I. RAPPORT SCIENTIFIQUE

*Date limite : **14 janvier 2013** à envoyer sous le nom rapport2012-acronyme à :*

direction@gisclimat.fr

Nom – Prénom du porteur :

Kinney, Patrick
Hauglustaine, Didier (co-porteur)

Acronyme du projet :

ACHIA

Titre du projet :

Air Pollution and Climate Change Health Impact Assessment

Date de démarrage du projet :

17 novembre 2011

Durée du projet :

26 mois

Report should be preferably written in English to be examined by the GIS Scientific Committee Nevertheless, a French version can be accepted

1. Project title

Air Pollution and Climate Change Health Impact Assessment

2. Summary (ca 20 lines)

Climate change may affect human health via interactions with air pollutants such as ozone and $PM_{2.5}$. These air pollutants are linked to climate because they can be both affected by and have effects on climate. In coming decades, substantial, cost-effective improvements in public health may be achieved with well-planned strategies to mitigate climate impacts while also reducing health effects of ozone and $PM_{2.5}$. To better understand the potential of

such strategies, studies are needed that assess possible future health impacts under alternative assumptions about future emissions and climate across multiple spatial scales.

The overall objective of ACHIA is to apply state of the art climate, air quality, and health modelling tools to assess future health impacts of ozone and $PM_{2.5}$ under different scenario of climate change, focusing specifically on pollution-related health co-benefits which could be achieved under alternative climate mitigation pathways in the period 2030-2050. This question will be explored at three spatial scales: global, regional (Europe), and urban (Paris). ACHIA is comprised of an integrated set of four work packages, as described below.

ACHIA is designed to create an interdisciplinary approach to the impacts of climate change on health through air quality changes, and to start longer-term collaborations between communities. We expect the project to advance state of art across all WPs, with important implications for research groups around the world. A particular innovation of the project is the multi-scale aspect, i.e., the analysis of climate, air quality and health at the global, regional and urban scales using consistent methodologies. Comparison of health findings across scales will provide unique insights into the importance of geographic scale in assessing health impacts of alternative climate and air quality scenarios.

3. Key words

Climate change; air quality; ozone, PM2.5, health impact assessment

4. Objectives of the project (ca ½ page)

Please include the inflections to the original draft.

WP1. Global Climate and Air Pollution Impacts of Alternative Emissions Pathways

Projections of climate and air quality ($PM_{2.5}$ and ozone) at the global scale are being developed with the LMDz-INCA global model, run using the four IPCC representative concentration pathways (RCPs) for the 2030 to 2050 time horizon. Model outputs will be available at a spatial resolution of 3.75° in longitude and 1.9° in latitude. Comparison across the RCPs will answer the question, "what are the global health implications of various greenhouse gas control policies?"

WP2. Climate and Air Quality at Regional and Urban Scales: results for Europe and Paris

Here we develop projections of temperatures and air pollution concentrations at a 50x50 km^2 scale over Europe, and at a 4x4 km^2 scale over the Paris region using new multi-scale air quality projections that will be driven by the same RCPs as above based on the international coordinated programs CMIP5 and CORDEX. Deterministic, statistical and semi-empirical methods will be developed to downscale the large scale air-quality model (WP1) to regional (countries and regions) and urban scale grids. Emission projections will be adjusted to be consistent with the global RCPs and/or European and Parisian emissions targets. These results will be of direct value to national and local decision makers in quantifying health benefits of global and regional emissions pathways.

WP3. Health Impact Assessment

This work package is responsible for adapting, developing and applying state of the art health impact modelling tools within the overall objectives of the project. WP3 will use the air quality model outputs from WP1 and WP2 in combination with other relevant inputs (concentration-response functions, populations, and cause-specific mortality rates) to compute estimates of ozone- and $PM_{2.5}$-attributed mortality under alternative emissions scenarios at the global, regional and urban scales. WP3 will adapt HIA guidelines developed in the APHEKOM project for use with modeled data. It will take into account demographic projections to estimates future population and health data.

WP4. Dissemination, evaluation, management

This WP is responsible for overall project coordination and management. In addition, it is responsible for communicating goals, progress, and results of the project with outside parties, including policy makers. In addition, it will be responsible for evaluating the success of the project.

5. Major results of the project (ca 2 to 3 pages). Please provide figures

WP1. Air Quality Projections: Global

The simulation of future atmospheric composition under the ACCMIP intercomparison exercise and for the four RCP scenarios has been previously investigated and reported by Szopa et al. (2012) with the LMDz-INCA global model. The results from these simulations have been used in the frame work of the SALUT'AIR project in order to constrain the CHIMERE regional model as described in WP2. These previous simulations did not include nitrate particles which contribute significantly to the aerosol loading in northern Europe, the central US, or in China and India in particular. In order to assess the global impact of particles on health, this component has been introduced in the model during the first year of the ACHIA project. The ammonia cycle, coupling the gas phase and aerosol phase, has been introduced in LMDz-INCA along with the formation of $(NH_4)_2SO_4$ on existing sulfate particles and the formation of new NH_4NO_3 particles from the gas phase reaction and further condensation of NH_3 and HNO_3. The present-day model results have been extensively evaluated through careful comparison with surface observations for both concentration and deposition terms, in the framework of the AEROCOM plateform for global aerosol model intercomparison (http://aerocom.met.no/Welcome.html). The new model version has then been used to simulate the atmospheric composition and its future evolution during the XXIth century under the 4 RCP scenarios and for the 2030, 2050 (and 2100) time horizons and in addition to the present-day and 'pre-industrial' distributions. In order to investigate the impact of surface emission acting solely, the present day climate is considered in all these simulations in order to discriminate the role of anthropogenic emission changes. These future distributions of aerosols have been further used to calculate the direct forcing of particles on climate and the contribution of nitrates to the total aerosol forcing. These results are summarized in Hauglustaine et al. (manuscript in preparation, 2013), and show that nitrates can contribute by up to 60% to the total Aerosol Optical Depth by 2100 due to increasing NH_3 emissions from agriculture. These model results are now available in order to 1) provide the boundary conditions to the CHIMERE regional model – see section WP2, and 2) to estimate the impact of ozone and particles on global mortality rates.

As an example, Figure 1 shows the evolution of surface $PM_{2.5}$ particles (defined as the sum of Black Carbon, Organic Carbon, sulfates and nitrates fine particles) and ozone concentrations, averaged over Europe, northern America, northern and southern Asia for the various IPCC scenarios and for the 2030, 2050, and 2100 time horizons. This figure shows that over Europe and northern America, the PM concentrations will significantly decrease in the future under all RCP scenarios due to important reduction in emissions. In contrast, in Asia, the PM concentration will increase from an already high present-day level and reach a maximum in 2030 or 2050 depending on the considered scenario. In these regions, the level of pollution will remain a major threat for health and even worsen. In Europe and northern America, ozone decreases in all scenarios except for RCP8.5 where it slightly increases. In Asia, ozone remains at present day levels or even slightly increases under scenario RCP6.0 and RCP8.5 adding an additional threat in terms of health impact.

