Acronyme / Acronym	**ACASIS**		
Titre du projet	**A**lerte aux **C**anicules **A**u **S**ahel et à leurs **I**mpacts sur la **S**anté		
Proposal title	Sahelian heat waves and their health impacts warning		
Axe(s) thématique(s) / theme(s)	☑1 ☐ 2 ☐3 ☑4		
Type de recherche / Type of research	☑Recherche Fondamentale / Basic Research ☐ Recherche Industrielle / Industrial Research ☐ Développement Expérimental / Experimental Development		
Coopération internationale (si applicable) / International cooperation (if applicable)	Le projet propose une coopération internationale / International cooperation with (specify country): **Sénégal, Burkina Faso**		
Aide totale demandée / Grant requested	1379166 €	**Durée du projet / Projet duration**	48 mois
Partenaire coordinateur / Coordinator partner	**Serge Janicot (IRD)** **LOCEAN, UMR7159 CNRS/IRD/UPMC/MNHN**		
Lien avec un projet du programme *Investissements d'Avenir (IA) / Link with a project of the Investement for the Future program*	☑ Non ☐ Oui si oui : préciser :		

Personnes impliquées dans le projet / People involved in the project (Responsible of partners & people > 12 p.m) :

Etablissement / organization	Nom / Name	Prénom / First name	Emploi actuel / Current position	Discipline* / Field of research	Person.month** / Involvement (PM)	Rôle & Responsabilité dans le projet / Contribution to the project
LOCEAN France	Janicot	Serge	DR2		20	Coordinator; African climate and its predictability; Impact studies
OMP France	Fleury	Laurence	IR2		3	Resp Task 2; T6; information system
CRC France	Pohl	Benjamin	CR2		14,4	Resp Task 3; T4; climate variability, regional modelling
CNRM-GAME France	Guichard	Françoise	CR1		20	Resp Task 4; atmospheric processes and observations analysis
LOCEAN/LMD France	Hourdin	Frédéric	DR2		9,6	Co-resp Task 4; LMDZ, atmospheric processes and parametrisation
LPED France	Lalou	Richard	CR1	Demography	14,4	Resp Task 5; health and environment
ANACIM Senegal	Ndiaye	Ousmane	DR		12	Co-resp Task 6; T3; forecasting and statistical downscaling
DGM Burkina	Yaka	Pascal	DR		18	Co-resp Task 6; climate and health
UGB Senegal	Deme	Abdoulaye	MC		18	Coordinator UGB ; Tasks 3; climate
LPAOSF Senegal	Gaye	Amadou	PR		12	Coordinator LPAOSF ; Tasks 2,3,4; climate
CSE Senegal	Ndione	Jacques-André	DR	Environ & health	24	Coordinator CSE ; Tasks 5,6
CRSN Burkina	Diboulo	Eric	CR	Biostatistics	9,6	Coordinator CRSN ; Task 5
ISSP Burkina	Soura	Abdramane	DR	Demography	9,6	Coordinator ISSP & OPO ; Task 5
LOCEAN/LMD	Mellul	Lydia	IR1		15	Task 4; simulations and evaluation
LOCEAN/CIRED	Quirion	Philippe	CR1	Economy	12	Task 5
CRC	Roucou	Pascal	MC		19,2	Task 3; regional climate an variability
CRC	Ullmann	Albin	MC		14,4	Task 3; weather regimes and climate
CRC	Martiny	Nadege	MC		14,4	Task 3; climate and health
CRC/LTHE	Diedhiou	Arona	DR2		12	Task 3; atmospheric variability
CNRM-GAME	Roehrig	Romain	IPC		12	Tasks 3, 4 & 6; modelling, forecasting
LPED	Dos Santos	Stephanie	CR1	Demography	12	Obs. of Population Ouagadougou ; Task 5
ANACIM	Diongue	Aida	DR		12	Task 6; meteorological extreme events
LPAOSF	Daouda	Badiane	MC		18	Tasks 1 & 2; atmospheric physics
CSE	Faye	Abdoulaye	CR	Socio-economy	15	Task 5
CSE	Seck	Marieme Diallo	CR	Socio-economy	15	Task 5

1. RÉSUME DE LA PROPOSITION DE PROJET / EXECUTIVE SUMMARY OF THE PROPOSAL

While the heat wave impacts on public health have been widely addressed in developed countries especially after the intense event over West Europe during summer 2003, no effort has been made to detect them and evaluate their impacts in least developed countries, and especially Africa, where climate is warmer and adaptation capacities are low. Over West Africa preliminary interviews, climate and epidemiologic analyses show however that this problem is emerging and climate projections indicate that such events should increase in frequency and intensity in the coming decades. However these climate models display important temperature and radiative biases over this region, which must be reduced to provide robust information on the future evolution of heat waves.

Starting from this context, the main objective of ACASIS is to set-up a pre-operational heat wave warning system over West Africa tailored to health risks of the population living in this region. This is a demonstration project focused on Senegal and Burkina where national weather services have already started developing products dedicated to weather/climate and health relationships, and where several health and demographic observatories have been operating for up to several decades. Based on qualified meteorological, climate and demographic data bases, firstly, the dynamics of the heat wave events and their atmospheric patterns will be determined, as well as their evolution over the last decades. Their predictability at short and medium ranges will be evaluated on ensembles of multi-models forecasts outputs. On a longer time scale, control simulations and climate scenarios of the CMIP5/AR5 (5th phase of the Coupled Model Intercomparison Project the results of which are synthesised in the IPCC Assessment Report) database will be analysed and the simulated future evolution and associated uncertainty of these

events will be evaluated. More precisely the processes at the origin of model radiative biases will be examined and reduced as much as possible. In parallel, epidemiologic studies associated with interviews will be conducted in the health and demographic sites in Senegal and Burkina in order to evaluate the physiologic and social vulnerability of the African population to high temperature extremes. It will allow to define tailored bio-meteorological indicators to be used in the warning system. From these outcomes and by implementing downscaling to link the synoptic scale of the heat waves to local bio-meteorological indicators, we will set-up a demonstration warning system on a "testbed" platform named MISVA, already implemented as the result of a prior collaboration between Meteo-France, OMP and ANACIM, the meteorological agency of Senegal. Based on the interviews, and with the setting of several workshops with stakeholders and public institutions, we will be able to provide specific recommendations associated to these warnings. An implementation in the Meteo-France operational system at the end of the project or after might be possible.

To carry on this project, a pluri-disciplinary consortium has been set-up gathering climatologists, physical processes specialists, meteorologists, biostatisticians, demographers, socio-economists, epidemiologists, geographers, and operational meteorological agencies. It will work through a close collaboration between French and African teams where young African researchers will be highly involved.

2. CONTEXTE, POSITIONNEMENT ET OBJECTIFS DE LA PROPOSITION / CONTEXT, POSITION AND OBJECTIVES OF THE PROPOSAL

2.1. OBJECTIFS ET CARACTÈRE AMBITIEUX ET NOVATEUR DU PROJET / OBJECTIVES, ORIGINALITY AND NOVELTY OF THE PROJECT

The understanding of heat wave occurrences and of their impacts on public health has been widely addressed after the intense event over West Europe during summer 2003, and previous events like in July 1995 at Chicago were also investigated (Bessemoulin *et al.*, 2004 ; Beniston et Diaz, 2004 ; Black *et al.*, 2004) . An adaptation strategy was set-up in France after 2003 which proved to be successful during the 2006 summer heat wave. In the low-income states of Africa, the national priority for public health issues linked to climate are mostly related to rainfall-related diseases and the potential impact of warm/hot spells is not on the front line. However the reality at the local scale is different. One recent example in the Sahel is the very hot month of April 2010, which culminated for Niamey with a peak higher than 50°C on April 19th (the maximum temperature ever recorded there), with similar records in Senegal, Mali, Burkina, Chad. Associated with an increase of moisture, these high temperatures had a strong impact on morbidity and mortality; the number of deceases was multiplied by two, and even more among the youngest and elderly people (as reported in press conference of the Niamey National Hospital). Recent interviews realized for the ANR CEP&S ESCAPE project (see reports of the February 2012 meeting on http://www.locean-ipsl.upmc.fr/~ESCAPE/) carried out by the LPED (a team also involved in ACASIS) have highlighted that people in Benin, Niger and Senegal have a high perception of an increase in temperature variability and in hot extreme occurrences over the last 15 years, especially in spring before the onset of the summer rainy season. They quoted for instance as a new fact the occurrences of "warm winds". Climate scientists and meteorologists from Senegal and Burkina, involved in ACASIS too, report similar observations. A preliminary epidemiologic study (Diboulo et al. 2012; see below) led by CRSN (involved in ACASIS) over the Health and Demographic Surveillance System of Nouna (Burkina) identified some links between temperature and mortality. This human perception of the evolution of temperature extremes is in agreement with analyses of the data available over the last decades in this region, especially in spring (Guichard et al. 2013, from CNRM-GAME involved in ACASIS) which is the hottest season of the year, and with CMIP5 climate change projections which show a significant increase of heat wave occurrence over West Africa. A first question is therefore whether and how local population can cope with such a climatic evolution. The potential of climate projections for helping in setting-up an adaptation strategy at the regional scale is yet unclear. Indeed, these climate models display huge biases in their mean state, and recent studies carried out within the AMMA program (African Monsoon Multidisciplinary Analyses; www.amma-international.org/) have highlighted large radiative and low-level temperature biases over West Africa (Roehrig et al. 2013, involved in ACASIS). Reduction of these biases, which also means understanding their causes, is a key issue for providing robust information for adaptation strategies.

The goal of ACASIS is to set-up a pre-operational heat wave warning system over West Africa tailored to health risks of the population living in this region and to anticipate the impact of global warming. This is a demonstration project focused on Senegal and Burkina where national weather services have already started developing products dedicated to weather/climate and health relationships, and where several health and demographic observatories have been operating for up to several decades. Based on qualified meteorological, climate and demographic data bases, firstly, the dynamics of the heat wave events and their atmospheric patterns will be determined, as well as their evolution over the last decades. Their predictability at short and medium ranges will be evaluated on ensembles of multi-models forecasts outputs TIGGE, and the performance of the Meteo-France operational deterministic and ensemble forecast systems assessed in a similar way. For longer time scales, control simulations of the CMIP5/AR5 database will be analysed thanks to the measurements done during the AMMA field campaigns and longer-term data sets, and the simulated future evolution of heat waves in climate scenarios and their associated uncertainty will be evaluated. The processes at the origin of model radiative biases will be identified and their representation improved with newly-developed parametrizations in particular. On the health side, epidemiologic studies associated with interviews will be conducted in Senegal and Burkina in order to evaluate the physiologic and social vulnerability of the African population to high temperature extremes. It will allow to define tailored bio-meteorological indicators to be used in the warning system. From these outcomes and by implementing downscaling to link the synoptic scale of the heat waves to local bio-meteorological indicators, we will set-up a demonstration warning system on a "testbed" platform named MISVA, already implemented as the result of a prior collaboration between Meteo-France and OMP (both involved in ACASIS). The MISVA platform operated during the two last summers and successfully fostered exchanges at Dakar with Senegalese forecasters of ANACIM and allowed to test new forecasting products. Based on the interviews, and with the setting of several workshops with stakeholders and public institutions (national health and civil protection services, hospital centers,…), we will be able to provide specific recommendations associated to these warnings. The outcomes of the project may also motivate effort from national structures on their national demographic databases. An implementation in the Meteo-France operational system at the end of the project or after might be possible.

To carry on this project, we have set-up a pluri-disciplinary consortium. Some of its members have recently produced innovative but only preliminary results on perception and vulnerability of population to high temperatures, on links between temperature and mortality, on detection of warm/hot spells and their atmospheric patterns, and on climate model radiative and temperature biases over West Africa (see above). The reliable consortium which is needed to address and reach our objectives must also include (i) operational meteorological services from Senegal and Burkina, together with the CNRM team closely associated to the operational service of Meteo-France, and (ii) the demographic observatory sites of these two African countries where interviews and epidemiological studies will be conducted. It will work through a close collaboration between French and African teams where young African researchers will be highly involved. The motivation for ACASIS was reinforced by some recent results of ESCAPE as stated above, but the two projects are totally independent. Heat waves are out of the scope of ESCAPE that focuses on the long-term evolution of surface and natural resources, and on the development of adaptation strategy by the populations.

Three difficulties will have to be considered on the way to achieve our objectives :

The first concerns the modelling of the low-level temperature and in particular the daily minimum of temperature (Tmin). It is important to accurately predict Tmin for health issues but particularly difficult in this region. Nocturnal temperature often display strong vertical gradients near the surface, and the boundary layer turbulence, the distribution of humidity and aerosols, and their coupling with radiative processes strongly shape surface air temperature in the relatively dry and high dust load conditions encountered in spring (Guichard et al. 2009). Clouds, in particular mid-level clouds which are not well represented in climate models but frequent in this region, are expected to have an impact too (Bouniol et al. 2012). The project will at the least enable to improve our knowledge and understanding of the factors that control surface air temperature and help improving its predictability.

The second is related to the predictability of environmental conditions linked to heat waves and likely to affect population health, the skill of meteorological models to forecast them at a few days range, and of climate models for future projections. We cannot be fully sure that we will be able to build a relevant downscaling process from them. The project will enable to evaluate the various available model products, from which the "best" of them can be selected.

The third concerns the actual links between environmental and local conditions. These links are probably complex. For instance we don't know whether the impact of moderate but persistent heat waves are more or less or equally severe than those of short but intense heat waves. In order to identify such links a robust monitoring and tracking platform is needed. It must be able to integrate environmental, meteorological, and health data to reach populations vulnerable to climate-related hazards. Will our databases be good enough for this purpose? (if not, we will be able however to propose a method of evaluation in a context of "deficient information"). Other important questions arise: How are these links predictable? What will be the range of uncertainty when using ensemble of forecasts? Will this information be useful for stakeholders? The project should in any case provide valuable information on these issues.

In terms of success, we can anticipate:

- a qualified and if possible a homogenised daily meteorological database in Senegal and Burkina;
- a characterization of heat wave events over West Africa, an evaluation of their predictability from daily to climate scales;
- a better understanding of the processes associated to West Africa heat waves;
- a reduction of climate model radiative and temperature biases over West Africa and Sahara resulting in improved climate simulations;
- a determination of an accurate bio-meteorological variable adapted to West Africa, an identification of thresholds for triggering the warning system, skill scores of forecasting for this variable;
- an evaluation of perception, vulnerability and adaptation strategy to temperature extremes occurrences;
- an evaluation of gaps in the institutional information chain and recommendations for improvement;
- the set-up of a heat wave demonstration warning system and associated recommendations;
- an enhancing of capacity building in West Africa and of young African scientists expertise.

2.2. ÉTAT DE L'ART / STATE OF THE ART

West Africa is well-known as being the area in the world which has suffered from the highest rainfall decrease and droughts over the last 60 years (Lebel and Ali 2009). This explains why existing studies have mostly focused on the summer monsoon season, when most of the annual rainfall amounts are concentrated. However, the evolution of monthly temperature over the past decades (Fig.1) show a strong positive trend during spring (April-May-June), the hottest season. In summer (July-August-September) this signal is present but modulated by the interannual variability of rainfall (the dry years being warmer). The spring warming is at least twice as high as over western Europe, and stronger for Tmin than for Tmax (the daily maximum of temperature), which is often interpreted as a sign of higher greenhouse gas concentrations.

Climate simulations along the 21st century also predict a positive trend of temperature over West Africa, but with an amplitude that depends on the model used (Roehrig et al. 2013). Climate scenarios also predict more frequent warm/hot spells over this region in spring, a trend which has been detected over a shorter period starting in mid-1990's (Fontaine et al. 2013). In this work, the atmospheric patterns of heat waves were attributed to baroclinic Rossby waves associated with the subtropical westerly jet deformation, so that some predictability at a range of several days can be anticipated. Analyses of atmospheric patterns of heat waves are numerous for the mid-latitudes (e.g. Gershunov et al. 2009, Gershunov and Guirguis 2012 over California), but to our knowledge, none had ever been carried out over West Africa.

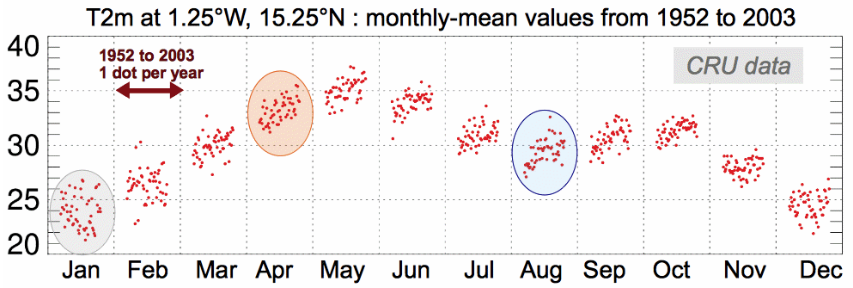


Fig.1: Annual cycle of monthly temperature over a 0.5° square degree centred on 1.25°W-15.25°N, from CRU (East Anglia). For each month, every dot represents one year from 1952 to 2003; F. Guichard (CNRM-GAME).

