A 5 year programme on weather, climate and air pollution in West Africa

DACCIWA Newsletter

6thEdition
Autumn 2017

COORDINATOR'S EDITORIAL

Dear Reader,

this newsletter – the sixth of its kind – is part of our effort to communicate our research activities with the scientific community, the general public and policymakers. If you missed previous newsletters, you can find them on our webpage www.dacciwa.eu, together with much more information on the project and the involved partners.

In the last issue we reported about overview papers on the DACCIWA campaign in West Africa in June-July 2016 and the successful postprocessing of the rich dataset we collected during this period. Since then, we have made substantial progress in analysing these measurements in conjunction with modelling experiments and satellite data. Through this we now have a much clearer idea of pollution levels and their sources, we better understand the diurnal cycles of the boundary layer, low clouds and precipitation systems, and we have been able to clarify the impacts of aerosols on the West African meteorology. All these exciting new findings have recently been discussed at our annual science meeting in Karlsruhe.

We are also making preparation for our second DACCIWA-organised session on the atmospheric composition, weather and climate of Sub-Saharan Africa at the General Assembly of the European Geosciences Union in Vienna from 08–13 April 2018. Please consider submitting an abstract (deadline 10 January)!

Thank you for your continued interest in DACCIWA!

Peter Knippertz, project coordinator

TOPICS THIS ISSUE

DACCIWA PROJECT MEETING OCTOBER 2017 IN KARLSRUHE

On 24-27 October 2017, the third interim project meeting was successfully held at the Karlsruhe Institute of Technology. About 80 scientists including a large fraction of African scientist and four members of the DACCIWA Advisory Board participated in the meeting. There was ample opportunity to exchange ideas and plan collaborations in order to further develop the DACCIWA work and to use the data from the main field research in summer 2016 in an optimal way.

The most important outcomes of the meeting are some first summary assessments of observations from the field campaign in conjunction with new modelling experiments.

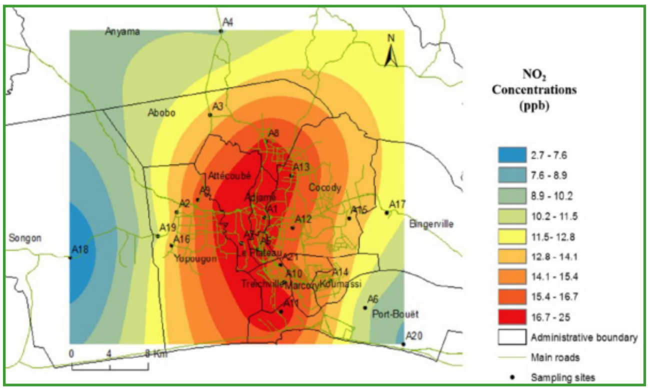
Participants of the DACCIWA project meeting in Karlsruhe

Publications

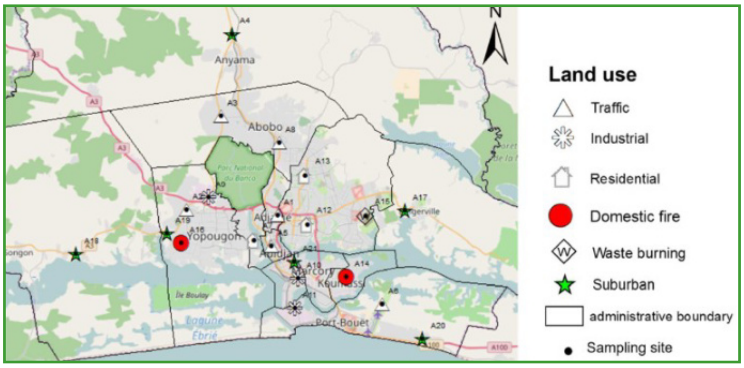
Bahino et al. accepted for discussion at ACP

Spatial distribution of gaseous pollutants (NO_2, NH_3, HNO_3, SO_2 and O_3) in Abidjan Cote d'Ivoire.