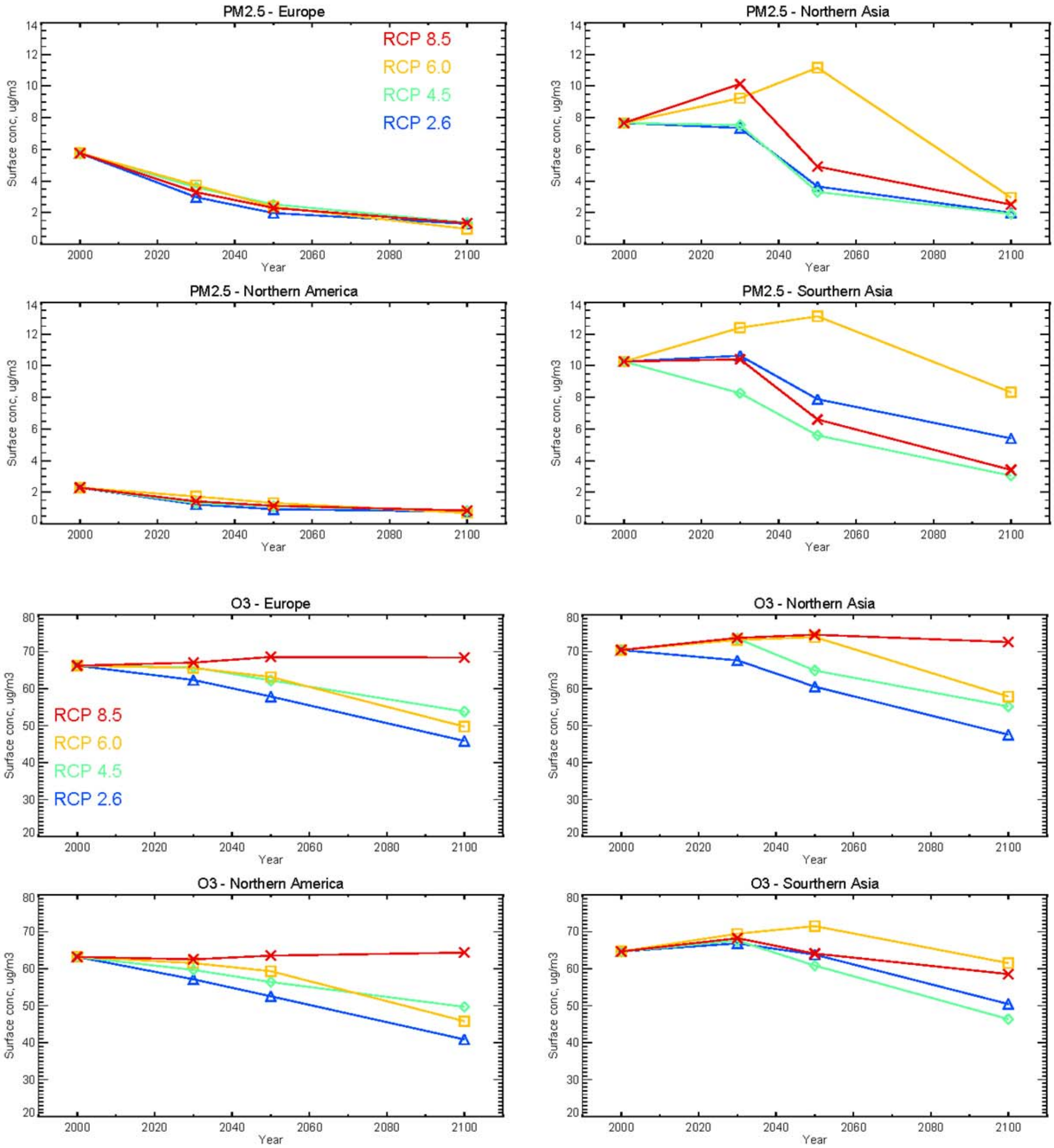

Figure 1. Evolution of $PM_{2.5}$ (top panel) and O_3 (bottom panel) surface concentrations ($\mu g/m^3$) averaged over various regions and following the four RCP scenarios as simulated with the LMDz-INCA global model.

WP2. Air Quality Projections: Regional to Urban

I. Air Quality Projections: Europe

To quantify changes in air pollution in Europe at the 2050 horizon, we implemented a comprehensive Regional Air Quality and Climate Modeling System that relies on the latest set of air pollution and climate scenarios. The suite of models is centered on the regional air quality model Chimere that is driven by meteorological fields computed with a regional climate model (itself embedded within a global climate model). The regional chemistry model is also constrained at its boundaries with a global chemistry-climate model.

The following paragraphs summarize the main features of the modeling chain.

<u>Models:</u>

Global climate: We use the IPSL-CM5 (Marti et al., 2010) coupled ocean-climate model simulations performed by CNRS/IPSL for the CMIP5 exercise.

Global chemistry: The LMDz-OR-INCA (Szopa et al., 2012) coupled climate-biosphere-chemistry system nudged within the IPSL-CM5 climate fields was used to capture the atmospheric composition change. These simulations were performed for the CMIP5/ACCMIP projects and provided by Sophie Szopa, LSCE.

Regional climate: The IPSL-CM5 fields were downscaled in a dynamical fashion with the WRF (Weather Research and Forecast (Skamarock et al., 2008)) mesoscale meteorological model. This initiative was performed in collaboration between INERIS and IPSL as part of the CORDEX exercise (coordinated regional climate modelling experiment) (Giorgi et al., 2009).

Regional air quality: The Chimere (Bessagnet et al., 2008) model was driven by the regional climate field obtained with IPSL-CM5/WRF, using the boundary conditions of LMDz-OR-INCA. The model has been involved in numerous model intercomparison exercises that demonstrated its capability to capture ozone and particulate matter concentrations (Colette et al., 2011; Cuvelier et al., 2007; Vautard et al., 2009; Vautard et al., 2006; Zyryanov et al., 2011; Pirovano et al., 2012).

<u>Scenarios and emissions:</u>

A combination of IPCC Representative Concentration Pathways (RCPs) and GEA (Global Energy Assessments) data is used in the present study as it is considered to offer the best degree of refinement available to date. The vast majority of global modelling is currently performed on the basis of the IPCC RCPs, therefore we decided to use these widely distributed pathways for the climate and global chemistry modelling. For selected regions there are however better alternative emissions scenarios that offer a more explicit description of air quality policies (GEA, or the forthcoming HTAP emissions). As a consequence we decided not to use the RCP emission for regional air quality and rather implement the most recent available air pollutant emission projections.

Climate scenarios: The long lived greenhouse gases (CO2, CH4, N2O) pathways are the RCP2.6 and RCP8.5 prepared for the forthcoming AR5 of IPCC (van Vuuren et al., 2011). The corresponding emissions of short lived species are also used in the global chemistry model nudged within the climate runs.

Air quality scenarios: The chemically active anthropogenic pollutant and precursors (NOX, VOC, primary particulate matter, etc.) emission scenario of the Global Energy Assessment (GEA) (Riahi et al., 2012) were used over Europe in the regional air quality model since they offer a superior degree of representation of air quality policies over the RCPs, yet being consistent in terms of climate policy storylines.

We explored two scenarios that are consistent in the climate and air quality models in terms of policy measures: a reference in which climate policies are absent and a mitigation scenario which will limit global temperature rise to within 2 degrees Celsius by the end of this century. The preliminary findings of the study (displayed on Figure 2) are:

- European PM2.5 concentrations are projected to strongly decrease by 2050 (by some 60%-70%), largely because of current air quality policies. The effect of climate change and changing hemispheric background concentrations on European PM2.5 concentrations is significant yet of second order compared to the effect of changes in European emissions of air pollutants.
- Maximum ozone concentrations in Europe in 2050 will be lower than current levels in both scenarios. In the mitigation scenario, maximum ozone levels decrease by some 35% while it decreases by about 10% in the reference scenario. The change in maximum ozone concentrations is dominated by changes in European emissions of air pollutants, but is also significantly affected by climate change and changes in hemispheric background concentrations.
- Average ozone maxima will decrease under all scenarios. However, for the reference scenario compensation between climate and emission trends is such that the trends differ in sign for the ozone exposure indicator relevant for human health (SOMO35, which increases), and that for vegetation (AOT40, which decreases); thereby illustrating the limited net signal in the scenario assuming no specific climate policy.

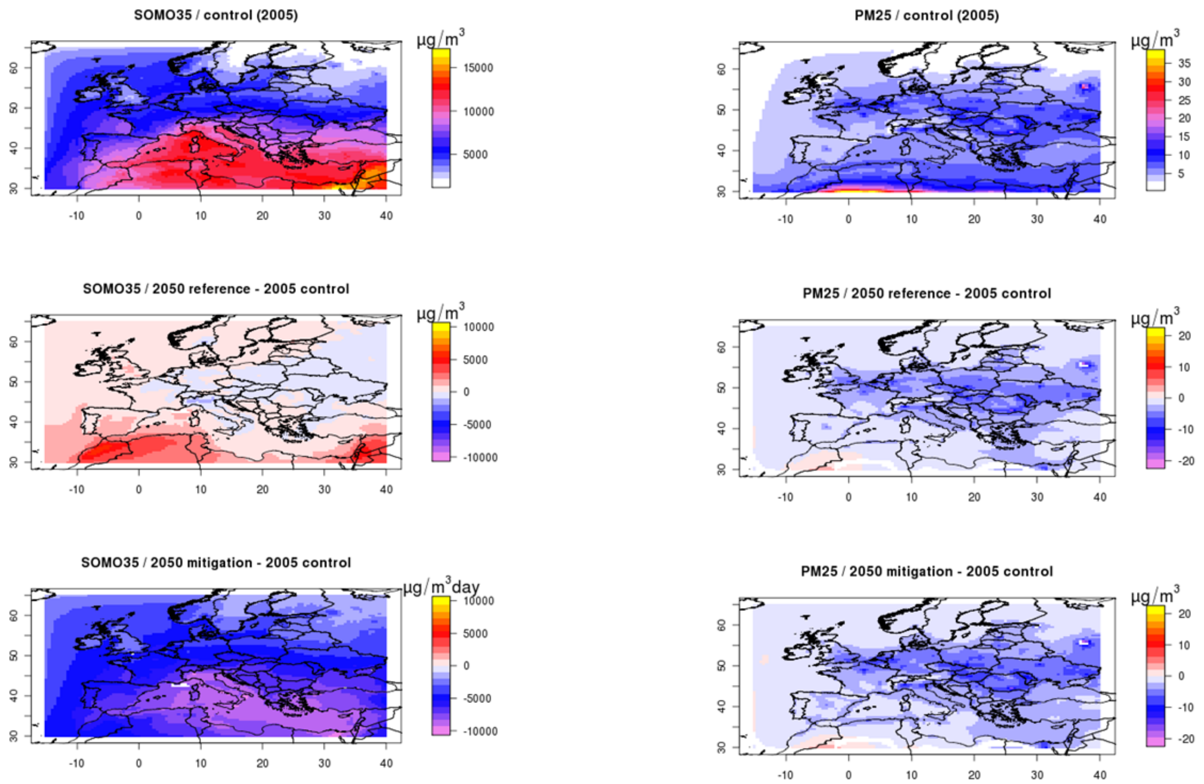

Figure 2 : Top row (from left to right): average fields of O3 (SOMO35 in µg/m3 day), and PM2.5 (annual mean in µg/m3) in the control (2005) simulation (averaged over 10 years corresponding to the current climate). Following rows: difference between the simulations for 2050 and the control (2005) for the reference projection (middle row) and the mitigation case (lower row), the differences are only displayed where significant given the interannual variability of ten simulated years.

