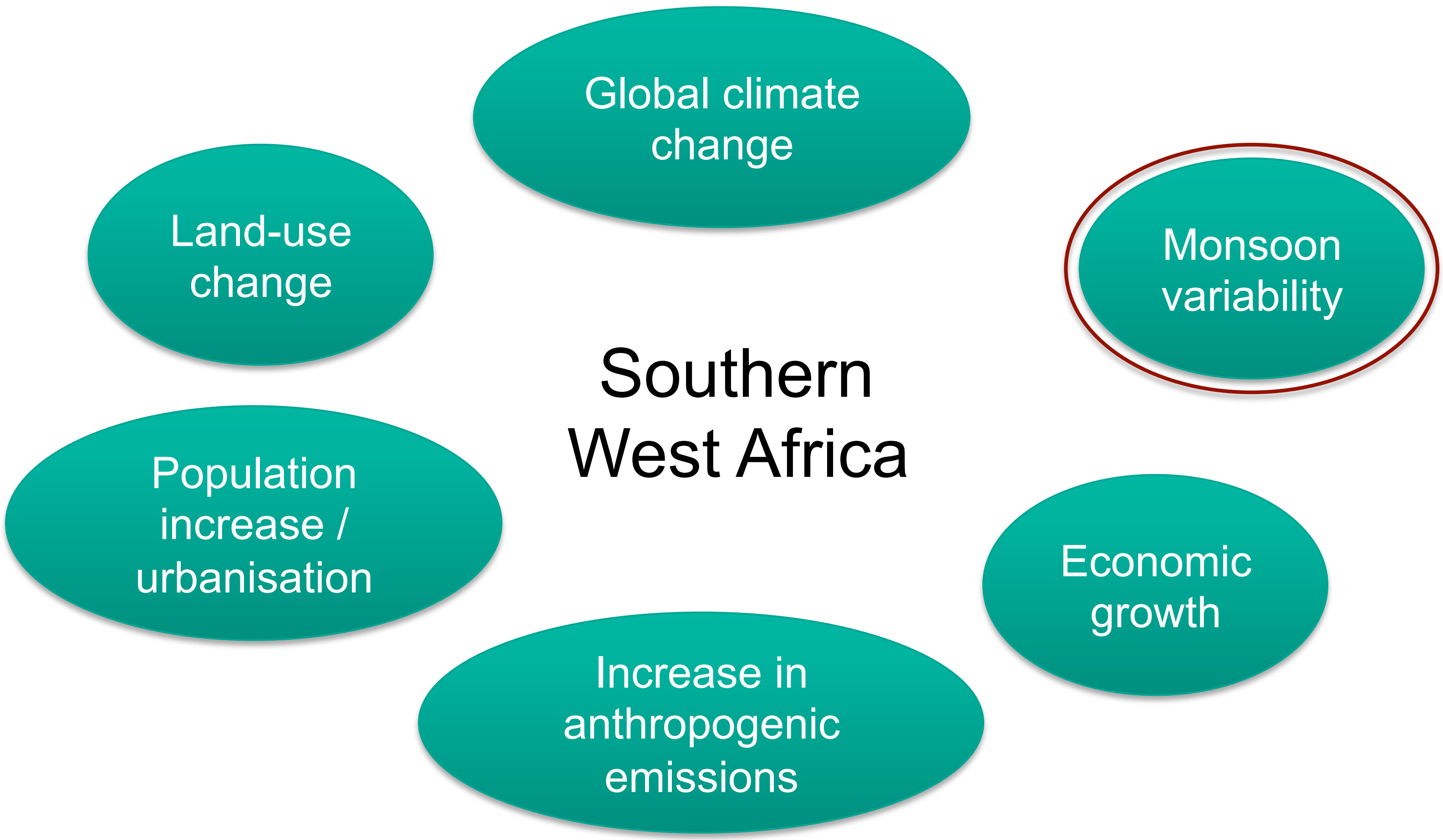
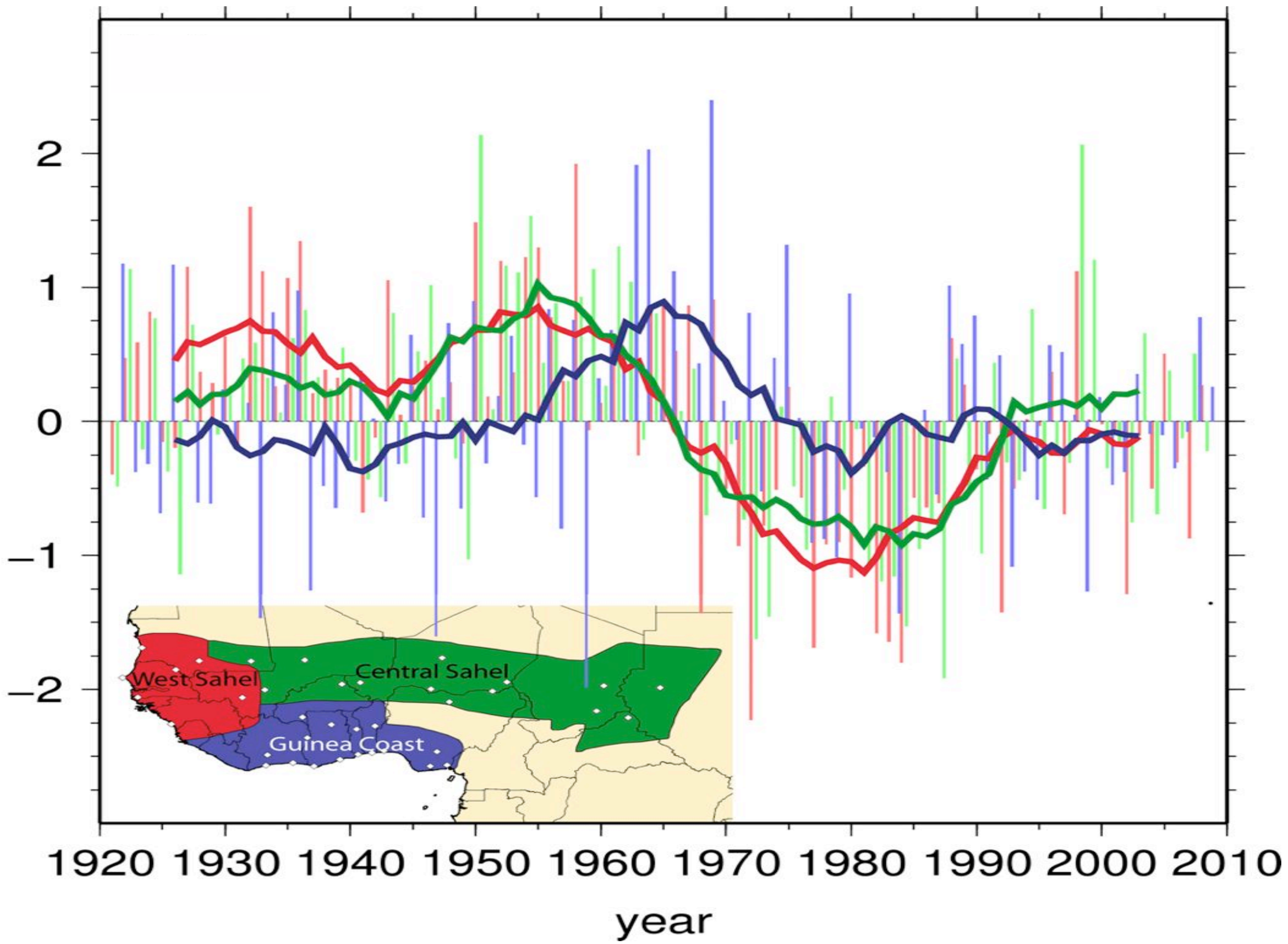


Why DACCIWA? Large decadal variability



Standardized precipitation indices

from Fink et al. 2010

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Why DACCIWA? Background and Motivation

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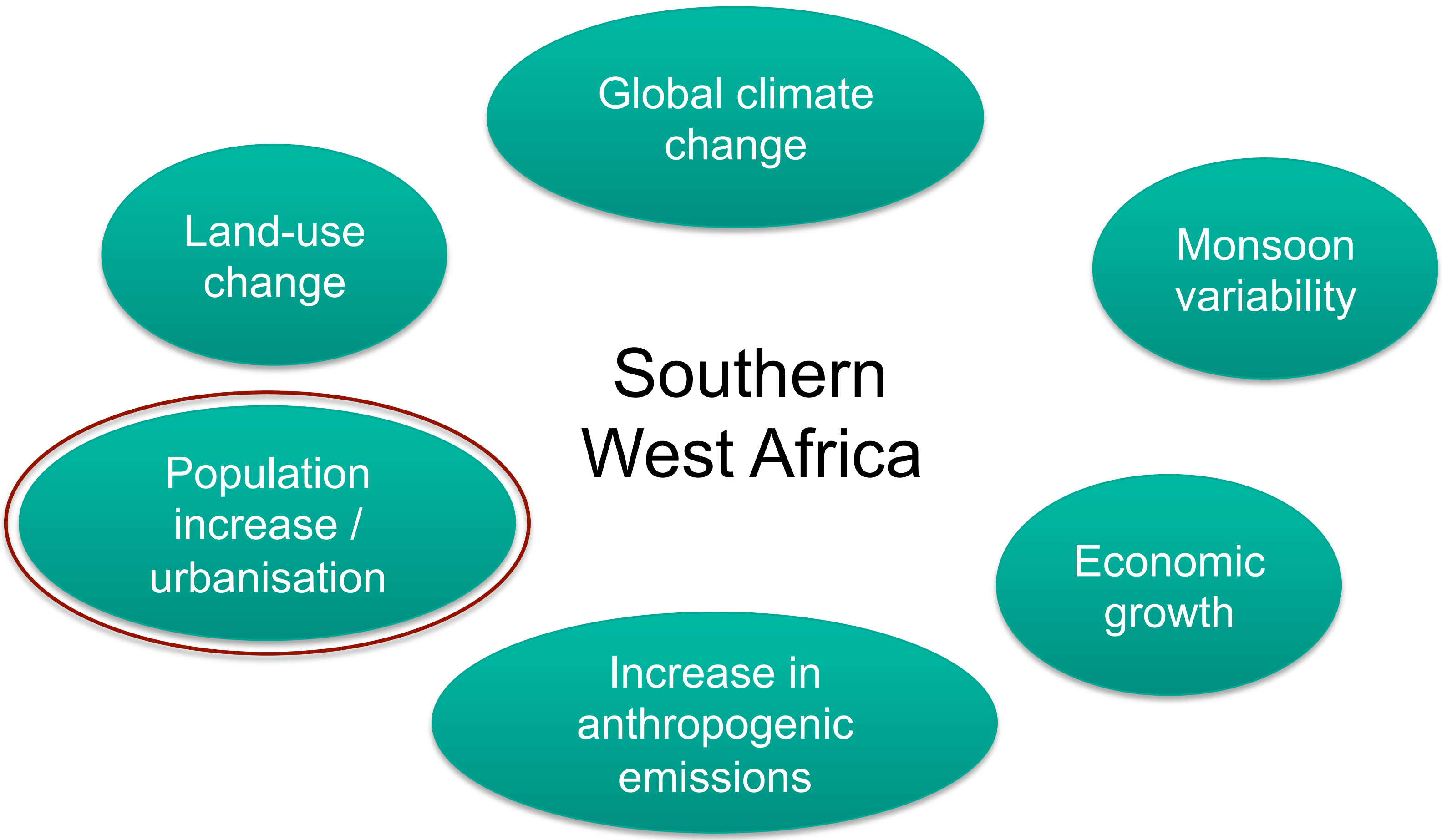

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Why DACCIWA? Population Increase & Urbanisation

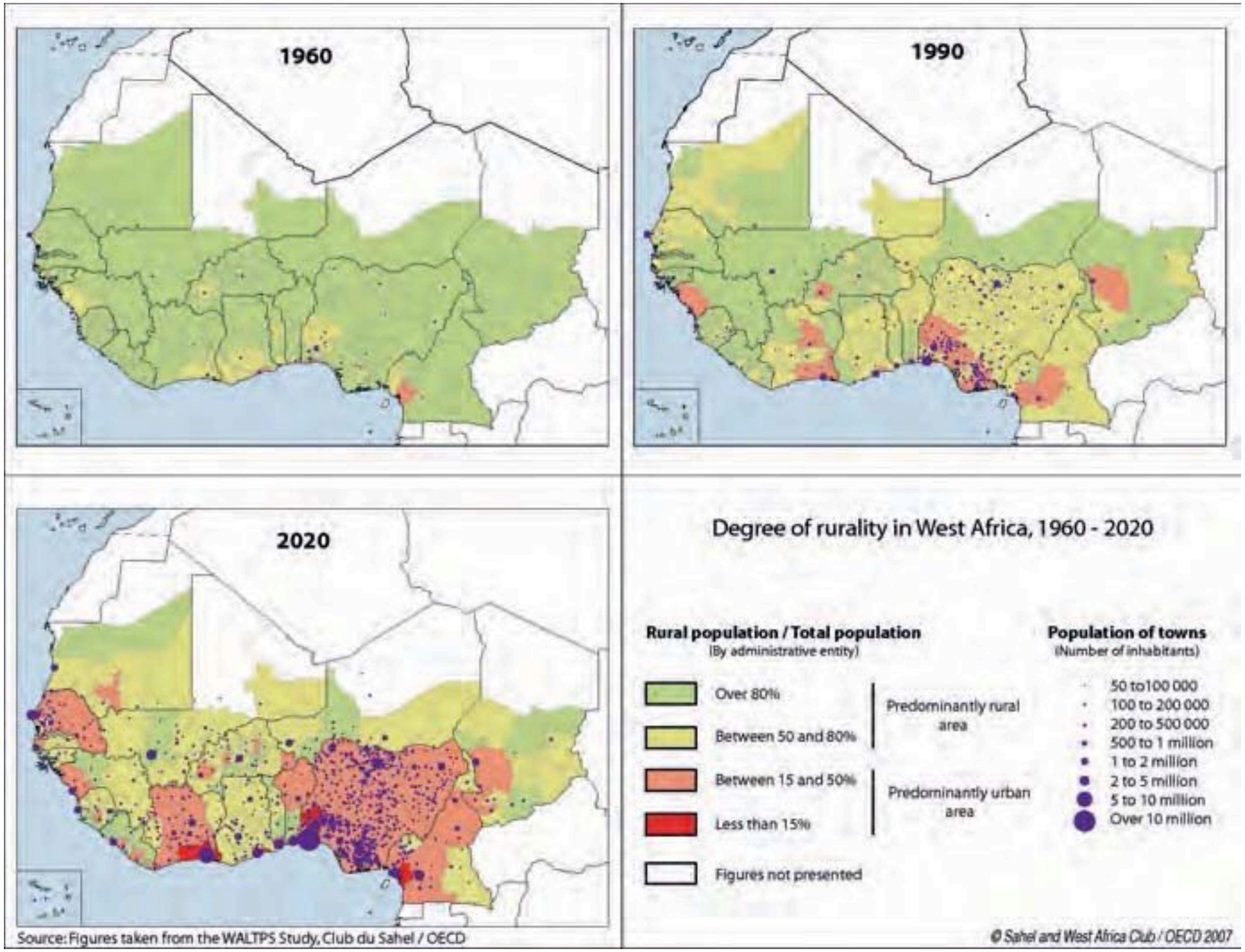

Fig. I-2.1.1: Change in the fraction of rural to total population and increase in number and size of cities: (a) 1960, (b) 1990, and (c) 2020 (Source: ECOWAS-SWAC/OECD 2006).