Abidjan is the metropolis with the fastest economic growth in West Africa. Economic upturn (rapid industrialization, improvement of transportation infrastructure, real estate and port activities) is associated to huge population growth with increasing urban activities (domestic fires, transport, wastes). These activities are potential sources of gaseous and particulate pollutants.



The spatial distribution of NO_2 concentrations.



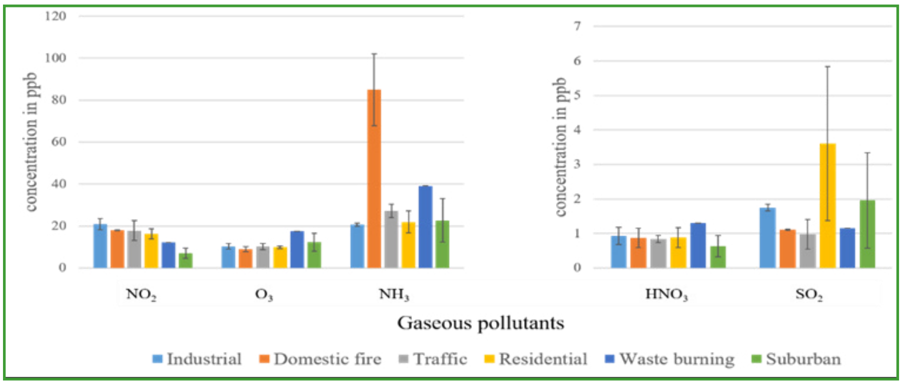
The location map of the sampling sites in Abidjan, Côte d'Ivoire

This study aims to characterize urban air pollution in the district of Abidjan through the measurements of 5 gaseous pollutants (NO_2, NH_3, HNO_3, SO_2 and O_3). The main source of air pollution has been identified and an intensive campaign was carried out on 21 sites during the dry season (15 December 2015 – 16 February 2016). Measurements used INDAAF passive samplers (Adon et al, 2010) and surface gas concentrations were interpolated using ArcGIS software and ordinary kriging as method of interpolation to produce pollution maps of the city.

High NO_2 concentrations ranging from 16 to 25 ppb have been measured in the city centre of Abidjan where road traffic is a more important source with traffic jams during the week days. Most of the industrial activities located in the city centre can also have an impact on NO_2 concentrations.

This study also investigated the relation between the concentration measured for each pollutant and the potential emission of each anthropogenic activity (ie. Industrial, domestic fires, traffic, residential, waste burning and suburban).

Reference: Bahino, J., Yoboué, V., Galy-Lacaux, C., Adon, M., Akpo, A., Keita, S., Liousse, C., Gardrat, E., Chiron, C., Ossohou, M., Gnamien, S. and Djossou, J.: Spatial distribution of gaseous pollutants (NO_2, SO_2, NH_3, HNO_3 and O_3) in Abidjan, Cote d'Ivoire, Atmos Chem Phys Discuss, 2017, 1–40, doi:10.5194/acp-2017-724, 2017.



The results shown indicate that industrial activities, domestic fires and traffic are the main sources of pollution for NO_2 while domestic fires and waste bumming are the main sources for NH_3.

Meet the DACCIWAs
Eleanor Morris

I am a PhD student at the Wolfson Atmospheric Chemistry Laboratories at the University of York working with Prof. Mat Evans. My work within the DACCIWA project falls under WP3, where I am looking at simulating atmospheric chemistry in the West African region. I am assessing the emission inventories available for the region and comparing the results of the modelling experiments to the chemical observations made during the DACCIWA field campaign in 2016. Our current focus is around the summer campaign period but the model will soon be used to simulate the annual cycle of pollutants and, using emission projections, will also investigate the possible human and ecosystem exposure to pollutants in the future.
Despite my work normally being entirely office-based, I was lucky enough to join the aircraft campaign in Lomé last summer and be involved in the forecasting as well as experiencing a research flight on the BAS Twin Otter aircraft. It was an amazing experience to be inside the plane and see all of the measurement equipment in action, and it has certainly given me a better appreciation for the challenges involved in making atmospheric measurements!
I find atmospheric chemistry a fascinating area of research and being part of the DACCIWA project has been a fantastic opportunity. I have loved getting to know the wide variety of people involved in the project and I am looking forward to all of the collaborations that the rest of the project will bring.
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Meet the DACCIWAs
Oluyinka Ayodeji Ogunwale

