Belgisch Instituut voor Ruimte-Aëronomie
(BIRA-IASB)
Institut d'Aéronomie Spatiale de Belgique

Aperçu des activités
2006
Overzicht van de activiteiten

Rapport d'activités 2006

Avant-propos

Partie 1 : Activités 2006

Partie 2 : Fonctionnement

Partie 3 : Conclusions et objectifs 2007

Annexes

Avant-propos

L'année 2006 a surtout été marquée par la continuation de la reconnaissance internationale des domaines d'activités scientifiques: la chimie et la physique des atmosphères, et les plasmas spatiaux. Un des principaux objectifs internes était d'atteindre une synergie et une masse critique plus importantes sous des thèmes communs de recherche et de prestation de services.

Une dynamique de groupe importante a été créée vers de nouveaux projets qui jettent un pont entre la recherche scientifique et la prestation de services. Quelques-unes des réalisations majeures de 2006 sont:

- Le développement des activités de services scientifiques pour les deux piliers thématiques : Chimie et physique des atmosphères (« Chemical Weather »), et Plasmas spatiaux (« Space weather »).

- L'approbation par le Conseil fédéral des Ministres du financement du Centre d'Excellence Solaire-Terrestre du Pôle Espace et la création du Fonds des idées pour les Etablissements scientifiques le 22 mars 2006.

- Le commissioning en orbite de l'expérience belge SOIR pour l'étude de l'atmosphère de Vénus, le démarrage des services et des activités scientifiques des expériences vénusiennes. Les spectres mesurés par SOIR sont d'une très bonne qualité.

- COSPAR a accordé à Viviane Pierrard la médaille Zeldovich. La remise a eu lieu lors de l'Assemblée scientifique de COSPAR à Beijing (le 17 juillet 2006).

- GMES: l'Union européenne a décidé de lancer un projet pilote autour des services atmosphériques. L'IASB, avec l'IRM et le VITO, y jouera un rôle-clé dans la prestation de services concernant le climat et l'environnement.

- PromISS-4 est une expérience belge dans la Station Spatiale Internationale (ISS), lancée avec le Progress 20P. Le B.USOC était responsable des opérations, en collaboration avec la NASA.

- A l'occasion de la Mission économique du 5 novembre, un accord de coopération a été signé avec le Canada (Air Quality Branch/MSC) pour l'étude, le développement de produits et la prestation de services opérationnels dans le domaine des services de météo chimique (« chemical weather ») de la stratosphère et de la troposphère.

- Pour le micro-satellite atmosphérique ALTIUS basé sur PROBA, l'étude de la phase A (aspects scientifiques et technologiques) a été démarrée, en collaboration avec l'ESTEC (Concurrent Design Facility), OIP et Verhaert.

- Un nombre impressionnant de publications scientifiques et de participations à des conférences et symposiums internationaux, ainsi qu'à des projets nationaux et internationaux.

Du point de vue opérationnel, on peut dire que tout un système analytique de gestion des projets a été développé, permettant de mener une politique dynamique et stratégique à partir de compétences et d'objectifs.
Les corps dirigeants comme le Conseil scientifique, le Jury de recrutement et de promotion, la Commission de gestion et le Comité de concertation de base ont valablement prouvé leur valeur.

Une gestion dynamique du personnel permet de répondre aux besoins de façon optimale, mais elle doit être développée plus encore dans le sens du planning de carrière.

En 2006, les plans de rénovation et d'expansion des infrastructures si nécessaires n'ont malheureusement pas encore pu être démarrés.

Ensuite, l'Institut a su renforcer sa reconnaissance internationale par son implication dans le développement de réseaux et par sa participation à des programmes internationaux.

La force de l'Institut réside dans son savoir, et nous continuerons à y investir.

N. Parmentier

Partie 1 : Activités 2006

1.1. Chimie et physique des atmosphères

Les activités des différents groupes du pilier « Chimie et physique des atmosphères » se situent dans différents sous-domaines de l'aéronomie, incluant d'une part la mésosphère jusqu'à la troposphère terrestres et la jonction avec la biosphère, et d'autre part l'aéronomie planétaire avec l'étude des phénomènes atmosphériques sur Mars et Vénus. Les méthodes de recherche comprennent des observations à partir de différentes plateformes, des calculs de modèles et l'assimilation de données, ainsi que des expériences d'appui en laboratoire.

1.1.1. L'étude fondamentale de l'atmosphère terrestre

Les données des instruments de chimie atmosphérique GOMOS, MIPAS et SCIAMACHY à bord d'**Envisat** ont été traitées davantage en détail. Tout d'abord nous avons atteint une meilleure compréhension de leur valeur (contenu en information, précision, exactitude) en participant à différents exercices de validation, en partie comme coordinateur de produit, et en caractérisant mieux le contenu en information des différentes mesures. La synergie entre des observations depuis différentes plateformes est exploitée, comme pour le développement d'une climatologie des profils de NO_2, ou encore par l'utilisation d'observations depuis la Terre, des ballons et des satellites pour une meilleure compréhension de la quantité troposphérique du BrO. Ensuite, des algorithmes ont été élaborés afin de définir les produits satellite avec une plus grande précision, comme pour la déduction de données d'aérosols à partir des mesures de GOMOS ou pour la détermination d'ozone, de NO_2 et d'autres gaz en trace (BrO, H_2CO, ...) à partir de SCIAMACHY et de son prédécesseur GOME.

Parallèlement à cette dernière activité, des préparations ont été faites en vue du traitement des données de GOME-2, lancé en octobre 2006 à bord de **METOP-1**. Le second instrument qui nous intéresse à bord de METOP-1 est IASI: l'IASB a élaboré un nouveau code, ASIMUT, pour la détermination des composantes chimiques et d'aérosols à partir des spectres de rayonnement infrarouge thermique de IASI, et a préparé la validation des produits de IASI.

L'IASB est reconnu mondialement pour son expertise en validation et en extraction de données satellite. Cette reconnaissance se manifeste, entre autres, par le fait que l'Institut exerce la vice-présidence du « **CEOS** (Committee for Earth Observation Satellites) Working Group on Calibration and Validation/Atmospheric Chemistry Sub Group », qu'il fait partie de différents « Satellite Quality Working Group » et « SAF » (Satellite Application Facility), et qu'il est le coordinateur du projet **TASTE** (Technical

ASsistance To Envisat), projet qui fait usage de spectromètres, de radiomètres et de sondes d'ozone.

En tant que membre de l'**ACE** Science Team, l'IASB est également fortement impliqué dans l'extraction et la validation de différents produits d'ACE-FTS et de MAESTRO, en partie comme coordinateur de produit. Un des produits traités par l'Institut sont les nuages (cirrus, nuages convectifs et nuages polaires stratosphériques ou PSC), à partir des images de l'ACE imager.

Suite à la déduction et à la validation de données atmosphériques de satellites, nous avons travaillé à leur exploitation, en combinaison avec des modèles.
Un nouveau modèle, **MOSTRA**, est en voie de développement pour intégrer une description précise de la microphysique des aérosols stratosphériques à un modèle de transport 3D. En même temps on a travaillé à l'intégration d'un modèle de microphysique pour les PSC dans un modèle de transport chimique (CTM) 3D. Le modèle a été appliqué avec succès à une étude de l'hiver 2003 au-dessus de l'Antarctique et s'accorde bien avec les observations satellite (POAM III et MIPAS).
Les données stratosphériques de satellite, en particulier les données d'Envisat, ont été largement utilisées dans **BASCOE** (Belgian Assimilation System for Chemical Observations from Envisat), le système d'assimilation de données 4D-Var de l'IASB. BASCOE a participé à des exercices de validation et au projet européen ASSET, où il a été comparé avec d'autres systèmes d'assimilation existants.
Des données troposphériques pour le CO de MOPITT et pour le NO_2 et l'H_2CO de SCIAMACHY ont été utilisées avec succès pour la **modélisation inverse**, basée sur le modèle IMAGES, afin d'améliorer les données d'émission, en particulier celles d'origine biogène et provenant de la combustion de biomasse. Une partie de ce travail cadre dans la contribution de l'IASB au réseau européen **ACCENT**, en tant que membre du Steering Committee de l'activité « Access to Emission Databases ».

