PROGRAMME CHANGEMENTS ENVIRONNEMENTAUX PLANETAIRES

DOCUMENT DE SOUMISSION B

EDITION 2009

Acronyme	**PAPRIKA**		
Titre du projet en français	Réponses de la cryosphère aux pressions anthropiques dans l' Hindu-Kush-Himalaya: impact sur la ressource en eau et l'adaptation socio-économique au Népal		
Titre du projet en anglais	CryosPheric responses to Anthropogenic PRessures in the HIndu Kush-Himalaya regions: impacts on water resources and society adaptation in Nepal		
Axe(s) thématique(s)	☒ 1 ☒ 2 ☐ 3 ☒ 4 ☐ 5 ☒6		
Type de recherche	☒ Recherche Fondamentale ☐ Recherche Industrielle		
Aide totale demandée	664261 €	**Durée du projet**	36 mois

1. CONTEXTE ET POSITIONNEMENT DU PROJET/CONTEXT AND PROJECT POSITIONING

Most recent glacier inventories in the HKH regions report since the 1950s an acceleration of the retreating rates. Evidences for reductions in snow cover extension and significant shrinkage of glaciers have also been recently reported in the Hindu Kush-Himalaya (HKH) region, leading to very much concern about future resources and availability of water. The region contains the headwaters of several major river basins largely fed by glaciers and snow packs and any reduction in the availability of freshwater in HKH countries, where the problems of water stress are already prevalent, will have serious consequences on the life of millions of people.

Glacier and snow cover changes are recognised as high-confident indicator of environmental changes and reactions to climatic forcing. However, the mechanisms by which the cryosphere system is affected by climate change are complex and not resulting solely from global temperature increases. Glacier dynamics is influenced both by local variables and by large scale features such as, in the HKH regions, the South Asian summer monsoon driving precipitation but also by recent changes due to increasing anthropogenic pressures. The recent observations of very high atmospheric concentrations of pollutants in the remote regions of HKH leads to new concerns about faster melting of the cryosphere and, hence, water dynamics (storage, availability) in the dryer regions.

This project therefore focuses on current and future evolution of the cryosphere system in response to global and regional environmental changes and their consequences on water resources in four main landscape units within Nepal. It addresses the driving physical and chemical processes acting on the evolution of the cryosphere, their evolution in a changing climate and their impact on water resource dynamics at regional scale. It also addresses perceptions and representations of the water resource and of changes in water availability, on subsequent adaptations already implemented, and on territorial and social restructurings taking into account people's indigeneous knowledge on the potential changes of natural resources and environmental hazards.

1.1. CONTEXTE ET ENJEUX ECONOMIQUES ET SOCIETAUX/CONTEXT AND SOCIAL STAKES

With an area of 59x103 km^2 covered by glaciers (out of a world total area of mountain glaciers of 540x103 km^2 (Dyurgerov and Meier, 2005)), the HKH region is the largest mountain range on the Earth, and the largest ice mass outside the polar regions. They provide a unique situation in which vast, perennial sources of water are available at elevations higher than elsewhere on earth. This region contains the headwaters of several major worldwide river basins: Brahmaputra, Ganges, Indus, Mekong, Salween, Tarim and Yangtse. Those seven basins cover a 6.7 10^6 km² area with a population above 1.2 10^9 inhabitants (Revenga et al, 2003) and are fed largely by glaciers and snow packs. This is potentially one of the most critical parts of the world in terms of sensitivity to near future climate change, considering the social and economical impacts of glacier shrinkage (Barnett and others, 2005), already observed and expected to intensify with further global warming. It is estimated that melting glaciers provide as much as 70% of the summer flow in the high basin of the Ganges and 50–60% of the flow in other high basins of major rivers (Barnett and other, 2005 and references therein); however, the relative contribution of melt water from glaciers or snow cover to the flow of these rivers in plains is poorly known (Rees and Collins, 2004).

Any reduction in the availability of freshwater in the HKH, where the problems of water stress are already prevalent due to increasing demands of domestic, agricultural, and industrial usages pushed by the rapid demographic and economic growth and urbanization, will have serious consequences for the economy, the agricultural practices, the water supply for large cities, the environment and the daily lives of hundreds of millions of people. The problem is exacerbated by increasing water demand from domestic and agricultural practices, the industry and the environment, and is worst in the countries where the rainfall is very unevenly distributed and occurs with large temporal variability.

The observed retreat of the HKH glaciers is, therefore, one of the major environmental problems facing the Asian region. Most recent glacier inventories, although rather incomplete, report significant volume and surface shrinkage since the 1950s over western China, Nepal and India, and an acceleration of the retreating rates. Evidence for reductions in snow cover extension have also been recently reported for this area, leading to very much concern about future resources and availability of water. Moreover, reduced storage of precipitation in solid form could imply greater risk of extreme flooding events during the Monsoon season in future climates.

Analysis of recent climatic trends reveals a significant warming trend in recent decades which has been even more pronounced at higher altitudes. However, there is increasing scientific evidence that the response of the HKH cryosphere to global change is not solely due to increasing temperature. The time evolution of equilibrium-line altitudes of glaciers is, in fact, a complex function of the local meteorological conditions throughout the year (air temperature, irradiance, humidity and precipitation) and variables related to the snow pack conditions (i.e. snow albedo) influencing the local energy balance. In turn, these variables are influenced by synoptic scale meteorological features such as the South Asian summer monsoon driving precipitation in the HKH.The project, therefore, addresses current and future evolution of the cryosphere in response to climate change and to changes in the composition of the atmosphere and their consequences on water resources and availability. It addresses global environmental changes in Nepal regions (see Figure 1) as an indicator of the potential changes over the larger HKH area.

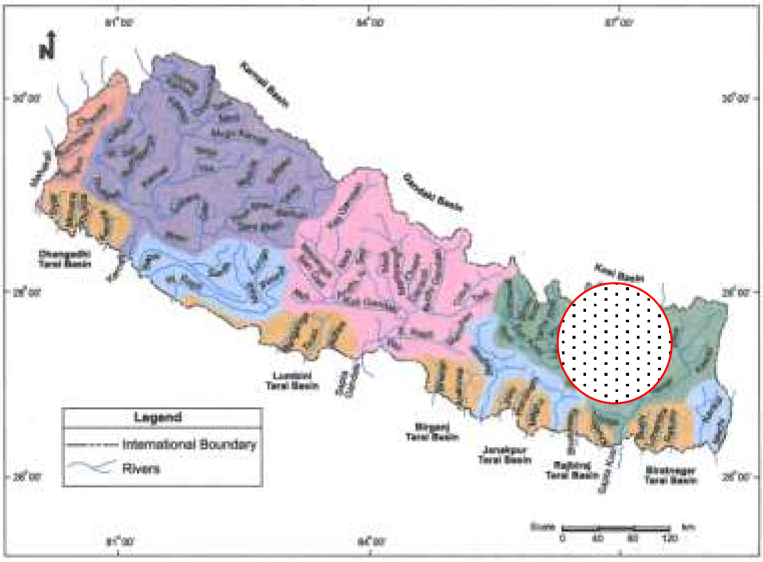

Figure 1: Hydrographical basins (Source: Gyawali, 2001,. Four main river basins, originating from the high chain and thus being affected by the melting of glaciers and snow, are identified on this figure. The shaded area is the Koshi catchment, which is a high glaciated area with eight peaks over 8,000 m, 36 glaciers (Bajracharya et al 2007) where experimental work of PAPRIKA is concentrated

The project will investigate how anthropogenic emissions affect the storage of frozen water in glaciers and snow through direct alteration of radiative forcing (both in the atmosphere and on the surface of the cryosphere) and induced changes in monsoon circulation including rainfall variability.

Considering the human dimension of global environmental changes in particular in relation to the use of water is a major challenge in these areas. The Ganges plain and Nepal are inhabited by millions of peoples who earn their living through agriculture-based activities and who are among the poorest in the world. Agriculture is either irrigated, or rainfed (80% of cultivated land in Nepal) with the monsoon supplying the latter with most of its water. Any change in the climate and in the availability of water will therefore have an important impact on the population. The stakes are economic (mostly changes or even losses in crop cultivation and vulnerability in the livelihood) and social with a problem of accessing drinking water, the displacement of populations, especially in case of floods (Oxfam, 2009). The challenges are thus of political dimension, and concern the type of policy to be implemented in order to mitigate the impact of Climate Change on agriculture and human activities.

The environmental issues that motivate this proposal are therefore global concern for the whole HKH area under increasing anthropogenic pressures on natural resources and where changes in water distribution will have consequences that are not yet quantifiable.

1.2. POSITIONNEMENT DU PROJET/PROJECT POSITIONING

Positionnement du projet par rapport au contexte développé précédemment. /Context Positioning

Facing the consequences of global changes will require implementing sustainable adaptation strategies derived from sound scientific understanding of the water dynamics and vulnerability in the mountain areas. There is, in fact, a general consensus that the HKH water towers are extremely vulnerable to global changes and that without action plans, the risk of deteriorating water availability, quality and efficient use is high. However, action plans for responding to environmental changes should account for the regional specificity, both in mountain regions and in the greater emission source areas, after a scientific links is properly quantified. A scientifically-sound assessment of causes and consequences of changes in the water availability in the HKH regions is of fundamental information for orienting the environmental and economical developments of the nations of these regions.
PAPRIKA will established close linkages with decision makers and designs project outputs in such a way that they can rapidly be used for policy making, including information about the risks involved and the possible options. Transmission of information and integration to stakeholder groups in Nepal will be facilitated by the long-term engagement of several partners in the HKH water management and global change issues ensuring that the key underpinning relevance and excellence of the project objectives are met. PAPRIKA provides response strategies that can be transferred to other regions. It should be considered that impacts of global change on mountain regions cut across the regional considerations and are to some extent similar in different regions of the world, though their downstream consequences may be different. Adaptation strategies and policy solution developed within PAPRIKA may be extended to other mountain areas of the world, in particular in Europe, within the Alpine regions, in the Andes or in some areas of Africa.

Positionnement du projet par rapport aux axes thématiques de l'appel à projets.

PAPRIKA responds to the main objectives of the CEP call as for instance: *Développer les compétences françaises en recherche intégrée sur la thématique émergente de la Science du Système Terre, en renforçant notamment la pluridisciplinarité des recherches.* Atmospheric scientists (LSCE, LGGE), hydrologists (HSM, LTHE), geographers (MCH, PACTE) and glaciologists (LGGE, LTHE) will share their understanding of the hydrological cycle and water management, thus responding to the interdisciplinary requirements for the call. It will contribute to : *Elaborer des outils de modélisation, de méthodes d'évaluation du changement global et d'indicateurs à l'usage des acteurs aux échelles globale, régionale, voire locale.* PAPRIKA relies on a model ensemble to couple glacier, hydrological and climate models that is unique in France. Global, Regional and Local modelling will provide inputs to a series of hydrological models. Going beyond PAPRIKA, this represents the engagement of a fully integrated climate-glacier-hydrology modelling hierarchy over an entire mountain range region. Because PAPRIKA is part of a large international effort to study environmental changes in the HKH regions and a contribution to UNEP supported ABC program it clearly contributes to the objective of « *Positionner les chercheurs français dans le contexte international de la thématique ESSP afin de renforcer leur participation dans les programmes européens et internationaux* ». PAPRIKA will undergo considerable amount of work directly in relation to the study of adaptability of Nepalese mountain communities to changes in water ressources thus contributing to : "*Renforcer les compétences françaises sur l'analyse des dimensions sociales et économiques de la vulnérabilité et de l'adaptabilité des sociétés aux changements environnementaux globaux* ». Finally, through our international partnership in Italy, the use of Geographic GIS by french researchers will be promoted thus responding to: "*Combler le retard relatif à la conception et la mise en oeuvre de systèmes d'informations spatialisés dédiés aux changements environnementaux planétaires* ».

This proposal addresses a number of thematic areas of the CEP call, most specifically 1, 2, 4 and 6.

<u>Thematic area 1</u> (*les vulnérabilités, dues aux changements environnementaux planétaires et aux évolutions sociales, économiques et politiques, ainsi que les conditions d'adaptation des sociétés à ces nouvelles contraintes*). In Nepal, any variation in the availability of the water resource –caused by the regression of glaciers, of snow cover or of monsoon precipitations–, will have major repercussions on the economy, and the organisation of territories and society, which is still 80% rural. By combining data to help estimate these climatic variations with the data concerning water use in the different Nepalese milieus, this project aims at making a fully determining contribution to evaluating the climatic changes to come. In addition to addressing societal impact of water resources, PAPRIKA will provide recommendations for response strategies, including adaptation actions for improved water management in the Himalaya region in particular for important sectors like agriculture and hydropower. By providing suggestions for effective adaptation measures, **PAPRIKA** will strongly focus on "*adaptation des sociétés aux nouvelles contraintes* ». This will be supported by retrospective studies on given Nepalese population, studied by a PAPRIKA partner more than 15 years ago. PAPRIKA finally addresses risk perception by local population and will propose methodologies for risk management.

Thematic area 2 (*aménagement des territoires et occupation des sols dans le contexte des CEP*) : PAPRIKA will provide an **assessment of the impacts of the melting of the Himalayan glaciers under anthropogenic pressures on the present and future water resources availability and usage in Nepal** thus responding to "*l'aménagement du territoire et l'utilisation des sols s'articulent avec (i) la circulation générale et régionale des marchandises et en particulier des ressources hydriques* ". Because PAPRIKA-FR involves local partnership in Nepal and direct work with mountain communities for risk assessment and management due to GLacial lake formation, it also contributes to "l'impact des risques naturels induits par les CEP"

Thematic area 4 (*Ressources naturelles et sécurité alimentaire dans le contexte des CEP*)**:** PAPRIKA deals with the melting of the Himalayan glaciers and the role of anthropogenic emission and therefore focuses on the future evolution of water availability for mountain communities in Nepal in the following 20-30 years. The model ensembles coupled with long-term trends in emissions will be used under different future climate scenarios to predict the future evolution of the cryosphere in the Hindu-Kush Himalaya region and the consequences for the water resources thus responding to the specific action of the call linked to water ressources "*Les ressources en eau et en sol sont limitées en volume et en surface. Leurs propriétés et/ou leur renouvellement sont-ils menacés ? (par exemple : diminution de la couverture glaciaire et neigeuse* »,

Thematic area 6 (*outils et methods pour la science du système Terre*)**:** PAPRIKA will investigate the methodology implemented to downscale the climate model integration to the resolution necessary to drive the glacier models. To model glacier evolution and the associated hydrological cycle for the whole Himalaya region, a range of downscaling methods will be established to derive gridded data using meteorological parameters and a high resolution digital surface evaluation map as input. The coupled MAR/CROCUS model will then be linked a fully distributed physically based hydrological models as a basis to meteorological/ glacier/water resources hierarchical modelling system. The complete model hierarchy system will be tested to determine the optimum combination of regional models in terms of horizontal resolution and downscaling methodology.

Positionnement du projet aux niveaux européen et international.

PAPRIKA is based on an original idea pushed forward by researchers in France (LTHE, LGGE) and Italy (CNR, EVK2CNR) involved since a long time in the study of the environmental climate system in Nepal. The strong collaboration between France and Italy will be a basis for the new PAPRIKA project (see letter Annexed to the project). PAPRIKA is strongly supported by ongoing national and international research, in part carried out by the participants. We have numerous contacts with scientists doing closely related research in the region beyond those who are included as partners in the proposal. PAPRIKA builds upon a strong collaboration with the UNEP/ABC (Atmospheric Brown Clouds) project. The Paprika consortium will benefit of the strong collaboration with the Coordinated Energy and Water Cycle Observations Project (CEOP). PAPRIKA activity and results will be relevant to regional studies on high elevation (CEOP-HE) coordinated byCNR-EVK2. PAPRIKA will benefit of the advances and methodologies of FP6 WATCH Project. The results obtained by the Paprika's field experiments should be used to improve the calibration of the two "cryospheric" modules (snow-pack and glacier) entering in the regional hydrological model proposed by WATCH. Finally, collaborations will be developed with the newly funded EU program HighNoon and with the World Bank initiative led by R. Armstrong (National Snow and Ice Data Center, University of Colorado). Finally, LGGE has a long-standing history of collaboration with

Chinese scientists involved in glacier monitoring in the Tibet area. We will thus build on this existing collaboration to ultimately extend the scientific endeavour of PAPRIKA to the northern slope of the Himalayas.

2. DESCRIPTION SCIENTIFIQUE ET TECHNIQUE/SCIENTIFIC AND TECHNIC DESCRIPTION

2.1. ÉTAT DE L'ART/STATE OF THE ART

Studying the consequences of global environmental changes on glacial water dynamics availability and storage has been the focus of a large number of studies in recent years. However, the complexity of feedback mechanisms between atmospheric/hydrological and cryospheric components of the Earth system still limits our ability to predict changes in hydrological regimes resulting from modification of the cryospheric component in the HKH regions. For each topic area addressed within the project, state of the art is reviewed and opened key questions are listed.

Shrinkage of Himalayan Glaciers. Most recent glacier inventories in the HKH regions, although rather incomplete, report significant volume and surface shrinkage since the 1950s over western China, Nepal and India, and an acceleration of the retreating rates. Very few long-term records of glacier mass balance are available for Nepal and India - measured mass balance time series are shorter than 9 years in India and 4 years in Nepal - where less than 10 glaciers, often of limited area, have been monitored. The longest time series (12 years) is for the Langtang glacier (Nepal) whose mass balance is not surveyed directly in the field but modelled from temperatures and precipitation measured in Kathmandu, 60 km away (Tangborn and Rana, 2000). Furthermore, the time series are usually old (8 ended before 1990) and no mass balance measurements have been reported since 2000 (Dyurgerov and Meier, 2005). PAPRIKA LTHE/LGGE team has recently concluded a 7-year monitoring of Chhota Shigri glacier (Himachal Pradesh, India) showing that, although retreating, this glacier has a different behaviour from glaciers of other parts of the world [*Wagnon et al.,* 2007 and 2008]. This contribution as well as some remote sensing studies (Berthier and others, 2007, Kulkarni and others, 2007) seem to indicate an increase in the pace of glacier wastage in western Himalaya probably related to global warming although this is still under debate (Yadav and others, 2004; Roy and Balling, 2005). In 2007, the same PAPRIKA team initiated the study of Mera-Naulek glacier (Hinku valley, Nepal), a Nepalese glacier directly influenced by the Asian monsoon influx but additional monitoring is required to confirm possible glacier retreat. In conclusion, long-term glacier monitoring is lacking in the HKH but most studies confirmed a general retreat and substantial melting of virtually all glaciers but also increasing evidence of a recent acceleration of the rate of melting which clearly needs to be further investigated.

Evolution of precipitation in the HKH regions. Climate of Himalayas is essentially dominated by the south-west monsoon which provides most of the precipitation in the eastern and central regions during the summer months. In addition to evidences that water availability in India is reducing (Kumar et al., 2005; Trenberth et al., 2007, among others), recent studies (Min et al., 2006) have shown that global warming induced a summer cooling in central south China and warming over the South China Sea and the western North Pacific Ocean that may be responsible for weakening the summer monsoon. The Monsoon circulation is caused by surface temperature differences due to land-sea thermal contrast, but the large number of feedbacks between atmosphere, ocean and land-surface included complicates the comprehension of the phenomenon (Webster et al., 1998). One of the key controls of the variability of the Asian summer monsoon is linked to the reversal of meridional temperature gradient in the upper troposphere over snow-covered elevated land-surface of the Tibetan Plateau (TP) (Yanai et al. 1992; Meehl 1994; Li and Yanai 1996). In addition, alteration of the monsoon circulation may be caused by the anthropogenic aerosols in atmospheric brown clouds that significantly alter the vertical thermal profile of the atmosphere as well as the meridional thermal gradient between the continent and the Indian Ocean (Ramanathan et al., 2007a, Seinfeld, 2008). Consequences and interactions with the monsoon dynamics and impact on precipitations need further investigations.