The Europe-wide regional climate and atmospheric composition fields were subsequently provided to the partner of the project investigating the Paris area (LMD) in order to constrain the boundary conditions of their local model.

II. Air Quality Projections: Paris

During the first year of the project we focused on the downscaling of air-quality concentrations to the urban scale with the CHIMERE model. Our area of interest is the city of Paris. Several researchers have studied the impact of climate change on air quality at global and regional scales (our colleagues in the SALUT'AIR project among others), but the challenges when one focuses on the urban scale are quite different. Regional scale emission projections, such as the dataset provided by the Global Energy Assessment (GEA) for Europe may be consistent with global scale climate scenarios but they are not representative of the future trend of a specific city (Butler et al., 2012). Therefore, they cannot be used in urban scale modeling as such. Here we developed a hybrid emission inventory where the spatial variability and the near future trend (2020) of the emission projections is based on a bottom-up inventory developed by a local agency for the city of Paris and the long term trend to the mid-century horizon is derived from the GEA emission projections (regional scale). This hybridisation of data has the advantage of using high-quality emission data from local sources for as long as projections may apply but also to remain consistent with global trends and the RCPs representing climate scenarios used in the ACHIA project.

Our first step is a thorough model evaluation with particular focus on specific urban features that may or may not be represented at the local scale. To do so we make a two-step comparison with available surface measurements. We focus on the Paris agglomeration represented by one single model grid-cell of the regional scale simulation (an area equal to 57km x 36 km) and several fine scale grid cells. We compare surface concentrations modeled at each grid with concentrations measured at urban monitor sites. So far six of the total ten years of control simulation are available (1995-2000). Monthly averaged results are shown in Figure 3 for ozone and $PM_{2.5}$. For ozone the impact of model resolution to the monthly bias is clear at all months. At coarse resolution the model overestimates ozone values at all months with biases that can be higher than 10 ppb during the summer season (i.e. overestimation of around 25%). This effect is clearly improved at the higher resolution where we observe a small underestimation of the observed values. One explanation of this difference is a net resolution effect: at coarse resolution we fail to represent local features such as high road emissions and consequently ozone titration by NO. This fast chemical reaction (in the order a few minutes) is much better represented at the finer grid. However another explanation stems from an analysis of the precursors emissions (NOx and VOCs) that are used as input for each of the two simulations (right panels of Figure 3). VOC emissions at the regional scale (GEA data) are much higher than those at the urban scale (hybrid dataset AIRPARIF+GEA) at all months. On the contrary, NOx emissions are higher at the hybrid inventory than at the GEA dataset. This means that the VOC:NOX ratios are very different in the regional and urban simulations. The dominant chemical regime in the Paris region is VOC-sensitive as it has been established through several studies (Deguillaume et al., 2008). The high VOC and low NOx values prescribed in the GEA inventory however seem to violate the VOC-sensitivity of ozone photochemical production in the city. With this remark we highlight the importance of using a local scale emission inventory to accurately represent the non-linear dependence of ozone production on its precursors. This is a point that requires further quantification.

As far as $PM_{2.5}$ is concerned the bias of both regional and urban scale simulations is significant with a strong underestimation of the observed values at all months but especially during the summer months. In almost all cases (with the exception of February and April) the fine scale simulation provides an improved picture of model results. In this case too the differences between model results between the two grids are partly due to the resolution itself (poor representation of physical and chemical processes) and partly in differences in emissions (not shown). In the case of $PM_{2.5}$ concentrations the main focus of our research is to develop a relevant bias adjustment method in order to be able to use modeled concentrations for further health impact assessment.

We have also conducted a preliminary analysis of the future simulations. So far we have produced six years of air-quality projections at the urban scale (2045-2050) for the less optimistic scenario, which assumes that no climate related emission reduction policy would be implemented. Following this scenario the average summertime (JJA) ozone levels in Paris will increase by 5.5 ppb. This rise is mainly due to the reduction in precursors emissions (mainly NOx) and the rise of temperature in the city (1 ºC increase in 2m temperature). Interestingly, the regional scale for the same time horizon and over the city of Paris predicts a fall in ozone concentrations from 36ppb to 33 ppb (JJA). This significant difference in the future ozone projections as a function of model resolution enhances our hypothesis that the GEA emission datasets prescribes a NOx-sensitive photochemical regime following which small reduction of NOx emissions leads to decrease in O_3 concentrations. A sharp drop of the annual $PM_{2.5}$ average concentrations is modeled with both the regional and urban simulations: by 8.3µg/m3 (from 10.9 $\mu g/m^3$ in the control 1995-2005 period to 2.6 $\mu g/m^3$ in the mid-century horizon) according to the urban simulation and by 5µg/m3 (from 6.7 to 1.7 µg/m3) according to the regional simulation. In both cases this decrease is mainly driven by large reductions in the primary emissions of particulate matter (not shown).

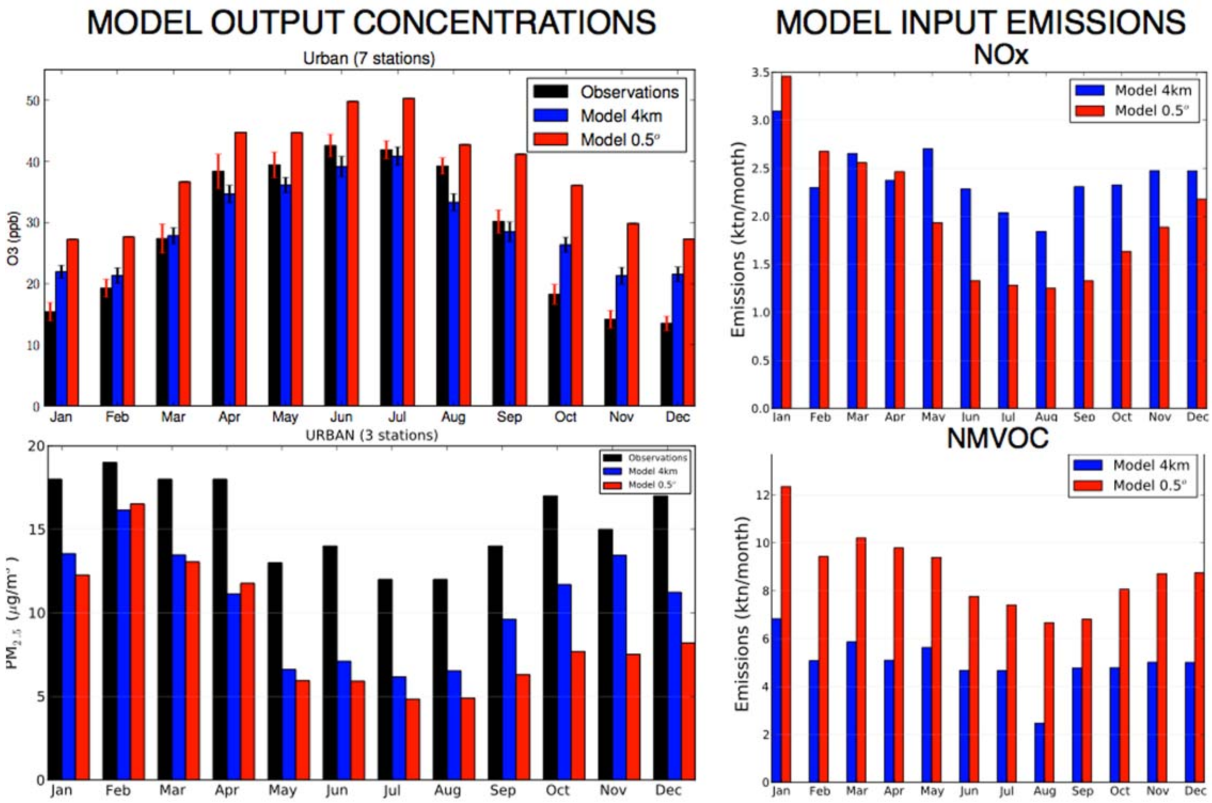

Figure 3: Left panels: Monthly averaged modeled concentrations compared with surface measurements for ozone (top) and particulate matter of diameter lower than 2.5µm (bottom). Observed concentration levels are in black, concentrations modeled at 4km resolution (urban scale) are shown in blue and concentrations modeled at 0.5º resolution (regional scale) are shown in red. Right panels: Surface emissions used as model input over an area equal to a 0.5ºx0.5º (57km x 36km) grid-cell over the Paris agglomeration for nitrogen oxides (top) and non-methane volatile organic compounds (bottom).