I am a PhD student at Obafemi Awolowo University, Ile-Ife, Nigeria working under the supervision of Prof. O. O. Jegede. My investigation within the DACCIWA project is the analysis of Sodar and Tethersonde observational data with respect to the formation and breakdown of nocturnal low-level jets. This is with a view to identifying how the observed jets influences low cloud formation and dissolution over Southern West-Africa. Also to serve as an input to both local and regional models on pollution. I have always been captivated by the atmospheric phenomena since my undergraduate studies at the University of Ado-Ekiti, Nigeria. The understanding of these features and how they influence our lives has been my keen interest. This is why my passion is for atmospheric physics during my masters degree programme. Most intriguing was the hands-on in-situ and remote sensing of the wind with the SODAR which I first got the opportunity to use at OAU, Ile-Ife. When the DACCIWA project started I was able to key in using the acoustic sounder to observe the appearances and breakdown of low-level jets at Ile-Ife, Nigeria. The DACCIWA project further gave me the opportunity to observe hands-on other remote sensors at Save, Benin, during the DACCIWA campaign in June/July 2016. I was able to see the setting up and operation of wind profilers and Radar from KIT and UPS stations which could probe further into the troposphere more than the vertical extent of the acoustic sounder. Personally, it was a great experience meeting other scientists and technicians from KIT and UPS participating in the project. During the DACCIWA project, I have understood how thermodynamic conditions influence the appearance of these low-level jets in the West African region. I hope that my work will serve as an input into other work packages and for air pollution modelling. I wish to acknowledge the support for my PhD studentship at the Obafemi Awolowo University and travel assistance to attend the DACCIWA project meeting in Toulouse in 2015.
Contact: Oluyinka Ogunwale (ogunwaleoa@gmail.com)

Publications

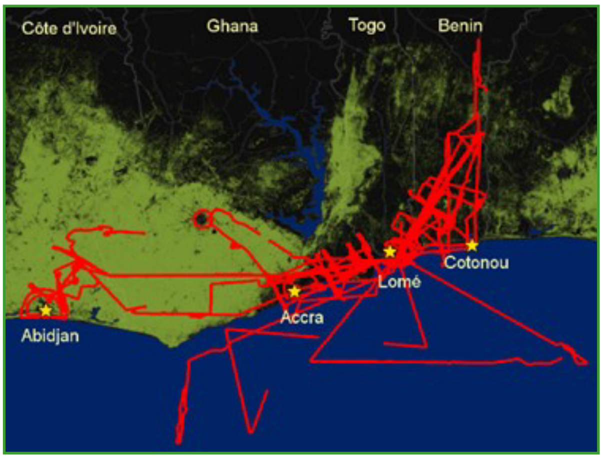
Brito et al. accepted for discussion at ACP

Assessing the role of anthropogenic and biogenic sources on PM_1 over Southern West Africa using aircraft measurements.

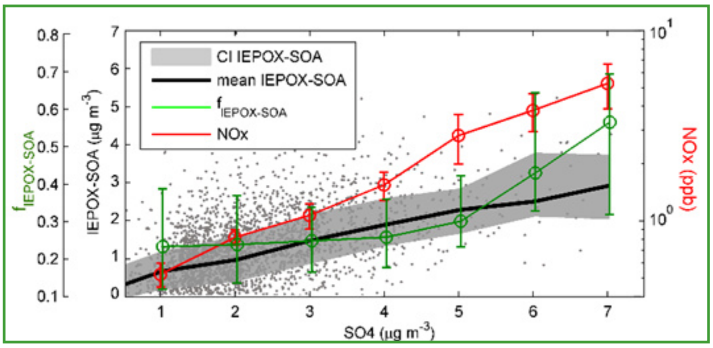
The presented study details results of the French ATR42 research aircraf during the field campaign carried out in June/July. The aircraft flight paths covered large areas of Benin, Togo, Ghana and Ivory Coast, focusing on emissions from large urban conurbations such as Abidjan, Accra and Lomé, as well as remote continental areas and the Gulf of Guinea. This manuscript focuses on aerosol particle measurements within the boundary layer (< 2000 m), in particular their sources and chemical composition in view of the complex mix of both biogenic and anthropogenic emissions, based on measurements from a compact time-of-flight aerosol mass spectrometer (C-ToF-AMS) and ancillary instrumentation.