UN 2011:

Current: 345M
+50% in next 20 yrs
Reach 743M in 2050

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Why DACCIWA? Background and Motivation

West Africa is a region affected by multiple stresses on food, water and health

Global climate change

Land-use change

Monsoon variability

Southern West Africa

Population increase / urbanisation

Economic growth

Increase in anthropogenic emissions

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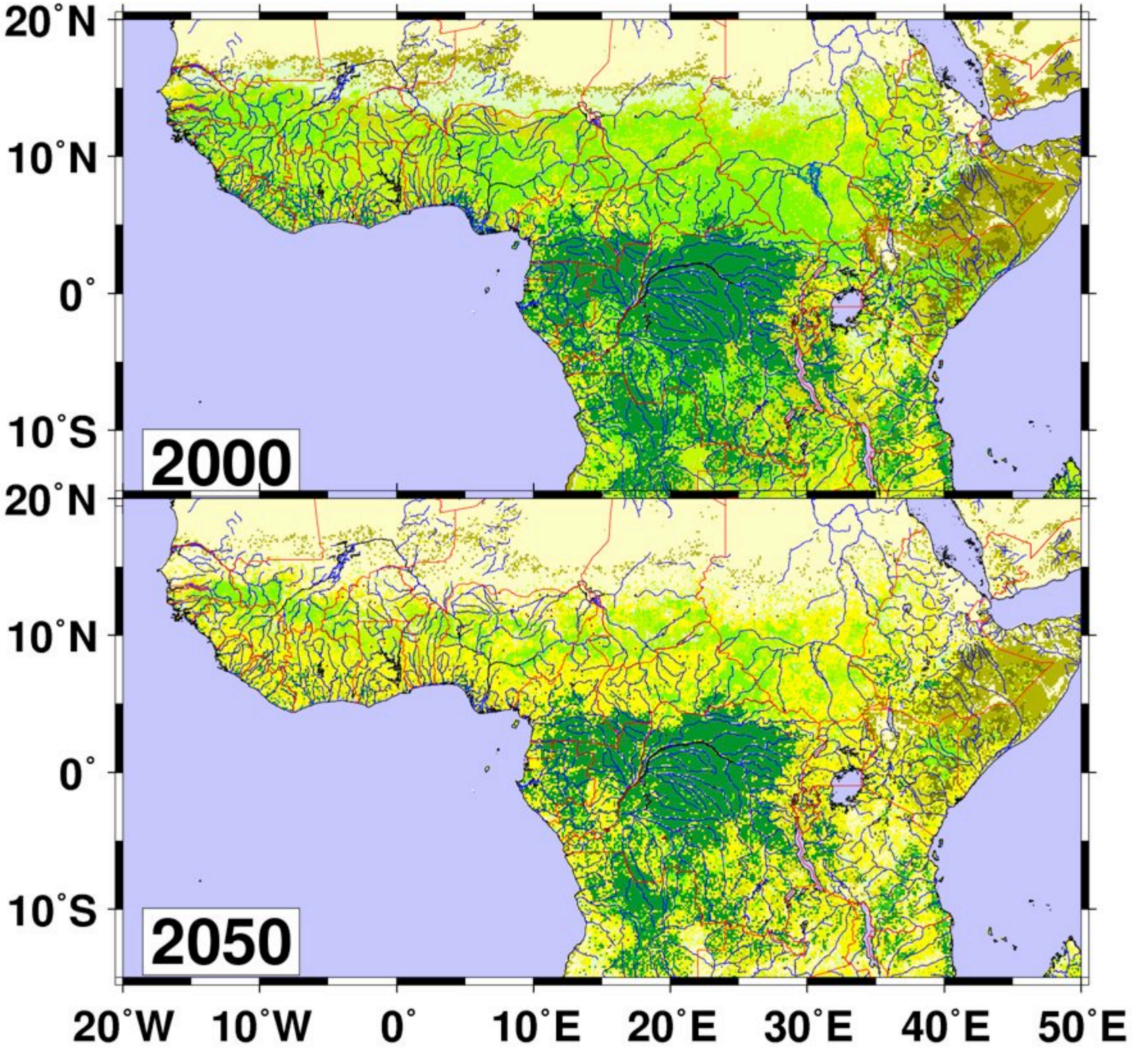
Land-use Changes in Sub-Saharan Africa

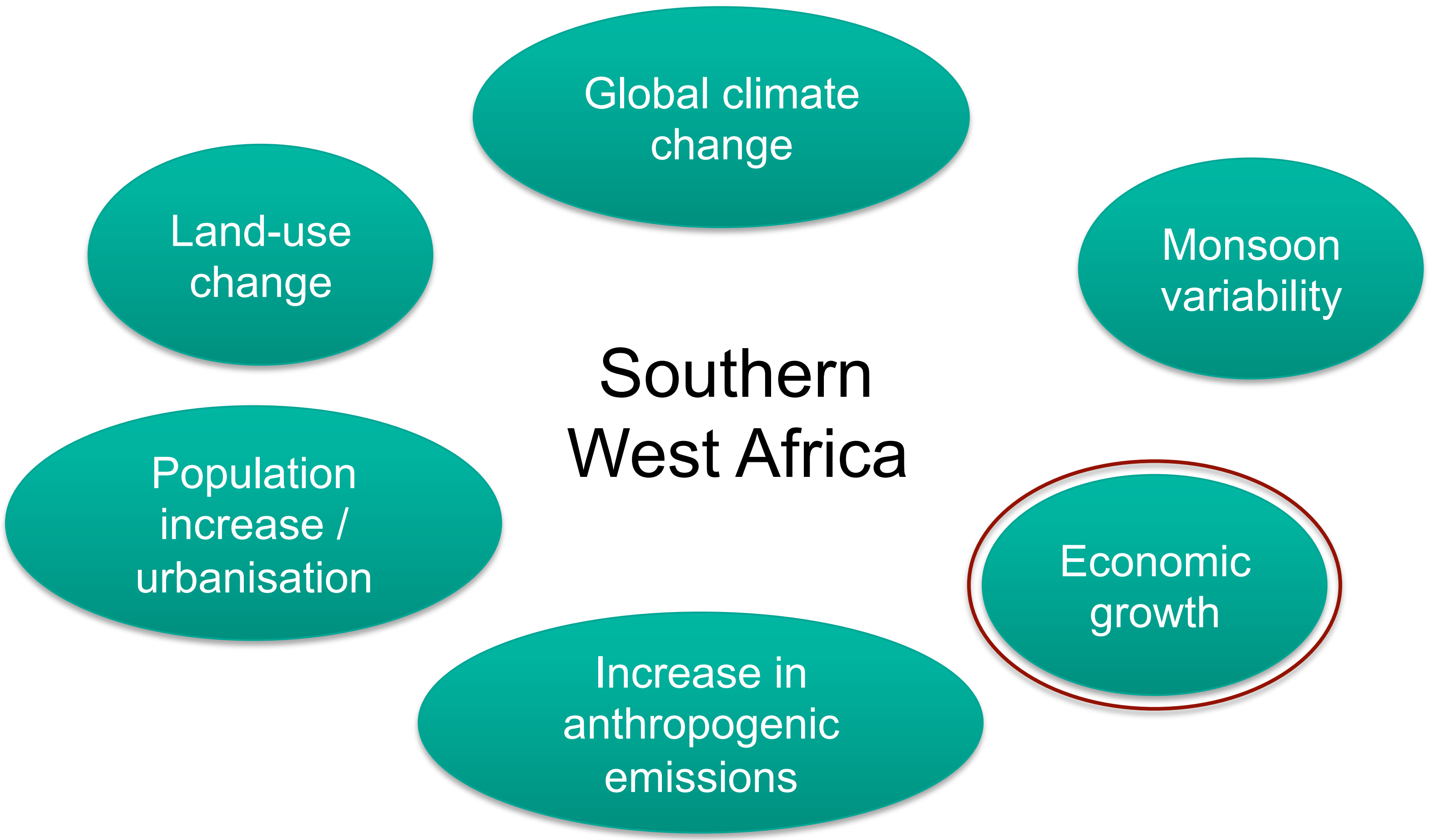


- Substantial loss of biomass and biodiversity
- Shrinking forests along with expanding croplands, especially in the savannah regions of West Africa

Source: Born, IMPETUS

Why DACCIWA? Background and Motivation

West Africa is a region affected by multiple stresses on food, water and health



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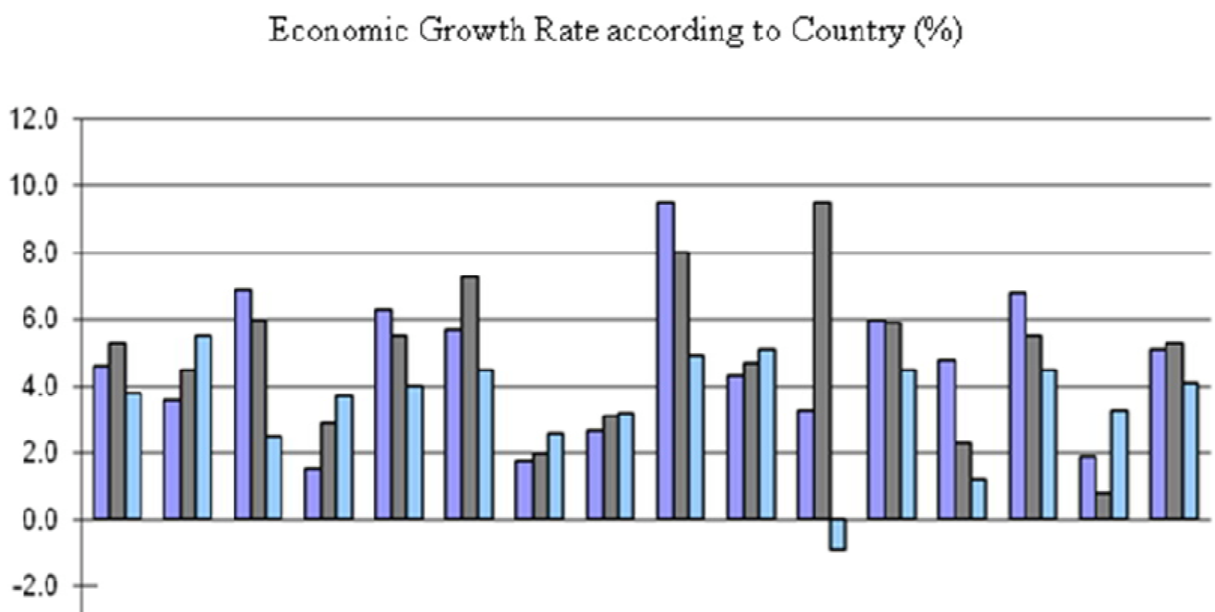
Why DACCIWA? Economic Growth



	Benin	B/Faso	C/Verde	C/d'Ivoire	Gambia	Ghana	Guinea	G/Bissau	Liberia	Mali	Niger	Nigeria	Senegal	S/Leone	Togo	ECOWAS
2007	4.5	3.6	6.9	1.5	6.3	5.7	1.8	2.7	9.5	4.3	3.3	6.0	4.8	6.8	1.9	5.1
2008	5.3	4.5	6	2.9	5.5	7.3	2	3.1	8	4.7	9.5	5.9	2.3	5.5	0.8	5.3
2009	3.8	5.5	2.5	3.7	4	4.5	2.6	3.2	4.9	5.1	-0.9	4.5	1.2	4.5	3.3	4.1

UN Economic Commission for Africa, 2010

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Why DACCIWA? Background and Motivation

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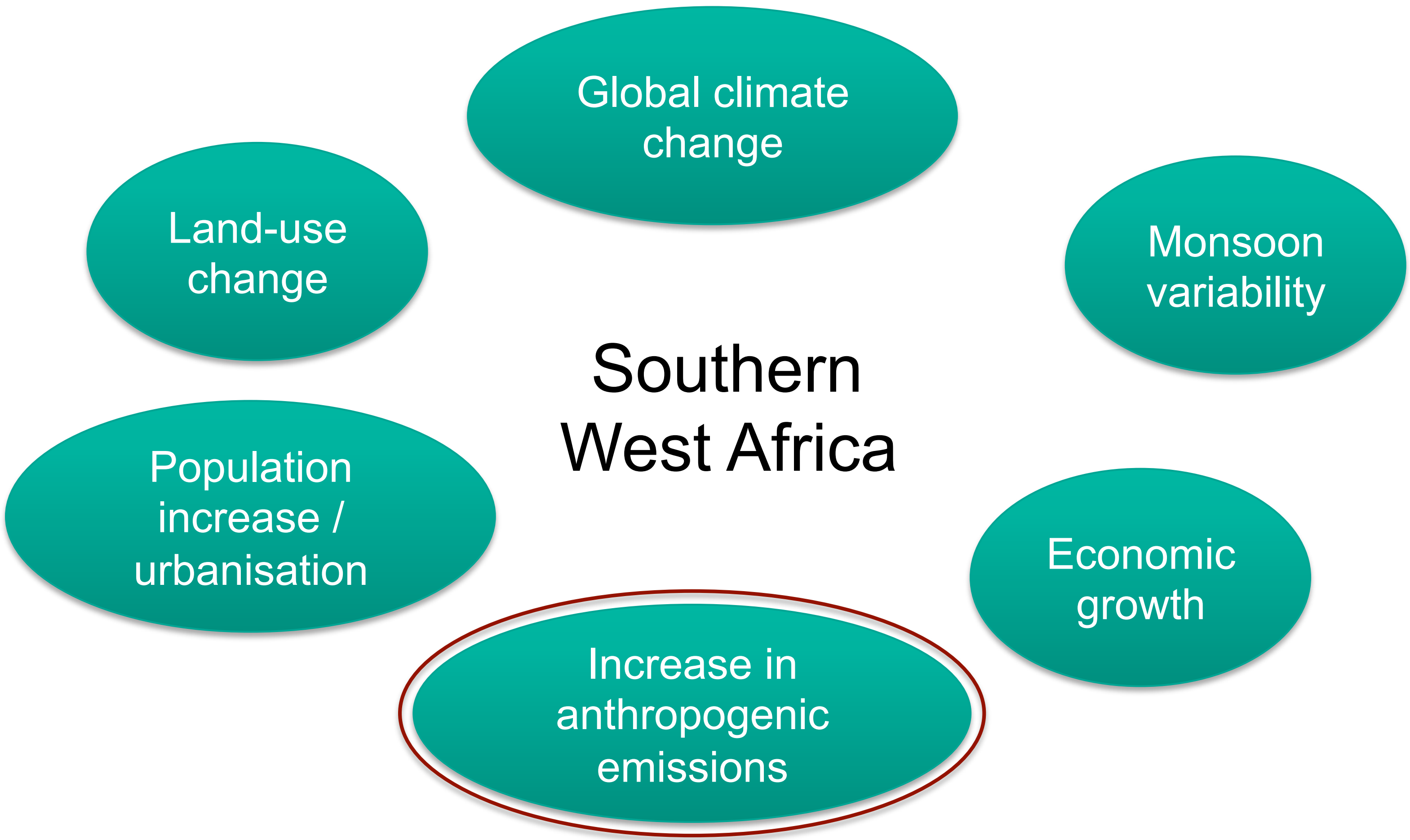

Why DACCIWA? Air pollution

- increased emissions
- outdated technology
- intense photochemistry
- source mixing

➔ Respiratory deseases
➔ Increased cancer burden

Traffic and Domestic fire emissions:
Assamoi and Liousse 2010, Liousse et al., 2013
Savanna fires: Liousse et al. 2010
Dust: Marticoréna et al.

