SIXTH FRAMEWORK PROGRAMME

SUB-PRIORITY 1.1.6.3

Global Change and Ecosystems

Contract for the

SPECIFIC TARGETED RESEARCH OR INNOVATION PROJECT

HYMN

HYdrogen, Methane and Nitrous oxide:
Trend variability, budgets and interactions with the biosphere

Annex I — "Description of Work"
(Revision I)

Proposal acronym: HYMN

Project full title: HYdrogen, Methane and Nitrous oxide: Trend variability, budgets and interactions with the biosphere

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1. Project Summary

The global atmospheric cycles of methane, nitrous oxide and hydrogen, are coupled and include various interactions with the biosphere. Apart from classical surface observations of these gases that are part of the GAW and CMDL networks, new detailed information on the regional scale about methane and nitrous oxide can and will be obtained from recently become available satellite observations by SCIAMACHY and IASI and from remote sensing observations by FTIR. In Hymn these observational data sets will be homogenised and evaluated against each other in order to derive consistent long-term time series. The error statistics of the observations will be carefully determined. By subsequently applying advanced emission inversion and data assimilation techniques to the validated observations in atmospheric chemistry models coupled to a new biosphere model, the sources and sinks of these gases will be quantified on regional scales (up to 1x1 degree). The coupling between the cycles of these gases and OH will be investigated focussing on presently not well understood relations between variations in their trends.

The new models will furthermore be applied to investigate the effects of a future transfer to a *hydrogen economy* and of the associated reduction in fossil fuel burning emissions (NO_X, CO, VOCs) on the coupled cycles of H_2, CH_4 , OH, and O_3 taking into account interactions with the biosphere.

2. Project Objectives

Ever-extending human activities on a global scale are the cause of the rising concentrations of several long-lived gases in the atmosphere, including the greenhouse gases methane (CH_4) and nitrous oxide (N_2O). The possible transition to a so-called ‘hydrogen economy’ in the coming decades is likely to cause a significant increase in future atmospheric molecular hydrogen (H_2) levels. The HYMN project focuses on the impact and mechanisms of three important gases: H_2, CH_4, and N_2O, which we will refer to in the following as the ‘HYMN gases’.

Recently, the Kyoto Protocol has been ratified. Concrete ceilings have been set for the 2012 greenhouse gas emissions of the participating countries, including the EU. The gases targeted by the Kyoto Protocol include CO_2, the HYMN gases CH_4, N_2O, and the fully human-made HFCs, PFCs and SF_6. For the EU this implies a targeted reduction of 12 % in 2012 relative to 1990 levels. A significant contribution to this target is expected to be made by reductions in CH_4 (about 32 %) and N_2O (about 12%) emissions. Atmospheric molecular hydrogen (H_2) is receiving increased attention because of the perturbations of its budget in a prospective *hydrogen economy*. In the future, hydrogen emissions could double compared to the present, and consequent impacts on climate forcing, air quality and ozone depletion have been hypothesized.

For the post-Kyoto era new regulations will be required. The need for a quantitative reduction in anthropogenic greenhouse gas emissions is internationally recognised – less agreement exists on methods to achieve such reductions. For the climate gases with both natural and anthropogenic components (CO_2, CH_4 and N_2O) a thorough assessment of their budgets is needed as a starting point for future regulations. Furthermore, different abatement strategies will have different potential, efficiency and impact. Finding the optimal strategy for reductions in greenhouse gas emissions is complex, and different trade offs can be made. For example, the efficacy of methane emission regulation to mitigate climate forcing has been reported to be relatively high, also because of its impact on tropospheric ozone (Hansen et al., 2005).

Emission regulation is important for different environmental issues such as anthropogenic climate change, air quality degradation and ozone depletion. Methane emissions as well as pollutant emissions of NO_X, CO and VOCs contribute to tropospheric O_3 which is a toxic gas, an important oxidant and contributor to photochemical smog formation as well as a potent greenhouse gas. HYMN will provide necessary input information for assessments to provide guidance to policy making with respect to future emission regulations related to climate change, air quality degradation and ozone depletion.

In order to find optimal abatement strategies for the HYMN gases, in-depth knowledge is required of the budgets and biogeochemical cycles of the gases, including their geographical distribution, the magnitude and variability of their sources, sinks and dispersion, and the feedbacks that connect land-biosphere processes with the life cycles of these gases through atmospheric chemistry and long-range transport. HYMN will integrate knowledge on all these aspects.

The overall project-objectives of HYMN are therefore:

1) To improve the process modelling of the land-biosphere-atmosphere exchange of the HYMN gases and to provide global and regional estimates of their natural sources and sinks
2) To contribute to global monitoring by provision of multi-year global satellite data sets of the CH_4 and CO distribution and long-term time series for CH_4 and N_2O at a range of observing stations
3) To provide advice on the further optimisation of monitoring networks for the HYMN gases.
4) To quantify atmospheric loss of CH_4 and H_2 and the impact of changing anthropogenic and natural (climate-induced) emissions on regional OH trends and on current and future global CH_4 and H_2 levels
5) To quantify how the possible future change to a *hydrogen economy* will affect the H_2 distribution and the distribution of CH_4 and O_3 through changes in emissions of H_2 and pollutants (NO_X, CO, VOCs).
6) To evaluate the simulations with a novel coupled atmospheric chemistry-biosphere model for CH_4, N_2O and H_2 by comparison with ground based and satellite observations on a global and regional scale
7) To make new estimates of the sources and sinks of CH_4 and H_2 including their temporal and spatial variability

HYMN will make use of several basic methods to improve knowledge on global and regional natural sources and sinks of atmospheric gases: up-scaling of local (flux) measurements, process-based land-biosphere modelling and top-down inverse modelling using atmospheric concentration variabilities. HYMN will use these three methods in their optimal combination and confront the obtained results with satellite and surface-based observations.

The direct coupling of land-biosphere processes to anthropogenic emission distribution patterns, atmospheric chemistry and long-range transport models will allow to quantify important feedback mechanisms related to wetlands, permafrost, wildfires, soil moisture and temperature, and vegetation changes.

Using the newly developed modelling and inversion tools HYMN will be able to provide advice on future emission reduction strategies based on improved knowledge on the budgets, biogeochemical cycles and spatio-temporal distributions of sources and sinks of the HYMN gases.

Given the possible transition to a hydrogen economy, HYMN will be able to answer the questions on the potential environmental impact of increased H_2 on the atmosphere, also in combination with an associated decrease in NO_X emissions (Schulz et al., 2003) and taking into account interactions with the biosphere. Thus HYMN will also be able to give advice on future emission controls.

The overall objectives listed above break down into the individual objectives of the work packages. These objectives are listed in Chapter 7.6 with milestones.

3. Participant list

The following table lists the participants of HYMN and their contractual status. Further information on the participants is provided in Appendix A.1.

Participant role	Number	Participant name	Participant short name	Country	Date enter project	Date exit project
CO	1	Royal Netherlands Meteorological Institute	KNMI	NL	1	40
CR	2	University of Bristol	UNIVBRIS	UK	1	40
CR	3	University of Oslo	UiO	NO	1	40
CR	4	University of Heidelberg	**UHEI.IUP**	DE	1	40
CR	5	Centre National de la Recherche Scientifique- Laboratoire des Sciences du Climat et de l'Environnement	CNRS-LSCE	FR	1	40
CR	6	University of Bremen	**Uni-HB**	DE	1	40
CR	7	Belgian Institute for Space Aeronomy	BIRA-IASB	BE	1	40
CR	8	University of Liège	ULg	BE	1	40
CR	9	Chalmers Tekniska Hoegskola Aktiebolag	Chalmers	SV	1	40
CR	10	Forschungszentrum Karlsruhe, Institut für Meteorologie und Klimaforschung – Atmospheric Environmental Research	**FZK-IMK-IFU**	DE	1	40
CR	11	University of Karlsruhe, Institut für Meteorologie und Klimaforschung – Atmospheric Trace Constituents and Remote Sensing	**UniKarl**	DE	1	40
CR	12	Commisariat à l'Energie Atomique - Laboratoire des Sciences du Climat et de l'Environnement	**CEA-LSCE**	FR	1	40

4. Relevance to the objectives of the Global Change and Ecosystems Sub-Priority

HYMN is a research and technology proposal in response to a thematic call in the area "Global Change and Ecosystems", a sub-priority of the FP6 Framework Program (FP6-2005-Global-4). In the work programme to this sub-priority seven areas are distinguished. The call is part of Area I on the 'Impact and mechanisms of greenhouse gas emissions and atmospheric pollutants on climate, ozone depletion and carbon sinks' (SUSTDEV-3.1). The objective for this area is *to detect and describe global change processes, associated with greenhouse gas emissions and atmospheric pollutants from all sources, including those resulting from energy supplies, transport and agriculture, to improve prediction and assessment of their global and regional impacts, evaluate mitigation options and improve the access of European researchers to facilities and platforms for global change research.* The set-up of HYMN is chosen to reflect all of these general objectives.

Research in the thematic area is divided into different topics. The topic relevant for this call is on "Atmospheric pollutants and their regional impacts" and research activities for this topic should focus on:

(i) The chemistry of atmospheric pollutants and greenhouse gases and their impact on regional air quality and climate
(ii) The quantification and prediction of the emissions and long range transport of atmospheric constituents, and
(iii) Atmospheric chemistry-climate interactions, including their links with land and ocean processes at regional and global scale

The research activities proposed in HYMN covers the three focal points (i), (ii), and (iii) of this topic by a combination of monitoring activities from satellite platforms as well as using a ground-based network and the application of global integrated biosphere-atmosphere models that are adequate for climate impact assessments and the study of long-range transport and still have sufficient spatial resolution to study regional air quality and chemistry-climate interactions at the regional scale. The regional aspect is further emphasized by the process-based approach for the description of the biosphere-atmosphere interactions.

The five specific scientific objectives for this call which are relevant for the atmospheric composition change of methane, nitrous oxide and molecular hydrogen include:

1. Provide a better understanding of the global cycles of the HYMN gases (H_2, CH_4, and N_2O)
2. Quantify sinks and sources of the HYMN gases, including the regional scale
3. Contribute to the monitoring of the HYMN gases
4. Quantify current H_2 levels, variability and trends, and
5. Investigate the role of H_2 in the global atmosphere on the budgets of OH, CH_4, and O_3

Each of the five scientific objectives, quoted from the FP6 work programme to the sub-priority, is covered by the research activities proposed in HYMN. For aspects 1 and 5, on global cycles, chemical budgets and better understanding, mainly modelling tools will be used including global atmospheric chemistry models and process-based biosphere-atmosphere models. Satellite observations as well as the observations from ground networks (FTIR, CMDL, and GAW) cover the required monitoring contribution (aspects 3 and 4), and the combination of observations, integrated atmosphere-biosphere models and inverse modelling and advanced data assimilation techniques will be used to address the quantification of sources and sinks on a regional scale (aspect 2). Regionalisation of source and sink estimates is refined by using a nested domain modelling approach (zooming in into Europe).

The research undertaken under “Global change and Ecosystems” has to be considered as a major support to the European Union (EU) Strategy for Sustainable Development which has been emphasized at the Göteborg European Council in 2001 and enlarged to an international scale in the Johannesburg Summit on Sustainable Development in 2002. HYMN will strengthen the necessary scientific basis, including socio-economic assessments and tools and management practices, for the future orientation and implementation of abatement strategies for climate and air quality, as well as for the assessment of the potential effects of conversion to a hydrogen economy. HYMN will give important input to current and future policies on the most effective emission controls on greenhouse gas emissions in order to limit global warming. HYMN will also supply fundamental information to support the post-Kyoto negotiations.

Research undertaken under this priority should strengthen the scientific and technological capacities needed for Europe to understand and control global change. HYMN will contribute by an integrated approach to biosphere-atmosphere interactions and their role in the budgets of greenhouse gases, as well as on the possible future role of molecular hydrogen in the Earth system. In particular the tools developed in this project can and will be applied to yield top-down estimates of emissions derived from atmospheric observations. This provides a baseline, against which bottom-up emission numbers provided by EU-member states as well as countries outside the EU, or from in dependently constructed emission inventories, can be compared.

HYMN will encourage international cooperation to achieve common strategies to respond to global change issues. In the context of the Group-on-Earth-Observations (GEO) initiative, and the European contribution to GEO, Global Monitoring for Environment and Security (GMES), HYMN will contribute to the long-term monitoring programs, both from the surface and from space, and provide scientific input for the further development of a system of earth observation systems.

5 Potential impact

Strategic impact

The HYMN project will yield improved top-down regional estimates of greenhouse gas sources and sinks for Europe and elsewhere. It will therefore make a direct contribution to EU policies with respect to the Kyoto Protocol and global compliance to it.

It will also make a direct contribution to the EU policies for the post-Kyoto era. Improved top-down emission estimates and better understanding of the atmospheric cycles of these gases improves the knowledge base for developing post-Kyoto policies. The inversion methodology will also offer an interesting perspective on present regional bottom-up emission estimates.

The project will provide information relating economic activity (fossil fuel burning) to climate change. The impact of wetlands and fires on greenhouse gas emissions will be detailed. As such HYMN supports implementation of climate targets in several fields, such as energy use, agriculture, and nature protection. Dissemination and use of the project results will thus help the development of policies for sustainable growth.

The HYMN project results also contribute to the GMES goals in the sense that it demonstrates a few services (greenhouse gas monitoring and emission inversions) that might be considered for inclusion in GMES.

Innovation-related activities

In the project for the first time a comprehensive integrated biosphere-atmosphere model will be applied for studying the coupled budgets of H_2, CH_4 and N_2O and their relationship to changes in the major atmospheric cleansing agent, OH. The capability for determining sources and sinks of these greenhouse gases through inversions will also be greatly increased by applying improved modelling and retrieval techniques to new global observations from satellite instruments. Finally, a new common standard for monitoring of CH_4 and N_2O by FTIR will be developed and implemented in the existing network of FTIR.

Dissemination plan

The plans, progress and results of the project will be presented publicly through the external project web site.

In month 12 a brochure explaining the objectives, approach and expected outcomes of the project will be produced. At the end of the project a brochure explaining the results will be made and distributed. A (powerpoint) presentation of the project will be made and kept up-to-date with the results obtained within the project. This will be used by the coordinator and partners to present the project at relevant conferences, meetings and workshops, and it will be made available to the responsible EU officer.

An open conference will be organised at the end of the project. The conference will deal with both scientific and policy subjects in the field. The organising committee will consist of representatives active in science, policy making and related economic activities.

The scientific results from the project will be published in peer-reviewed international journals and presented at international conferences. The results will also provide direct input to the next (5th) assessment report of the IPCC.

The developed emission inversion and data assimilation products will be integrated in the ESA PROMOTE / TEMIS web service at the end of the project, which will open the possibility to continue their operation after the HYMN project itself has finished.

The developed methodology for greenhouse gas monitoring by FTIR will be proposed as a standard for the global NDSC FTIR network.

Spreading awareness and information about the project and its results beyond the research community with the public as a whole

When important results from the project become available (e.g. D5.2) of when major scientific publications from the project appear, media coverage will be sought by preparing press releases. These will, of course, be discussed with the responsible EU officer before actual release. A press conference may also be organised in the framework of the Open Science Conference at the end of the project.

The web sites of some of the institutions, such as KNMI, attract large numbers of visitors from the general public, and thus provide an alternative way to access the general public by publishing short news items about the project.

As described above, in month 12 a brochure explaining the objectives, approach and expected outcomes of the project will be produced. At the end of the project a brochure explaining the results will be made and distributed. These brochures will contain links to the project web page where further information is made available and will be distributed at meetings and by the participating institutions. The brochures and the web site will also serve as background material for media events.

Further plans and activities to spread awareness and information will be developed as part of the project by the Coordinator.

Added-value of the European level

The HYMN project establishes a consortium of world leading institutes in various disciplines, bringing together expertise in the fields of greenhouse gas monitoring, satellite observations, biosphere and atmospheric chemistry modelling and emission inversions. Such a consortium cannot be formed at the national level of any of the participating countries. The HYMN cooperation will increase the European capability in assessing the anthropogenic impacts on the chemical composition of the atmosphere and on climate, in particular with respect to the role of the biosphere for the HYMN gases. The integration of biosphere modelling and atmosphere modelling is a large effort and requires a multi-angle approach, such as proposed in HYMN. HYMN will increase the cohesion between European research institutes in an interdisciplinary way.

Monitoring by a ground network requires international coordination and harmonization of measurement practices, calibration, and data processing. These common practices are also essential for the validation of global satellite measurements. The monitoring activities proposed in HYMN are in accordance with the recommendations made in recent strategy reports on long-term monitoring, including the report of the EU GMES-GATO project (EC, 2004), and the IGOS theme report on atmospheric chemistry Integrated Global Atmospheric Chemistry Observations (WMO, 2005).

Relation to other research activities

HYMN will make use of the existing and planned monitoring capacities in Europe and elsewhere:

- Greenhouse gas measurements from surface stations are collected by GAW and available through the World Data Centre for Greenhouse Gases. The NOAA CMDL baseline observations are part of GAW, but we also have direct access to NOAA CMDL through an existing cooperation that includes application of the TM5 model for greenhouse gas inversions. CMDL is probably the only laboratory that can provide globally distributed H_2 observations.