Background concentrations observed from the ATR42 indicate a fairly polluted region during the time of the campaign...

... with average concentrations of carbon monoxide of 131 ppb, ozone of 32 ppb, and aerosol particle number concentration (> 15 nm) of 735 cm^{-3} stp. Average background PM_1 in the region was 5.9 µg m^{-3} stp. During measurements of urban pollution plumes, mainly focusing on the outflow of Abidjan, Accra and Lomé, pollutants are significantly enhanced (e.g. average concentration of CO of 176 ppb, and aerosol particle number concentration of 6 500 cm^{-3} stp), as well as PM_1 concentration (11.9 µg m^{-3} stp). Two classes of organic aerosols usually associated with interactions of anthropogenic and biogenic sources were quantified, namely particulate organic nitrates (pON) and isoprene epoxydiols secondary organic aerosols (IEPOX-SOA). During DACCIWA, pON have a fairly small contribution to OA (around 5%) and are more associated with long-range transport from central Africa than local formation. Conversely, IEPOX-SOA provides a significant contribution to OA (around 24 % and 28 % under background and in-plume conditions). It is important to note that IEPOX-SOA constitutes a lower limit to the contribution of biogenic OA, given that other processes (e.g. non-IEPOX isoprene, monoterpene SOA) are likely in the region. Given the significant contribution to aerosol concentration, it is crucial that such complex biogenic-anthropogenic interactions are taken into account in both present day and future scenario models of this fast-changing, highly sensitive region.



ATR42 flight path overlaid by forest cover in the region.



Variation of IEPOX-SOA (black line), the fraction of IEPOX-SOA in OA (green line) and NOx (red line) according to SO_4 concentration bins.

Reference:

J. Brito, E. Freney, P. Dominutti, A. Borbon, S. L. Haslett, A. Colomb, R. Dupuy, C. Denjean, F. Burnet, T. Bourriane, A. Deroubaix, K. Sellegri, H. Coe, C. Flamant, P. Knippertz and A. Schwarzenboeck: Assessing the role of anthropogenic and biogenic sources on PM1 over Southern West Africa using aircraft measurements. Atmos Chem Phys Discuss, 2017, https://doi.org/10.5194/acp-2017-717

News

DACCIWA session at EGU 2018

AS4.9/CL2.12 Atmospheric composition, weather and climate in Sub-Saharan Africa (co-organized)

Session description

This session is open to a wide range of contributions on atmospheric sciences in Sub-Saharan Africa, with a focus on tropical regions.
This includes work based on field observations (campaign, long-term), satellite remote sensing and numerical models as well as work targeting socio-economic implications of atmospheric phenomena.
Contributions are invited on various relevant topics, related to Sub-Saharan Africa, including:
* dynamical meteorology;
* atmospheric chemistry, aerosols and associated health impacts
* cloud microphysics and precipitation
* climate variability and change
* radiative processes
One focus of the session is the ongoing DACCIWA (Dynamics-Aerosol-Chemistry-Cloud Interactions over West Africa) project funded by the European Commission under FP7. DACCIWA organized a large international field campaign in June-July 2016 in southern West Africa.
Young scientist/student presentations are especially encouraged and we will reserve several oral units for such papers in this session.