While our understanding of the future of climate over West Africa must rely on CMIP5-type simulations of climate models, these models show still huge biases in their mean state (Fig.2) and recent studies carried out in the AMMA program have highlighted large and coupled radiative and surface air temperature and humidity biases over West Africa. (Roehrig et al. 2013). This is indeed a major issue because if indexes defining heat waves are numerous, they all rely on accurate information about surface air temperature and humidity. This includes their daytime and nighttime extrema and fluctuations from seasonal normal. Future evolution of these heat waves will depend to first order on the evolution of the seasonal normal, as well as on the possible modifications of the fluctuations from the normal. It is important to mention here that the spread among models is typically the larger in spring, which is also the hottest period of the year. Thus, any future increase in the frequency, duration or intensity of heat waves in spring is likely to have more consequences on health and mortality than in any other period of the year.

The reasons behind models spread in temperature and humidity involve errors of distinct natures. First, large-scale biases can develop from interactions arising at smaller scale among the dynamic and physical components of the models. They correspond to first order geographic and climatic biases and often prevent drawing direct, definite conclusions from climate projections. On the other hand, even when the large-scale features are correctly captured, the parametrizations of physical processes (e.g. cloud cover, dust, nighttime turbulence) strongly shape the evolution of surface air temperature and humidity at short time scales, on the order of a few days or less (Couvreux et al. 2013), and these sets of parametrizations are currently not well constrained.

On the basis of previous work (Guichard et al. 2009), we expect to find couplings between surface air temperature, humidity and surface radiative fluxes. Observations show that nighttime minimum temperatures increase by several degrees during the first intrusions of the moist monsoon flow in spring (a flow which is typically less than 1 km deep), and the incoming longwave fluxes are found to increase accordingly. On the other hand, daytime temperature during such moist events often decreases as water vapour, clouds and aerosols then limit the incoming shortwave flux (Bouniol et al. 2012) and daytime boundary layer growth. Thus, compensating nighttime and daytime processes are able to partly damp synoptic-scale fluctuations but with sharp contrasts in minimum and maximum temperature and humidity.

Reducing biases in the representation of the involved processes is essential for the confidence in climate projections of West African heat waves future evolution, and needed to provide relevant information to stakeholders and decision makers.

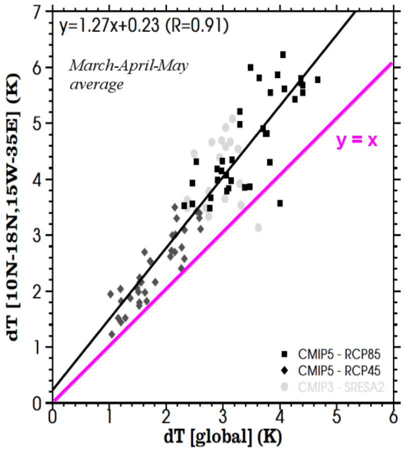


Fig.2: Future projections of global 2-meter temperature against those of 2-meter temperature averaged over a Sahelian band 10°N-18°N/15°W-35°E in spring (MAM) from CMIP3 (grey) and CMIP5 (black) climate simulations. The differences are computed between 2071-2100 and 1971-2000. This figure highlights that the warming over the Sahel is projected to be substantially stronger than the global mean, with large quantitative uncertainties (Roehrig et al. 2013).

Climate change and its rapid emergence in the past decades are a major challenge to public health together with health inequity and weakening of health systems. Its effects on health will affect most of the world's population in the next decades and put the lives and well-being of billions of people at increased risk. Yet, the health impacts of climate change will not be distributed evenly and the distribution of the most severe health burdens is almost opposite to the global distribution of greenhouse gas emissions. Although the appraisal is difficult, we believe along with A. Costello and colleagues that Sub-Saharan Africa will bear the highest regional burden of climate change, with 34% of the global disability adjusted life years (DALY's) attributable to climate change, while it represents only 11% of the world's population (Costello A et al., 2009).

Despite a few scientific comments and increasing media coverage on the theme of potential health vulnerability to actual and projected global climate change among populations in Africa, detailed scientific evidence has been extremely poor so far (P. Byass, 2009). On almost one and half million scientific citations matching at least one of these keywords: "health", "climate change" and "Africa", and published as far back as 1990, the intersection contained a mere 58 hits (0.0004%); a search undertaken in Medline database on 11 March 2013.

Vector-borne diseases, as malaria, and water-borne diseases, as cholera, are constant reminders of the climate impact could have on health and development, and they are probably the most documented infectious diseases in relation to climate change. Part of this attention seems to arise from concerns that the global disease distribution might be extended outside current endemic zones, in areas that have become wetter and warmer (Diallo et al., 2012; Dramé et al., 2012; Githeko et al, 2000; Pagès et al., 2008; Pascual et al., 2006; Peterson et al. 2009; Tanser et al., 2003; Yé et al., 2008). At regional scale, malnutrition also remains one of the better documented health crises in Africa. Droughts and other climate extremes have direct impacts on food crops, and can also influence food supply indirectly by altering the ecology of plant pathogens (Parry et al., 2004; WHO, 2000).

From a broader perspective, in Africa as elsewhere, global climate change directly affect health effects, when it occurs predominantly through the impacts of climate variables on human biology or disease risk factors. The summer of 2003 was probably Europe's hottest summer in last five centuries and the most striking recent example of health risks directly resulting from temperature change. Approximately, 22,000 to 45,000 heat-related deaths occurred over two weeks in August 2003. Most of temperature-mortality studies have taken place in developed countries and regions with temperate climates (Basu, 2008; Rey et al., 2007; Schar et al., 2004). However, the pattern of temperature-mortality relationship, found in European and North-American regions, is likely to occur in developing countries under tropical or subtropical conditions.

Very few studies have been carried out with a conspicuous lack of research on how socioeconomic and environmental factors may modify this temperature-mortality association. Diboulo et al. (2012) is one of them, and provides a 10-year retrospective analysis of weather-mortality links over the Health and

Demographic Surveillance System of Nouna (Burkina). This study highlights a close association between higher temperature and daily mortality, which is particularly strong on the under-five child mortality rate. Human populations, as individuals, vary in their vulnerability to certain health and climate outcomes. Some people will physiologically better adapt to warmer temperatures – which results in an increase of the comfortable temperature range – while others are unable to acclimatize to high temperatures, because of their health's frailty. Moreover, the vulnerability of a population depends on factors such as its density and age-specific distribution, household income level and distribution, local environmental conditions, pre-existing health status and the quality and availability of public health care. This is well shown in the WHO report "Climate change and human health - risks and responses", which suggests, on the basis of European and North-American population literature, that people's vulnerability to extreme heat is complex, as a result of the following contextual and social factors (WHO, 2003):

- Exposure to high temperatures at home or in local communities because of the design and fabric of their housing or residential environment;
- Sensitivity to heat stress, influenced by their respiratory, physical or mental health, age or relative acclimatization to heat;
- Capacity to adapt to circumstances in order to anticipate, escape or treat heat stress;
- Self-perception of vulnerability, willingness to act to avoid heat stress, and awareness of heat stress and how to prevent it;
- Lack of local knowledge which may reduce people's chances of receiving support during heat waves;
- Social networks that can increase information and coping skills.

Observations	Niakhar (43000 personnes & 30 villages)		Mlomp (8000 personnes & 1 village)		Dielmo-Ndiop (700 personnes & 2 villages)		Bandafassi (13000 personnes & 42 villages)		Nouna (90000 personnes & 58 villages et 1 petite ville)		Ouagadougou (87000 résidents & 5 quartiers)	
	Fréquence	Couverture temporelle	Fréquence	Couverture temporelle	Fréquence	Couverture temporelle	Fréquence	Couverture temporelle	Fréquence	Couverture temporelle	Fréquence	Couverture temporelle
Population couverte (Naissances, décès)	une fois par an	1983-1986	une fois par an	1985-2013	tous les jours	1990-2013 (Dielmo)	une fois par an	1975 - 2013	quatre fois par an	1992-2013	Une fois par an	2009 - 2013
	hebdomadaire	1987-1997			tous les jours	1993-2013 (Ndiop)						
	tous les 4 mois	1998-2012										
	tous les 6 mois	2013-										
Causes de décès par autopsie verbale	même fréq. pour tous les décès	1989-1998	une fois par an	1985-2013	tous les jours	1990-2013 (Dielmo)	une fois par an	1975 - 2013	quatre fois par an	1992-2013	Une fois par an	2009 - 2013
	même fréq. pour décès 0-55 ans	1999-2004										
	même fréq. pour tous les décès	2005-2013			tous les jours	1993-2013 (Ndiop)						
Morbidité	à partir des registres de 3 postes de santé	1990-2003	nd	nd	nd	nd	nd	nd	une fois par an	1992 - 2013 (sur échantillon de 8000 pers.)	nd	nd
coordonnées géographiques des concessions	une fois	2003	nd	nd	une fois	2006	nd	nd	une fois par an	1992 - 2012	Une fois par an	2009 - 2013
Données météorologiques	tous les jours (pluies)	1982-2013 (variables selon les stations)	nd	nd	tous les jours (pluies)	1990-2013	nd	nd	tous les jours	2004 - 2013	nd	nd

As a result, anticipating the public health impacts of climate change requires a robust monitoring and tracking platform that can integrate environmental, meteorological, and health data to identify and reach populations vulnerable to climate-related hazards. The widespread lack of population-based data explains that there is very little scientific evidence connecting climate and population health in Africa.

It is important to stress here that the gaps in public health information in sub-Saharan Africa, especially the limited availability and poor quality of data on mortality patterns, trends and causes, are partly filled with data from the health and demographic surveillance system (HDSS) sites. The HDSS sites (32 in Africa) are exceptional because they provide such data in settings lacking any comparable information on births, deaths and causes of death. A strength of ACASIS is that it will rely on six of these sites (four in Senegal and two in Burkina Faso) and Task 5 will take place almost exclusively on these population observatories. The above table summarizes the data needed to complete the project ACASIS.

2.3. POSITIONNEMENT DU PROJET / POSITION OF THE PROJECT

ACASIS is motivated by the expected consequences of global warming on the heat waves occurrence and intensity over West Africa, by the poor performances of state-of-the art climate models to simulate spring surface temperature in that region, and by the lack of knowledge and understanding of heat waves an their repercussion on health and mortality in this region.

ACASIS aims to set-up the first pre-operational heat wave warning system over West Africa tailored to health risks of the population living in this region. ACASIS addresses complex multidisciplinary scientific questions involving together weather and climate, health and social issues. The complementarity of expertise achieved within the proposed consortium should provide an effective way to encompass the range of issues raised from the basic scientific research level up to the design of a pre-operational prototype.

We focus on Senegal and Burkina, where national weather services are already involved in developing products linked to weather/climate and health relationships, and where several long term populations observatories have been set-up. These observatories allow to characterize the impact of extreme temperatures on morbidity and mortality, to evaluate the perception and vulnerability of the population to these events, and to define tailored bio-meteorological indicators to be used in the warning system. If the results are conclusive, they can be moved into an operational system, and could serve as an example and a motivation to set-up such a system in other countries in West Africa.

ACASIS will address the characterization of temperature extremes occurrences over West Africa both in historical data sets and in meteorological forecasting and climate models. The processes responsible for the low-level temperature and radiative biases over this region in the models, including dust aerosols, will be examined and we expect being able to reduce these biases. CMIP5 and CORDEX simulation products will be part of this investigation. So **ACASIS addresses the first thematic axis of the call**. ACASIS will also develop an interdisciplinary investigation of the heat wave "object" thanks to its multidisciplinary consortium and his expertise on these fields, and will evaluate the impact of this phenomenon in terms of public health. Then **ACASIS addresses also the fourth thematic axis of the call** as a secondary axis**.**

ACASIS will take advantage of the efforts developed these last ten years (or more) in terms of intensive, medium and long term observation networks in the AMMA international program, as well as the knowledge gained within this program and the tools developed (for instance the AMMAMIP platform of intercomparison of regional and climate models and evaluation against AMMA observations). As emphasized above, it will also benefit from its connections with the distinct but complementary ongoing ESCAPE project. It will contribute strongly to the international THORPEX-Africa program focused in predictability and forecast of extreme meteorological events. It will also contribute to the French DEPHY project (Développement et Evaluation des PHYsiques des modèles de climat et de prevision du temps) through the evaluation and reduction of biases in French climate models.

3. PROGRAMME SCIENTIFIQUE ET TECHNIQUE, ORGANISATION DU PROJET / SCIENTIFIC AND TECHNICAL PROGRAMME, PROJECT ORGANISATION

3.1. PROGRAMME SCIENTIFIQUE ET STRUCTURATION DU PROJET / SCIENTIFIC PROGRAMME AND PROJECT STRUCTURE

The project is organized in 7 Tasks (see chart below). Each Task has been assigned a leader who will be in charge of the good achievement of the work and timely delivery of outputs. Task 1 is in charge of coordination and animation, and assures the links with African partners. It is also in charge of the

dissemination of the results (Task 7). The coordinator (S. Janicot, LOCEAN) will not be in charge of any of the scientific tasks, so as to be fully available. Together with the coordinator, the Task leaders will form an executive committee who will monitor the project and meet on a regular basis through videoconferencing. Besides specific Task meetings, three workshops (kick-off, mid-term, final) will be organized for all the project participants with the purpose to specially emphasize Tasks interactions. A management committee will be also set-up gathering Task leaders and African partners leaders at these workshops.
The Heat Wave (HW) “object” is at the centre of the project. Task 2 will extract, store and evaluate the quality of the different datasets necessary for the other Tasks of the project. Homogeneity tests will be carried out in order to deliver back these new products to the meteorological services of Senegal and Burkina. Task 3 will characterize the variability of West African heat waves and analyse associated large-scale atmospheric configurations, then document their low-frequency component and assess their potential predictability and document the skill of current state-of-the-art weather forecasting models for predicting such events. Evaluation of forecasts will also be done over the population sites used in Task 5 through downscaling procedures. In parallel, Task 4 will investigate the physics and couplings of the heat wave events, in particular through specific case studies identified in Task 3, and work more generally at the understanding and reduction of the climate model biases critical for heat wave modelling and forecast. Task 5 will analyse the heat wave events in terms of physiological, societal and environmental vulnerability, and establish as precisely as possible the statistical links between critical variables as temperature and humidity and morbidity/mortality occurrences through data analysis and ensemble of interviews in four sites of health and demographic surveillance system (HDSS), two in Burkina and two in Senegal. Adaptative capacity of the populations of these sites will be evaluate too. All the results from Tasks 2 to 5 will be combined into Task 6 in order to set-up a pre-operational warning system tailored to the population needs. Workshops gathering ACASIS partners and identified stakeholders and public institutions will be organized (one in the first part of the project and a second one near the end) to evaluate the usefulness of the products that ACASIS could provide, identify the remaining gaps and produce recommendations for a better information about heat wave occurrences and related health risks. Task 7 will support the dissemination of these results.
The project, if it is funded, will be presented as far as it is necessary to ethical commissions to be validated.

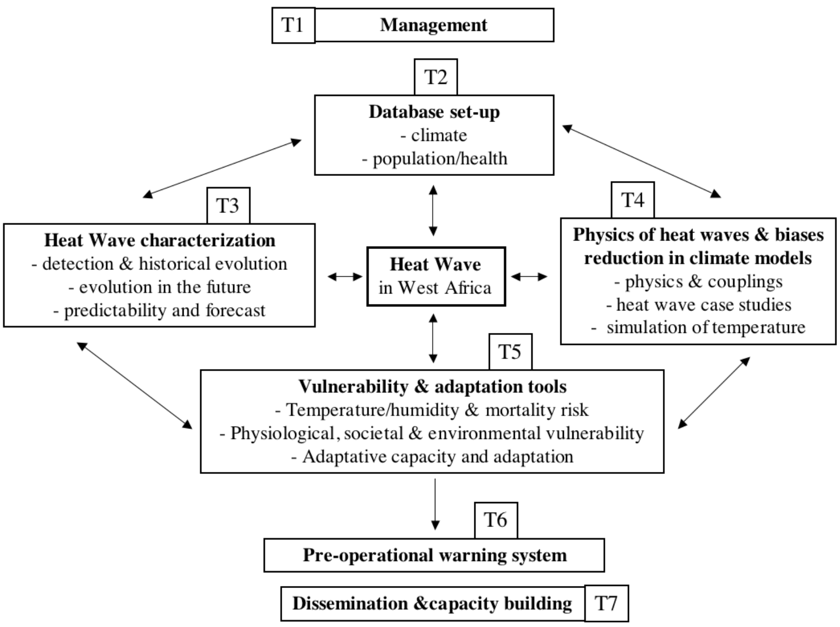


Chart of the organization of the project

A short presentation of the HDSS data available has been given above. It shows that despite we will operate in a "difficult" area where survey networks and databases are deficient, the data that we will work with are of quality and with sufficient samples to provide a good support for the realization of the project. The map on Fig.3 shows the mean temperature at 2 meters in April-May, and the stars (two green over Burkina and four (three red and one green) over Senegal) localize the HDSS sites. Spring is the season we focus on because it is the period of the highest mean temperature along the year over the Sahel. Sites in Burkina are located within the area of mean temperatures higher than 32°C, while a strong zonal temperature gradient is present over Senegal. The inter-comparison of the sites will be very interesting in this context. Note that they are outside of orange and red security areas produced by the Ministry of Foreign Office.