Nous avons également effectué de la recherche fondamentale sur la chimie et le rôle dans la troposphère des substances organiques volatiles (VOS), sur la base de calculs théoriques, de calculs à l'aide de modèles et d'expériences de laboratoire, dans le cadre du projet national **IBOOT**, coordonné par l'IASB. Des expériences d'appui en laboratoire **VOCCIMS** (Volatile Organic Compound measurements by Chemical Ionization Mass Spectrometry) comprennent des études « Selected Ion Flow Tube » (SIFT) des réactions ion/molécule et la détection SIFT-MS de composants émis par des blessures végétales (hexénal, hexénol, méthanol, acétone,…). On a travaillé pour rendre opérationnel un spectromètre de masse quadripolaire triple (Triple Quadrupole Mass Spectrometer, TQMS), acheté en 2005, alors qu'un nouveau spectromètre de masse de réaction de transfert de protons (Proton Transfer Reaction Mass Spectrometer, PTR-MS) sera utilisé pour la première fois en 2007 dans le cadre du projet national **IMPECVOC** (Impact of Phenology and Environmental Conditions on BVOC Emissions from Forest Ecosystems), sous la conduite de l'Université de Gand, entre autres pour faire des études de laboratoire et sur le terrain sur les émissions biogènes des VOS.

Des observations terrestres à long terme de la composition atmosphérique à l'aide de spectromètres infrarouges à transformée de Fourier (FTIR) et de spectromètres DOAS UV-visible ont été poursuivies dans le cadre du **NDACC** (Network for the Detection of Atmospheric Composition Changes) et de projets européens et

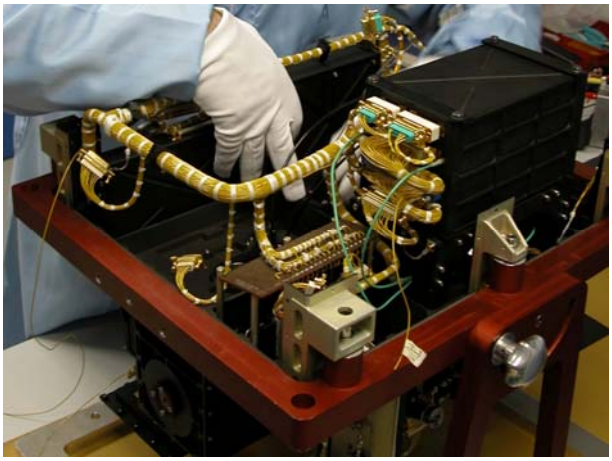
nationaux, dans les stations de la Jungfraujoch, de l'Observatoire de Haute Provence, de Harestua et, depuis 2002, sur l'Ile de la Réunion. L'expertise de l'IASB dans ce domaine a été reconnue par la nomination et la confirmation des coprésidents des groupes de travail UV-visible, Infrarouge et Satellites du NDACC. L'IASB a également obtenu la direction de l'activité « Stratospheric Ozone & Climate » au sein du projet européen intégré **GEOMON**, lancé en février 2007.

Nous avons aussi participé à différentes campagnes d'observation à l'aide d'instruments DOAS UV-visible pour la validation de données de SCIAMACHY/Envisat et d'OMI/Aura sur l'ozone et le NO_2.

Un nouvel instrument pour la mesure des paramètres d'aérosols, plus précisément un photomètre solaire CIMEL, a été utilisé pour la première fois à Uccle et a été intégré à AERONET. Une campagne d'observations CIMEL, UV-visible, DOAS et FTIR a eu lieu à Uccle dans la deuxième moitié de 2006, dans le cadre du projet national **AGACC** coordonné par l'IASB.

L'IASB participe également au projet européen **NOVAC** qui créera un réseau terrestre de spectromètres DOAS UV-visible pour l'observation d'émissions volcaniques (BrO, SO_2, …).

Le réseau belge de détection de **rayonnement solaire UV spectral** a été complété par une station à Ostende pour étudier le littoral. Des études ont été faites sur l'effet de l'ozone et des nuages sur le rayonnement UV et afin de déterminer les tendances à long terme (sur 19 années). L'expérience spatiale **SOLSPEC**, considérée comme une référence pour la mesure du spectre solaire extraterrestre absolu entre 180 et 3000 nm, et qui doit être installée à bord de la Station Spatiale Internationale (ISS), a subi en 2006 plusieurs tests (EMC, thermique, optique). L'instrument sera livré à Alenia en 2007.

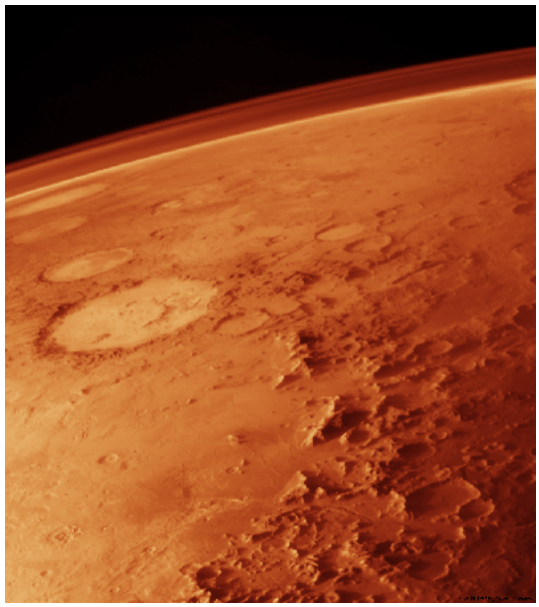


Pour appuyer les observations de télédétection optique, **les paramètres spectroscopiques** des gaz atmosphériques pertinents sont mesurés en laboratoire. En 2006 l'accent a été mis sur le H_2O avec ses isotopes, le NO_2 avec ses isotopes dans la zone UV-visible et dans les sections actives d'absorption du benzène, du toluène et des xylènes.

Deux nouveaux projets importants ont été lancés, à savoir **ALTIUS** et **UAV**. ALTIUS est un instrument spatial qui sera lancé dans le cadre du programme belge des microsatellites, pour mesurer la composition de la haute troposphère et de la stratosphère en UV-vis-NIR limb scattering mode, après Envisat. Le projet UAV vise à développer des spectromètres compacts et ultralégers pour fonctionner à bord d'un

drone (ou UAV, unmanned aerial vehicle), afin d'observer la qualité de l'air, en particulier du NO_2 et du CO.

1.1.2. Recherche fondamentale sur les atmosphères de Mars et de Vénus



Les données de **SPICAM** ont été exploitées pour déterminer les propriétés optiques des nuages (de poussière ou autres) sur Mars et pour développer une climatologie des nuages et une carte de l'albédo de la surface de Mars. Le Modèle Global Multiéchelle de Mars est un modèle de circulation générale développé pour l'atmosphère martienne et réalisé à l'IASB afin d'y implémenter un modèle de microphysique de glace et de nuages de CO_2.
Un autre modèle 2D de l'atmosphère martienne a été implémenté pour déduire la température, la pression et la composition chimique de cette atmosphère à partir des données UV de SPICAM, et pour réaliser une climatologie du rayonnement UV à la surface de Mars.
On a également démarré le traitement des spectres **SPICAV/SOIR**, pour déterminer la composition chimique de l'atmosphère de Vénus. A cette fin a été développée une version adaptée du code ASIMUT.

1.2. Milieu interplanétaire et plasma

En 2006, le groupe « Plasmas » de l'Institut d'Aéronomie Spatiale de Belgique comprenait huit chercheurs (trois statutaires et cinq contractuels). Le nombre de publications de ce groupe en 2006 s'élève à 39.

Nous nous sommes intéressés aux divers aspects de la physique des plasmas de l'espace et aux relations Soleil-Terre.