Abstract submission deadline: 10 January 2018, 13:00

Conveners: Céline Mari
Co-Conveners: Peter Hill , John Marsham

Venue: Vienna 08-13 April 2018

DACCIWA Meeting in Africa

The next DACCIWA meeting will take place

14-17 October 2018 in Yamoussoukro
Côte d'Ivoire

on 18 October 2018
a DACCIWA stakeholder meeting will take place in Abidjan
Côte d'Ivoire

Commemoration Abdourahamane Konaré

With great sadness and regret we learned that Professor Abdourahamane Konaré of the University "Félix Houphouët-Boigny" in Abidjan, Côte d'Ivoire has passed away.
Professor Konaré has long had a close working relationship with DACCIWA in WP2 but was also involved in facilitating the digitization of weather data in Côte d'Ivoire for DACCIWA.
Working hard and passionated to improve the climate sciences in West Africa, Professor Konaré recently established a new PhD school in Abidjan within WASCAL (West African Science Service Center on Climate Change and Adapted Land Use), for which he was the governing board 1st deputy chairman, and he was also instrumental in bringing new supercomputing services to Côte d'Ivoire which will soon be operational and will considerably enhance the capability of cutting-edge climate science in West Africa. Professor Konaré will be remembered for his contributions to climate science and capacity building in the region, but also for his enthusiasm, energy and optimistic and encouraging attitude. He will be missed by his colleagues and friends at DACCIWA and our thoughts are with his family at this difficult time.

Meet the DACCIWAs
Alima Dajuma

I am a PhD WASCAL student at Federal University of Technology Akure (FUTA) in Nigeria. Within the DACCIWA project, my focus is on modeling aerosol-radiation-clouds interactions on the state of atmosphere using the regional atmospheric model COSMO-ART, under the supervision of Dr. Bernhard Vogel at Karlsruhe Institute of Technology (KIT).

Originally, from Ivory Coast, I studied my BSc in Physics and MSc in Environment and tropical climate at the University Felix Houphouet Boigny, Abidjan, Ivory Coast. I also had the chance to write a second master thesis on Climate change and Energy under the WASCAL Program in Niamey, Niger.

I have always been interested in atmospheric science, especially atmospheric chemistry and I believe that numeric models are tools that are very helpful in understanding what is going on in the atmosphere.

Due to the increase of air pollution in some megacities in West Africa, such as Abidjan where I live, I am particularly interested in how the anthropogenic activities affect the weather on short scale and on large scale the West African monsoon circulation, which bring most of the rainfall expected by farmers during the rainy season.

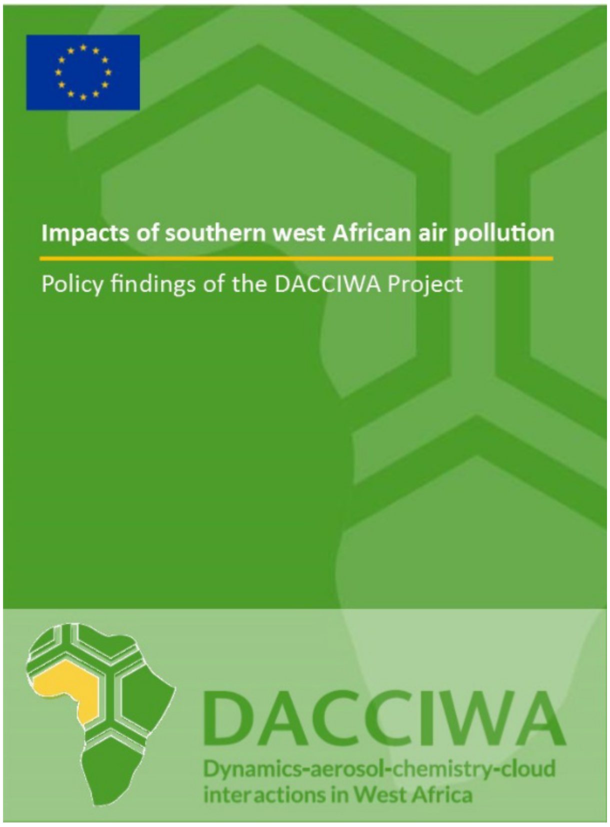
Using the DACCIWA database, the aim of my PhD research project is to quantify the interaction between aerosol-radiation and aerosol-cloud on cloud properties, temperature, radiation and precipitation for different sources (natural, anthropogenic and biogenic) through the use of the high-resolution regional model COSMO-ART and to compare the models results with observations. Scenarios from increasing anthropogenic emissions can be used to make projections on what will likely be the weather of those cities in the future.