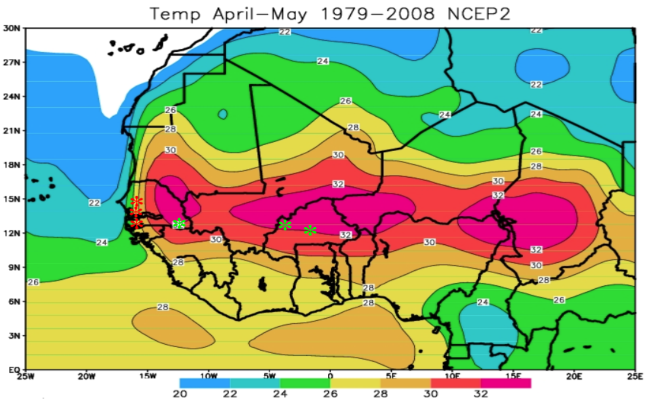


Fig.3: Mean April-May temperature at 2m from NCEP2 data

Meteorological tations data are available over Senegal and Burkina at least from 1980 to present, both through the GTS (12 for Senegal, 9 for Burkina) on the AMMA database, and locally at the two meteorological agencies. For a high part of them, data are available from 1950. Dunn's paper (2012) presents a free dataset of qualified daily synoptic data over the world where most of the stations presently available over Senegal and Burkina in the project were retained as qualified in this dataset.

3.2. DESCRIPTION DES TRAVAUX PAR TÂCHE / DESCRIPTION BY TASK

Task 1 : Management

Task leader: Serge Janicot (LOCEAN)

The general objective of this Task is to carry out the coordination and animation, and assures the links with African partners. It is also in charge of the dissemination of the results (Task 7). Together with the coordinator, the Task leaders will form an executive committee who will monitor the project and meet on a regular basis through videoconferencing. Besides specific Task meetings, three workshops (kick-off, mid-term, final) will be organized for all the project participants with the purpose to specially emphasize Tasks interactions. A management committee will be also set-up gathering Task leaders and African partners leaders at these workshops.

Task 2 : Database set-up of measured climate and population/health variables

Task leader: Laurence Fleury (SEDOO/OMP)

Teams involved: SEDOO (Brissebrat, 3-month CDD funded by ANR)**, LOCEAN/IPSL** (Ramage, Bouffies-Cloche)**, ANACIM** (Ndiaye), **DGM** (Yaka), **CRSN** (Diboulo), **ISSP** (Soura), **LPED** (Delaunay)

The general objectives of this WP are (i) to inventory and store all the data available among the partners in terms of synoptic daily meteorological and population observatories data over Senegal and Burkina, inventory supplementary synoptic data over the other West African countries, as well as reanalyses data and CMIP5 products; (ii) participate to a workshop at Meteo-France and bringing meteorological data from Senegal and Burkina to learn and apply quality tests as well as homogeneity tests in order to build, if possible, reference daily time series. One can notice that the Dunn's dataset (see Task 2.1) contains qualified data from meteorological stations and that most of the stations presently available over Senegal and Burkina in the project are stations that were retained in the Dunn's dataset. That means that all the studies depending on the presently available meteorological stations can start without waiting for supplementary quality and homogenization tests that will be applied during the first semester of the project.

Task 2.1 (SEDOO/OMP, LOCEAN/IPSL, ANACIM, DGM) : Inventory of daily meteorological and climate data bases which can be used for the project *[Resp. L. Fleury]*

Concerning historical meteorological and climate data, it includes (i) synoptic data on the AMMA data base and at ECMWF, on R. Morel's data base, on Meteorological Services at Dakar and Ouagadougou, and a new database of daily synoptic data available from Dunn et al. (2012); (ii) reanalyses ERA-Interim, NCEP2, MERRA, CFSR; (iii) CMIP5/AR5 multi-models simulations (control, historical with/without natural/anthropogenic forcings, AMIP-type, RCP scenarios); (iv) ensembles of multi-models forecast products of TIGGE, new ensemble of NOAA reforecasts, SPECS and EUROSIP seasonal forecast products. Concerning thermodynamical processes data, it includes the AMMA-CATCH and some satellite data.
M2.1a T0+2: identification of relevant meteorological and climate data [Fleury]

Task 2.2 (LPED, CRSN, ISSP) : Inventory of population observatories data which can be used for the project *[Resp. LPED]*

It concerns all the data available at the beginning of the project in the various population observatory sites. The common periods with the meteorological and climate data available in Task 2.1 will be defined.
M2.2a T0+2: identification of relevant population observatory data [LPED]

Task 2.3 (SEDOO/OMP) : Inventory of new daily meteorological and climate data bases which can be used for the project *[Resp. L. Fleury]*

Extract new data not yet stored and store them on the AMMA database when necessary. identification of daily synoptic data of the same station coming from different data sets.
M2.3a T0+4: Extension of the meteorological and climate data base [Fleury]

Task 2.4 (SEDOO/OMP ANACIM, DGM) : Homogenization of daily meteorological data *[Resp. ANACIM & DGM]*

The participation of ANACIM and DGM to a workshop organized by Meteo-France at Toulouse on the homogenization of meteorological data will enable to identify missing data and outliers with quality tests, and learn to apply homogeneity tests on the monthly and daily temperature data over Senegal and Burkina in order to evaluate the possibility to build homogenized time series in the context of African networks, using a R software developed through the European COST-HOME action (Venema et al. 2012). Provide back Senegal and Burkina meteorological services with these datasets. Make recommendations at the end of this exercise to be valuable for other African countries networks.
D2.4a T0+6: Produce homogenized synoptic data of Senegal and Burkina stations [ANACIM & DGM]

Task 3 : Heat waves over West Africa: characterization, historical and future evolution, predictability and forecast

Task leader: Benjamin Pohl (CRC)
Teams involved: CNRM (Déqué, Guichard, Roehrig)**, CRC** (Fontaine, Martiny, Pohl, Roucou, Ullmann + Moron [CEREGE] + Diedhiou, Rome, Pellarin [LTHE] + Camara [univ. Ziguinchor, Sénégal])**, LOCEAN** (Sultan + Bastin, Brogniez [LATMOS]), **ANACIM** (Ndiaye, Diongue)**, LPAOSF** (Gaye, Sall, Badiane)**, UGB** (Deme, Diop), **DGM** (Yaka), 18-month Post-Doc funded by ANR for CRC-CEREGE-LTHE common activities

The general objectives of this Task are (i) to characterize the variability of West African heat waves (HWs) in time and space (spatial coherence, persistence, frequency, ...) and analyse associated large-scale atmospheric configurations (influence from remote regions, favourable background conditions, teleconnections, possible relationships with modes of large-scale atmospheric variability, ...); (ii) document their low-frequency component (recent evolutions according to in situ measurements, reanalyses and GCM hindcast simulations on the one hand, and future trends as simulated by CMIP5 models for the 21st century on the other hand), and (iii) assess their potential predictability and document the skill of current state-of-the-art weather forecasting models for predicting such events. Data available at ANACIM, LPAOSF and DGM, will be used to better characterize the local conditions associated with HWs. An 18-month post-doc support is requested for Tasks 3.1-3.2.

Task 3.1 (CNRM, CRC, LOCEAN, LPAOSF, UGB): Detection of heat waves over West Africa, their atmospheric patterns, frequency, duration, historical evolution over the last three decades *[Resp. A. Diedhiou]*

Based on Task 2, the **first step** consists in selecting stations and periods over Senegal and Burkina, to study HW occurrences (ideally: at least ten stations per country cover a 30-year period ending in 2012 of daily temperature data). National or sub-national daily indices based on observation will next be computed, and compared with indices derived from the reanalyses and satellite products (e.g., MODIS) over the same periods. The quality of the various reanalyses available (ERA-Interim, CFSR, MERRA, NCEP2) in terms of representation of West African HWs will be addressed. The spatial signature of HWs will be analyzed by classifying lower-layer temperature patterns (e.g., T2m) in order to identify statistically robust, and temporally recurrent structures.

Close analysis of the spatial coherence of the identified patterns (or symmetrically, of the spatial representativity of selected observations) will be carried out. Are HW events predominantly organized spatially at regional scales encompassing the whole West African region, or sub-regional variability corresponding to "national" HWs identified by most national weather services, or even at "local" scales corresponding to the sites of the observational stations? Are long-term positive trends of temperature (over the last three decades at least) discernible for the available stations, and to what extent do they vary spatially (i.e., what is the spatial coherence of long-term trends over the region) ? The urban context of some of the selected stations needs also to be taken account since (i) it could alter temperature measurements, although probably much less than in developed countries where heating and air cooling devices are much more frequent; (ii) the development of cities could have amplifying effects locally. For instance, can we detect a urban heat island trend for Dakar and Ouagadougou in comparison with the other surrounding stations ? (our current knowledge and field experience tends us to answer no but it needs to be checked).

It should be noted that no formal homogenisation procedure will be applied at a first stage (this will be done in Task 2.4 (M6) and will be used later to revisit the results): the use of many stations and the fact that their quality are a priori good (see remark above about Nunn's paper) will reduce possible biases arising from occasional spurious glitches.

M3.1a T0+6: identification of relevant stations and constitution of a coherent database; assessment of the quality of reanalysis and satellite products [Guichard, Fontaine]

M3.1b T0+12: analysis of the recurrent spatial patterns of HWs and their spatial coherence [Martiny, Ullmann, Roucou]

D3.1a T0+18: publication on the spatial organization of HW events over West Africa [Martiny, Ullmann, Roucou]

Since there is no objective and uniform definition of HW events, a review of their various definitions in the literature is needed (**second step**). It is also proposed to assess which related atmospheric variables (daily mean temperature, maximum and minimum, wet bulb temperature) and associated thresholds should be used to monitor HWs and provide results both coherent physically and relevant for impact studies (see Task 5). These definitions will then be tested in order to select one. In collaboration with Task 5 it will be attempted to define new indicators close to the perception of the population, and use them henceforth whenever possible.

This task will be a basis for computing a composite HW and selecting a case study (or a few contrasted case studies) that will be analysed in details in Task 4 through dedicated model simulations. These cases should be as representative as possible of West African HWs. Due to the increased vulnerability of local population, and as said above, focus will be on the warmest seasons (northern spring and summer).

M3.1c T0+6: review of the various definitions of HWs and identification of a metrics (atmospheric variables, thresholds and persistence) used to define HW composites (collab. Task 5) [Camara, Fontaine, Diedhiou, Rome, Pellarin]

M3.1d T0+9: identification of relevant HW case studies (collab. Task 4) [Camara, Fontaine, Guichard, Diedhiou, Roehrig, Rome, Pellarin]

Over the last three decades and using various reanalyses it is proposed here (**third step**) to adopt the composite approach defined in the previous step in order to examine (i) the atmospheric configurations associated with HWs over Senegal / Burkina, (ii) their synoptic evolution, including their development, mature and decaying stages, and possible propagations of associated atmospheric and surface anomalies, and (iii) possible relationships with adjacent / remote regions. This analysis should include usual atmospheric fields (vertical profiles of air humidity and temperature, horizontal and vertical components of the wind, surface pressure, ...), indices describing large-scale variability patterns (e.g., NAO, ENSO, MJO, Atlantic/Mediterranean SST, ...). The aims here are (i) to identify possible precursors, and (ii) possible teleconnections with larger scale climate conditions. Such teleconnections could either denote an influence of modes of large-scale climate variability (which are, or not, intrinsic to the West African region), and / or favourable background conditions, and / or significant associations with remote regions (such as the Mediterranean or the Asian monsoon).

M3.1e T0+12: analysis of atmospheric configurations associated with HW events using reanalysis [Camara, Fontaine, Diedhiou]

D3.1b T0+18: publication on synoptic/atmospheric configurations associated with HW events [Camara, Fontaine, Diedhiou, Rome, Pellarin]

M3.1f T0+18: analysis of teleconnections and relationships with remote regions [Bastin, Brogniez, Diedhiou]

D3.1c T0+24: publication on HW teleconnections and relationships with remote regions [Bastin, Brogniez, Diedhiou]

The **fourth step** aims at analyzing issues similar and complementary to the third step, but the other way round. We attempt here to carry out a general analysis of atmospheric weather types, and explore to what extent they are relevant for HW analysis. It is first required to test different classifications into weather types / regimes (like fuzzy classifications, k-means or self-organizing maps). It can next be determined (i) to which weather type(s) HWs correspond; (ii) whether one can observe an evolution along the last three decades of the frequency and / or intrinsic properties (e.g. lower-layer temperature anomalies) of such types. Then, we plan to assess to what extent such types are useful to explain local / national / regional HW signals such as identified in the first step, including their characteristic spatial extensions. In particular, can we build a transfer function between the weather types and the probability distribution functions of local daily temperatures through statistical downscaling ? Such weather type approach will first be applied to current reanalysis products, in line once again with step 1. It can also be used with hindcast AGCM or CMIP5 simulations, and / or projected onto daily fields provided by recent re-forecasting products (such as TIGGE or NOAA's RF2 ensembles), in line with 3.3.

M3.1g T0+12: determination of recurrent weather types using various partitioning or classification algorithms, and their relationships with HW events at synoptic timescale and for low-frequency variability [Moron, Ullmann]

M3.1h T0+18: application of the same approach for AGCM outputs, seasonal forecasting and medium-range reforecasting ensemble runs [Moron, Pohl for link with T2.3, Ullmann]
D3.1d T0+24: publication on weather regimes and their usefulness (hopefully) for HW event analysis [Moron, Ullmann]

Task 3.2 (CNRM, CRC, LOCEAN, ANACIM): Evolution of African HWs in CMIP5/AR5 simulations and role of different forcings *[Resp. P. Roucou]*

We aim here at investigating the long-term evolutions of heat waves as simulated by GCM (Global Climate Model) and RCM (Regional Climate Model), using the CMIP5 and CORDEX-Africa modelling exercises.

The **first step** of this task is dedicated to CMIP5/AR5 GCM simulations (considering both control / hindcast runs and climate projections over the 21st century). We aim here at comparing HW statistics and their patterns depending on the type of forcings over the historical period, and then doing the same depending on the scenarios (representative concentration pathways, RCP) for future greenhouse gases evolutions. The CMIP5/AR5 database will be analysed with the diagnostics defined in Task 3.1. Weather regimes computed in observation will be compared to their counterparts for GCM simulations for present conditions. Simulated evolutions over the century can then be analysed as long-term evolutions of their frequency / intrinsic properties. Besides, as improved versions of the physics of participating models will be available from Task 4 along the project, the sensitivity to the model physics of the simulated long-term trends will be assessed. These analyses allow documenting how short-lived (synoptic-scale) HW events evolve / are modified by / contribute to the simulated long-term trends. Note complementarities here between Tasks 3.2 and 4.3, as the latter aims at identifying climatic changes arising from robust larger-scale features

M3.2a T0+24: documentation and assessment of West African HW events in CMIP5 simulations (hindcast and RCP) [Roehrig, Roucou, Ullmann]
D3.2a T0+30: publication on HW evolutions over West Africa according to CMIP5 simulations [Roehrig, Roucou, Ullmann]

The **second step** proposes to use the same methodologies for the CORDEX-Africa database. Compared to the first step of the task, focus is given here on the potential added-value provided by RCM (such as the inter-model spread compared to that of the forcing GCM, leading to reduced uncertainties). Of course, the increased horizontal resolution (50km) should allow for a more realistic regionalization of the variables identified in Task 3.1 to be relevant for HW analysis. As for CMIP5 data, both the control simulations and climate projections (periods 2030-2050 and 2080-2100) will be considered. In addition, we will consider ERA-Interim (1989-2008) driven simulations, which enable to investigate the quality of the RCM irrespective of their driving GCM.

M3.2b T0+24: documentation and assessment of West African HWs in CORDEX-Africa simulations (control and RCP) [Bastin, Déqué, Roehrig, Roucou, Diedhiou]
D3.2b T0+30: publication on HW events over West Africa simulated by CORDEX-Africa regional climate models: uncertainties and evolutions [Bastin, Déqué, Roehrig, Roucou, Diedhiou]

Task 3.3 (CNRM, CRC, LOCEAN, ANACIM): Predictability and forecast of African HWs and associated uncertainties *[Resp. M Déqué]*

The **first step** of this task is devoted to document the predictability of HW synoptic-scale events using the recent medium-range re-forecasting products made available by various weather forecasting centres over a few recent years. It consists thus in exploring the TIGGE database of multi-model forecast products (period 2008-2012) up to the 15-day range with the diagnostics defined in Task 2.1. The 15-day forecast skill of HW synoptic-scale events within the new NOAA re-forecast2 ensemble products (1985 onwards) will also be assessed. Our goals are to evaluate the models' skills using different scores and associated level of uncertainty. In the TIGGE database, is there a "best" model, in terms of West African HW forecasts ? We will also address what controls the forecast skill (or predictability) of HW events, especially in terms of large-scale environment, by distinguishing at least two categories of events (predicted and missed).