Les études sur l'interaction des poussières avec le plasma coronal se sont achevées en 2006. Le modèle d'ablation qui avait été développé pour l'atmosphère terrestre a été étendu au cas de l'atmosphère solaire en tenant compte de l'état de plasma de ce milieu.

D'autre part, le groupe « Plasmas » s'est fortement impliqué dans l'analyse et l'interprétation des données de la mission CLUSTER de l'ESA. Cette mission est constituée de quatre satellites lancés en 2000. Elle restera opérationnelle au moins jusqu'au 31 décembre 2009. Nous sommes en effet Co-I dans deux

expériences CLUSTER. L'objectif de cette mission est d'établir une cartographie tridimensionnelle et non stationnaire des régions clés où l'interaction de la magnétosphère avec le vent solaire est la plus manifeste. Les quatre satellites de la mission CLUSTER, qui évoluent en formation rapprochée, nous ont permis d'étudier en détail la région de la plasmasphère (cette région constitue le prolongement de l'ionosphère aux basses et moyennes latitudes). Nous avons mis en évidence le développement de structures particulières telles que les « plumes », les « épaules » et les « canaux ». Toutes ces structures ont été analysées. Leur développement spatio-temporel a été modélisé et comparé avec les mesures simultanées des instruments EUV (à bord du satellite IMAGE) et WHISPER (à bord de CLUSTER). En 2006, les mesures les plus récentes de CLUSTER et d'IMAGE ont été analysées et comparées avec les simulations. Le modèle de la plasmasphère a été mis en ligne sur le portail de l'« European Space Weather ». Nous avons développé également un nouvel algorithme très performant, nous permettant de calculer les gradients spatiaux et temporels à partir de mesures multipoints, comme celles obtenues par les quatre satellites CLUSTER.

Un des objectifs du groupe « Plasmas » est de remettre à l'honneur l'étude du couplage entre l'ionosphère et la magnétosphère. Une des manifestations les plus spectaculaires de ce couplage se traduit notamment par la formation d'aurores, dont les arcs auroraux discrets sont une des formes les plus intenses. A l'IASB nous visons à donner une description de deux dimensions du couplage ionosphère-magnétosphère, en partant des principes de base régissant le mouvement des particules chargées, et en utilisant des conditions frontières pertinentes au niveau de l'ionosphère et de la magnétosphère. Des études ont abordé l'origine de la chute de potentiel électrique, responsable de l'accélération des électrons auroraux au-dessus des arcs discrets. En 2006, nous avons également utilisé les méthodes de la tomographie aurorale pour reconstruire la structure à trois dimensions des arcs auroraux discrets, dans le domaine des longueurs d'ondes correspondant aux trois raies les plus intenses de l'émission aurorale (raies verte, rouge et bleue).

Un logiciel très performant continue à être développé par le groupe « Plasmas ». Il est composé de modules interactifs permettant de visualiser et d'analyser les données satellite et d'utiliser différents outils, comme par exemple l'outil de calcul de gradients dans la plasmasphère. Ce logiciel a été baptisé « MIM » (Manager of Interactive Modules).

La science cométaire et planétaire n'a pas été oubliée en 2006. D'une part, en préparation à la mission ROSETTA, nous avons développé des outils et des bases

de données concernant les réactions chimiques dans les comètes. Ces recherches serviront à l'analyse des données de l'instrument ROSETTA, vis-à-vis duquel l'IASB a une responsabilité de Co-I. La sonde ROSETTA a été lancée le 2 mars 2004 à destination de la comète 67P/Churyumov-Gerasimenko qu'elle devrait atteindre en mai 2014. D'autre part, nous avons soumis une proposition PRODEX pour une participation à la construction d'instruments qui seront embarqués à bord des orbiteurs MMO (instrument MSA) et MPO (instrument PICAM) dans le cadre de la mission d'exploration BepiColombo. Cette mission de l'ESA a pour objectif l'étude de l'environnement de la planète Mercure.

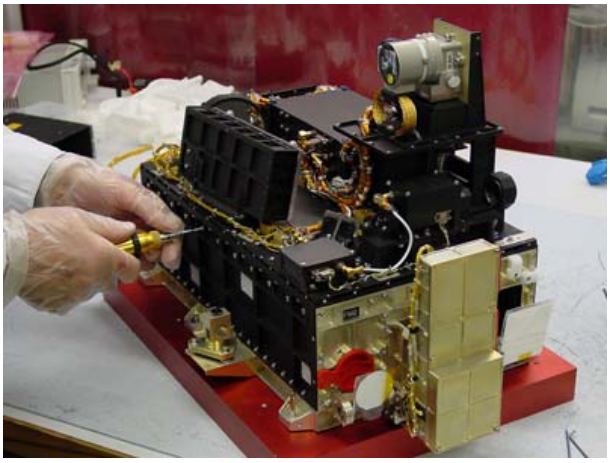
L'électricité atmosphérique est un domaine en pleine expansion. C'est pourquoi nous nous sommes penchés sur l'étude des relations entre les événements lumineux transitoires (les sylphes, les jets bleus et les elfes) et divers aspects du système atmosphérique, notamment le climat.

Du point de vue organisationnel, nous avons contribué à définir les structures du futur Centre d'Excellence des relations Soleil-Terre (STCE). Plusieurs membres ont été actifs dans l'organisation de conférences et de groupes de travail de niveau international. **Viviane Pierrard** a reçu la prestigieuse **médaille Zeldovich** pour l'excellence de ses travaux. Plusieurs membres de l'Institut d'Aéronomie Spatiale de Belgique font partie de comités et/ou d'associations actives sur le plan international.

1.3. Instrumentation

1.3.1. VENUS EXPRESS – SOIR

Depuis son lancement en novembre 2005 et pendant toute l'année 2006, l'instrument belge SOIR (Solar Occultation in the InfraRed: une composante de SPICAV - Spectroscopy for the Investigation of the Atmosphere of Venus) a été actif dans toutes les phases de la mission Venus Express. Un nombre de tests a été effectué pendant la période du Venus commissioning, p.ex. un premier test de visée (nov. 2005, janv. 2006) pour épurer l'alignement du champ de vision de SOIR par rapport aux axes du satellite. Des check-out ont eu lieu (fév. 2006) pour calibrer optiquement l'instrument. SOIR a aussi participé à la phase de commissioning, où il a entre autres mesuré le premier spectre d'absorption de l'atmosphère vénusienne (mai 2006).



Depuis fin mai 2006, le satellite se trouve sur son orbite nominal. Des tests de calibration et de visée sont exécutés de façon régulière.

Les tâches opérationnelles de l'instrument SOIR consistent en la planification des observations en collaboration avec les partenaires de l'équipe SPICAV, la définition d'une visée correcte, tenant compte de la réfraction dans l'atmosphère vénusienne (routines software développés à l'Institut), la composition des télécommandes pour chaque observation, l'essai des télécommandes sur le modèle de réserve de SOIR dans la salle d'essais de l'IASB, l'échange de données (plannings d'observation, séquences de télécommandes et de données de télémesure) avec le Venus Express Science Operations Team (VSOC à l'ESTEC) et le Venus Express Mission Operations Team (VMOC à l'ESOC), la participation à des téléconférences hebdomadaires pour le planning et les aspects opérationnels, etc.

Les données de l'instrument SOIR sont téléchargées à partir du Data Dispositioning System (DDS) de l'ESOC et stockées sur un serveur de l'IASB. Un premier traitement des données est effectué pour corriger la non-linéarité du détecteur, calibrer l'échelle des longueurs d'ondes, séparer les ordres de grille et élaborer et appliquer des spectres de référence. Toutes ces étapes de calibration générale ont été réunies dans un logiciel convivial qui peut ensuite être utilisé par l'équipe scientifique lors de l'analyse approfondie des données.

Une archive complète au format PSA (Planetary Science Archive) complète a été constituée et est mise à jour chaque fois que de nouvelles données de SOIR sont enregistrées.