Why DACCIWA? Increase in road traffic

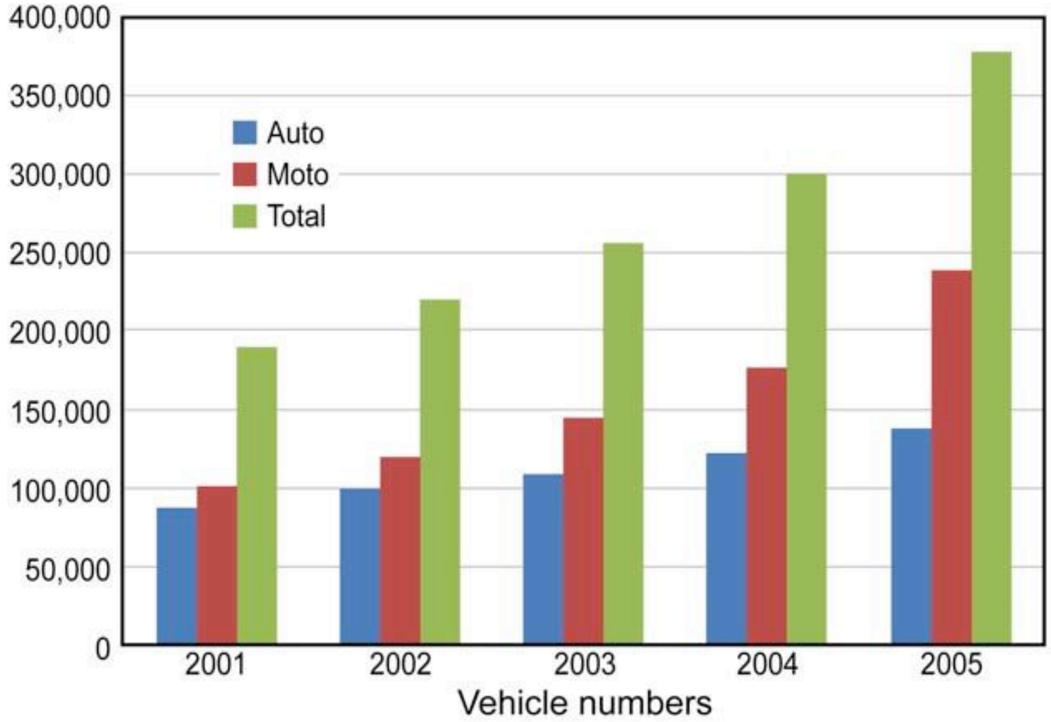

Figure 4 - Evolution of the number and composition of the pool motor vehicles in Burkina Faso

GAW Report No. 205, 2012

Why DACCIWA? Increase in emissions

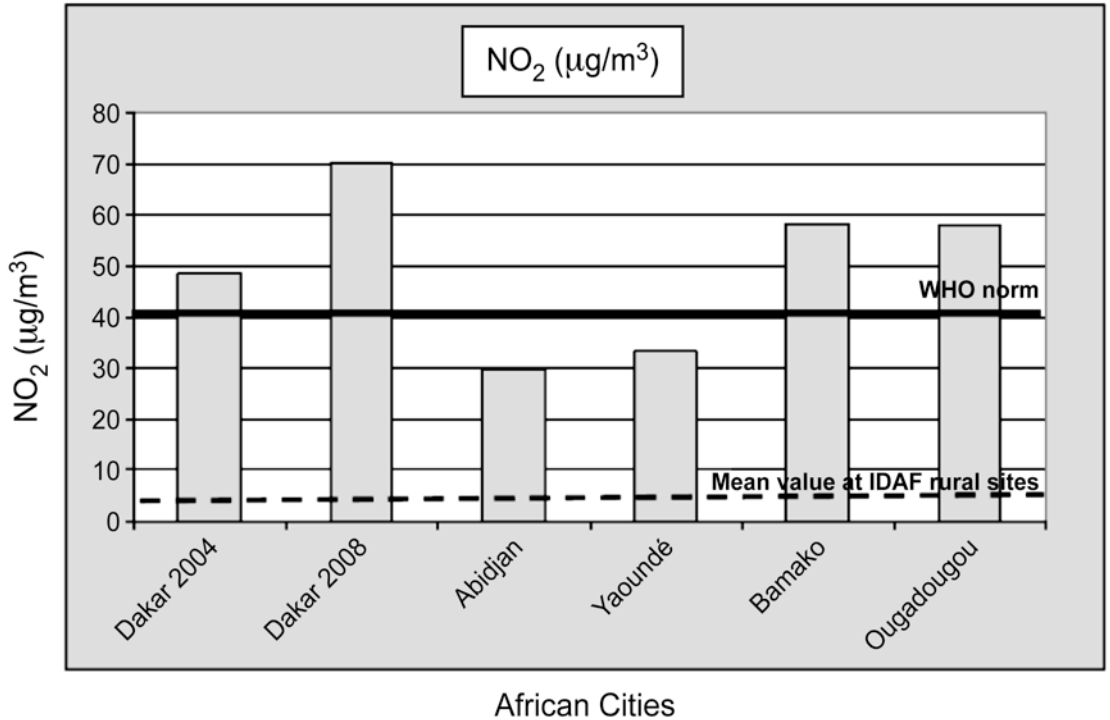

Figure 5 - NO_2 measurements in African capitals [*Liousse and Galy-Lacaux*, 2010].
(Also shown in Chapter 7 as Figure 15)

GAW Report No. 205, 2012

Pollutants have tripled from 1950–2000 and are expected to triple again by 2030 (Lamarque et al. 2010, Liousse et al. 2013)

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Why DACCIWA? Secondary aerosol formation

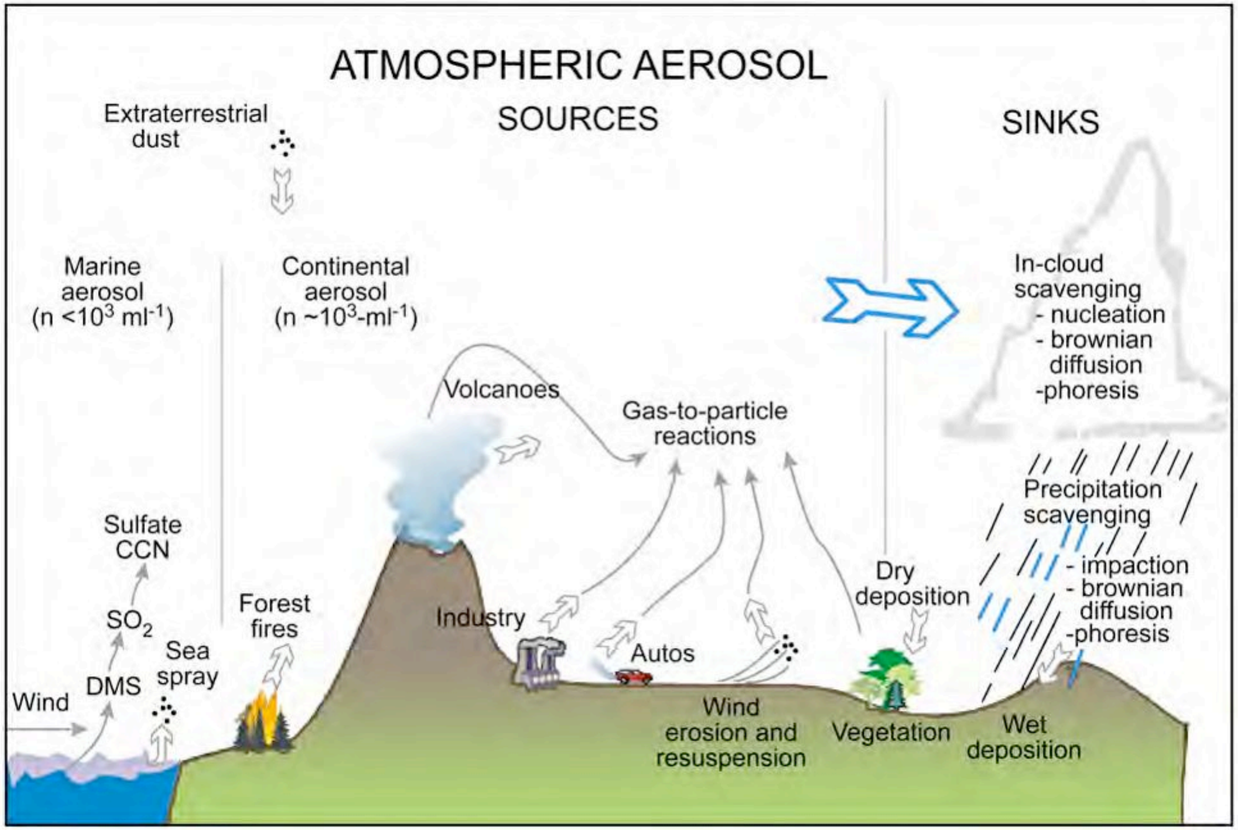
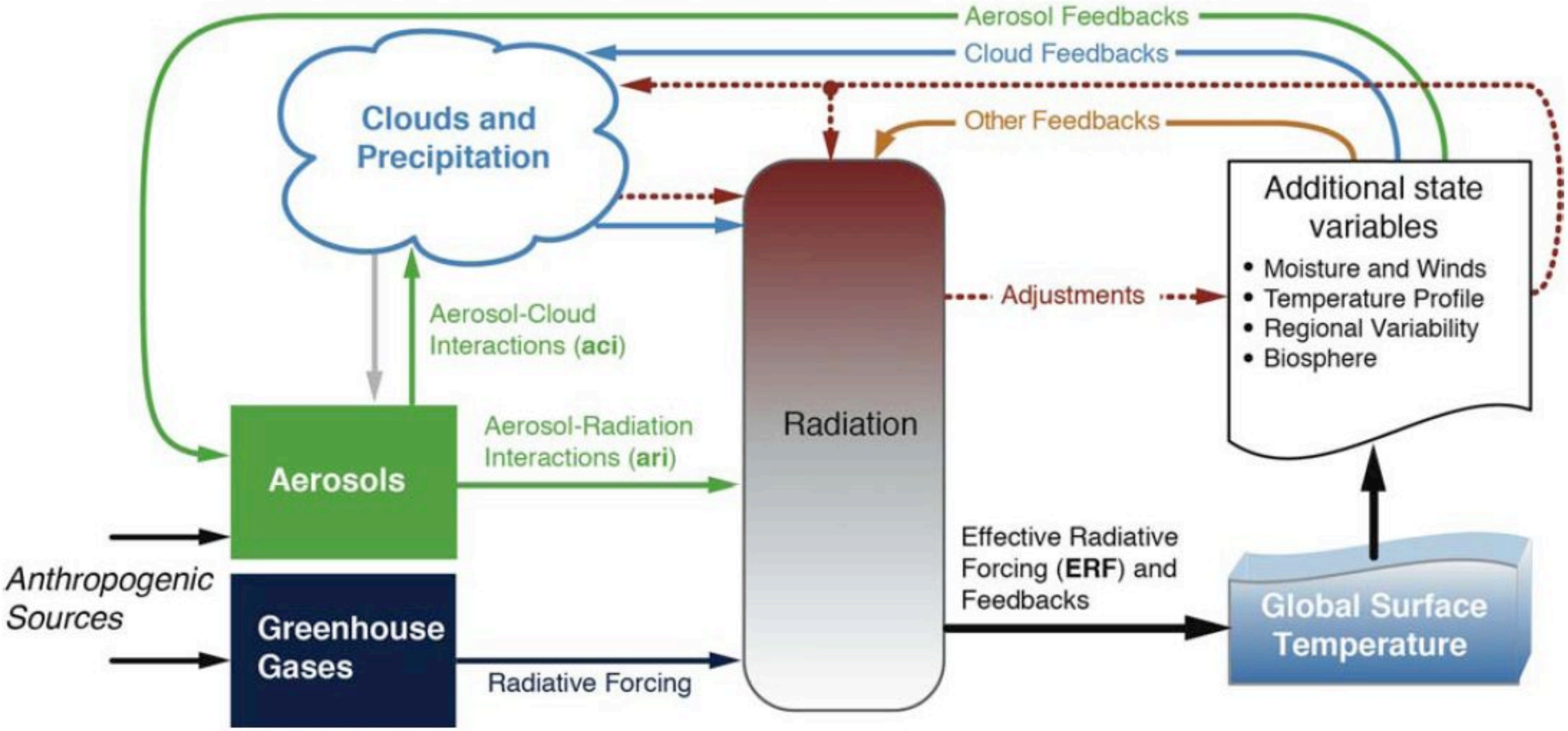


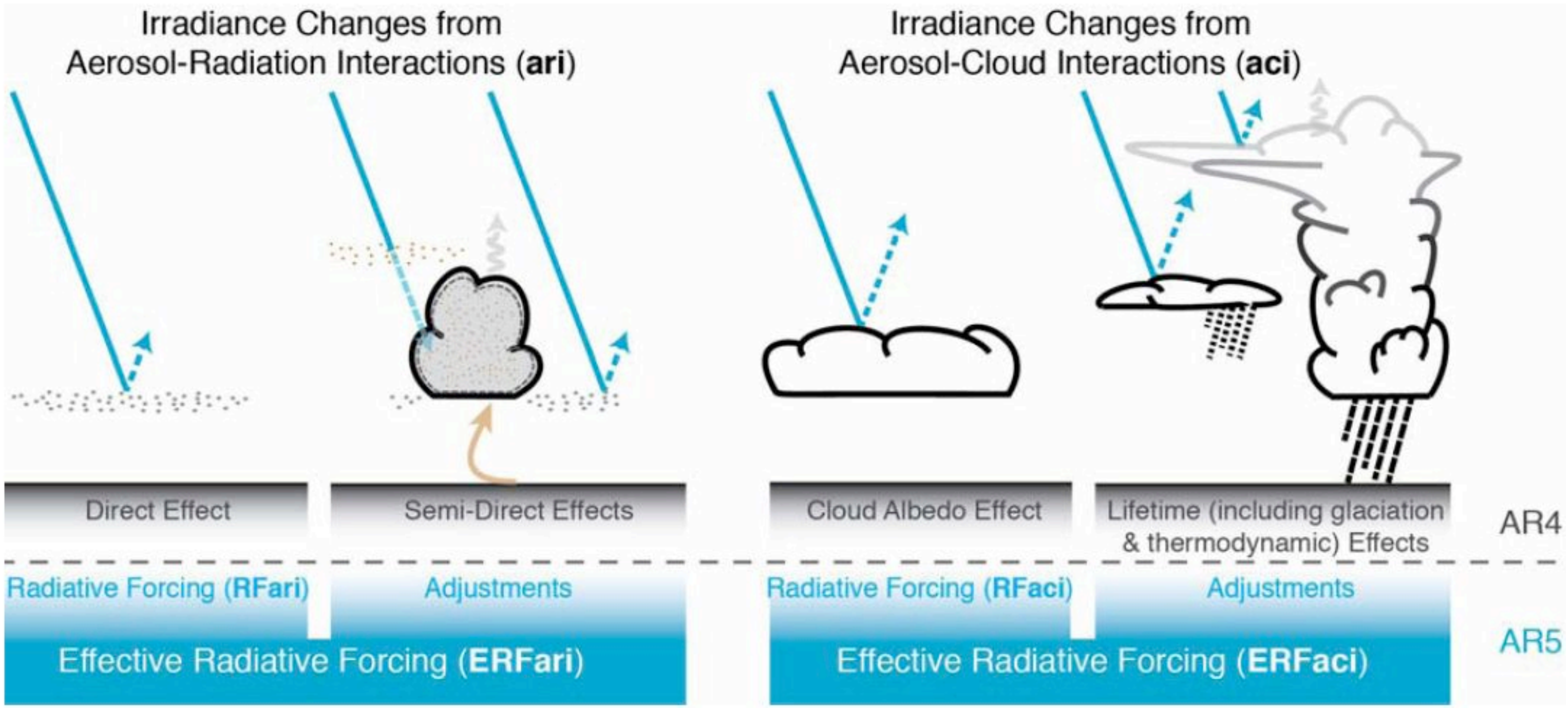
Figure 5 - Sources of atmospheric aerosol [*http://www.ems.psu.edu/~lno/Meteo437/Figures437.html*]

Why DACCIWA? Aerosols, clouds & radiation



IPCC draft, 2013

Why DACCIWA? Aerosols, clouds & radiation



Solar radiation

Terrestial radiation

Surface-cloud couplings important for rapid-adjustments

IPCC draft, 2013

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How well do we monitor this?

How well can we model this?

How well do we understand the mechanisms?