Impact of absorbing material on snow and glacier melting. Due to general circulation patterns, the Himalayan area is a strong receptor of the Indian/Pakistan source area as recently shown by satellite-borne lidar systems (Huang et al., 2007; Ramanathan et al., 2007b). The issue of BC and other optically active material impact on local energy budget in the HKH area as been put forward by recent work of Bonasoni et al. (2008), Ramanathan et al., 2007, and Ming et al., (2007) showing the first direct evidence that pollution aerosol from India and Nepal can be transported by mountain breezes up to the 5000 m and, episodically, further penetrate over the Tibetan Plateau. Transport of optically active material directly contributes to changes in solar irradiance (Dumka et al., 2006, Dumka et al., 2008; Ramachandran, 2008). In addition, soot carbon deposition on snow surfaces has a strong effect on albedo, which is one of the most important parameter of the radiative balance (Flanner and Zender, 2005). Flanner et al. (2007) determined that the addition of 500 ppbw of black carbon to snow decreased its visible albedo from 0.98 to 0.88, and calculated that the instantaneous forcing over the Tibetan Plateau, due to the presence of BC in snow, exceeds 20 Wm^{-2} in some places confirming that snow darkening is an important component of carbon aerosol climate forcing. Preliminary calculations shows by PAPRIKA LGGE team shows that BC induces locally up to a 1,5°C/day increase in temperature, during high pollution events. This leads to new and serious concerns about increased melting rates of the cryosphere in the HKH regions and addresses the question of future deglaciation of the HKH regions as a result of increased emissions in the Pakistan/Nepal/India regions.

Capacities of local communities in response to Environmental changes. During the 20th century, populations in Nepal have had to undergo various changes and territorial restructurings, notably because of demographic growth and pressure on natural resources (Smadja 2009a, b; Smadja 1986, 1991, 1992, 1995). Contrary to popular opinion, these Himalayan populations are far from being set in their ways. Nevertheless, the impact of climate change and of extreme events on these populations has been the subject of only a few studies. "The recession of glaciers in the Himalayan range will affect the overall water balance in the respective basins but the exact nature of its impact needs more investigation" (Moench *et al.,* 2007: 128). And as we propose to do in this research project, each geographical region "must be viewed differently in order to assess critical impacts" (*Ibid.).* Studies have mostly focused on the flood process in the plain (*Ibid.;* CSE report 2005), showing the complex combination of factors including meteorological and social factors (poverty and demography), as well as technical and political choices. For example, the Koshi flood in 2008 cannot be attributed to climatic causes, but to various factors, including the state of dam maintenance and the technical choice of embanking the river in a certain way (Dixit 2009), whilst over the last 220 years the river has shifted about 115 km (*Ibid*. referring to Gole and Chitale 1966). Populations have adapted to floods by diversifying their crops on land affected by sand deposits, but there is a lack of institutional building to mitigate the impact of floods.

It is clear that addressing these opened questions will require a pluri-disciplinary approach that is proposed within the PAPRIKA project.

2.2. OBJECTIFS ET CARACTÈRE AMBITIEUX/NOVATEUR DU PROJET / SPECIFIC AIM, ORIGINALITY AND NOVELTY OF THE PROJECT

The main objectives of PAPRIKA are:

1. To contribute to a more accurate assessment of glacier retreat and snow cover changes in the HKH region and a better understanding of the surface processes governing glacier and snow melt
2. To quantify the relative contribution of seasonal snow cover and glaciers to regional water supply in the HKH region
3. To evaluate the distribution and variability of absorbing aerosol particles from anthropogenic origin transported to the high altitude regions of HKH
4. To establish and model the current energy budget of snow surfaces, including the effect of absorbing aerosols deposited in snow and their impact on water melting rates.
5. To provide climate trends and scenarios at the regional level based upon an examination of results from an ensemble of models focussing on water availability and variability in the HKH region.
6. To use these projections to quantify current and future water resource in the area of Nepal
7. To study adaptation options of mountain communities to changes in water availability.
8. To propose plausible adaptation strategies for changing risks, including analysis of their economic efficiency and benefits within the social welfare context.

PAPRIKA is innovative in a number of aspects dealing with the impact of climate change on water resources in Nepal and their consequences in socioeconomic sectors linked to water management and agriculture. The scientific understanding of processes and feedbacks as well as the impacts will be described and quantified within PAPRIKA beyond what has been done previously:

New information on glacier and snow dynamics
Both snow and glaciers account for a significant portion of fresh water availability in particular during the dry season, but precise quantification still is an opened question and prediction of their future evolution is complex. As mentioned, very few long-term records of glacier mass balance are available in the HKH area. Hence, by continuing Mera glacier monitoring and identify key variables acting on its mass balance, PAPRIKA will provide information on present glacier dynamics and contribute to understanding future evolution of glaciers in the HKH regions.

Advanced scientific knowledge on the impact absorbing aerosol
Determining the atmospheric concentration of absorbing aerosol particles in the free troposphere over the HKH is crucial to understand the impact of anthropogenic aerosol on monsoon circulation (Lau et al. 2006; Ramanathan et al. 2007a), but measurements of the aerosol chemical composition and optical properties in this area are scarce, due to severe logistical and technical problems for long-term studies. This is a very innovative aspect of the project which will provide new field measurements of the atmospheric burden and deposition of anthropogenic light-absorbing aerosols in the high-altitude HKH region, including continuous measurements at a permanent research station located above 5000 m a.s.l.

Improved modelling of the effect of optically active aerosols in the snowpack
While several physical snowpack models exist, for example for the French and Swiss Alps (Bartelt and Lehning, 2002), to our knowledge such models have not been applied to the Himalayan mountain range. We propose to adapt the physical snowpack model CROCUS (Brun et al., 1989, 1992) to the conditions encountered in the HKH region. An improved radiation transfer scheme will be implemented into the model taking into account the λ-dependent absorption by the snow grains and by absorbing impurities (dust and BC) in the snow. We will investigate the effects of the impurities on energy fluxes in the snow pack, surface snow temperatures, and snow melting rates. We will address the direct changes in snow albedo due to the presence of absorbing impurities in the snow, and investigate the indirect effect of absorbers by accelerating snow metamorphism. Finally, such a model allows to separately investigate the impact of changing temperatures and of changing amounts of impurities on snowpack properties.

A model ensemble to improve modelling of the cryospheric component of the water cycle
The link between reduction of water availability in Nepal, the potential role of southern Asian monsoon precipitation, and the contribution of GHG and absorbing aerosols to temperature changes in the mountain environment need to be addressed by a model ensemble. A new state-of-the-art integrated tool to predict snow, glacier and water production responses to large-scale monsoon dynamics changes and atmospheric loadings provided within the consortium will be used to perform a number of future climate change scenario experiments (e.g. from present-day to 2050). PAPRIKA will build a fully integrated modelling system that couples glacier, snow, hydrological and climate models. Most previous studies have been concerned with single glaciers in Northern America or Europe for the reasons of data availability and have not included the integration of the hydrological modelling component. Going beyond the studies of single glaciers, PAPRIKA will represent the engagement of a fully integrated climate-glacier-snow-hydrology modelling hierarchy over Koshi Basin.

Social impact and adaptation to future climate change (rainfall and altered stream flow regimes) on water resource systems, agriculture and floods
Among the various changes in farming practices, and territorial and social restructurings that characterise Himalayan populations, those related to the water resource's availability and how these changes in it are perceived by local populations will be examined through case studies in the country's four main landscape units (high mountains, middle mountains, low mountains and hills, and the Terai plain). A second theme concerning adaptation will be addressed, linked to how the risk of floods is perceived (by local populations, and national and international agencies), the social impact of floods and the strategies developed by the

populations concerned. Using results from the various models (monsoon pattern, snow covering shrinkage and stream flow) put together by WP3 and WP5, and comparing them with the population's perception, the PAPRIKA project will provide new insight into the local population's adaptation to climate change. Moreover, the GIS tool will help to map the areas affected and to estimate the populations concerned by each type of change and risk.

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

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

PAPRIKA is divided into two main elements that contain four and three work packages, respectively (Figure 3)**. Element 1** (Water Resources Input, Climate and Anthropogenic Pressures on the Cryosphere, Climate, and Monsoon System) deals with a better understanding of physical processes driving the dynamics of the glacier/ snow / precipitation system in Nepal It includes the development of new scientific knowledge in particular linked to the impact of BC on snow melting and delivers research results through the acquisition of atmospheric and glaciological data as well as the development of a modelling tool for the snow pack. Element 1 develops new scientific knowledge and implements the modelling tools (global / regional / local) and the downscaling methods used later in the projects. **Element 2** (Impact on the Water Resource System and Population) uses data and modelling outputs generated in Element 1 to provide a state-of-the-art integrated tool for analysing snow, glacier and water production responses to large-scale Monsoon dynamics and atmospheric aerosol loadings under different climate scenarios. It includes adaptation studies to understand effective perception of change by local communities and adaptation strategies.

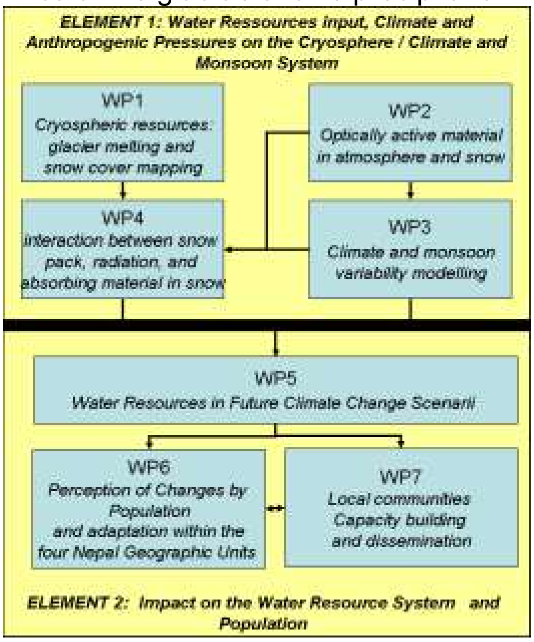

Figure 3: information flows within PAPRIKA

Element 1 is very strongly based on on-going observations (glacier, snow and atmosphere) detailed in Annexe 3). The existing data base is already available to the project, in particular for the modelling activities. This ensures very rapid and efficient use of data. Continuing and completing current observations effort is, however, necessary. In fact, **WP1** (**Cryospheric resources: glacier melting and snow cover mapping**) has the objectives (i) to quantify the general trends of deglaciation and related water resources on a local (glacier scale) as well as regional scale, (ii) to assess the climate-glacier relation in these climatic zones, (iii) to evaluate the long-term surface changes of the seasonal snow cover and its variability in Nepal, and (iii) to quantify the contributions snow and glacier melting and of rainfall events to the river discharges at the KOSHI basin scale. **WP1** is based on the continuous monitoring of the Mera glacier (Nepal, Hinku valley) using ground based and remote sensing tools.

Information retrieved within **WP1** is directly used to validate the simulation of the cryospheric / hydrologic components of the models used in **WP4** and **WP5**. In parallel, **WP2 (Optically active material in atmosphere and snow: observation and modelling)** addresses the variability of aerosol atmospheric concentrations and deposition in surface snow in the Khumbu valley, identifying the main source regions, and providing first estimates of the direct aerosol forcing at various elevated locations in both atmosphere and snow. The atmospheric measurements at the high altitude are completed by measurements of BC in snow samples. Knowledge of temporal and spatial variability of absorbing aerosol in air and snow is used as input to WP4 and also to validate the regional model MAR for **WP3**. **WP3 (Climate and monsoon variability modelling) develops** a clear understanding of the destiny of the HKH cryospheric components accounting for monsoon dynamics and transport of optically active aerosols to the HKH regions. WP3 investigates the dynamics of the South Asian monsoon circulation focussing on transport patterns to the HKH and on precipitation over the HKH region, using a global coupled climate model (LMDz). The focus of the monsoon study will be in terms of precipitation amount at seasonal (onset, active and break phases) and interannual timescales. An important improvement in the analysis of the mechanism responsible for monsoon circulation changes is related to the role of absorbing aerosols that will be included in global model radiative schemes. **WP3** uses modelling results obtained in **WP2** (regional modelling) to validate BC fields at large scale and model developments. **WP3** will provide monsoon related information to **WP4** and **WP5**. **WP4 (Modelling the interaction between the snowpack, radiation, and the absorbing material deposited in snow)** in turn, addresses the specific issue of enhanced snowpack melting due to the presence of absorbing material. It uses the information derived from **WP2** to estimate the impact of absorbers on snow. WP1 and WP4 examines the surface mass balance of the selected benchmark glaciers and investigate the properties of the seasonal snow cover, respectively. They will generate run-off data from the snowpack melting at high spatial resolution used in **WP5**. Further sensitivity studies will be performed for both regions to analyse the snowpack sensitivity regarding changes in atmospheric aerosol loading and air temperatures derived from the simulations in **WP3**.

The approach taken in **Element 2** to address the quantification of hydrological changes and its socio-economical impacts is to focus on the well-constrained Koshi basin and identify four main landscape units with the water resource as one of the key criteria, since it is a major factor in the organisation of human activities and territories (see Figure 2).

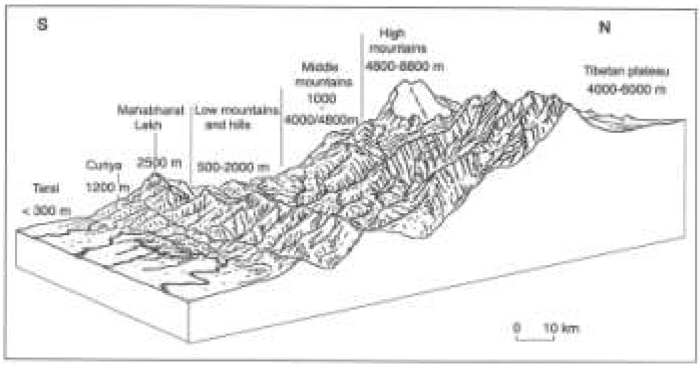

Figure 2: Main geographical units in the Nepalese Himalayas used in PAPRIKA. The 3 identified basins are Imja River at Dingboche: 157 km² (alt. 4 165m, 86°49'04"E 27°52'50"N) Hinku River at Khote: 166 km² (alt. 3 421m, 86°48'41"E

Figure 2 illustrates these four units and names the 3 identified basins of concern to the hydrological studies**.**

(1) The head water scale in the high mountains (3,000-4,500m, catchment area < 200 km²) with a high percentage of glacierized area and a dominance of the snow pack in the hydrological processes. There changes will affect irrigation –on which agriculture relies exclusively- and whose water supply depends mainly on meltwater from glaciers and snow. About 3% of Nepal's population

27°39'10"N) and Dudkoshi River at Phakding: 1 318 km² (alt. 2 520 m, 86°42'41"E 27°43'19"N)	lives in these valleys

(2) The valleys scale in the middle mountains (2500-3000 m, catchment area > 1000 km²,) with still a significant percentage of glacierized area, but a combination of solid and liquid precipitation and a quite significant use of the water resources (agriculture, water supply, waterpower, etc.); any variation in snow cover, in areas affected by frost, as well as rainfall altering the flow of sources and of torrents, will have repercussions on: the irrigation of paddy fields; times for using water mills and operating micro hydro-electric turbines; the drinking water supply; pastoral practices; rainfed agriculture that is predominant in such areas, sheltering 15 to 20% of Nepal's population. **(3)** the basin scale in the low mountains (1000-2500 m catchment area > 20 000 km²) where the impact of the cryosphere is associated with a hydrological regime largely influenced by the liquid precipitations and their seasonal distribution and where the land use/cover is widely devoted to the human activities. In the low mountains, outside the monsoon period, people already have to face a shortage of water as they benefit neither from storm rains, nor from meltwater. Here, the population (about 25% of the population of Nepal) would suffer from any eventual variation in the rainfall schedule. **(4)** In addition, socio-economic and impact studies of WP6 and 7 identify a fourth region in the Terai plain, which is not specifically studied for hydrological changes because almost totally dependent on monsoon dynamics, where densely populated areas (more than 500 inh./km²), are extremely sensitive to any change in the flow of rivers that may have disastrous consequences amplified by the developments in the various infrastructures that have blocked the natural drainage of old river courses.

WP5 (Integrated Atmosphere/Glacier/hydrology modelling) that is central in PAPRIKA uses the 3 spatial scales identified previously (1, 2, and 3) to establishes the methodology to best integrate global and regional climate models with glacier, snow and hydrological models to form a water resources modelling hierarchy. The hydrological modelling integrates 3 types of inputs: glacier melt, snow pack melt, and rainfalls at different time scales: daily time step is needed for the scale (1); a monthly time step is sufficient for the scale (3); for the scale (2), both time steps can be used, in accordance with the aim of the modelling approach. The climatic forcing data will come from **WP3** while **WP1** provides the volumes of the water delivered by the glaciers and **WP4** the carboned induced snow melt on the glaciers and in the middle mountains. This information will be integrated by the most appropriate hydrological distributed or semi-distributed models developed by HSM and LTHE for applications in the Alps and the Andes. In addition, EDF-based model will serve estimating hydro-electricity potential in region (3). WP5 in turn, provides direct information to **WP6** (**Perception of changes by populations and adaptation within the four Nepal geographic units)** where the model hierarchy will be used to estimate potential changes in water resources. Changes in farming practices as well as social and territorial restructurings in the Himalayas occurred during the 20th century. However, those related to the water resource's availability may be quite recent and have to be specifically addressed. We will focus on the perception of such changes by local populations through case studies in the country's four main landscape units. Another consequence of climate change is the increase in the risk of flooding that will be studied in the Terai plain through populations' representation of risks and their strategic adaptations. The "risk" issue will be tackled in collaboration with **WP7**. Field research concentrates on listing the practices and the perception of changes related to water resources. Future scenarios of rainfall pattern as well as water resource availability in the streams provided by **WP3** and **WP5** will be compared with our previous results and discuss them with local populations. Finally, **WP7 (Local**

communities Capacity building and dissemination) integrates data from **WP5** and **WP6** to investigate how changes in natural resources and environmental hazards will be integrated to people's traditional knowledge. It considers that people's ability to face potential changes in natural resources and environmental hazards depends on the sustainability of their livelihoods. These activities will rely on participatory methodologies such as Participatory Rural Appraisal and Capacities and Vulnerabilities Analysis (Gailard and Maceda, 2009; Maceda et al, 2009). All activities will be conducted with two target communities within different regional units defined for the overall Paprika project. WP7 contributes in defining community-based strategies and plans to enhance local capacities to overcome potential changes of natural resources and environmental hazards. It also provides national authorities with recommendations on how to consider and integrate those strategies into national planning and strategies.

The use of observations to validate different models at various scales, the very complex uncertainties of the Monsoon/Aerosol/Cloud feedback mechanisms not developed in PAPRIKA- , the use of emission scenarios in areas of the world where present-day emissions inventories are subject to caution and the work to integrate a hierarchy of models will all lead to substantial uncertainties in quantifying future changes in water resources in the Nepal regions. We are clearly aware of these current limitations which are not going to be solved in the framework of PAPRIKA. However, the project will rather develop an integrated methodology for transferring information from different compartments of the biosphere, including the social dimension. Not only the PAPRIKA methodology may be used as a reference in future studies and applied elsewhere but any future improvements in emission inventories, monsoon/hydrological modelling, etc.. may be rapidly integrated into the methodology to derive more accurate impact assessments.