- The EU project Evergreen has set up European capacity for greenhouse gas retrievals and inversions from satellite observations. KNMI led and UHEI.IUP was partner in Evergreen. The present proposal builds on retrieval and inversion algorithms constructed during Evergreen.

- The EU project UFTIR project is built around the European part of the NDSC FTIR community. Within the project a common strategy has been established for the retrieval of vertical profiles of several gases from FTIR ground-based measurements. Available spectral data have been re-analysed and revised consistent time series of vertical profiles and total columns have been provided for N_2O, HCFC-22, CO, C_2H_6 and O_3. The retrieval strategy for CH_4 has been investigated but more work needs to be done for making it optimal.

- Within the EU project STAR a Pilot Study was conducted in order to assess the feasibility of operating an FTIR instrument at the inner-tropical station at Paramaribo (Suriname). Three campaigns have been conducted at Paramaribo and the spectra are available for the retrieval of CH_4 and N_2O.

- The EU project SCOUT focuses on the upper troposphere/lower stratosphere region and provides some support to FTIR-measurements on board the research vessel Polarstern and at the Ile de La Réunion. These measurements will be also available for CH_4 and N_2O retrieval within HYMN.

- GEOMON is a proposal for an integrated project enhancing the European monitoring capabilities. Through its coordinator CNRS-LSCE , HYMN will have direct access to its results. A cooperation agreement will be established whence both projects have been approved.

- HYMN will seek cooperation with related projects funded by the EU such as EUROHYDROS.

- HYMN plans to contribute to HyCARE, which is an open communication forum where the environmental impacts of a future hydrogen economy are discussed.

HYMN also makes use of past and ongoing modelling activities:

- UiO leads the model evaluation activity in the EU ACCENT network. The models involved in this project all take part in the model benchmarks executed in this activity, allowing an assessment of implemented model improvements and identification of potential model flaws.

- KNMI has experience in coupling different earth system model components with the model coupling system developed in the EU PRISM project, presently for instance being applied in the EU GEMS and ENSEMBLES projects. As much as possible use will be made of the existing PRISM concepts and facilities for coupling and evaluating the atmosphere and biosphere models involved in HYMN.

CNRS-LSCE is part of the IPSL consortium that also participated in PRISM. Within PRISM and other activities, IPSL has developed multiple climate analysis and diagnostic tools that are available to HYMN. CNRS-LSCE also has analysis tools available from the model intercomparisons they have organised themselves, such as AEROCOM.

5.1 Contribution to standards

In work package 4 of the project a common strategy for making consistent FTIR measurements of methane and nitrous oxide from 7 European NDSC stations is developed and implemented. This involves harmonisation of various measurement and retrieval parameters used by FTIR teams. The procedures will be documented in reports (D4.1 and D4.4) that will be made available to other groups operating FTIR worldwide. The FTIR data will be archived in a standard HDF format agreed for satellite validation purposes.

5.2 Contribution to policy developments

HYMN will contribute to the regulations, emission ceilings and policies related to the implementation of the Kyoto protocol by better quantifying the impact of anthropogenic activities on the CH_4 and N_2O budgets as well as the role of the biosphere. For the EU the targeted emission reductions for CH_4 and N_2O are substantial and amount to about 32% and 12%, respectively. For the post-Kyoto era new regulations will be required. There will be several mitigation options. Finding the optimal strategy is complex, and HYMN will provide the information that is needed for several of the trade-offs that can be made.

With respect to the emission trading system it is required to know what is the impact of reductions of one component on the concentration of other components. These interactions will be better quantified within HYMN in relation to the climate gases as well as with regard to regulated pollutant emissions, including the emissions of NO_X, CO and VOCs. In this respect HYMN will also contribute to the European policies on Air Quality.

Given the possible future change to a *hydrogen economy* HYMN will quantify how this will affect the H_2 distribution and the distribution of CH_4 and O_3 through changes in the emissions of H_2 and pollutants such as NO_X.

In accordance with one of the key objectives of the FP5 'Global Change and Ecosystems' Sub-Priority HYMN will significantly advance the state-of-the-art with respect to greenhouse gas emissions and atmospheric pollutants to improve upon the prediction and assessment of their global and regional impacts and to evaluate mitigation options.

The above policy-relevant information will be distributed to policy makers and stakeholders at the European level but also at various national levels, since some of the organisations, e.g. KNMI, also have the task to inform the national government about climate related matters and thus dispose over efficient channels to reach policymakers at his level.

5.3 Risk assessment and related communication strategy

We can foresee no risks for society or citizens as a consequence of this project. Any communication of results from the project to the media will be coordinated with the responsible EU officer.

6. Project management and exploitation/dissemination plans

6.1 Project management

Organisational structure

The organisational structure of HYMN is illustrated in figure 1:

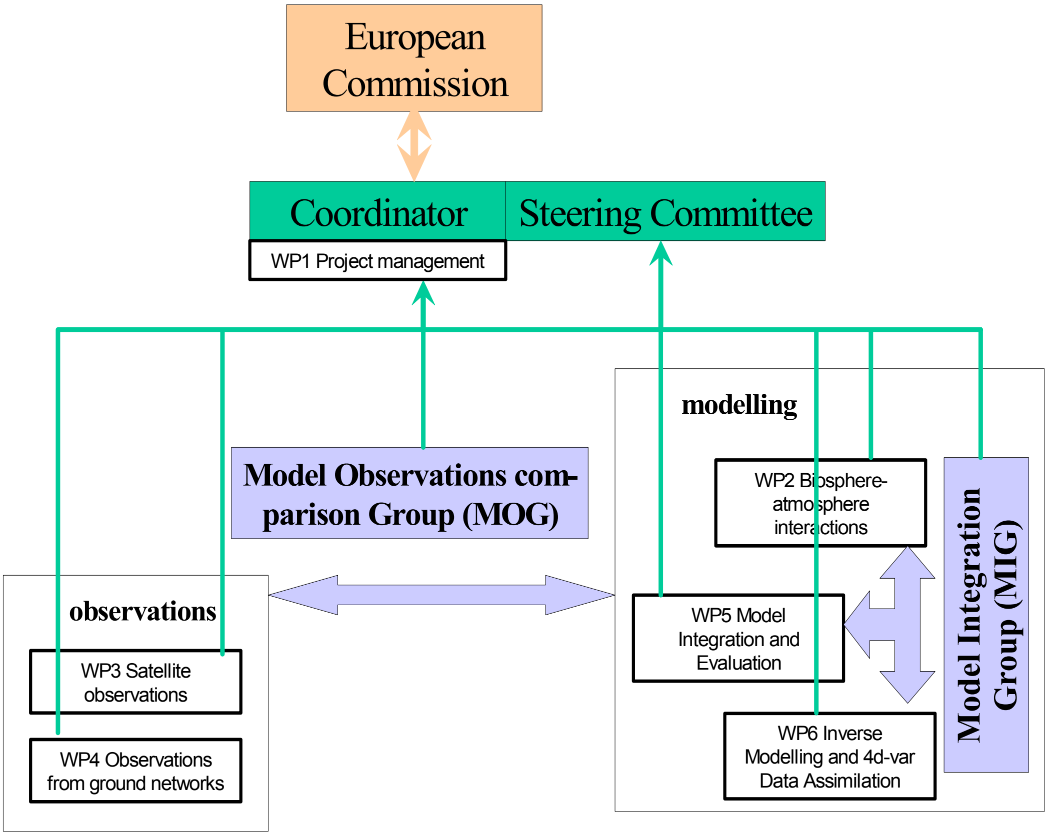

Figure 1 Organisational structure of the HYMN project

The HYMN project is broken down into 6 individual work packages (white boxes) with clearly defined tasks, one of which is the management of the project by the coordinator (WP1). Deliverables and milestones have been identified per work package. Each work package (WP) has a WP leader. The WP leader is responsible for the progress within the work package and for reporting progress and possible problems to the Coordinator and the Steering Committee (green boxes).

The Coordinator of the project will monitor the progress of work on a regular basis and ensure flow of information and (intermediate) results within the project. He will be aided by 2 cross-lateral working groups (blue boxes) that will be installed to organize the data and information flow between the work packages. A Model

Integration Group (MIG) will focus on information exchange between biosphere and atmospheric chemistry modelling groups (WP2, WP5 and WP6) and a Model-Observations comparison Group (MOG) on information exchange between the modellers and the observationalists in WP3 and WP4. Further cross-lateral working groups may be set up if such a need would arise in the course of the execution of the project.

The Coordinator will collect all reports and assemble collective project management and financial reports for the EU. This will likely include three annual reports and three more concise intermediate reports. These progress reports will be prepared according to the time schedule fixed by the EU and be ready 2 weeks in advance of meetings of the Steering Committee, so that they can be used for monitoring of the progress and the identification of problem areas by the Steering Committee and Coordinator.

Plenary Progress meetings with all consortium partners will be held twice each year, logically timed with respect to the subsequent deliverables and milestones that have been specified. The main purpose of the bi-annual meetings is the exchange of results and experience, reporting of progress, discussion of (intermediate) results and implications to the project objectives and preparation of reports. Representatives from related EU projects may be invited to the bi-annual project meetings in order to ensure potentially useful information flow between projects.

Meetings of the MIG and MOG will generally take place in conjunction with the Plenary Progress meetings and sometimes in between if needed. The members of the MIG and MOG will in most cases be the work package leaders. It is expected that most problems arising during the project can be solved by the MIG and MOG together with the Coordinator by e-mail and telephone (conferences).

The Steering Committee is also planned to convene in conjunction with the Plenary Progress meetings. All contacts of the consortium with the EU will be taken care of by the coordinator.

Decision making mechanisms

The Steering Committee (SC) consists of one representative for each participating institute. It will make decisions regarding the project on the basis of a majority of votes and will be chaired by the Coordinator.

The EU officer responsible for the project will be invited to attend the meetings of the SC himself or send another EU representative of his choice.

6.2 Plan for using and disseminating knowledge

Management of knowledge

The knowledge generated by HYMN will first be in the form of quality checked model and observational data, stored in HYMN data bases. The data will be in a standard format (mostly hdf) and will be easily accessible to the participants through web- or ftp-sites. On the project web site to be established by KNMI descriptions of the data sets will be made available with links to the data bases. KNMI will also establish a password-protected central ftp-site with full archiving facilities where most of the project data will be stored (after the project has been ended this will be opened to a wider audience). The web-services based on satellite data will at the end of the project be integrated in the ESA TEMIS website at KNMI, which will open the possibility to continue their operation after the HYMN project itself has finished. The FTIR observational data will be included in the existing international NDSC data base. The developed methodology for greenhouse gas monitoring by FTIR will be proposed as a standard for the global NDSC FTIR network.

The scientific results of the work packages will be published in peer-reviewed journals. At least one week before submission of a paper about HYMN results, the first author will send a digital copy of the manuscript to the Coordinator for inclusion on the password protected part of the HYMN website. The Coordinator will also maintain a list of publications related to HYMN. Any partner may ask for delaying the submission of a paper if he has justified arguments that his interests are harmed. In such a case, the Steering Committee will decide if and how the paper can be submitted. Each publication arising fully or in part from work under the project will contain an acknowledgement of the EC support as follows: [This workwas][(Names(s) was (were)] supported by the European Commissions Sixth Framework Programme, HYMN contract (GOCE-CT-2006-037048).

The results from the project will also be provided as input to the next (5th) assessment report of the IPCC, and any other relevant assessments on the national, European or international level.

General information about the project and its progress will be made available on the public project web-site. The Coordinator and partners will present (intermediate) results form the project in international conferences to increase the visibility of the project and to obtain useful comments from scientific experts outside the project.

Extensive exchange of knowledge amongst work packages and participants will take place during the bi-annual Plenary Progress meetings. These meetings will consist mainly of presentations and workshops. Each periodic and the final project meeting will include on the agenda a specific point on the exploitation of the project results for EU policies. The aim will be to optimise the usefulness and dissemination of present and upcoming deliverables and other results. At request, policy makers will also be supported directly regarding questions concerning the HYMN gases. The HYMN website will be constructed such that output from the project can be easily accessed.

An open conference will be organised at the end of the project. The conference will deal with both scientific and policy subjects in the field. The organising committee will consist of representatives active in science, policy making and related economic activities. Participants from these fields will be invited to attend and contribute to the open conference.

Further research and exploitation

The developed emission inversion and data assimilation products will be integrated in the ESA PROMOTE / TEMIS web service at the end of the project, which will open the possibility to continue their operation after the HYMN project itself has finished.

The developed methodology for greenhouse gas monitoring by FTIR will be proposed as a standard for the global NDSC FTIR network.

The results from the project will be contributed to European, national and international assessments such the fifth climate assessment to be made by IPCC.

The improved models will likely continue to be applied in related research and research projects in the future.

Furthermore, each periodic report and the final report will contain a specific short section suggesting how the results could be used directly by e.g. DG-ENV, the EEA or other identified potential users.

6.3 Raising public participation and awareness

When important results from the project become available (e.g. D5.2) or when major scientific publications from the project appear, media coverage will be sought by preparing press releases. These will, of course, be discussed with the responsible EU officer before actual release. A press conference may also be organised as a side event of the Open Conference at the end of the project.

The web sites of some of the institutions, such as KNMI, attract large numbers of visitors from the general public, and thus provide an alternative way to access the general public by publishing short news items about the project.

As described above, in month 12 a brochure explaining the objectives, approach and expected outcomes of the project will be produced. At the end of the project a brochure explaining the results will be made and distributed. These brochures will contain links to the project web page where further information is made available and will be distributed at meetings and by the participating institutions. They will also serve as background material for media events.

Further plans and activities to spread awareness and information will be developed as part of the project by the Coordinator.

7. Detailed Implementation Plan – for full duration of the project

7.1 Introduction – general description and milestones

The HYMN project objectives will be achieved by a combination of bottom-up and top-down modelling of sources and sinks, employing a comprehensive biosphere model, coupled to state-of-the-art atmospheric chemistry models, both evaluated using global satellite observations and time series from monitoring networks, as well as advanced inverse modelling and 4D-Var data assimilation techniques to improve on sources and sinks estimates.

The work plan consists of 6 work packages:

- WP1 Project Management
- WP2 Biosphere-Atmosphere Interactions
- WP3 Satellite Observations
- WP4 Observations from Ground Networks
- WP5 Model Integration and Evaluation
- WP6 Inverse Modelling and 4D-Var Data Assimilation

In the following the work packages (WP1-WP6) are described, showing their rationale and overall methodology to produce the deliverables and meet the verifiable objectives.

Project Management (WP1)

The management activities are combined in WP1 and include overall project management, progress monitoring and reporting, organisation of meetings, dissemination activities and external relations.

The coordinator will set up the organisational structure of the project including the Steering Committee and the cross-lateral MOG and MIG working groups (figure 1).

The project coordinator will monitor the work progress on a regular basis and ensure flow of information and (intermediate) results within the consortium. An active role of the coordinator in the MIG and MOG working groups will be very useful for this.

The Coordinator will organize regular meetings of the Steering Committee. The coordinator will collect work package reports compiled by the work package leaders and assemble them into collective project reports. These progress reports will be prepared according to a strict time schedule and be ready 2 weeks in advance of meetings of the Steering Committee, so shat they can be used for monitoring of the progress and the identification and resolution of problems by the Steering Committee and the Coordinator.

Plenary progress meetings with all consortium partners will be held twice each year, logically timed with respect to the subsequent deliverables and milestones that have been specified. The main purpose of the bi-annual meetings is the exchange of results and experience, reporting of progress, discussion of (intermediate) results and implications to the project objectives and the preparation of reports.

A project mailing list shall be set up by the coordinator. Flow of data and files will be organised through a password-protected central ftp-site at KNMI with full archiving facilities (after the project has been ended this will be opened to a wider audience). More general information about the project and its progress will be made available on a public project web-site and through a project presentation.

All contacts with the EU will be taken care of by the coordinator.

Further details about the project management can be found in chapter 6.

Biosphere-Atmosphere interactions (WP2)

A new comprehensive, climate-driven global land-biosphere model will be developed for the exchanges of key reactive trace gas species between the atmosphere and the terrestrial biosphere. The model will be built on the existing well-established dynamic global vegetation modelling framework (LPJ, Sitch et al, 2003; Thonicke et al., 2005). The extensions to this framework will include dedicated modules (which are already under active development) on wetland dynamics and permafrost and associated emissions of CH_4, as well as frequency, intensity and area burned by fires, allowing emission factors to be used to estimate sources of multiple trace gases including CH_4, CO and H_2. Other important elements that will be integrated in the land-biosphere model include the soil uptake of CH_4, the emission fluxes of NO_X and N_2O from soils, and the deposition of NO_X to vegetation. Finally, the emissions and deposition of H_2 will be embedded in the model. A modular setup will be used to allow for process-based evaluation with observations (WP3/WP4) and to interface with the ACMs (WP5/WP6).