1.3.2. BEPICOLOMBO

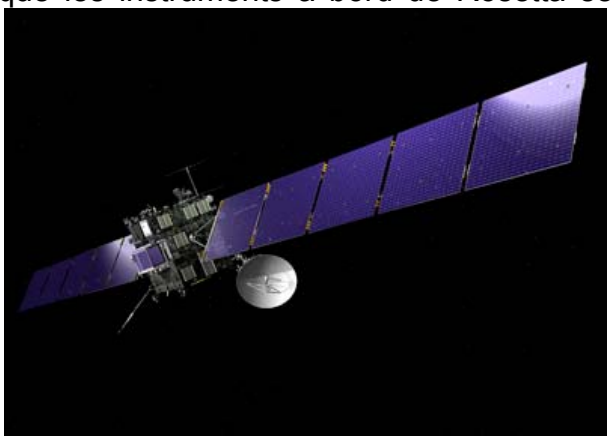
L'IASB a participé entre autres à la mission BepiColombo, une mission « cornerstone » de l'ESA vers la planète Mercure, avec l'instrument PICAM

(Planetary Ion Camera) qui fera partie de la charge utile du MPO (Mercury Planetary Orbiter), la partie européenne de la mission BepiColombo. PICAM est une caméra à haute résolution qui scrute l'hémisphère entière à la recherche de particules chargées et permet ainsi de déterminer la distribution tridimensionnelle de la vitesse et le spectre de masse des ions dans un champ de vision complet de 2π radians.

En 2006, une étude de la phase A a été démarrée par l'IASB, le CETP-IPSL et l'IMEC pour examiner la faisabilité de la livraison des composantes hardware (les ASIC).

1.3.3. ROSETTA – ROSINA/DFMS

Le satellite Rosetta a été lancé en 2003 et s'avance depuis lors toujours plus loin dans le système solaire. On a constaté que les instruments à bord de Rosetta se refroidissent plus vite que prévu initialement. Si la tendance actuelle se prolongeait, cela mènerait à des températures extrêmement basses à l'arrivée près de la comète Churyumov-Gerasimenko.



Des températures très basses sont surtout attendues (inférieures à -60°C) sur le module de détection du DFMS (Double Focusing Mass Spectrometer),. Pour vérifier si le détecteur et son électronique RDP (Remote Detector Pack) pourront survivre à ces basses températures et, si oui, s'il est acceptable de démarrer les modules de détection et d'électronique dans ces conditions, nous avons effectué des tests sous vide thermique (dans la chambre propre de l'IASB), en collaboration avec notre partenaire français (le CETP-IPSL).

Les résultats des essais montrent que le détecteur est capable de démarrer et de fonctionner à des températures jusque -60°C. Plus de tests seront menés au cours de 2007.

1.3.4. Support au projet IMPECVOC

L'IASB a développé et testé un logiciel LabView pour soutenir le projet IMPECVOC, dans lequel un spectromètre de masse PTR-MS sera utilisé pour mesurer des composés volatils organiques biogéniques. Ce logiciel est constitué autour d'une unité de distribution en d'un datalogger qui est capable d'effectuer le monitoring d'un grand nombre de paramètres environnementaux et instrumentaux (températures, luminosité, débits, …). L'ensemble est pourvu d'une interface flexible et conviviale, qui permet de définir et d'observer tous les paramètres. L'utilisateur a également la possibilité d'utiliser des scripts. Dans son atelier de mécanique, l'IASB a développé un prototype des containers (appelés cuvettes) utilisés dans ce projet.

1.3.5. Support au projet BRUKER

Pour supporter le projet BRUKER, l'IASB a continué à développer le logiciel LabView de pilotage du spectromètre et du traqueur de Soleil complémentaire, en améliorant la mécanique (séparation entre la fonction du traqueur de Soleil et le système de fermeture du traqueur, à l'aide d'un système de fermeture pneumatique ; remplacement du miroir de 45° sur le chemin optique) et l'électronique (combinaison d'une caméra CCD et d'un détecteur à 4 quadrants dans boucle de pointage solaire) de l'instrument. L'IASB a aussi entamé l'ébauche et la construction d'un traqueur de Soleil compact tout à fait nouveau.

1.3.6. Support engineering au projet EPT

L'IASB a conçu la structure mécanique entière de l'instrument EPT (Energetic Particle Telescope), en collaboration avec l'UCL. L'IASB a fabriqué des accessoires et un container de transport pour les tests de vibration de 2007 (à l'ESTEC). Entre le 4 et le 8 mai 2006 l'IASB a effectué des tests sous vide thermique dans sa chambre d'essai.

1.4. Le B.USOC

1.4.1. Introduction

Pendant la phase de préparation des incréments du programme d'utilisation du module Columbus de la Station Spatiale Internationale, le B.USOC est responsable des activités telles que l'implémentation du segment sol, les opérations des différents modèles au sol, le développement des procédures opérationnelles des expériences, l'optimisation et le calibrage des opérations des charges utiles et des expériences, et le support aux activités de formation et d'entraînement des équipes scientifiques et opérationnelles. Pendant les opérations avec les charges utiles en orbite, le B.USOC réceptionnera les données des expériences et apportera son support au « Columbus Control Center » (COL-CC) en assurant les opérations des charges utiles pour lesquelles le B.USOC est responsable. La préparation et l'exécution globale des activités d'utilisation est une responsabilité partagée entre l'ESA, le B.USOC et l'industrie (cette dernière comprenant les opérateurs industriels ayant développé les charges utiles).

1.4.2. Harmonisation de la structure contractuelle

Dans ce contexte, l'année 2006 fut une année déterminante pour la finalisation de l'implémentation de l'infrastructure ainsi que pour l'évolution de la structure de management.

Au plan purement organisationnel, l'ESA HME a accepté de faire jouer au Steering Committee du B.USOC (composé de représentants de Belspo, de l'IASB, du B.USOC et de l'opérateur industriel chargé de l'implémentation) le rôle de centre décisionnel de manière à ce que formellement, le B.USOC puisse avoir un schéma organisationnel similaire aux autres USOC du réseau.

La contrepartie évidente de la part de l'ESA HME est une transformation des relations contractuelles avec l'industrie, de manière à rendre possible la responsabilisation managériale et la sous-traitance du B.USOC vers l'industrie (dans la pratique l'opérateur industriel devenant sous-traitant du B.USOC).

1.4.3. La mission PromISS-4

Au début de l'année 2006, Le B.USOC a été le centre de mission européen responsable pour la conduite de l'expérience PromISS-4. Cette expérience belge de cristallisation de protéines a été réalisée dans la Station Spatiale Internationale et plus particulièrement dans la « Microgravity Science Glove Box » (MSG), située dans le laboratoire américain. Cette expérience a été activée la nuit du 19 janvier et le B.USOC a conduit les opérations en temps réel pendant plusieurs semaines.

1.4.4. Préparation des opérations Columbus

Le 6 décembre 2007, le module européen Columbus sera mis sur orbite et attaché à la Station Spatiale Internationale. Dans le contexte de ce programme et de la vision décentralisée de l'ESA, la Belgique s'est vu octroyée la responsabilité du centre de mission du laboratoire solaire (SOLAR) et du centre de mission de la « Protein Crystallization Diagnostic Facility » (PCDF). Dans ce contexte, l'année 2006 a vu :

- la finalisation de l'implémentation du segment sol ISS dans le cadre du FRC SOLAR et du FSC EDR/PCDF
- la réception du Columbus Emulator
- la réalisation des tests des procédures et du segment sol ISS
- l'entraînement et la formation du personnel (B.USOC et SAS) à la conduite des opérations pour l'incrément 1E
- la finalisation de la documentation contractuelle pour le « Check point » ESA (16/10/2006)
- l'équipement du laboratoire PCDF, le développement de logiciels pour le support aux scientifiques dans le cadre de la préparation de l'expérience EDR/PCDF, pour son implémentation en microgravité.