WP3. Health Impact Assessment

A literature review on the health impact assessment (HIA) of air pollution and climate was initiated by the two postdocs. Its main objective was to analyze the prior academic research on quantitative health impact assessment of ozone (O_3) and particulate matter ($PM_{2.5}$) under a changing climate and explore the strengths and weaknesses of the approaches to assess the health effects of predicted air pollution in a context of climate change.

The search for the literature review was conducted in October 2012 through major academic databases including SCOPUS, PubMed, HUB and GoogleScholar using the corresponding sets of keywords: “(health, mortality) in title or (climate, future) in title and model in title/abstract”, “(health, mortality) in title or (climate, future) in title and model in title/abstract”, “**health** and **mortality** and **respiratory** or **cardiovascular** and **ozone** or “**particulate matter**” or **PM** and **future** within **15** terms of “**climate change**” and **global** or **regional** and **model**”, “intext:future “air pollution” “particulate matter” ozone PM model simulation "health impact" mortality OR morbidity “health impact assessment” “HIA” “climate change””. The initial search resulted in 378 hits (without duplicates).

To narrow the list the authors excluded: (a) studies assessing health impacts of temperature, (b) studies in which future climate change scenarios were not considered, or (c) studies focusing on the environmental impact under climate change without giving the health impact estimates. After the initial review 67 articles were selected for further analyses. The majority of references were the journal articles (online or print) retrieved mainly from SCOPUS database. The papers, which were not originally found within the search of electronic databases, were also included in the initial review, followed the suggestions of experts within the HIA field. To finalize the list, the authors selected 23 studies, which focused on: (a) the health status measures, such as mortality or morbidity, disease incidence (total, respiratory, cardiovascular/cardiopulmonary); (b) the health impacts mediated through the impacts of ozone (O3) or/and particulate matter (PM2.5); (c) the prospective quantitative HIAs or the HIA processes, that is, provided quantitative risk estimates of health effects under a changing climate; (d) assessing the health impact on one or more geographical scales and/or under various climate change scenarios.

In most of the studies discussed the health impact of air pollution was assessed under the IPCC scenarios on a regional scale. Reference scenarios vary among the studies from 2020 to 2100. The geographic scales cover mostly the regions of Europe or U.S., or the entire globe. The standard metrics for ozone and PM2.5 concentrations were the maximum daily 8-hr running mean and the annual average respectively. Methodology to estimate health effects differed from study to study; most of the studies used a concentration-response (CR) or exposure-response (ER) function from the epidemiological quantitative risk assessment studies, in order to calculate the attributable number of cases due to the air pollution exposure (attributable health impact of burden).

The estimates in the studies are the subject to large uncertainties mostly due to their dependency on the following assumptions: (1) the U.S.-based CR functions can be applied globally and to any year (e.g, a CR function cannot be a subject to confounding factors, such as temperature); (2) all $PM_{2.5}$ species are equally toxic; (3) there will be no health effects of climate change (e.g., effects of temperature); (4) the present-day baseline mortality rates will remain the same though decades; (5) downscaling from global or regional impacts to a finer resolution grid can be simplified; (6) precursor emissions will remain the same in the future; (7) there will be no further regulatory policies that control local and regional emissions; (8) the weather condition will not change in the future; (9) there is no bias in the outputs from the climate and air quality models, hence the future meteorology and air quality in the models do not need to be calibrated; (10) no adaptation or acclimatization measures need to be taken into account; (11) for the choice of a climate change scenario; (12) the changes in population (anticipated to decrease) and the age-specific mortality rates (expected to decrease) will not affect the future health estimates. A few studies have addressed various uncertainties by applying Monte-Carlo method or using standard methods of parametric statistics.

A paper discussing this literature review is currently being drafted and will be submitted during the first trimester of 2013.

A protocol for the health impact assessment is under finalization. Choices were made to work on the long-term mortality impacts of $PM_{2.5}$ and ozone. These health endpoints were chosen based on available concentration response functions (CRF) in the literature. For Europe and Ile-de-France, the CRF can be derived directly from the literature. Sensitivity analysis involving different CRF published in the literature will be performed. For the global HIA, assumptions will have to be made for the CRF in highly polluted areas in Asia and Africa (as the published CRF are valid for a lower range of concentrations). The method developed for the global burden of disease will be used here.

At the Ile-de-France scale, analysis will be performed on a 10km*10km grid (2km*2km in the urban center). Mortality data will be obtain at the commune, and disaggregated to a lower scale, weighted by population data. For that scale, the project will be consistent with an on-going project at InVS, performing an HIA of $PM_{2.5}$ for the year 2009.

At the European scale, the geographical scale for the mortality data has not been chosen yet. At the global scale, mortality data have been obtained at the country level from the World Health Organisation database.

The protocol will be finalized in January 2012.

WP3. Dissemination, evaluation and management

A series of in-person project planning and dissemination meetings were held in Paris before and during the first year of the project, as noted briefly below.

20 September, 2011
Project staff and advisors were assembled at InVS for a half-day meeting to review the aims of the proposed study, and to address reviewer comment on the original proposal.

13 March 2012
A full day project “kick-off” meeting was held at InVS, attended by about 20 persons, including all project staff, key partners, and interested policy makers. The morning session was devoted to a series of introductory talks on the various topics relevant to the ACHIA project, including health impact assessment, air pollution epidemiology, global climate and air quality modeling, regional and urban scale air quality modeling. In the afternoon, discussions were focused on the methodologies to be employed in the ACHIA project to accomplish the proposed aims. A summary of the meeting agenda and discussions is available on the project dropbox folder.

11 July 2012
A two hour project meeting was held at LSCE, in connection with a workshop the following day at InVS where Patrick Kinney and Joel Schwartz presented on air pollution and climate health impacts. We invited Joel to join the project as an external advisory, which he agreed to.

12-14 November 2012

A two hour project meeting was held at ADEME on 12 November, in connection with a conference on 13-14 November organized by ADEME entitled, "Ateliers scientifiques « Pollution par les particules : impacts sur la santé, l'air et le climat." On the afternoon of 12 November, Drs. Kinney and Scwartz, along with Mathilde Pascal, Christophe Declerq and Sylvia Medina, participated in a question/answer session with ADEME staff on the topic of climate change, air quality, and human health. At the conference on 13-14 November, these project staff presented talks related to these same themes. This provided an excellent opportunity to communicate the goals and plans for the ACHIA project, and these generated considerable interest among ADEME staff.

Bi-weekly staff meetings

To manage ACHIA on an ongoing basis, we held 1 hour staff conference calls every two weeks on Wednesday afternoons at 15:00 Paris time, except when in-person meetings were planned or during holidays.

6. Publications of the project

Please separate publication from the project and publications linked to the project.

For each publication from the project, please include a short text of 500 characters that will summarize and explain how it is integrated in the project.

The preliminary results of continental scale ACHIA simulations were introduced in a report of the European Topic Centre on Air Quality and Climate Mitigation of the European Environmental Agency for which INERIS leads the task on Air Quality and Climate Interlinkages

Colette, A., Bessagnet, B., Rouïl L., Koelemeijer R., Maas R., On the role of low carbon scenarios on 2050 European air quality and radiative forcing, ETC/ACM Technical Report, EEA, 2012.

Under preparation:

K. Markakis, M.Valari, O. Sanchez, O. Perroussel, A. Colette, Fine resolution air-quality modeling air-quality in Paris, France based on local emission projections for year 2020. Under preparation.

K. Markakis, M.Valari, A. Colette, D.Hauglustaine, O. Sanchez, O. Perroussel, Air quality modelling for the mid-21st century in the greater Paris area under 2 climate scenarios, Under preparation.

V. Likhvar et al., Literature review, Under preparation.

Hauglustaine, D. A., Y. Balkanski, M. Schulz, and A. Cozic, A global model simulation of present and future nitrate aerosols and their direct radiative forcing of climate, *Atmos. Chem. Phys.*, en préparation, 2013.

The following papers are related to the ACHIA project. The first proposes an analysis of 2030 emission scenarios that ignore climate impacts. It is the scope of the ACHIA project to explore the impact of climate in relation with the same emission scenarios. The second paper addresses the bias correction of regional climate models that constitute one of the main challenges to perform quantitative assessments of the impact of climate on air quality. The third addresses regional climate modeling in Europe in the context of climate change.

Colette, A., C. Granier, O. Hodnebrog, H. Jakobs, A. Maurizi, A. Nyiri, S. Rao, M. Amann, B. Bessagnet, A. D'Angiola, M. Gauss, C. Heyes, Z. Klimont, F. Meleux, M. Memmesheimer, A. Mieville, L. Rouïl, F. Russo, S. Schucht, D. Simpson, F. Stordal, F. Tampieri and M. Vrac, Future air quality in Europe: a multi-model assessment of projected exposure to ozone, Atmos. Chem. Phys., 12, 10613-10630, 2012.