Satellite observations (WP3)

Global CH_4 column measurements from SCIAMACHY onboard ENVISAT recently have become possible with adequate precisions to distinguish methane source regions (Frankenberg et al., 2005a,b). At the same time CO column measurements from SCIAMACHY are becoming available from 2003 onwards (Frankenberg et al, 2005c). The combination of CH_4 and CO satellite measurements will be used to better constrain the models on the methane lifetime which also depend on the CO distribution. ENVISAT operates in a near polar, sun-synchronous orbit at an altitude of 800km with a local equator crossing time of approximately 10:00 am. The instrument alternates between limb and nadir modes of measurement. In the latter mode, a swath of 960 km gives full global coverage every six days (14 orbits everyday) with ground pixel size of 30 km (along track, i.e. approx. north-south) times 60 (across track, i.e. approx. east-west). Following Frankenberg et al. [2005a,b], we only used spectra from channel 6 for the CH_4 retrievals. The data sets will be homogenised to cover the time period from January 2003 onwards.

For earlier years mainly CH_4 satellite observations from IMG are available (Clerbaux et al., 2003). Simultaneous with the SCIAMACHY observations are the CH_4 infrared observations from IASI onboard MetOp, to be launched in June 2006 (Turquety et al. 2004). After the commissioning phase (6 months), the data will be available in near-real time as IASI is on the METOP meteorological payload with operational commitments. The measurements will be performed 2 times per day, at every location on the globe, and the time period should be for 15 years from 2006 onwards as there will be 3 METOP platforms.

It will be investigated to what extent combined retrievals of CH_4 from SCIAMACHY and IASI will help to better separate the boundary layer column from the total column. Also the observations of the ground network (WP4) will be used for this purpose. More detailed information on the vertical profile of CH_4 will help to better constrain the source inversions based on satellite observations (WP6).

Observations from ground networks (WP4)

Through NDSC coordinated activities all FTIR-partners (partners 6-11) are experienced in handling data quality issues and have participated in a number of instruments and algorithm intercomparisons. They also have collaborated in the past in European projects like the successive ESMOS projects, COSE and UFTIR.

FTIR observations are needed in HYMN for satellite validation, model evaluation and emission inversions. Raw FTIR observations are available for several years, but require homogenisation with regard to retrieval and calibration before they can be used for HYMN. In the UFTIR project the retrieval strategy for several gases was partially optimised and homogenised for the European NDSC stations. In case of N_2O this has been accomplished to a large extent but for CH_4 much more work is needed to optimise and homogenise the measurements. Furthermore, HYMN will detail the error budget of the FTIR-data to allow application for satellite validation and a-priori error estimates for emission inversions. In addition to the European NDSC stations, also FTIR observations from outside Europe are needed, especially from tropical regions because of the present-day emission uncertainties in this region. The retrieval approach has to be adapted for tropical measurements.

In HYMN a consistent set of total column densities and vertical profiles of CH_4 and N_2O will be made available for the different FTIR instruments in Europe and elsewhere, covering up to more than 10 years of data. The possible addition of the earliest data of Jungfraujoch data corresponding to measurements performed in the early nineties will be evaluated after careful investigation and characterization of the retrieved products.

For the evaluation of model simulated H_2 and inversions of the H_2 sources and sinks use will be made of the CMDL surface measurements available at about 20 sites since 1989. Regular observations of European GAW stations of CH_4 and N_2O will be collected.

Model integration and evaluation (WP5)

The sources and sinks of CH_4, N_2O and H_2 are strongly affected by interactions with the biosphere. In this project two atmospheric chemistry models will be coupled with the detailed biosphere model developed in WP2. Apart from the biosphere, the atmospheric distribution of CH_4 and H_2 is in addition to emission from natural and anthropogenic sources controlled by oxidation with OH. OH varies significantly in time and space, its future trend, necessary to understand future trends in CH_4, H_2 and also O_3 is expected to vary significantly from region to region depending on changes in precursor emissions (NO_X, CO, VOCs) and on changes in climate. It is therefore essential to have good knowledge about the variation in space and time of the chemical oxidation process and how it changes with changing atmospheric conditions.

With the HYMN models we will calculate the atmospheric chemical distribution and changes due to human impact (emissions, climate change) for CH_4, H_2 and N_2O. The HYMN models all have extensive chemistry modules that take into account the chemical interactions in the ozone-methane chemistry and have sufficient spatial resolution to study regional differences (up to 1°×1° horizontal resolution).

The models will be evaluated with the observations from the ground networks (WP4) and the satellite observations (WP3). The three atmospheric-chemistry models (ACMs) applied in this study are the CTM2 and TM5 chemistry-transport models (Krol et al., 2005) and the LMDz-INCA chemistry-climate model (relaxed towards ECMWF meteorology). Three different ACMs are applied in order to assess the dependency of the results on model formulation. Taking into account sensitivity on model formulation is particularly important in case of emission inversions (WP6). Detailed investigations are undertaken on the impact of emission changes for H_2, CH_4 and N_2O and the possible interactions and feedbacks in the response. The TM5 global model will be used in zoom mode to regionalise the forward simulations.

The analysis of the model output will be done using climate diagnostic tools available at KNMI, CNRS-LSCE and UiO. KNMI (e.g. Dr. Peter Siegmund) and CNRS-LSCE (e.g. Dr. Frédéric Chevallier) have extensive expertise in the analysis of climate model simulations and tools for the detection of trends. UiO has output analysis tools available from previous EU projects such as TRADEOFF and the model intercomparisons performed in the framework of ACCENT. For the IPSL chemistry-climate model (applied by CNRS-LSCE) multiple analysis and diagnostic tools have been developed in the framework of the EU PRISM project and of the IPCC 4AR exercises. CNRS-LSCE also has analysis tools available from the model intercomparisons they have organised themselves, such as AEROCOM. These tools will be very useful for HYMN.

Top-down emission inversions and 4D-Var data assimilation (WP6)

The ACMs will be used in conjunction with satellite and ground based observations to improve the estimates in sources and sinks of atmospheric CH_4, H_2, and N_2O. Forward modelling with the new coupled model versions and systematic evaluation against satellite data (CH_4) and observations from ground networks (CH_4, N_2O, H_2) will already provide information on errors in the applied sources and sinks, as in Frankenberg et al. (2005a,b). However, in the HYMN project we will go one step further by performing regional inversions and 4D-var assimilation. The forward runs and their evaluation (WP5) are used to derive error estimates and biases in the model results that are needed for the inversions.

Inverse modelling of surface emissions and sinks by OH oxidation of CH_4 will be performed using the LMDz-INCA model as well as inverse modelling of surface emissions, atmospheric photochemical production, destruction by OH and surface uptake of H_2. These inversions will be performed on a regional basis. For TM5 use is made of the existing 4D-var assimilation scheme for CH_4 source and sink estimations

(Meirink et al., 2005), extending on the work performed over the last three years in the 5th FP project EVERGREEN (EnVisat for Environmental Regulation of GREENhouse gases, Feb 2003 – Jan 2006). For LMDz-INCA a 4D-var assimilation system for CH_4 observations will be developed. Both schemes will be applied to derive global distributions of optimized sources and sinks of CH_4 through variational assimilation of CH_4 satellite data (WP3) and observations from ground networks (WP4).

7.2 Planning and timetable

In order to allow the work in the different work packages to proceed efficiently most work packages are planned to provide preliminary or draft products in the first 18 months as shown in the Gantt chart in figure 2:

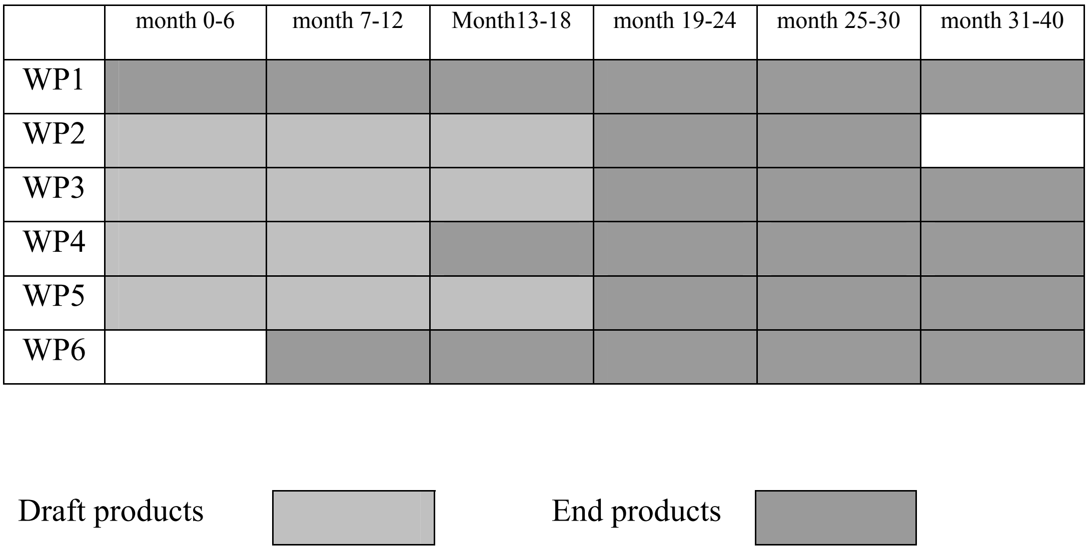

Figure 2. *Gantt chart showing the timing of the different WPs and their components*

The main critical dependencies between the work packages are the following (see also the PERT diagram in figure 3):

A. Between model development and application

Work package 2 improves a global biosphere model and interfaces it to an atmospheric chemistry transport model by month 18 (D2.3). The integrated model is then applied in work package 5 to evaluate feedbacks with the biosphere in the greenhouse gas cycles. Some of the work in work package 6 will also be done with this integrated model, although this in principle could also already be done with present model versions.

B. Between observations and modelling

Work package 4 will deliver preliminary historical observational data sets D4.2 in month 12 and improved historical data sets D4.5 in month 24.

Work package 3 will deliver preliminary satellite observational data sets D3.2, D3.3 in month 18 and final data sets D3.4 and D3.5 in month 33.

These will be used by work package 5 for model evaluation and by work package 6 for inverse modelling of sources and sinks and data assimilation.

As described above in the management work package 1 above (see figure 1), these two critical dependencies will be managed by the establishment of 2 cross-lateral working groups, A Model Integration Group (MIG), and Model Observations comparison Group (MOG) that will support the Coordinator.

The Model Integration Group (MIG) will consist of experts from participants 1, 2, 3 and 5. This group has as task to define and ensure that the biosphere and atmospheric chemistry models are coupled in an optimal way.

The Model-Observations comparison Group (MOG) will at least involve the coordinator (participant 1), a satellite observations expert (participant 4) and two experts from the FTIR network (likely participants 6 and 7). This group has as task to define the selection of data and specification of data exchange between the modelling and observations partners, and to resolve any other problems regarding information flow between modellers and observationalists.

Contingency

The work plan has been constructed in such a way that preliminary data and software modules should become available between month 12 and 18.

If the delivery of new satellite data sets (D3.2, D3.3) would suffer a delay, existing SCIAMACHY data sets from partner 4 could be used. From the FTIR network (D4.2) also some reduced data sets already exist that can be used.

7.3 Graphical representation of work packages

The organisation of the work packages and the interactions between the work packages is most clearly illustrated in the PERT diagram in figure 3. The interactions between the modelling work packages WP2, WP5 an WP6 will be coordinated by the Model Integration Group (MIG) and the interactions between Modelling (WP5 and WP6 mainly) and Observations (WP3 and WP4) will be coordinated by the Model Observations comparison Group (MOG) as illustrated in figure 1 and described in 6.1. The PERT diagram in figure 3 also shows the output flows of the HYMN project in terms of trends, assessments, knowledge on sources and sinks, and monitoring data sets.

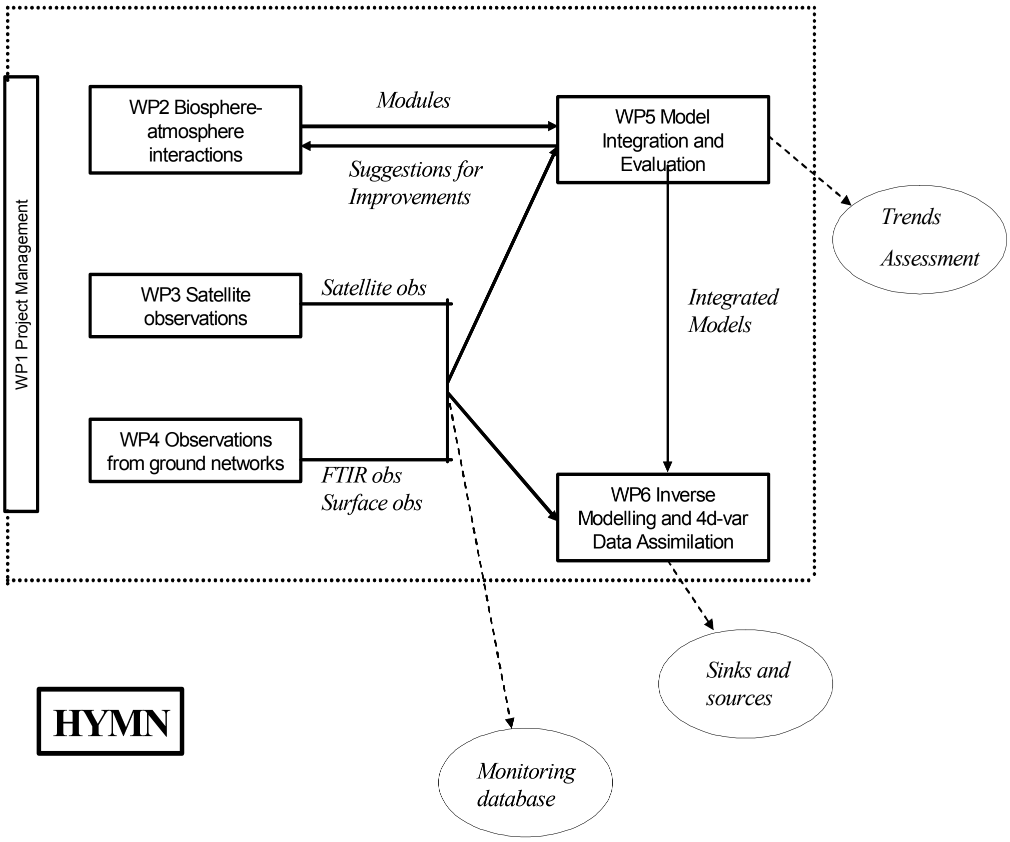

Figure 3. *Pert diagram showing the interdependencies between the work packages and the main deliverables*

7.4 Work package list

(for full duration of the project)

Work-package No	Workpackage title	Lead contractor No	Person-months	Start month	End month	Deliverable No
1	Project Management	1	3	0	40	D1.1 – D1.9
2	Biosphere-Atmosphere Interactions	2	49	0	40	D2.1 – D2.3
3	Satellite Observations	4	46	0	40	D3.1 – D3.6
4	Observations from Ground Networks	6	104	0	40	D4.1 – D4.8
5	Model Integration and Evaluation	3	77	0	40	D5.1 – D5.5
6	Inverse Modelling and 4D-Var Data Assimilation	5	62	0	40	D6.1 – D6.3
	TOTAL		341			

7.5 Deliverables list

Del. No[1]	Deliverable name	WP no.	Lead particip ant	Est. Person months	Nature [2]	Dissemi nation level [3]	Delivery date[4] (project month)
D1.1	Mailing list	1	1	0,1	O	Pu	1
D1.2	Internal website and ftp-site	1	1	0,3	O	PP	3
D1.3	External website	1	1	0.5	O	Pu	3
D1.4	Project presentation	1	1	0,1	O	Pu	4
D4.1	Report on common measurement strategy	4	6	6	R	Pu	8
D1.5	Information leaflet about project	1	1	0,3	O	Pu	12
D4.2	For all FTIR stations: preliminary historical time series of total column abundances and vertical profiles for CH_4 and N_2O (for model evaluation and satellite validation)	4	6-11	24	O	PP/Pu[4*]	12
D3.1	First report on estimates of possible statistical and systematic errors for retrievals from SCIAMACHY	3	4	6	R	Pu	15
D2.1	A structurally complete, initial version of a comprehensive, climate-driven global model for the exchanges of key reactive trace gas species between the atmosphere and the terrestrial biosphere, built on the LPJ dynamic global vegetation modelling framework ready for coupling to the atmospheric chemistry-transport model	2	2	24	P	PP	18

[1] Deliverable numbers in order of delivery dates: D1 – Dn
[2] Please indicate the nature of the deliverable using one of the following codes:
R = Report
P = Prototype
D = Demonstrator
O = Other
[3] Please indicate the dissemination level using one of the following codes:
PU = Public
PP = Restricted to other programme participants (including the Commission Services).
RE = Restricted to a group specified by the consortium (including the Commission Services).
CO = Confidential, only for members of the consortium (including the Commission Services).
[4*] All observational data sets and model output will only be open to the programme participants initially, so that the results can be published in scientific literature by them. 1 year after delivery of the data sets they will become public.
[4] Month in which the deliverables will be available. Month 0 marking the start of the project, and all delivery dates being relative to this start date.