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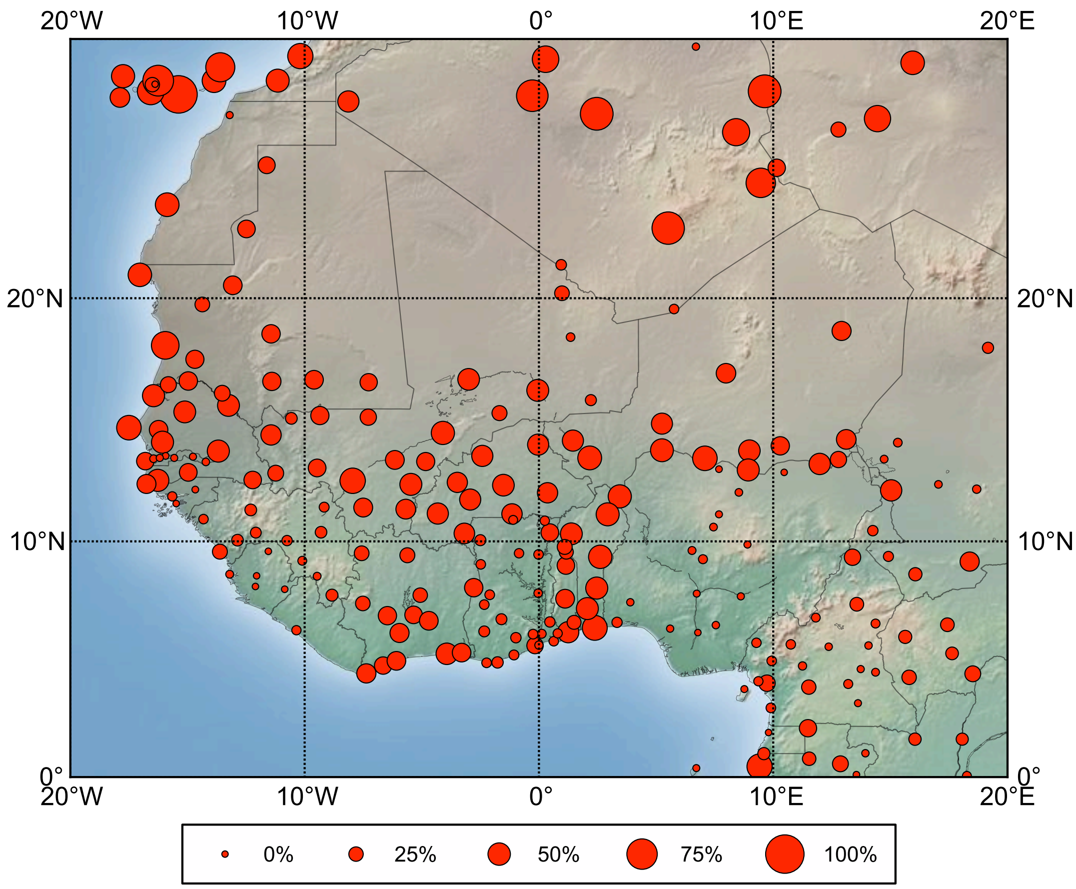
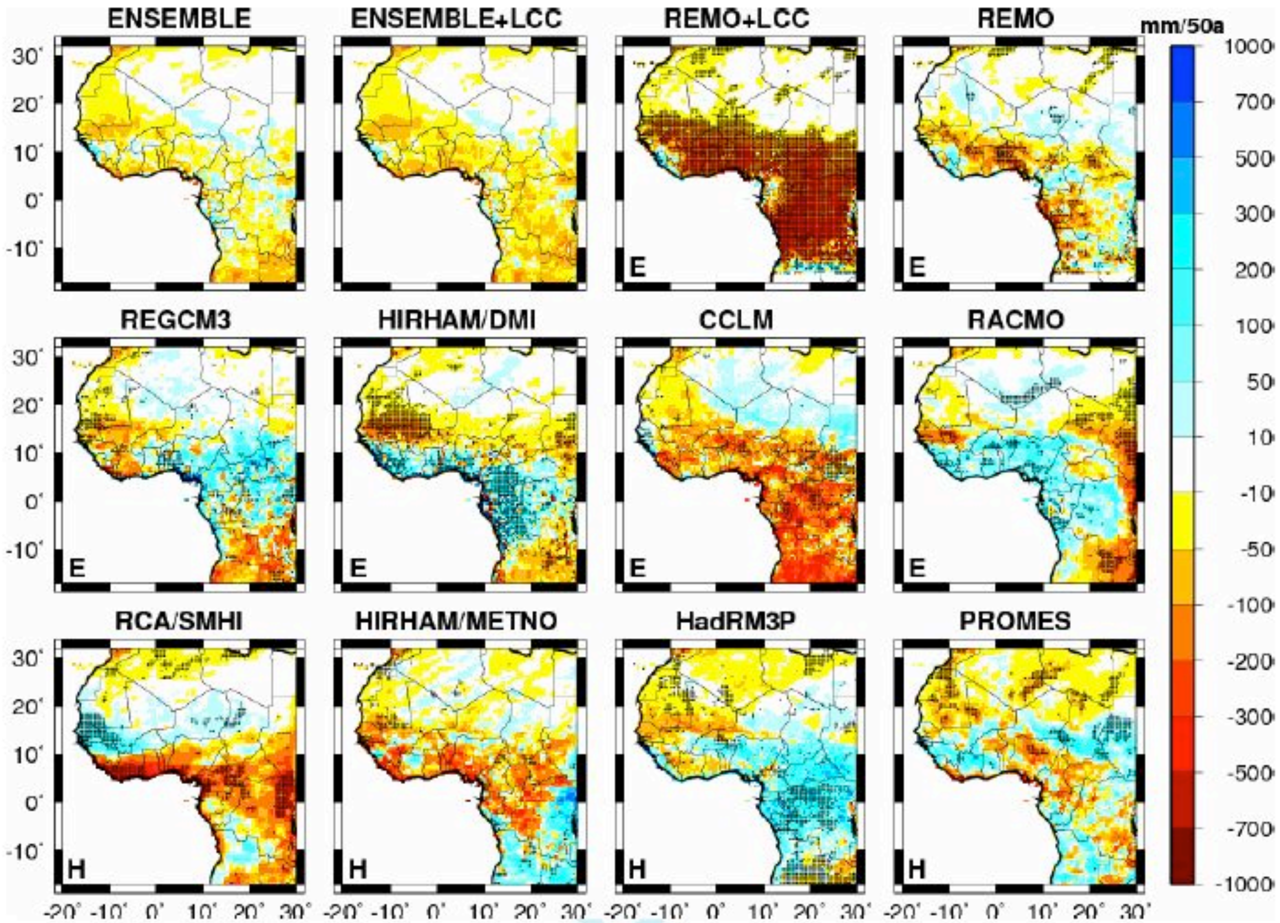
Why DACCIWA? Observational network



Networks that go beyond standard meteorological parameters are very sparse!

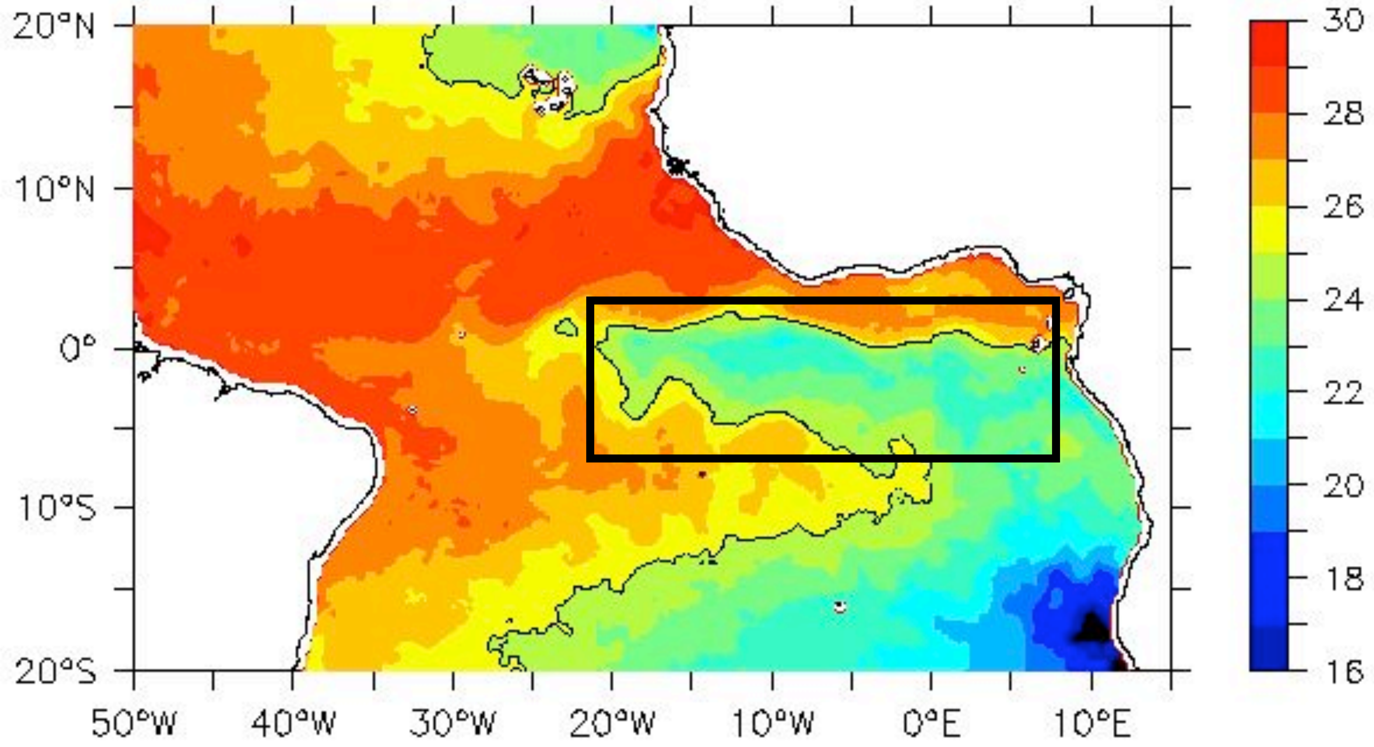
Why DACCIWA? Predicting the WAM

Precipitation trends from 2000 to 2050



Source: Paeth et al. 2011

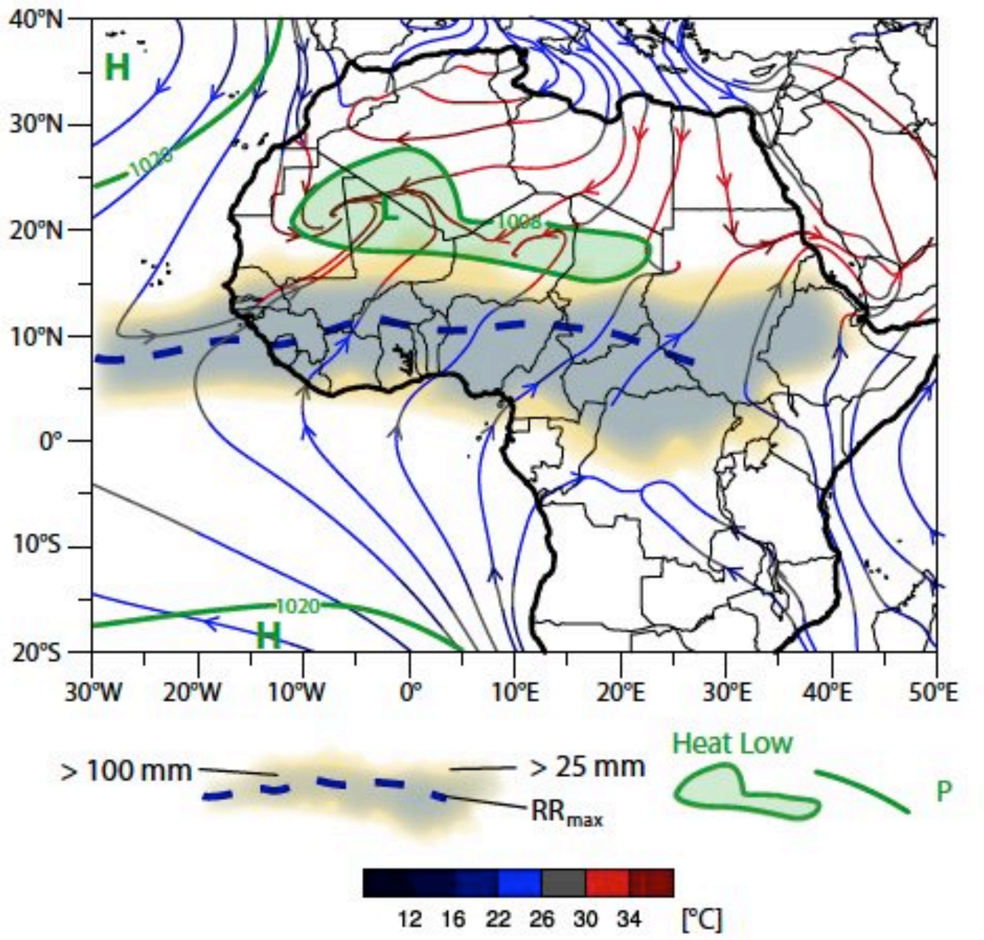
Main players of the WAM: the equatorial cold tongue



from AMMA press material

New FP7 consortium PREFACE!

Main players of the WAM: the Saharan heat low



Focus of recent project FENNEC

Source: Fink et al., 2014, adapted

Main players of the WAM: Sahelian convection

Focus of AMMA programme

from Guichard/ Kergoat (AMMA)

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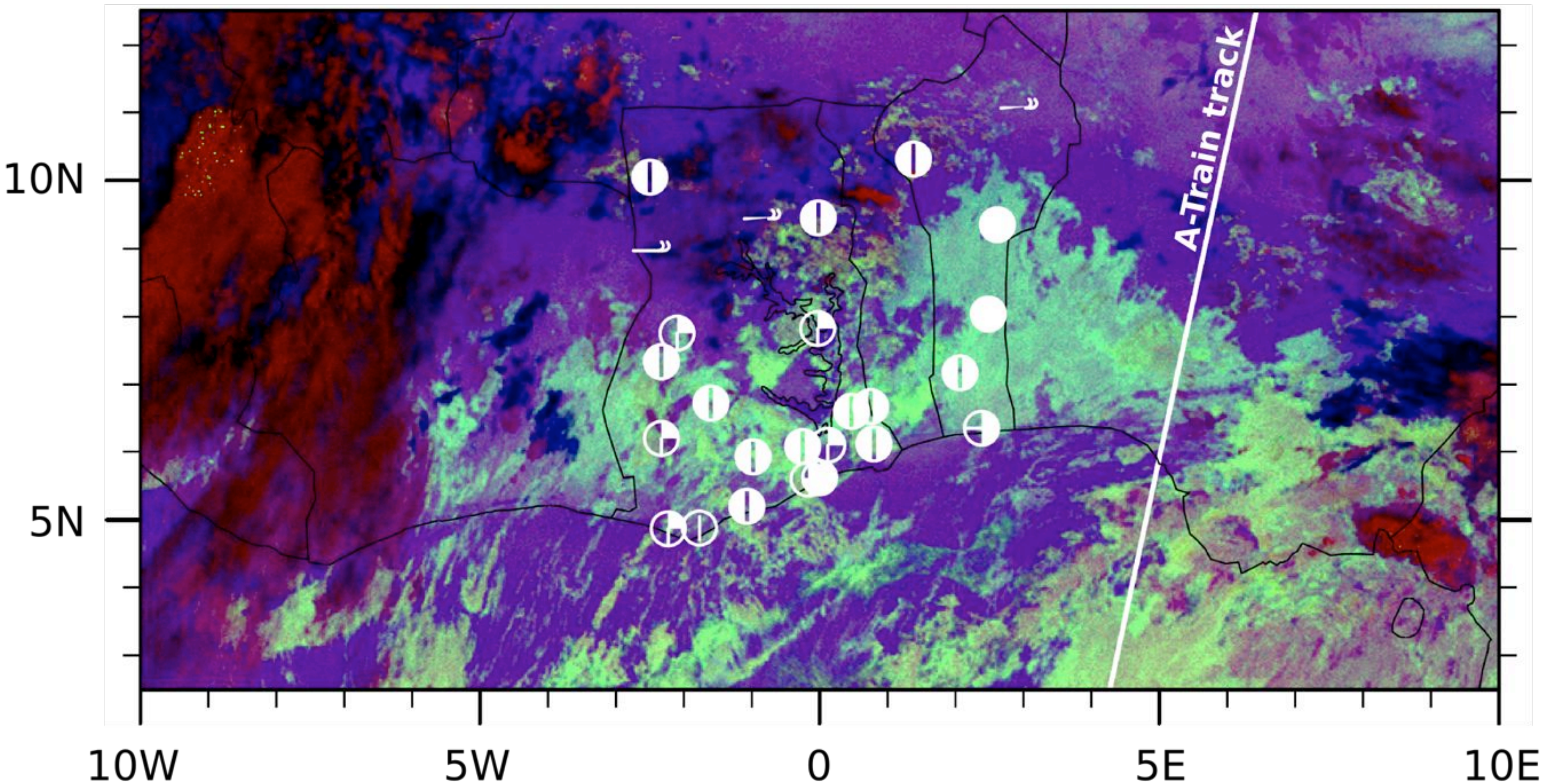
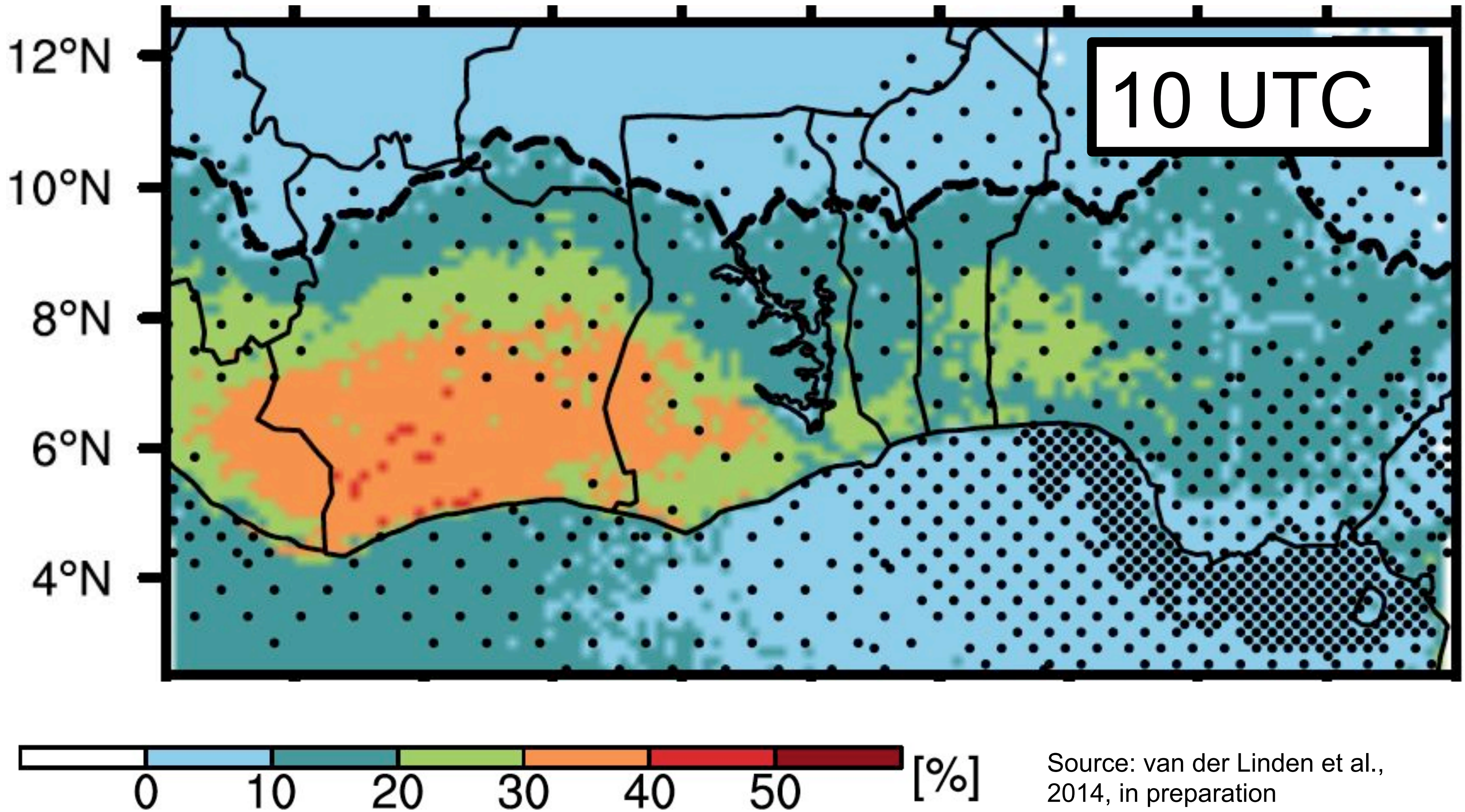
A new player? Monsoonal stratus