Colette, A., R. Vautard and M. Vrac, Regional climate downscaling with prior statistical correction of the global climate forcing, Geophysical Research Letters, 39, L13707, doi:10.1029/2012GL052258.

Colette, A. Bessagnet, B., Vautard, R., Szopa, S., Clain, G., Menut, L., Tripathi, O., Schucht, S., Rao, S. Europe in 2050, a regional air quality and climate perspective. to be submitted to Atmos. Env.

7. Communications to conferences

Kinney, P. Global health and climate impacts of particle emission sources: optimizing benefits of mitigation, Assises de la qualité de l'air : pollution par les particules: impact sur la santé, l'air et le climat, Paris, 13-14 novembre 2012.

Pascal, M., A. Ung, S. Medina, C. Declercq, Evaluation de l'impact sanitaire de la pollution atmosphérique : méthode et résultats, Assises de la qualité de l'air : pollution par les particules: impact sur la santé, l'air et le climat, Paris, 13-14 novembre 2012.

Hauglustaine, D., Impact des particules sur le climat : exemple du trafic routier, Assises de la qualité de l'air : pollution par les particules: impact sur la santé, l'air et le climat, Paris, 13-14 novembre 2012.

The following abstract was submitted to the EGU 2013 conference.

Air quality modelling for the mid-21st century in the greater Paris area under 2 climate scenarios.

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There has been an increasing interest on the impact of climate change on future air quality at both global and regional scales. The largest amount of research up to now used global-scale modelling tools to address the issue, while few recent papers use regional scale models to assess the impact of climate change on large urban agglomerations. The main issues of concern related to a regional scale set-up focusing on a city are the representativeness of the emission estimates of a regional inventory for the city as well as uncertainties in the emission projections. Regional scale projections may be consistent with global scale climate scenarios but they are not representative of the future trend of a specific city. In this study we modelled air quality in the city of Paris, France at a mid-21st century horizon (2045-2055) under two emission and climate scenarios. The emission scenarios were developed for Europe from the Global Energy Assessment (GEA) to be consistent with the IPCCs recently developed Representative Concentration Pathways (RCPs) which incorporate only climate change actions. The emission scenarios include both climate (RCP consistent) and regional air quality policies. To cope with the aforementioned problems we combined two sources of information to project emissions for the city of Paris to the mid-century horizon. The first stems from a local agency (AIRPARIF) and includes a bottom-up high-resolution emission inventory compiled for the year 2008 based on information on local activity and statistics. This inventory is projected by AIRPARIF to the year 2020 based on various air-quality policies already in place or planned for the next years. The second is a set of projection coefficients extracted from the two GEA scenarios for France and applied to the 2020 local inventory in order to obtain an emission inventory for 2050. Global scale concentrations were modelled with the coupled LMDz-INCA system and then downscaled with the regional scale air-quality model CHIMERE using two-level one-way nesting first at 0.5º (50km) grid covering Europe and then at a 4km horizontal resolution grid over the greater Paris area (Ile-de-France region). The IPSL-CM5-MR global-scale model was used to drive the WRF meteorological model for a regional domain in 50km resolution covering Europe which was subsequently downscaled to 10km resolution in order to derive meteorology for the Ile-de-France region. Two sets of simulations are performed: a continuous control run from 1995 to 2004 representing present time air-quality and a continuous run over the 2045-2054 decade representing air-quality projection to the mid-21st century. This effort aims in the development of a health impact assessment study for ozone and $PM_{2.5}$ in the area and the potential differences that arise in air quality and health by using a local scale setup-up compared with a regional scale setup-up.

8. International collaboration and visiting researchers

NA

9. Employment : please provide a curriculum vitae for each master, thesis, postdoctoral fellow recruited for the project

Please see attached.

10. Problem encountered and solutions proposed

NA

11. Describe further steps

1. WP1 global scale

The global model results described earlier will be used in order to constrain the CHIMERE regional model in link with WP2 but mostly to estimate the impact of ozone and $PM_{2.5}$ on global mortality rates in link with WP3. At this stage of the project, the monthly mean aerosol concentrations and the 24h-averaged ozone concentrations have been prepared. Various metrics could be needed for ozone and in particular the 8h averaged ozone daily maximum. These dataset will have to be prepared.

For selected cases and time horizons, the global simulations will be rerun including not only the changes in surface anthropogenic emissions but also the future climate. These simulations will be used in order to investigate the impact of climate change on air quality and in particular on surface ozone concentrations and nitrate formation, but also in order to estimate the impact of nitrate particles to the total aerosol *indirect* forcing. The results for these simulations will also be available for health impact assessment.

An alternative scenario for future anthropogenic emissions has been prepared by IIASA. Based on global energy scenarios from the World Energy Outlook until 2035 and POLES model thereafter, and FAO agricultural projections, this new GAINS scenario has been developed and projects emissions for all GAINS regions globally until 2050. For Europe, more detailed data from PRIMES and CAPRI, respectively, have been included. The data set includes five years (2005, 2010, 2030 and 2050) for nine substances and a sector split following RCP. The same scenario will be used across a range of EU projects (PEGASOS, ECLIPSE) and within HTAP, thus allowing for comparability of results. The LMDz-INCA global model will be used to simulate the future evolution of atmospheric composition from the present to 2050 under this new scenario. The results will be compared to the RCP simulations, will be used to constrain CHIMERE (WP2) and for health impact assessment (WP3).

2.1 WP2 regional scale

In the last year of the project, the regional air quality projections will be revised to achieve a better consistency with the global and local scale. We will first implement a common set of anthropogenic emission projections in the global and regional scale (that will be made available through the HTAP/ECLAIRE initiatives). And we will use the revised boundary condition from the global simulation performed by D. Hauglustaine (LSCE), instead of the field used up to now that were developed originally for the ACCMIP exercise and had therefore a lower focus on particulate matter than ACHIA.

2.2 WP2 urban scale:

Complete the on going work on the evaluation of the local emission projections of AIRPARIF with a thorough analysis of the air-quality in the Ile-de-France region in 2020 with a fine resolution simulation (2km). This paper will focus on the ability of the urban-scale model set-up to represent realistic features driving the air-quality at the urban scale (urban heat island, photochemical regimes, ozone titration).

Complete the ongoing work on the analysis of the mid-century air-quality projections at urban scale based on the two climate scenarios (optimistic and pessimistic).

As a further step we will apply the newly developed emission scheme that models the subgrid scale variability of pollutant concentrations due to heterogeneous surface emissions. This subgrid scale model will provide intra-urban features of air-pollution (at the order of 100m) that are impossible to be represented at the resolution of a chemistry-transport model (at the order of 1km). We will especially focus on near-road pollutant levels in order to provide a full dataset to the Health Impact Assessment team for further analysis.

Our last step is to combine the spatially resolved pollutant concentration fields with demographic and activity data and develop an exposure model that will account on the same time for climate change, local policies that may affect future emissions and population data that may be affected due to adaptation practices.

3. WP3

In the first trimester, the literature review will be completed. The strengths and limitations of the studies will be discussed and the practical considerations for the use of quantitative methods in HIAs or a HIA processes under the changing climate will be provided.

In spring, we will develop protocols for characterizing and reporting uncertainties (quantitative and qualitative).

The HIA will be finished at the global scale in spring, in autumn for the regional and local scale. Results will be presented to the local stakeholders during a workshop in October. Papers presenting the results of the HIA will be submitted (1 for the global scale, 1 for the local scale, 1 for the European scale, and 1 paper linking these three scales).

4. WP4

We have begun discussing a workshop to be held at the end of 2013 to present the key findings of the ACHIA project to the research and policy community in Paris.

12. Did this project help you start other grants or collaborations? Please describe.

One of the scientific challenges of the ACHIA project had been the downscaling of the future climate simulations to the urban scale. How could we create urban emission and climate scenarios that would be on the same time consistent with the global trends and the city plans? Hopefully we developed a relevant methodology to address this issue within the ACHIA project. Based on this experience, part of the ACHIA team, in collaboration with other international researchers have taken the initiative to respond to an ERA-NET call (http://www.era-envhealth.eu/servlet/KBaseShow?sort=-1&cid=23174&m=3&catid=23184) which explicitly focuses on the urban scale. Here the downscaling goes all the way to the human exposure scale. Our future scenarios in this new project (ACCEPTED) will include changes in the buildings' air-tightness and therefore, changes in future exposure conditions.

Changes in urban design and traffic policy, demography, climate and associated adaptation and mitigation measures, and environmental policies, are likely to modify both outdoor and indoor air quality and therefore public health. The ACCEPTED project aims to improve our understanding of future exposure situations and their impact on health, from an interdisciplinary approach. This will be achieved by using various state-of-the-art atmospheric models and measurements and epidemiological studies and reviews. To assess population full exposure we will develop an integrated view accounting both for indoor and outdoor air pollution as well as for population time-activity data. Coupled modelling systems will be developed to assess the interaction between climate and urbanization. We will estimate new dose-response functions between health outcomes and air pollution as well as temperature in order to better estimate the effects on the foetus and young children. Ultimately we will simulate scenarios of future urban climate and air quality, combine future exposure scenarios, population scenarios and exposure-response functions to describe the effects of different trends and relevant policies on relative risk and burden of illness attributed to urban pollutants, especially particles and ozone, and their interactions with extreme temperatures.