I am optimistic that the DACCIWA database will help us bring results, which will be useful for decisions-making Governments to mitigate the impact of climate change in West Africa.

Contact: alima.dajuma@partner.kit.edu

Dissemination
Policy brief

As part of the WP8 dissemination activities we are going to produce a document outlining the policy relevant conclusions of the DACCIWA project. This document is aimed at being circulated to a range of stakeholder groups ranging from government agencies, universities, weather services, commercial interests and to the media both within the DACCIWA countries and the EU. The aim is to summarize the scientific conclusions in an easy to understand manner. The document will be prefaced by a high-level summary / communique aimed at senior policy makers outlining the problems and possible solution that DACCIWA has identified.



Presently the main sections and some potential conclusions for the report are likely to be:

Urban concentrations of pollutant and impact on health

- Pollutant concentrations are highest in the winter months

Dissemination

Policy brief (cont.)

- Aerosol concentrations are above WMO standards along the Guinea Coasts
- Concentrations of gas-phase polluants are high but currently do not exceed WHO standards
- Health impact of air pollution on population

Sources of urban pollution

- Emission factors for West Africa differ significantly from western standards
- Africa specific emissions inventories perform better than standard global emissions inventories
- Low temperature combustion sources are dominant

Regional pollution and impacts

- Summer-time regional-scale pollution is dominated by SH biomass-burning aerosol
- Very high overall aerosol number concentrations create low susceptibility for cloud-aerosol effects

Aerosol radiative effects

- Aerosols modify diurnal cycle of circulation, clouds and rainfall
- Aerosol radiative effects depends crucially on water uptake

Future state of the southern west African atmosphere

- Population and industrial growth will change the emissions in the region
- There will likely be a reduction in low temperature combustion sources to be offset by an increase in higher temperature sources.

Deficiencies of current observations and models

- Existing network and data sharing insufficient to support forecasting, assessment and research activities
- State-of-the-art models have substantial deficiencies in representing key atmospheric processes

The authors of the policy brief will be identified from the various DACCIWA WPs and will be professionally produced using the DACCIWA branding.

We will be looking for input into the policy brief over the next year. If your research has anything that contribute to the brief let Mat Evans know (mat.evans@york.ac.uk).

Meet the DACCIWAs

Fabien Brosse

I am a PhD student at Laboratoire d'Aérologie (LA) in Toulouse, France, working under the supervision of Maud Leriche (LA) and Céline Mari (LA) who leads the Workpackage 3 “Atmospheric Chemistry” of the DACCIWA project.

I obtained my Bachelor's degree in Physics in 2013 from the University Paul Sabatier (UPS) of Toulouse where I spent the last year learning mostly thermodynamics and fluid dynamics. My Master degree in environmental sciences, obtained at UPS, had given me the opportunity to study the interactions between turbulence and chemistry and provided me with an essential first contact with the DACCIWA project.

Strongly interested in atmospheric sciences, I joined DACCIWA thanks to the prospect of working in an international framework on a field campaign in collaboration with passionate scientists. During the field campaign, I was a member of the chemistry forecast team in which model outputs were analyzed in order to predict the chemical composition over the DACCIWA domain. Especially, predictions of the transport of polluted city plumes and biomass burning intrusions were used, together with meteorological forecasts, to establish flight plans.

Since the beginning of my PhD, I have studied the impact of turbulent structures on the chemical reactivity in the boundary layer in West Africa. My goal is to better understand the turbulent transport of chemically reactive species, with a focus on the hydroxyl radical which is the main oxidant of the atmosphere. This analysis is conducted by performing simulations with Meso-NH, a french research model coupled to a detailed chemical scheme, the most energetic part of turbulence being resolved thanks to a fine horizontal grid spacing of 50 meters. This modeling strategy have been applied to a study case documented during the AMMA (African Monsoon Multidisciplinary Analyses) campaign.