Meteosat RGB composite & SYNOP low-cloud cover 20 Aug. 2006



Knippertz et al. 2011

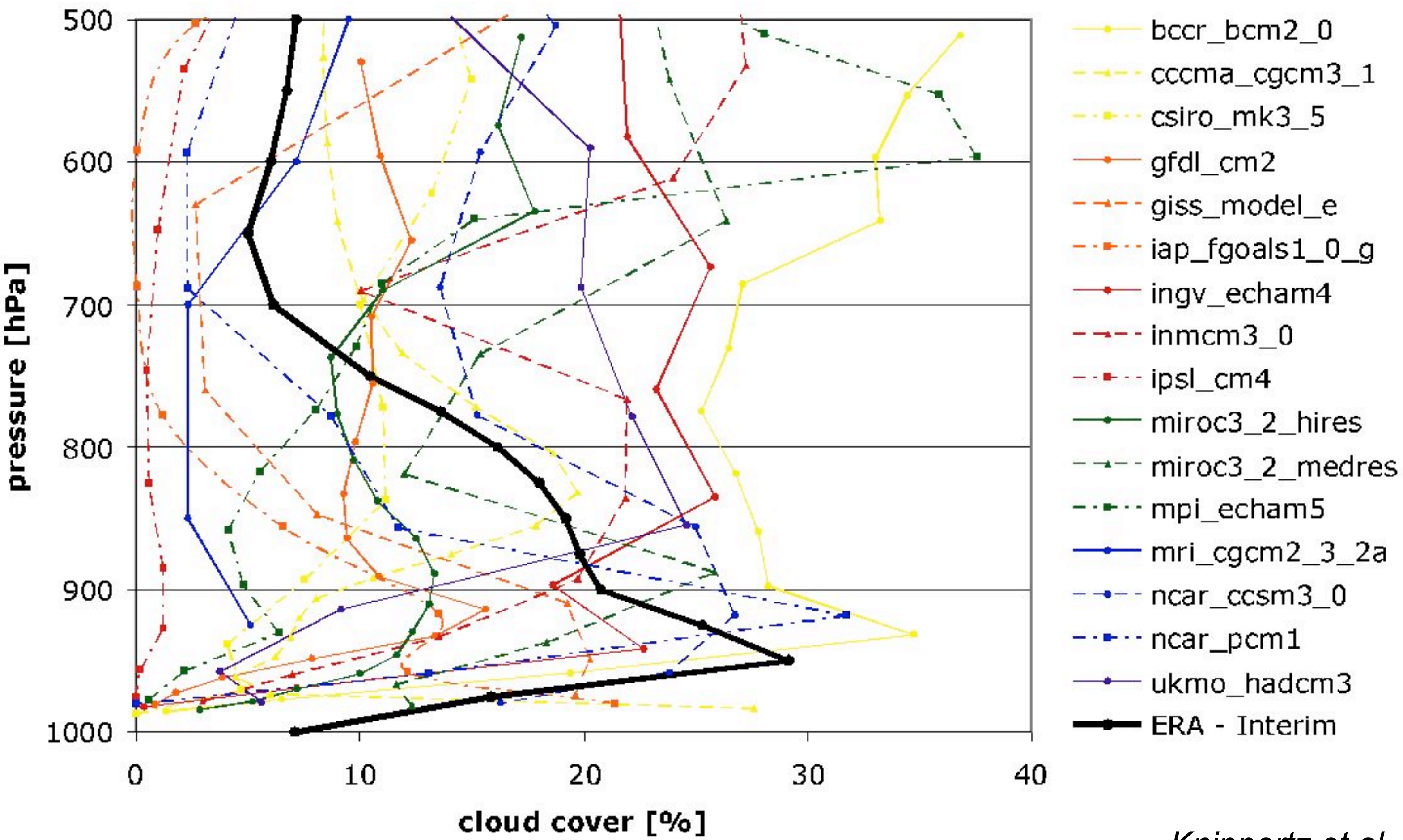
Stratus Occurrence Frequency



Source: van der Linden et al., 2014, in preparation

Difficulties to simulate low-level clouds in WAM

Mean summer (JAS) vertical profile of cloud cover IPCC models



Knippertz et al. 2011

What is DACCIWA going to do?

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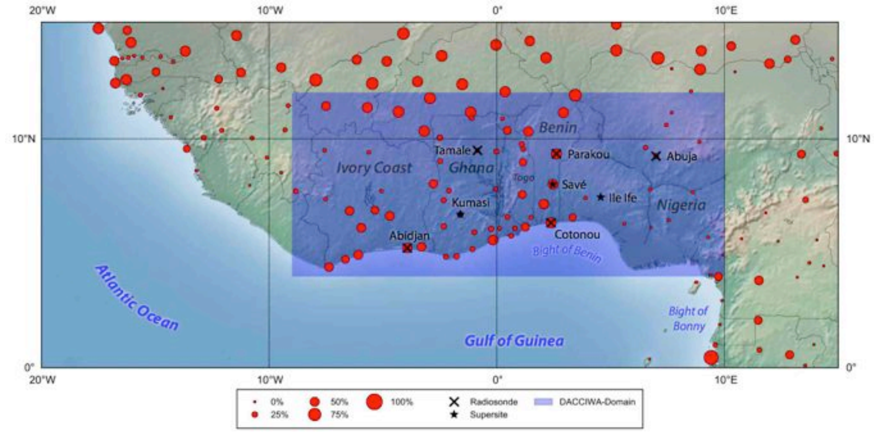
DACCIWA Focal Points

Concentrate on:

- **southern West Africa** (SWA; large increase in population and emissions)
- **summertime** (monsoon season, stratus and warm-rain showers)

➔ ideal natural laboratory



- impacts on **human health in cities** directly affected by pollution increase
- impacts on **ozone concentrations downwind**, which affect health of rural population, agricultural productivity and ecosystem health
- impacts on aerosol generation and associated **modification of regional weather and climate** (clouds, precipitation, radiation, monsoon circulation)

DACCIWA Objectives in brief

1) Quantify atmospheric composition
2) Assess impact on human and ecosystem health and agricultural productivity
3) Quantify coupling between aerosols and cloud and raindrops
4) Identify controls on low-level stratiform clouds
5) Identify controls on precipitation
6) Quantify impacts on radiation and energy budgets
7) Evaluate and improve models and satellite retrievals
8) Analyse effect on West African monsoon circulation and water budget
9) Assess socio-economic implications of future changes
10) Effectively disseminate research findings and data

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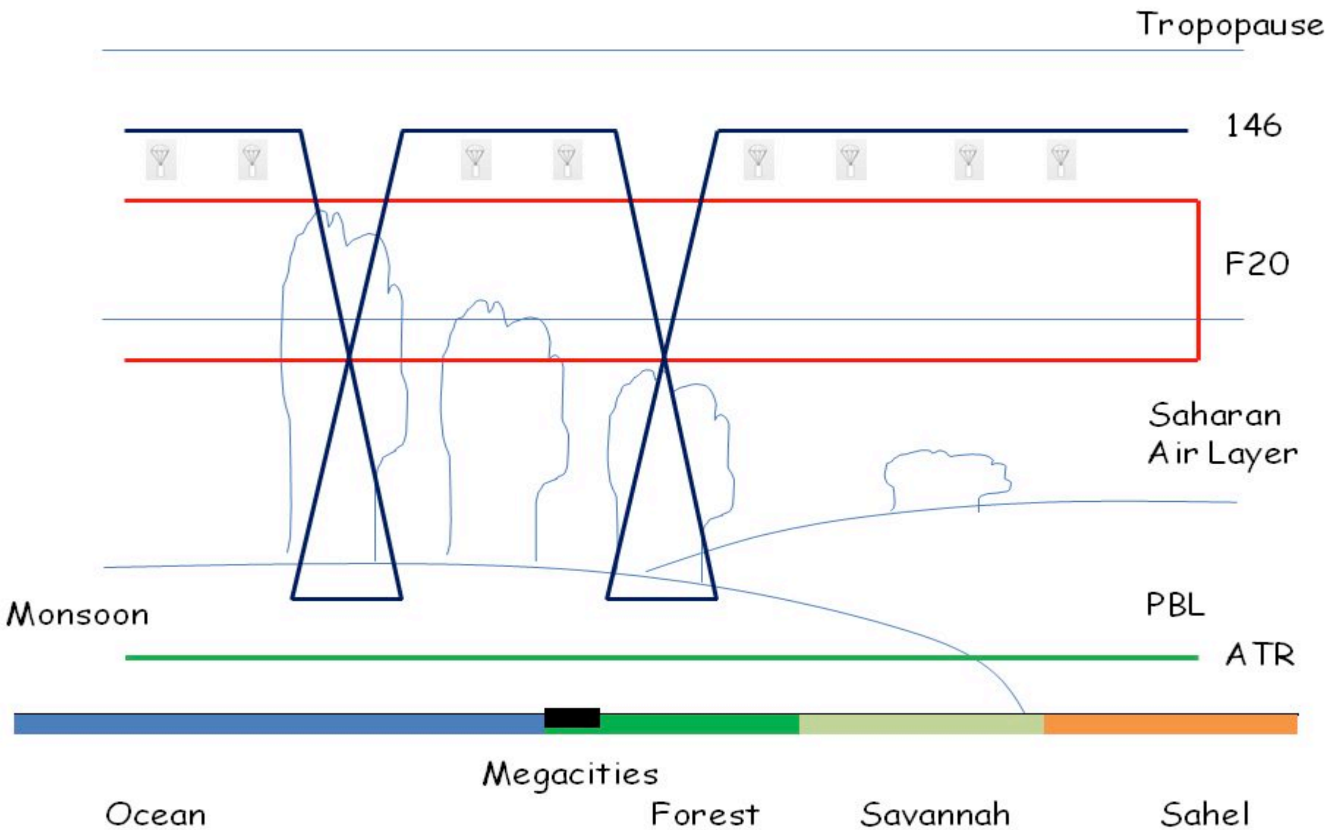
The DACCIWA field campaign (June–July 2015)

Base: Cotonou, Benin

The DACCIWA field campaign (June–July 2015)



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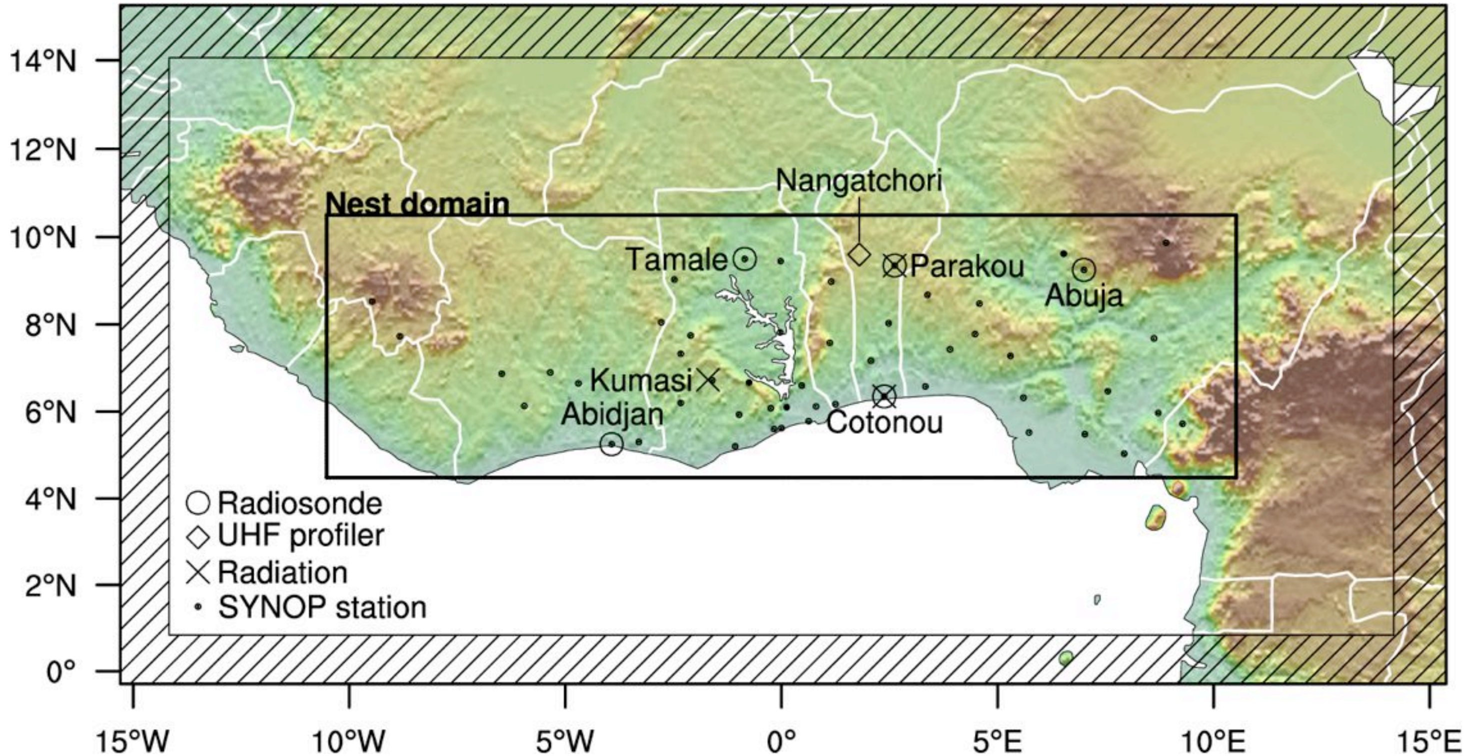
The DACCIWA field campaign (June–July 2015)

Supersite Kumasi (Ghana)

Supersite Savé (Benin)