1.4.5. Installation du Centre de Mission Scientifique PICARD (CMS-P)

La mission PICARD s'inscrit dans le cadre de la filière MYRIADE du CNES. Il s'agit d'un microsatellite scientifique embarquant 3 instruments pour la caractérisation du Soleil (diamètre, limbe, activité).
Les laboratoires impliqués sont français (Service d'Aéronomie du CNRS, instrument SODISM), belges (Institut Royal de

Météorologie, instrument SOVAP) et suisse (World Radiation Center, instrument PREMOS).
Le lancement est prévu pour l'année 2009, pour une durée de mission nominale de 3 ans.

Le CNES est responsable de la gestion technique et financière de l'ensemble de la mission PICARD, et le service DCT/PS/CMI a la délégation pour le développement du Centre de Mission Scientifique PICARD (CMS-P). Le financement du CMS-P vient de l'état belge via le programme PRODEX de l'ESA.

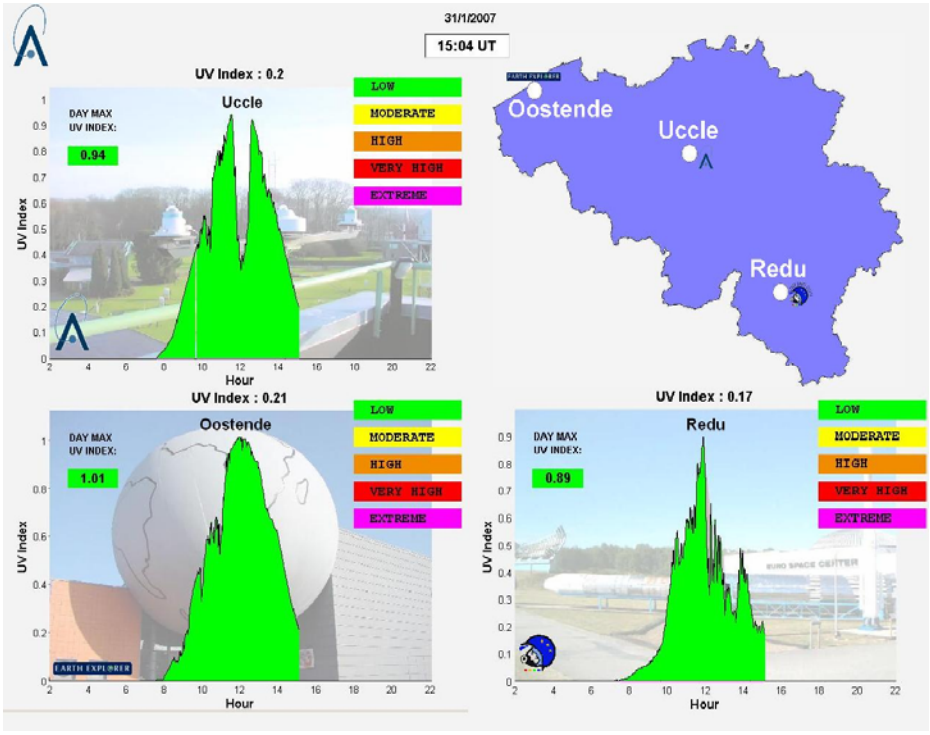
L'année 2006 a vu la finalisation des spécifications techniques du Centre de Mission Scientifique PICARD. La réalisation a été confiée à la société SPACEBEL, suite à un appel d'offre lancé en juin 2006 auprès de 4 industriels belges.

1.5. Valorisation

L'IASB a étendu ses activités de prestation de services scientifiques.

1.5.1. L'index UV

En 2006 l'IASB gérait trois stations automatiques pour mesurer les UV de façon continue. La combinaison des différentes techniques de mesure utilisées permet de définir la climatologie UV du site d'observation et d'étudier l'influence de l'ozone, des



aérosols, de la couverture nuageuse etc. sur la pénétration du rayonnement UV jusqu'à la surface du sol. Un effort spécial a été réalisé pour rendre ces données visibles et accessibles au grand public. Pour cela, un service d'**index UV** a été créé sur les pages web de l'IASB, qui indique en temps réel l'index UV et des informations complémentaires pour les 3 stations de mesure UV à Uccle, Ostende et Redu. L'adresse de cette page est http://www.aeronomie.be.

1.5.2. BACCHUS

L'IASB et le Direction générale des sciences atmosphériques et climatiques d'Environnement Canada ont conclu en 2006 un accord de coopération pour développer des services tels que la prévision de la qualité de l'air et de la pollution, et pour proposer de ces services à la société. En présence du Prince Philippe et du Ministère fédéral de la Politique scientifique, des représentants des deux instituts de recherche ont signé une déclaration d'étroite coopération dans le domaine de la chimie atmosphérique.

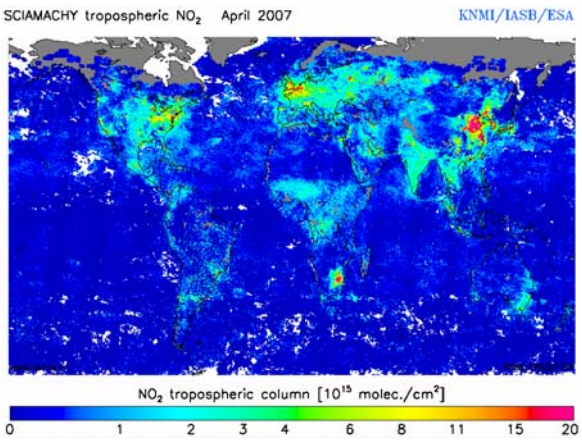
Concrètement il s'agit de produits dérivés, comme:

- une meilleure prévision de la qualité de l'air
- des prévisions chimiques de la basse atmosphère
- des analyses à long terme de la pollution troposphérique et des dégâts infligés aux plantes agricoles
- le contrôle des émissions de gaz à effet de serre et de composantes chimiques jouant un rôle important dans les processus de désintégration d'ozone (les précurseurs d'ozone)
- des prévisions de l'index UV (sur 3 jours).

Cette recherche se situe dans le GEOSS (Global Earth Observation System of Systems), et en particulier dans la contribution européenne GMES (Global Monitoring for Environment and Security). Utilisant l'expertise développée dans BASCOE et dans le projet **ACHEDYRE**, l'IASB développe donc, en collaboration avec le Service Météorologique de Canada, un nouveau système opérationnel d'assimilation de données qui représentera tant la troposphère que la stratosphère, la dynamique comme la chimie. Cela forme le contenu du projet **BACCHUS** (Belgium And Canada for CHemical weather User-oriented Services).

1.5.3. TEMIS

L'Institut joue un rôle important dans le projet ESA DUE **TEMIS**, en collaboration avec le KNMI, où il propose des produits satellite troposphériques avancés pour le H_2CO et le NO_2, et où il étudie la possibilité de caractériser le transport à longue distance sur la base de données satellite, éventuellement sur une base opérationnelle. Pour ces dernières études, les modèles de trajet FLEXSTRA et FLEXPART ont été implémentés et exploités avec succès à l'IASB.



1.5.4. GMES - PROMOTE

L'IASB prend par ailleurs part au projet GMES **PROMOTE** avec les services « Stratospheric Aerosol and Gas », « Ozone Record Profiles » (la continuation de BASCOE), « Support to Aviation Control », le développement de produits satellite de haute qualité pour le H_2CO et le NO_2 de GOME, SCIAMACHY, OMI et GOME-2, et le « PROMOTE Quality Assessment/Validation Office ».

L'IASB participe au deuxième projet phare de la Commission Européenne **GMES** (Global Monitoring for Environment and Security), dont le quatrième projet pilote, axé sur l'atmosphère, devrait permettre de proposer aux responsables politiques et au grand public des services de mesure de l'ozone, des aérosols, de l'index UV, de la qualité de l'air…

D'ores et déjà, l'IASB développe ces produits en coopération avec des industriels et de nombreuses universités belges (Université de Liège, UCL, KU Leuven, Universités de Gand et d'Anvers…).

La présence de l'IASB dans des projets proches de GMES, comme **GEMS**, PROMOTE et GEOMON, est importante pour s'assurer une bonne position dans le futur Service Atmosphérique GMES (**GAS**) de l'Union Européenne.