M3.3a T0+12: documentation and assessment of the HW predictability and model skills in TIGGE and NOAA re-forecast2 products, and analysis of associated uncertainties [Pohl, Sultan]

D3.3a T0+18: publication on HW predictability and uncertainties [Pohl, Sultan]

In a **second step** we plan to evaluate the most extended range of skilful HW forecasts in the ensemble seasonal forecast products of the SPECS and EUROSIP projects. We will investigate both the chronology of HW (month 1) and the probability of occurrence (month 1 to 4). If some of these products show some interest, they could be considered in the operational production line at Meteo-France through the monthly bulletin. The forecast will be essentially multi-model but downscaling computations on the Meteo-France forecast will be applied for a better calibration of the local temperature if the quality of the large-scale prediction is of sufficient quality.

M3.3b T0+18: evaluation of potential predictability from SPECS stream 1 experiments [Déqué]

D3.3b T0+36: a publication on the consolidated results including EUROSIP system 5 hindcasts and SPECS stream 2 experiments [Déqué]

Task 4 : Physics of heat waves and bias reduction in models

Task leaders: Françoise Guichard (CNRM-GAME) and Frédéric Hourdin (LMD/IPSL)

Teams involved: CNRM-GAME (Beau, Bouniol, Couvreux, Déqué, Favot, Guichard, Honnert, Joly, Labadie, Piriou, Roehrig, Kergoat + Mougin [GET], Experts: Bouyssel, Arbogast, Mestre + Chaboureau [LA], 12-month Post-Doc funded by ANR), **LOCEAN** (+ Armante, Cheruy, Crevoisier, Hourdin, Mellul, Musat, Lefebvre, Rio, Sèze, Experts: Alain Chédin [LMD], + Bastin [Latmos], 12-month Post-Doc funded by ANR), **CRC** (Pohl, Fontaine), **LPAOSF** (Gaye)

Up to now, the physics of Sahelian spring temperature and heat waves has never been studied as such, and the work proposed hereafter aims first at filling this gap. Multi-year datasets will be used for this purpose, and also to provide basic guidances for models. The second objective is to assess and to improve the physical parametrizations employed in models. A multi-day case-study will be selected and documented with both local and larger-scale datasets and used to test models and share work on this issue. The third and last objective of this Task is to improve the simulation of temperature at large-scale in climate models and to identify indirect but robust information that can be extracted from climate models concerning heat waves and their climatic evolutions. Notice that Task 4 is jointly carried out by researchers of complementary expertises on processes and on parametrizations, and involves collaborative work with Tasks 3 and 6.

Task 4.1 (CNRM-GAME, LOCEAN): Document and understand the physics and couplings operating in spring and during heat waves *[Resp. Guichard]*

Our goal is first to identify and understand the processes that control near surface temperature in spring and to document better, in particular, the influence of water vapour, aerosols and clouds on radiative processes, and how they balance with boundary layer turbulence and advection to lead to the observed temperatures. To do so, we will exploit the multi-year automatic weather stations and surface flux stations datasets provided by AMMA-Catch, and where available, collocated Photon Aeronet, radio-soundings, GPS and ARM data, together with information from satellite above each site (MSG cloud product and land surface temperature, IASI...).

Statistical analyses of the observed (co)fluctuations of temperature, water vapour, surface fluxes, clouds and aerosols in spring will be performed in order to identify in a systematic way the couplings arising between thermodynamics and radiative fluxes; the influence of wind conditions on these couplings will be addressed and the differences prevailing between daytime and nighttime conditions worked out. These analyses will be complemented by budget studies where collocated high-frequency soundings are available.

Finally, daytime and nighttime temperature-humidity couplings in close and more remote SYNOP data will be analysed in order to assess their variations in space, at small scale but also in latitude and between the western and central Sahel. The physics of spring heat waves themselves will be characterized more specifically (using Task 3 detected events). We will determine the day-to-day evolution of heat wave diurnal and nocturnal temperature anomalies, and how they couple with anomalies in other variables (water vapour at the surface and precipitable water, aerosols and clouds as well as surface fluxes). We will also analyse whether the locally identified surface heat wave sequences are associated with consistent changes in boundary-layer structure, low-level wind and advection.

In order to analyse the relative influence of water vapour, clouds and aerosols on radiative fluxes, 1D computations will be performed with the RRTM model (the radiative transfer scheme employed in most of our models). We will also test the importance of surface properties and boundary layer structures (e.g. nighttime stable stratifications) on surface fluxes. The atmospheric soundings used here together with radiative estimations are expected to further help interpreting observations of surface fluxes as well as top-of-the-atmosphere satellite data, IASI observations in particular. The complementarity provided by satellite datasets available over the recent years (ClouSat-Calipso, Caliop, MSG cloud and land surface products, IASI) will be used to further document the physical processes taking place in spring and during heat waves at larger scale. The analysis will be focused at first at mesoscale on the Senegal, Burkina and Catch sites and then extended to the West African region as a whole. If relevant, this work will allow to design a physical heat wave composite, which is of interest for basic understanding, but also model evaluation (collab. Tasks 3 and 6).

M4.1a T0+12: Temperature in spring: budgets and couplings in local datasets [Guichard, Hourdin, Kergoat]
D4.1a T0+18: Influences of water vapour, clouds and aerosols on surface radiation: data-based local studies [Guichard, Couvreux, Kergoat]
D4.1b T0+18: Diurnal fluctuations, boundary layers and clouds of heat waves [Couvreux, Bouniol, Cheruy, Seze]
M4.1b T0+24: Interpretation of IASI observations with data and RRTM radiative estimations [Armante, Crevoisier, Hourdin]
D4.1c T0+24: Documentation of heat waves at larger scales with satellite and synop datasets [Bouniol, Armante, Guichard, Seze]

<u>**Task 4.2 (CNRM-GAME, CRC, LOCEAN, LPAOSF):** Simulations of heat waves in a forecast mode: focus on a case-study</u> *[Resp. Roehrig and Couvreux]*

As an efficient way to assess the role of physical parametrizations for heat waves, we propose to focus on the simulation of a particular case-study selected from those identified in Task 3 and extensively documented with local and larger-scale high-frequency datasets. In this way, we will be able to provide a detailed account of the chronology of the heat waves, all along its life cycle.

Distinct types of simulations will be performed, with different models. First, we will perform reference high–resolution (1-3 km) cloud resolving simulations with Meso-NH and AROME to address the role of processes on the heat wave dynamics as simulated in state of the art mesoscale models. The sensitivity of the results to dust and boundary layer parametrizations, and to resolution will be analysed. WRF simulations will also be carried out with a set of sensitivities to surface, boundary layer and radiative parametrizations. Simulations will be performed with large-scale climate models as well, using configurations such that the large-scale environment can be constrained to remain close to observed (this can be achieved for instance by a "nudging" towards meteorological analyses, applied everywhere outside the region of interest). Simulations will be performed both with standard global grid configurations (resolution of 150-250 km) of the IPSL LMDZ and CNRM Arpege models, and with finer grids (30-80 km) using zoomed or limited area versions of the same models in order to assess the sensitivity to horizontal resolution. Several new parametrizations will be tested on this case, including the new ARPEGE CMIP6 physical package, and the recently developed dust module of the IPSL model. More academic tests could be performed too for testing the significance of clouds, dusts or surface properties on the heat wave life cycle.

On the basis of these simulations, we aim to address the capabilities of the sets of physical parametrizations to capture the heat wave main properties, including its temporal evolution. Thus, we will evaluate the simulations with local and satellite data, and as opposed to common practice, at fine, sub-diurnal time scale. Apart from diagnostics such as diurnal cycle of surface air temperature and humidity, surface energy budget and clouds, we will analyse the simulated boundary layers, evaluate the thermodynamic-radiative couplings obtained from the different simulations, assess the sensitivity of the simulated heat wave life cycle to the parametrized physics. The simulations are further expected to allow addressing the importance of remote versus local factors on the predictability of the heat wave at this scale.

As a result of this exercise, we will be able to provide useful guidance about the major issues encountered with parametrized processes in large-scale models, including forecast models, together with recommendations. Depending on our results, it may even be possible to propose the implementation of well-suited heat wave forecast indexes into operational French models.

M4.2a T0+18 Selection and preparation of observationally-based documentation of the case study [Fontaine, Guichard] (collab. with Task 3)
M4.2b T0+24 Definition of simulation set ups, sensitivity tests and common outputs [Roehrig, Couvreux]
D4.2a T0+36 Evaluation of the simulations (CNRM, CRC, LMD) [Couvreux, Beau, Roehrig, Guichard, Hourdin] (collab. with Task 6)
D4.2b T0+48 Report on the capabilities of models to simulate heat wave and recommendations for forecast systems [Roehrig, Pohl, Bouyssel, Déqué (joint with Task 32)

Task 4.3 (CNRM-GAME, CRC, LOCEAN) : Simulation of mean temperature in spring with climate models *[Resp. Hourdin]*

For longer time scales, in view of the very large temperature biases affecting CMIP5 climate models in spring over the Sahel and Sahara, we think that is critical to reduce biases and aim to do so by carrying the work presented below.

Process and budget studies will be extended beyond case-studies to analyse the simulation of the mean spring temperature. The physical sources of biases are probably not unique, including the representation of surface-atmosphere radiative and turbulent fluxes exchanges, the dynamics of the boundary layer and nocturnal turbulent processes, and their sensitivity to surface, water vapour, aerosols and clouds. Recently, several physically-based parametrizations have been developed both at LMD and CNRM, in order precisely to better account for these processes. This project offers a unique opportunity to evaluate and improve these new parametrizations.

The boundary layer and cloud parametrizations (LMDZ and ARPEGE) and the dust module (LMDZ) in particular will be extensively tested, with results systematically compared to surface and satellite data across the west African meridional transect. The new physical packages will be tested both in climatic mode (the model is run freely over several years, forced only by radiation and sea surface temperatures) and in a more constrained mode, by keeping the model close to the observed synoptic situation, either by relaxing the winds toward reanalysis (nudging + zoom configuration for LMDZ) or by running short initialized simulations (transpose AMIP protocol, ARPEGE). Contrasting climatic and constrained configurations will allow to determine better the source of temperature biases and the relative importance of large-scale and long versus short term and more local drifts on biases.

High-frequency CMIP5-type type outputs will also be used to assess improvements in the simulations (note that we plan to add a few points to the list of AMMA points previously defined for CMIP5, in order to include both the Burkina and Senegal sites). With these outputs, we will be able to evaluate the realism of the balances arising between physical and dynamic processes and their sensitivities to parametrizations.

The outcome of this work will be a reduction of the mean temperature biases over the Sahel, with considerations of both Tmin and Tmax values, and an improvement of the thermodynamic-surface radiative couplings in models.

Beyond present day biases, we will analyse how the physics contribute to the temperature changes over the Sahel during spring. The anticipation of a significant global warming under the effect of greenhouse gazes increase due to human activity is now well established. The dispersion in the sensitivity of the global temperature to greenhouse gases, which remains quite large (typically a factor of 2 in global warming between the most and less sensitive models), will in part determine the dispersion of the climate change response at regional scales. The regional warming will also in part differ from the global response. The warming is for instance generally expected to be stronger over continents than over oceans, or stronger in high than in low latitudes. This amplification factor, i.e. the ratio of the regional/seasonal warming to the mean global warming, may also vary significantly from one model to another. Preliminary analyses of observations of the 20th century observations suggest that warming has been particularly strong over the Sahel, with a mean warming of typically 2 K to be compared to an elevation of about 0.5 K of the global average. Based on the analysis of existing CMIP5 simulations, and on specific simulations conducted with LMDZ, we will assess which physical, local or remote process, affect the amplification of global warming over the Sahel during spring, and thus help reduce the uncertainty in this regional amplification. The simulations will all be conducted with imposed sea-surface-temperature because biases in coupled atmosphere-ocean models are too large so far on the region. Various forcing will be prescribed, such as increased greenhouse gas concentration and warmer sea-surface temperature, for simulations conducted with or without wind nudging, in order to separate the contribution of local and remote feedbacks to the warming amplification.

On the basis of this new knowledge, we will further seek to identify in CMIP5 simulations robust large-scale climatic changes which could potentially inform on the evolution of Sahelian heat waves in the future. This approach is motivated by current limitations associated with the direct utilization of simulations outputs and complement Task 3.2. For instance, nighttime surface air temperature appears to be extremely sensitive to fluctuations in low-level water vapour in the Sahel, so that models lacking this sensitivity (because they are overall too moist or dry, or because their parametrization of radiative processes is too crude) are likely to provide limited information from their simulated surface air temperature only. Indeed, a too-dry model could well overemphasize the importance of surface and boundary-layer nighttime processes in setting temperature minima while a too-moist model would damp this sensitivity.

At this stage, it is not possible to elaborate too much about robust large-scale features. However, a few recent studies provide valuable inferences here. For instance, Biasutti and Sobel (2009) point to a climatic change in the annual cycle of SST inducing a delay in the arrival of rainfall in the Sahel. As the summer cooling is mainly driven by rainfall, it means that the length of the warm season would increase in the future, and therefore, potentially, the frequency of heat waves. From another side, the constraints imposed by large-scale atmospheric circulations on the thermodynamics suggest limited changes of the relative humidity in the free troposphere (Sherwood et al 2006, 2010). Given a fixed relative humidity, a tropospheric warming thus implies an increase of precipitable water and changes in the diurnal temperature range associated with enhanced nighttime downwelling longwave radiation. Such large-scale constraints could drive changes in the mean properties of heat waves and their identification will be pursuit to help identify robust elements in climate change projections.

M4.3a T+12: Documentation of current results in LMDZ and ARPEGE [Hourdin, Roehrig]

D4.3a T+36: Reports on the improvement due to the new physical parametrizations in ARPEGE and LMDZ [Rio, Beau, Chéruy]

M4.3b T+36: Links between the spread in CMIP5 simulations over the Sahel and at global scale [Hourdin, Guichard]

D4.3b T+48: Assessment of robust changes in future heat waves [Roehrig, Pohl, Hourdin]

Task 5 : Objective n°5 : Health and societal vulnerability; towards to a new adaptation strategy

Task leaders: Richard Lalou (LPED)

Teams involved: LPED (Valérie Delaunay, Aldiouma Diallo, Stéphanie Dos Santos, Cheikh Sokna, Richard Lalou, 48-month PhD funded by ANR), **ISSP** (Abdaramane Soura, K. Kombassere, B. Lankouande), **CRSN** (Eric Diboulo), **UGB** (Diop, Diongue), **CSE** (Faye, Seck), **DGM** (Yaka)

The overall objective of this WP is to evaluate and characterize vulnerabilities in the Sahelian societies to extreme heat waves. It aims to better identify and understand the components of vulnerability of human health to extreme heat as well as to assess alternative strategies to manage negative health outcomes. From the routine data collected by HDSS in Burkina Faso and Senegal, we will first analyse the impact of extreme heat events on mortality and morbidity of the study sites' population over the past twenty-five years (task 5.1). Once this relationship is identified, we will examine to what extent some individual characteristics of vulnerability can modify the climate effect on mortality and morbidity during heat waves (task 5.2). Finally, we will measure, using specific surveys, the capacity of adaptation of populations to extreme heat (task 5.3). A support of a CDD of 48 months will be funded by ANR on Tasks 5.1 and 5.2.

<u>**Task 5.1 (LPED/URMITE, CRSN, ISSP):** Temperature and morbidity/mortality</u> *[Resp. G. Constantin de Magny et Eric Diboulo]*

In this sub-task, we will examine the association between temperature and mortality among population in the six HDSS sites for the 1990–2013 period. The central goal of time-series analyses in this context is to quantify the relationship between daily temperature and daily death counts (mortality rates), controlling for other potential confounding factors, such temporal trends and cycles in daily mortality and age-specific distribution of deaths. In time series studies, only factors that vary over time can pose problems of confounding, since the analysis focuses on day-to-day changes in temperature and associated mortality. The exposure assessment will involve four steps.

First step: Assess validity, reliability and matching possibilities between HDSS data. Information on dates and causes of death will be analyzed according to procedures of internal validity and also by using the mortality indicators in HDSS Niakhar and Dielmo sites for the common period 1987–1997, when routine monitoring was weekly. The maximum available data record for each city will be examined to give a more reliable representation of any associations with mortality, and more precise regression coefficients than if shorter periods were used. We will proceed also to the calculation of the annualized mortality rates by using the person-years method.

Second step: Summary statistics will be produced over the period 1990-2013 about the number, the age structure, and the temporal and spatial aggregation of excess of morbidity/mortality due to heat waves. Seasonal and inter-annual variability of heat related morbidity/mortality and climatic parameters (temperature, humidity…) will be investigated through wavelet analysis methodology as described in Cazelles et al. (2007) and Constantin de Magny et al. (2007). Correlation and synchrony between disease incidences dynamics and climatic parameters will be explored to identify key parameters that will be integrated in the modeling section.

Briefly, Fourier analysis has traditionally been used for time series analyses. This method is not always appropriate when dealing with complex population time series, since it cannot take into account the often-observed changes in the periodic behavior of such series (i.e., their lack of stationarity). Because epidemiological time-series are typically noisy, complex and strongly non-stationary, we therefore will use the more adapted wavelet analysis, which is well suited to the exploration of local variations in frequency (and periodicity) as time progresses. Wavelet coherency analysis, similar to some classical correlation will be used to quantify statistical relationships between disease incidence dynamics and the different climatic parameters (ground-truth and/or remotely sensed). Coherency analysis is methodology based on wavelets decomposition and used to quantify the relationships between two non-stationary signals. The coherence function calculated is a direct measure of the correlation between the spectra of two time-series. The advantage of this 'wavelet-based' method is that the correlation between the two spectra may vary in time and can detect transient associations. If correlation between two spectra is detected, the phase relationships between the two time series can be extracted and compared in order to characterize possible synchrony or delay by computing the phase difference.