Obafemi Awolowo University

The DACCIWA field campaign (June–July 2015)



after Schuster et al. 2013

Re-activation of AMMA radiosonde stations at the Guinea Coast

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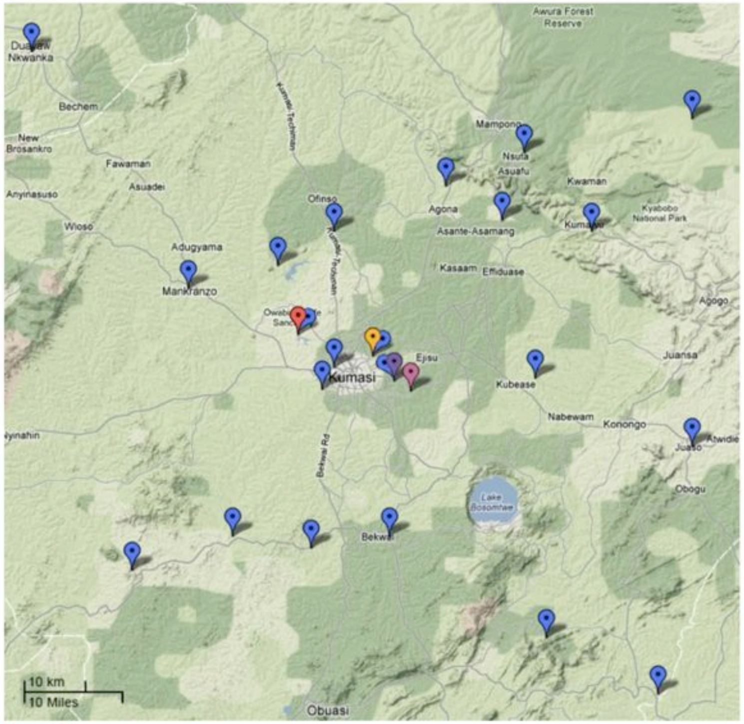
Long-term monitoring: air pollution and health data

Cotonou (Dantokpa)

Abidjan (Côte d’Ivoire) with local partners

Cotonou (Benin) with local partners

Long-term monitoring of precipitation around Kumasi



(red)	Owabi	- AWS and rain gauge from KNUST - rain gauge form GMET
(orange)	Airport Kumasi	- AWS from GMET - manned SYNOP station, - high-precession rain gauge from KNUST
(purple)	Agromet	- AWS and high-precession rain gauge from KNUST - rain gauge from GMET
(pink)	Emena-Hospital	- high-precession rain gauge from KNUST
(blue)	various	- rain gauges from GMET

Agromet (KNUST Campus)

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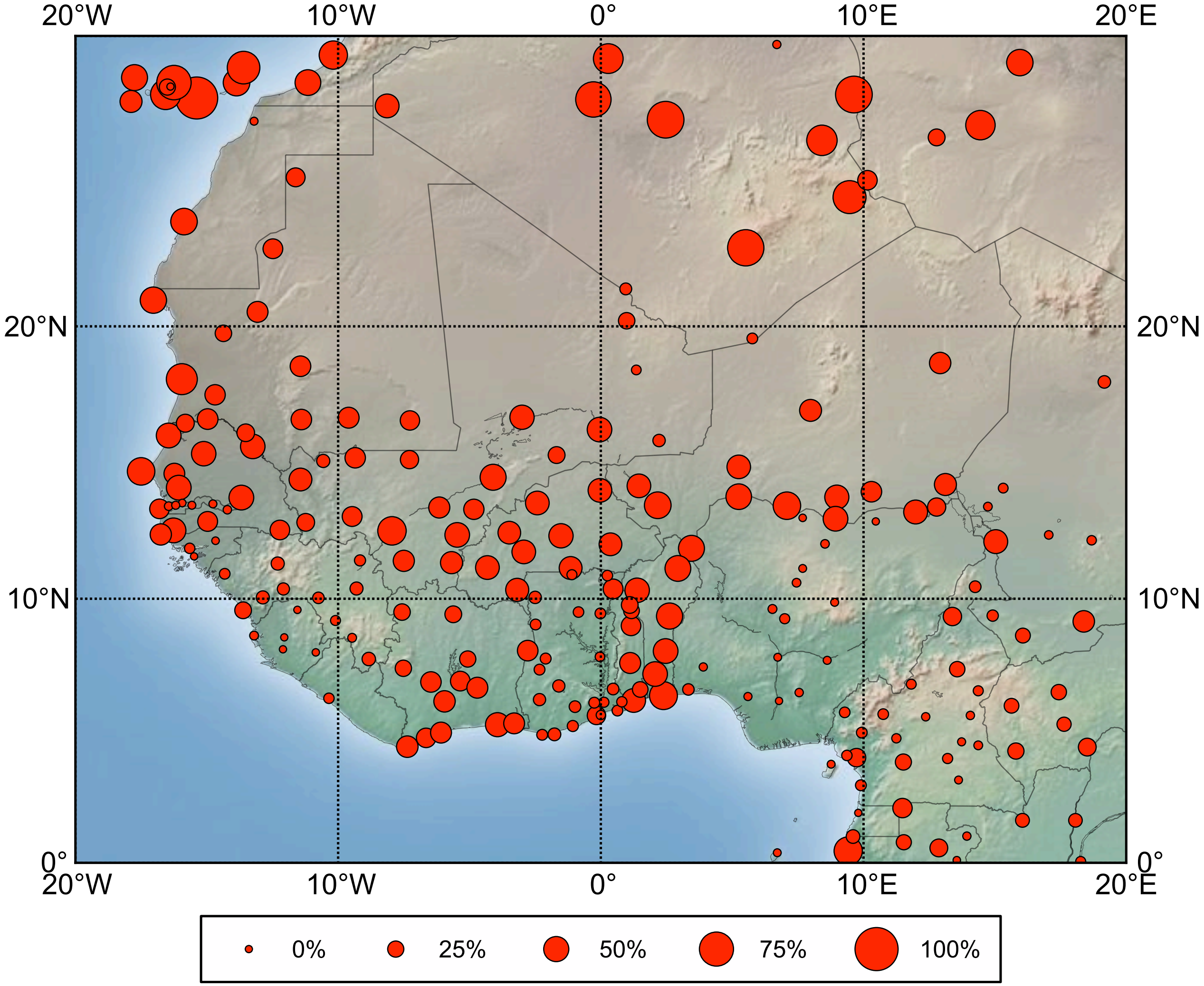
Long-term monitoring: data digitisation



Collaboration with West African weather services:

- Nigeria
- Benin
- Ghana
- Côte d'Ivoire

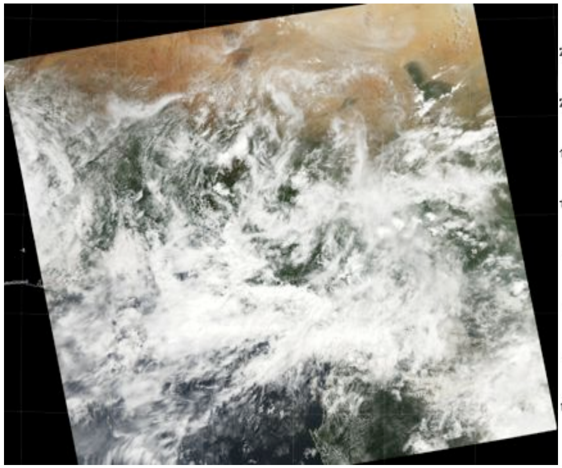
Long-term monitoring: satellite data

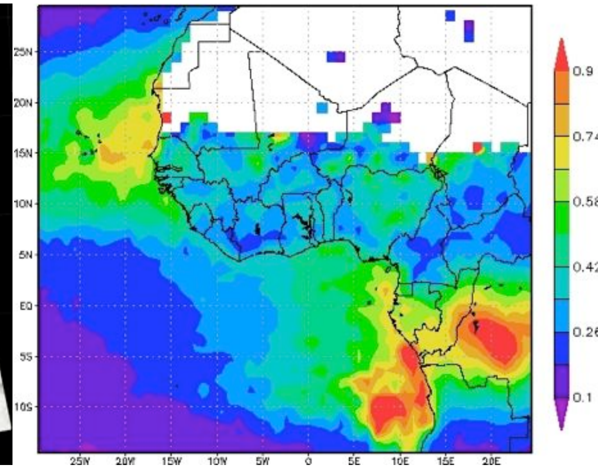
Cloud

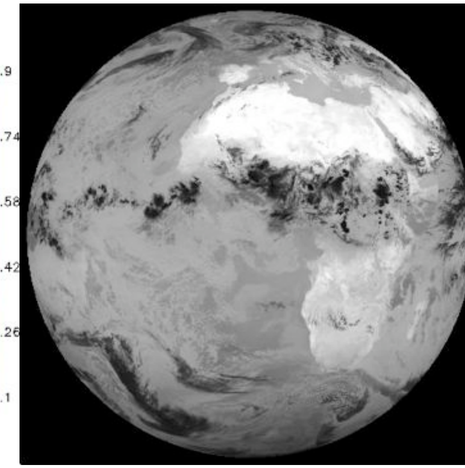
Aerosol

Radiation

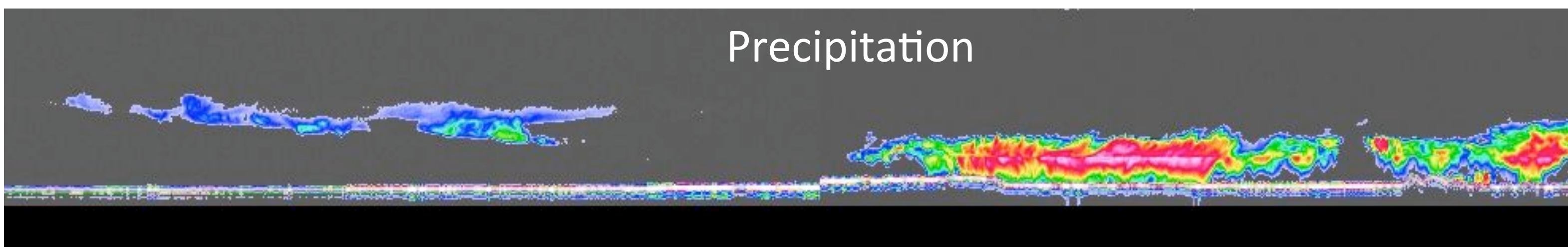
Passive sensors







Active sensors



courtesy of NASA

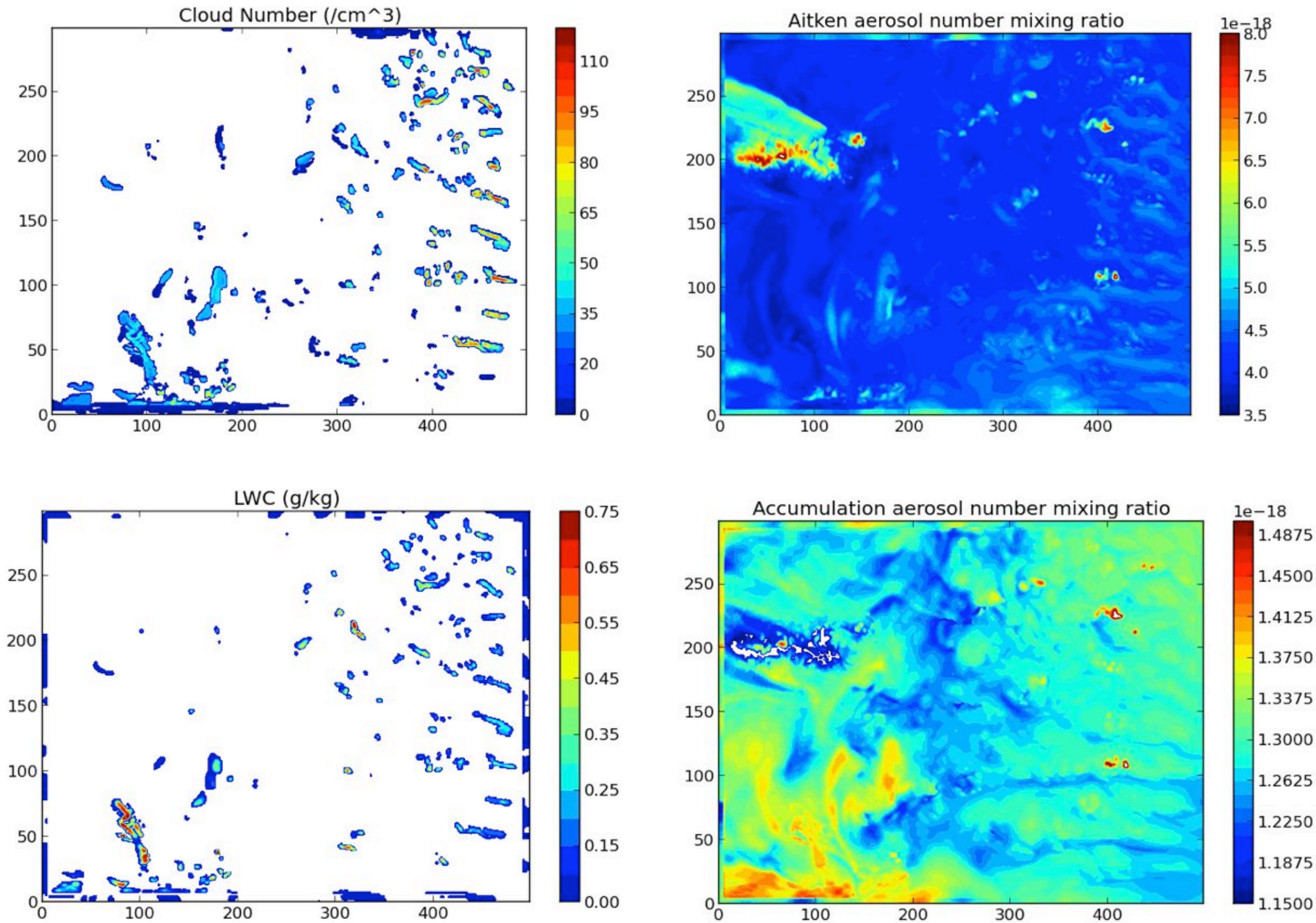
➔ Data from various sources will be combined to DACCIWA climatology!

➔ DACCIWA field campaign data will be used to evaluate recently launched and future satellite retrievals (e.g., NPP, Megha-Tropiques, GPM)