1.5.5. Les effets de la radiation spatiale (SPENVIS)

Comprendre les interactions entre l'héliosphère et la magnétosphère terrestre est indispensable pour la météo spatiale, c'est-à-dire la prévision de l'impact des conditions héliosphériques sur les activités humaines.

Par exemple, la construction d'un satellite nécessite de connaître la dose de radiation ionisante qu'il va accumuler pendant sa durée de vie. On a donc besoin de modèles de la distribution de la radiation, y compris leur évolution avec l'activité solaire. L'IASB a développé un outil à cette fin: le système SPENVIS (http://www.spenvis.oma.be/).

1.5.6. La météo spatiale

L'infrastructure software du réseau « Space Weather European Network » (SWENET) est disponible à http://www.esa-spaceweather.net/swenet, site portail qui propose l'accès à des services et des données liés à l'environnement spatial et à ses effets, parmi lesquels:

- des prévisions d'aurores
- l'activité géomagnétique et des prévisions de CIG (courants induits géomagnétiquement)
- les conditions de communications radio
- la qualité des services de navigation par satellite
- les anomalies de satellites et leur support opérationnel.

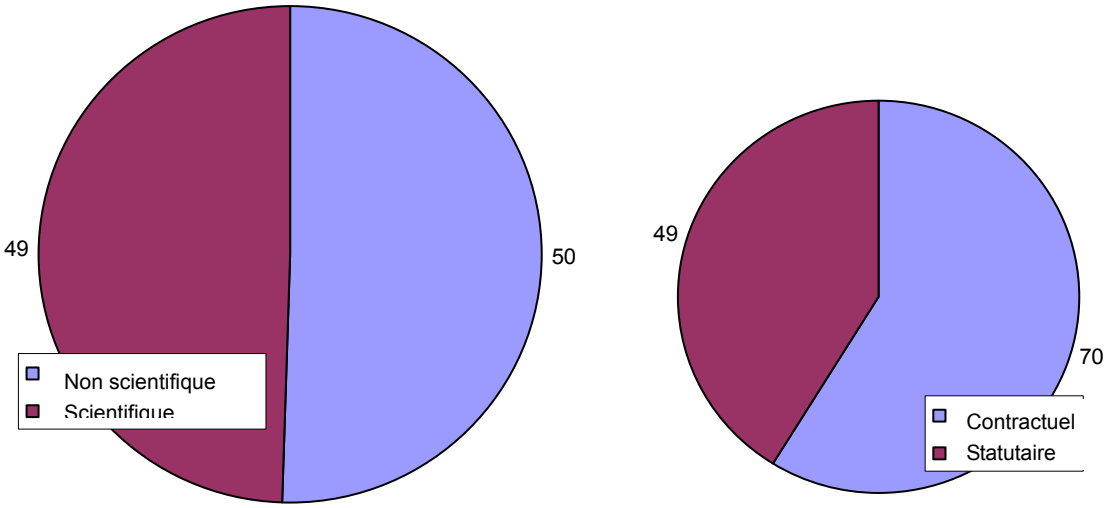
Le portail SWENET propose également un large choix de données sur l'environnement spatial, rassemblées de sources externes diverses et rendues accessibles à travers une base de données commune. Les utilisateurs peuvent rechercher des données de périodes précises et combiner différentes sources grâce à un puissant outil d'analyse. Les résultats peuvent alors être affichés dans le navigateur web, téléchargés comme fichiers de texte ou tracés graphiquement.

SWENET a été développé dans le cadre du projet pilote de météo spatiale de l'ESA pour supporter des utilisateurs européens par de l'information et des services liés aux effets de la météo spatiale.

Cost 724, une initiative de l'UE soutenue par 28 pays, a développé la base scientifique pour le monitoring, le modelage et la prévision de la météo spatiale. Les résultats sont actuellement en cours de publication sur le site web intégré « European Space Weather Portal ». A côté des fonctionnalités destinées aux scientifiques et aux ingénieurs (p.ex. l'accès aux modèles et aux bases de données distantes), l'« European Space Weather Portal » attache beaucoup d'importance à l'outreach et contient une section spéciale qui y est dédiée. Le portail européen de la météo spatiale peut être consulté à l'adresse http://www.spaceweather.eu.

Partie 2 : Fonctionnement

2.1. Personnel



2.2. Communication

2.2.1. Le matériel didactique

Le site général de l'IASB (http://www.aeronomie.be) existe en français et en néerlandais depuis sa création. En 2006, à côté de sa gestion journalière, il a été presque entièrement traduit en anglais. Une banque de données de projets scientifiques à été ajoutée, dans laquelle les visiteurs scientifiques et les autres

membres de l'IASB peuvent trouver les informations sur les projets et les publications des membres du personnel de l'IASB.

Pour la mission Venus Express de nouvelles pages ont été crées en avril 2006.

Outre les prévisions à long terme concernant l'UV, l'évolution de l'index UV peut être suivi en ligne sur notre site, minute par minute, depuis les différents endroits où sont installés nos instruments de mesure (IASB/Uccle, Earth Explorer/Ostende et Euro Space Center/Redu).

De nouvelles pages web ont aussi été crées pour suivre le lancement de la mission MetOp-1 avec IASI et GOME-2 à bord.

En plus du site général de l'IASB, il existe un site particulier consacré au projet B.USOC (http://www.busoc.be). Outre la maintenance, des pages sur le projet PromISS-4 (janvier 2006) ont été crées.

La cellule communication s'occupe de la remise à jour régulière des questions du quiz et de la maintenance des **bornes PC interactives**.

Divers **posters pour les expositions** ont été créés sur les différents thèmes de l'Institut. Il existe des posters généraux et des posters sur les missions auxquelles participe l'IASB. L'accent est toujours mis sur la participation belge et plus particulièrement sur la participation de l'IASB à ces missions.

2.2.1.1. Evénements et expositions

L'IASB a installé une exposition composée de posters sur **Venus Express**, du modèle de vol de **l'instrument SOIR** et d'une animation en 3D de l'instrument SOIR (réalisée grâce au département engineering). Cette exposition a été montrée:

- au Planétarium de Bruxelles (*d'avril à décembre 2006*)
- à l'Euro Space Center de Redu-Transinne *(de juin à décembre 2006).*

Les missions **Venus Express et Mars Express** ont été mises en évidence au Centre de Culture Scientifique de Parentville (Charleroi) via des posters, le SpaceQuiz et des maquettes (*de mars 2006 à août 2006).*

Lors du Forum des Entreprises à l'Université du Travail de Charleroi l'IASB s'est **présenté d'une manière générale** avec des posters, la mise à disposition de deux bornes interactives et l'animation du stand (*17 et 18 mars 2006*).

Une exposition itinérante sur Hubble combinée à une présentation générale de l'IASB et deux bornes quiz ont voyagé pendant 4 mois à l'observatoire de Beisbroek (Brugge) à l'Observatoire Urania (Hove) et à l'observatoire Mira (Grimbergen).

A l'Expo Science des Jeunesses Scientifiques de Belgique, l'IASB était présent via une **présentation générale de l'Institut** faite de posters et de bornes *(mai 2006).*

La Politique Scientifique Fédérale à organisé une exposition au Palais royal dans laquelle l'IASB était présent aux côtés de l'ORB et de l'IRM et où il a présenté le projet cométaire Rosetta, avec une maquette de la sonde Rosetta.

La Politique Scientifique à organisé un évènement au château de Seneffe dont le thème était « les couleurs ». l'Institut était présent via un atelier sur **« la couleur des aurores »** (*septembre 2006*). Le même atelier a été utilisé lors de la Nuit européenne des Chercheurs, également en septembre.

L'IASB a pris part, en octobre, à la Wetenschapfeest au Flanders Expo de Gand avec un stand interactif (4 bornes) et des panneaux représentant les couches de l'atmosphère. La brochure éducative de l'IASB y a été distribuée en masse.

L'exposition sur le rayonnement UV, les stations UV de l'IASB, l'index UV en temps réel et les dangers des UV pour l'homme a été installée à Earth Explorer à Ostende *(de juin à septembre 2006).* Une exposition sur ce thème est prévue à l'Euro Space Center pour 2007.