This project will in particular address the issue of the mitigation strategies that can be used to reduce urbanization and climate change effects on the local urban meteorology and air quality. The accurate determination of the impact of such scenarios is hindered, at the large-scale end by the change in global climate and at the small-scale end by the difficulty in modelling details of surface and emissions. One of the main objectives of the project is to bridge processes across these scales using a suite of state-of-the-art atmospheric model from global to local (i.e. urban). With applications in several large European cities including Paris, Stockholm and Brussels we will study the impact of several alternative adaptation scenarios on urban air-quality and human health to a mid-century horizon (2030-2060) accounting for the effects of changing urban climate. To account for increased heating over urban areas (heat island effect) and atypical mixing processes induced by the three-dimensional structure of the city and artificial material (e.g. buildings, street canyons, urban vegetation, green roofs etc.) we will run dedicated flux models over the city (Town Energy Budget models). Future emission projections will be developed in collaboration with local agencies of each city based on available scenarios on local policies, urban planning, traffic management, vehicle fleet, economic growth etc. State-of-the-art chemistry transport models (MATCH and CHIMERE) will be used to assess concentrations at urban scale under the aforementioned adaptation scenarios. Novel subgrid scale approaches will be developed to describe air pollutant concentrations within the intra-urban area with special attention to street concentrations. We will also evaluate the impact of the implementation of Low Emission Zones (LEZ) in several European cities in Germany, France and Sweden on traffic-related air pollutants levels.

Due to the overwhelming amount of time spent indoor (homes, workplaces, transport) by the population of the urban centres of the industrial countries personal exposures are driven by indoor air-quality. Not accounting for exposure indoors leads to exposure misclassification and is bound to modify epidemiological results. Therefore, to link air quality modelling activities with epidemiological models it is necessary to account for indoor/outdoor relationships. Several approaches will be followed in this project including indoor air-quality measurements, numerical models for air transfer from outdoors indoors, personal exposure measurements and integrating modelling systems combining air-quality data, indoor/outdoor relationships and human activity patterns. With these activities we study further how indoor/outdoor relationships depend on building characteristics (building envelope, ventilation and energetic systems), meteorological conditions, the proximity to outdoor air-pollution sources (e.g. busy roads) or the type of area (urban, suburban, rural).

Epidemiological studies within this project will focus on vulnerable groups. More specifically, we will study early life exposures before birth and in the first year of life both as chronic exposures and as triggers. Birth cohorts and large birth register cohorts will be used to construct exposure-response functions between pregnancy outcomes (e.g. birth weight and risk of preterm birth) and air pollution (PM from different sources, pollen and ozone) as well as temperature. In addition to measured concentrations we will improve exposure data using output data from the air-quality and exposure modelling activities described above.

In the final phase, scenario-based health impact assessments will combine exposure information from climate models, emission scenarios, policy evaluation studies and concentration calculations with exposure-response functions from epidemiological studies of vulnerable groups within the project and previously published functions for mortality and hospital admissions. We will discuss effects of socioeconomic and demographic trends, describe the predicted health impacts and the benefits associated with different interventions and policies such as LEZ and other urban changes such as residential density, urban vegetation, energy saving buildings etc.

The study will benefit from a large consortium with an interdisciplinary mix of experts involved in many projects (meteorology, air quality modelling, exposure measurements, epidemiology, environmental management, health impact assessment) and with large experience of interaction with policy-makers and stakeholders. There will be many partners in each WP and staff visiting and working in other partner organizations. We plan to produce novel scientific papers, policy-relevant end-user reports and arrange a final seminar for policy makers.

References

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Cuvelier, C., Thunis, P., Vautard, R., Amann, M., Bessagnet, B., Bedogni, M., Berkowicz, R., Brandt, J., Brocheton, F., Builtjes, P., Carnavale, C., Coppalle, A., Denby, B., Douros, J., Graf, A., Hellmuth, O., Hodzic, A., Honoré, C., Jonson, J., Kerschbaumer, A., de Leeuw, F., Minguzzi, E., Moussiopoulos, N., Pertot, C., Peuch, V. H., Pirovano, G., Rouil, L., Sauter, F., Schaap, M., Stern, R., Tarrason, L., Vignati, E., Volta, M., White, L., Wind, P., and Zuber, A.: CityDelta: A model intercomparison study to explore the impact of emission reductions in European cities in 2010, Atmospheric Environment, 41, 189-207, 2007.

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Zyryanov, D., Foret, G., Eremenko, M., Beekmann, M., Cammas, J. P., D'Isidoro, M., Elbern, H., Flemming, J., Friese, E., Kioutsioutkis, I., Maurizi, A., Melas, D., Meleux, F., Menut, L., Moinat, P., Peuch, V. H., Poupkou, A., Razinger, M., Schultz, M., Stein, O., Suttie, A. M., Valdebenito, A., Zerefos, C., Dufour, G., Bergametti, G., and Flaud, J. M.: 3-D evaluation of tropospheric ozone simulations by an ensemble of regional Chemistry Transport Model, Atmos. Chem. Phys. Discuss., 11, 28797-28849, 2011.

SUIVI FINANCIER

1. Informations générales

Merci de renseigner les rubriques pour les laboratoires concernés par le budget :

LABORATOIRE	NOM	PRENOM	TELEPHONE	EMAIL
LMD	Valari	Myrto	0169335139	myrto.valari@lmd.polytechnique.fr
LSCE (U. Columbia)	Kinney	Patrick	+12123053663	plk3@columbia.edu
LSCE	Hauglustaine	Didier	0169087731	didier.hauglustaine@lsce.ipsl.fr
INERIS	Colette	Augustin		augustin.colette@ineris.fr
REEDS	Remvikos	Yorghos		

2. Embauche Personnel

Merci d'indiquer les embauches effectuées en 2012 et/ou celles prévues sur 2013

LABORATOIRE	LMD	LSCE	INERIS	
NOM DE L'AGENT	Konstantinos MARKAKIS	Victoria LIKHVAR	Bertrand BESSAGNET	
STATUT	Post-doc	Post-doc	Ing. INERIS	
DATE DEBUT CONTRAT	1/4/2012	1/10/2012		
DUREE DU CONTRAT	18 mois	15 mois		
COÛT ANNUEL CHARGE	45 000 €	45 000 €	36 793 €	

3. Dépenses de fonctionnement / équipement 2012

Merci d'indiquer vos dépenses équipement/fonctionnement **2012** dans chaque laboratoire impliqué dans le projet.

LABORATOIRE	LMD	LSCE	INERIS	REEDS
BUDGET 2012 ATTRIBUE	5000	8000	750	0
DEPENSES 2012	0	4042,51	0	0

4. Prévisions pour 2013

Merci d'indiquer les dépenses envisagées pour 2013 dans chaque laboratoire impliqué dans le budget.

LABORATOIRE	LMD	LSCE	INERIS	REEDS
DEPENSES DE SALAIRE*	33750€	45 000€	19 954€	0
DEPENSES DE FONCT.	11 020€	14 934€	1 546€	5 000,40€

**Pour les salaires, voir la grille CNRS. Pour info, le coût chargé annuel est de 34k€ par an pour une thèse et de 48k€ par an pour un post-doc. En cas de dépassement, veuillez en indiquer les raisons.*

VICTORIA LIKHVAR, PHD

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EDUCATION AND TRAINING

2006.04 ～ 2009.03

University of Tsukuba, Japan
Graduate School of Comprehensive Human Sciences
Department of Human Care Sciences
PhD student

2004.04 ～ 2006.03

University of Tsukuba, Japan
Graduate School of Comprehensive Human Sciences
Department of Human Care Sciences
MSc student

2002.10 ～ 2004.03

University of Tsukuba, Japan
Research student

2000.09 ～ 2000.11

The Arctic and Antarctic Research Institute (AARI), St.Petersburg, Russia
Preparatory training courses for the Russian Antarctic Expedition 2001-2003, organized by VAISALA OYI, RAE&INT AARI
(Certificate of proficiency in operating a meteorological station MILOS 500)

1998.10 ～ 1999.04

Education Center “AF Konto”, St.Petersburg, Russia
Specialist for Computer Graphics
(Certificate of proficiency in Computer Design)

1992.09 ～ 1997.07

Russian State Hydrometeorological University (RSHU), St.Petersburg, Russia
Department of Meteorology
Student
(Master of Engineering degree in Meteorology)

PROFESSIONAL EXPERIENCE

2012.10 ～ present

Centre national de la recherche scientifique (CNRS), Gif sur yvette, France
Chercheur en climatologie

2009.05 ～ 2011.03

National Institute for Environmental Studies (NIES), Tsukuba, Japan
NIES Postdoctoral Fellowship

2000.03 ～ 2002.08

373rd Center of the Russian Navy, St.Petersburg, Russia
Engineer meteorologist (meteorological data decoding, quality controlling, collecting and processing of the data)

Physical meteorologist (studying the physical nature of the acoustical properties of atmosphere and ocean, researching how the atmosphere and ocean affects the transmission of sound.)