DACCIWA Modelling – Overview

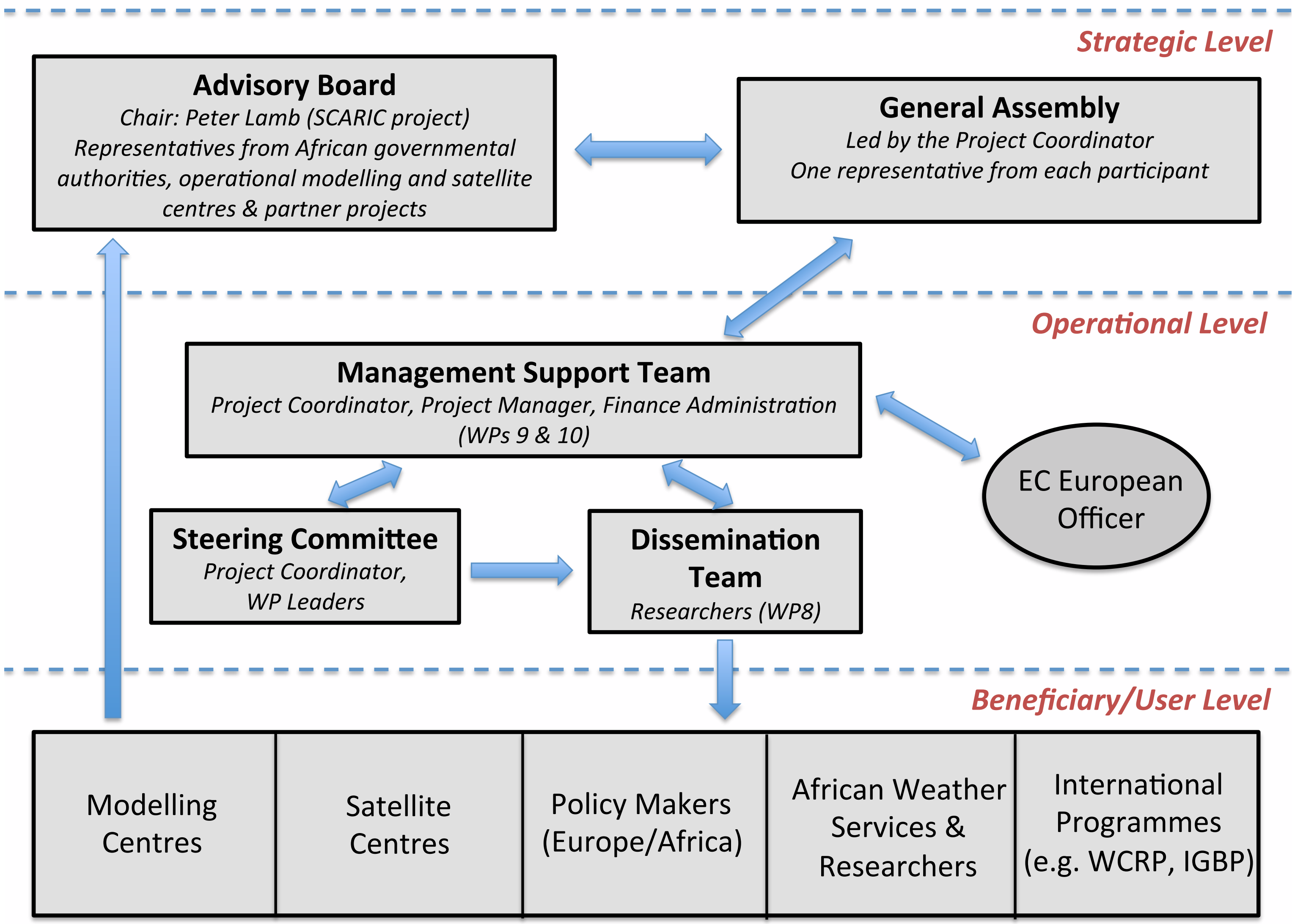
Model	Run by	Run in	Period	Grid-spacing	Meteorology	Chemistry+aerosol species
RESEARCH MODELS						
NCAR LES	UPS	WP1	IOP	10 m to 100m	Idealised	Just meteorology (may be possible to add chemistry)
UKMO LES	UNIVLEEDS	WP1	IOP	10m to 500m	Idealised	Just meteorology + idealised tracers
RegCM4	UPS	WP2	Extended	1-50km	Regional	aerosol and gas-phase chemistry/exposure/doses/imapcts
UM-UKCA	UNIVLEEDS	WP4	IOP	100m to 40km	Online, nested	UKCA chemistry + multi-moment bulk aerosol , many runs may be online aerosol with offline chemistry
COSMO-ART/M7	KIT, ETHZ	WP4 & 3	IOP		Online,nested	Chemistry+aerosol, gases and aerosols fully interactive with radiationa nd cloud pshyics
Chimere	UPMC	WP3+4	Extended	regional (10-50km)	Regional with WRF	Gas-phase and aerosols (bins resolved, anthro., bio, dust, fires)
Bin-LES	UNIVLEEDS	WP4	IOP cases	10 m to 500m	Idealised	Bin resolved aerosol + clouds
Radiative transfer model	UREAD	WP5	IOP cases and Extended	200 m to 40 km	1D and 3D	meteorology +aerosol + cloud
Meso-NH	UPS	WP3 + 6	IOP cases	100 m to 1km	Online, nested	Chemistry + idealised tracers
WRF	KIT	WP6	IOP cases + summer 2015	3 km	regional, self-nested, forced with ECMWF analysis	N/A
UM	UNIVLEEDS	WP7	Extended	regional+global	Global+nested	UKCA or none
ECMWF - MACC	ECMWF	WP7	Extended	global	global	Aerosol and recative gases
ECHAM	ETHZ	WP7	Extended	global	global	
Geos-Chem	UoY	WP3	IOP+extended		Global+regional	Offline, nested chem+Aerosol
FORECAST MODELS						
UM	MO				Global + nested?	Dust
ECMWF-MACC	ECMWF				Global	Aerosol and reactive gases

DACCIWA Modelling – High-resolution on large domains

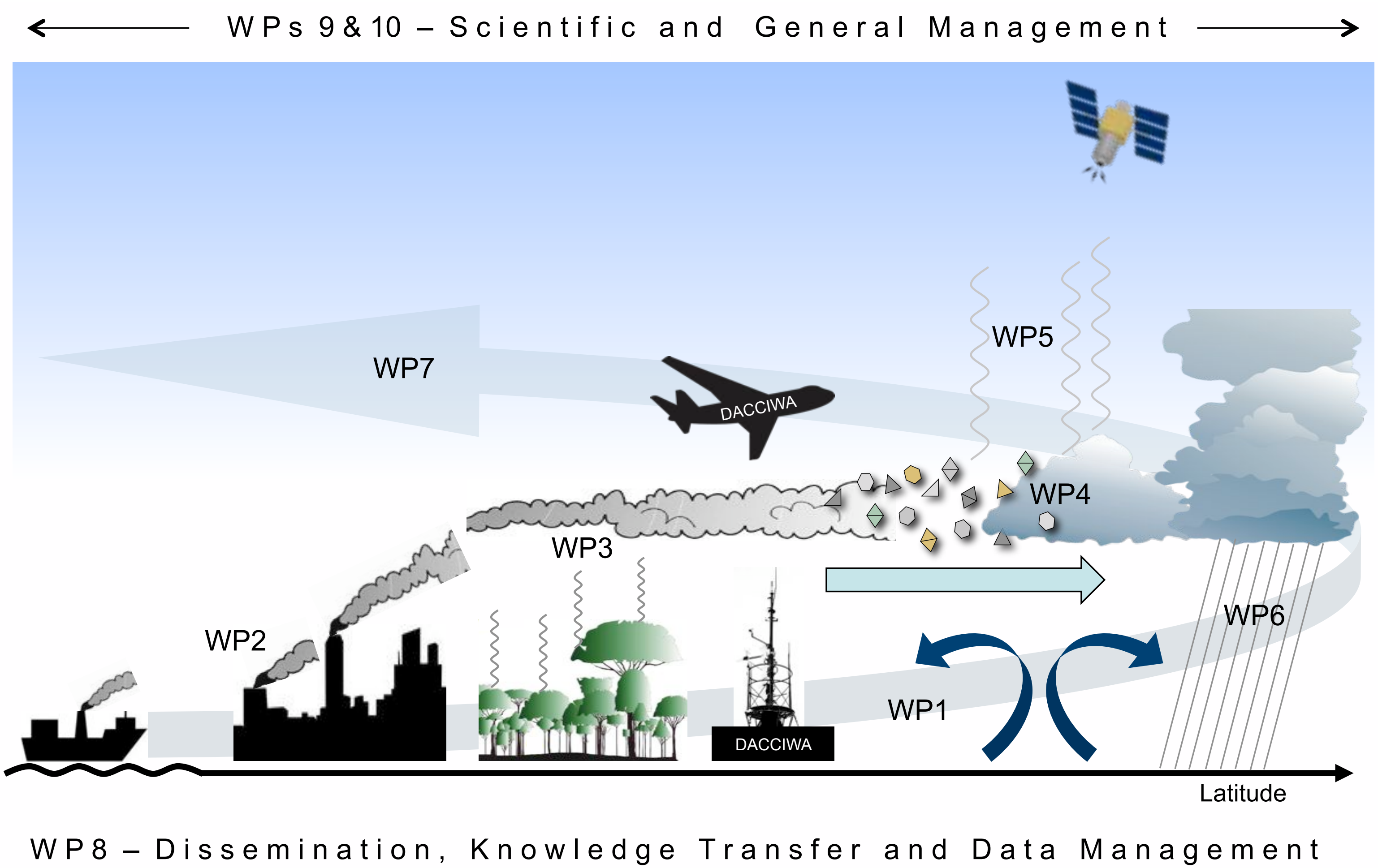


Courtesy of Paul Field, MO

How is DACCIWA organised?


Strategic Level
Advisory Board
Chair: Peter Lamb (SCARIC project)
Representatives from African governmental authorities, operational modelling and satellite centres & partner projects
General Assembly
Led by the Project Coordinator
One representative from each participant
Operational Level
Management Support Team
Project Coordinator, Project Manager, Finance Administration (WPs 9 & 10)
EC European Officer
Steering Committee
Project Coordinator, WP Leaders
Dissemination Team
Researchers (WP8)
Beneficiary/User Level
Modelling Centres
Satellite Centres
Policy Makers (Europe/Africa)
African Weather Services & Researchers
International Programmes (e.g. WCRP, IGBP)

The DACCIWA Workpackages

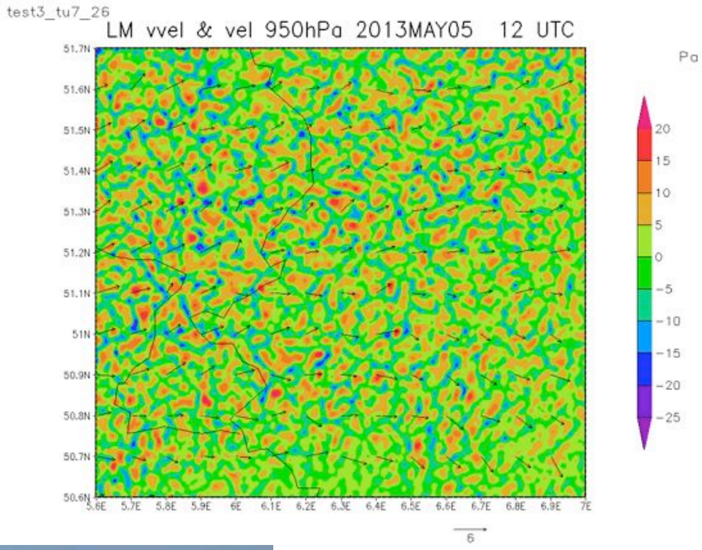


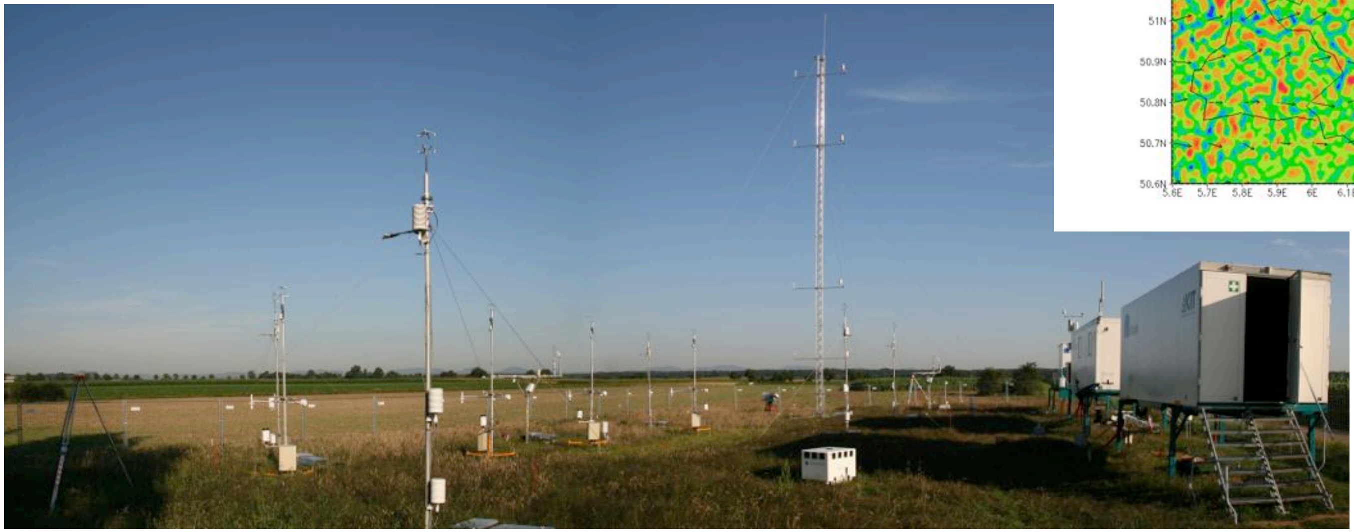
WP1: Boundary Layer Dynamics

Leader: Norbert Kalthoff (KIT)
Participants: KIT, UNIVLEEDS, UPS, OAU, KNUST

Main Tasks and Deliverables

- Plan, install and operate ground sites
- Postprocess data
- Large-Eddy simulations
- Model evaluation
- Conceptual model development





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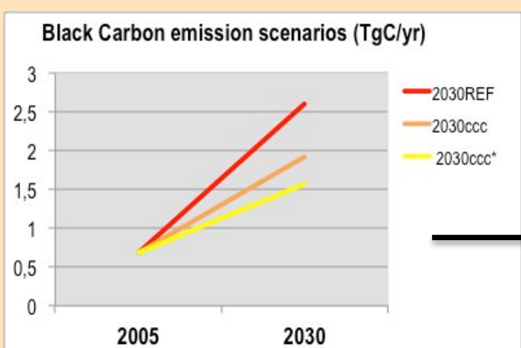
WP2: Air Pollution and Health

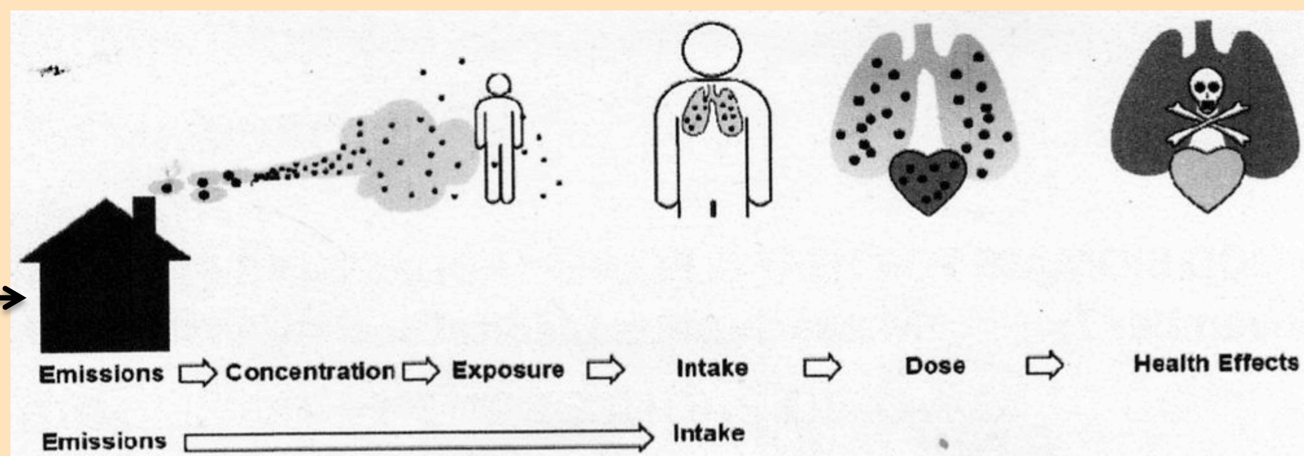
Leader: Cathy Liousse (UPS)
Participants: UPS, UoY, UPMC, UPD
+ University Houphouët Boigny, Abidjan, University of Cotonou

Main Tasks and Deliverables

- Emission inventories and scenarios (traffic, domestic …)
- Air pollution and health modelling
- Long-term measurements
- Census of respiratory diseases (epidemiology)
- Toxicological effect of combustion aerosol
- Inflammation risk maps



Liousse et al., 2013



WP3: Atmospheric Chemistry

Leader: Celine Mari (UPS)
Participants: UPS, UoY, ECMWF, KIT, ETHZ, UPMC, UNIVMAN

Main Tasks and Deliverables

- Plan, install and operate field campaign
- Multi-scale modelling (LES-global)
- Modell assessment and validation
- Synthesis of field measurements
- Impacts on radiation
- Impacts on public health and ecosystems
- Future scenarios

Focus on short-lived pollutants:
ozone and aerosols
Contrast emissions (anthropogenic,
biogenic, biomass burning, ship plume, ...)

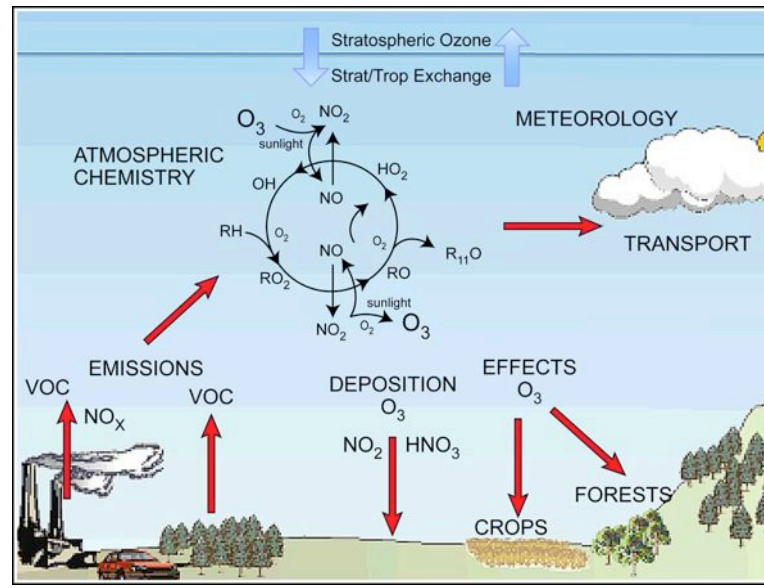


Figure 4 - Physical and chemical processes affecting tropospheric ozone
[http://www.globalchange.umich.edu/gctext/Inquiries/Inquiries_by_Unit/Unit_9.htm]

WP4: Cloud-Aerosol Interactions

Leader: Hugh Coe (UNIVMAN)
Participants: UNIVMAN, UNIVLEEDS, KIT, DLR, UPMC, UBP, MO, ECMWF, ETHZ, CNRS

Main Tasks and Deliverables

- Plan, install and operate field campaign
- Evaluate existing models
- Synthesis of field measurements
- Process model studies
- Regional modelling

ACPIM (Aerosol-Cloud-Precipitation Interactions Model) Manchester:

Process driven studies: ACPIM trajectory model

ADDEM: detailed aerosol thermodynamics

Coupled gas phase-aerosol scheme, considering activation.