Third step: Separate empirical–statistical non-linear regression models between daily maximum and minimum temperatures (Tmax & Tmin) and heat-related deaths (the difference between observed and expected deaths) will be develop for the six HDSS sites over the period 1990-2013 in order to model the current relationship between weather and heat-related mortality (Gosling et al., 2006; Kinney et al., 2008, Diboulo et al., 2012). Because strong seasonal cycles in mortality rates might bias an analysis of heat-related mortality, we will convert daily mortality counts into daily mortality *anomalies* or *excess mortality* by subtracting from daily mortality counts a stable mortality baseline for each day. Likewise, we proceed to age-standardization of the crude mortality rate to eliminate the bias of the population structure.

Fourth step: statistical modeling of relationship between Tmax and heat-related morbidity will be explored by counting records of consultation of patients attending health facilities located on the HDSS sites.

At the end of this study, the team will have established a standardized database on the dates and causes of death and the maximum and minimum temperatures for the six HDSS sites. Modeling of the temperature-mortality relationship will give rise to an analysis report and production of a scientific article.

M5.1 T0+10: Standardized database on the dates and causes of death and the maximum and minimum temperatures for the six HDSS sites.

D5.1 T0+18: Analysis report on the modeling of temperature/humidity-mortality relationship

Task 5.2 (LPED/URMITE, ISSP,CRSN, UGB, LOCEAN): Physiological, societal and environmental vulnerability *[Resp. Valérie Delaunay et Cheikh Sokhna]*

In the previous task, we have investigated the relationship between extreme temperatures and the short-term increase of daily deaths; this task will enable us to better evaluate the effects modification of social, medical and environmental vulnerabilities on the mortality risk associated with extreme temperature. The underlying idea behind this approach is that if a characteristic increases the risk of dying on an unusually hot day, we can expect that a greater proportion of the people who died during those days would have the characteristic, compared with people who died during milder weather periods. Thus, for example, if a characteristic is a risk modifier for deaths during unusually hot days, then unusually hot days should be a predictor of the occurrence of that characteristic on death certificates using logistic regression. To study which factors modify a person's risk due to a time-varying exposure, one may restrict analysis to the deceased persons. *The case-only approach* has been widely used in genetic epidemiology, and Armstrong has recently pointed out that it can be extended to study the acute effects of weather (Armstrong, 2003; Medina-Ramòn, 2006; Schwartz, 2005). In our study, we will apply this approach by comparing the individual characteristics of those dying on extremely hot days with those dying on other days.

Population factors—at the socio-economic, environmental and medical level—regarding the vulnerability to heat waves will be defined according to three components:

Greater exposure to the warmth of the household to which belongs the deceased: housing quality, scarcity of housing, housing in a densely populated area, exposure to the sun...

Frailty of the deceased: cause of death, age at death, co-morbidity...

An unfavorable socio-economic environment that reduces the capacity to adapt: lack of support of the household (size, composition), distance to health facilities, economic household level, lack of water in the compound, social and human capital of the head of household...

The mortality and weather series validated and the biases corrected during the previous step will be reused for this case-only analysis. The daily minimum and maximum temperature/humidity series will serve to define extremely hot days or periods.

D5.2 T0+30: Methodological and Analysis report on vulnerability factors associated to heat-related death risk (meta-analysis on six HDSS sites)

Task 5.3 (LPED, ISSP,CRSN, DGM, UGB, LOCEAN): Adaptive capacity and adaptation: study of the protective behaviour against extreme heat and dehydration *[Resp. Stéphanie Dos Santos, Abdramane Soura et Richard Lalou]*

Improving health outcomes related to exposure to extreme heat requires moving beyond the standard analysis of quantitative socio-demographic data toward understanding knowledge, attitudes and practices (KAP) regarding extreme heat events (EHE). Prevention of the health risks linked to EHE comprises 2 axes: i) household adaptations that include the measures taken by households to ventilate housing or maintain its freshness; (ii) individual adaptations that are essentially measures to freshen up personally or protect themselves against the heat. All these responses demand that vulnerable people and their families be educated to the EHE's threats and be informed on the measures that must be taken before and during an EHE. Overall, this study will be based on the framework developed by Wilhelmi and Hayden (2010).

In subtropical and tropical areas, more than elsewhere, the knowledge of heat waves and the perception of health risks associated with them should be a real challenge for public health. First, heat waves are less dramatic and conspicuous than other natural disasters, especially for populations living in hot conditions. Whereas most natural disasters pose a sudden and abrupt risk to human health, the danger of hyperthermia gradually increases with duration of exposure, as a person's ability to withstand excessive heat gradually diminishes over time; the epidemiologic evidence for this can be seen in the 2- to 3-day lag in mortality following the start of a heat wave. Second, along with individual perceptions of the risk of heat stroke during hot weather, economic factors should also play an important role. The measures to ventilate housing or to maintain its freshness, and to hydrate frequently impose a significant economic burden, especially on poor people living in developing countries.

In this study, we will describe populations' knowledge and perceptions of heat waves, their awareness of the health risks, the socioeconomics barriers to heat adaption and the degree to which they practice the protective behaviors recommended by public health. It will be conducted on four HDSS sites (two in Senegal and two in Burkina Faso). The information necessary for this study is not collected in routine. We will proceed to specific surveys, which will take place in two stages:

Participatory workshops and qualitative diagnosis surveys on each of the four sites. The researchers team will ask local stakeholders (health, meteorology) and populations about the recent heat waves, their perceptions of these extreme events, the health risks perceived and known and the responses given by the populations. These rapid investigations will indicate the latest heat wave that people remember, and the most common protection practices. This event and these practices will be documented in the second stage.

Questionnaire surveys in general population. On each site, households and individuals, drawn at random, will be surveyed on their knowledge and perceptions of EHE, attitudes and protective behaviors. The investigation will also characterize economic, social and human capital of households and their members, as well as their conditions of life and housing. The questionnaire will draw on the investigation tools of the ESCAPE project (ANR grant, program CEP&S 2010), designed to collect and validate information about the perception of climate change and extreme events. It will be the same for all four sites of investigation.

D5.3a T0+ 24: HDSS site reports and synthesis report on participatory workshops ;
M5.3a T0+24: Semi-structured interviews records ;
M5.3b T0+36: Survey questionnaire and datafile.
D5.3b T0+42: HDSS site reports on knowledge and perceptions of EHE and synthesis report ;
D5.3c T0+46: HDSS site reports on adaptive capacities and protective behaviors against extreme heat, and synthesis report.

Task 6 : Objective n°6 : Pre-operational warning system

Task leaders: Ousmane Ndiaye (ANACIM) & Pascal Yaka (DGM)

Teams involved: ANACIM (Ndiaye, Diongue)**, DGM** (Yaka), **CNRM-GAME** (Roehrig, 12-month Post-Doc funded by ANR)**, LPED** (Lalou), **ISSP** (Soura), **CRSN** (Diboulo), **CSE** (Ndione), **CRC** (Pohl), **LPAOSF** (Gaye)**, UGB** (Deme, Diop), **SEDOO/OMP** (Fleury, 3-month CDD funded by ANR) **LOCEAN** (Janicot)

All the results from Tasks 2 to 5 will be combined into Task 6 in order to set-up a pre-operational warning system tailored to the population needs. Workshops gathering ACASIS partners and identified stakeholders and public institutions will be organized (one in the first part of the project and a second one near the end) to evaluate the usefulness of the products that ACASIS could provide, identify the remaining gaps in the process chain and the synergy between institutions of health x and of public security, and produce recommendations for a better information about heat wave occurrences and related health risks.
A framework for the pre-operational warning system could be build around the following components :

- Early warning and HW detection components:
    - a) Weather and climate scale (lead-time in days to months)
    - b) Monitoring of Heat wave risk factors
- Heat wave Control response:
    - a) Assess opportunities for timely temperature control and act accordingly
    - b) Raise community awareness and call for greater personal protection
    - c) Ensure prompt and effective case management
- Post Heat wave assessment:
    - a) Was the early warning system useful?
    - b) Were the indicators sufficiently sensitive/specific?
    - c) Were effective preventive opportunities enabled?
    - d) What were the strengths/weakness in control operations?
    - e) Does the HW preparedness plan need to be modified?

Task 6.1 (CNRM-GAME, ANACIM, DGM, CRC, SEDOO/OMP): Implementation of HW diagnostics on the MISVA platform *[Resp. R. Roehrig]*

The MISVA framework aims at initiating and helping in the transfer of knowledge acquired during the AMMA project regarding intraseasonal variability into operations. A website (http://isv.sedoo.fr) was implemented, with various diagnostics derived from the ECMWF forecast system made available during the monsoon season (June-September) to monitor in near real time the intraseasonal fluctuations of the West African monsoon and to provide large-scale guidance to forecasters for issuing their forecasts. A close collaboration with ANACIM in Senegal was initiated two years ago with diagnostics more specific to Senegal.

The goal is here to use the framework of the MISVA platform as a "test-bed" to implement diagnostics dedicated to the monitoring and forecast of heat waves. The MISVA platform will be extended to the spring season with diagnostics issued from the various analyses performed within Task 3 and 4, according to their pertinence as analysed in Task 5. An emphasis will be put on Senegal and Burkina Faso, in collaboration with ANACIM and DGM. In particular, the statistical diagnostics developed in Task 3 will be adapted to the constraint of real time. A specific focus will be made on the use of the Météo-France operational deterministic and ensemble forecast systems for the computation of the relevant diagnostics. If needed, inline diagnostics will be tested within the Météo-France forecast system, on previous seasons. If shown relevant, recommendations will be issued to implement such inline diagnostics in the Météo-France operational forecast systems by the end or after the project. In addition, depending on their added value as evaluated in Task 3, the TIGGE dataset will also be used in addition to the ECMWF and Météo-France forecasts. Finally, benefit is expected from the established dialog between the CNRM-GAME and the ANACIM along the MISVA framework to evaluate the usefulness of these real-time diagnostics from the perspective of forecasters. ANACIM forecasting team will daily test products developed through MISVA platform during spring period and report on their usefulness in predicting heat wave in the medium range, typically one week ahead. The added value of MISVA products will be emphasized. Table of contingency will be dressed in order to measure the hits, misses, false alarm and correct on-events and drive scores.

All this will be achieved through the iterating and incremental development of weekly (or more frequent when relevant) syntheses on HW monitoring and forecast, in close collaboration with ANACIM and DGM. From the second year, and until its end, these syntheses will be issued during the Spring season, possibly completed by seasonal forecasts (Task 3.3). Diagnostics and synthesis format will be updated each year. Maps similar to those developed at Météo-France for heat wave alerts will be targeted. By the end of the project, if successful, we expect to transfer part of this pre-operational platform for HW forecasts to the Senegalese and Burkinabe meteorological services, for operational implementation and use.

M6.1a T0+12: implementation of HW diagnostics in the MISVA platform and development of weekly syntheses for real-time monitoring of the project second year Spring season [Roehrig, Bouyssel, Pohl, Ndiaye, Diongue]

M6.1b T0+24: update of HW diagnostics and weekly syntheses in the MISVA platform, with extension to Burkina Faso, for real-time HW monitoring of the project third year Spring season [Roehrig, Pohl, Ndiaye, Diongue, Yaka]

M6.1c T0+36: update of HW diagnostics and weekly syntheses in the MISVA platform for real-time HW monitoring of the project fourth year Spring season [Roehrig, Pohl, Ndiaye, Diongue, Yaka]

D6.1a T0+48: report or publication on the added value of HW diagnostics and weekly syntheses along the MISVA platform for HW monitoring and forecast over Senegal and Burkina Faso [Roehrig, Pohl, Ndiaye, Diongue, Yaka]

Task 6.2 (ANACIM, DGM, CSE, CNRM-GAME): Workshops gathering ACASIS partners, public institutions and stakeholders *[Resp. O. Ndiaye]*

We propose to organise two workshops with public institutions and stakeholders: (i) One at the end of the first year of the project to present our objectives, the first results, exchange with them about the reliability and the understanding of our approach, identify gaps in the communication of the meteorological information and define a plan of actions; (ii) A second one near the end of the project to present our final results and the outcomes, and exchange with them about the assessment of the plan of actions, the recommendations to be done and the perspectives after the end of the project. In particular, warning bulletins for HW issued by ANACIM could be discussed for improvement.

A preliminary list of public institutions and stakeholders has been proposed and will be improved : Senegal: Ministère de la Santé et la Prévention (Division Etudes et Recherches; Direction de la Santé; Direction de la Prévention); Ministère de l'Intérieur (Direction de la protection civile); Institut Pasteur de Dakar; Direction des services vétérinaires; Centres Hospitaliers Universitaires Le Dantec, Fann,…; Burkina: Direction générale de la protection sanitaire (Direction de la lutte contre la maladie); Ministère de l'Intérieur (Direction générale de la protection civile); Conseil national de secours d'urgence et de reassurance, …; Regional organizations: ACMAD (Centre Africain pour les Applications de la Météorologie au Développement), OAAS (Association Ouest Africaine de la Santé), ...

D6.2a T0+12 First workshop [Ndiaye, Yaka, Diongue, Ndione]

D6.2b T0+46 Second workshop [Yaka, Ndiaye, Diongue, Ndione]

3.3. CALENDRIER / TASKS SCHEDULE

Task 1: Management

T0: Kick-off meeting

T0+24: Mid-term meeting

T0+48: Final meeting

Every 6 months: Semester progress report

Every year: Annual progress report

T0+48: Final report

Task 2: Database set-up

M2.1a T0+2: identification of relevant meteorological and climate data

M2.2a T0+2: identification of relevant population observatory data

M2.3a T0+4: Extension of the meteorological and climate data base
D2.4a T0+6: Produce homogenized synoptic data of Senegal and Burkina stations

Task 3: Heat wave characterization

M3.1a T0+6: identification of relevant stations and constitution of a coherent database; assessment of the quality of reanalysis and satellite products
M3.1b T0+12: analysis of the recurrent spatial patterns of HWs and their spatial coherence
D3.1a T0+18: publication on the spatial organization of HW events over West Africa
M3.1c T0+6: review of the various definitions of HWs and identification of a metrics (atmospheric variables, thresholds and persistence) used to define HW composites (collab. WP5)
M3.1d T0+9: identification of relevant HW case studies (collab. WP4)
M3.1e T0+12: analysis of atmospheric configurations associated with HW events using reanalysis
D3.1b T0+18: publication on synoptic/atmospheric configurations associated with HW events
M3.1f T0+18: analysis of teleconnections and relationships with remote regions
D3.1c T0+24: publication on HW teleconnections and relationships with remote regions
M3.1g T0+12: determination of recurrent weather types using various partitioning or classification algorithms, and their relationships with HW events at synoptic timescale and for low-frequency variability
M3.1h T0+18: application of the same approach for AGCM outputs, seasonal forecasting and medium-range reforecasting ensemble runs
D3.1d T0+24: publication on weather regimes and their usefulness (hopefully) for HW event analysis
M3.2a T0+24: documentation and assessment of West African HW events in CMIP5 simulations (hindcast and RCP)
D3.2a T0+30: publication on projected HW evolutions over West Africa according to CMIP5 simulations
M3.2b T0+24: documentation and assessment of West African HW events in CORDEX-Africa simulations (control and RCP)
D3.2b T0+30: publication on HW events over West Africa simulated by CORDEX-Africa regional climate models: uncertainties and evolutions
M3.3a T0+12: documentation and assessment of the HW predictability and model skills in TIGGE and NOAA re-forecast2 products, and analysis of associated uncertainties
D3.3a T0+18: publication on HW predictability and uncertainties
M3.3b T0+18: evaluation of potential predictability from SPECS stream 1 experiments
D3.3b T0+36: a publication on the consolidated results including Eurosip system 5 hindcasts and SPECS stream 2 experiments

Task 4: Physics of heat waves and bias reduction in climate models

M4.1a T0+12: Temperature in spring: budgets and couplings in local datasets
D4.1a T0+18: Influences of water vapour, clouds and aerosols on surface radiation: data-based local studies
D4.1b T0+18: Diurnal fluctuations, boundary layers and clouds of heat waves
M4.1b T0+24: Interpretation of IASI observations with data and RRTM radiative estimations
D4.1c T0+24: Documentation of heat waves at larger scales with satellite and synop datasets
M4.2a T0+18 Selection and preparation of observationally-based documentation of the case study
M4.2b T0+24 Definition of simulation set ups, sensitivity tests and common outputs
D4.2a T0+36 Evaluation of the simulations (CNRM, CRC, LMD)
D4.2b T0+48 Report on the capabilities of models to simulate heat wave and recommendations for forecast systems
M4.3a T0+12: Documentation of current results in LMDZ and ARPEGE
D4.3a T0+36: Reports on the improvement due to the new physical parametrizations in ARPEGE ann LMDZ
M4.3b T0+36: Links between the spread in CMIP5 simulations over the Sahel and at global scale
D4.3b T0+48: Assessment of robust changes in future heat waves

Task 5: Vulnerability and adaptation tools

M5.1 T0+10: Standardized database on the dates and causes of death and the maximum and minimum temperatures for the six HDSS sites.
D5.1 T0+18: Analysis report on the modeling of temperature/humidity-mortality relationship
D5.2 T0+30: Methodological and Analysis report on vulnerability factors associated to heat-related death risk (meta-analysis on six HDSS sites)
D5.3a T0+ 24: HDSS site reports and synthesis report on participatory workshops ;
M5.3a T0+24: Semi-structured interviews records ;
M5.3b T0+36: Survey questionnaire and datafile.