1999.08 ～ 2000.02

Consortium of Investments and Creditors (CIC), St.Petersburg, Russia
Project coordinator (coordinating tasks for the realization of scientific projects)

1999.04 〜 1999.07

Printing Company “New Polygraphic Technologies”, St.Petersburg, Russia
Computer designer and printing maker-up (page proof, computer graphics, preprinting and computing)

1998.01 〜 1999.04

373rd Center of the Russian Navy, St.Petersburg, Russia
Operational meteorologist (meteorological data processing, programming, coding)

1997.09 〜 1997.12

Medical journal „Meditech”, St.Petersburg, Russia
Printing maker-up

1997.07 〜 1997.08

NorthWest Office of Hydrometeorological Center of Russia, S.Petersburg, Russia
Practical experience in the weather forecasting (analyzing of a weather situation, weather predicting, working out the reports and informing Office officials and weather agencies of threatening weather events)

1997.06 〜 1997.07

Meteorological Center of Pulkovo airport, S.Petersburg, Russia
Practical experience in the weather forecasting (analyzing of a weather situation, weather predicting, working out the reports and informing airport officials of threatening weather events)

PROFESSIONAL ACTIVITIES

Membership

2008 ~ International Society of Biometeorology (ISB): Climate and Health Commission (CHC)
2008 ~ Pharmaceutical Society of Japan (PSJ)
2009 ~ Japan Epidemiological Association (JEA)
2009 ~ Institute of Electrical and Electronics Engineers (IEEE)
2010 ~ IEEE Communications Society
2010 ~ Integrated Research System for Sustainability Science (IR3S)

Commentator

2009 COMPASS INTERDISCIPLINARY VIRTUAL CONFERENCE “Breaking Down Barriers”

SCHOLARSHIPS AND RESEARCH GRANDS

Modelling the Temperature-Mortality Relation in Japan (2004-2009), Given Monbukagakusho Scholarship, supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan

Research on a New Environmental Monitoring System Using Mobile Technologies (2010-2013), 「モバイルテクノロジーを応用した新しい都市環境モニタリングシステムの研究」, Given “Grants-in-aid for Scientific Research”,「科学研究費補助金」, Supported by Japan Society for the Promotion of Science (JSPS), Japan

PUBLICATIONS

Victoria N. Likhvar, Yasushi Honda, Masaji Ono (2011). Relation between temperature and suicide mortality in Japan using time-series analysis with semiparametric approach. *Environmental Health and Preventive Medicine*, 16(1), 36-43. (Winner of the EHPM award for the best paper published in 2011.)

Yasushi Honda, Victoria N. Likhvar, Kazutoshi Sugimoto, Masaji Ono (2009). Cold Counts, but How Cold May Not. Epidemiology, 20(6), S117.

本田　靖、Victoria N. Likhvar, 杉本　和俊 (2008). 中国３都市における気温と死亡の関連. *Japanese Journal of Health and Human Ecology*, 74(Suppl.), 124-125.

Yasushi Honda, Victoria N. Likhvar, Yu-Chun Wang, Fung-Chang Sung (2008). Do Taiwan cities show similar pattern to Japanese data? – temperature-mortality relation and its relation to climate. 18th International Congress of Biometeorology, 22-26 September 2008, Tokyo, Japan.

Victoria Likhvar and Yasushi Honda (2008). Choice of Degree of Smoothing in Fitting Nonparametric Regression Models for Temperature-mortality Relation in Japan Based on a Priori Knowledge, *Journal of Health Science*, 54(2), 143-153.

SKILLS

Languages: Russian (fluent), English (fluent), Japanese (Basic)
Statistical software: R, S-PLUS, STATA
Operating systems: Windows, Linux, Mac OS X

Curriculum Vitae

PERSONAL DATA

SURNAME:	Markakis
FIRST NAME:	Konstantinos
NATIONALITY:	Greek
BIRTH DATE:	14 - 01 - 1979
ADDRESS:	Cite Universitaire, Maison de Provinces de France, 75014, Paris, France
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EDUCATION

- B.Sc in Physics, Aristotle University of Thessaloniki. Graduation in 2003. Grade **7.11**
  Post graduate thesis: "El - Nino global socio-economic effects"

- M.Sc in Atmospheric Physics, Aristotle University of Thessaloniki. Graduation in 2005. Grade **8.58**
  Master thesis: "Calculation of road transport emissions in Greece and the two large Urban centers of Athens and Thessaloniki".

- PhD (December 2006 – March 2010), Laboratory of Atmospheric Physics, Department of Physics, Aristotle University of Thessaloniki.
  PhD thesis: "Contribution to the study of aerosol pollution in the Balkan region".

Languages

English:	Certificate of Competency in English (University of Michigan)/Excellent communication skills
Italian:	Basic knowledge (No degree)
French:	Basic knowledge (No degree)

Software

Computer knowledge	Working in computer environments for 19 years, very good computer skills (hardware, software) and standard software packages e.g. Office
Advanced/Scientific software	**Photoshop**: Good knowledge **Windows environment**: Excellent knowledge **Linux environment**: Good knowledge **GIS**: Excellent knowledge (Mapinfo/ArcGIS) with programming capabilities
Programming languages	**FORTRAN:** Very good knowledge **SQL**: Good knowledge **MapBasic**: GIS language, Excellent knowledge **Bash Scripting:** Good knowledge **Python:** Good knowledge

Models	**Meteorological:** WRF **Photochemical:** CHIMERE

Bursaries / Travel grants

- Travel/accommodation bursary granted by the ACCENT network to attend the 2nd ACCENT symposium, 22-29 July 2007, Urbino, Italy.
- Full bursary granted by the HAAR (Hellenic Association for Aerosol Research) to attend the European Aerosol Conference (EAC), 6-11 September 2009, Karlsruhe, Germany.
- The COST action 728 founded the Short Term Scientific Mission (STSM) in the Finnish Meteorological Institute (FMI) titled “Computational methods for the quantification of biogenic VOC and sea salt emissions”, 9 – 16 November 2008.
- Bursary granted by the GEIA Conference committee to attend in the GEIA Conference, 26-28 October 2009, Oslo, Norway.
- Travel/accommodation bursary granted by the ACCENT network to attend the 3rd ACCENT symposium, 13-16 September 2011, Urbino, Italy.

Personal attendance in conferences / workshops

- NATO ARW Workshop, 8-12 May 2004, Borovetz, Bulgaria.
- TFEIP, Task force of emission inventories and projections, 30-31 October 2006, Thessaloniki, Greece.
- EGU General Assembly 13-18 April 2007, Vienna, Austria.
- 2nd ACCENT symposium, 22-29 July 2007, Urbino, Italy.
- European Aerosol Conference (EAC), 23-28 August 2008, Thessaloniki, Greece.
- HARMO Conference, 6-9 October 2008, Cavtat, Croatia.
- Air Quality Conference, 24-29 March 2009, Istanbul, Turkey.
- European Aerosol Conference (EAC), 6-11 September 2009, Karlsruhe, Germany.
- Global Emission Inventory Activities (GEIA) Conference, 26-28 October 2009, Oslo, Norway.
- 3rd ACCENT symposium, 13-16 September 2011, Urbino, Italy.

Attendance in summer schools

- ACCENT - CMAS Training Workshop on Air Quality Modeling, 30 July - 8 August 2006, Sofia, Bulgaria.
- Air Quality and Air Quality Management in Eastern Europe, training workshop, 1-8 June 2007, Riga, Latvia.
- QUANTIFY Summer School, 10 – 26 September 2007, Athens, Greece.
- EUFAR – ACAS summer school, KNMI, 17 – 21 April 2008, Utrecht, Netherlands.
- Formation and growth of atmospheric aerosols, Summer school, 4 – 14 August, 2008, Helsinki, Finland.

Participation in projects / Scientific missions

National projects

- Study of the Mesoscale Effects on the Air Pollution of Bulgaria and Northern Greece, 2003-2005.
- Radiative forcing estimates over the Mediterranean and SE Europe (PYTHAGORAS II: Funding researchers in Universities), General Secretariat for Research and Technology, Ministry of Development, 2005-2007.
- Impact of meteorological parameters in gaseous pollutants transport in the atmosphere, Greek-Albanian collaboration, 2006 - 2008.
- Assessment of atmospheric pollution at the municipality of Dimitrios Ypsilantis for existing and future pollution sources, 2008 - 2010.
- Air Pollution and Climate Change Health Impact Assessment (ACHIA), 2011 - 2013.