D3.2	First set of total columns CH_4 and CO from the year 2003 onwards, retrieved from SCIAMACHY	3	4	12	O	PP/Pu[4*]	18
D3.3	First set of total CH_4 columns retrieved from IMG/IASI including error estimates	3	5	5	O	PP/Pu[4*]	18
D5.1	Output from sensitivity runs (in database)	5	1,3,5	20	O	PP/Pu[4*]	18
D4.3	Assessment report of associated retrieval error budget	4	6	4	R	Pu	20
D4.4	Report on optimized retrieval strategy	4	10	4	R	Pu	20
D4.5	For all FTIR stations: revised historical time series of total column abundances and vertical profiles for CH_4 and N_2O (for model evaluation and satellite validation)	4	6-11	37	O	PP/Pu[4*]	24
D4.6	Preliminary results on the validation of the satellite data with FTIR observations from all sites. At all sites solar absorption measurements extent back several years, hence the validation can be done for the lifetime of SCIAMACHY, IMG and first years of IASI.	4	7	10	R	Pu	24
D5.2	Report on the influence of the biosphere on trends and variability in CH_4, H_2 and N_2O	5	5	3	R	Pu	27
D5.3	Output from decadal runs (in database)	5	1,3,5	30	O	PP/Pu[4*]	27
D6.1	Report on model performances in terms of forward simulations of CH_4, H_2, and N_2O using a-priori distribution of emissions and atmospheric sinks and derived error and biases against model results and observations	6	5	20	R	Pu	27
D2.2	Report on the evaluation of the model's ability to simulate observed trace gas fluxes from observations in different regions	2	2	5	R	Pu	27
D2.3	A comprehensive, climate-driven global model fully set up to interface with the atmospheric chemistry-transport models	2	2	20	P	PP	40
D5.4	Report on variability in the trends of CH_4, H_2 and N_2O and associated feedbacks	5	3	4	R	Pu	40
D3.4	Complete final set of total columns CH_4 and CO from the year 2003 onwards, retrieved from SCIAMACHY	3	4	14	O	PP/Pu[4*]	33
D3.5	Complete set of total CH_4 columns retrieved from IMG//IASI	3	5	5	O	PP/Pu[4*]	33

D3.6	Final report on estimates of possible statistical and systematic errors for retrievals from SCIAMACHY	3	4	4	R	Pu	36
D4.7	For all FTIR stations: time series of total column abundances and vertical profiles for CH_4 and N_2O, extending to the last year of the project	4	6-11	14	O	PP/Pu[4*]	36
D4.8	Final results on the validation of the satellite data with FTIR observations from all sites	4	7	5	R	Pu	36
D5.5	Assessment report on the possible future effects on methane and ozone and on climate and pollution levels of the transformation to a hydrogen economy	5	3	20	R	Pu	40
D6.2	Report on emissions of CH_4 and H_2 over the 1980-2000 period derived from inverse modeling of available satellite and ground-based observations on a regional basis. Comparison with *a priori* emissions	6	5	22	R	Pu	36
D6.3	Report on fully optimized distributions of emissions, production, and sinks for CH_4 and H_2 obtained through 4D var data assimilation	6	1	25	R	Pu	40
D1.6	Information leaflet about project results	1	1	0,2	O	Pu	40
D1.7	Final project report	1	1	1	R	Pu	41
D1.8	Final Plan for using and disseminating knowledge	1	1	0,2	R	Pu	41
D1.9	Report on raising public participation and awareness	1	1	0,3	R	Pu	41

7.6 Work package descriptions

Work package 1 (led by KNMI, participant 1)

PROJECT MANAGEMENT

Workpackage number	1	**Start date or starting event:**	1
Activity type: Management			

Participant id	**1**	2	3	4	5	6	7	8	9	10	11	12
Person-months per participant:	3											

Objectives

- Financial management of the project
- Coordinating the work flow (project and SC meetings, reporting, monitoring progress)
- Providing internal communication tools (external and internal website, ftp-site, mailing list, etc.)
- External communication (EU, other EU projects, dissemination and consultation of external parties, open conference, project leaflets)

Description of work

The coordinator will coordinate financial reporting by the partners and take care of the distribution of funding according to the EU rules and guidelines.

The coordinator will organise regular Project meetings, where possible connected with bi-annual meetings of the Steering Committee (SC).

The coordinator will set up an internal and external project web site, as well as an ftp-site for data exchange and a mailing list including mailing addresses of all persons involved in the project.

The coordinator will coordinate the writing of bi-annual progress reports and submit all deliverables to the EU.

The coordinator will monitor the project progress, identify problems and risks, and report and resolve them as far as possible.

The coordinator will coordinate the organisation of an open science and policy workshop at the end of the project.

The coordinator will prepare updates to the Plan for using and disseminating knowledge and provide a final version of this plan at the end of the project.

The coordinator will take care of external contacts of importance to the project

The coordinator will prepare a leaflet about project goals and a leaflet with project results.

Deliverables **D1.1** Mailing list *(month 1, partner 1)* **D1.2** Internal website and ftp-site *(month 3, partner 1)* **D1.3** External website *(month 3, partner 1)* **D1.4** Project presentation (*month 4, partner 1*) **D1.5** Information leaflet about project *(month 12, partner 1)* **D1.6** Information leaflet about project results *(month 40, partner 1)* **D1.7** Final project report *(month 41, partner 1)* **D1.8** Final Plan for using and disseminating knowledge (month 41, partner 1) **D1.9** Report on raising public participation and awareness (month 41, partner 1)
Milestones and expected result **M1.1** Project mailing list *(month 1)* **M1.2** Kick-off Project and SC meetings *(month 1-2)* **M1.3** Internal and external project website and ftp-site *(month 3)* **M1.4** Project presentation ready (*month 4, partner 1*) **M1.5** SC meeting *(month 6)* **M1.6** Financial and progress report *(month 7)* **M1.7** Project and SC meeting *(month 12)* **M1.8** Information leaflet about project *(month 12)* **M1.9** Financial and progress report *(month 13)* **M1.10** SC meeting *(month 18)* **M1.11** Financial and progress report *(month 19)* **M1.12** Project and SC meeting *(month 24)* **M1.13** Financial and progress report *(month 25)* **M1.14** Project and SC meeting *(month 30)* **M1.15** Financial and progress report *(month 31)* **M1.16** Open science and policy workshop and SC meeting *(month 38)* **M1.17** Information leaflet about project results *(month 40)* **M1.18** Final financial and project report *(month 41)* **M1.19** Final Plan for using and disseminating knowledge *(month 41)* **M1.20** Report on raising public participation and awareness (*month 41*)

Work package 2 (led by UNIVBRIS, participant 2)

BIOSPHERE-ATMOSPHERE INTERACTIONS

Workpackage number	2	**Start date or starting event:**									1
Activity type: Innovation												
Participant id	1	**2**	3	4	5	6	7	8	9	10	11	12
Person-months per participant:	2	45	1		1							

Objectives

A comprehensive, climate-driven global model will be developed for the exchanges of key reactive trace gas species between the atmosphere and the terrestrial biosphere. The model will build on the well-established Lund-Potsdam-Jena (LPJ) dynamic global vegetation modelling framework with the modules added for wetland dynamics, permafrost and associated CH_4 emissions; frequency, intensity and area burned by fires, and associated emissions of CH_4, CO, H_2, and NO_X as well as new components on the aerobic soil uptake of CH_4, the emission fluxes of NO_X, H_2, and N_2O from soils and the deposition of NO_X to vegetation, and the various biospheric sources and sinks of H_2 and major NMHCs. The modules will be set up so that standard runs of the model can be compared with the observational data sets (WP3/4) and interfaced with the atmospheric chemistry-transport models (WP5/6).

Description of work

1. Complete a process-based global model of CH_4 emissions from wetlands, including representation of permafrost dynamics interacting with vegetation and soil properties, based on the LPJ modelling framework.

2. Derive CH_4, CO, NO_X and H_2 emissions from fires (natural and human-set) by applying emission factors to results of a process-based fire module coupled to LPJ

3. Derive N_2O and NO_X soil fluxes, using a semi-empirical approach with emissions tied to the rate of microbial N transformations in the soil

4. Derive H_2 fluxes associated with N-fixation and wetland biogeochemistry and plant emissions of major VOCs (isoprenes, monoterpenes), using a semi-empirical approach

5. Produce outputs from standard model runs in the form of trace gas fluxes for comparison with observations

6. Set up the global model for interfacing with the atmospheric chemistry-transport model

Deliverables

D2.1 A structurally complete, initial version of a comprehensive, climate-driven global model for the exchanges of key reactive trace gas species between the atmosphere and the terrestrial biosphere, built on the LPJ dynamic global vegetation modelling framework ready for coupling to the atmospheric chemistry-transport models *(month 18, partner 2).*

D2.2 Report on the evaluation of the model's ability to simulated observed trace gas fluxes from observations in different regions *(month 27, partner 2).*

D2.3. A comprehensive, climate-driven global model fully set up to interface with the atmospheric chemistry-transport models *(month 40, partner 2)*.
Milestones and expected result **M2.1** A structurally complete model, evaluated in a preliminary sense and ready for coupling to the atmospheric chemistry-transport models *(month 18)*. **M2.2** Final evaluation of the model's ability *(month 27)* **M2.3** Final model version *(month 40)*.

Work package 3 (led by UHEI.IUP, participant 4)

SATELLITE OBSERVATIONS

Workpackage number	3				**Start date or starting event:**						1
Activity type: Innovation											
Participant id	1	2	3	**4**	5	6	7	8	9	10	11	12
Person-months per participant:				36	10							

Objectives

- Compilation of a consistent dataset of CH_4 and CO retrievals from SCIAMACHY onboard ENVISAT from the year 2003 onwards, accompanied by a detailed error analysis of the retrievals.
- Compilation of CH_4 infrared retrievals from IMG onboard Adeos-1 and IASI onboard MetOp (when available).
- Evaluate the possibility of combined retrievals using SCIAMACHY and IASI satellite measurements of CH_4

Description of work

The retrieval of methane and carbon monoxide will be performed using the IMPA-DOAS algorithm developed at IUP Heidelberg. As to carbon monoxide, several instrumental effects have to be analysed in detail to ensure a bias-free retrieval.

The error analysis will include statistical errors due to instrumental noise and possible systematic biases due to partial cloud cover, aerosol loadings and high-frequency changes in surface and/or cloud albedo. Sophisticated radiative transfer models will be used to simulate and quantify the factors that might introduce these systematic errors.

The Infrared Atmospheric Sounding Interferometer (IASI) is a nadir-viewing remote sensor due for launch on board the European Metop satellites (METOP 1 is scheduled for June 2006). Atmospheric concentrations are retrieved at CNRS from the high resolution radiance spectra recorded in the thermal infrared spectral range, along with error budget and information content. The efficiency of the retrieval algorithm was demonstrated on the atmospheric measurements provided by the Interferometric Monitor for Greenhouse Gases (IMG)/ADEOS, allowing to obtain the first remote-sensing simultaneous distributions of ozone and its two precursors, CO and CH_4.

Deliverables

D3.1 First report on estimates of possible statistical and systematic errors for retrievals from SCIAMACHY *(month 15, partner 4)*

D3.2 First set of total columns CH_4 and CO from the year 2003 onwards, retrieved from SCIAMACHY (*month 18, partner 4).*

D3.3. First set of total CH_4 columns retrieved from IMG/IASI including error estimates *(month 18, partner 5)*

D3.4 Complete final set of total columns CH_4 and CO from the year 2003 onwards, retrieved from SCIAMACHY *(month 33, partner 4)*

D3.5 Complete set of total CH_4 columns retrieved from IMG//IASI *(month 33, partner 5)*

D3.6 Final report on estimates of possible statistical and systematic errors for retrievals from SCIAMACHY *(month 36, partner 4)*
Milestones and expected result **M3.1** Optimised the IMAP algorithm setup for the retrieval of CH_4 and CO from 2003 onwards *(month 15)* **M3.2** First consistent methane and carbon monoxide datasets from SCIAMACHY and IMG with preliminary error budget in database *(month 18)* **M3.3** Completion of the data set for recent years and full quantification of all possible error sources influencing the SCIAMACHY CH_4 and CO retrievals, including possible revisions *(month 33)* **M3.4** Final reporting on retrievals *(month 36)*

Work package 4 (led by Uni-HB, participant 6)

OBSERVATIONS FROM GROUND NETWORKS

Work package number	4			**Start date or starting event:**								1
Activity type: Innovation												
Participant id	1	2	3	4	5	**6**	7	8	9	10	11	12
Person-months per participant:						18	18	15	15	24	14	

Objectives

- To perform solar absorption measurements in the mid-infrared spectral region at the 7 European NDSC stations spanning latitudes from 28°N to 80°N, throughout the duration of the project, at a minimal frequency of about 1 meas./week provided clear sky conditions occur.
- To perform solar absorption measurements at Ile de La Réunion (France) in the tropics during a 3-months campaign.
- To optimise the retrieval of CH_4 in the mid-infrared spectral region.
- To evaluate the error budget of CH_4 and N_2O vertical profile data.
- To provide a consistent set of total column densities and vertical profiles of CH_4 and N_2O for model evaluation and satellite validation.
- To validate and calibrate the SCIAMACHY and infrared satellite measurements.

Description of work

1. The FTIR measurements at the 7 European NDSC stations will be continued at all sites for the duration of the project.

2. A three months measurement campaign will be performed at Ile de La Réunion (France)

3. Optimize the retrieval strategy for CH_4 in terms of precision and consistency among the measurement stations. Extent the optimized retrieval strategy for N_2O, developed for the European NDSC within the EU project UFTIR, to the tropical stations. Among the most important retrieval parameters are: the selection of spectral microwindow(s) and associated spectroscopic parameters, the instrument line shape function, a priori profiles and parameters and associated error covariance matrices, choice of ancillary data (p, T, a priori profiles of interfering species), fitting options, etc.

4. At all stations, the retrieval strategy developed will be applied to retrieve CH_4 and N_2O from the spectra. This includes all available time series of FTIR spectral measurements, back at least to the mid-nineties.

5. Perform a detailed error analysis.

6. Determine a common strategy to validate CH_4 total columns of SCIAMACHY as well as the infrared satellite instruments

7. Validate the satellite measurements of CH_4 total columns

Deliverables

D4.1 Report on common measurement strategy *(month 8, partner 6)*

D4.2 For all FTIR stations: preliminary historical time series of total column abundances and vertical profiles for CH_4 and N_2O (for model evaluation and satellite validation) *(month12, partners 6-11)*

D4.3 Assessment report of associated retrieval error budget *(month 20, coordinated by* *partner 6)*

D4.4. Report on optimized retrieval strategy *(month 20, coordinated by partner 10)*

D4.5 For all FTIR stations: revised historical time series of total column abundances and vertical profiles for CH_4 and N_2O (for model evaluation and satellite validation) *(month 24, partners 6-11)*

D4.6. Preliminary results on the validation of the satellite data with FTIR observations from all sites. At all sites solar absorption measurements extent back several years, hence the validation can be done for the lifetime of SCIAMACHY, IMG and first years of IASI. *(month 24, coordinated by partner 7)*

D4.7 For all FTIR stations: time series of total column abundances and vertical profiles for CH_4 and N_2O, extending to the last year of the project *(month 36, partners 6-11)*

D4.8. Final results on the validation of the satellite data with FTIR observations from all sites. *(month 36, coordinated by partner 7)*

Milestones and expected result

M4.1 A common measurement strategy will be determined and implemented *(month 3).*

M4.2 Historical time series column abundances and vertical profiles for CH_4 and N_2O in database *(month 12)*

M4.3 Optimised retrieval parameters and associated retrieval error budget determined *(month 20).*

M4.4 Revised (new retrieval) historical observations time series of total column abundances and vertical profiles for CH_4 and N_2O in database *(month 20)*

M4.5 A strategy for the validation of the satellite measurements has been determined *(month 20).*

M4.6 First full validation of available satellite measurements *(month 24)*

M4.7 Observations made during the project included in the database *(month 36)*

M4.8 Completed validation of all satellite measurements *(month 36)*

Work package 5 (led by UiO, participant 3)

MODEL INTEGRATION AND EVALUATION

Workpackage number	5	**Start date or starting event:**	1
Activity type: Innovation			

Participant id	1	2	**3**	4	5	6	7	8	9	10	11	12
Person-months per participant:	15	15	35		12							

Objectives

- Evaluation of the coupled global model results for CH_4, H_2, and N_2O by comparison satellite observations and observations from ground networks.
- Identify atmospheric loss of methane and hydrogen and the impact of changing anthropogenic and natural (climate induced) emissions on the regional OH trends and on current and future global methane and hydrogen.
- Quantify how the transfer to a future hydrogen economy affect hydrogen distribution and the distribution of methane and ozone and their impact on the environment through changes in emission of hydrogen and pollutants (NO_X, CO, VOCs).

Description of work

Three global atmospheric chemistry models are used to calculate the atmospheric chemical distribution and changes due to human impact (emissions, climate change). The models also calculate stratospheric distributions where CH_4 and H_2 are partly converted to water vapour. The model calculations will be performed by coupling to the land-biosphere modules from WP2. The observations from WP3 and WP4 will be used for model evaluation. The following modelling studies will be performed:

1. Sensitivity/model performance runs to quantify current sinks and their regional differences. Improvement of models for distribution and trend studies through the use of improved land-biosphere modules from WP2 and observational data from WP3 and WP4 for model validation. Improvement of model performance through participation in ACCENT model intercomparison and evaluation studies (models of all 3 partners).