D5.3b T0+42: HDSS site reports on knowledge and perceptions of EHE and synthesis report ;

D5.3c T0+46: HDSS site reports on adaptive capacities and protective behaviors against extreme heat, and synthesis report.

<u>Task 6: Pre-operational warning system</u>

M6.1a T0+12: implementation of HW diagnostics in the MISVA platform and development of weekly syntheses for real-time monitoring of the project third year spring season

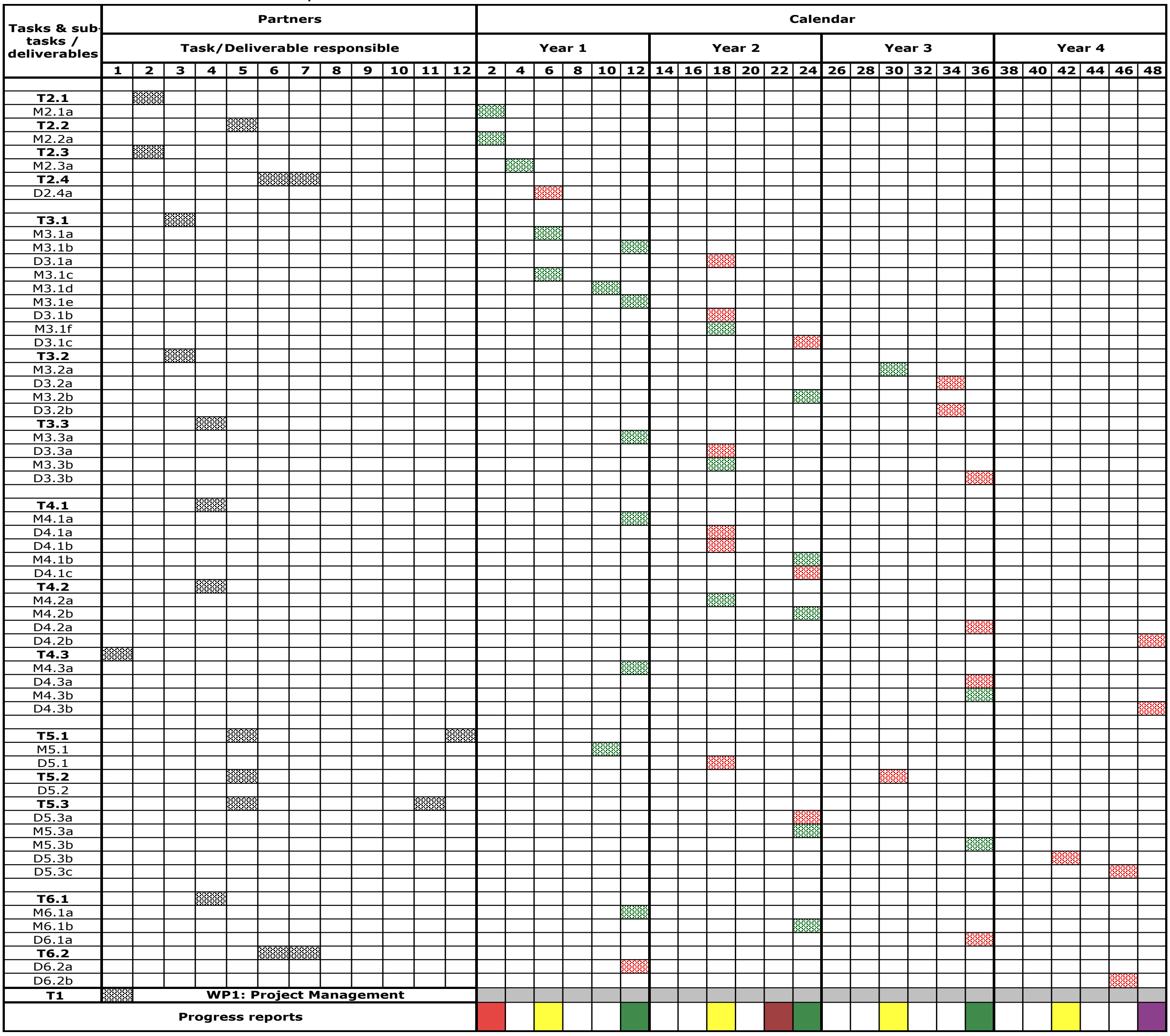
M6.1b T0+24: update of HW diagnostics and weekly syntheses in the MISVA platform, with extension to Burkina, for real-time HW monitoring of the project third year spring season

M6.1c T0+36: update of HW diagnostics and weekly syntheses in the MISVA platform for real-time HW monitoring of the project fourth year Spring season [Roehrig, Pohl, Ndiaye, Yaka]

D6.1a T0+48: report or publication the added value of HW diagnostics and weekly syntheses along the MISVA platform for HW monitoring and forecast over Senegal and Burkina

D6.2a T0+12 First workshop

D6.2b T0+46 Second workshop



Partner numbers: 1:LOCEAN/2:OMP/3:CRC/4:CNRM-GAME/5:LPED/6:ANACIM/7:DGM/8:LPAOSF/9:UGB/10:CSE/11:ISSP/12:CRSN

WP1 (Task 1) Progress reports: Red:Kick-off/Brown:mid-project meeting/Purple:end-project meeting/Yellow:mid-year report/ Green:end of year report. For the other Tasks: Green:Milestone; Red:Deliverable.

4. STRATÉGIE DE VALORISATION, DE PROTECTION ET D'EXPLOITATION DES RÉSULTATS / DISSEMINATION AND EXPLOITATION OF RESULTS. INTELLECTUAL PROPERTY

Task 7 : Dissemination and capacity building

Task leader: Serge Janicot (LOCEAN)

The main objective of ACASIS is to produce a warning system associating forecasting of heat wave occurrences associated to tailored criteria of health impact, and recommendations for the population behaviour, for two countries in West Africa, Senegal and Burkina. This is a demonstration project which could induce at its end, (i) an enhanced motivation for public institutions to improve their demographic survey from local to national scales as well as their chains of decision-making, (ii) and capacities and new expertise for setting-up similar warning systems over other West African countries. As the national meteorological services, national and regional stakeholders, public institutions and scientists will work together, we can anticipate that the knowledge gained during this project will be accurately transferred to these actors of the society. In particular these two countries have been chosen because their meteorological services have been already used to work on dissemination of their products towards society; for instance DGM in Burkina publishes every year a forecast of the climate-related risk of meningitis epidemics. However these efforts of communication will have to be pursued by the local and national authorities after the end of the project, which is not so easy in these low-income countries.

In terms of capacity building, collaborations between French and African scientists in this project will be close as all of them have been working together for a while thanks to the huge efforts that the international program AMMA have produced for more than ten years. The coordinator of ACASIS is one of the main leaders of AMMA and has organized in 2012 the 4th AMMA international conference where 300 researchers were attending whose about 100 from West Africa. Funds for enabling young African scientist to come and work in some of the French teams of ACASIS is requested to ANR, and the post-doctoral positions, requested to be funded by ANR, will be proposed as far as possible to African scientists. Other PhD scholarship requests will be submitted to IRD as well as funds for scientific exchanges for permanent African staff. Co-publications will be produced as far as possible in both French-speaking and English-speaking revues, and we will realize a special issue on the project with IRD Eds, as ACASIS leader did in 2012 by editing freely a special issue of *La Meteorologie* on the French-African research outcomes of AMMA.

One effort will be put on the homogenisation of daily meteorological data of Senegal and Burkina and on learning how to proceed. If this is conclusive (as the network density is may be not high enough to reach this objective), it will be a step forward necessary to evaluate properly the detection of local/national climate signals associated to global warming. Anyway some recommendations can be provided at the end of ACASIS to be valuable for other African countries networks.

We can benefit from the journalists network of IRD in Africa as well as African teams of ACASIS can use their own network. This project will be a great opportunity to communicate about the heat wave phenomena that is underestimated over Africa in comparison to water-related diseases. We will also produce a project brochure description and use the AMMA international Newsletter to communicate about our scientific results. At last but not least, a website of the project will be implemented at LOCEAN.

5. DESCRIPTION DU PARTENARIAT / CONSORTIUM DESCRIPTION

5.1. DESCRIPTION, ADÉQUATION ET COMPLÉMENTARITÉ DES PARTENAIRES / PARTNERS DESCRIPTION, RELEVANCE AND COMPLEMENTARITY

The consortium is made of 12 main teams, 5 in France and 7 in Senegal and Burkina. African partners have all sent a letter of engagement in the project (see last page of this document).

Partner 1: The LOCEAN team (124p.m+ 12 to be funded) (UMR IRD-CNRS-UPMC-MHNH; IRD being the French research Institute dedicated to tropical areas) will coordinate ACASIS with S. Janicot. He will benefit from the collaboration of B. Sultan, the coordinator of the ANR project ESCAPE. He will also be helped by the administrative staff. It gathers other teams from the IPSL federation of Parisian laboratories working on climate and its impacts: The LMD will be associated to LOCEAN. It will co-lead Task 4 with CNRM-GAME. It is a team mostly of climate physicists, with a large component of climate modellers. The team involves key people of the development of LMDZ, in particular F. Hourdin who was also the coordinator of the evaluation and improvement of climate model within the French and European AMMA project, or M.-P. Lefebvre who leads the program DEPHY; I. Musat has been in charge of the building of the AMMA-MIP web site and database; In ACASIS she will be helped by L. Mellul. The team also includes people familiar with satellite data as G. Seze or C. Crevoisier. LMD's expertise will be completed by those of LATMOS (S. Bastin and H. Brogniez) on regional modelling and satellite. The ESPRI/IPSL team will also contribute to the database of ACASIS for modelling and reanalyses data sets in coordination with OMP/SEDOO team.

Partner 2: The OMP/SEDOO team (5pm+ 6 to be funded) will lead Task 2. It is a service of Observatoire Midi-Pyrenees in Toulouse dedicated to scientific data and products management associated with online dissemination tools. The team manages the data of about 20 national and international scientific projects. It is composed of 6 permanent engineers and 5 contract workers. For the AMMA information system, SEDOO works jointly with ESPRI/IPSL team in Paris and Centre regional Agrhymet at Niamey. In the project SEDOO will support the management of the database and of the extension of the MISVA platform that was set-up in collaboration with CNRM-GAME.

Partner 3: The CRC team (109p.m+ 18 to be funded) (Centre de Recherches de Climatologie) [regrouping CRC (Dijon), CEREGE (Aix-Marseille) and LTHE (Grenoble) members] will lead Task 3. A key part of the scientific expertise at CRC is dedicated to African climate variability. Bernard Fontaine and Pascal Roucou have been strongly involved in the AMMA program on the West African monsoon since its beginning in 2002. They have analyzed the monsoon mean climate and variability, including its sensitivity to anthropogenic influence, in observations, reanalyses, as well as global and regional climate simulations. Nadège Martiny is specialized in remote sensing and relationships between climate variability, air quality and health issues. Benjamin Pohl works on observed and simulated climate variability in time and space, and regional climate modelling, using non-hydrostatic model WRF. Albin Ullmann was originally specialized in the Mediterranean climate; his recent work uses multivariate statistics (esp. weather regimes) to analyze regional climate variability over the Eurafrican sector. The team also includes Vincent Moron (CEREGE), as well as Arona Diedhiou, Thierry Pellarin and Sandra Rome (LTHE) and Moctar Camara (univ. Ziguinchor, Senegal). Vincent Moron is an expert in statistics, downscaling and signal processing (esp. weather regimes and model output statistics). Arona Diedhiou and Sandra Rome work on the atmospheric water cycle and the impact of the present and future climate variability, including climate regionalization. Thierry Pellarin analyses surface feedbacks and associated effects on extreme hydroclimatic events. Moctar Camara has been working on the relationships between the West African monsoon and cyclonic activity over the Atlantic, and contributes now to the analysis of the CORDEX-Africa database.

Partner 4: The CNRM-GAME team (82p.m+ 24 to be funded) will co-lead Task 4 with LMD. It is a joint lab of CNRS (UMR 3589) and the Research Laboratoire of Meteo-France. It has a recognized expertise on atmospheric modelling, in terms of meteorological weather forecast and climate projection (with implications in TIGGE, CMIP5 and CORDEX projects) as well as physical process understanding and parametrizations and played a major role in the AMMA program. The team involved in ACASIS is composed of specialists who have a long-standing expertise in atmospheric physical processes including their modelling and parametrization (F. Guichard, D. Bouniol, R. Roehrig), and in the analysis of observational data, as well as in meteorological weather forecast and climate projection (M. Deque, R. Roehrig) with implication in TIGGE, CMIP5 and CORDEX programs).

Partner 5: The LPED team (51p.m + 48 to be funded) (Laboratoire Population Environnement Développement, UMR 151 Aix-Marseille University-IRD) will lead Task 5. It has been carrying out studies on interrelationships between human beings and its environment for 25 years. LPED has developed an interdisciplinary approach mainly in the Mediterranean and sub–Saharan regions. Research performed at

LPED deals with the diversity of the social-environmental interactions within the development paradigm. LPED examines environmental perceptions and practices as an interface between knowledge and technical, ecological, economic and social rationalities. LPED works on the following issues: Governance of natural resources (forests, pasturelands, water, etc.) and urban and rural areas, biodiversity management in regions enduring demographic and ecological pressure. Today the LPED members include 40 teacher-researchers and researchers from the University of Provence and IRD as well as about 50 Ph.D. students belonging to different disciplines: Demography, Ecology, Sociology, Economy, Geography, Agronomy. The LPED members are involved in the ESCAPE program.

Partner 6: The ANACIM team (30p.m) represents the national meteorological agency of Senegal. It will co-lead Task 6 with DGM. It is one of the most important national meteorological department in Africa and has a lot of international cooperations. It is very active in building connections with end-users to promote meteorological forecast products. It has developed a research department from some years in order to contribute to the improvement of the forecasting skill. It is collaborating with CNRM-GAME on the MISVA platform. O. Ndiaye and A. Diongue are recognized as international experts, in THORPEX-Africa program on high impact meteorological events as well as in application programs like the CCAFS on food security.

Partner 7: The DGM team (66p.m) represents the national meteorological agency of Burkina. It will co-lead Task 6 with ANACIM. As ANACIM, it is very active in building connections with end-users to promote meteorological forecast products. For instance within the framework of the national working group Climate-Health (DGM, Direction Générale de la Protection Sanitaire, NCEP African Desk at Washington and LOCEAN), it has been producing for several years an annual bulletin related to the forecast of climate risks associated to the meningitis epidemics. P. Yaka is recognized as an international expert in this field for the international project HEALTHMET and for OMS.

Partner 8: The LPAOSF team (40p.m) (Laboratoire de Physique Atmospherique et de l'Ocean - Simeon Fongang) belongs to UCAD (Dakar). He has developing researches on atmospheric physics for more than 30 years, in particular in close collaboration with LMD, and more recently with LOCEAN and other French laboratories, which enables it to get new and good experience in climate modelling and evaluation. A lot of master and theses have been realized at LPAOSF in this context. A. Gaye has led the African component of the AMMA-EU project. He is also coordinating the workshops on climate risk assessment of the Climate Change Adaptation in Africa program of IDRC/DFID.

Partner 9: The UGB team (58p.m) belongs to University Gaston Berger (UGB) of Saint-Louis which started in 1990. UGB has now 6000 students, 150 faculty members and 12 laboratories, centers and research teams. UGB collaborates with many European institutions located mainly in France. ACASIS will be supported by the UFR of Applied Sciences and Technology which is one of the 8 faculties of UGB. It has a department of applied mathematics (Pr. A. Diop) that provides training and research on numerical analysis, probability and statistics. Research in applied mathematics and Informatics is conducted in two main research teams: the Laboratory of Numerical Analysis and Computing (LANI) and the Laboratory for Studies and Research and Development Statistics that have a very good experience research and an extensive network of sub-regional and international collaborators. Research in applied physics is supported by two research teams: the Laboratory of Atmospheric Sciences and Oceans and the Laboratory of Electronics, Telecommunications, Informatics and Renewable Energy.

Partner 10: The CSE team (69p.m) (Centre de Suivi Ecologique) is a centre of excellence in the Ministere de l'Environnement et du Developpement durable in Senegal, using geomatics for natural resources management, in particular to collect, treat and diffuse data and information at the national scale. It has a long experience in multidisciplinary collaboration at national and international levels. It develops works on various themes like environmental survey and food security, vulnerability and adaptation to climate change, health and environment through tele-epidemiology, socio-economy of the environment, development of geographical information systems, etc. J.A. Ndione is an expert recognized at the international level for his works on the links between environment and Rift Valley Fever.