3.2. MANAGEMENT DU PROJET/PROJECT MANAGEMENT

WP 0: "General coordination," is responsible for the scientific and administrative management of the project and ensures that the project is coordinated in a coherent manner in particular with respect to external collaboration (i.e. CNR-EVK2) and the exchange of information outside of the consortium (Medias, data access). In PAPRIKA, each partner is at least responsible of one WP and will administer his own budget and WP research activity in collaboration with others involved partners (see WP description). **The coordinator** will make sure the proper resources of the project are dedicated to the coordination of PAPRIKA:

- to conduct the daily management of PAPRIKA;
- to receive, compile, and distribute to the partners and other relevant recipients documents, reports, statements of expenditure, and other information from the partners.
- to ensure an efficient liaison within the project by organizing progress meetings and to control that project milestones and deliverables are met on schedule,
- to ensure dissemination of information inside the project and to users outside of the project
- to manage the web site data base shared by partners in collaboration with EVK2-CNR
- to manage the link with Medias

The WP leaders will meet regularly during the course of the three-year project period (once a year as a minimum). Meeting will mainly take place in France but could also take place in Nepal. Additional meetings may be called by the PAPRIKA Coordinator, or at the request of participants, especially in the first year of the project. In order to facilitate communication, most of the information will be distributed electronically: by exchange of email and by internet (the coordinator will establish a website with the shared data base).

Knowledge management, including dissemination of information from the project, the development of a dedicated project web-site and bibliography, and the establishment of a project database will be undertaken in conjunction with the International PAPRIKA partnership through EVK2CNR committee in Italy (see letter of support annexed to the document). All these actions will be under the responsibility of EV-K2-CNR, at no-cost to PAPRIKA France and PAPRIKA coordinator will be responsible of the link with EVK2-CNR.

The expected and requested budget for the management of PAPRIKA is the following:

- Travel costs of the coordinator and the WP managers for kick off meeting and annual meetings (8 persons during 3 years) = 6000.

3.3. DESCRIPTION DES TRAVAUX PAR TACHE/ WORK PACKAGES DESCRIPTION

3.3.1 TÂCHE 1/ WP1: CRYOSPHERIC RESOURCES: GLACIER MELTING AND SNOW COVER MAPPING

Participants: LTHE, LGGE, HSM
International Partner: DHM, EV-K2-CNR
Additional Expertise: LEGOS, CNRM-GAME
Duration: Month 1-36

Objectives: The main objective is to provide input data in order to assess the relative contribution of seasonal snowcover, glacier ice and rainfall to the runoff of streams draining 3 elevated highly glacierized basins. Specific objectives are:

1. Glacier mass balance series of two white benchmark glaciers (Mera and Pokalde) at glacier scale (using direct field measurements) as well as regional scale
2. long-term mass balance series of one debris-covered glacier (to be identified), in order to compare with the mass balance of the white benchmark glacier cited above.
3. Application of energy balance model to compute glacier mass balance and melt discharge for the 3 glaciers identified
4. Quantification of physical processes governing glacier and snow melt using hydrometeorological data available in the Khumbu valley / Koshi basin.
5. Assessment of the relative contribution of seasonal snow cover and glaciers to regional water supply through hydrological monitoring of glacierized basins
6. Validation of climate and the hydrological models to capture the variability observed, in particular spatio-temporal monthly variations of snow cover from 2000 and the snowpack characteristics at the regional and local scales

Methodology: Continuation of the mass balance (winter and summer mass balances) series measured since 2007 on Mera (Nepal) and Pokalde glacier (Khumbu valley). Pokalde glacier, is located very close to atmospheric station in order to compare the mass balance of the glacier and the seasonal cycle of the atmospheric composition of the atmosphere. This glacier is rather small and then easily monitored for mass balance and spatial albedo distribution (using albedometer and automatic terrestrial photographs) and suitable for quantifying the impact of pollutant deposition on glacier melting. Glacier survey is performe using method of SO Glacioclim used on Alpine, Andean glaciers and more recently in northern India (Wagnon et al, 2007). It requires meteorological measurements, photogrametry to derive every year DEM hydrological measurements using limnimetric stations located close to the glacier and farther down, monthly snow cover variations over Eastern Nepal using MODIS satellite data. Similar work will be done for one debris-covered glacier in order to assess its annual mass balance and to compare it to white glaciers,

The complete mass balance will then be simulated with a distributed energy balance model developed by Hock, 2005. The model computes snow accumulation and melt for every time step and each grid cell of a digital elevation model. Ice melt is derived from the atmospheric energy fluxes simulated over all the grids of the glacier. The model is used to investigate the sensitivity of the mass balance to various meteorological. It is also used to investigate the sensitivity to the debris cover for partly covered glaciers. A distributed energy balance model allows investigating the processes of glacier response to climate change and is a complement of more simple approaches as degree-day models. The results will be compared with a second modelling approach based on the ISBA-CROCUS models and already applied on Alpine (Gerbaux and al., 2005) and Bolivian (Lejeune, 2009) glacierezed areas. The ISBA-CROCUS approach is also a distributed energy balance model, which additionnaly includes a physical parametrization of albedo based on grain type evolution. It will be able to take into account the albedo changes due to soot that will be developed in task 1.1.4 and the balck carbon effects on energy mass balance. ISBA-CROCUS will also allow to simulate the morainic areas close to glacier and hence provide a global modelling of partially glacierezed areas. This is particularly important in order to assess impacts of a climate change on glacier and water resources evolution. For instance the ISBA-CROCUS will help to model the effects of the decrease of glacier areas and of the ratio of the glacier-origin water resources.

The spatialisation of the mass balance to the whole region will be done by remote sensing for both glacier types. The first method consists in the ponderation of the benchmark glacier mass balance by the surface of each glacier in order to calculate their respective mass balance. The second method is the direct observation by comparison of topographies derived from satellite or topographical maps developed by Berthier et al, 2004, 2006, 2007 .Enhanced snow cover products will be produced from daily large scale image, i.e. 500m to 250m MODIS/TERRA database, and validated to local scale representative case using ASTER vs SPOT HRVIR data (respectively 15m and 10m). Specific MODIS products such as the surface reflectance (MOD09, Bands 1-7, 500 m), the cloud mask (MOD35), the geometry (MODMGGAD) will be used, jointly with the DISORT Snow Spectral Library (Bands 1-7) and the relevant Digital Elevation Models (DEMs) of the investigated areas (Crane and Anderson, 1984; Hall et al, 2002; Painter et al, 2003;).

Description of work and role of participants

- Task 1.1: glacier monitoring for mass balance, meteorology, glacier energy and mass balance modelling, snow properties, and hydrology on one benchmark glaciers. One debris-covered glacier will also be surveyed using photogrametric technique
- Task1.2: quantification of the effect of optically active aerosols deposition on glacier albedo and mass balance
- Task 1.2: extrapolation of the results obtained at the glacier scale to the whole region using remote sensing approach.
- Task 1.3: assessment of the monthly variations of the snow cover over Western Nepal, using satellite images available since 2000 retrieved from spectral methods

Deliverables

D1.1 (Month 12, 24, 36): Annual reports of Mass balance series (observed and modelled) of a white benchmark glacier and a debris-covered glacier.

D1.2 (Month 24,): Measurement of albedo changes as a function of seasonal deposition of BC on glacier mass balance for the 3 glaciers of interest

D1.3 (Month 12, 24, 36): Annual reports of meteorological data recorded by the AWS located on and outside glaciers.

D1.4 (Month 24 and 36): Hydrological balance at glacier and headwaters basins scale, including the partition of the discharges between snow, ice and rainfall origins for the Hinku River (Nepal).

D1.5 (Month 24 and 36): Snow cover dynamics in Himalayan basins with monthly maps from 2000 showing the snow cover of Nepal: Snow Cover mapping (binary), Fractional Snow Cover (%), Snow line altitude and orientation (DEM)

D1.6 (Month 24 and 36): Glacier regional mass balance from space borne data. First (24 months) provided for the site where field measurements are available for validation and then (36 months) for others ice covered study areas.

Milestones

M1.1 Installation of the Automatic Weather Stations (Month 6)
M1.2 Hydrology (runoff, precipitation) (Month 6)
M1.3 Glaciology network (and modelling) for one glacier (Month 10, 22, 34)
M1.4 Image Data base (MODIS) (Month 12)
M1.5 SPOT5-HRS data acquisitions (Month 12, 24)
M1.6 Installation of automatic camera (Month 12)

3.3.2 TÂCHE 2/ WP2: OPTICALLY ACTIVE AEROSOL IN ATMOSPHERE AND SNOW: OBSERVATION AND MODELLING

Participants: LGGE
International Partner: EV-K2-CNR
Additional Expertise: none
Duration: Month 1-30

Objectives: WP2 deals with the role of absorbing aerosol in changing the radiative forcing in atmosphere and after deposition onto the snow. Presence of elevated levels of optically active aerosol (Dust and BC) in the high valleys of Himalaya has been documented in the atmosphere (Bonasoni et al., 2007) and snow (Ming et al., 2007). Preliminary estimates of radiative impact from the presence of adsorbing aerosol indicate that the local radiative budget is significantly altered. The objective of WP2 is therefore to address the variability of BC and dust in both atmosphere and fresh snow, to identify main source areas as a constraint to regional modelling, to estimate local radiative forcing for present time and to determine the optimal model setups in MAR for simulating BC and dust deposition in snow in present conditions.

Methodology: The WP is based on data provision of black carbon (BC) and dust concentration in the atmosphere on one side and in fresh snow in the other side. In the atmosphere, we will use at the NCO-P station located in the Himalaya mountain range far from emission sources to monitor the long-range transport of aerosol from the source areas in India, Nepal and Pakistan. By the second year of PAPRIKA, the station will be able to provide a 6-year climatology for the air concentrations of BC and of other aerosol components which can show light-absorbing properties but originating from natural sources, like mineral dust. On the other side, specific field campaigns will be dedicated to collect surface snow in the proximity of the benchmark glaciers for determination of the content of aerosol-derived absorbing materials. This will be done using newly developed Single Particle Soot Photometer (SP2) technique that provides extremely low detection limits on one side (required to perform snow filtration in the field) and additional information as respect to more conventional methods (light attenuation and thermal). Results of the chemical analyses of aerosol samples will be also used for source apportionment of BC, to evaluate the anthropogenic activities responsible for the observed levels of absorbing aerosols in the HKH region. Finally, comparison of observation with regional model predictions of BC concentration in atmosphere and snow will be used to constrain seasonal dependent BC deposition to snow in MAR.

Description of work and role of participants:
Task 2.1 (month 0-24, LGGE). Origin and impact of light-absorbing components of aerosol at NCO-P. Developed in the framework of the project SHARE-ASIA, the NCO-P station is operative since March 2006. LGGE (and CNR) perform continuous measurements aerosol characterization with respect to concentration, size-distribution, chemical composition (including tracers for specific emissions), light-absorbing properties, and BC content (using both light attenuation technique and more specific BC instrument (SP2). Results will be used for a) identifying source areas (chemistry based) and b) estimating the atmospheric heating rate due to absorbing particles.

Task 2.2 (month 0-24, LGGE) Determination of aerosol-derived absorbing materials in fresh snow and snow deposits. The amount of BC deposited on surface snow will be measured in the proximity of the benchmark glaciers. Snow samples will be collected and filtered for subsequent analysis of BC and other absorbing materials (mineral dust). Specific investigation will be performed with SP2 to differentiate BC from other absorbing material as well as identifying the brown carbon fraction of absorbing material. Additional Counter Coulter measurement will be performed. Results will provide a) seasonal variations of dust and BC in surface snow and b) inputs to WP4 to provide heating rates in snow
Task 2.3. (month 12-24, LGGE) Constraining simulated BC/Dust concentrations with observations. Simulations will be conducted for the present-day situation using MAR implemented with interactive aerosol module (dry/wet deposition) and constrained by LMDz BC concentration fields obtained in WP3. Output of simulation will be compared to observations in atmosphere and snow in order to determine the validity of MAR for sensitivity simulations of absorbing aerosols in the region. Results will provide deposition schemes in MAR to correctly simulate BC and Dust in snow and atmosphere usable for Element 2 WPs.

Deliverables
D2.1 (Month 24): 6-year climatology of absorbing aerosols in atmosphere in Nepal Higher Himalayas and identification of main emission sources of absorbing aerosol.
D2.2 (Month 24): deposition rate of BC and in surface snow in Higher Himalayas regions (2 seasons x 2 years)
D2.3 (Month 30): MAR model with improved schemes for simulation of regional absorbing aerosol distribution, deposition and effects)
Milestones
M2.1 (Month 24): 6-year atmospheric observation completed
M2.2 (Month 12): set-up methodology for BC and dust identification in snow using newly developed SP2 technique. Intercomparison with light attenuation and thermal techniques to identify the true BC fraction in snow
M2.3 (Month 24).conclude collection of snow samples
M2.4 (Month 30): Determination of optimal model setups for long-term coupled aerosol-climate sensitivity simulations

3.3.3 TÂCHE 3/WP 3: CLIMATE AND MONSOON VARIABILITY MODELLING

Participants: LSCE, LGGE
International Partner: none
Additional Expertise: none
Duration: Month 1-30

Objectives: This WP intends to analyze changes in the circulation and precipitation that are brought about by the presence of absorbing aerosols (e.g. from present-time up to 2050). Of particular interest to this workpackage are the changes in the vertical distribution of clouds, in the precipitation, in the temperature and aerosol loads resulting from the direct, semi-direct and indirect effects. These changes will be analyzed based on long simulations. The simulation with BC loads determined from this task over the region of interest will be compared to the reference simulation when no aerosol is present. The main objectives of the work package are:
• To establish changes brought about to the physical fields of clouds, precipitation and temperature by the aerosol present in the region,
• To determine which aspects and phases of the monsoon (onset, length or intensity) are affected by the presence of aerosol
• To study the impact of the changes in surface albedo (snow melt and aerosol effect on snow) have on the regions
• To analyze the mechanisms that trigger changes in the circulation and the precipitation.

Methodology:
The simulation with aerosols will be built upon the inventory of Indian black carbon (BC) and organic carbon (OC) produced for the next IPCC exercise under present and future conditions. The radiative fields both at the surface and at the top of the atmosphere will be analyzed to relate changes in temperature and hydrological cycle to these forcings. We will use the zoom capability of the LMDz GCM coupled to the land surface/hydrological model ORCHIDEE with the resolution of 50x50km^2 over the region of interest. The model allows to vary the position of the aerosol distribution to see how the aerosol layer height and intensity affect the monsoon. The changes in snow albedo that will have been studied in WP 2 will be included in the model. We will verify through key sensitivity studies the influence of the positioning and load of the aerosol prior on the circulation and precipitation over the region. Simulations will be run both in forced mode (fixed SST) and with the interactive oceanic model (ORCA) within the IPSL ESM (Earth System Model). This will allow isolating the role of the ocean in response to the presence of the aerosol.

Description of work and role of participants:
Task 3.1. Preparation of present aerosol emissions and projection future ones using detailed inventory at 50x50 km2 for Indian BC and OC (LSCE).
Task 3.2 Global 3D forced simulations with fixed SSTs. Analysis of the changes in temperature and precipitation due to the aerosol radiative forcings. This simulation will be used to prepare the limit conditions for running the MAR model (LSCE).
Task 3.3: Specific sensitivity simulations will be designed to test the role of the aerosol load and snow albedo and position in setting up monsoon changes (LSCE and LGGE).

Task 3.4 Long simulation (more than 50 years) with the IPSL-ESM in the presence of aerosol. This long simulation is necessary to evaluate the signal to noise ratio in the monsoon response to aerosol. This simulation allows to pinpoint the role of the ocean in the climatic system. A similar control simulation without aerosols will be used.

Deliverables

D3.1 (Month 14). 4D fields of temperature, precipitation and aerosol loads that will be used as boundary condition to the regional model MAR (Task 3) and to the CROCUS model (Task 4) (LSCE)

D3.2 (Month 24): Changes in monsoon characteristics due to different aerosol loads and snow albedo in the forced GCM (LSCE)

D3.3 (Month 30): Analysis of the mechanism that govern changes in circulation and precipitation over the region (LGGE and LSCE)

Milestones

M3.1 (Month 12) Radiative forcings from BC/OC over India, Tibet and more broadly over Asia

M6.2 (Month 18) Definition of different sensitivity studies to isolate monsoon response to aerosols

M6.3 (Month 30) temperature, precipitation changes due to aerosol forcings and albedo changes and description of the mechanism setting up these changes

3.3.4 TÂCHE 4/ WP4: MODELLING THE INTERACTION BETWEEN SNOWPACK, RADIATION, AND THE ABSORBING MATERIAL DEPOSITED IN THE SNOW

Participants: LGGE
International Partner: none
Additional Expertise: none
Duration: Month 1-30

Objectives: The impact of the presence of optically active aerosols in the snowpack on the albedo and on melting rates of the snow in the Koshi Basin will be investigated. The aerosols in the snow increase the absorption of radiation in the snowpack altering the albedo and the thermal budget of the snowpack. As a consequence, the melting rates and dates of the snowpack can change. Therefore, the objective of this task is to develop a snowpack model that is able to capture the effects of the aerosols on the radiative budget of the snowpack, to model the albedo and melting rates of the snow on top of the glaciers in the high mountains as well as of the seasonal snowpack in the middle mountains, and to estimate the sensitivity of the snowpack properties related to changing climatic conditions and aerosol loads.

Methodology: The one-dimensional snowpack model CROCUS (Brun et al., 1989; 1992) will be used to analyse the impact of the presence of absorbers on surface snow properties. The model contains a fully coupled description of physical processes in the snow related to snow grain properties. It simulates the snow metamorphism to describe the change of shape and size of the snow grains over time. However, the model currently simulates the vertical radiation transfer taking into account only the absorption by the snow grains itself, while the absorption of radiation due to impurities in the snow is neglected. We will implement the effect of impurities to investigate the impact on energy fluxes in the snowpack, on surface snow temperatures, and on melting rates. We will use an approach proposed by Qian et al. (2009) relating the change of the snow albedo to the concentration of black carbon in the snow. The developed equation is based on previous simulations regarding the effect of aerosols on the albedo of snow (Jacobson, 2004; Warren and Wiscombe, 1980; Flanner et al., 2007). To our knowledge such a model has not been applied to the Himalayan mountain range. Previous studies have shown that modifications are necessary for the application of CROCUS to other regions than the Alps (e.g. Dang et al., 1997; Genthon et al., 2001). Therefore, the model will be modified and validated using the measurements performed at NCO-P station and along the Khumbu valley. The model will be run with and without aerosols to investigate the impact of the optically active impurities. Moreover, the model will be applied to the high and middle mountains using topographic information and after disaggregation of the results of the regional modelling studies in task 3. For the middle mountains, the simulations will focus on the melting dates because it can be expected that an earlier melting of the seasonal snowpack has a large overall impact on the albedo. The sensitivity of the snowpack regarding changes in climate and aerosol loading will be studied using the results of the tasks 2 and 3, which will deliver a range of temperatures and BC concentrations in the snow. These ranges will be further analysed regarding their impact on snow albedo and melting rates and dates for the high and middle mountains in the future.