European projects

- Modeling System for Emergency Response to the Release of Harmful Substances in the Atmosphere, Science for Peace and Security (SPS), 2006-2009.
- Protocol Monitoring for the GMES Service Element, Stage 2 (PROMOTE II) EU 6th FP, ESA, 2006-2009.
- Global and regional Earth-system Monitoring using Satellite and in-situ data (GEMS) EU 6th FP, 2005-2009.
- Central and Eastern Europe Climate Change Impact and Vulnerability Assessment (CECILIA), EU 6th FP, 2006-2009.
- megaCITY Zoom on the Environment (CITYZEN), EU 7th FP, 2008 – 2011.

- Actions for the mitigation of Port, Industries and Cities Emissions (APICE), EU 7th FP.
- Monitoring Atmospheric Composition and Climate (MACC), EU 7th FP, 2009-2011.

Missions

- Aerosols and cloud measurements over the Northern Sea with the FAAM aircraft (Flight mission B359) under the training course of EUFAR-ACAS 17-21 April 2008.
- Short Term Scientific Mission (STSM) in the Finnish Meteorological Institute (FMI) with title "Computational methods for the quantification of biogenic VOC and sea salt emissions", 9 – 16 November 2008.

Employment

- **September 2006 – March 2012**. Laboratory of Atmospheric Physics, University of Thessaloniki, Thessaloniki. Greece.
  Supervisor: Dimitrios Melas, Tel: +30 2310 998124, e-mail: melas@auth.gr.
- **April 2012 – September 2013.** Laboratorie de Meteorologie Dynamique (LMD), Institute Pier-Simon Laplace (IPSL), Paris, France.
  Supervisor: Myrto Valari, Tel: +33 1 69 335204, e-mail: myrto.valari@lmd.polytechnique.fr.

Publication in peer reviewed journals (with citations)

- Poupkou, A., Symeonidis, P., Ziomas, I., Melas, D., **Markakis, K**., 2007. A spatially and temporally disaggregated anthropogenic emission inventory in the southern Balkan Region, Water, Air & Soil Pollution 185: 335-348.

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  - Kryza, M., Werner, M., Blas, M., Dore, A.J., Sobik, M., 2010. The effect of emission from coal combustion in nonindustrial sources on deposition of sulfur and oxidized nitrogen in Poland. Journal of Air and Waste Management Association 60 (7): 856-866.
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  - Kalabokas, P.D., Papayannis, A.D., Tsaknakis, G., Ziomas, I. A study on the atmospheric concentrations of primary and secondary air pollutants in the Athens basin performed by DOAS and DIAL measuring techniques. Science of the Total Environment, 414: 556-563.

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  - Nishanth, T., Ojha, N., Satheesh Kumar, M.K., Naja, M., 2011., Influence of solar eclipse of 15 January 2010 on surface ozone. Atmospheric environment, 45 (9): 1752-1758.
  - Kwak, K.-H., Ryu, Y.-H., Baik, J.-J., 2011. Temporal and spatial variations of NOx and ozone concentrations in Seoul during the solar eclipse of 22 July 2009. Journal of Applied Meteorology and Climatology, 50 (3): 500-506.
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  - Girach, I.A., Nair, P.R., David, L.M., Hegde, P., Mishra, M.K., Kumar, G.M., Das, S.M., Ojha, N., Naja,

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- ❖ Huijnen, V., Eskes, H-J., Poupkou, A., Elbern, H., Boersma, K.F., Foret, G., Sofiev, M., Valdebenito, A., Flemming, J., Stein, O., Gross, A., Robertson, L., D'Isidoro, M., Kioutsioukis, I., Friese, E., Amstrup, B., Bergstrom, R., Strunk, A., Vira, J., Zyryanov, D., Maurizi, A., Melas, D., Peuch, V-H., Zerefos, C., 2010. Comparison of OMI NO2 tropospheric columns with an ensemble of global and European regional air quality models. Atmospheric Chemistry and Physics 10, 3273-3296.
- ❖ Aleksandropoulou, V., Torseth, K., Lazaridis, M., 2011. Atmospheric emission inventory for natural and anthropogenic sources and spatial emission mapping for the Greater Athens Area. Water Air and Soil Pollution, 219 (1-4): 507-526.
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- ❖ Muntaseer Billah Ibn Azkar, M.A., Chatani, S., Sudo, K., 2012. Simulation of urban and regional air pollution in Bangladesh. Journal of Geophysical Research D: Atmospheres, 117 (7), art. no. D07303.
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Publication submitted / in preparation

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- **Markakis, K.,** Poupkou, A., Liora, N., Giannaros, T., Melas, D. NEMO-PM: A new emission model for the calculation of wind erosion dust and PBAPs emissions. Application in the European continent. *In preparation*.

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- Zyrichidou, I., Koukouli, M.E., Balis, D.S., Katragkou, E., Poupkou, A, Kioutsioukis, I., **Markakis, K**., Melas, D., Van Der A, R., Boersma, F.K., Van Roozendael, M., 2010. Comparison of satellite NO_2 observations with high resolution model simulations over the Balkan Peninsula. AIP Conference Proceedings 1203: 632-637. DOI: 10.1063/1.3322525.
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Climatology and Atmospheric Physics, 30 May- 1 June, 2012, Athens, Greece.

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- Poupkou, A., Ziomas, I., Papayannis, A., Georgopoulos, P., Efstathiou, C., Eleftheriadis, K., **Markakis, K.,** N. Sifakis, N., Housiadas, C., P. Nicolopoulou-Stamati, P., Avdikos, G., Lazaridis, M., Giannaros, T., 2008. Evaluation of aerosol and ozone simulations over Athens using in situ sensors combined with health indicators. European Aerosol Conference, 24-29 August 2008, Thessaloniki, Greece.
- Poupkou, A., Giannaros, T., **Markakis, K.,** Melas, D., 2008. The Contribution of Biogenic NMVOCs to the Formation of Secondary Organic Aerosols in the Balkan Peninsula. IGAC 10th International Conference 7-12 September 2008, Annecy, France.
- Agacayak, T., Unal, A., Tayfun, K., Im, U., **Markakis, K.** Compilation of emissions inventory for the city of Istanbul and verification via air quality model (CMAQ). Global Emission Inventory Activities (GEIA) Conference, 26-28 October 2009, Oslo, Norway.
- Balis, D., Giannakaki, E., Katragkou, E., Wiegner, M., **Markakis, K.,** Amiridis, V. Differences of the aerosol load between an urban and suburban site using remote sensing measurements and model estimates. European Aerosol Conference, 6-11 September 2009, Karlsruhe, Germany.
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- Poupkou, A., Katragkou, E., Koukouli, M-E., Kazadzis, S., **Markakis, K.,** Giannaros, T., Balis, D., Daskalakis, N., Kanakidou, M., Melas, D. 2010. Evaluation of simulated PM_{10} concentrations over Greece using gridded satellite measurements. International Astronautical Congress, 27 September – 1 November 2010, Prague, Czeck Republic.
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- Im U., Daskalakis, N., Gerasopoulos, E., Kindap, T., Kocak, M., **Markakis, K.,** Melas, D., Mihalopoulos, N., Poupkou, A., Unal A., Kanakidou, M., 2011. Impacts of the emissions from the eastern Mediterranean megacities on air quality. ACCENT 3rd Symposium, 13-16 September 2011, Urbino, Italy.
- Poupkou, A., **Markakis, K.,** Liora, N., Giannaros, T., Im, U., Daskalakis, N., Myriokefalitakis, S., Melas, D. Kanakidou, M., 2011. First results on the impact of the Greek forest fires in summer 2007 on the air quality of the eastern Mediterranean. ACCENT 3rd Symposium, 13-16 September 2011, Urbino, Italy.
- Liora, N., **Markakis, K.,** Poupkou, A., Giannaros, T., Ziomas, I., Melas, D., 2011. A bottom-up high resolution emission inventory from natural and anthropogenic sources for the port city of Thessaloniki, Greece. ACCENT 3rd Symposium, 13-16 September 2011, Urbino, Italy.

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- **Markakis, K.**, Im, U., Unal, A., Melas, D., Yenigun, O., Incecik, S. A computational approach for the compilation of a high spatially and temporally resolved emissions inventory for the Istanbul Greater Area. Air Quality Conference, 24-29 March 2009, Istanbul, Turkey.
- **Markakis, K.**, Giannaros, T., Poupkou, A., Melas, D., Sofiev, M., Soares, J. Evaluating the impact of particle emissions from natural sources in the Balkan region. European Aerosol Conference, 6-11 September 2009, Karlsruhe, Germany.
- **Markakis, K.,** Melas, D. A new emission model for the compilation of model-ready emission inventories. GEIA Conference, 26-28 October 2009, Oslo, Norway.
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- **Markakis K.,** Poupkou A., Giannaros T., Liora N., Melas D. Parameterization of emissions fluxes of Biogenic VOCs. An emission modeling application for Europe using the NEMO emission model. MUSCATEN Workshop on Biogenic Volatile Hydrocarbons, 19-21 October 2011, Tartu, Estonia.