Growth of precipitation mass-bins using moving centre grid

Growth of variable habit ice mass-bins using moving centre grid

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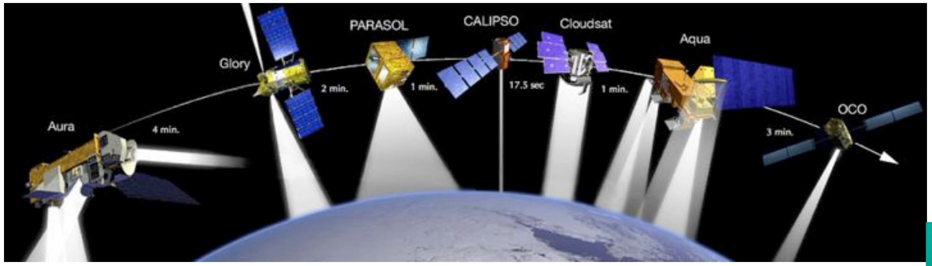
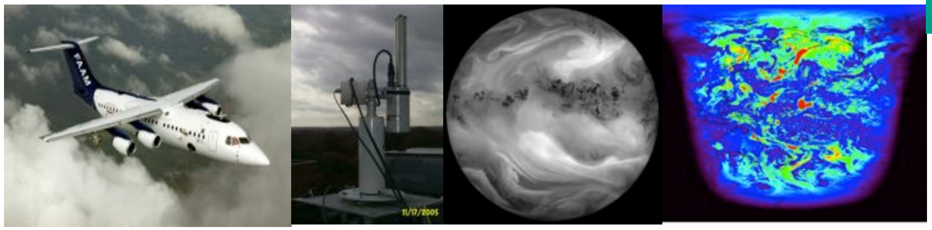
WP5: Radiative Processes

Leader: Christine Chiu (UREAD)
Participants: UREAD, ECMWF, MO

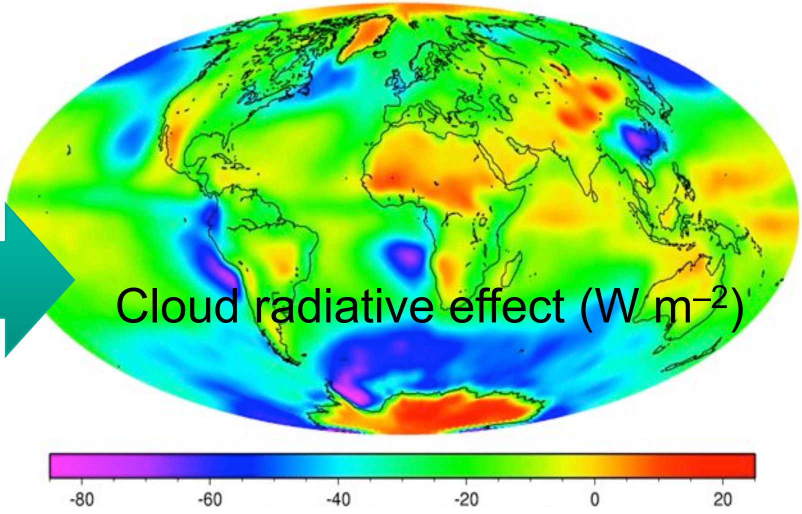
Main Tasks and Deliverables

- Multi-satellite climatology
- Retrievals from field campaign data
- Evaluate current and future satellite products
- Aerosol and cloud radiative effects
- Model evaluation





courtesy of NASA



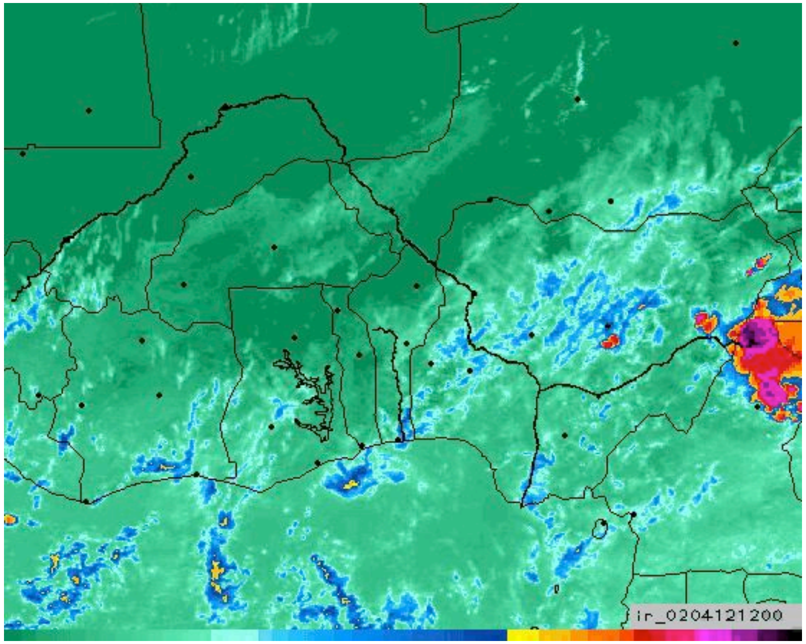
Better estimates of aerosol and cloud radiative effects from combined DACCIWA and satellite obs.

WP6: Precipitation Processes

Leader: Andreas Fink (KIT)
Participants: KIT, UNIVLEEDS, UPS, KNUST, OAU, UNIVMAN

Main Tasks and Deliverables

- Radiosonde campaign
- Rainfall types
- Role of land-sea breeze
- Monsoon-season climatology
- Case studies
- Model assessment of warm rain
- Evaluation of satellite rainfall products



Source: SAFNWC/van der Linden/Fink

Interaction between westward propagating Mesoscale Convective Systems (MCS), land-sea breeze and polluted coastal air not well understood

SEVENTH FRAMEWORK PROGRAMME

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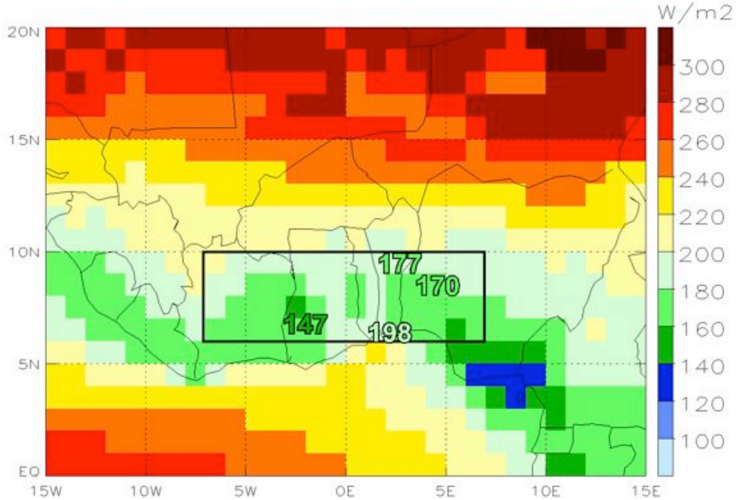
WP7: Monsoon Processes

Leader: Peter Knippertz (KIT)
Participants: KIT, ECMWF, ETHZ,
KNUST, OAU, MO

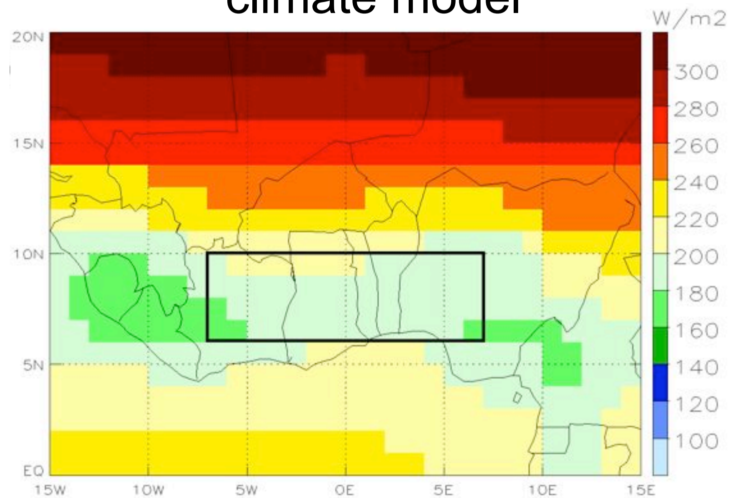
Main Tasks and Deliverables

- Digitisation of station data
- Forecasts for field campaign
- Forecast evaluation
- Model evaluation
- Sensitivity experiments
- Scenario simluations

satellite



climate model



Mean summer (JJA) solar irradiance from satellite and ground stations (top) and CMIP3 models (bottom)
(from Knippertz et al. 2011)

WP8: Dissemination, Knowledge Transfer & Data Management

Leader: Mat Evans (UoY)
Participants: UoY, KIT & all others

Main Tasks and Deliverables

- Website, newsletter, content
- Media communication, press releases
- Overview article
- Special sessions
- Special issue
- Stakeholder database
- Policy briefs
- Workshops
- Education
- Technical reports

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2. Dezember 2013, 21:37 Uhr

dpa

Forschungsprojekt zu Klimaprozessen in Westafrika

Abgase von veralteten Autos in den Millionenstädten Lagos oder Abidjan verändern das Klima in Westafrika - mit möglichen Folgen auch für unser Wetter.

Twittern 0 | Empfehlen 0 | Teilen | g+1 0 | Versenden | 0 Bewertungen

Karlsruhe - Abgase von veralteten Autos in den Millionenstädten Lagos oder Abidjan verändern das Klima in Westafrika - mit möglichen Folgen auch für unser Wetter.

Wie solche von Menschen verursachten Emissionen mit natürlichen Prozessen zusammenwirken und die Wolkenbildung beeinflussen, will ein EU-Forschungsprojekt herausfinden. Dafür wurden jetzt 8,75 Millionen Euro bewilligt, wie das Karlsruher Institut für Technologie (KIT) mitteilte.

"Wir haben nun das Geld, wir fangen jetzt an zu forschen und hoffen, dass wir den Menschen in Westafrika in naher Zukunft relevante Forschungsergebnisse geben können", sagte der Klimaforscher Peter Knippertz. Im Blickpunkt der Forscher stehen Aerosole, also ein Gemisch von Gasen und festen oder flüssigen Schwebeteilchen. Diese beeinflussen die Wolkenbildung. "Wir vermuten, dass sich eine verstärkte Wolkenbildung auf das gesamte Monsunsystem auswirkt", erklärte Knippertz. "Diese Zusammenhänge sind für Westafrika bisher kaum erforscht."

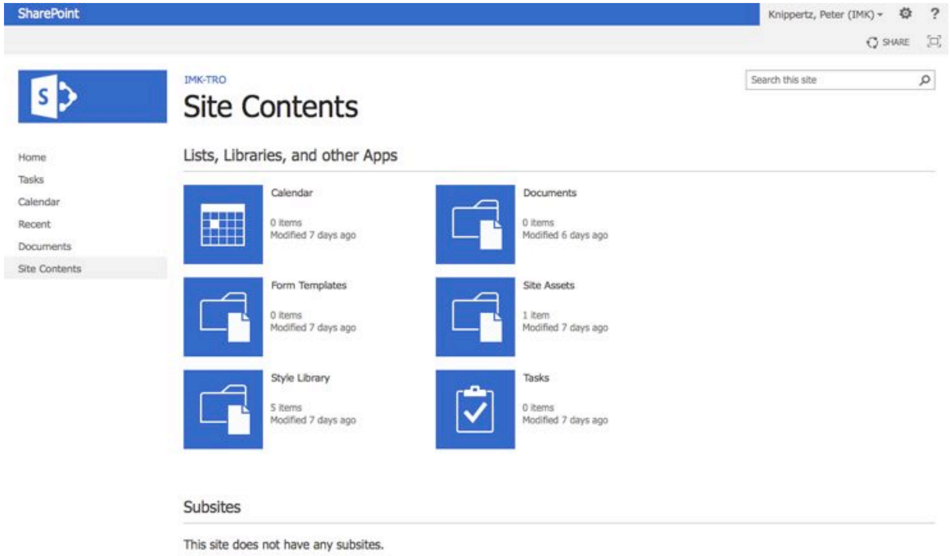
WP9: Scientific Management
WP10: General Management

Leader: Peter Knippertz (KIT)
Project Manager: Roswitha Marioth (KIT)

Main Tasks and Deliverables

- Activity management
- Exchange with scientific partners
- Meeting organisation

- Internal communication (Share point)
- Financial management
- Legal management
- Reporting
- Gender equality



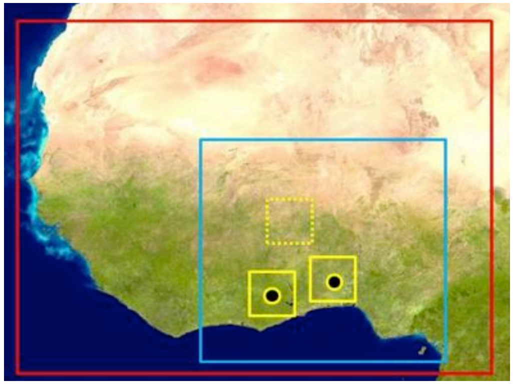
DACCIWA Technical Coordinators

Purpose

- Facilitate the flow of information and interactions between WPs
- Coordinate logistical, technical and data-management requirements

Areas

- Supersite Ghana: *Barbara Brooks (UNIVLEEDS)*
- Supersite Benin: *Fabienne Lohou (UPS)*
- Aircraft campaign: *Cyrille Flamant (UPMC)*
- Satellite data: *Richard Alllan (UREAD)*
- Modelling: *John Marsham (UNIVLEEDS)*



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DACCIWA Advisory Board

Related international programs

- *Peter Lamb* (designated chair) – Sahel Cloud-Aerosol-Radiation Interaction Campaign (SCARIC)
- *Serge Janicot* – African Monsoon Multiscale Analysis (AMMA)
- *Ulrike Lohmann* (BACCHUS)
- *Markus Rex* (StratoClim)

Policy

- *Georges Kouadio* – Ministry of Environment, Health and Sustainable Development (Ivory Coast)
- TBD

Satellite

- *Christina Hsu* – Suomi-NPP
- *Walt Petersen* – Global Precipitation Measurement (GPM)

Modelling

- *Leo Donner* – Geophysical Fluid Dynamics Laboratory (GFDL)
- *Sarah Jones* – German Weather Service (DWD) (?)

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Other International Collaborators

European collaborators

- West African Science Service Center on Climate Change and Adapted Land Use (WASCAL)
- African Climate Exchange (AfClix)
- Institut de recherche pour le développement (IRD)

African collaborators

- Direction de la Météorologie Nationale (Cote d'Ivoire)
- Ghana Meteorological Agency (Ghana)
- Direction Nationale de la Météorologie (Benin)
- Nigerian Meteorological Agency (Nigeria)
- AMMANET
- Université d'Abomey-Calavi (Benin)
- Pasteur Institute (Ivory Coast)
- Centre Suisse de Recherches Scientifiques en Côte d'Ivoire (CSRS)
- Ministry of Higher Education and Scientific Research (Ivory Coast)

Other International Collaborators

Remote Sensing

- Satellite Application Facility on Climate Monitoring (CM-SAF)
- University of Wisconsin (CloudSat group)
- Baseline Surface Radiation Network (BSRN)
- NASA Langley (CALIPSO group)

Modelling

- National Center for Atmospheric Research (NCAR)
- Pacific Northwest National Laboratory (PNNL)
- NASA Goddard Institute for Space Science (GISS)

THANK YOU!