Partner 11: The ISSP team (24p.m) (Institut Supérieur des Sciences de la Population - University of Ouagadougou) is hosted the Ouagadougou Health and Demographic Surveillance System (O-HDSS). It already has a history of involving researchers across disciplines, and has established partnerships with local governmental and non-governmental organizations. The O-HDSS is located in five neighborhoods at the northern periphery of the capital of Burkina Faso, was established in 2008. Data on vital events (births, deaths (and cause of deaths), unions, migration events) are collected every 8-10 months. Three informal neighborhoods and two formal areas were selected to understand the problems of the urban poor, and testing innovative programs that promote the well-being of this population. The O-HDSS is one of only two urban health and demographic surveillance system sites, in Africa, and one of 38 members of the INDEPTH network. Unlike the other urban African HDSS in Nairobi, the population is quite stable, with only a 6.6% average rate of loss to follow-up between rounds.

Partner 12: The CRSN team (48p.m) (Nouna Health Research Centre) is a HDSS site located in the Nouna health district's catchment area in northwest Burkina Faso, 300 km from the capital, Ouagadougou. The current geographic extent of the HDSS comprises one district hospital and 14 peripheral health facilities. It has conducted regular population censuses since 1992 (baseline of individuals), maintained a vital events-registration system, and performed routine verbal autopsy interviews. It is a set of field and computing operations that handle the longitudinal follow-up of well-defined entities or primary subjects (individuals, households, and residential units) plus all related demographic and health outcomes within a clearly circumscribed geographical area.

All partners have already had inter-collaborations through programs like AMMA or the ANR project ESCAPE, which will assure an efficient work. "Geophysicians" of ACASIS have been used to work together for a long time as explained above, especially within AMMA. "Geophysicians" and "Social/Human" scientists have begun to learn working together during AMMA and presently within the ESCAPE project. ACASIS will be a new opportunity to strengthen this inter-disciplinary that we know to be a long process. A management committee will be also set-up gathering Task leaders and African partners leaders to strengthen this network. This consortium gathers climatologists, physical processes specialists, meteorologists, biostatisticians, demographers, socio-economists, epidemiologists, clinicians, geographers, and operational meteorological agencies. By including operational meteorological services from Senegal and Burkina, as well as the CNRM team closely associated to the operational service of Meteo-France, and by including several observatory populations sites in these two African countries where interviews and epidemiological studies will be conducted, we consider to have a very reliable consortium to address and reach our objectives. We have also established a list of priority stakeholders to collaborate with (national health and civil protection services, hospital centers,…) in order to set-up or provide recommendations for a warning system as realistic and efficient as possible. Then we will be able to investigate the Heat Wave "object" through the various dimensions that we presented above, and transfer research onto application and action. Finally notice that Meteo-France has got a high expertise on heat wave analysis and the set-up of adaptation strategies that will be very useful for ACASIS.

5.2. QUALIFICATION, RÔLE ET IMPLICATION DES PARTICIPANTS / QUALIFICATION AND CONTRIBUTION OF EACH PARTNER

Serge Janicot (DR2 at IRD, **LOCEAN,** Paris, France), HDR, 55 year-old, is the coordinator of ACASIS. He is a climatologist who has worked on African climate for 25 years, first at Meteo-France, then at CNRS (LMD) and presently at IRD (LOCEAN). He has studied the African monsoon in all its geophysical dimensions (80 papers). He has been involved in the organization of AMMA international program since its beginning at the end of the 1990's. He is now one of its main co-leaders and he leads the French AMMA community. He contributed significantly to the elaboration of the second international scientific plan of AMMA (2010-2020). He was also co-organizer of the first three AMMA international conferences and the responsible for the fourth one in 2012. He will spend 40% of his time on ACASIS.

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Janicot, S., F. Mounier, S. Gervois, B. Sultan and G. Kiladis, 2010: The dynamics of the West African monsoon. Part V: The role of convectively coupled equatorial Rossby waves. J. Climate, 23, 4005-4024.

Mohino, E., S. Janicot and J. Bader, 2011: Sahel rainfall and decadal to multi-decadal sea surface temperature variability. Climate Dyn. doi:10.1007/s00382-010-0867-2.

Janicot, S. et al, 2011; Intra-seasonal variability of the West African monsoon. Atmos. Sci. Lett., Special issue on AMMA, doi:10.1002/asl.280.

Janicot. S., J.P. Lafore and C.D. Thorncroft, 2011 : The West African monsoon. In The Global Monsoon System : Research and Forecast, 2nd Edition, World Scientific Series on Asia-Pacific Weather and Climate, Vol.5, World Scientific Publication Company, 111-136.

We focus now in this section on the main French and African leaders of ACASIS. All these researchers are participating to other national, European and international programs whose themes have common features with ACASIS in terms of : atmospheric processes, climate models parametrizations, CMIP5 and CORDEX activities, climate variability and its socio-economics impacts, environment and public health, social vulnerability and resilience,... All of them have applied their expertise in tropical areas for many years and mainly in West Africa. In particular most of them are playing a significant role in the AMMA program that addresses the West African monsoon variability and its predictability, and its impact on African societies. Most of them are also involved in the ANR project ESCAPE (Environmental and Social Changes in Africa: past, present and future). We will pay attention to maintain links and support with AMMA and ESCAPE.

Benjamin Pohl, 33 year-old, CR2 at CNRS (**CRC,** Dijon, France), PhD, Researcher with expertise in observed and simulated tropical climate variability (West, East and South Africa, and Indian ocean), regional climate modelling, statistics and signal analysis. 26 publications in peer-reviewed international journals.
Full list available at: http://climatologie.u-bourgogne.fr/perso/bpohl/Publications.html

Boulard D, B Pohl, J Crétat & N Vigaud (2013) Downscaling large-scale climate variability using a regional climate model: the case of ENSO over Southern Africa. Climate Dynamics, 40, 1141-1168. doi:10.1007/s00382-012-1400-6

Pohl B & N Fauchereau (2012) The Southern Annular Mode seen through weather regimes. Journal of Climate, 25, 3336-3354. doi:10.1175/JCLI-D-11-00160.1

Crétat J & B Pohl (2012) How physical parameterizations can modulate internal variability in a regional climate model. Journal of the Atmospheric Sciences, 69, 714-724. doi:10.1175/JAS-D-11-0109.1

Pohl B, J Crétat & P Camberlin (2011) Testing WRF capability in simulating the atmospheric water cycle over Equatorial East Africa. Climate Dynamics, 37, 1357-1379. doi:10.1007/s00382-011-1024-2

Pohl B & H Douville (2011a) Diagnosing GCM errors over West Africa using relaxation experiments. Part I: Summer monsoon climatology and interannual variability. Climate Dynamics, 37, 1293-1312. doi:10.1007/s00382-010-0911-2

Françoise Guichard, 49-year old, CR1 at CNRS (**CNRM-GAME,** Toulouse, France), HDR. Researcher with expertise in observation and modelling of atmospheric physical processes, land-surface-atmosphere couplings and feedbacks, West African monsoon. She has participated to many European projects like presently EMBRACE on model processes and their parametrizations. 60 publications in peer-reviewed international journals since 1996 – Full list available at http://www.cnrm-game.fr/spip.php?article624&lang=en

Guichard, F., L. Kergoat, E. Mougin, F. Timouk, F. Baup, P. Hiernaux & F. Lavenu (2009) Surface thermodynamics and radiative budget in the Sahelian Gourma: seasonal and diurnal cycles, *J. Hydrology*, **375**, 161-177. doi: 10.1016/j.jhydrol.2008.09.007

Taylor, C.M., A. Gounou, F. Guichard, P.P. Harris, R.J. Ellis, F. Couvreux & M. de Kauwe (2011) Frequency of Sahelian storm initiation enhanced over mesoscale soil-moisture patterns. *Nature Geoscience*, **4**, 430-344, doi: 10.1038/NGEO1173

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Roehrig, R., D. Bouniol, F. Guichard, F. Hourdin & J.-.L. Redelsperger (2013)The present and future of the West African monsoon: a process-oriented assessment of CMIP5 simulations along the AMMA transect. *J. Climate*, in press.

Frederic Hourdin, 46-year old, DR2 at CNRS (**LMD,** Paris, France), HDR. Researcher with expertise in climate modelling in: 1) Study and numerical modelling of the general circulation of planetary atmospheres (the Earth, Mars, Titan, Venus, **10** publications), 2) Coupling between atmospheric dynamics, chemistry and haze microphysics on Titan (**4**); 3) Numerical modelling of the Earth climate and climate change (**6**); 4) Numerical modelling of the advection of atmospheric trace species (**2**), 5) Inversion of atmospheric transport (**4**), 6) Parameterization of the atmospheric boundary layer and clouds (**6**), 7) Parameterization of pyro-convection (**1**); 8) West African climate (**5**). Frederic Hourdin is In charge of the LMDZ global climate model. Publications are available at http://www.lmd.jussieu.fr/~hourdin/publis.html

Romain Roehrig, 32-year old, IPC at Meteo-France (**CNRM-GAME,** Toulouse, France), PhD. Researcher in charge of the development of the atmospheric component of the CNRM climate global and regional models. Expertise in observed and simulated intraseasonal variability over West Africa, climate modelling and parametrizations. Active participant of the MISVA initiative.

Roehrig, R., D. Bouniol, F. Guichard, F. Hourdin and J.-L. Redelsperger, 2013: The present and future of the West African monsoon : a process-oriented assessment of CMIP5 simulations along the AMMA transect. *Journal of Climate*, in press. doi:10.1175/JCLI-D-12-00505.1

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Chauvin, F., R. Roehrig, and J.-P. Lafore, 2010 : Intraseasonal variability of the Saharan Heat Low and its link with mid-latitudes. *Journal of Climate*, **23**, 2544-2561. doi: 10.1175/2010JCLI3093.1

Richard Lalou, 49-year old, CR at IRD (**LPED**, Marseille, France), PhD. Has headed the research unit called “Population-Environment-Development Laboratory” (2008-2011). Expert on health demography. Currently, he is a team leader for several projects, as the ESCAPE project. Has worked more than ten years in Africa (Senegal, Mali) where he conducted research on health practice improvement related to HIV/AIDS and malaria, on design, implementation, evaluation and sustainability of public policy and public health interventions, and presently on the impact of environmental change on human health. Over 50 scientific articles (in peer-reviewed journals

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Ousmane Ndiaye, Meteorology Professionnal at **ANACIM** (Dakar, France) and research associate at LPAOSF, and at Columbia University where he holds a PhD since 2010. Expertise area: Interannual Seasonal Rainfall Forecasting and its applications over Sahel, statistical and dynamical downscaling. He has contributed to climate outlook forums and regional capacity building at the African Center of Meteorological Application for Development (ACMAD) and as expert in the CLIMAG (Climate and Agriculture) project, running the Regional Spectral Model (RSM). He was also coordinating the climate and health project in ACMAD. He also conducts research on the forecast of the date of rainy season in Senegal with applications in agriculture and health (Malaria).

Ndiaye O., M.N Ward and W. Thiaw, 2011: Predictability of seasonal Sahel rainfall using GCMs and lead-time improvements through the use of a coupled model. J. Climate, 24, 1931-1949.

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Pascal Yaka, 41-year old, Meteorology Professionnal at **DGM** (Ouagadougou, Burkina), PhD. Responsible of the department of Environment and Bioclimatology at DGM since 2008. Expert in meteorological forecasting, climate variability, environment-climate-health relationships. Regional expert (West Africa) of the HEALTHNET project for Burkina, Mali, Mauritania, Niger and Nigeria, supported by WMO. Expert at WHO for Tropical Diseases Research.

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Amadou Gaye, Director of **LPAOSF** (Dakar, Senegal), Professor at UCAD, PhD. Expertise in atmospheric processes, African climate, Impact of climate variability.

Salack S, Giannini A, Diakhaté M, AT Gaye, Muller B, 2012: Oceanic influence on the sub-seasonal to interannual timing and frequency of extreme dry spells over the West African Sahel. Climate Dynamics, DOI 10.1007/s00382-013-1673-4

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Jacques-Andre Ndione, 45-year old, Researcher at **CSE** (Dakar, Senegal). HDR. Areas of expertise: General Climatology, Applied Climatology, Environment, Climate and Health, Integrated Environment Assessment, Physical Geography. Presently Head of Research Development Program at the Ecological Monitoring Center. National Focal Point of the AEIN (Africa Environment Information Network), he is involved in AEO and GEO projects with UNEP.

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Abdramane Soura, Health and Demographic Surveillance System manager at **ISSP** (Ouagadougou, Burkina), PHD. Expertise area: Quantitative research including techniques of sampling, supervision of field work, data management and data analysis in the domain of population and health; evaluation of project impacts

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6. JUSTIFICATION SCIENTIFIQUE DES MOYENS DEMANDÉS / SCIENTIFIC JUSTIFICATION OF REQUESTED RESSOURCES

6.1. PARTENAIRE 1 / PARTNER 1 : LOCEAN

The budget requested to ANR is higher than the upper limit proposed in the call but this is due to the specific profile of this project that associates climate research on heat waves to field investigations in Senegal and Burkina in order to evaluate the social and institutional vulnerability of the population to this type of extreme events. As it is known, field campaigns are rather expensive (about 30% of the requested budget; without this part, our budget would have been in the limits) but in our case, it appears necessary as we are addressing a new topic and have the aim to "translate research into action" through the set-up of a pre-operational warning system. It is then crucial to built diagnostics as realistic and efficient as possible. This is also the reason why we have planned to organise 3 workshops with stakeholders and public institutions. We have also decided to limit our field investigations around the HDSS sites where high-quality demography and epidemiologic data are available and can be crossed with interviews. On another hand it appeared necessary to be present in two countries in order to maximise the samples of the HDSS data sets and to compare two contrasted climates, one in the extreme west of Sahel and the other one within the continent; it may also induce different ways of perception and adaptation of the populations to extreme events like heat waves.

Aside the HDSS, our project is also based on the collaboration with African meteorological departments and research teams. The "plus-value" of this partnership is : (i) to enable transferring the results of our research into operational tools, (ii) to benefit from their knowledge of and their connections with the national institutions involved in the health system, (iii) that "local" data not available on the GTS can be integrated in the research field since these African teams will use these data to provide a better characterisation of the heat waves at national and sub-national scales over Senegal and Burkina.

It must be noticed that we will provide a high investment in ACASIS with 706p.m of permanent researchers and that we request a moderate funding to ANR in terms of non-permanent people (60p.m for post-doc, 48p.m for PhD, 60p.m for post-doc at a African-cost level). Costs for publications can appear to be weak but we will publish as far as possible in high-level journals with no or weak charges. We will edit freely a special ACASIS issue in IRD Editions as we did in 2012 for AMMA outcomes in *La Meteorologie.*

In the following description of the budget, the African teams are considered as partners for ANR but they cannot be funded directly. So two French laboratories will ask them for services: LOCEAN with ANACIM, DGM, LPAOSF, CSE and UGB, and LPED with ISSP and CRSN. For LOCEAN three budgets are now presented: (i) its own budget, (ii) the budget for the coordination of the project, (iii) the budget for the services asked to African partners.

LOCEAN own budget

Equipment

- Two workstations (6000€) and two laptop computers (2000€) for LMD
- External raid device (15Tb; 14.5k€) are necessary for the storage of the different ensemble of multi-models forecast data (TIGGE and more particularly the NOAA RF2 reforecasts) at ESPRI/IPSL

Staff

- A 12-month Post-doctoral position is requested at LMD for candidates having a PhD in atmospheric sciences who will work on tasks 4.1&4.2; he (she) will compare case study simulations with surface and satellite data to better understand processes controlling radiative flux and 2-m temperature.

Operating costs

Travel expanse:

- 6 international conferences: 5 x 2 = 10000 euros (LMD)
- Working meetings in France, on the basis of one during the 4-year period for each participant: 750*13 =10000 euros (LMD & LATMOS)

- Four 6-month visits at LMD in collaboration with CRC (4x11800€) for African students (PhD ou post-docs) from Senegal and Burkina working on CMIP5/CORDEX and LMDZ simulations evaluations in tasks 3 and 4.

Others:

- Publication fees**:** **€**5000.

LOCEAN Coordination budget

Travel expenses:

- 3 4-day meetings in Paris for the whole project at the beginning, mid-term and at the end (20 people from Africa, 20 from province, 20 from Paris; 3x48400€)
- 3 workshops between ACASIS scientists, stakeholders and public institutions at Dakar (15000€) and Ouagadougou (15000€) at the end of the first year, and one regional (20000€) near the end of the project.
- 4 one-week workshop at Toulouse for learning to qualify and homogenize meteorological data for 4 people (2 from ANACIM, 2 from DGM; 4x2000€)

LOCEAN Services budget

ANACIM, DGM, LPAOSF, CSE and UGB will contribute to all Tasks, ANACIM and DGM leading also Task 6. For that, they will receive support in terms of student scholarships, equipment for the realization of the services and travel expenses to meet together, meet French teams, and present their results through publications and in international conferences. The support for Task 6 is available in the Coordination budget.