2. Decadal runs (~10-20 year) for a better understanding of recent variability in trends of CH_4 and H_2, possibly related to interactions with the biosphere, and feedbacks due to CH_4, H_2 and N_2O trends, such as on the oxidizing capacity and the stratosphere (three models).

3. Model runs of future changes to explore the impact of future emission changes of pollutants and climate on hydrogen and methane through changes in OH oxidation. (with CTM2 only)

4. Scenario runs to quantify the effect of transformation to a H_2 economy on the CH_4 and ozone budgets and estimates of the climate impact (with CTM2 only).

The analysis of the model simulations will be done using climate analysis and diagnostic tools available at KNMI, CNRS-LSCE and UiO from various projects (e.g. TRADEOFF, ACCENT, PRISM) and from model intercomparisons (e.g. IPCC 4AR, AEROCOM). Climate analysis experts from CNRS-LSCE and KNMI will be involved.

Deliverables

D5.1 Output from sensitivity runs (in database, *month 18, partners 1, 3 and 5*)

D5.2 Report on the influence of the biosphere on trends and variability in CH_4, H_2 and N_2O

(*month 27, coordinated by partner 5)*

D5.3 Output from decadal runs (in database, *month 27, partners 1, 3 and 5)*

D5.4 Report on variability in the trends of CH_4, H_2 and N_2O and associated feedbacks (month partner *(month 40, partner 3)*

D5.5 Assessment report on the possible future effects on methane and ozone and on climate and pollution levels of the transformation to a hydrogen economy *(month 40, partner 3)*.

Milestones and expected result

M5.1 Sensitivity runs ready *(month 17)*

M5.2 Improved model tools for studies of the interaction of methane and hydrogen with atmospheric chemistry *(month 27)*.

M5.3 Decadal runs ready *(month 27)*

M5.4 Model study of CH_4-H_2-OH coupling ready *(month 28)*

M5.5 Estimated future changes in OH, methane, hydrogen and ozone under changing atmospheric conditions *(month 40)*.

M5.6 Scenario runs ready *(month 37)*

M5.7 Estimated changes in OH, methane, hydrogen and ozone and the environmental impact of such changes due to the transformation to a hydrogen economy *(month 40)*.

Work package 6 (led by CNRS-LSCE , participant 5)

INVERSE MODELLING AND 4D-VAR DATA ASSIMILATION

Work package number	6	**Start date or starting event:**	1
Activity type: Innovation			

Participant id	1	2	3	4	**5**	6	7	8	9	10	11	12
Person-months per participant:	34				23							5

Objectives

- Estimate the surface emissions of CH_4 and H_2 on a regional basis based on inverse modelling and their evolution over the period 1980-2000.
- Estimate the evolution of global and hemispheric OH in the atmosphere over the period 1980-2000 through inverse modelling.
- Derive the global optimized distributions of CH_4 and H_2 sources and sinks on a pixel by pixel basis based on 4D variational data assimilation.

Description of work

Global chemistry-transport models will be used in conjunction with satellite and ground based observations to improve the estimates in sources and sinks of atmospheric CH_4, H_2, and N_2O.

1. Global forward modelling of CH_4, N_2O, and H_2 and systematic evaluation against satellite data (CH_4) and ground based measurements (CH_4, N_2O, H_2). Derive error estimates and biases in model results.

2.1 Inverse modelling of surface emissions and sink by OH oxidation of CH_4.

2.2 Inverse modelling of surface emissions, atmospheric photochemical production, destruction by OH and surface uptake of H_2. This work will be done based on available surface measurements and satellite observations of CH_4. These inversions will be performed on a regional basis.

3. Derive global distributions of optimized sources and sinks of CH_4 and H_2 through variational assimilation of methane satellite data and surface measurements.

Deliverables

D6.1 Report on model performances in terms of forward simulations of CH_4, H_2, and N_2O using a-priori distribution of emissions and atmospheric sinks and derived error and biases against model results and observations *(month 27, coordinated by partner 5*).

D6.2 Report on emissions of CH_4 and H_2 over the 1980-2000 period derived from inverse modeling of available satellite and ground-based observations on a regional basis. Comparison with *a priori* emissions *(month 36, partner 5).*

D6.3 Report on fully optimized distributions of emissions, production, and sinks for CH_4 and H_2 obtained through 4D var data assimilation (*month 40, partner 1).*

Milestones and expected results

M6.1 Forward simulations of H_2, CH_4, and N_2O using a priori emissions and comparison with available observations *(month 12).*

M6.2 Inversion of CH_4 surface emissions and atmospheric OH over the 1980-2000 period and comparison with *a priori* emissions *(month 33).*

M6.3 Inversion of H_2 surface emission and soil uptake and photochemical production over the period 1980-2000 period *(month 33)*.

M6.4 Fully optimized distribution of sources and sinks of CH_4 and H_2 through variational data assimilation *(month 39)*

8. Project resources and budget overview

8.1 STREP Project Effort Form
(Full duration of project)

(person-months for activities in which participants are involved)

Project acronym - **HYMN**

	KNMI (1)	UNIVBRIS (2)	UiO (3)	UHEI.IUP (4)	CNRS-LSCE (5)	Uni-HB(6)	BIRA-IASB (7)	Ulg (8)	Chalmers (9)	FZK-IMK-IFU (10)	UKarl-IMK-ASF (11)	CEA-LSCE (12)	TOTAL
Research/innovation activities													
WP2	2	45	1		1								49
WP3				36	10								46
WP4						18	18	15	15	24	14		104
WP5	15	15	35		12								77
WP6	34				23							5	62
Total research/innovation	**51**	**60**	**36**	**36**	**46**	**18**	**18**	**15**	**15**	**24**	**14**	**5**	**338**
Consortium management activities													
WP1	3												3
Total consortium management	**3**												**3**
TOTAL per participant	**54**	**60**	**36**	**36**	**46**	**18**	**18**	**15**	**15**	**24**	**14**	**5**	
Overall TOTAL EFFORTS													**341**

8.2 Overall budget for the full duration of the project

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

Specific Targeted Research or Innovation Project

A3.1

Please use as many copies of form A3.1 as necessary for the number of partners

Proposal Number	037048	Proposal Acronym	HYMN

Financial information - whole duration of the project

Participant n	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (whole duration of the project)		Costs and EC contribution per type of activities: RTD or innovation related activities (1)	Demonstration activities (2)	Consortium Management activities (3)	Total (4)=(1)+(2)+(3)	Total receipts
1	KNMI	FC	Eligible costs	*Direct Costs (a)*	324.250,00	,00	25.133,00	349.383,00	,00
				of which subcontracting	,00	,00	,00	,00	
				Indirect costs (b)	318.750,00	,00	13.323,00	332.073,00	
				Total eligible costs (a)+(b)	643.000,00	,00	38.456,00	681.456,00	
			Requested EC contribution		321.500,00	,00	38.456,00	359.956,00	
3	UiO	AC	Eligible costs	*Direct Costs (a)*	191.667,00	,00	1.500,00	193.167,00	,00
				of which subcontracting	,00	,00	,00	,00	
				Indirect costs (b)	38.333,00	,00	,00	38.333,00	
				Total eligible costs (a)+(b)	230.000,00	,00	1.500,00	231.500,00	
			Requested EC contribution		230.000,00	,00	1.500,00	231.500,00	
4	UHEI.IUP	AC	Eligible costs	*Direct Costs (a)*	160.166,00	,00	2.000,00	162.166,00	,00
				of which subcontracting	,00	,00	,00	,00	
				Indirect costs (b)	32.033,00	,00	,00	32.033,00	
				Total eligible costs (a)+(b)	192.199,00	,00	2.000,00	194.199,00	
			Requested EC contribution		192.199,00	,00	2.000,00	194.199,00	
5	CNRS	FCF	Eligible costs	*Direct Costs (a)*	186.780,00	,00	,00	186.780,00	,00
				of which subcontracting	,00	,00	,00	,00	
				Indirect costs (b)	37.356,00	,00	,00	37.356,00	
				Total eligible costs (a)+(b)	224.136,00	,00	,00	224.136,00	
			Requested EC contribution		112.068,00	,00	,00	112.068,00	
7	BIRA-IASB	AC	Eligible costs	*Direct Costs (a)*	75.000,00	,00	,00	75.000,00	,00
				of which subcontracting	,00	,00	,00	,00	
				Indirect costs (b)	15.000,00	,00	,00	15.000,00	
				Total eligible costs (a)+(b)	90.000,00	,00	,00	90.000,00	
			Requested EC contribution		90.000,00	,00	,00	90.000,00	

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

Specific Targeted Research or Innovation Project

A3.1

Please use as many copies of form A3.1 as necessary for the number of partners

Proposal Number 037048 Proposal Acronym HYMN

Financial information - whole duration of the project

Participant n	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (whole duration of the project)		Costs and EC contribution per type of activities: RTD or innovation related activities (1)	Demonstration activities (2)	Consortium Management activities (3)	Total (4)=(1)+(2)+(3)	Total receipts
8	ULg	AC	Eligible costs	*Direct Costs (a)*	73.250,00	,00	3.600,00	76.850,00	,00
				of which subcontracting	,00	,00	,00	,00	
				Indirect costs (b)	14.650,00	,00	,00	14.650,00	
				Total eligible costs (a)+(b)	87.900,00	,00	3.600,00	91.500,00	
			Requested EC contribution		87.900,00	,00	3.600,00	91.500,00	
11	UniKarl	AC	Eligible costs	*Direct Costs (a)*	75.000,00	,00	,00	75.000,00	,00
				of which subcontracting	,00	,00	,00	,00	
				Indirect costs (b)	15.000,00	,00	,00	15.000,00	
				Total eligible costs (a)+(b)	90.000,00	,00	,00	90.000,00	
			Requested EC contribution		90.000,00	,00	,00	90.000,00	
10	FZK	FC	Eligible costs	*Direct Costs (a)*	86.000,00	,00	1.500,00	87.500,00	,00
				of which subcontracting	,00	,00	1.500,00	1.500,00	
				Indirect costs (b)	94.000,00	,00	,00	94.000,00	
				Total eligible costs (a)+(b)	180.000,00	,00	1.500,00	181.500,00	
			Requested EC contribution		90.000,00	,00	1.500,00	91.500,00	
9	Chalmers	AC	Eligible costs	*Direct Costs (a)*	75.000,00	,00	1.500,00	76.500,00	,00
				of which subcontracting	,00	,00	1.500,00	1.500,00	
				Indirect costs (b)	15.000,00	,00	,00	15.000,00	
				Total eligible costs (a)+(b)	90.000,00	,00	1.500,00	91.500,00	
			Requested EC contribution		90.000,00	,00	1.500,00	91.500,00	
6	Uni HB	AC	Eligible costs	*Direct Costs (a)*	75.000,00	,00	1.500,00	76.500,00	,00
				of which subcontracting	,00	,00	,00	,00	
				Indirect costs (b)	15.000,00	,00	,00	15.000,00	
				Total eligible costs (a)+(b)	90.000,00	,00	1.500,00	91.500,00	
			Requested EC contribution		90.000,00	,00	1.500,00	91.500,00	

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

Specific Targeted Research or Innovation Project

A3.1

Please use as many copies of form A3.1 as necessary for the number of partners

Proposal Number	037048	Proposal Acronym	HYMN

Financial information - whole duration of the project

Participant n	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (whole duration of the project)		Costs and EC contribution per type of activities: RTD or innovation related activities (1)	Demonstration activities (2)	Consortium Management activities (3)	Total (4)=(1)+(2)+(3)	Total receipts
2	UNIVBRIS	AC	Eligible costs	*Direct Costs (a)*	250.000,00	,00	,00	250.000,00	,00
				of which subcontracting	,00	,00	,00	,00	
				Indirect costs (b)	50.000,00	,00	,00	50.000,00	
				Total eligible costs (a)+(b)	300.000,00	,00	,00	300.000,00	
			Requested EC contribution		300.000,00	,00	,00	300.000,00	
12	CEA	FC	Eligible costs	*Direct Costs (a)*	32.342,00	,00	,00	32.342,00	,00
				of which subcontracting	,00	,00	,00	,00	
				Indirect costs (b)	26.078,00	,00	,00	26.078,00	
				Total eligible costs (a)+(b)	58.420,00	,00	,00	58.420,00	
			Requested EC contribution		29.210,00	,00	,00	29.210,00	
TOTAL			Eligible costs		**2.275.655,00**	**,00**	**50.056,00**	**2.325.711,00**	**,00**
			Requested EC contribution		**1.722.877,00**	**,00**	**50.056,00**	**1.772.933,00**	

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

Specific Targeted Research or Innovation Project

A3.2

Proposal Number	037048	Proposal Acronym	HYMN

Estimated breakdown of the EC contribution per reporting period

Reporting Periods	Start month	End month	Estimated Grant to the Budget	
			Total	In which first six months
Reporting Period 1	1	12	591.000,00	,00
Reporting Period 2	13	24	591.000,00	295.500,00
Reporting Period 3	25	36	590.933,00	295.466,00
Reporting Period 4	37	48	,00	,00
Reporting Period 5	49	60	,00	,00
Reporting Period 6	61	72	,00	,00
Reporting Period 7	73	84	,00	,00

8.3 Management level description of resources and budget

Personnel

The predominant fraction of the costs in table 1 and the A3.1 and A3.2 forms from the CPFs are for personnel The personnel resources have been estimated such that HYMN can successfully achieve its main objectives and the manpower allocation to the various partners is in alignment with the tasks attributed in the project (see also the STREP Project effort form in 8.1):

- The coordinator (KNMI, partner 1) has been attributed some more man power in order to facilitate project, data and information management.
- Relatively much man power is attributed to the University of Bristol (UNIVBRIS) to support the major task of including new biosphere processes in the biosphere model and to couple it to an atmospheric chemistry model, and evaluate this coupled model against observations.

Participant N°	1	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
Participant name	**KNMI management**	**KNMI**	**UNIV BRIS**	**UiO**	**UHEI. IUP**	**CNRS-LSCE**	**Uni-HB**	**BIRA-IASB**	**ULg**	**Chal mers**	**FZK-IMK-IFU**	**UniKarl**	**CEA-LSCE**	
Participant Role	**CO**	**CO**	**CR**	**CR**	**CR**	**CR**	**AC**	**CR**	**CR**	**CR**	**CR**	**CR**	**CR**	
Cost basis	**FC**	**FC**	**AC**	**AC**	**AC**	**FCF**	**AC**	**AC**	**AC**	**AC**	**FC**	**AC**	**FC**	
Indirect costs	13.323	318.750	50.000	38.333	32.033	37.356	15.000	15.000	14.650	15.000	94.000	15.000	26.078	**684.523**
Personnel costs	25.133	292.880	232.800	179.667	150.166	159.780	45.000	72.000	62.750	65.100	78.000	68.600	32.342	**1.464.218**
Person months	3	51	60	36	36	46	18	18	15	15	24	14	5	**341**

Table 1. *Personnel costs.*

- Relatively modest amounts for personnel costs are attributed to most of the partners from the FTIR network (participants 6-11) concerning similar activities at different measurement stations for standardisation, execution and analysis of FTIR observations. The HYMN budget for manpower requested for the European FTIR groups will be used:
  - to guarantee at least 1 meas/week at the European NDSC stations (provided clear sky conditions occur)
  - to support the data analysis, characterisation and homogenisation, and
  - to support the satellite validation.

Note that the Project management costs are 100 % re-imbursable through the coordinator, while other costs for FC and FCF partners can be maximally re-imbursed for 50% by the EU.

For comparison also the total indirect costs (excluding indirect costs of audits, but including indirect costs of personnel, traveling and consumables) for each partner are listed in table 1.

Travel costs

Each group has travel costs to the 4 planned consortium meetings and the Open Science and Policy workshop. Besides this, there are 2 additional meetings of the Steering Committee. The kick-off and final project meetings will be at a central location in Europe, likely at KNMI. The other project meetings will be in the countries of the different partners. Travel for a campaign in Reunion is funded elsewhere (national funding). These different needs as well as different geographical locations are reflected in the different travel budgets for the different partners as outlined in Table 2 below:

Partner	**Cost (Euro)**	**Justification**
1. KNMI	25.370	3 project meetings x 3 persons, 2 SC meetings, 2 visits to EU, 2 related EU project meetings, 6 conference presentations, guests to plenary meetings
2. UNIVBRIS	13.000	2.5 persons x 4 project meetings, 2 SC meetings, HYMN open workshop, conference presentations
3. UiO	12.000	~2 persons x 4 project meetings, 2 SC meetings, HYMN open workshop, conference presentations
4. UHEI.IUP	10.000	~2 persons x 4 project meetings, 2 SC meetings, HYMN open workshop, conference presentations
5. CNRS-LSCE	18.000	3 persons x 4 project meetings, 2 SC meetings, HYMN open workshop, conference presentations
6. Uni-HB	10.000	1.5 person x 4 project meetings, 2 SC meetings, HYMN open workshop, conference presentations, 2 trips to Spitsbergen for instrument maintenance
7. BIRA-IASB	2.000	1 person x 2 project meetings, 2 SC meetings, HYMN open workshop
8. ULg	10.500	1 person x 4 project meetings, 2 SC meetings, HYMN open workshop, travel to Jungfraujoch station
9. Chalmers	6.900	1 person x 4 project meetings, 2 SC meetings, HYMN open workshop, 7 site trips
10. FZK-IMK-IFU	8.000	1 person x 4 project meetings, 2 SC meetings, HYMN open workshop

11. UniKarl	6.400	1 person x 4 project meetings, 2 SC meetings, HYMN open workshop, 1 trip Kiruna, 1 trip Izana
12. CEA-LSCE		Is taken care of by participant 5 (mixed unit)
Total	**122.170**	

Table 2. *Travel costs*

Consumables costs

Some of the modeling partners have (modest) computing costs related to running their models and processing and visualizing the model output.