L'IASB a aussi participé aux Ruimtevaartdagen à Ostende *(nov. 2006)* avec 4 bornes multimédia et une exposition sur Venus Express (SpicaV-SOIR), qui le reste de l'année se trouvait au planétarium de Bruxelles. Ce stand a aussi été monté au salon Innova/Eureka à Bruxelles.

Présence de l'IASB avec des posters sur Envisat, Mars et Venus Express, l'effet de serre, les changements climatiques et une borne interactive dans le cadre de l'exposition « Découverte et conquête spatiale » organisée par l'Expo Espace et Environnement Mariemont au centre culturel de Manage *(nov. 2006)*.

2.2.1.2. Les relations avec la presse

En 2006, des communiqués de presse ont été envoyés à propos de ces sujets:

- la campagne Sodankyla (projet SAUNA) *(mars)*
- l'arrivée de la sonde Venus Express avec l'instrument SOIR *(avril)*
- la recherche IASB sur l'index UV *(juin)*
- le lancement de MetOp-1 avec IASI et GOME-2 à bord *(octobre)*
- la journée mondiale de l'ozone *(septembre)*
- le montage de la dernière partie de l'instrument SOLSPEC *(novembre).*

2.2.1.3. Le magazine Science Connection de la Politique Scientifique Fédérale

La cellule communication soutient les scientifiques de l'IASB ou et/écrit elle-même des articles de vulgarisation de leurs recherches pour le magazine Science Connection. Voici les thèmes abordés en 2006 :

- Envisat (Gomos), auteur Didier Fussen *(février)*
- le rayonnement UV *(août)*
- Venus Express (SpicaV-SOIR) *(août)*
- les hobbys de scientifiques, exemple: guitariste *(septembre)*
- les phénomènes lumineux au-dessus des orages *(décembre)*
- le chercheur Christian Hermans à Jungfraujoch *(décembre).*

2.2.2. La communication interne

La cellule communication s'occupe aussi de la communication interne par la gestion quotidienne d'une partie du site web interne. D'autres « événements » de communication, comme la participation d'une équipe de l'IASB au 20km de Bruxelles, sont organisés par cette cellule aussi.

2.2.3. La communication scientifique

La communication scientifique en est une qui ne nécessite pas l'implication de la cellule communication. Par ce terme nous désignons un des éléments fondamentaux de la recherche scientifique: la communication des scientifiques entre eux. Les chercheurs de l'IASB ont réalisé en 2006 une quarantaine de publications présentées à des experts, dans des revues ou des livres spécialisés, une vingtaine de publications non présentées à des experts et une thèse de doctorat. Nos scientifiques ont donné plus de 75 présentations (oralement ou à travers des posters) à des symposiums, et on a eu 4 invitations (ou plutôt des demandes) pour venir donner une conférence. Enfin on peut encore mentionner que l'IASB est impliqué dans plus de 40 projets nationaux et internationaux, souvent avec d'importantes responsabilités, p.ex. comme dirigeant des activités ou comme coordinateur.

2.3. Budget

Les moyens budgétaires de l'Institut peuvent être subdivisés de la manière suivante:

- Enveloppe du personnel : les coûts salariaux du personnel statutaire
- Dotation de l'administration fédérale (section 0)
- Revenus propres (section 1)
- Lotto, programmes d'investigation ministérielle (section 2)
- Revenus de tiers, contrats d'investigation (section 3)

Pour la section 0 - dotation de l'administration fédérale:

Recettes : le total des recettes s'élevait, avec solde, à 1.319.000 euros.

Dépenses :

Personnel : 153.430 euros
Fonctionnement de subsistance : 251.275 euros
Fonctionnement spécifique lié aux projets : 331.200 euros
Équipement de subsistance : 101.300 euros
Équipement spécifique : 457.500 euros

Pour la section 1 - recettes propres :

Personnel : 121.600 euros
Fonctionnement : 36.000 euros

Pour la section 2 - budgets Lotto, programmes de recherches d'initiative ministérielle :

Recettes (subventions) : 849.275 euros, dont 233.000 euros pour le Lotto

Dépenses :
Personnel : 564.800 euros
Fonctionnement : 47.750 euros
Equipement : 207.000 euros

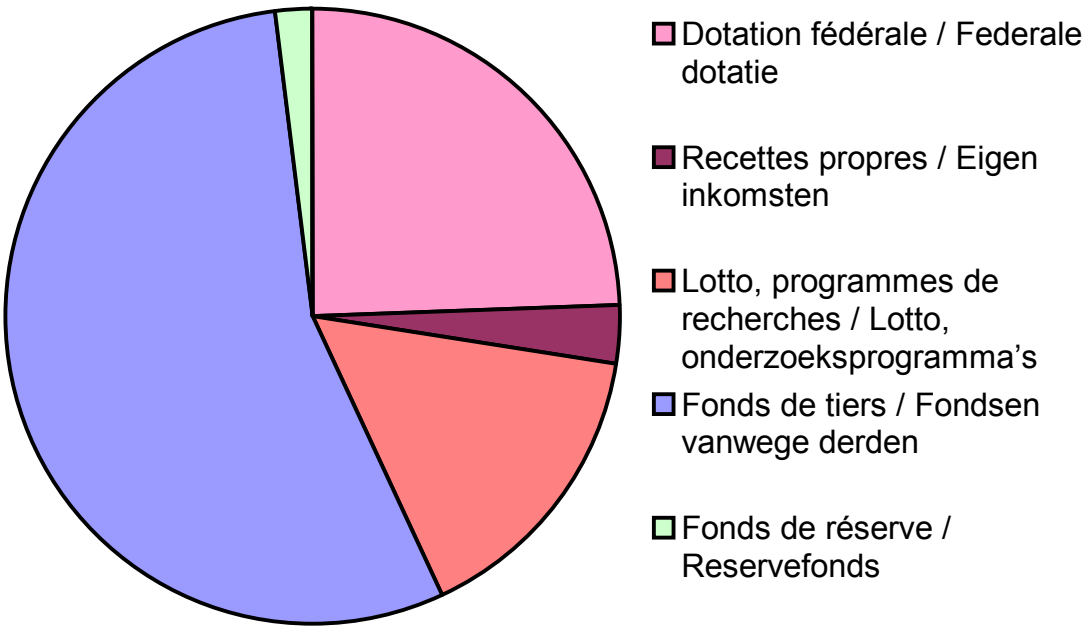
Pour la section 3 - fonds de tiers (ESA, CE, ...) :

Recettes : 2.965.700 euros

Dépenses :
Personnel : 1.881.000 euros
Fonctionnement : 569.200 euros
Equipement : 78.500 euros

Pour la section 4 - fonds de réserve :

Le solde du fonds de réserve s'élève actuellement à 100.608 euros.



2.4. ICT

Les activités de l'équipe ICT de l'IASB peuvent être divisées en deux catégories: les activités quotidiennes qui sont effectuées toute l'année, et le travail lié aux projets, qui concerne des objectifs spécifiques pour l'infrastructure entière ou pour certains projets.

Activités quotidiennes

Ce sont les activités qui nous font le plus entrer en contact avec nos utilisateurs à l'intérieur de l'Institut. Les plus importantes sont :

- Garder opérationnelle l'infrastructure de base : l'entretien des imprimantes, le remplacement ou la réparation du matériel défectueux, l'installation de nouvelles versions de programmes ou de mises à jour de sécurité, vérifier le bon fonctionnement de tous les serveurs et services.

- Le support des utilisateurs dans leurs tâches quotidiennes et la résolution de problèmes spécifiques qu'ils peuvent avoir avec les programmes ou les services. Ceci englobe aussi l'assistance au développement ou à l'adaptation de leurs propres applications.

- L'installation de nouveaux utilisateurs et le clôturage des comptes d'utilisateurs de personnes qui quittent l'Institut. En 2006 il y a eu une vingtaine de nouveaux utilisateurs.