Risk: No universal technique for the downscaling of the output of the regional model exists for the Himalaya region to generate needed input data for the snowpack modelling. A dynamical downscaling method is currently under development at LGGE for Antarctica, which may, however, not directly be applicable to conditions in the Himalaya. In that case we will rely on a statistical downscaling method of the meteorological data based on observations along the Khumbu valley. This method might introduce additional errors in the results of the snowpack modelling impacting also the simulated albedo and melting rates and the sensitivity of the snowpack.

Description of work and role of participants

Task 4.1. (LGGE) Development of an aerosol module for snowpack modelling. Such a module takes into account the presence of optically active aerosols in the snow to calculate the absorption and transfer of solar radiation in the visible range in the snowpack. It will be implemented to generate the CROCUSabs model.

Task 4.2. (LGGE) Modification of CROCUSabs. The model will be calibrated and validated for the high and middle mountains using atmospheric and snow measurements at NCO-P station and along the Khumbu valley performed in WP 1.2. If necessary, the model will be adapted to improve the reproduction of the observations.

Task 4.3. (LGGE, CEN, LSCE) Application of validated CROCUSabs. Model runs will be performed for the high and middle mountains taking into account output from the regional modelling in task 3 and topographic information like altitude and slope orientation. These model runs will be used to estimate the impact of aerosols in the snowpack on the melting rates and days in the high and middle mountains of the Koshi Basin and to estimate the contribution of the snow melting to the run-off.

Task 4.4. (LGGE, LSCE) Sensitivity studies of future snowpack properties. Model runs will be performed to investigate the impact of changes in climatic conditions and aerosol loads on the snow albedo, melting rates, and run-off in the Koshi Basin based on the results of the sensitivity studies from the regional modelling performed in task 3.

Deliverables

D 4.1. (Month 14) Estimation of the present-day effect of absorbers in the snow on energy fluxes in the snowpack, on surface snow temperatures, and on snow melting days and rates for the observational sites.

D 4.2. (Month 22) 4D fields of present-day snowpack properties for the high and middle mountains of the Koshi Basin regarding albedo, surface temperature, and melting rates and maps of the melting days for the high and middle mountains.

D 4.3. (Month 32) Maps of the sensitivities of the snowpack properties in the Koshi Basin with respect to changes in climatic conditions and aerosols loadings.

Milestones

M 4.1. (Month 8): Snowpack model CROCUSabs taking into account the absorption due to optically active aerosols

M 4.2. (Month 12) Validated CROCUSabs model for the high and middle mountains

3.3.5 TÂCHE 5/ WP 5 – FUTURE OF THE WATER RESOURCES: ATMOSPHERE-CRYOSPHERE-HYDROPHERE MODELLING

Participants
Coordination: HSM – Pierre Chevallier
Partners: LTHE, LSCE, LGGE
Associated local partner: DHM, ICIMOD
Experts: CNRM-GAME, EDF-DTG

Duration: *Month 1-36*

Objectives

The task concerns the integration of the three components ((1) the glacier melt, (2) the snowpack melt, (3) the rainfalls (considered as precipitation in the liquid phase)) in a hydrological modelling to form a hierarchical atmosphere/cryosphere/hydrological modelling system, which can be used to simulate the hydrological response at both the local and regional scales to meteorological forcing.

Methodologies

The climatic forcing data (including precipitation and temperature) will come from the outputs of the LMD-MAR model (WP3) at a resolution of 12*12 km², the glacier melt model (WP1) will provide the volumes of the water delivered by the glaciers. Snow melt on the glaciers and in the middle mountains come from WP4 at a resolution of 1*1 km².

Several hydrological distributed or semi-distributed models (production and routing) gave satisfactorily approaches in high mountains in accordance with the spatial scales. HSM and LTHE experienced some of them in the Andes and in the Alps. The WP5 will research the most appropriate in order to integrate the initial conditions given by the results of the WP3 (climate, phase and volume of precipitation, temperature, radiation), WP1 (glacier melt), WP4 (snowpack melt).

An assessment of the uncertainties is needed at each step of the modelling processes.

The modelling system will be:

1. tested using the data collected in task 1 in Khumbu region and applied on Dudh Koshi and Hinku River basins;
2. tested using the coupled global/regional model forcing from experiments conducted in WP 3 in order to determine how using the climate model impacts the modelling system performance;
3. used to assess how the enhanced melting of the snow due to the presence of absorbing aerosols in the snowpack (WP 4) impacts the water resources at local and regional scales;
4. used to simulate the future of the water resources under different scenarios (SRES and local options) at headwater scale (< 200 km²), with a high proportion of glacierized areas, as well as upper valleys scale (> 1000 km²), where the people are living and using the water resources for their activities.

Tasks:

Task 1 *(HSM, LTHE, LSCE, ICIMOD)*: choice and test of consistent scenarios for the environmental changes in the future, considering that the SRES scenarios could be refined, taking into account the specificities of the high mountains environments. This step is very important in order to reduce the uncertainties on the impacts assessments and improve the adaptation behaviours.

Task 2 (*HSM, LTHE, CNRM-GAME):*. forcing of distributed hydrological models at local and regional spatial scales with the glacier melting model (WP 1), the regional climate model (WP 3) and the snow pack model (WP 4) will be quantified.

Task 3 (*HSM, LTHE, DHM, EDF-DTG):* Tests will be carried on using various regional model resolutions ranging from 50 to less than 10 km. Applications will be developed for the present and the future using regional hydrological modelling. The regional climate model MORDOR will be experimented in the Himalayan context. The application will be mainly done on the Dudh Koshi basin (1320 km²) and extended at the scale of the whole Koshi basin (> 20 000 km²).

Task 4 (*HSM, LTHE, DHM):* hydrological modelling approaches will be developed at a small spatial scale on basins with a high rate of glacierized areas. It has been noted that models like CAB or ISBA has given in the past interesting results in the Andes. But distributed models like TOPKAPI or others will be tested (Liu and Todini, 2002; Liu et al,2005). The application will be mainly done on the Imja and Hinku River basins (respectively 157 and 166 km²).

Tasks 5 *(LGGE, LTHE, HSM, CNRM-GAME)*: the optimal configuration of the hierarchical modelling system (regional model resolution and down-scaling methodology choice) will be determined for use in the longer term climate integrations. The final result should be an assessment of the regional response of hydrology to climatic forcing and of the future of the water resources for mountain basins, highly influenced by the cryosphere. This includes an assessment of changes of hydro-energy power potential in the region

Deliverables

D5.1 (Month 15): Integration of output from WP1/2 and 3 into hydrological models.
D5.2 (Month 24): Results from test modelling at basin scale for Koshi Basin
D5.3 (Month 30): Results of test modelling at river scale for Imja and Hinku rivers basins
D5.4 (month 36): Assessment report of the regional response of hydrology to climatic forcing and of the future of the water resources for mountain basins.
D5.5 (Month 36): Evaluation report of change in hydrological power potential under various climate scenarios

Milestones

M5.1 (Month 12). Most suited climate scenarios identified for high mountain environments
M5.2 (Month 24): Hydrological models to be used in the hierarchical modeling system are identified and integration of WP1/2/3 inputs to hydrological models achieved
M5.3 (Month 30) Optimal configuration of the hierarchical modeling system identified
M5.4 (Month 30): Hierarchical modeling methodology operational for work at river and basin scales

3.3.6 TÂCHE 6/ WP 6: PERCEPTION OF CHANGES BY POPULATIONS AND ADAPTATION WITHIN THE FOUR NEPAL GEOGRAPHIC UNITS

Participants: UPR 299; PACTE (UMR 5194);
Associated Partners: ICIMOD; University of Kirtipur, Nepal Water Conservation Foundation
Duration: months 6-36

Objectives: The aim of this WP is to study the consequences of climate change on populations, through two main themes: (i) variations in agricultural calendars and changes in human activities and water uses caused by variations in the availability of the resource, and the consequent territorial and social restructurings. This will be studied in the four main landscape units within the country (high mountains, middle mountains, low mountains and hills, and the Terai plain) for which the origin of water from three types of source is relevant: melting of glaciers, melting of snow, and rainfall. (ii) risks, that we will study through floods in the Terai plain for water courses originating from high mountains and therefore benefiting from a water supply from the melting of both glaciers and snow. Only four such river outlets exist in Nepal, but their floods may have consequences on the densely populated Ganga plain, as demonstrated by the breach in the Koshi dam embankment in September 2008. One of the objectives is also to map the areas concerned and to estimate the affected populations for each type of change and risk, using a GIS combining data from a hydrological basin with those from the population census.

Methodology:
Work we previously carried out in Nepal has led us to define four main landscape units within the country, for which water as a resource is one of the key criteria: it is a major factor in the organisation of human activities and territories. Zoning in the four geographical units is thus necessary in such a project insofar as the origin of the water resource differs in each unit, and therefore variations will have different consequences.

Geographical units	Origin of water			
	Melting of glaciers	Melting of snow	Rain	
			Spring storms	Monsoon
High mountains	x	x	(x)	(x)
Middle mountains		x	xx	xxx
Low mountains or hills			(x)	xxx
Terai plain areas drained by rivers flowing - from the high chain	x	x	(x)	xxx
- from the Mahabharat			(x)	xxx

Table: Hydrological resources in the four geographical units of Nepal

A site (on a village scale) in each of the four geographical units will be selected for fieldwork along a north-south transect in the Sapta Koshi basin to benefit from work which is being carried out at the Everest Pyramid station and on the Mera glacier. They will be selected in collaboration with WP5.
This part of the research focuses on perceptions and representations of the water resource, on perceived changes, on subsequent adaptations already implemented and on territorial

and social restructurings. Interviews will be carried out in Nepali within sections of the population. Terminology and toponymy will be among the investigating tools used to grasp the importance of the water resource in the construction of the territory. During the last field trip, we will discuss with local populations our results with those obtained by WP3 and WP5.
Some points of comparison will be made with an ongoing study in the Western Terai, where hydrological conditions differ (water courses here are solely supplied by monsoon rains).
Regarding the "risk" theme, we intend to focus exclusively on populations' perception and representation of risks in the Terai, with the mapping done for analysing uses being effective in addressing the "risk" issue, a theme which will be tackled for the most part by WP 7.

Description of work and role of participants:
For each site earmarked for fieldwork, we will list and map the following on a village scale:

- the various water courses, sources, snow covered areas, for which we will describe the patterns and add climatic data: local weather stations, those from the Climatological Census, as well as the on-going data collected by WP3 and WP5.
- the various water uses and the areas concerned (irrigation canals, mills, fountains, cattle watering, places for mountain summer pastures which depend on snow cover…);
- changes which have been introduced within the past 50 years (refer to Smadja 2003 on the redistribution of the resource through the shrinking of territory around farms).

This work will be carried out by researchers from UPR 299 (O. Aubriot and J. Smadja), a PhD student in villages located in high and middle mountains, M.A. students in low mountains and the Terai, as wells as scholars from ICIMOD, Nepal Water Conservation Foundation and Tribhuvan University.

Deliverables:
D6.1- Data on main changes perceived and observed by populations in the four geographical units and on adaptation to these changes, if any; on the estimation of the changes in water resource availability (in association with other WPs)
D6.2- List of the priorities expressed by populations regarding water (availability and use), compared to those of the National Planning Commission and NGOs
D6.3- Map of the areas affected by various changes, and estimation of the populations concerned
D6.4- Feedback communicated to local populations, and to local and national authorities.

Milestones:
M6.1- Selection of 4 villages along the north-south transect (Year 1)
M6.2- PhD student and group of students to be based at their sites for fieldwork (high and middle mountains and low mountains to study variations in the monsoon flux) (Year 1)
M6.3 - Partnership to be established with Nepalese scholars and members of WP 7 to concentrate on the Terai fieldwork discussion groups (Year 1)
M6.4 - Terai: 3-week field trip to study flood risk management (mapping and enquiries) and adaptation (Year 2)
M6.5 - Data integrated in a GIS (Year 2)
M6.6 - Back to the areas earmarked for fieldwork to talk with populations about the quantitative data and climatic change projections obtained by other WPs (Year 3)
M6.7 - Feedback to local population, and local and national authorities. (Year 3)

3.3.7 TÂCHE 7/WP 7: LOCAL COMMUNITIES AND CAPACITY BUILDING AND DISSEMINATION

Participants: UMR 5194 PACTE - CNRS, UPR 299– CNRS, ICIMOD
Associated Partners: ICIMOD

Duration: 12-36 months

Objectives
WP7 aims at confronting and integrating data from previous WPs with people's traditional knowledge, and at enhancing capacities of local communities to overcome potential changes in natural resources and environmental hazards. Specific objectives are:
1/ To confront scientific (both environmental and social) and traditional knowledge on the potential evolution of natural resources and the ability of local communities to overcome such changes;
2/ To integrate scientific data and traditional knowledge on people's vulnerability in the face of natural hazards in the context of global and local environmental changes;
3/ To define strategies and plans to enhance local capacities to overcome potential changes in natural resources and environmental hazards;
4/ To provide local and national authorities with recommendations on how to consider and integrate people's ability to overcome potential changes in natural resources and environmental hazards into national planning and strategies.

Methodological framework
WP7 considers that people's ability to face potential changes in natural resources and environmental hazards depends on the sustainability of their livelihoods. The Sustainable Livelihoods Approach (SLA) will thus constitute the guiding framework for all activities conducted in this WP. These activities will rely on participatory methodologies such as Participatory Rural Appraisal (PRA) and Capacities and Vulnerabilities Analysis (CVA). Particular emphasis will be given to Participatory 3-Dimensional Mapping (P3DM). P3DM consists in the building of stand-alone scaled relief maps over which are overlapped thematic layers of geographical information. It facilitates the interpretation, assimilation and understanding of geo-referenced information by making them visible and tangible to everyone. P3DM raises local awareness of territories, provide stakeholders with powerful mediums for development planning and serve as effective community-organizing tools. All activities will be conducted with one target community within each of the regional units defined for the overall Paprika project or a total of four communities.

Description of work and role of the participants:
Task 7.1: Selection of target communities and rapport building through interviews with key informants and immersion will be conducted during Year 1 by Pacte in coordination with UPR- 299 and ICIMOD.
Task 7.2: PRA will be carried out to confront and integrate scientific and people's knowledge on natural resources and environmental hazards. It shall resort on Focus Group Discussions, calendars, profiles, problem trees, transect walk conducted Pacte in coordination with UPR-299 and ICIMOD between the second half of Year 2 and the first half of Year 3.
Task 7.3: P3DM will be carried out to confront and integrate scientific and people's knowledge on natural resources and environmental hazards. It shall further resort on Focus

Group Discussions led by Pacte in coordination with UPR- 299 and ICIMOD between the second half of Year 2 and the first half of Year 3.

Task 7.4: Community-based strategic planning shall enable to define strategies and plans to face changes in natural resources and environmental hazards and to build and train community-based organizations. It shall rely on Focus Group Discussions, calendars, drills and community dramas conducted Pacte in coordination with UPR- 299, ICIMOD and local authorities during Year 3.

Task 7.5: Implementation, monitoring and adjustment of the foregoing strategies and plans will be conducted during Year 3 by ICIMOD.

Task 7.6: A general workshop intended to assess participants' evaluation of the project and to share experiences with national authorities will be held with all stakeholders at the end of Year 3.

Deliverables:

- D7.1: Profile of four target communities in the face of potential changes in natural resources and hazards based on both scientific and traditional knowledge
- D7.2: Participatory 3-dimensional maps of four target communities
- D7.3: Community-based strategies and plan to overcome potential changes in natural resources and hazards
- D7.4: Policy brief on how to consider and integrate people's ability to overcome potential changes in natural resources and hazards into national planning and strategies

Milestones:

- M7.1: Selection of target communities (Month 12)
- M7.2: Community approval of strategies/plans to face changes in natural resources and hazards (Month 24)
- M7.3: General workshop (Month 33)
- M7.4: Submission of final report (Month 36)

Risk for all the WP and backup plan:

The main risk is a situation of political instability, which may determine our access to the field. In such an event, the project would be transferred to sites in India (Himachal Pradesh), downstream of the Chhota-Shigri glacier which is studied by LTHE/LGGE since 2003. The climate in this area is different than in Nepal. The monsoon is less pronounced and the zone is influenced by westerlies.

3.4. CALENDRIER DES TACHES, LIVRABLES ET JALONS

	Partenaires*						Chronogramme / chemin critique																	
							Année 1						Année 2						Année 3					
	1	2	3	4	5	6	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
Tâche 1.1																								
Tâche 1.2																								
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Tâche 7.5																								
Tâche 7.6																								
Rapports d'avancement / états des dépenses									☺			☺			☺			☺			☺			☺
Accord de consortium/rapport final																								☆

☺ : Rapport d'avancement semestriel
□ : Rapport d'avancement semestriel + état des dépenses
☆ : Rapport de synthèse + récapitulatif des dépenses
Rouge : coordinating partner
Black : contributing partner

The numbers of the tasks correspond to the numbers described in the detailed WP descriptions. The partner numbers correspond to the French partners: 1 LTHE, 2 LGGE, 3 LSCE, 4 HSM, 5 UPR 299, 6 PACTE.

4. STRATEGIE DE VALORISATION DES RESULTATS ET MODE DE PROTECTION ET D'EXPLOITATION DES RESULTATS/ DATA MANAGEMENT, DATA SHARING, INTELLECTUAL PROPERTY STRATEGY

PAPRIKA contributes to an international effort to investigate how anthropogenic activities affect glaciers shrinkage and snow cover dynamics in the HKH area and to establish the optimal reduction efforts for preserving the HKH cryosphere in support to local adaptation policies. In that sense, significant efforts in the project will be taken to collect information and scenario analyses developed within the WPs where an integrated assessment of Himalayas concerning the impact of glaciers and changing water regime on the availability of water resources will be undertaken and insure proper transfer of information to the scientific community, the general public but also to user communities, relevant national authorities and intergovernmental and/or non-governative organisations.

4.1. DIFFUSION OF SCIENTIFIC INFORMATION

The dissemination of scientific results will be performed by publishing methodologies and findings of the scientific work in the peer-reviewed scientific literature and giving presentations in international conferences. We expect that a number of journal articles will be produced that describe the various elements of the project and the results in a variety of scientific fields such as atmospheric sciences, glaciology, hydrology, and human and physical geography. Of particular importance is the link of the project with other initiatives in the area from European, Asian and US scientists and to the scientific user community in general. Here, we will continue the opened data policy implemented in our on-going work in the Himalayas and other regions by granting free and rapid access to data. All results will be freely available, upon acknowledgement of ANR funding, both within the consortium, the user community and the wider public, including education institutes, for most part during the course of the project. Note that NCO-P data and GLACIOCLIM data are already opened to the scientific community and widely used and we will use identical format and data transfer protocols in the context of this project. By the end of the project, we will undergo a critical evaluation of the different methodologies used throughout the project, leading to the development of a transferable toolkit of methodologies and guidelines suitable for application in HKH and other mountain regions in the world.

4.2. DIFFUSION OF INFORMATION TO POLICY-MAKERS

Of particular relevance to the potential for success in the capacity building targets is the fact that PAPRIKA's partners, through their past and present involvement in the area, will rapidly mobilize a number of local institutions both non-profit non-governmental organizations and international/national authorities in the Hindu Kush-Himalayas. More specifically, links are already established between PAPRIKA partners and DHM (Department of Hydrology and Meteorology), ICIMOD (International Centre for Integrated Mountain Development) as well as Tribhuvan University (Kirtipur) and Nepal Water Conservation Foundation in Katmandu. Through our partnership and the long-term involvement in Nepal of our Italian counter-parts (EV-K2-CNR), PAPRIKA will directly address key stakeholder communities in the different mountain areas and at the national and international level., national agencies in Nepal (Nepal National Academy of Science), NGOs (Resources Himalaya Foundation, Kathmandu, http://www.resourceshimalaya.org), national parks (Sagarmatha National Park).