All the measurement groups (partner 6-11) already have a high resolution state-of-the-art FTIR instrument that is operational. Occasionally replacements of minor optical components are needed. Spectrometers also require liquid nitrogen for their operation. To be able to fully exploit the vertical profiling capabilities of ground-based FTIR measurements it is necessary to routinely measure the instrument line shape of the individual instruments. Several groups have already low pressure cell systems suitable for ILS measurements. Additional reference gases and optics are required for these measurements. The partners also dispose of the necessary computing infrastructure to carry out the data analyses. Nevertheless upgrading the computing power is required regularly, as well as the renewal/upgrading of particular scientific software licenses

Consumables			
Partner	**WP**	**Cost (Euro)**	**Justification**
1. KNMI	6	6.000	Computing
2. UNIVBRIS	2	4.200	Computing
3. UiO			
4. UHEI.IUP			
5. CNRS-LSCE	6	9.000	Computing, disks, IDL licenses
6. Uni-HB	4	11.000	Upgrade of PC computing, accessories, licenses, beamsplitter, optical and chemical equipment, mirrors for solar tracker, media for data storage and transport
7. BIRA-IASB	4	1.000	Upgrade of PC computing power
8. ULg			
9. Chalmers	4	3.000	Liquid nitrogen, computing, replacement of minor

			optics
10. FZK-IMK-IFU			
11. UniKarl			
12. CEA-LSCE			
Total		**34.200**	

Table 3. *Consumable costs*

Costs for durable equipment

The University of Bremen, Uni-HB, needs to buy a system for data storage because they presently have insufficient capacity to store the observational FTIR data they will produce in the project:

Durable equipment			
Partner	Work package	Cost (euro)	Justification
6. Uni-HB	4	9.000	Raid system for data storage

Table 4. *Durable equipment*

Audit costs

Audit costs will be made by some of the institutes, as listed in table 5 below. They can be considered as management costs and are thus 100 % reimbursable.

Partner	**Audit costs (Euro)**

1. KNMI	
2. UNIVBRIS	
3. UiO	1.500
4. UHEI.IUP	2.000
5. CNRS-LSCE	
6. Uni-HB	1.500
7. BIRA-IASB	
8. ULg	3.600
9. Chalmers	1.500
10. FZK-IMK-IFU	1.500
11. UniKarl	
12. CEA-LSCE	
Total	**11.600**

Table 5. *Audit costs*

Own contributions by AC partners

The partners that use an AC cost model will contribute significantly from their own resources to the project. Table 6 gives an overview of those estimated contributions. The given man months in table 6 are additional to the man months in table 1 (and anywhere else in the DOW).

Estimates of own contributions by AC partners					
Partner	**Man months**	**Personnel costs**	**Other costs**	**Description other costs**	**Total own contribution**
1. KNMI	N/A	N/A	N/A		N/A (FC)
2. UNIVBRIS	8	40.000	260.000	Space and facilities, and indirect costs	300.000
3. UiO	8	50.000	40.000	Computing, disk storage	90.000
4. UHEI.IUP	12	60.733	10.000	Computers for data anylysis + Storage media	70.733
5. CNRS-LSCE	N/A	N/A	N/A		N/A (FCF)
6. Uni-HB	9	54.000	5.000	Instrument maintenance and computing	59.000
7. BIRA-IASB	6	30.000	60.000	Instrument maintenance, campaign costs at Ile de La	90.000

				Reunion, and computing	
8. UL. g	8	40.000	15.000	Instrument maintenance and operation, computing, storage, backup	55.000
9. Chalmers	9	54.000	48.000	Operation of Harestua station, travel costs, computing and housing	102.000
10. FZK-IMK-IFU	N/A	N/A	N/A		N/A (FC)
11. UniKarl	6	35.000	65.000	Operation of Kiruna and Izana FTIR stations, computing	100.000
12. CEA-LSCE	N/A	N/A	N/A		N/A (FC)
Total	**66**	**363.733**	**503.000**		**866.733**

Table 6. *Estimate of own contributions by AC participants*

9. Ethical Issues

No ethical issues are associated with the subjects of the HYMN project.

10. Other issues (optional)

Gender issues

The project will promote and facilitate the participation of women in science and technology, e.g. when positions in the framework of the project are opened. Meetings will be scheduled such that unnecessary weekend travelling is avoided as much as possible. A female representative of one of the participating institutes will monitor the implementation of these objectives and progress with respect to gender issues will be part of the reporting to the EU.

Appendix A – Consortium description

A.1 The consortium and the respective roles of the participants

The consortium was constructed to cover in an efficient way the different expertise and tools required to attain the objectives of the project and thereby to answer the questions posed in the FP6-2005-Global-4 call.

The modelling includes world leading expertise in the fields of biosphere modelling (UNIVBRIS), atmospheric chemistry modelling (UiO, KNMI), and chemistry-climate modelling (IPSL) in order to construct innovative coupled biosphere-chemistry models needed for obtaining accurate estimates of sources and sinks of the HYMN gases.

The observations include the new and promising technique of monitoring greenhouse gases from space with SCIAMACHY and IMG/IASI, which will be applied and improved by UHEI.IUP, IPSL, and KNMI. UHEI.IUP and KNMI have collaborated on CH_4 satellite measurements in the past within the European project EVERGREEN. Ground based observations are needed as independent truth against which the satellite observations and model simulations can be evaluated, and vice versa. All six European partners of the FTIR network are in the project (though with modest budgets; partners 6-11) in order to ensure full homogenisation of procedures and data quality over the network. Through NDSC coordinated activities the FTIR-partners are experienced in handling data quality issues and have participated in a number of instruments and algorithm inter-comparisons. They also have collaborated in the past in European projects like the successive ESMOS projects, COSE and UFTIR.

The models and observations are combined in emission inversions and data assimilation by IPSL and KNMI in order to quantify regional sources and sinks. UiO will lead a comprehensive comparison of observations and models as well as scenario studies of the impact of a future hydrogen economy. The comparison to observations will include an analysis of trends. KNMI and IPSL have long-lasting expertise in the analysis of climate model simulations and tools for the detection of trends. UiO has output analysis tools available from previous EU projects such as TRADEOFF and the model intercomparisons performed in the framework of ACCENT.

The paragraphs below list the respective descriptions of the participants and their specific skills. Please note that participants 5 and 12 form a single mixed research unit, which is included here as two participants only for administrative reasons.

Royal Netherlands Meteorological Institute (KNMI);1
KNMI is the national meteorological service of the Netherlands. Its department of Atmospheric Composition Research has as task to investigate the changes in atmospheric composition in relation to climate change through modelling and satellite observations. KNMI is the co-PI of the SCIAMACHY instrument and PI of the OMI-instrument, and has a wide spectrum of satellite activities including operations, calibration, retrieval, chemical data assimilation and inverse emission modelling. KNMI has co-developed the global atmospheric chemistry transport model TM, which has been applied to perform chemical reanalyses, evaluate future emission scenarios and perform chemical data assimilation and emission inversions in multiple national and European projects. Version 5 of the TM model, TM5, has several levels of nested domains allowing zooming in into regions of interest such as Europe

with a resolution of 1x1 degree. KNMI has extensive experience in administrating and managing European and other research projects.
KNMI will coordinate this project (WP 1) and couple its atmospheric chemistry model TM5 to the biosphere model developed by UNIVBRIS. The resulting coupled biosphere-chemistry model will be evaluated against ground-based and satellite observations, and applied to determine the budgets and trends of CH_4 and N_2O including consequent changes in the oxidising capacity (WP5). Regional sources and sinks of CH_4 will be determined by inverse modelling of the SCIAMACHY satellite observations with TM5 (WP6).
Dr. Peter van Velthoven leads the working group of Atmospheric Composition Modelling at KNMI and directs the further development of the TM model. He has almost 15 years experience in atmospheric chemistry modelling. He has more than 70 peer-reviewed publications and has been participant in more than 10 European projects, presently in the FP5 project RETRO and FP6 QUANTIFY IP and ACCENT NE.
Dr. Michiel van Weele got his PhD in 1996 on photo-dissociation processes in the atmosphere. As a Post-Doc at KNMI since 1997 he is participating in diverse international research projects. His key expertises include global atmospheric chemistry-transport modeling with focus on CH_4 and the oxidizing capacity, radiative transfer, and satellite remote sensing of the atmospheric composition. Last years he has been involved in different ESA projects and the FP5 project EVERGREEN. He is co-author of a recent paper in Science on the interpretation of CH_4 measurements from SCIAMACHY.
Dr. Peter Siegmund has an MSc in applied physics from the Eindhoven University of Technology (1985) and a PhD in physics from Utrecht University (1994). Since 1987 he has worked as a scientist at the Royal Netherlands Meteorological Institute in the field of atmospheric and climate research. He is (co)-author of more than 35 papers in refereed journals. A major part of his current work consists of the diagnosis of atmospheric climate processes, using analyses as well as climate model simulations.
Dr. Henk Eskes joined KNMI in 1996 and is an expert in 4D-var and statistical interpolation data assimilation schemes for GOME/SCIAMACHY/OMI type of satellite observations. He has coordinated the EU project GOA (GOME assimilated and validated O_3 and NO_2 fields for scientific users and model validation) and is currently involved in the EU ASSET and GEMS projects, the ESA GSE project PROMOTE, and the OMI project. He has participated in the EU project EVERGREEN for the development of 4D-Var emission estimation and data assimilation software for CH_4 measured by SCIAMACHY.

University of Bristol (UNIVBRIS);2

The University of Bristol is continuing to make major investments in biogeochemistry and Earth System Science, building on the strengths of its Department of Earth Sciences and Schools of Geographical Sciences and Chemistry, which work together within the framework of the Bristol Biogeochemistry Research Centre on a vast range of process studies and modelling activities, including close interaction between model developers and experimental biogeochemists. Earth Sciences also houses the core team of the new Natural Environment Research Council programme QUEST (Quantifying and Understanding the Earth System). QUEST is developing a new generation of integrated models of the Earth System, incorporating biological and chemical as well as physical components. Geographical Sciences houses the BRIDGE group, which has a strong focus on modelling and understanding present and past global climates and environments. The continuing development of LPJ as a comprehensive model of biosphere dynamics and function, in partnership with co-developers at Lund University and the Potsdam Institute for Climate Change Research, is a major goal for Bristol, including a strategy for model development and evaluation which draws on a wide range of approaches and time scales. Bristol also participates in the GREENCYCLES EU research and training network which aims to contribute to the development of the next generation of Earth System models and modellers. The present work builds on a growing cross-departmental team of young scientists, including research students working on modelling the climate control of methane emissions from wetlands and dust emissions from drylands in LPJ.

Professor Colin Prentice is the original developer of LPJ, a very intensively tested and widely applied modelling framework for terrestrial biosphere dynamics, and he is the co-chair of the new IGBP project AIMES (Analysis, Integration and Modelling of the Earth System). He has been Professor of Plant Ecology at Lund University and then Director of the Max Planck Institute of Biogeochemistry, Jena, before moving back to the UK in 2003 as Professor Earth System Science at Bristol and Leader of QUEST.

Professor Paul Valdes was Professor of Earth System Science at Reading University before moving to Bristol in 2003 as Professor of Physical Geography and head of BRIDGE. He has carried out pioneering work on climate modelling and the role of changing biospheric emissions on atmospheric chemistry as shown in ice core records.

Professor Sandy Harrison, recruited to Bristol in 2003, is a member of BRIDGE and a leading expert on the reconstruction and modelling of past climates and environments as well as a prominent member of international panels dealing with land-atmosphere interactions (iLEAPS) and global terrestrial observations relating to climate (TOPC).

Dr Kirsten Thonicke is currently a Marie Curie Fellow in BRIDGE. She has pioneered global fire dynamics and trace gas emissions modelling in the LPJ framework.

University of Oslo (UiO);3

The Department of Geosciences at the University of Oslo has long experience in studies related to atmospheric pollution, ozone depletion and climate processes. The studies are performed by the atmospheric chemistry group led by professor Ivar S.A. Isaksen, and consists of 12 scientists (researchers, PhD students, and post docs.). The focus is on modelling of distributions and long-term changes in pollutants and chemically active greenhouse components and their forcing due to human activity. Studies of the atmospheric impact of aircraft emissions and the impact of ship emissions on chemical composition and on climate forcing have been performed. In particular, the modelling includes interactive studies of particles and gaseous compounds (involving sulphate, mineral dust, nitrates, organics and sea salt), climate-chemistry interactions (involving particles, and ozone/methane chemistry). The group is participating in several EU environmental projects on atmospheric chemistry and climate studies, and has participated actively in international assessments on climate and ozone (IPCC climate assessments, WMO/UNEP ozone assessment, IPCC and EU assessments on atmospheric aircraft emissions), and have close collaboration with research groups in the US, Europe and in China. UIO will apply their CTM2 model to investigate the coupling between the HYMN gases and the related changes in atmospheric OH and evaluate it against the satellite and ground-based observations.

Professor Ivar S.A. Isaksen is professor in Meteorology at the University of Oslo. He has 30 years of experience in research and teaching in atmospheric sciences, and has supervised 16 PhD students during the last 10 years. He has published more than 120 peer reviewed papers, and presented more than 50 invited papers and lectures at international meetings and conferences during the last 5 years. He has coordinated several EU projects and been lead author of IPCC climate and WMO/UNEP ozone assessments. He is president of the International Ozone Commision (IOC). He has obtained the National Oceanographic and Administration (NOAA) Award for outstanding scientific achievement, and the Norwegian Ministry of Environment award for Environmental Research. Research emphasis is on modeling of ozone depletion and changes in greenhouse gases, and on the impact of man made emissions of pollutants on regional and global scales.

Stig Dalsoren will take his PhD degree during spring of 2006, and will continue as a post doc at the Department of Geosciences, University of Oslo. He has studied tropospheric chemical changes from man made emissions, with particular emphasis on modelling the large scale effects of man made emissions on tropospheric OH distribution and methane lifetime. He has also modelled the impact of ship emissions on atmospheric chemical composition. He will participate in the project with preparation of emission date and in the modelling of changes in chemical oxidation and in distribution due to changing emissions.

University of Heidelberg (UHEI.IUP);4

IUP is the Institute of Environmental physics at the University of Heidelberg in Germany. The "Atmosphere and remote sensing" department deals mainly with the chemical composition of the Earth's atmosphere. Key expertise is in differential optical absorption spectroscopy (DOAS) in general, including instrument design, algorithm development and application of the DOAS technique using instruments on various platforms (ground based, airborne, multi-axis, tomographic approaches, satellite based). The satelliteborne remote sensing of the Earth's atmosphere at the University of Heidelberg started in 1996 with the retrieval of atmospheric trace gases, namely NO_2 and BrO. Today, a wide variety of trace gases, aerosols, and cloud parameters from different satellite instruments are investigated at the IUP (http://satellite.iup.uni-heidelberg.de). As regard to HYMN, there is a renowned and long-term expertise in satellite based retrievals from GOME and SCIAMACHY. In addition to key target species in the UV/Vis spectral regions, retrievals of CO, CH_4 and CO_2 are now feasible using the near-infrared channels featured by SCIAMACHY. A modified DOAS algorithm for an optimized retrieval of trace gases in the near infrared spectral region has been developed at IUP and led to the discovery of underestimated tropical methane sources. IUP has extensive experience with national and European research projects such as ACCENT, SCIAMACHY validation, NOXTRAM, STAR, FORMAT or EVERGREEN.

Prof. Dr. U. Platt leads the Atmosphere and Remote Sensing group at IUP. He established the DOAS method and is internationally renowned as expert in the field of atmospheric chemistry.

Dr. Christian Frankenberg is working at IUP since 2002 and established a modified DOAS algorithm for trace gas retrievals in the near infrared. He is involved in the EVERGREEN and ACCENT project and lead author of a recent paper in Science about first precise global methane measurements from SCIAMACHY.

Dr. Thomas Wagner leads the satellite (sub)group at IUP and has long-term and renowned experience with trace gas retrievals from GOME and SCIAMACHY (lead author of a Nature article about BrO measurements from GOME).