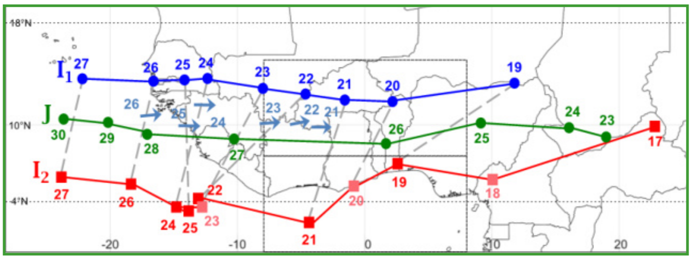
Contact: fabien.brosse@aero.obs-mip.fr

Knippertz et al. 2017 at ACP

A meteorological and chemical overview of the DACCIWA field campaign in West Africa in June–July 2016

During the international field campaign in southern West Africa in June-July 2016 careful daily synoptic analyses were produced to guide flight-planning and post-analysis of observations.

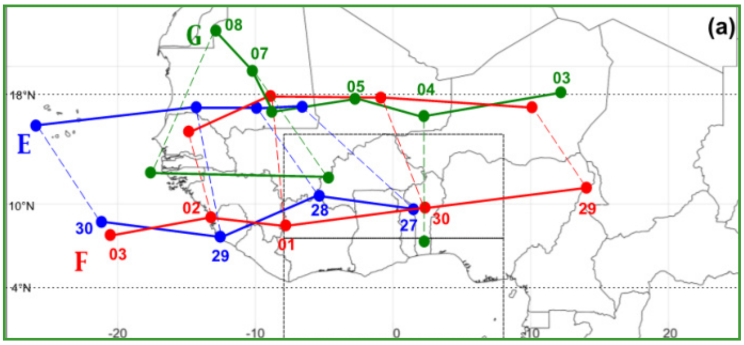
The results are a strong illustration of the richness of synoptic-scale weather systems encountered over the African tropics in summer. Three types of behaviours can be distinguished: The first type is classical African easterly waves (AEWs) with a northern and southern cyclonic vortex evident in streamlines at 850 hPa. They usually have a discernable signal in vorticity, wind and precipitation fields. Particularly before the monsoon onset, a second type, single cyclonic vortices, occur at different latitudes with different propagation speeds. They are often related to long-lived mesoscale convective systems (MCSs) and thus modulate rainfall on the regional scale, but the exact dynamical reason for their existence is not entirely clear.



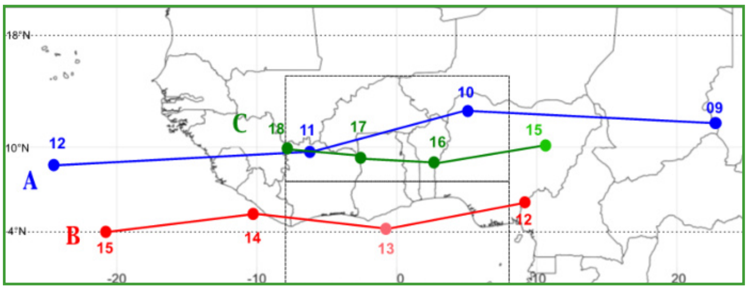
Example of a track of a cyclonic-anticyclonic vortex couplet during the DACCIWA field campaign (labelled I_1 (cyclonic) and I_2 (anticyclonic)). The strong westerly winds between the two centres are marked by blue arrows. These winds transport moist air eastward from the warm water off the west coast of West Africa and bring very moist conditions. A single vortex (Feature J) is also marked. Numbers in the plot stand for July 2017, respectively. Figure taken from Knippertz et al. (2017, ACP).

The third type, which appears to be rarer and whose climatological and dynamical characteristics are barely covered in the literature, are jointly propagating cyclonic and anticyclonic vortices, which create an anomalous westerly flow in between them.

The resulting conditions appear to depend on the origin of the involved air masses. If the westerly flow taps into moist air off the West African west coast, where high sea-surface temperatures are common, this can lead to anomalously moist conditions across the region. More work is needed to develop conceptual models for the latter two types of disturbances that share characteristics of both equatorial (e.g., mixed Rossby-gravity waves) and AEW features.



Examples of African easterly wave tracks during the DACCIWA field campaign. These are typically characterised by two cyclonic centres at the 850 hPa level. Numbers in the plot stand for June and July 2017, respectively. Figure taken from Knippertz et al. (2017, ACP).