Some PAPRIKA partners, either as institutions or the PIs as individuals, hold key positions in the existing national and international underpinning work, and these positions will be used to convey the value of the project findings in the relevant policy arenas and to bring specific user needs to the attention of the project. The partners will use their involvement in the on-going technical underpinning mechanisms to make sure the project research results as well as its methodology development will have the maximum impact on policy both during the project and afterwards. The associated local partners in the project (ICIMOD, DHM in particular) will use the project results and methodologies to strengthen the scientific basis for the advice to their national authorities. In this way the project will strengthen existing mechanisms for policy development and compliance analysis.

4.3. DIFFUSION OF INFORMATION TO GENERAL PUBLIC / CAPACITY BUILDING / OUTREACH ACTIVITIES

Knowledge management, including dissemination of information from the project, the development of a dedicated project web-site and bibliography, and the establishment of a project database will be undertaken in conjunction with the International PAPRIKA partnership through EVK2CNR committee in Italy (see letter of support annexed to the document). This will ensure a very efficient transmission of information outside the consortium and includes design, development and maintenance of a web-site containing both public and Project-specific private components with interactive links to the Project meta-database. In particular, PAPRIKA will be supported by a multidisciplinary information system covering scientific and technological activities in the HKH areas, to the benefit of government and inter-government scientific agencies. A full array of techniques and methodologies will be adopted for knowledge transfer in the PAPRIKA web-sites. All these actions will be under the responsibility of EV-K2-CNR, at no-cost to PAPRIKA France. Of course, we will ensure that ANR CEP and the French contribution will be easily recognized and acknowledged.

The project will engage local people through its outreach activities. In particular, CNRS researchers at LGGE participate to the ERCA (European Research Course on Atmospheres) organized by University of Grenoble. LGGE will promote the participation of participant from Nepal research institutions at ERCA through provision of money for 1 participant/year at ERCA. In addition, participation of young scientists from associate partners in the region will be informed about career training opportunities in Europe (i.e. WMO courses for instance) For example, PAPRIKA's coordinator Y. Arnaud recently participated in the International Mass Balance Monitoring Training Course on Yala Glacier Langtang Valley, Central Nepal, organized by HKH-FRIEND Group on Snow and Ice Nepal National IHP Committee, IACS-ICIMOD-UNESCO.

4.4. SOCIO-ECONOMIC AND INDUSTRIAL IMPACTS

One of the central objectives of the PAPRIKA project is to develop policy scenarios addressing medium term remediation strategies to deal with the implications of changing water supply regime due to glacial melt and summer monsoon changes. Thus, dissemination activities will be crucial for reaching the local policy makers, wider group of scientists so that results could be effectively transformed into actions with socio-economical impacts. Direct links with mountain communities in Nepal to anticipate global environmental changes and propose local adaptation methods have strong societal impacts if methodologies are implemented at a wider scale.

Through the use of the EDF-based MORDOR model, alteration of streamflow regime due to climate change and assessment of impacts on electricity production will be conducted. This

is a very operational deliverable with strong socio-economical and industrial impacts whenever electricity companies will investigate investments in the area and management strategies to minimize the risk of failure in meeting the demand.
PAPRIKA will further foster the participation and training of local community in strengthening their capacity to face potential changes in natural resources and environmental hazards. Community-based activities shall ensure long-lasting impacts beyond the end of the project for end-user communities.

5. ORGANISATION DU PARTENARIAT/CONSORTIUM ORGANISATION

5.1. DESCRIPTION, ADEQUATION ET COMPLEMENTARITE DES PARTENAIRES/CONSORTIUM RELEVANCE

As a collaborative effort, a solid framework has been developed to bring together the know-how to realize the project objectives. Special attention has been paid to form a partnership with long-term experience of mutual cooperation and with long-term interest in the study of the HKH

LTHE and HSM: The Institut de Recherche pour le Développement (IRD) is a French scientific establishment under the joint authority of the Ministry of High Education and Research and of the Ministry of Foreign and European Affairs. The IRD has three main missions: research, consultancy and training. It conducts scientific programs contributing to the sustainable development of the countries of the South, with an emphasis on the relationship between man and the environment. The Research Unit Great Ice (18 permanent scientists) studied the glaciers in the Andes and in the Himalayas in order to evaluate the water flows coming from the cryosphere (snow and ice), to characterize the climatic variability during the last 500 years and to simulate its impacts in the near future. The research carried out since 1991 with partners of South America, Europe, and more recently of India, Central Asia and Nepal, made it possible to establish a databank in meteorology, hydrology and glaciology. Great Ice was responsible in the Andes for the observatory GlacioClim. It combines instrumental measurements for the recent periods influenced by the global change (climatic and anthropogenic) and indirect indicators (historical documents and environmental proxies) for the past periods. Great Ice carried out ice core drillings, glaciers and high altitude watersheds monitoring, and develops methods based on space imagery analysis, dating techniques and environmental proxies proceeding (stables isotopes, pollens, lichens, moraines, etc.). The results are used in modelling approaches. Since January 2009, the IRD Research Unit “GREAT ICE” no long exist and researchers from the unit joined two laboratories (LTHE and HSM) where IRD is already involved.
LTHE and HSM ((the “Himalaya” team of former IRD-Great Ice) have a long experience on glaciers in the Andes and since 2002 in Himalaya. The experience of both LTHE and HSM in hydrology will reinforce the capabilities of the team. The first role in this project is his contribution in field work (hydrology, glaciology and meteorology) on one benchmark glaciers in cooperation with Nepalese (DHM) partner. The second role is in the use of remote sensing both for snow monitoring and glacier mass balance spatialisation. LTHE, HSM will also contribute to the modelling of the snow pack, glacier/snow melting modelling and for the study of the effect of the presence of absorbers on the physical properties of snow.

LGGE is one of the leading laboratories dealing with the use of polar ice cores for environmental studies (past concentrations of gases and aerosols, climate records). Over the last decade, the LGGE was also a leading partner in European atmospheric programmes dedicated to the studies of aerosol in Europe (CARBOSOL, EUSAAR, EUCAARi, MEGAPOLI). The main role of the LGGE in this project is the modelling of the snow pack at the reference stations and the effect of the presence of absorbers on the physical properties of the snow. LGGE will also contribute to field measurements of physical properties of the snow. Further, LGGE will assess the effects of rising air temperatures and the amount of absorbers in the snow on the snow melting rates of glaciers in the HKH region. From Sept. 2009, LGGE will also take the lead in aerosol monitoring at the Nepal station, for data analysis and analysis of source regions. In particular, a collaboration with Mike Bergin at Georgia Tech. USA is foreseen for the identification of sources and estimation of radiative impacts of anthropogenic aerosols in the mountain regions. In close cooperation with CNR-EvK2 LGGE will bring its expertise in aerosol monitoring at the Nepal-Pyramid observatory. In particular, LGGE will be in charge of aerosol measurements at the station and will derive primary information such as the levels of absorbing material in air.

LSCE (Laboratoire des Sciences du Climat et de l'Environnement -Gif/Yvette) is part of IPSL, l'Institut Pierre Simon Laplace, a federative institute based in Paris, France. LSCE employs researchers in the fields of biogeochemical cycles modelling and observation, past and future climate studies and isotopic markers in the environment. Over the last 10 years the LSCE has developed an expertise on the study of biogeochemical cycles and climate studies through its Biogeochemical Cycles research department. This research group is active in the areas of atmospheric composition monitoring, development of process-based models of carbon cycling over terrestrial ecosystems and in the ocean, development of inverse methods to quantify sources and sinks from atmospheric observations, and atmospheric chemistry and aerosols global modelling. The Biogeochemical Cycles group is conducting studies on aerosol formation and transformations. The institute is also largely involved in the cooperative development of a joint climate model involving several laboratories in France. Over the last 5 years the LSCE has developed for this purpose an interactive chemistry-aerosol-climate model LMDz-INCA coupled to the IPSL earth system model.

UPR 299 or "Milieux, sociétés et cultures en Himalaya (*Milieux, societies and cultures in the Himalayas*)" is a CNRS-only (Centre National de Recherche Scientifique: *National Centre for Scientific Research*) research unit. The unit boasts a resolutely pluridisciplinary team, and has carried out, over the last 40 years, various pluridisciplinary projects. Most common projects are centred around notions of territory, environmental stakes and recent changes.
The team has thus developed an expertise in field work in the Himalayas (Nepal, India, China), as well as a knowledge on societies in the Himalayan region and on their relationship with the natural environment.
http://www.vjf.cnrs.fr/himalaya/eng/presentation.htm

Pacte is a social sciences research unit based in Grenoble, which includes about a hundred researchers and 120 PhD candidates. Its latest 4-year research plan gave rise to research groups on Risks, Crises and Disasters, as well as Development Studies. Both groups combine the skills of geographers, sociologists, political scientists and urban studies experts. As part of the PAPRIKA project, Pacte will be in charge of WP7. It will lead community-based and participatory activities to 1/ foster the integration of scientific and indigenous knowledge, and 2/ to help local communities in enhancing their capacities to face potential changes in natural resources and environmental hazards. Members of Pacte involved in PAPRIKA have more than thirty cumulated years of professional experience in the fields of natural resources management and disaster risk reduction in Asia and Africa. Pacte is also a pioneer unit in fostering the use of Participatory 3-Dimensional Mapping for enhancing disaster risk reduction at very fine scale. Furthermore, Pacte has developed particular strengths on mountainous environments.

Complémentarité et synergie des partenaires/Added value of the consortium
The consortium members were carefully chosen to ensure that the diverse expertise and skills are delivered to the project and that contribution and resources are well shared amongst the different WPs. PAPRIKA aims to bring together glaciologists, atmospheric scientists (including atmospheric chemists and climatologist), remote sensing specialists, but also human and physical geographers.This is needed to overcome an integrated and interdisciplinary approach to the assessment of the impacts of climate change on water resources and to consider effective adaptive management strategies. The nature of the research problems calls for a combined use of observational and modelling capabilities, which has determined the selection of a consortium. In PAPRIKA, both experimental (field observations, laboratory experiments, satellite retrievals) and theoretical (models from process level to global and policy feedback models) and participatory efforts are included.

The main strength of the consortium is the availability of

- Advanced observational capability in the field of atmospheric sciences, in particular state-of-the-art observing plate-forms in Nepal and access to long term records necessary to detect trends, validate modelling and identify main source areas
- Advanced observational capability in the field of glaciology, in particular state-of-the-art pilot glacier in Nepal and access to long term records necessary to detect trends, and validate modelling as well as observing capability using remote sensing instruments.
- Advanced Climate modelling capability at the regional and the global spatial scales and in the bridging of the spatial scales in a unified approach,
- Advanced Glaciological and snow pack modelling capability at the regional and the global spatial scales and in the bridging of the spatial scales in a unified approach,
- Advanced Climate modelling with the emphasis on regional scale, high resolution coupled calculations of climate, hydrology, glaciology and atmospheric chemistry processes
- mitigation options and the technical underpinning of policy in many contexts on a (semi) operational basis
- Pacte Advanced skills in conducting participatory research and community-based strategic planning in the fields of natural resources management and disaster risk reduction
- Pioneering skills in the use of Participatory 3-Dimensional Mapping for disaster risk reduction at very fine scale

We also will work closely with partners in Nepal, with which PAPRIKA partners and collaborating institutes have had a long-term involvement. Namely DHM, ICIMOD

5.2. QUALIFICATION DU COORDINATEUR DU PROJET/ PROJECT COORDINATOR QUALIFICATION

Immediately after his Phd, in 1992, Yves Arnaud was engaged as IRD researcher. His first position was at the head of the IRD/AGHRYMET Remote Sensing Unit in Niger where he worked during four years mainly in Hapex-Sahel and EPSAT-Niger programs. In 1997, he joined the IRD unit “Snow and Tropical Glaciers” as responsible of remote sensing activities in Bolivia and after he became steward (responsible of tropical Andes) of the international project GLIMS (Global Land Ice Measurement from Space). In 2002, he initiated and led a 3 year federative project on Mountain glaciers in the frame of the French ACI “Earth Observation” in collaboration with the 3 others French institutes working in the field of remote sensing and glaciers at this time (LEGOS, LGGE, Cemagref). During his career he worked in partnership in Niger, Bolivia, Canada, Peru, India and Nepal. Since 2006, he was co-responsible of the LGGE team “Climate and glaciers”, and he is now leading the mutual team “Cryosphere, Climate and Mountain Hydrology” between LGGE and LTHE laboratories. Since 2007, he is involved in a Hindu/French Project (CEFIPRA) on “Mass Energy and Hydrological Balance of Chhota Shigri glacier” and he recently joined a French-Italian group working in Khumbu region of Nepal in the framework of the consortium Ev-K2-CNR. Since 2001, Yves Arnaud is co-author of 18 rang A publications in the field of snow, glacier and remote sensing. Since 2003 he has supervised 2 PhDs in the field of remote sensing of the cryosphere and he is currently supervising 2 others PHd. He has also a field experience on Himalayan glaciers and partnership with India and Nepal since 2004. In may 2009 he participated in the International Mass Balance Monitoring Training Course on Yala Glacier Langtang Valley, Central Nepal, organized by HKH-FRIEND Group on Snow and Ice Nepal National IHP Committee, IACS-ICIMOD-UNESCO.

5.3. QUALIFICATION, ROLE ET IMPLICATION DES PARTICIPANTS

Partner 1: LTHE	Nom	Prénom	Emploi actuel	Discipline	Personne. mois	Rôle/Responsabilité dans le projet 4 lignes max
Coordinateur/responsable	Arnaud	Yves	Researcher	Remote sensing and glaciology	27	Coordination, shared data base management, remote sensing
Autres membres	Wagnon	Patrick	Researcher	glaciology	18	Energy and mass balance on glaciers
1	Sicart	Jean-Emmanuel	Researcher	Glaciology/ hydrology	10	Glacier melt modelling
1	Dedieu	Jean-Pierre	Researcher	Remote Sensing	13	Snow cover mapping
1	Zin	Isabella	Assistant professor	Hydrology	4	Hydro modelling
1	XXX				10	Cryosphere-hydrosphere modelling
1	J.E. Sicart	80% sur 3 ans	ANR JC TAG	Turbulent exchanges in glacial environments	J.E. Sicart	2006-2009

Partner 2 : LGGE	Nom	Prénom	Emploi actuel	Discipline	Personne. mois	Rôle/Responsabilité dans le projet 4 lignes max
Coordinateur/responsable	JACOBI	Hans-Werner	Chargé de recherche	Chimie et physique de la neige	9	Responsable WP4. Modélisation neige
Autres membres	VINCENT	Christian	Ingénieur de recherche	Glaciologie	8	Bilan de masse et bilan d'énergie des glaciers
	RABATEL	Antoine	Physicien adjoint	Glaciologie	3	Bilan de masse et bilan d'énergie des glaciers
	FAVIER	Vincent	Physicien adjoint	Régionalisation du bilan de masse	6	Désagrégation de données météorologiques
	LAJ	Paolo	Physicien	Aérosols atmosphérique	6	Responsable WP2. Mesures atmosphériques à la station NCO-P. Organisation des prélèvements et analyses de neige. Contribution aux mesures SP2. Interaction du

						programme avec EV-K2-CNR (Italie)
	JAFFREZO	Jean-Luc	Directeur de recherche	Chimie analytique	3	Prélèvements et analyses chimiques de la neige. Mise en place nouvelles technique de mesure SP2 et validation
	GINOT	Patrick	Ingénieur de recherche	Chimie de la neige	3	Prélèvement neige et analyses chimiques
	GALLEE	Hubert	Directeur de recherche	Physique atmosphérique	6	Modélisation régionale et downscaling
	COZIC	Julie	Ingénieur de recherche	Chimie d'aérosol	3	Analyses chimiques neiges
	VILLANI	Paolo	Ingénieur de recherche	Instrumentation scientifique	3	Mise en place mesure SP2 et maintenance NCO-P

Partner 3: LSCE	Nom	Prénom	Emploi actuel	Discipline	Personne. mois	Rôle/Responsabilité dans le projet 4 lignes max
Coordinateur/responsable	Balkanski	Yves	Directeur de Recherche	Modelisation	7	Coordinator for the study of the role of aerosols on the climate and monsoon variability
Autres membres	Schulz	Michael	Directeur de Recherche	Modelisation	2	Evaluation of the aerosol distribution with regards to observations
3	Cozic	Anne	Ingenieur de recherche	Modelisation	2	Preparation d'une version du modèle LMDZ avec un zoom au-desus de l'Inde et du TIbet. Préparation des fichiers aux limites qui serviront au modèle MAR
3	XX	XX	POstDoctorant	Modélisation	18	The role of absorbing aerosol on the climate and the monsoon over Asia

Partner 4: HSM	Nom	Prénom	Emploi actuel	Discipline	Personne. mois	Rôle/Responsabilité dans le projet 4 lignes max
Coordinateur/ responsable	CHEVALLIER	Pierre	DR1, IRD	Hydrologie	9 (25%) CV en annexe	Responsable de la tâche 5. Hydrologie (tâche 1), information spatiale, modélisation aux échelles moyennes (tâche 5).
Autres membres	DELCLAUX	François	IR1, IRD	Hydrologie	9,6 (26,7%) CV en annexe	Modélisation aux échelles moyennes (tâches 1 et 5).
4	NEPPEL	Luc	MdC, Univ. Montpellier 2	Hydrologie	3,6 (10%)	Modélisation aux échelles fines (tâches 1 et 5).
4	CHAZARIN	Jean Philippe	TCE, IRD	Hydrologie	1	Installation et mise en route des équipements de terrain (tâche 1)
4	X	X	Stagiaire M2	Hydrologie	6	Modélisation aux échelles fines et moyennes (tâche 5) [Les deux postes pourraient être occupés successivement par la même personne.]
4	X	X	Vacataire, niv. IE2	Hydrologie	6	

Il convient de mentionner un poste sur une bourse d'échange scientifique et technique (BEST) dont le financement a été sollicité auprès de l'IRD (département DSF) pour un ingénieur du DHM (Népal) dont l'activité, en cas de succès à l'AAP ANR et à l'AO BEST de l'IRD, sera entièrement consacrée au projet.

4	POKHREL	Bijay	Ingénieur DHM	Hydrologie	12	Hydrologie, modélisation aux échelles fines

Partner 5: UPR 299	Nom	Prénom	Emploi actuel	Discipline	Personne. mois	Rôle/Responsabilité dans le projet 4 lignes max
Coordinateur/responsable	AUBRIOT	Olivia	CR1	Agronomie, géographie	18	Co-coordination avec J. Smadja des recherches sur les usages, perceptions, adaptations et recompositions territoriales en montagnes ; coordination pour les mêmes thèmes dans le Teraï.
Autres membres	SMADJA	Joëlle	DR2	Géographie	7	Directeur de l'UPR 299, géographe, coordination des travaux sur le versant de Salmé et co-coordinatrice avec O. Aubriot des recherches sur les perceptions, représentations et changements d'utilisation des ressources hydriques en montagnes.
	xx	xx	Phd	Agronomy Anthropolo gy Geography	24	Water use and perception in mountain

Partner 6: PACTE	Nom	Prénom	Emploi actuel	Discipline	Personne. mois	Rôle/Responsabilité dans le projet 4 lignes max
Coordinateur/responsable	GAILLARD	JC	MCF	Géographie	15	Conduite des activités de recherche participative et de la planification des stratégies de renforcement des capacités locales
Autres membres	GIAZZI	Franck	MCF	Géographie	3	Expert pour la gestion participative des ressources naturelles
	MIALHE	François	Doctorant	Géographie	12	Post-doctorant en charge des activités de recherche participative et de la planification des stratégies de renforcement des capacités locales

6. ANNEXES

6.1. RÉFÉRENCES BIBLIOGRAPHIQUES

Aasa, T.H. and O.R. Vetaas (2007) Risk Management by Communal Decision in Trans-Himalayan Farming: Manang Valley in Central Nepal. *Human Ecology*, 35: 453–460.