CNRS-LSCE ;5

CNRS-LSCE (Laboratoire des Sciences du Climat et de l'Environnement) is a joint research unit from Centre National de la Recherche Scientifique (CNRS) and Commissariat à l'Energie Atomique (CEA, **see participant 12**), two major research agencies in France. The LSCE is also part of IPSL, l'Institut Pierre Simon Laplace, a federative institute based in Paris, France. The Institute is composed of 6 laboratories working on global environmental and climate studies. LSCE employs currently 150 people, in the fields of biogeochemical cycles modelling and observation, past and future climate studies and isotopic markers in the environment. The BiogeoCycles research department at LSCE is active in the areas of atmospheric composition monitoring, development of process-based models of carbon cycling over terrestrial ecosystems and in the ocean, and development of inverse methods to quantify carbon sources and sinks from atmospheric observations. The LSCE has developed an expertise over the last 10 years on the study of biogeochemical cycles and climate studies.

Frédéric Chevallier (Dr), was appointed permanent research scientist at LSCE in December 2003, after a PhD at Laboratoire de Météorologie Dynamique (LMD, Palaiseau, France) and a six-year stay at the European Centre for Medium-Range Weather Forecasts (ECMWF, Reading, UK). His work initially focused on the modeling of atmospheric radiation, then broadened towards climate studies (radiation and clouds) and shifted towards data assimilation. In particular he initiated the assimilation of cloud-affected and rain-affected satellite radiances at ECMWF and developed a 4D-Var system at LSCE. He also built and analysed a global cloud climatology based on 30 years of satellite measurements. He is a co-investigator in three EU-funded projects about the carbon cycle (CARBOEUROPE, GEOLAND and GEMS of FP6).

D. Hauglustaine (Chargé de recherche au CNRS) has 15 years research experience in atmospheric sciences. He graduated from the University of Liège (Belgium) in 1987 and got his PhD in Physics in 1992. He entered CNRS in 1993 and spent 4 years as a post-doctoral fellow at the National Center for Atmospheric Research (NCAR), Boulder, CO (1994-1998).

He has developed 1-D, 2-D, and 3-D atmospheric models and has been involved in the simulation of the distribution and budget of tropospheric ozone and its precursors on various geographical and time scales. He has been involved in the simulation of the evolution of atmospheric composition under anthropogenic activities and calculation of ozone radiative forcing on the climate system. D. Hauglustaine has been involved in the development of the chemical-transport-model MOZART widely used in the scientific community and is currently leading the development of an interactive chemistry model (INCA) coupled to a general circulation model (LMDz) in order to investigate in more details the coupling between atmospheric chemistry, aerosols and climate. D. Hauglustaine has published a first global modelling study H_2 budget in the troposphere. He is co-I of several EU projects dealing with climate-chemistry interactions or the impact of aircraft on atmospheric composition. D. Hauglustaine has also participated to the several WG1 IPCC reports has a lead authors.

Dr. Philippe Bousquet got his phD in inversion of CO_2 measurements to infer surface fluxes in 1997. He joined LSCE/IPSL and university of Versailles as an assitant professor in 1998. He is now part of the assimilation team of LSCE/IPSL. His research focuses on estimates of greenhouse gases sources and sinks using inverse modelling of atmospheric transport and chemistry. He more precisely worked on estimation of sources and sinks of CO_2, CH_3CCl_3 and recently of CH_4 and H_2. He has strong links with other European institutes (MPI-Iena-Germany, ECN-Netherlands) and international institutes (NOAA-CMDL, CSIRO-Australia) and developed an expertise on assimilating greenhouse gas measurements that suits HYMN project.

Dr. Cathy Clerbaux obtained her PhD in Physics in 1993 from the Université Libre de Bruxelles. She moved to Service d'Aéronomie in Paris where she became a CNRS research scientist in 1995. She is currently involved in the study of atmospheric constituents using measurements provided by infrared remote sensors, which includes development of trace gases retrieval algorithms, validation, and analysis of the observations using chemistry-transport atmospheric models and data assimilation tools. She has been involved in the analysis of satellite data for several missions, including MOPITT/TERRA, IMG/ADEOS and ACE. As a member (PI) of the IASI Sounding Science Working Group (ISSWG), she is in charge of the development of the operational retrieval algorithm for the trace gases inversion from the IASI data. She is also a remote sensing expert for Eumetsat and contributes to the definition of the Meteosat Third Generation satellite.

University of Bremen (Uni-HB);6

The Institute of Environmental Physics (IUP) at the University of Bremen (Uni-HB) focuses of on the investigation of the atmosphere, the cryosphere, and the oceans of the earth. More than 100 scientists are working at the IUP. Remote sensing of the atmosphere from ground- and space-based platforms is one of the fields of expertise of the institute. Relevant to HYMN are the solar and lunar absorption measurements by FTIR-spectrometry which are performed at the NDSC-sites in NyAlesund (Spitsbergen), Bremen (Germany) and on board the research vessel Polarstern as well as during several campaigns e.g. in Paramaribo (Suriname). The instruments at NyAlesund, on Polarstern and the campaign instrument are operated in cooperation with the Alfred Wegener Institute for Polar and Marine Research (AWI) in Bremerhaven. In HYMN, Uni-HB will contribute to the delivery and characterization of vertical profile and total column data of N_2O and CH_4, from FTIR observations performed at Ny-Ålesund (Spitsbergen), Bremen (Germany), Paramaribo (Suriname) and during ship cruises on the Atlantic. The measurements at Ny-Ålesund and Bremen will be continued for the duration of the project.

Prof. Dr. Justus Notholt graduated in Solid State Physics at the University of Kassel in 1985 and received his PhD degree in Physical Chemistry at the same University in 1989. During a two years stay as postdoctoral fellow at the Joint Research Centre of the EC, Environment Institute, Ispra (Italy), he initialised DOAS observations applied to trace gas and aerosol measurements in the free atmosphere and to laboratory investigations. Since September 1990, he has been associated with the Alfred-Wegener-Institute for Polar and Marine Research. He began atmospheric trace gas measurements by FTIR-spectrometry at the NDSC station Ny-

Ålesund in February 1992 and developed measurement and analysis techniques for IR observations during the polar night. In 1994 he started the IR observations during ship cruises and in 2000 he performed a measurement campaign in Antarctica. In April 2002 he obtained a professorship at the university of Bremen. The FTIR-activities in the high Arctic, during the ship cruises and in the tropics are conducted in close cooperation with AWI. In addition to the FTIR-activities he is responsible for the trace gases observations at several stations by the Microwave radiometers.

Dr. Thorsten Warneke graduated in physics from the University of Heidelberg in 1998 and received his PhD degree in terrestrial environmental physics at the Southampton Oceanography Centre in 2002. Since August 2002 he is doing postdoctoral research at the Institute of Environmental Physics of the University of Bremen. He has participated in diverse national and international research projects involving FTIR spectroscopy. Currently he focusses on solar absorption measurements in the tropics.

Belgian Institute for Space Aeronomy (BIRA-IASB);7

The Belgian Institute for Space Aeronomy (BIRA-IASB) has a strong expertise in atmospheric physics and chemistry research, including UV-VIS DOAS and FTIR remote-sensing observations from space and ground (algorithm developments, data retrieval and analysis), as well as tropospheric and stratospheric modelling, including inverse source modelling and 4D var data assimilation. It also performs laboratory spectroscopy experiments for atmospheric applications. It has a strong involvement in the satellite experiments GOME, ENVISAT, and ACE as well as in OMI, GOME-2 and IASI. BIRA-IASB has been involved in many EU projects, often as coordinator, e.g., the past ESMOS and COSE projects and the current UFTIR project. At present, it is partner in the EU projects Evergreen, STAR, SCOUT-O3 and GEMS, and in the ESA GSE project PROMOTE. BIRA-IASB plays an important role in the NDSC, being co-chair of the infrared, UV-Vis and satellite working groups (WG).

In HYMN, BIRA-IASB will contribute to the delivery and characterization (incl. evaluation of error budgets) of vertical profile and total column data of N_2O and CH_4, from campaign observations at Ile de La Réunion in 2002, 2004 and during a campaign to be performed in the course of the project. If planning is kept nominal, the FTIR measurements at Ile de La Réunion will become continuous (and automatic) in 2008. BIRA-IASB will coordinate the validation of the satellite data for CH_4 using the FTIR data available in HYMN. Key personnel involved:

Dr. Martine De Mazière, Dr. Sciences (Physics), Head of Section at BIRA-IASB since 1994. Special expertise in atmospheric remote-sensing with FTIR spectrometry (operations, algorithm development, data retrieval and analysis). Responsible for the FTIR observations at Ile de La Reunion and for the development of a system for automatic operation of the FTIR instrument, in collaboration with Dr. E. Neefs (engineer). Collaboration with ULg for the FTIR observations at the Jungfraujoch. Coordinator of the EU projects COSE and UFTIR and of several national projects for atmospheric chemistry research; co-chair of the NDSC IRWG (2006). Involved with satellite validation using ground-based FTIR data, for ACE, SCIAMACHY, MIPAS and IASI (future) through projects funded by ESA, EU (Evergreen) and Belgian Science Policy. M. De Mazière is (co-)author of many scientific papers, and of the recent EU reports GMES-GATO and AIRES III.

Dr. Corinne Vigouroux obtained her PhD in Physics in 2002 from the Université Catholique de Louvain (UCL). She has expertise in retrieval of ground-based FTIR data and their use for satellite validation. She is currently working on the projects UFTIR and STAR.

Dr. Bart Dils obtained his PhD in Physical Chemistry in 2003 at the University of Leuven (KUL). He has expertise in the interpretation of FTIR ground-based data and their use for satellite validation. He is currently working on the project Evergreen.

University of Liege (UL);8

The GIRPAS group (Groupe Infra-Rouge de Physique Atmosphérique et Solaire) of the University of Liège (ULg) has been involved in atmospheric research activities since the mid-1970s, using state-of-the-art instrumentation to monitor the Earth atmosphere from the ground

and from stratospheric balloon- and space-based platforms. In particular and within this framework, the group has built, installed and operated on a regular basis high-resolution infrared instruments at the Jungfraujoch station. This has resulted in gaining instrumentation expertise and in the gathering of a unique observational database presently spanning three decades. In 1989, the GIRPAS became affiliated to the NDSC network. Since then, two FTIRs have been operated intensively at the Jungfraujoch to record solar absorption spectra under clear sky conditions, with on average 110 days of observations per year. Consistent spectrometric analysis of these observations with NDSC-recommended algorithms has allowed to monitor about two-dozen atmospheric species of key relevance to the Montreal and/or the Kyoto Protocols. The group has also regularly supported atmosphere-dedicated European campaigns (EASOE, SESAME, and THESEO); it has also contributed to the data validation of numerous space missions (ATMOS, HALOE, CLAES, MAPS, CRISTA), it is currently involved in the ENVISAT, ACE and MOPITT validations and is prepared to do so for ACE, AURA and IASI. These various and complementary activities have essentially been carried out within the frame of national and EU projects (the GIRPAS has been active partner of four EU projects over the last five years). Within the specific frame of HYMN, ULg will participate to the definition of optimum retrieval strategies for CH_4 and N_2O, assess their error budgets, perform the retrievals of both species from the Jungfraujoch observations and further validate satellite measurements of CH_4 total columns. All these activities are part of WP4.
Philippe Demoulin, member of the group since 1978, has been responsible for various improvements brought to the "home-made" FTIR instrument, for the implementation of the related software and for its regular operation since the mid-1980. He participates to observational missions and contributes to the analysis and interpretation of the Jungfraujoch data. He has been involved in several research projects at the national and European levels.
Pierre Duchatelet is a physicist who joined the GIRPAS group at the end of 2000. He is deeply involved in data analysis with the SFIT-2 algorithm of species of relevance to the HYMN project. He also participates to observational missions at the Jungfraujoch.
Dr Emmanuel Mahieu has been with GIRPAS since 1991. His expertise is in IR remote sensing data analysis of space- and ground-based high-resolution observations. He is further involved in data interpretation and validation, in algorithm intercomparisons and in the archiving of the geophysical databases derived from the Jungfraujoch observations. He has been involved in several EU and national research projects since 1992. Together with Philippe Demoulin, he is the PI of the Jungfraujoch NDSC-affiliated FTIRs.
Dr Christian Servais has been working in the field of High Resolution Fourier Transform Spectroscopy and Jungfraujoch IR observations since 1982. He is specialized in programmable electronics and instrumental developments. He has designed or installed a large part of the equipments now used by the GIRPAS at the Jungfraujoch (suntracker, hydraulics, computer network, telescope control,…) and is now involved in the installation of an improved and remotely controlled acquisition system for the Bruker FTIR interferometer. He is the leader of the Laboratory of Atmospheric and Solar Physics, the observational resource of the GIRPAS at the Jungfraujoch.

Chalmers University of Technology (ChUT);9
Chalmers University of Technology is one of the leading Technical Universities in Sweden, located in Gothenburg on the west coast of southern Sweden. The optical remote sensing group at the Radio and Space department has more than 20 years experience in optical remote sensing of the atmosphere. In 1994, a site for ground-based high resolution solar FTIR spectroscopy was established at 60^{o}N 11^{o}E at Harestua in Southern Norway. In 1996 the activity was approved as a complimentary FTIR site within NDSC (Network for the Detection of Stratospheric Change).
The group has participated in several EU projects (SESAME, COSE and UFTIR) and measurement campaigns: SESAME, ESMOS-Arctic and THESEO/SOLVE. In addition has the group contributed to the validation of the satellite instruments CRISTA II, SCHIMACHY, MIPAS and MOPITT. The measurements at the Harestua site were originally focused on winter/spring stratospheric chemistry related to vortex and vortex edge phenomena but more

recently there has been considerable focus on measurements of tropospheric species such as CO, ethane and N_2O in the EU project UFTIR. The work has involved development and assessment of algorithms for retrieval of vertical concentration profiles from high resolution FTIR spectra. The role of Chalmers in the project will be to work with the following: measurements, measurement strategy, retrieval strategy for CH_4, error budget, satellite validation and homogenization of column and profile data.
The key personnel involved will be:
Dr. Johan Mellqvist received a MS.c. in Engineering Physic 1990 a Licenciate of Engineering in 1995, and a PhD in experimental physics in Feb 1999, all at the Chalmers University of Technology. He is presently an associate professor at the Radio and Space department at the Chalmers University of Technology, responsible for developing and applying remote sensing measurements for flux and atmospheric composition measurements. Between 1990 and 1999 he was employed by the Swedish Environmental Research Institute in Göteborg as a research scientist in applied spectroscopy and remote sensing techniques. Such techniques involve DOAS (Differential optical Absorption Spectroscopy) and FTIR (Fourier Transform InfraRed) applied for remote sensing of atmospheric pollutants both in the troposphere and stratosphere. He is PI for the NDSC measurements at a Norwegian site and has more than 10 years of experience with high resolution FTIR for atmospheric composition measurements.
Dr. Bo Galle received a MS.c in Engineering Physics in 1976 and a PhD in Environmental Science in 1999, both at Chalmers University of Technology in Gothenburg and is associate professor and group leader of the ORS group. During 1979 – 1999 he was employed at Swedish Environmental Research Institute as research scientist responsible for applied spectroscopy and remote sensing techniques. This work comprised development and application of various optical techniques; LIDAR, correlation spectroscopy, DOAS and Long Path FTIR.

Institut für Meteorologie und Klimaforschung, Atmospheric Environmental Research (IMK-IFU);10
FZK/IMK-IFU located at Garmisch-Partenkirchen, Germany is a partial institute of Forschungszentrum Karlsruhe, which again is part of the Germany Helmholtz Society of Research Centers. About 60 employees and about 20 PhD-students are working at the Garmisch institute which is studying the impact of man's activities on the chemical composition of the atmosphere and determining the subsequent consequences of a changing atmosphere on the environment. Major activities are studying the atmosphere-biosphere exchanges and the chemistry of the troposphere, determining the distribution of trace constituents in the troposphere and stratosphere, modeling the transport processes as well as developing measurement techniques for special research tasks. The institute's activities in remote sensing are covering FTIR solar absorption spectrometry, lidars for aerosol, O_3, and H_2O, and UV spectro-radiometry; three of the systems (FTIR, aerosol lidar, and UV-B) are part of the NDSC Primary Alpine Station. Based upon this remote-sounding instrumentation a focus of the institute´s current research program is the built up and operation of a Permanent Ground-Truthing Facility at Zugspitze, Garmisch, Germany. Experience in satellite validation covers a variety of activities related, e.g. to MAPS, SAGE, EOS-Aqua/AIRS, EOS-Aura, ENVISAT, EPS.
In HYMN, FZK/IMK-IFU will deliver and characterize vertical profiles and total columns of N_2O and CH_4 from the continuous FTIR measurements at Zugspitze/Garmisch, which started in 1995 in a fully operational mode with approximately 2 measurement days per week on average since then. FZK/IMK-IFU will put its focus on optimizing the FTIR retrieval strategy for N_2O and CH_4 and on performing problem oriented validation studies for the satellite measurements of CH_4. The key personnel involved will be:
Dr. Ralf Sussmann is head of the FTIR NDSC Primary Station at the mountain Zugspitze, Germany and working group leader for Sounding of the Atmosphere at FZK/IMK-IFU. He obtained his PhD in laboratory spectroscopy in 1994 and built up the FTIR observatory at the Zugspitze summit in 1995 as well as the Garmisch FTIR observatory in 2003. His research

experience includes lidar remote sensing of contrails, and he is first author of more than 20 peer reviewed papers in spectroscopy and atmospheric sciences journals. He has contributed to a number of national and international research and satellite validation projects and campaigns. Recently, he has been PI of a German project for SCIAMACHY validation by FTIR, and he currently is PI of a EUMETSAT project on EPS/MetOp validation. He is first author of three 2005 ACP papers on ENVISAT validation by FTIR for the species CO, CH_4, and NO_2.
Dipl.-Phys. W. Stremme and **Dipl.-Inf. T. Borsdorff** will contribute to this project with their expertise obtained during their ongoing PhD theses dealing with the optimized retrieval from the Zugspitze long-time measurement series of N_2O, CH_4, and CO.