Equipment

- in order to realize their work, 40000€ will available for the whole five partners (2000€/year/partner) for workstations, laptop computers for Master students and doctorants/post-doctorants, printers, software licences, fees for publications.

Staff

- ANACIM and LPAOSF will share a 2-year post-doc (2x12000€) for contributing to a sub-regional characterization of heat waves over Senegal by using their own denser observational networks data, evaluate French climate model simulations of heat waves at this scale and their sensitivity to areosols, and compare dynamical/statistical downscaling (Tasks 3 & 4). UGB will contribute to this work through its expertise in statistics.
- CSE and UGB will share a 2-year post-doc (2x12000€) for contributing to the analysis of institutional vulnerability in Senegal (which is not considered by LPED). UGB will also contribute to the epidemiology studies by proposing/developing specific statistics tools.
- DGM will receive a one-year post-doc (12000€) to contribute to regional climate modelling compared to statistical downscaling by using their own denser observational networks data.
- LPAOSF, UGB and CSE will get support for Master students (2500, 5000, 2500 € respectively).

Travel expenses:

- An amount of 20000€ (5000€/year) will be available for each of the five partners in order for them to manage their travels during the project: (i) presentation of results in any international conference; (ii) travels in France to meet French partners outside of the consortium meetings; (iii) short missions in Africa to promote their activities within ACASIS.

Others:

- DGM is presently managing 3 meteorological stations located at 3 out of the 5 sites of the Ouagadougou HDSS. We propose to buy 3 automatic stations in order to cover the remaining sites and to have one in stock (37000€ including maintenance).

6.2. PARTENAIRE 2 / PARTNER 2 : OMP

Équipement / Equipment

In order to sustain the information system and to ensure the operationality of the MISVA website via a hardware and service duplication, the acquisition of rapid access disks is needed. A computer for the expected CDD is required too. The total equipment cost will be 3 k€ per year.

Personnel / Staff

The contract engineer (IE level) will extract from other systems (ECMWF,…), homogenize and convert new meteorological and climate datasets in the AMMA database format. Inserting the new datasets will need about 4 person-months. He/She will also adapt the MISVA platform to distribute the heat wave diagnostics and syntheses, and will improve its operational robustness. This work will need about 2 person-months.

6.3. PARTENAIRE 3 / PARTNER 3 : CRC

Équipement / Equipment

Instead of paying the effective cost of calculation hours for WRF simulations (6 euro cents / hour CPU) we propose to increase the calculation capabilities of the supercomputer owned by Univ. of Burgundy, through one Dell C6220 computation machine (64 cores, 1.1Tflops, 20351.13€).

Personnel / Staff

- One 18-month post-doctoral position (for candidates having a PhD in atmospheric sciences) will be shared by the 3 labs constituting the CRC group. The recruited person will contribute to the analyses done in Tasks3.1 and 3.2 by defining recurrent regimes summarizing HW variability in reanalyses, CMIP5 and CORDEX-Africa databases. (75000€)
- 6 Master students will be funded by ACASIS, during yrs 2 et 3 (2 CRC, 2 CEREGE, 2 LTHE): 6 x 4 x 420 = 10080€

Dépenses de fonctionnement / Operating costs

- Working meetings in France (coordination between the 3 labs of the group and with other ACASIS partners) and international conferences: 10000€
- Publication fees / other expanses: 8000€

6.4. PARTENAIRE 4 / PARTNER 4 : CNRM-GAME

Équipement / Equipment

- Two portable computers: 3000 euros (one for CNRM-GAME and one for sub-contracting GET)
- Support for data storage: 5000 euros (archive of very large observational datasets and model outputs)
- Diverse supplies (disks, licences): 2000 euros (1000 CNRM-GAME and 1000 sub-contracting GET)

Personnel / Staff

- Two 12-month Post-doctoral positions are requested for candidates having a PhD in atmospheric sciences
    - The first one will work on task 4.2 (heat wave case study), he (she) will study the physics of the observed heat wave and will be involved in the evaluation of the simulations
    - The second one will work on task 3.3 (heat wave forecast) and will be involved in the analysis of the model skills.

Dépenses de fonctionnement / Operating costs

Travel expanse:

- 6 international conferences: 6 x 2 = 12000 euros (5 CNRM-GAME, 1 sub-contracting GET)
- Working meetings in France, on the basis of one during the 4-year period for each participant: 750*17 =13000 euros (15 for CNRM-GAME, 2 for GET subcontracting)

Publication fees: 5000 euros

6.5. PARTENAIRE 5 / PARTNER 5 : LPED

It is important to note that LPED's budget makes it possible to finance activities for LPED, and CRSN and ISSP services (subcontractors) responsible of data collection in Burkina Faso.

Equipment

- Six laptop computers (2 for LPED and 2 for each sub-contractors: ISSP and CRSN) for field activities: total €9000
- Diverse supplies (software licences): €2000 for LPED

Staff

- A 48-month doctoral position is requested: €115200. The candidate must have a Master's degree in MASS or biostatistics. He will work on tasks 5.1 and 5.2 (modelling relationships temperature/mortality).
- Two 6-month grants for 2 Master 2: €5244.

Operating costs

This budget line (provision of services) mainly concerns the subcontracts implemented by LPED and other partners (ISSP and CRSN) to achieve the following tasks on the six study fields of Task 5. Most of these expenditures are made by the local staff to carry out the following activities:

- Collect and enter data from 6000 questionnaires for 4 study sites : total €113771 (task 5.3)
- Go through the consultation registers of 5 health centers in Senegal for 1985-2013: €18518 (task 5.1)
- Manage databases – 3 computer scientists for 6 months (one in Senegal and two others in Burkina Faso) : total €14841 (task 5.1, 5.2 and 5.3)
- Analyze collected data – 3 statisticians for 12 months (one in Senegal and two others in Burkina Faso) : total €49652
- Translate and transcribe the interviews collected during the participatory workshops: €3713 (task 5.3)

These expenditures must be supplemented with fees for access to mortality and morbidity routine data in the six HDSS (about €50000).

Travel expenses:

- 3 international conferences: 3 x 1000 = €3000 (1 for LPED, 1 for each sub-contractors: ISSP and CRSN)
- Two work missions Montpellier/Dakar : total €2250
- Two work missions Montpellier/Burkina Faso : total €2250
- Two work missions Burkina Faso/Senegal : total €2000
- Two work missions Senegal/Burkina Faso : total €2000
- Organization of four participatory workshops (expenses relative to travelling and accommodation for 15 guests for each workshop) : total €20000

Others:

- Car rent and fuel expenses for LPED and two subcontractors (ISSP and CRSN): total €8880 (tasks 5.1 and 5.3)
- Publication fees**: €**5200.

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MINISTERE DE LA SANTE
SECRETARIAT GENERAL
CENTRE DE RECHERCHE EN SANTE DE NOUNA

BURKINA FASO
Unité – Progrès - Justice

Nouna, le 05 mars 2013

Le Directeur

A

Monsieur le Responsable du Programme ANR « Sociétés, Changements Climatiques et Environnementaux »

Objet : Participation du Centre de Recherche en Santé de Nouna au projet ACASIS

Monsieur le Responsable,

Nous venons par cette lettre confirmer notre accord pour collaborer au projet de recherches *Alertes au Canicules Au Sahel et à leurs Impacts sur la Santé* ACASIS (2014-2017), tel qu'établi dans le cadre de l'appel à projet SOCENV-2013.

Ainsi qu'il en a été convenu avec le responsable de projet, Monsieur Serge Janicot de l'unité de recherche LOCEAN, notre participation sera effective dans la tâche n°5, coordonnée par le LPED. Les thèmes abordés dans cette tâche sont tout à fait dans les compétences du Centre de Recherche en Santé de Nouna.

Par ailleurs nous acceptons de participer au comité de pilotage du projet ACASIS.

En vous souhaitant bonne réception, recevez mes salutations distinguées.

Dr Ali SIE

MINISTERE DES INFRASTRUCTURES, DU DESENCLAVEMENT ET DES TRANSPORTS
SECRETARIAT GENERAL
DIRECTION GENERALE DE LA METEOROLOGIE

BURKINA FASO
Unité - Progrès - Justice

Ouagadougou, le 07 MARS 2013

N° 13 - 049 /MIDT/SG/DGM

LE DIRECTEUR GENERAL

A

Monsieur le Responsable du Programme ANR « Sociétés, Changements Climatiques et Environnementaux »

- OUAGADOUGOU -

Objet : Participation de la Direction Générale de la Météorologie au projet ACASIS

Monsieur le Responsable,

Nous venons par cette lettre confirmer notre accord pour collaborer au projet de recherches Alertes aux Canicules Au Sahel et à leurs Impacts sur la Santé ACASIS (2014-2017), tel qu'établi dans le cadre de l'appel à projet SOCENV-2013.

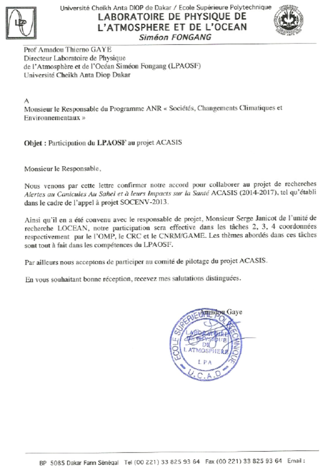
Ainsi qu'il en a été convenu avec le responsable de projet Monsieur Serge Janicot de l'unité de recherche LOCEAN, notre participation sera effective dans les tâches : 2a, 2b, 2c, 3a, 3b, 4a, 4b, 4c et 6, coordonnées par les laboratoires LOCEAN/OMP/CRC/CNRM-GAME/LPED. Les thèmes abordés dans ces tâches sont tout à fait dans les compétences de la Direction Générale de la Météorologie (DGM) qui assurera la codirection de la tâche 6 avec l'ANACIM du Sénégal.

Par ailleurs nous acceptons de participer au comité de pilotage du projet ACACIS.

En vous souhaitant bonne réception, recevez mes salutations distinguées.

Le Directeur Général P/I

Ernest K. OUEDRAOGO
Chevalier de l'Ordre National



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A
Monsieur le Responsable du Programme ANR « Sociétés, Changements Climatiques et Environnementaux »

Objet : Participation du **LPAOSF** au projet ACASIS

Monsieur le Responsable,

Nous venons par cette lettre confirmer notre accord pour collaborer au projet de recherches *Alertes au Canicules Au Sahel et à leurs Impacts sur la Santé* ACASIS (2014-2017), tel qu'établi dans le cadre de l'appel à projet SOCENV-2013.

Ainsi qu'il en a été convenu avec le responsable de projet, Monsieur Serge Janicot de l'unité de recherche LOCEAN, notre participation sera effective dans les tâches 2, 3, 4 coordonnées respectivement par le l'OMP, le CRC et le CNRM/GAME. Les thèmes abordés dans ces tâches sont tout à fait dans les compétences du LPAOSF.

Par ailleurs nous acceptons de participer au comité de pilotage du projet ACASIS.

En vous souhaitant bonne réception, recevez mes salutations distinguées.

Amadou Gaye

BP 5085 Dakar Fann Sénégal Tel (00 221) 33 825 93 64 Fax (00 221) 33 825 93 64 Email :

UNIVERSITE DE OUAGADOUGOU
03 BP 7118 Ouagadougou 03
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Centre d'excellence régional de l'Union économique et monétaire ouest africaine

Ouagadougou le 7 mars 2013

Le Responsable de l'OPO

A

Monsieur le Responsable du Programme ANR « Sociétés, Changements Climatiques et Environnementaux »

Objet : Participation de l'Observatoire de Population de Ouagadougou au projet ACASIS

Monsieur le Responsable,

Nous venons par cette lettre confirmer notre accord pour collaborer au projet de recherche *Alertes au Canicules Au Sahel et à leurs Impacts sur la Santé* ACASIS (2014-2017), tel qu'établi dans le cadre de l'appel à projet SOCENV-2013.

Ainsi qu'il en a été convenu avec le responsable de projet, Monsieur Serge Janicot de l'unité de recherche LOCEAN, notre participation sera effective dans la tâche 5, coordonnée par le Laboratoire Population Environnement Développement (LPED – UMR 151). Les thèmes abordés dans cette tâche sont tout à fait dans les compétences de l'Observatoire de Population de Ouagadougou.

Par ailleurs, nous acceptons de participer au comité de pilotage du projet ACASIS.

En vous souhaitant bonne réception, recevez mes salutations distinguées.

Le responsable de l'Observatoire de Population de Ouagadougou,

Dr Abdramane SOURA

République du Sénégal
Un Peuple - Un But - Une Foi
Ministère des Infrastructures et des Transports

Agence Nationale de l'Aviation Civile et de la Météorologie

N° 00487 /ANACIM/DG/SG/DEM/DCAR

Dakar, le 12 MAR 2013

A
Monsieur le Responsable du Programme ANR «Sociétés, Changements Climatiques et Environnementaux »

Objet : Participation de l'ANACIM au projet ACASIS

Monsieur le Responsable,

Nous venons par cette lettre confirmer notre accord pour collaborer au projet de recherches Alertes au Canicules au Sahel et à leurs Impacts sur la Santé ACASIS (2014-2017), tel qu'établi dans le cadre de l'appel à projet SOCENV-2013.

Ainsi qu'il en a été convenu avec le responsable de projet, Monsieur Serge JANICOT de l'unité de recherche LOCEAN, notre participation sera effective dans **les tâches 2, 3** et **6**.

Les thèmes abordés dans ces tâches sont tout à fait dans les compétences de l'ANACIM.

L'ANACIM assurera la co-direction de la tache 6 avec la Direction Générale de la Météorologie du Burkina Faso.

Par ailleurs nous acceptons de participer au comité de pilotage du projet ACASIS.

Veuillez agréer, **Monsieur le Responsable**, mes salutations distinguées.

Le Directeur Général p.i

Mamina KAMARA

Aéroport Léopold Sédar SENGHOR - BP : 8184 DAKAR-YOFF - Tél. (221) 33 869 53 35 - Fax : (221) 820 04 03/33 820 39 67

Modèle de lettre d'engagement pour les partenaires Sud

N° 00236 CSE/ PRD/JAN

Centre de Suivi Ecologique
Pour la Gestion des Ressources Naturelles

Dakar, le 11 MAR. 2013

LE DIRECTEUR GENERAL

A Monsieur le Responsable du Programme ANR « Sociétés, Changements Climatiques et Environnementaux »

Objet : Participation du **Centre de Suivi Ecologique** au projet ACASIS

Monsieur le Responsable,

Nous venons par cette lettre confirmer notre accord pour collaborer au projet de recherches *Alertes au Canicules Au Sahel et à leurs Impacts sur la Santé* ACASIS (2014-2017), tel qu'établi dans le cadre de l'appel à projet SOCENV-2013.

Ainsi qu'il en a été convenu avec le responsable de projet, Monsieur Serge Janicot de l'unité de recherche LOCEAN, notre participation sera effective dans **les tâche n°5 (*Health and social vulnerability*) et n°6 (*Set-up an operational warning system*), coordonnées** respectivement par le LPED, l'ANACIM et la DGM. Les thèmes abordés dans **ces tâches** sont tout à fait dans les compétences du **Centre de Suivi Ecologique**.

Par ailleurs nous acceptons de participer au comité de pilotage du projet ACASIS.

En vous souhaitant bonne réception, recevez mes salutations distinguées.

Signature du responsable du **Centre de Suivi Ecologique**

Dr Assize TOURE

REPUBLIQUE DU SENEGAL
MINISTERE DE L'ENSEIGNEMENT SUPERIEUR ET DE LA RECHERCHE

UNIVERSITE GASTON BERGER

N° 0001319 U.G.B./CAB.R/DRICS

Saint-Louis, le 14 MAR. 2013

LE RECTEUR,
Président de l'Assemblée de l'Université

Objet : Participation de l'UGB au projet ACASIS

Monsieur le Responsable,

Nous venons par cette lettre confirmer notre accord pour collaborer au projet de recherches *Alertes aux Canicules Au Sahel et à leurs Impacts sur la Santé* ACASIS (2014-2017), tel qu'établi dans le cadre de l'appel à projet SOCENV-2013.

Ainsi, qu'il en a été convenu avec le responsable de projet, Monsieur Serge Janicot de l'unité de recherche LOCEAN, notre participation sera effective dans **les tâches 1.1, 1.3, 1.4, 2a.1, 2a.2, 2a.3, 2a.4, 2b.1, 2b.2** et celles décrites dans l'objectif n°4, **coordonnées** par le **Laboratoire des Sciences de l'Atmosphère et des Océans (LSAO) et le Laboratoire d'Etude et de Recherche en Statistique et Développement (LERSTAD)**. Les thèmes abordés au niveau de **ces tâches** sont tout à fait dans les compétences de l'UGB.

Par ailleurs nous acceptons de participer au comité de pilotage du projet ACASIS.

En vous souhaitant bonne réception, recevez mes salutations distinguées.

A

Monsieur le Responsable du Programme ANR « Sociétés, Changements Climatiques et Environnementaux »

Pr. Lamine GUEYE

BP. : 234 - Tél. 961.17.68 / 961.23.56 – Fax : 961 5139 UNIV.G.B. – email : cabinet@ugb.sn – Saint-Louis – (Sénégal)