Ageta Y. and Higuchi K. (1984) – Estimation of mass balance components of a summer-accumulation type glacier in the Nepal Himalaya. Geografiska Annaler, 66A (3), 249-255.

AUBRIOT O., 2004, Irrigation history in central Nepal: the interface between agriculture and technology *Water Nepal* 11:19-43.

AUBRIOT O., 2004, *L'eau, miroir d'une société. Irrigation paysanne au Népal central*. Paris: CNRS Éditions (Collection du Monde indien -Sciences Sociales 15e-21e siècle).

AUBRIOT O., 2008, "Les terrasses rizicoles de l'Himalaya," in *Agricultures singulières*. Edited by A. Walter and E. Mollard, pp. 292-296. Paris IRD.

AUBRIOT O., 2009, "Eau," in *Dictionnaire de l'Inde*. Edited by C. Clémentin-Ojha, C. Jaffrelot, D. Matringe, and J. Pouchepadass, pp. 223-225. Paris: Larousse (à présent).

AUBRIOT O., 2009, "Irrigation of paddy fields: a technical and social trace in the landscape (Frame 5)," in *Reading Himalayan landscapes over time. Environmental perception, knowledge and practice in Nepal and Ladakh*. Edited by J. Smadja, pp. 64-65. Pondicherry: Institut Français de Pondichéry (Collection Sciences Sociales 14).

AUBRIOT O., C. Jest and J.-L. Sabatier, 2008, "Quelles unités de mesures pour partager l'eau d'irrigation ? Exemples dans les moyennes montagnes du centre du Népal," in *Poids et mesures en Asie du Sud-Est. Systèmes métrologiques et sociétés,*, vol. 2. Edited by F. Robinne, J. Ivanoff, and P. Le Roux. Paris/ Marseille: Ecole française d'Extrême-Orient / Institut de Recherche sur le Sud-Est Asiatique (Etudes thématiques 13).

Barnett, T. P., J.C. Adam and D.P. Lettenmaier. 2005. Potential impacts of a warming climate on water availability in snow-dominated regions. Nature, 438(7066), 303-309, doi:10.1038/nature04141.

Bartelt, P., and M. Lehning, A physical SNOWPACK model for the Swiss avalanche warning. Part I: Numerical model, *Cold Reg.Sci.Technol.* 35, 123-145, 2002.

Berthier, E., Arnaud, Y., Baratoux, D., Vincent, C., & Remy, F. (2004). Recent rapid thinning of the "Mer de Glace" glacier derived from satellite optical images. *Geophysical Research Letters, 31*(17)

Berthier, E., Arnaud, Y., Vincent, C., & Remy, F. (2006). Biases of SRTM in high-mountain areas: Implications for the monitoring of glacier volume changes. *Geophysical Research Letters, 33*(8)

Berthier, E., Arnaud, Y., Kumar, R., Ahmad, S., Wagnon, P., & Chevallier, P. (2007). Remote sensing estimates of glacier mass balances in the Himachal Pradesh (Western Himalaya, India). *Remote Sensing of Environment, 108*(3), 327-338

Berthier, E., & Toutin, T. (2008). SPOT5-HRS digital elevation models and their application to the monitoring of glacier elevation changes. A case study in North-West Canada and Alaska. *Remote Sensing of Environment, in press*

Bonasoni, P., P. Laj, F. Angelini, J. Arduini, U. Bonafè, F. Calzolari, P. Cristofanelli, S. Decesari, M.C. Facchini, S. Fuzzi, G.P. Gobbi, M. Maione, A. Marinoni, A. Petzold, F. Roccato, J.C. Roger, K. Sellegri, M. Sprenger, H. Venzac, G.P. Verza, P. Villani, E. Vuillermoz. The ABC-Pyramid Atmospheric Research Observatory in Himalaya for aerosol, ozone and halocarbon measurements. Sci. Tot. Environ., 391, 252-261, 2008.

Brun, E., Martin, E., Simon, V., Gendre, C. and Coleou, C., 1989. An energy and mass model of snow cover suitable for operational avalanche forecasting. *J. Glaciol.* **35** 121, pp. 333–342.

Brun, E., David, P., Sudul, M. and Brugnot, G., 1992. A numerical model to simulate snow cover stratigraphy for operational avalanche forecasting. *Journal of Glaciology* **38** 128, pp. 13–22.

Crane, R. G., & Anderson, M. R. (1984). Satellite discrimination of snow / cloud surfaces. International Journal of Remote Sensing. 5, 213–223.

CSE, 2005 (1st publ. 1991), Floods, flood plains and environmental myths. *State of India's environment. A citizens' report 3.* Delhi, Centre for Science and Environment.

Dang, H., C. Genthon, and E. Martin, Numerical modeling of snow cover over polar ice sheets, *Ann.Glaciol.* 25, 170-176, 1997.

Dixit, Ajaya. 2009. Koshi embankment breach in Nepal: need for a paradigm shift in responding to floods. *Economic and Political Weekly* 44 (6):70-8.

DOBREMEZ J.-F., 1976, *Le Népal* : *Écologie et biogéographie*, Paris, Éditions du CNRS.

Dumka, U. C., S. K. Satheesh, P. Pant, P. Hegde, K. Krishna Moorthy. Surface changes in solar irradiance due to aerosols over central Himalayas. Geophys. Res. Lett., 33, L20809, doi:10.1029/2006GL027814, 2006.

Dumka, U. C., S. K. Satheesh, P. Pant, P. Hegde, and K. K. Moorthy (2008), Reply to comment by S. Ramachandran on Surface changes in solar irradiance due to aerosols over central Himalayas, Geophys. Res. Lett., 35, L04813,

Dyurgerov, M.B. and M.F. Meier. 2005. Glaciers and the changing earth system: a 2004 snapshot. Occasional paper 58 http://instaar.colorado.edu/other/download/OP58 dyurgerovmeier.pdf.

Fichefet T, Morales Maqueda MA (1999) Modelling the influence of snow accumulation and snow-ice formation on the seasonal cycle of the Antarctic sea-ice cover. Clim Dyn 15: 251-268

Flanner, M.G., and C.S. Zender, Snowpack Radiative Heating: Influence on Tibetan Plateau Climate, *Geophys.Res.Lett.* 32 (6), L06501, doi: 10.1029/2004GL022076, 2005.

Flanner,M.G., C. S. Zender, J. T. Randerson, and P. J. Rasch, Present-day climate forcing and response from black carbon in snow, J. Geophys. Res, VOL. 112, D11202, doi:10.1029/2006JD008003, 2007

Gaillard, J.-C. and E.A. Maceda (2009) Participatory 3-Dimensional Mapping for Disaster Risk Reduction. *Participatory Learning and Action*: in press.

Genthon, C., M. Fily, and E. Martin, Numerical simulations of Greenland snowpack and comparison with passive microwave spectral signatures, *Ann.Glaciol.* 32, 109-115, 2001.

Gerbaux M., Genthon C., Etchevers P., Vincent C., Dedieu J.-P. (2005) : Surface mass balance of glaciers in the French Alps : distributed modeling and sensitivity to climate change. *Journal of Glaciology*, Vol. **51**, No. 175. pp. 561-572.

Gole, C.V., and S.V. Chitale. 1966. Inland delta building activity of Koshi river. *Journal Hydraulic Division* (March):111-26.

Guilyardi E, Delecluse P, Gualdi S, Navarra A (2003) Mechanisms for ENSO phase change in a coupled GCM. J Clim 16: 1141-1158

Hall, D. K., Riggs, G., Salomonson, V. V., DiGirolamo, N. E., & Bayr, K. J. (2002). MODIS snow-cover products. Remote Sensing of Environment. 83, 181–194.

Hegde, P., P. Pant, M. Naja, U. C. Dumka, R. Sagar. South Asian dust episode in June 2006: Aerosol observations in the central Himalayas. Geophys. Res. Lett., 34, L23802, doi:10.1029/2007GL030692, 2007.

Huang, j., P. Minnis, Y. Yi, Q. Tang, X. Wang, Y. Hu, Z. Liu, K. Ayers, C. Trepte, D. Winker. Summer dust aerosols detected from CALIPSO over the Tibetan Plateau. Geophys. Res. Lett., 34, L18805, doi:10.1029/2007GL029938, 2007.

Jacobson, M.Z., Climate response of fossil fuel and biofuel soot, accounting for soot's feedback to snow and sea ice albedo and emissivity, *J.Geophys.Res.* 109, D21201, doi: 10.1029/2004JD004945, 2004.

Hock, R., and B. Holmgren (2005), A distributed surface energy-balance model for complex topography and its application to Storglaciaren, Sweden, Journal of Glaciology, 51(172), 25-36.

Kulkarni, A.V., I.M. Bahuguna, B.P. Rathore, S.K.Singh, S.S. Randhawa, R.K. Sood and S. Dhar. 2007. Glacial retreat in Himalaya using Indian remote sensing satellite data. Current Science 92(1), 69-74.

Kumar R, Singh R D and Sharma K D 2005 Water resources of India; *Curr. Sci.* **89** 794–811.

Lau, K.-M., and K.-M. Kim, Observational relationship between aerosol and Asian monsoon rainfall, and circulation. Geophys. Res. Lett., 33, L21810, doi:10.1029/2006GL027546, 2006.

Lejeune Y. (2009) : Apports des ré analyses ERA40 et du modèle CROCUS d'évolution du manteau neigeux à l'étude de la sensibilité climatique d'un glacier tropical. *Thèse de doctorat de l'Université Joseph Fourrier (à paraître), Grenoble , France*.

Li C.F. and Yanai M. 1996 The onset and interannual variability of the Asian summer monsoon in relation to land sea thermal contrast, JOURNAL OF CLIMATE Vol. 9 N° 2 Pages: 358-375

Liu, Z. and E. Todini, (2002) Towards a comprehensive physically-based rainfall-runoff model, Hydrology and Earth System Sciences, 6(5), 859–881.

Liu, Z., M. L. V. Martina and E. Todini, (2005) Flood forecasting using a fully distributed model: application of the TOPKAPI model to the Upper Xixian Catchment, Hydrol. Earth Syst. Sci., 9, 347-364.

Maceda E.A., Gaillard J.-C., Stasiak E., Le Masson V., Le Berre I. (2009) Experimental use of Participatory 3-Dimensional Models in island community-based disaster risk management. Shima: *The International Journal of Research into Island Culture*, 3(1): 46-58.

Meehl, G.A. Couplet Land-Ocean-Atmosphere processes and South Asian Monsoon, 1994, Science, vol. 266, n°: 5183, pp. 263-267.

Ming, J., H. Cachier, C. Xiao, D. Qin, S. Kang, S. Hou, and J. Xu. Black carbon record based on a shallow Himalayan ice core and its climatic implications. Atmos. Chem. Phys. Discuss., 7, 14413–14432, 2007a.

Moench M. and A. Dixit (Eds), 2007, *Working with the winds of change. Towards strategies for responding to the risks associated with climate change and other hazards.* ProVentium consortium, ISET-International, ISET-Nepal.

Moench, M., Fajber, E., Dixit, A., Caspari, E. and Anil Pokhrel (2009) Catalyzing Climate and Disaster Resilience: Processes for Identifying Tangible and Economically Robust Strategies - Final Report of the Risk to Resilience Study. ISET, ISET-Nepal, Kathmandu.

Oxfam (2009) *Helping Communities in Bangladesh and Nepal to Cope with Disasters*. Oxfam, Oxford.

Painter, T. H., Dozier, J., Roberts, D. A., Davis, R. E., & Green, R. O. (2003). Retrieval of subpixel snow-covered area and grain size form imaging spectrometer data. Remote Sensing of Environment. 85, 64–77.

Qian, Y., W.I. Gustafson Jr., L. Ruby Leung, and S.J. Ghan, Effects of soot-induced snow albedo change on snowpack and hydrological cycle in western United States based on Weather Research and Forecasting chemistry and regional climate simulations, *J.Geophys.Res.* 114, D03108, doi: 10.1029/2008JD011039, 2009.

Ramachandran, S. (2008), Comment on Surface changes in solar irradiance due to aerosols over central Himalayas by U. C. Dumka et al., Geophys. Res. Lett., 35, L04814,

Ramanthan, V., M. V. Ramana, G. Roberts, D. Kim, C. Corrigan, C. Chung, D. Winkler. Warming trends in Asia amplified by brown cloud solar absorption. Nature, 448, 575-578, 2007a.

Ramanathan, V, Li F, Ramana MV, Siva PS, Kim D., Corrigan CE, Nguyen H, Stone EA, Schauer JJ, Carmichael GR, Adhikary B, and Yoon SC. Atmospheric Brown Clouds: Hemispherical and regional variations in long range transport, absorption and radiative forcing. J. Geophys. Res., 112, doi:10.1029/2006JD008124, 2007b.

Rees, G. and Collins, D. N. 2004: Sagarmatha - Snow and ice aspects of water resources management in the Himalays. An assessment of the potential impact of deglaciation on the water resources of Himalaya. DFID Kar Project No R7980. Wallingford: CEH, DFID, 88.

Revenga, C., Nackoney, J., Hoshino, E., Kura, Y. and Maidens, J., 2003. Watersheds of the world_CD. IUCN, IWMI, Ramsar, World Resources Institute, Washington

REYES-GARCÍA V., O. AUBRIOT, P. ARIZA-MONTOBBIO, E. GALÁN-DEL-CASTILLO, T. SERRANO-TOVAR, and J. MARTINEZ-ALIER, in press, Local perception and use of the multifunctionality of water tanks in two villages of Tamil Nadu, South India. *Society and Natural Resources*:29p.

Roy, S.S. and J.R.C. Balling. 2005. Analysis of trends in maximum and minimum temperature, diurnal temperature range, and cloud cover over India. Geophys. Res. Lett., 32(12), doi:10.1029/2004GL022201.

Seinfeld, J., Black carbon and brown clouds, Nature Geoscience 1, 15 - 16 (2008) doi:10.1038/ngeo.2007.62

SMADJA J., 1986, Géodynamique des milieux d'un versant de mousson en moyenne montagne himalayenne. Le versant de Salmé, Népal Central, PhD dissertation, Université Paris 1.

SMADJA J., 1991, "Particularités climatiques d'un grand versant de mousson himalayen", Revue de géographie Alpine, n°2, vol. 79, Juin 1991, pp 99-119

SMADJA J., 1992, "Studies of Climatic and Human Impacts and their Relationship on a Mountain Slope Above Salme in the Himalayan Middle Mountains, Nepal", Mountain Research and Development, vol. 12, no. 1, p. 1-28.

SMADJA J., 1995, "Sur une Dégradation annoncée des milieux népalais : initiatives villageoises pour remplacer les ressources forestières", Natures Sciences Sociétés, vol. 3, no. 3, p. 190-204.

SMADJA J. (sous la direction de), 2003, Histoire et devenir des paysages en Himalaya. Représentations des milieux et gestion des ressources au Népal et au Ladakh, Paris, Éditions du CNRS, collection Espaces et Milieux, cartes, tab. Fig., 646 p

SMADJA J., (Ed. J. Smadja, transl. B. Sellers.) 2009, Reading Himalayan Landscapes over Time. Environmental perception, Knowledge and Practice in Nepal and Ladakh. Collection Sciences Sociales n°14. Institut Français de Pondichéry, Inde, 671 p.

SMADJA J., 2009, "Geographic Units and Landscapes in Nepal. Local Terminologies", in J.SMADJA, (Ed.) Reading Himalayan Landscapes over Time. Environmental perception, Knowledge and Practice in Nepal and Ladakh. Collection Sciences Sociales n°14. Institut Français de Pondichéry, Inde, pp 43-84

SMADJA J., 2009, "A reading of the Salme Tamang's Territory and Landscape", in J.SMADJA, (Ed.) Reading Himalayan Landscapes over Time. Environmental perception, Knowledge and Practice in Nepal and Ladakh. Collection Sciences Sociales n°14. Institut Français de Pondichéry, Inde, pp 199-240 + annex and map

Tangborn, W. and B. Rana. 2000. Mass balance and runoff of the partially debris-covered Langtang glacier, Nepal. In M. Nakawo, C.F.Raymond and A. Fountain (Eds), Debris-Covered Glaciers, 264, IAHS publications.

Trenberth, K.E., Smith, L. and Qian, T.T. 2007 Estimates of the global water budget and its annual cycle using observational and model data, JOURNAL OF HYDROMETEOROLOGY Volume: 8 Issue: 4 Pages: 758-769

Wagnon P., J.E. Sicart, E. Berthier & J.P. Chazarin, Wintertime high altitude surface energy balance of a Bolivian glacier, Illimani, 6340 m above sea level (a.s.l.), J. Geophys. Res., 108 (D6), ACL 4.1-4.14, 2003

Wagnon, P., A. Linda, Y. Arnaud, R. Kumar, P. Sharma, C. Vincent, J. Pottakal, E. Berthier, A. Ramanathan, S.I; Hasnain & P. Chevallier, Four years of mass balance of Chhota Shigri glacier (Himachal Pradesh, India), a new benchmark glacier in western Himalaya, J. Glaciol., 53(183), 603-610, 2007

Wagnon P. , Y. Arnaud, P. Chevallier, La source Himalayenne se tarit, La Recherche, 421, 48-51, 2008

Warren, S.G., and W.J. Wiscombe, A model for the spectral albedo of snow. II: Snow containing atmospheric aerosols, *J.Atmos.Sci.* 37, 2734-2745, 1980.

Webster PJ Moore AM, Loschnigg JP, et al, Coupled ocean-atmosphere dynamics in the Indian Ocean during 1997-98 NATURE Volume: 401 Issue: 6751 Pages: 356-360 Published: SEP 23 1999

Yadav, R.R., W.K. Park, J. Singh and B. Dubey. 2004. Do the western Himalaya defy global warming? Geophys. Res. Lett., 31(17), doi:10.1029/2004GL020201.

Yanai, M.H., LI, C.F. and Song, Z.S. Seasonal heating of the Tibetan plateau and its effect on the evolution of the Asian summer monsoon. 1992, J. Meteo. Soc. Japan, vol. 70, n°1B, pp. 319-351.

6.2. PUBLICATIONS OF THE PARTICIPANTS RELEVANT FOR THE TOPIC (FOLLOWING THE WP NUMBERS)

WP1

Dumont M., **Y. Arnaud**, D. Six, J. G. Corripio, Détermination de l'albédo de surface des glaciers à partir de photographies terrestres, La Houille Blanche, 2009 DOI 10.1051/lhb:2009021

Soruco, A, C. Vincent, B. Francou, P. Ribstein, T. Berger, J.E. Sicart, P. Wagnon, **Y. Arnaud,** V. Favier, Y. Lejeune, Mass balance of Zongo glacier, Bolivia, between 1956 and 2006, using glaciological, hydrological and Geodetic methods, Annals of Glaciology Annals of Glaciology vol.50, 2009

Pascal Sirguey, Renaud Mathieu, and **Yves Arnaud,** "Subpixel monitoring of the seasonal snow cover with MODIS at 250 m spatial resolution in the Southern Alps of New Zealand: methodology and accuracy assessment," *Remote Sensing of Environment,* vol. 113, pp. 160–181, 2009.