Examples of tracks of single cyclonic vortices during the DACCIWA field campaign. These differ by latitudinal position, propagation speed and their impact on precipitation (not shown). Numbers in the plot stand for June 2017, respectively. Figure taken from Knippertz et al. (2017, ACP).

Reference: P. Knippertz, A.H. Fink, A. Deroubaix, E. Morris, F. Tocquer, M.J. Evans, C. Flamant, M. Gaetani, C. Lavaysse, C. Mari, J.H. Marsham, R. Meynadier, A. Affo-Dogo, T. Bahaga, F. Brosse, K. Deetz, R. Guebsi, I. Latifou, M. Maranan, P.D. Rosenberg, and A. Schlueter
Atmos. Chem. Phys., 17, 10893–10918, 2017
https://doi.org/10.5194/acp-17-10893-2017

Acknowledgments

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Next Newsletter

Spring 2018

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More DACCIWA Publications

Accepted for Publication:

- Flamant et al.: **The Dynamics-Aerosol-Chemistry-Cloud Interactions in West Africa field campaign: Overview and research highlights.** *Bull. Amer. Meteor. Soc.*, in press, https://doi.org/10.1175/BAMS-D-16-0256.1
- Dunning et al.: **Identification of deficiencies in seasonal rainfall simulated by CMIP5 climate models.** *Environ. Res. Lett*. 12 (2017) 114001, https://doi.org/10.1088/1748-9326/aa869e
- McFarquhar et al.: **Processing of Ice Cloud In Situ Data Collected by Bulk Water, Scattering, and Imaging Probes: Fundamentals, Uncertainties, and Efforts toward Consistency,** *AMS Meteor. Monogr.* https://doi.org/10.1175/AMSMONOGRAPHS-D-16-0007.1

Accepted for Discussion:

- Deroubaix et al.: **Interactions of Atmospheric Gases and Aerosols with the Monsoon Dynamics over the Sudano-Guinean region during AMMA,** *in ACP,* https://doi.org/10.5194/acp-2017-552
- Kalthoff et al.: **An overview of the diurnal cycle of the atmospheric boundary layer during the West African monsoon season: Results from the 2016 observational campaign,** *in ACP,* https://doi.org/10.5194/acp-2017-631
- Keita et al.: **Aerosol and VOC emission factor measurements for African anthropogenic sources,** *in ACP,* https://doi.org/10.5194/acp-2017-944
- Djossou et al.: **Mass concentration, optical depth and carbon composition of particulate matter in the major Southwestern Africa cities of Cotonou (Benin) and Abidjan (Côte d'Ivoire) ,** *in ACP*, https://doi.org/10.5194/acp-2017-973
- Brosse et al.: **LES study of the impact of moist thermals on the oxidative capacity of the atmosphere in southern West Africa,** *in ACP*, https://doi.org/10.5194/acp-2017-969

DACCIWA

Project Partners

- Karlsruher Institut für Technologie (DE)
- University of Leeds (UK)
- University of York (UK)
- The University of Reading (UK)
- The University of Manchester (UK)
- Deutsches Zentrum für Luft- und Raumfahrt e.V. (DE)
- Université Paul Sabatier Toulouse III (FR)
- Université Blaise Pascal Clermont-Ferrand II (FR)
- Université Paris Diderot - Paris 7 (FR)
- European Centre for Medium-Range Weather Forecasts (UK)
- Eidgenoessische Technische Hochschule Zürich (Switzerland, CH)
- Kwame Nkrumah University of Science and Technology Kumasi (Ghana, GH)
- Obafemi Awolowo University (Nigeria, NGR)
- Université Pierre et Marie Curie - Paris 6 (FR)
- Met Office (UK)
- Centre National de la Recherche Scientifique (FR)

Academic partners associated through subcontracts

- Université Félix Houphouet Boigny, Abijan, Ivory Coast
- Université d'Abomey-Calavi, Cotonou, Benin
- Technische Universität Braunschweig

Front picture courtesy of Sébastien Chastanet