Institut für Meteorologie und Klimaforschung, Karlsruhe (Univ K-IMK);11

The stratospheric ozone depletion, especially in the middle and high latitudes of the northern hemisphere, is one of the main research areas of the IMK. Moreover, exchange processes between the stratosphere and troposphere as well as the distribution of tropospheric and stratospheric trace constituents are investigated. All these atmospheric processes are studied by means of extended field measurement campaigns and by numerical modelling of the middle atmosphere. Several Fourier Transform infrared (FTIR) spectrometers of the MIPAS type have been developed and successfully employed during national and international campaigns. IMK has strongly been involved in the design and the data analysis of the space-borne MIPAS instrument aboard ENVISAT.
Within the framework of the NDSC (Network for Detection of Stratospheric Change) ground-based FTIR measurements are performed at Kiruna (Sweden, since 1996) and at Izaña, Tenerife Island (since 1999). At the IMK radiative transfer models and least squares fit retrieval techniques have been developed and applied since many years. In particular, the retrieval software PROFFIT (PROFile FIT) to derive profiles from ground-based spectra has been developed at the IMK. The accurate knowledge of the instrumental line shape (ILS) is essential for a good profile retrieval. Therefore, the ILS is determined routinely by low pressure gas cell measurements analyzed with the LINEFIT software. The LINEFIT software has been developed at the IMK, and the NDSC-FTIR community has been provided with this software. Key personnel:
Dr. Thomas Blumenstock is leader of the group ‘groundbased FTIR measurements’. He has more than 15 years of experience in ground-based FTIR spectroscopy, in operating high-resolution FTIR instruments as well as in retrieving atmospheric parameters and their interpretation. He has participated in several international campaigns like CHEOPS-III, EASOE, ESMOS, SESAME, THESEO-2000, VINTERSOL, ENVISAT and ILAS validation experiments. He is PI of an ENVISAT-AO validation project.
Dr. Frank Hase, has investigated and improved the instrumental line shape of the instruments. He developed the software for LINEFIT and for profile retrieval (PROFFIT) from ground-based FTIR measurements. He is an expert in applied spectroscopy and profile retrieval theory.
Dr. Matthias Schneider is in charge of the FTIR measurements at Izaña Observatory. He is performing FTIR measurements and analyzing spectra. He has several years of experience in operating optical instruments and analyzing spectra.

CEA-LSCE;12

CEA-LSCE (Laboratoire des Sciences du Climat et de l’Environnement) is a joint research unit from Centre National de la Recherche Scientifique (CNRS, **see participant 5**) and Commissariat à l’Energie Atomique (CEA), two major research agencies in France. The LSCE is also part of IPSL, l’Institut Pierre Simon Laplace, a federative institute based in

Paris, France. The Institute is composed of 6 laboratories working on global environmental and climate studies. LSCE employs currently 150 people, in the fields of biogeochemical cycles modelling and observation, past and future climate studies and isotopic markers in the environment. The BiogeoCycles research department at LSCE is active in the areas of atmospheric composition monitoring, development of process-based models of carbon cycling over terrestrial ecosystems and in the ocean, and development of inverse methods to quantify carbon sources and sinks from atmospheric observations. The LSCE has developed an expertise over the last 10 years on the study of biogeochemical cycles and climate studies.

Frédéric Chevallier (Dr), was appointed permanent research scientist at LSCE in December 2003, after a PhD at Laboratoire de Météorologie Dynamique (LMD, Palaiseau, France) and a six-year stay at the European Centre for Medium-Range Weather Forecasts (ECMWF, Reading, UK). His work initially focused on the modeling of atmospheric radiation, then broadened towards climate studies (radiation and clouds) and shifted towards data assimilation. In particular he initiated the assimilation of cloud-affected and rain-affected satellite radiances at ECMWF and developed a 4D-Var system at LSCE. He also built and analysed a global cloud climatology based on 30 years of satellite measurements. He is a co-investigator in three EU-funded projects about the carbon cycle (CARBOEUROPE, GEOLAND and GEMS of FP6).

D. Hauglustaine (Chargé de recherche au CNRS) has 15 years research experience in atmospheric sciences. He graduated from the University of Liège (Belgium) in 1987 and got his PhD in Physics in 1992. He entered CNRS in 1993 and spent 4 years as a post-doctoral fellow at the National Center for Atmospheric Research (NCAR), Boulder, CO (1994-1998). He has developed 1-D, 2-D, and 3-D atmospheric models and has been involved in the simulation of the distribution and budget of tropospheric ozone and its precursors on various geographical and time scales. He has been involved in the simulation of the evolution of atmospheric composition under anthropogenic activities and calculation of ozone radiative forcing on the climate system. D. Hauglustaine has been involved in the development of the chemical-transport-model MOZART widely used in the scientific community and is currently leading the development of an interactive chemistry model (INCA) coupled to a general circulation model (LMDz) in order to investigate in more details the coupling between atmospheric chemistry, aerosols and climate. D. Hauglustaine has published a first global modelling study H_2 budget in the troposphere. He is co-I of several EU projects dealing with climate-chemistry interactions or the impact of aircraft on atmospheric composition. D. Hauglustaine has also participated to the several WG1 IPCC reports has a lead authors.

Dr. Philippe Bousquet got his phD in inversion of CO_2 measurements to infer surface fluxes in 1997. He joined LSCE/IPSL and university of Versailles as an assitant professor in 1998. He is now part of the assimilation team of LSCE/IPSL. His research focuses on estimates of greenhouse gases sources and sinks using inverse modelling of atmospheric transport and chemistry. He more precisely worked on estimation of sources and sinks of CO_2, CH_3CCl_3 and recently of CH_4 and H_2. He has strong links with other European institutes (MPI-Iena-Germany, ECN-Netherlands) and international institutes (NOAA-CMDL, CSIRO-Australia) and developed an expertise on assimilating greenhouse gas measurements that suits HYMN project.

Dr. Cathy Clerbaux obtained her PhD in Physics in 1993 from the Université Libre de Bruxelles. She moved to Service d'Aéronomie in Paris where she became a CNRS research scientist in 1995. She is currently involved in the study of atmospheric constituents using measurements provided by infrared remote sensors, which includes development of trace gases retrieval algorithms, validation, and analysis of the observations using chemistry-transport atmospheric models and data assimilation tools. She has been involved in the analysis of satellite data for several missions, including MOPITT/TERRA, IMG/ADEOS and ACE. As a member (PI) of the IASI Sounding Science Working Group (ISSWG), she is in charge of the development of the operational retrieval algorithm for the trace gases inversion from the IASI data. She is also a remote sensing expert for Eumetsat and contributes to the definition of the Meteosat Third Generation satellite.

A.2 Sub-contracting

Partner 9 (Chalmers) and 10 (FZK) intend to subcontract their audits for 1500 euro each.

These partners are unable to perform internal audits. They will select a subcontractor for the auditing by asking offers from several auditing companies or use an external auditor that already has been selected in a transparent way.

A.3 Third parties

No third parties will be involved in the project.

A4. Funding of Third country participants

There are no Third country participants involved in this project.

Appendix B – References

Bergamaschi, P., Krol, M., Dentener, F., Vermeulen, A., Meinhardt, F., Graul, R., Ramonet, M., Peters, W., and Dlugokencky, E. J., Inverse modelling of national and European CH_4 emissions using the atmospheric zoom model TM5, Atmos. Chem. Phys., 5, 2431-2460, 2005

Bousquet, P., D. A. Hauglustaine, P. Peylin, C. Carouge, P. Ciais, Two decades of OH variability as inferred by an inversion of atmospheric transport and chemistry of methyl chloroform, Atmos. Chem. Phys., 5, 2635-2656, 2005.

Chen, Y-H., and R.G Prinn, Atmospheric modeling of high- and low-frequency methane observations: importance of interannually varying transport, J. Geophys. Res., 110, doi:10.1029/2004JD005542, 2005

Clerbaux, C., J. Hadji-Lazaro, S. Turquety, G. Mégie and P.-F. Coheur, Trace gas measurements from infrared satellite for chemistry and climate applications, Atmos. Chem. Phys., 3, 1495-1508, 2003

Dentener, F., M. van Weele, M. Krol, S. Houweling, and P. van Velthoven, Trends and interannual variability of methane emissions derived from 1979-1993 global CTM simulations, Atmos. Chem. Phys., 3, 73-88, 2003a.

Dentener, F., W. Peters, M. Krol, M. van Weele, P. Bergamaschi, and J. Lelieveld, Interannual variability and trend of CH_4 lifetime as a measuer for OH changes in the 1979-1993 time period, J. Geophys. Res., 108, doi:10.1029/2002JD00216, 2003b.

Dlugogencky, E.J., S. Houweling, L. Bruhweiler, A. Masarie, P.M. Lang, J.B. miller, and P.P. Tans, Atmospheric methane levels off: Temporary pause or a new steady-state?, Geophys. Res. Lett., 30, (no 19), 1992, doi:10.1029/2003GL018126, 2003.

Eskes, H. J., P. F. J. van Velthoven, P.J.M. Valks, and H. M. Kelder, Assimilation of GOME total ozone satellite observations in a three-dimensional tracer transport model, Q. J. Royal Met. Soc., 129, 1663-1681, 2003.

European Commission, GMES-GATO: A European Strategy for Global Atmospheric Monitoring, Office for Official Publications of the European Communities, Luxemburg, EUR 21154, 2004.

Frankenberg, C., J.F. Meirink, M. van Weele, U. Platt, and T. Wagner, Assessing methane emissions from global space-borne observations, Science, 308, 1010-1014, 2005a.

Frankenberg, C., J.F. Meirink, P. Bergamaschi, A.P.H. Goede, M. Heimann, S. Körner, U. Platt, M. van Weele, and T. Wagner, Satellite cartography of atmospheric methane from SCIAMACHY onboard ENVISAT: Analysis of the years 2003 and 2004, submitted to J. Geophys. Res., 2005b.

Frankenberg, C. , Platt, U. and Wagner, T., Retrieval of CO from SCIAMACHY onboard ENVISAT: detection of strongly polluted areas and seasonal patterns in global CO abundances, Atmospheric Chemistry and Physics, Vol. 5, pp 1639-1644, 2005c.

Gupta, M.L., R.J. Cicerone, and S. Elliot, Perturbation to global tropospheric oxidizing capacity due to latitudinal redistribution of surface sources of NO_X, CH_4 and CO, Geophys. Res. Lett., 25, 3931-3934, 1998.

Hansen, J., and co-authors, Efficacy of climate forcings, J. Geophys. Res., 110, doi:10.1029/2005JD005776, 2005.

Hauglustaine, D., and D.H. Ehhalt, A three-dimensional model of molecular hydrogen in the troposphere. J. Geophys. Res., 107, doi:10.1029/2001JD001156, 2002.

Intergovernmental Panel on Climate Change (IPCC), Climate Change 2001: The Scientific Basis, Cambridge Univ. Press, New York, USA, 2001.

Karlsdóttir, S., and I.S.A. Isaksen, Changing methane lifetime: possible cause for reduced growth, Geophys. Res. Lett., 27, 93-96, 2000.

Krol, M. and Lelieveld, J.: Can the variability in tropospheric OH be deduced from measurements of 1,1,1-trichloroethane (methyl chloroform)?, J. Geophys. Res., 108, doi:10.1029/2002JD002423, 2003.

Krol, M., S. Houweling, B. Bregman, M. van den Broek, A. Segers, P. van Velthoven, W. Peters, F. Dentener, and P. Bergamaschi, The two-way nested global chemistry-transport zoom model TM5: algorithm and applications, Atmos.Chem.Phys. 5, 417-432, 2005.

Meirink, J.F., H. J. Eskes, and A. P. H. Goede, Sensitivity analysis of methane emissions derived from SCIAMACHY observations through inverse modelling, Atmos. Chem. Phys. Discuss., 5, 9405-9445, 2005.

Mikaloff Fletcher, S.E.M., P.P. Tans, L.M. Bruhwiler, J.B. Miller, and M. Heimann, CH_4 sources estimated from atmospheric observations of CH_4 and its $^{13}C/^{12}C$ isotope ratios: 1. Inverse modelling of source processes, Global Biogeochem. Cycles, 18, doi:10.1029/2004GB002223, 2004a.

Mikaloff Fletcher, S.E.M., P.P. Tans, L.M. Bruhwiler, J.B. Miller, and M. Heimann, CH_4 sources estimated from atmospheric observations of CH_4 and its $^{13}C/^{12}C$ isotope ratios: 2. Inverse modelling of CH_4 fluxes from geographical regions, Global Biogeochem. Cycles, 18, doi:10.1029/2004GB002224, 2004b.

Peylin, P. , Rayner, P. J., Bousquet, P., Carouge, C., Hourdin, F., Heinrich, P., Ciais, P. and AEROCARB contributors, Daily CO_2 flux estimates over Europe from continuous atmospheric measurements: 1, inverse methodology, Atmos. Chem. Phys. Disc., 5, 1647-1678, 2005.

Prinn, R. G., Huang, J., Weiss, R. F., Cunnold, D. M., Fraser, P. J., Simmonds, P. G., McCulloch, A., Harth, C., Salameh, P., O Doherty, S., Wang, R. H. J., Porter, L., and Miller, B. R.: Evidence for substantial variations of atmospheric hydroxyl radicals in the past two decades, Science, 292, p1882, 2001.

Sanderson, M.G., W.J. Collins, R.G. Derwent, and C.E. Johnson, Simulation of global hydrogen levels using a Lagrangian three-dimensional model. J. Atmos. Chem, 46(1), 15-28, 2003.

Schultz, M.G., T. Diehl, G.P. Brasseur, and W. Zittel, Air pollution and climate-forcing impacts of a global hydrogen economy. Science, 302, 624-627, 2003.

Simpson, I.J., D.R. Blake, and F. Sherwood Rowland, Implications of the recent fluctuations in the growth rate of tropospheric methane, Geophys. Res. Lett.,29, doi:10.1029/2001GL014521, 2002.

Sitch, S.; Smith, B.; Prentice, I. C.; Arneth, A.; Bondeau, A.; Cramer, W.; Kaplan, J.; Levis, S.; Lucht, W.; Sykes, M.; Thonicke, K. and Venevski, S., Evaluation of ecosystem dynamics, plant geography and terrestrial carbon cycling in the LPJ Dynamic Vegetation Model, Global Change Biology, 9, p. 161-185, 2003.

Sussmann, R., Stremme, W. Buchwitz, M., and de Beek, R.: Validation of ENVISAT SCIAMACHY columnar methane by solar FTIR spectrometry at the Ground-Truthing Station Zugspitze, Atmos. Chem. Phys., 5, 2419-2429, 2005.

Thonicke, K., I. C. Prentice, and C. Hewitt, Modeling glacial-interglacial changes in global fire regimes and trace gas emissions, Global Biogeochemical Cycles, 19, doi:10.1029/2004GB002278, 2005.

Turquety, S., J. Hadji-Lazaro, C. Clerbaux, D. A. Hauglustaine, S. A. Clough, V. Cassé, P. Schlüssel and G. Mégie, Operational trace gas retrieval algorithm for the Infrared Atmospheric Sounding Interferometer, J. Geophys. Res., 109, doi:10.1029/2004JD004821, 2004

Wang, J.S., J.A. Logan, M.B. McElroy, B.N. Duncan, I.A. Megretskaia, and R.M. Yantosca, A 3-D model analysis of the sowdown and interannual variability in the methane growth rate from 188-1997, Global Biogeochem. Cycles., 18, doi:10.1029/2003GB002180, 2004.

Walter, B.P., and M. Heimann, A process-based, climate-sensitive model to derive methane emission from natural wetlands: application to five wetland sites, sensitivity to model parameters, and climate, Global Biogeochemical Cycles, 14, 745-765, 2000.

Warwick, N.J., S. Bekki, K.S. Law, E.G. Nisbet, and J.A. Pyle, The impact of meteorology on the interannual growth rate of atmospheric methane, Geophys. Res. Lett., 29, 1947, doi:10.1029/2002GL015282, 2002.

World Meteorological Organisation, IGACO: An Integrated Global Atmospheric Chemistry Observation Theme for the IGOS Partnership, Report GAW No. 159 (WMO TD No. 1235; ESA SP-1282), Geneva, Switzerland, 2004.