Wagnon P. , **Y. Arnaud**, P. Chevallier, La source Himalayenne se tarit, La Recherche, 421, 48-51, 2008

Racoviteanu, A**., Y. Arnaud**, M. Williams, and J. Ordonez. Decadal changes in glaciers parameters in cordillera Blanca, Peru, derived from remote sensing. Journal of glaciology. *Journal of Glaciology, VOl 54, N°186, 2008*

Lopez P., Sirguey P., **Arnaud Y**., Pouyaud B., Chevallier P. Snow cover monitoring in the Northern Patagonia Icefield using MODIS satellite images (2000-2006), Global and Planetary Change, (61), pp. 103 – 16, 2008

Sirguey, P. R. Mathieu, **Y Arnaud**, M. M. Khan, J. Chanussot. Improving MODIS spatial resolution for snow mapping using wavelet fusion and ARSIS concept, IEEE Geoscience and Remote Sensing letters, Vol 5, N1, 2008

Racoviteanu A. E., W. F. Manley, **Y. Arnaud** and M. Williams Evaluating Digital Elevation Models for glaciological applications: An example from Nevado Coropuna, Peruvian Andes, Global and Planetary Change, doi:10.1016/j.gloplacha.2006.11.036, 2007

Sicart J., **Y. Arnaud**, Preliminary spectral characterization of snow in a high altitude tropical glacier and potential effects of impurities in snow on albedo of tropical glaciers, Hydrological Processes, 10.1002/hyp.6741, 2007

Berthier E., **Arnaud Y**., Rajesh K., Sarfaraz A., Wagnon P., & Chevallier P., Remote sensing estimates of glacier mass balances in the Himachal Pradesh (Western Himalaya, India). Remote Sensing Environ., 108(3), 327-338, 2007

Raup, B., A. Racoviteanu, S.J.S Khalsa, C. Helm, R. Armstrong, **Y. Arnaud,** The Glims Geospatial Glacier database: a new tool for studying glacier change, Global and Planetary Change, special issue on Climate change impacts on glaciers and permafrost, 56:101—110.doi:10.1016/j.gloplacha.2006.07.018, 2007

Berthier E*.**, **Arnaud Y**.**, Vincent C. &** Rémy ***F. Biases of SRTM in high-mountain areas. Implications for the monitoring of glacier volume changes. Geophysical Research Letters, Geophys. Lett. 33 (L17401), 2006

Berthier E. , H. Vadon, D. Baratoux, **Y. Arnaud**, C. Vincent, K.L. Feigl, F. Rémy and B. Legrésy. Surface motion of mountain glaciers derived from satellite optical imagery, Remote Sensing of Environment, Volume 95, Issue 1, Pages 14-28, 2005

*Berthier E***., Arnaud Y**., Baratoux D., Vincent C., and Rémy F. Recent rapid thinning of the "Mer de Glace "glacier derived from satellite optical images, Geophysical Research Letters, Vol 31 (17), 2004

Ponzoni J. F., Zullo J., Lamparelli R. Pelligrino G.R. and **Arnaud Y**. In-flight absolute calibration of the Landsat-5 TM on the test site salar de Uyuni, IEEE Transaction on Geoscience and remote Sensing, Vol 42, N° 12, 2004

Lamparelli, R. A. C., Ponzoni, F. J., Pellegrino, G. Q., J., Z. J. and **Arnaud, Y**. Characterization of the "Salar of Uyuni" for in-orbit satellite calibration. IEEE Transaction on Geosciences and Remote Sensing, 41(6): 1461-1468, 2003

Wan, Z., Zhang, Y., Li, Z.-l., Wang, R., Salomonson, V., **Arnaud, Y**., Bosseno, R. and Hanocq, J. F. Preliminate estimate of calibration of the moderate resolution imaging spectroradiometer thermal infrared data using Lake Titicaca. Remote sensing of Environment, 80: 497-515, 2002

Arnaud, Y., Muller, F., Vuille, M. and Ribstein , P. El Niño-Southern oscillation (ENSO) influence on a Sajama volcano glacier (Bolivia) from 1963 to 1998 as seen from Landsat data and aerial photography. Journal of geophysical research, 106, D16: 17773-17784, 2001.

Wagnon P., Delmas R.J. & Legrand M. Loss of volatile acid species from upper firn layers at Vostok, Antarctica. *J. Geophys. Res., (104)*D3, 3423-3431, 1999a.

Wagnon P., Ribstein P., Francou B. & Pouyaud B. Annual cycle of energy balance of Zongo Glacier, Cordillera Real, Bolivia. *J. Geophys. Res., (104)*D4, 3907-3923, 1999b.

Wagnon P., Ribstein P., Kaser G. & Berton P. Energy balance and runoff seasonality of a Bolivian glacier. *Global and Planetary Change. 22,* 49-58, 1999c.

Wagnon P., Ribstein P., Francou B. & Sicart J.E. Anomalous heat and mass budget of Zongo Glacier, Bolivia during the 1997-98 El Niño year. *J. Glaciol., 47*(156), 21-28*,* 2001.

Sicart J.E., Ribstein P., **Wagnon P.** & Brunstein D. Clear sky albedo measurements on a sloping glacier surface: A case study in the Bolivian Andes, *J. Geophys. Res., 106*(D23)*,* 31729-31738, 2001.

Wagnon P., J.E. Sicart, E. Berthier & J.P. Chazarin, Wintertime high altitude surface energy balance of a Bolivian glacier, Illimani, 6340 m above sea level (a.s.l.), *J. Geophys. Res., 108 (D6),* ACL 4.1-4.14, 2003.

Francou B., Vuille M., **Wagnon P.**, Mendoza J. & J.E. Sicart, Tropical climate change recorded by a glacier in the central Andes during the last decades of the 20th century: Chacaltaya, Bolivia, 16°S, *J. Geophys. Res., 108(D5),* ACL 1.1-1.12, 2003.

Favier, V., **Wagnon P.**, Chazarin J.P., Mashinsho L. & A. Coudrain, One-year measurements of surface heat budget on the ablation zone of Antizana glacier 15, Ecuadorian Andes, *J. Geophys. Res.,* Vol. 109, No. D18, D18105, doi: 10.1029/2003JD004359, 2004a .

L'Hôte, Y., Chevallier, P, Etchevers, P., Lejeune, Y. & **Wagnon, P**. Pluie ou neige ? Dispositif de mesures pluviographiques dans les Andes de Bolivie et interprétation des enregistrements. *Hydrological sciences journal*, *49*(2), 273-281, 2004.

Favier, V., **P. Wagnon** & P. Ribstein, Glaciers of the inner and outer tropics : a different behaviour but a common response to climatic forcing, *Geophys. Res. Lett.,* 31, L16403,doi:10.1029/2004GL020654, 2004b

Vincent, C., P. Ribstein, **P. Wagnon**, B. Francou, V. Favier, E. Le Meur & D. Six, Glacier fluctuations in the Alps and in the tropical Andes, *CR Geosciences 337,* 97-106*,* 2005.

Sicart, J.E., **P. Wagnon** & P. Ribstein, Atmospheric controls of the heat balance of Zongo Glacier (16°S, Bolivia), *J. Geophys. Res,* Vol. 110, D12106, doi:10.1029/2004JD005732, 2005.

Lejeune, Y., **P. Wagnon,** L. Bouilloud, P. Chevallier, P. Etchevers, E. Martin, J.E. Sicart, F. Habets, Melting of snow cover in a tropical mountain environment: processes and melting, *J. Hydrometeorol., 8,* 922-937, Doi: 10.1175/JHM590.1, 2007.

Lejeune, Y., Y. L'Hôte., P. Etchevers, **P. Wagnon,** J.P. Chazarin, P. Chevallier, Constitution d'une base de données météorologiques sur un site andin de haute altitude : le site du Charquini, 4795 m, Bolivie, *IAHS Red Book, 318,* 173-185, 2007*.*

Berthier E., Arnaud Y., Rajesh K., Sarfaraz A., **Wagnon P**., & Chevallier P., Remote sensing estimates of glacier mass balances in the Himachal Pradesh (Western Himalaya, India). *Remote Sensing Environ., 108*(3), 327-338, 2007.

Wagnon, P., A. Linda, Y. Arnaud, R. Kumar, P. Sharma, C. Vincent, J. Pottakal, E. Berthier, A. Ramanathan, S.I; Hasnain & P. Chevallier, Four years of mass balance of Chhota Shigri glacier (Himachal Pradesh, India), a new benchmark glacier in western Himalaya, *J. Glaciol., 53*(183), 603-610, 2007.

Vuille M., B. Francou, **P. Wagnon**, I. Juen, G. Kaser, B. Mark, R. Bradley, Climate change and tropical Andean glaciers - past, present and future, *Earth Science Review, 89*, 79-96, 2008.

Soruco, A., C. Vincent, B. Francou, P. Ribstein, T. Berger, J.E. Sicart, **P. Wagnon**, Y. Arnaud, V. Favier & Y. Lejeune, Mass balance of Glaciar Zongo, Bolivia, between 1956 and 2006, using glaciological, hydrological and geodetic methods, *Ann. Glaciol., 50,* 1-8, 2009.

Winkler, M., I. Juen, T. Mölg, **P. Wagnon**, J. Gómez, and G. Kaser, Measured and modelled sublimation on the tropical Glaciar Artesonraju, Perú, *The Cryosphere, 3,* 21-30, 2009.

Gascoin, S. A. Ducharne, P. Ribstein, E. Perroy and **P. Wagnon**, Sensitivity of bare soil albedo to surface soil moisture on the moraine of the Zongo glacier (Bolivia), *Geophys. Res. Lett*., *36,* L02405,doi:10.1029/2008GL036377, 2009.

Six, D., **Wagnon, P**., Sicart, J.E. & Vincent C., Meteorological controls on snow and ice ablation for two contrasting months on Glacier de Saint-Sorlin, France, *Ann. Glaciol., 50*(50), 66-72, 2009.

Gascoin, S. A. Ducharne, P. Ribstein, Y. Lejeune and **P. Wagnon**, Dependence of bare soil albedo on soil moisture on the moraine of the Zongo glacier (Bolivia): implications for land surface modeling, *J. Geophys. Res.,* Sous presse.

Wagnon, P., M. Lafaysse, Y. Lejeune, L. Maisinsho, M. Rojas & J.P. Chazarin, Understanding and modelling the physical processes that govern the melting of the snow cover in a tropical mountain environment in Ecuador, *J. Geophys. Res.,* Sous presse.

Sicart J. E., R. Hock, D. Six (**2008**), Glacier melt, air temperature, and energy balance in different climates: The Bolivian Tropics, the French Alps, and northern Sweden, ***Journal of Geophysical Research***, *113*, D24113, doi:10.1029/2008JD010406.

Pellicciotti, F., J. Helbing, A. Rivera, V. Favier, J. Corripio, J. Araos, **J. E. Sicart**, and M. Carenzo (**2008**), A study of the energy balance and melt regime on Juncal Norte Glacier, semi-arid Andes of central Chile, using melt models of different complexity, ***Hydrological Processes***, *22*(19): 3980-3997.

Sicart, J. E., and Y. Arnaud (**2007**), Preliminary spectral characterization of snow in a high altitude tropical glacier and potential effects of impurities in snow on albedo of tropical glaciers, ***Hydrological Processes***, *21*(26), 3642-3644.

Sicart, J. E., P. Ribstein, B. Francou, B. Pouyaud, and T. Condom (**2007**), Glacier mass balance of tropical Zongo glacier, Bolivia, comparing hydrological and glaciological methods, ***Global Planetary Change***, *59*(1), 27-36.

Lejeune, Y., P. Wagnon, L. Bouilloud, P. Chevallier, P. Etchevers, E. Martin, **J. E. Sicart,** and F. Habets (**2007**), Melting of snow cover in a tropical mountain environment in bolivia: Processes and modeling, ***Journal of Hydrometeorology***, *8*(4), 922-937.

Sicart, J. E., P. Wagnon, and P. Ribstein (**2005**), Atmospheric controls of the heat balance of Zongo Glacier (16°S, Bolivia), ***Journal of Geophysical Research***, *110*(D12106), doi:10.1029/2004JD005732.

Dedieu JP., Dullinger S., Randin C., Zappa M., Jonas T.,.and Hubacher R. Snow cover modelling under Climate Change conditions (present and future) for alpine dynamics (Austria). *Journal of Biogeography*, submitted.

Rabatel A., **Dedieu JP**, Thibert E., Letréguilly A. and Vincent C., 2008. 25 years (1981-2005) of equilibrium-line altitude and mass-balance reconstruction on the Glacier Blanc, French Alps, using remote-sensing methods and meteorological data. *Journal of Glaciology*, 54 (185); 307-314.

Niang M., **Dedieu JP**., Durand Y., Mérindol L., Bernier M. and Dumont M., 2007. New inversion method for snow density and snow liquid water content retrieval using C-band data from ENVISAT/ASAR alternating polarization in alpine environment. *ESA Publications*, SP- 636/4D2-459889de.

Bugmann, H., Björnsen-Gurung, A., **Dedieu JP**., Ewert, F., Haeberli, W., Guisan, A., Fagre, D. and Kääb, A., 2007. Modelling the Biophysical Impacts of Global Change in Mountain Biosphere Reserves. *Mountain Research and Development*, **27**(1) : 66-77.

Martini A., **Dedieu JP**., Ferro-Famil L and Pottier E., 2006. Dry Snow discrimination in a high mountainous environment (French Alps) using multi-frequency and multi-temporal polarimetric SAR data. *Télédétection, Contemporary Publishing International*, **6** (1) : 45-55.

Martini A., Ferro-Famil L., Pottier E. and **Dedieu JP**., 2006 : Dry snow discrimination in alpine areas from multi-frequency and multi-temporal SAR data. *IEE Radar, Sonar and Navigation*, **153** (3) ; 271-278.

Dedieu JP., Niang M., Durand Y., Bernier M., Guyomarc'h G., Mérindol L., Sergent C., Paquet E et Martini A., 2005. Le potentiel des données ASAR-Envisat en Bande-C pour la détermination des caractéristiques de la neige humide en environnement alpin. *Société Française de Photogrammétrie et de Télédétection(SFPT)*. **05-3** (179) ; 18-27.

Rabatel A., **Dedieu JP**. and Vincent C., 2005. Using remote-sensing data to determine equilibrium-line altitude and mass-balance time series: validation on three French glaciers, 1994–2002. *Journal of Glaciology*, **51** (175); 539-546.

Fortin JP., **Dedieu JP**., Savary, S., Bernier M. et Gauthier Y., 2005: "Estimating snow cover at the sub-pixel level over the French Alps from VEGETATION images", *IEEE Transaction on Geoscience and Remote Sensing*, 1827-**05** : 5161-5164.

Grabherr G, Björnsen A., **Dedieu JP.**, Haeberli H., Guisan A., Hohenwallner D., Lotter A., Nagy L., Pauli H. and Psenner R, 2005 . Long term environmental observations in mountain biosphere reserves ; recommendations from the EU project Glochamore. Mountain Research and Development, 25 (4) ; 376-382.

Corbane C., Somma J., Bernier M., **Dedieu JP.,** Gauthier Y. et Fortin JP., 2005 : « Estimation of water equivalent of the snow cover in Lebanese mountains by means of RADARSAT-1 images, *Hydrological Science Journal*, IAHS, **50** (2) : 355-370.

Gerbaux M.; Genthon C.; Etchevers P.; Vincent C. and **Dedieu, J.P**., 2005. Surface mass balance of glaciers in the French Alps: distributed modeling and sensitivity to climate change**,** *Journal of Glaciology*, **51** (175) ; 561-572.

WP2

Aymoz, G., Jaffrezo, J.-L., Chapuis, D., **Cozic J.** and Maenhaut, W., Seasonal variation of PM10 main constituents in two valleys of the French Alps, I: EC/OC fractions, Atmospheric Chemistry and Physics, 7, 661-675, 2007.

Cozic, J., Verheggen, B., Mertes, S., Connolly, P., Bower, K., Petzold A., Baltensperger, U. and Weingartner, E., Scavenging of black carbon in mixed phase clouds at the high alpine site Jungfraujoch, Atmospheric Chemistry and Physics, 7, 1797-1807, 2007.

Cozic, J., Verheggen, B., Weingartner, E., Crosier, J., Bower, K., Flynn, M., Coe, H., Henning, S., Steinbacher, M., Collaud Coen, M., Petzold, A. and Baltensperger, U.: Chemical composition of free tropospheric aerosol for PM1 and coarse mode at the high alpine site Jungfraujoch, Atmospheric Chemistry and Physics, 8, 407–423, 2008.

Cozic, J., Verheggen, B., Mertes, S., Petzold, A., Baltensperger, U. and Weingartner, E.: Field observations of black carbon enrichment in atmospheric ice particle residuals suggesting a potential ice nucelating capability, Journal of Geophysical Research, 113, D15209, doi:10.1029/2007JD009266, 2008.

Jaffrezo, J.-L., Aymoz, G. and **Cozic, J**., Size distribution of EC and OC in the aerosol of Alpine valleys during summer and winter, Atmospheric Chemistry and Physics, 5, 2915-2925, 2005.

Jaffrezo, J.-L., Aymoz, G., Delaval, **C., Cozic**, J., Seasonal variations of the Water Soluble Organic Carbon mass fraction of aerosol in two valleys of the French Alps, Atmospheric Chemistry and Physics, 5, 2809-2821, 2005.

Venzac, H., Sellegri, K. & **Laj, P,** Seasonal variation of aerosol size distribution at puy de Dôme (1465 m asl, Central France), Atmospheric Chemistry and Physics, Vol.9, n°4, p. 1465-1478, 2009.

Venzac, H., K. Sellegri, **P. Laj**, P. Villani, P. Bonasoni, A. Marinoni, P. Cristofanelli, F. Calzolari, S. Fuzzi, S. Decesari, M.-Cr.Facchini, E. Vuillermoz, G. P. Verza; 2008, High Frequency New Particle Formation in the Himalayas; PNAS, vol. 105, no. 41, 15666-15671

Villani, P. ; Picard, D. ; Michaud, V. ; **Laj, P.** ; Wiedensohler, A. 2008 Design and Validation of a Volatility Hygroscopic Tandem Differential Mobility Analyzer (VH-TDMA) to Characterize the Relationships Between the Thermal and Hygroscopic Properties of Atmospheric Aerosol Particles Aerosol Sci. Technol. Vol. 42 , No. 9 , p. 729-741

Bonasoni, P. ; **Laj, P**. ; Angelini, F. ; Arduini, J. ; Bonafè, U. ; Calzolari, F. ; Cristofanelli, P. ; Decesari, S. ; Facchini, M.C. ; Fuzzi, S. ; Gobbi, G.P. ; Maione, M. ; Marinoni, A. ; Petzold, A. ; Roccato, F. ; Roger, J.-C. ; Sellegri, K. ; Sprenger, M. ; Venzac, H. ; Verza, G.P. ; Villani, P. ; Vuillermoz, E. 2008 The ABC-Pyramid Atmospheric Research Observatory in Himalaya for aerosol, ozone and halocarbon measurements Sci. Total Environ. Vol. 391 , No. 2-3 , p. 252-261

Vimeux, F., **P. Ginot**, M. Schwikowski, M. Vuille, G. Hoffmann, L.G. Thompson and U. Schotterer, Some aspects of the climate variability during the last 1,000 years from Andean ice cores: a review of recent results. Palaeogeography, Palaeoclimatology, Palaeoecology, accepté.

Vimeux, F, M. De Angelis, **P. Ginot**, O. Magand, G. Casassa, B. Pouyaud, S. Falourd and S. Johnsen, A promising location in Patagonia for paleoclimate and paleoenvironmental reconstructions revealed by a shallow firn core from Monte San Vanlentin (Northern Patagonia Icefield, Chile). Journal Geophys. Res., 10.1029/2007JD009502, 113, (D16118) 2008.

Ginot, P., C. Kull, U. Schotterer, M. Schwikowski and H.W. Gäggeler, Masse balance reconstruction by sublimation induced enrichment of chemical species on Cerro Tapado (Chilean Andes). Climate of the Past, 2, 21-30, 2006.

Zagorodnov, V.S., L.G. Thompson, E. Mosley-Thompson, **P. Ginot** and V.N. Mikhalenko, Intermediate depth ice coring of high altitude and polar glaciers with light-weight drilling system. Journal of Glaciology, 51, (174) 491-501, 2005.

WP3

Fettweis, X., **H. Gallée**, F. Lefebre and J.P. Van Ypersele, Greenland surface mass balance simulated by a regional climate model and comparison with satellite-derived data in 1990-1991. Climate Dynamics, 24, (6) 623-640, 2005.

Gallée, H., W. Moufouma-Okia, P. Bechtold, Brasseur O., I. Dupays, P. Marbaix, C. Messager, R. Ramel and T. Lebel, A high-resolution simulation of a West African rainy season using a regional climate model. Journal of Geophysical Research, 109, D05108 1 of 13, 2004.

Lefebre, F., X. Fettweis, **H. Gallée**, J. Van Ypersele, P. Marbaix, W. Greuell and P. Calanca, Evaluation of a high-resolution regional climate simulation over Greenland.. Climate Dynamics, 2005.

Marbaix, P., **H. Gallee**, O. Brasseur, and J.P. van Ypersele,Lateral boundary conditions in regional climate models: A detailed study of the relaxation procedure, Monthly Weather Review 131 (3), 461-479, 2003.

Messager, C., **H. Gallée**, and O. Brasseur, Precipitation sensitivity to regional SST in a regional climate simulation during the West African monsoon for two dry years.. Climate Dynamics, 22, (2-3) 249-266, 2004.

Messager, C., **H. Gallée**, O. Brasseur, B. Cappelaere, C. Peugeot, L. Séguis, M. Vauclin, R. Ramel, G. Grasseau, L. Léger and D. Girou, Influence of observed and RCM-simulated precipitation on the water discharge over the Sirba basin, Burkina Faso/Niger. Climate Dynamics, 2006.

Naithani, J., **H. Gallee**, and G. Schayes, Marine air intrusion into the Adelie Land sector of East Antarctica: A study using the regional climate model (MAR), Journal of Geophysical Research, 107, (D11), doi: 10.1029/2000JD000274, 4124, 2002.

Ramel, R., **H. Gallée**, and C. Messager, On the northward shift of the West African Monsoon. Climate Dynamics, 2006.

Balkanski, Y., M. Schulz, T. Claquin And S. Guibert, Reevaluation of Mineral aerosol radiative forcings suggests a better agreement with satellite and AERONET data, Atmos. Chem. Phys., 7, 81–95, 2007.

Schulz M., C. Textor, S. Kinne, **Y. Balkanski,** et al, Radiative forcing by aerosols as derived from the AeroCom present-day and pre-industrial simulations, Atmos. Chem. Phys. , Vol. 6, pp. 5225-5246, 2006.

Krinner G., O. Boucher And **Y. Balkanski**, Reduced glacial ice sheet extent in Northern Asia and Alaska owing to deposition of mineral dust on snow, Geophys. Res. Let., 10.1007/s00382-006-0159-z, 2006.

Bauer S.E., **Y. Balkanski, M. Schulz,** D. Hauglustaine, And F. Dentener, Global Modelling of Heterogeneous Chemistry on Mineral Aerosol Surfaces: The Influence on Tropospheric Ozone Chemistry and Comparison to Observations, J. Geophys. Res., 109, D02304, doi:10.1029.2003JD003868, 2004.

Claquin T., C. Roelandt, K. Kohfeld, S. Harrison, C. Prentice, **Y. Balkanski**, G. Bergametti, M. Hansson, N. Mahowald, H. Rohde, H., **M. Schulz**, Radiative forcing by ice ace dust, Climate Dynamics, vol 20 (2-3), pp.192-202, 2003.

J. Quaas, Y. Ming,…. **Y. Balkanski, M. Schulz**, et al Aerosol indirect effects – general circulation model intercomparison and evaluation with satellite data, Atmos. Chem. Phys. Discuss., 9, 12731-12779, 2009.

Textor, C., M. Schulz,…, Y. Balkanski,et al : Analysis and quantification of the diversities of aerosol life cycles within AeroCom, Atmos. Chem. Phys., 6, 1777-1813, 2006.

Generoso, S., Breon, F.-M., Chevallier, **F., Balkanski, Y., Schulz**, M. & Bey, I. (2007) Assimilation of POLDER aerosol optical thickness into the LMDz-INCA model: Implications for the Arctic aerosol burden. J. Geophys. Res. 112, D02311, doi:10.1029/2005JD006954.

Textor, C., **M. Schulz,** S. Guibert, S. Kinne, **Y. Balkanski**, et al, The effect of harmonized emissions on aerosol properties in global models an AeroCom experiment, Atmos. Chem. Phys. Discuss., 7, 1699-1723, 2007.

Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, **M. Schulz**, and R.V. Dorland, Changes in Atmospheric Constituents and in Radiative Forcing, in Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, edited by S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor, and H.L. Miller, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2007.

WP4

Domine, F., M. Albert, T. Huthwelker, **H.W. Jacobi**, A.A. Kokhanovsky, M. Lehning, G. Picard and W. R. Simpson, Snow physics as relevant to snow photochemistry. Atmos. Chem. Phys., 8, 171-208, 2008.

Favier, V., M. Falvey, A. Rabatel, E. Praderio and D. Lopez, Interpreting discrepancies between discharge and precipitation in high-altitude area of Chile's Norte Chico region (26-32 degrees S). Water Resources Research, 10,1029/2008WR006802, 45, (W02424) 2009.

Gallée, H., and P.G. Duynkerke, Air-snow interactions and the surface energy and mass balance over the melting zone of west Greenland during the Greenland Ice Margin Experiment, Journal of Geophysical Research, 102 (D12), 13813-13824, 1997.

Gallée, H., G. Guyomarc'h, and E. Brun, Impact of snowdrift on the Antarctic ice sheet surface mass balance: possible sensitivity to snow-surface properties, Boundary-Layer Meteorology 99, 1–19, 2001.

Gallée, H., V. Peyaud and I. Goodwin, Simulation of the net snow accumulation along the Wilkes Land transect, Antarctica, with a regional climate model. Annals of Glaciology, 41, 17-22, 2005.

Gallée, H., and I. V. Gorodetskaya, Validation of a limited area model over Dome C, Antarctic Plateau, during winter. Climate Dynamics, 10.1007/s00382-008-0499-y, 2008.

Lefebre, F., **H. Gallée**, J.P. Van Ypersele and W. Greuell, Modeling of snow and ice melt at ETH Camp (West Greenland) : A study of surface albedo. Journal of Geophysical Research, 108, (D8), 4231, doi:10.1029/2001JD001160, 2003.

WP5

Caballero, Y., **Chevallier**, P., Boone, A., Noilhan, J. and Habets, F. 2007. Calibration of the Interaction Soil Biosphere Atmosphere land-surface scheme on a small tropical high-mountain basin (Cordillera Real, Bolivia). *Water Resources Research* 43.

Caballero, Y., **Chevallier, P.**, Gallaire, R. and Pillco, R. 2004. Flow modelling in a high mountain valley equipped with hydropower plants: Rio Zongo Valley - Cordillera Real - Bolivia. *Hydrological Processes* 18, 939-957.

Suarez, W., **Chevallier, P**., Pouyaud, B. and Lopez, P. 2008. Modelling the water balance in the glacierized Parón Lake basin (White Cordillera, Peru). *Hydrological Sciences Journal* 53, 266-277.

Condom T., Coudrain A., Dezetter A., Brunstein D., **Delclaux F.** and Sicart J. E. (2004) Transient modelling of lacustrine regressions. Two cases studies from the andean Altiplano. *Hydrological Processes,* 18, 0-0

Leblanc M. J., Favreau G., Nazoumou Y, Leduc C., Stagnitti F., Van Oevelen P., **Delclaux F.**, Lemoalle J., Maley J. (2005) Reconstruction of Megalake Chad using Shuttle Radar Topographic Mission data. *Palaeogeography, Palaeoclimatology, Palaeoecology* (239), p. 16–27

Delclaux F., Coudrain A. and Condom T. (2007) Evaporation estimation on Lake Titicaca: a synthesis review and modelling. *Hydrological Processes.* (21) 1664-1677.

Le Coz M., **Delclaux F.**, Genthon P., and Favreau G. (2009) Sensitivity of watershed simulations to relief aggregation in the case of a flat basin, Lake Chad, Africa. *Computer and GeoSciences.* doi:10.1016/j.cageo.2008.07.009.

Bastola S. and **Delclaux F.** (submitted) Temporal extension of meteorological records for simulation modeling of Lake Chad Basin (Africa) using satellite rainfall data and reanalysis datasets, *Journal of Hydrology*

WP6

AUBRIOT O., 2004, Irrigation history in central Nepal: the interface between agriculture and technology *Water Nepal* 11:19-43.

AUBRIOT O., 2004, *L'eau, miroir d'une société. Irrigation paysanne au Népal central*. Paris: CNRS Éditions (Collection du Monde indien -Sciences Sociales 15e-21e siècle).

AUBRIOT O., 2008, "Les terrasses rizicoles de l'Himalaya," in *Agricultures singulières*. Edited by A. Walter and E. Mollard, pp. 292-296. Paris IRD.

AUBRIOT O., 2009, "Eau," in *Dictionnaire de l'Inde*. Edited by C. Clémentin-Ojha, C. Jaffrelot, D. Matringe, and J. Pouchepadass, pp. 223-225. Paris: Larousse (à présent).

AUBRIOT O., 2009, "Irrigation of paddy fields: a technical and social trace in the landscape (Frame 5)," in *Reading Himalayan landscapes over time. Environmental perception, knowledge and practice in Nepal and Ladakh*. Edited by J. Smadja, pp. 64-65. Pondicherry: Institut Français de Pondichéry (Collection Sciences Sociales 14).

AUBRIOT O., C. Jest and J.-L. Sabatier, 2008, "Quelles unités de mesures pour partager l'eau d'irrigation ? Exemples dans les moyennes montagnes du centre du Népal," in *Poids et mesures en Asie du Sud-Est. Systèmes métrologiques et sociétés,*, vol. 2. Edited by F. Robinne, J. Ivanoff, and P. Le Roux. Paris/ Marseille: Ecole française d'Extrême-Orient / Institut de Recherche sur le Sud-Est Asiatique (Etudes thématiques 13).

REYES-GARCÍA V., O. AUBRIOT, P. ARIZA-MONTOBBIO, E. GALÁN-DEL-CASTILLO, T. SERRANO-TOVAR, and J. MARTINEZ-ALIER, in press, Local perception and use of the multifunctionality of water tanks in two villages of Tamil Nadu, South India. *Society and Natural Resources*:29p.

SMADJA J., 1986, *Géodynamique des milieux d'un versant de mousson en moyenne montagne himalayenne. Le versant de Salmé, Népal Central*, PhD dissertation, Université Paris 1.

SMADJA J., 1991, "Particularités climatiques d'un grand versant de mousson himalayen", *Revue de géographie Alpine*, n°2, vol. 79, Juin 1991, pp 99-119

SMADJA J., 1992, "Studies of Climatic and Human Impacts and their Relationship on a Mountain Slope Above Salme in the Himalayan Middle Mountains, Nepal", *Mountain Research and Development*, vol. 12, no. 1, p. 1-28.

SMADJA J., 1995, "Sur une Dégradation annoncée des milieux népalais : initiatives villageoises pour remplacer les ressources forestières", *Natures Sciences Sociétés*, vol. 3, no. 3, p. 190-204.

SMADJA J., 2000, "Landscape Diversity and Water Availability", p. 1-50, in P. RAMIREZ (ed.). *Resunga. The Mountain of the Horned Sage, Two districts in Central Nepal*, Kathmandu, Himal Books.

SMADJA J. (sous la direction de), 2003, *Histoire et devenir des paysages en Himalaya. Représentations des milieux et gestion des ressources au Népal et au Ladakh,* Paris, Éditions du CNRS, collection Espaces et Milieux, cartes, tab. Fig., 646 p

SMADJA J., 2005, co-direction avec P. Sorgues du dossier Himalaya, *Géo*, janvier 2005, n° 311, pp 42-89, interview, conceptions et légendes des dessins des unités de paysage en Himalaya, légendes de photos, carte panoramique des aires protégées et barrages en Himalaya, légendes.

SMADJA J., (Ed. J. Smadja, transl. B. Sellers.) 2009, *Reading Himalayan Landscapes over Time. Environmental perception, Knowledge and Practice in Nepal and Ladakh*. Collection Sciences Sociales n°14. Institut Français de Pondichéry, Inde, 671 p.

SMADJA J., 2009, "Geographic Units and Landscapes in Nepal. Local Terminologies", in J.SMADJA, (Ed.) *Reading Himalayan Landscapes over Time. Environmental perception, Knowledge and Practice in Nepal and Ladakh*. Collection Sciences Sociales n°14. Institut Français de Pondichéry, Inde, pp 43-84

SMADJA J., 2009, "A reading of the Salme Tamang's Territory and Landscape", in J.SMADJA, (Ed.) *Reading Himalayan Landscapes over Time. Environmental perception, Knowledge and Practice in Nepal and Ladakh*. Collection Sciences Sociales n°14. Institut Français de Pondichéry, Inde, pp 199-240 + annex and map

SMADJA J., in collaboration with Bruslé T and Fort M., 2009, "A Bocage Landscape, Masyam and the Hamlet of Kolang", in J.SMADJA, (Ed.) *Reading Himalayan Landscapes over Time. Environmental perception, Knowledge and Practice in Nepal and Ladakh*. Collection Sciences Sociales n°14. Institut Français de Pondichéry, Inde, pp 509-552

WP7

Dekens, J. (2007) The Snake and the River Don't Run Straight: Local Knowledge on Disaster Preparedness in the Eastern Terai of Nepal. ICIMOD, Kathmandu.

Amilhat-Szary A.-L., Elamé E., Gaillard J.-C., Giazzi F. eds. (2009) Culture et développement: la durabilité renouvelée par l'approche interculturelle. Publibook, Paris.

Anthelme F., Waziri Mato M., de Boissieu D., Giazzi F. (2006) Dégradation des ressources végétales au contact des activités humaines et perspectives de conservation dans le massif de l'Aïr (Sahara, Niger). Vertigo 7(2): 1-12.

Flety Y., Giazzi F. (2008) The Aïr-Ténéré National Natural Reserve (RNNAT) observatory: territorial intelligence for sustainable development. In International Conference of Territorial Intelligence, Huelva 2007. Papers on territorial intelligence and governance, participative action-research and territorial development, Observatorio Local de Empleo, Huelva, pp. 213-222.

Gaillard J.-C. (2002) Implications territoriales et ethno-culturelles d'une crise volcanique: Le cas de l'éruption du Mont Pinatubo aux Philippines. Annales de Géographie 627-628: 574-591.

Gaillard J.-C. (2006) Traditional communities in the face of natural hazards: The 1991 Mt Pinatubo eruption and the Aetas of the Philippines. International Journal of Mass Emergencies and Disasters 24(1): 5-43.

Gaillard J.-C. (2006) La culture comme enjeu majeur de la gestion des catastrophes dites "naturelles" au sein des sociétés traditionnelles. In Leone F., Vinet F. (eds.), La vulnérabilité des sociétés et des territoires face aux menaces naturelles: Analyses géographiques. Publications de Montpellier III: Montpellier, 43-53.

Gaillard J.-C. (2006) "Naturelles", les catastrophes? Pour la Science (French edition of Scientific American). Dossier N° 51: 118-119.

Gaillard J.-C. (2006) Was it a cultural disaster? Aetas' resilience following the 1991 Mt Pinatubo eruption. Philippine Quarterly of Culture and Society 34(4): 376-399.

Gaillard J.-C. (2007) Resilience of traditional societies in facing natural hazards. Disaster Prevention and Management 16(4): 522-544.

Gaillard J.-C. (2007) De l'origine des catastrophes: Phénomènes extrêmes ou âpreté du quotidien? Natures Sciences Sociétés 15(1): 44-47.

Gaillard J.-C. (2008) Alternative paradigms of volcanic risk perception: The case of Mt Pinatubo in the Philippines. Journal of Volcanology and Geothermal Research 172(3-4): 315-328.

Gaillard J-C., Dibben C.J.L. eds. (2008) Editorial: Volcanic risk perception and beyond. Journal of Volcanology and Geothermal Research 172(3-4): 163-169.

Gaillard J.-C., Le Masson V. (2007) Traditional societies' response to volcanic hazards: Some implications for community-based disaster recovery. Mountain Research and Development 27(4): 313-317.

Gaillard J.-C., Texier P. eds. (2008) Guest editorial: Social perspectives on disasters in Southeast Asia. Disaster Prevention and Management 17(3): 346-349.

Gaillard J.-C., Texier P. eds (2010) Religions, natural hazards, and disasters: an introduction. Religion, 40(2): in press.

Gaillard J.-C., Liamzon C.C., Maceda E.A. (2005) Act of Nature or Act of Man? Tracking the Root Causes of Increasing Disasters in the Philippines. Philippine Geographical Journal 49(1-4): 45-66.

Gaillard J.-C., Liamzon C.C., Villanueva J.D. (2007) 'Natural' disaster? A retrospect into the causes of the late-2004 typhoon disaster in Eastern Luzon, Philippines. Environmental Hazards 7(4): 257-270.

Gaillard J.-C., Pangilinan M.R.M., Cadag J.R., Le Masson V. (2008) Living with increasing floods: Insights from a rural Philippine community. Disaster Prevention and Management 17(3): 383-395.

Gaillard J.-C., Liamzon C.C., Maceda E.A. (2008) Catastrophes dites "naturelles" et développement: Réflexions sur l'origine des désastres aux Philippines. Revue Tiers Monde 194: 371-390.

Gaillard J.-C., Clavé E., Vibert O., Azhari, Dedi, Denain J.-C., Efendi Y., Grancher D., Liamzon C.C., Sari D.S.R., Setiawan R. (2008) Ethnic groups' response to the 26 December 2004 earthquake and tsunami in Aceh, Indonesia. Natural Hazards 47(1): 17-38.

Gaillard J.-C., Maceda E.A., Stasiak E., Le Berre I. Espaldon M.A.O. (2009) Sustainable livelihoods and people's vulnerability in the face of coastal hazards. Journal of Coastal Conservation: in press.

Kelman I., Gaillard J.-C. (2008) Placing climate change within disaster risk reduction. Disaster Advances 1(3): 3-5.

Maceda E.A., Gaillard J.-C., Stasiak E., Le Masson V., Le Berre I. (2009) Experimental use of Participatory 3-Dimensional Models in island community-based disaster risk management. Shima: The International Journal of Research into Island Culture, 3(1): 46-58.

Mialhe F., Gunnell Y., Mering C. (2008) Synoptic assessment of water resource variability in reservoirs by remote sensing: general approach and application to the runoff harvesting systems of south India. Water Resouces Research 44: W05411, doi:10.1029/2007WR006065.