Le temps investi dans ces activités quotidiennes augmente avec le nombre d'utilisateurs, ainsi qu'avec la diversité et la complexité croissante des applications et du matériel utilisé.
D'autre part nous essayons de garder sous contrôle cette charge permanente par une extension de la gestion centrale, une meilleure standardisation et une automatisation maximale des tâches courantes.
Pourtant, ces tâches mineures exigent une part toujours plus grande de notre temps.

Projets

Les projets majeurs qui ont été démarrés et/ou réalisés l'année passée se rapportent surtout au renouvellement et l'élargissement de l'infrastructure existante, pour mieux répondre aux exigences et attentes toujours plus grandes des utilisateurs. Voici les principales :

- Créer, émettre et tenir à jour un grand cahier des charges(+/- 1 million d'euros) pour l'achat d'un nouveau serveur de fichiers central pour le Pôle Espace. Un tel cahier des charges demande un important investissement de temps (avec, entre autres, l'analyse de marché, l'examen des besoins, la définition des exigences techniques) pour pouvoir être mené à bonne fin. La concession a enfin eu lieu en janvier 2007.

- Un changement important pour les utilisateurs d'Unix était le passage à un nouveau pseudo et à un nouveau serveur d'application basé sur Linux. ceci a été combiné avec l'installation d'une nouvelle génération de postes de travail Unix/Windows (thin clients) pour les utilisateurs. La combinaison de ces deux investissements a sensiblement augmenté la souplesse d'emploi pour les utilisateurs.
- Des investissements supplémentaires ont porté la capacité de stockage en ligne du serveur Envisat à 35 TB.
- Un réseau sans fil sécurisé a été mis en service pour donner aux visiteurs de l'Institut un accès facile à internet. Pour des raisons de sécurité, ce réseau et entièrement séparé du réseau interne de l'Institut.
- La configuration du serveur central Zeno a été ajustée, et une série de cours a été donnée pour mieux renseigner les utilisateurs sur l'utilisation de cette machine.
- Le firewall entre le réseau du Pôle Espace et internet a été étendu ensemble avec le routing switch central, en vue de la future mise à jour de la connexion internet et pour prévoir une largeur de bande supplémentaire pour le nouveau serveur de fichiers central.
- En plus, nous investissons de façon permanente pour rendre l'infrastructure entière plus fiable. Ceci se fait en investissant dans du hardware tolérant aux fautes et dans des solutions software garantissant un service continu. Ceci reste une question prioritaire, vu que de plus en plus de services informatiques peuvent être considérés comme critiques pour le bon fonctionnement de l'Institut.

Partie 3 : Conclusions et objectifs 2007

2006 était une année de consolidation des activités scientifiques et de prestation de services, mais également une année d'optimisation de l'organisation et des systèmes de gestion financière/contractuelle et des différents projets.

Pour 2007, les objectifs suivants ont été retenus :

- Continuer à optimaliser les connaissances scientifiques en vue de la création d'un Centre d'Excellence dans les domaines de la chimie et physique des atmosphères, ainsi que des plasmas spatiaux.

- Le développement, en collaboration avec l'ORB et l'IRM, du Solar-Terrestrial Center of Excellence. Pour l'IASB cela implique entre autres de rendre opérationnel le European Space Weather Portal et les services connexes.

- Poursuivre l'intégration des activités de prestation de services sous le dénominateur de « Service Center » de l'IASB. De surcroît, les activités du B.USOC, comme l'exploitation des expériences à bord de la Station Spatiale Internationale (ISS) et le Mission Control Center, feront partie intégralement de l'IASB.

- Le positionnement de l'IASB dans le projet pilote Atmosphère du programme européen GMES (Global Monitoring for Environment and Security).

- L'ouverture du 7e programme-cadre de la CE (2007-2013) est la plateforme où l'on poursuivra une participation active aux programmes internationaux.

- Une coopération structurelle internationale, vu que la recherche effectuée à l'IASB a une dimension avant tout globale. La collaboration avec d'autres continents est une valeur ajoutée très importante.

- La rationalisation de la coopération avec les universités et instituts de recherche belges.

- Une contribution active à la politique nationale et internationale, p.ex. dans le contexte du climat et de l'environnement.

Annexes

Annexe 1 : Chimie et physique des atmosphères (rapport détaillé en anglais)

Table of contents

Solar irradiance and spectral UV

Planetary atmospheres

Publications

- **Peer-reviewed**
- **Conference Proceedings**
- **Presentations at workshops and symposia (oral, poster,…)**

Introduction of the teams

This activity report is structured according to scientific themes. The contributions from different teams have been identified by the team's short name, as indicated below. In case the contact person is different from the team leader, his/her Email address is given in addition.

Teams

Infrared atmospheric observations and related laboratory experiments (IR)
M. De Mazière, B. Dils, C. Hermans, M. Kruglanski, A. Merlaud, C. Senten, A.C. Vandaele, C. Vigouroux

UV-visible atmospheric observations and related laboratory experiments (UVVIS)
M. Van Roozendael, F. Hendrick, I. De Smedt, N. Theys, J. van Geffen, G. Pinardi, C. Lerot, C. Fayt, C. Hermans, A. Merlaud, J. van Gent

Limb Remote Sounding group (LRS)
Didier Fussen, Christine Bingen, Filip Vanhellemont, Jan Dodion, Nina Mateshvili, Emmanuel Dekemper, Nicolas Loodts

Atmospheric composition and related laboratory studies using mass spectrometry (MS)
Crist Amelynck, Niels Schoon

Solar radiation radiometry (SOL)
D. Gillotay, C. Depiesse, D. Bolsée, A. Michel, W. Peetermans

Modelling of atmospheres; data assimilation and inverse modelling; theory (MOD)
J.-F. Müller, T. Stavrakou, S. Wallens, E. Capouet, F. Daerden, Q. Errera, S. Chabrillat

Synergistic exploitation of atmospheric data (SYN)
J.C. Lambert, C. De Clercq, P. Gérard, J. Granville, P. Skarlas

Activity report

Mesospheric and stratospheric ozone and related species; stratospheric aerosol and PSC.

ALTIUS
(LRS)
In view of the important gap to be expected in the next 5 years for atmospheric sounders having a good vertical resolution, BIRA-IASB has started an important space project named ALTIUS. The instrument will make use of the recently developed technique of limb scattering but it will introduce an original concept to achieve this goal, i.e., to develop one or several spectral camera's for solving the altitude registration problem. ALTIUS is intended to be launched within the the frame of a Belgian micro-satellite programme and the Institute, which is fully supported by the Belgian Scientific Policy, will be the prime for the entire mission.
Activities:
Phase 0 (CDF) – phase A study (started on Aug 1, 2006)

GOMOS
(LRS)

Working since March 2002, the GOMOS instrument is still almost fully operational. Furthermore, a second general reprocessing has delivered a considerable amount of data, covering several years of data on a global scale. The limb remote sounding team is an Expert Support Laboratory of ESA for the GOMOS mission and participates on a very regular basis to the improvement of the official products. According to our experience in the field, we paid a special attention to the stratospheric aerosols as well as to the minor constituents (Na and OClO).

Activities:
- Development of GOMOS stratospheric aerosol extinction climatology for the years 2002-2005.
- Further development of the BIRA GOMOS retrieval algorithm.
- GOMOS QWG actions: calculation of GOMOS PSC extinction profiles with our algorithm.
- ACE-GOMOS aerosol extinction validation as preparation for the ACE meeting in Canada.
- ACE-GOMOS aerosol validation organisation with teams for the instruments GOMOS, SAGE, OSIRIS and POAM.
- Binning of all data (using 'longitudinal data' statistics)
- Transmittance climatology.
- PSCs and cirrus

ACE (PRODEX)
(LRS)
BIRA-IASB is member of the ACE-MAESTRO Science team since many years. One of its responsibilities is leading the aerosol validation campaign. In this context, the

LRS team has focussed his research on the data produced by the Belgian imagers. In particular, it discovered that they may be used to discriminate between PSC's, thin cirrus and convective clouds with a spectacular accuracy. It is also developing a temperature profile product from the imager data.

Activities:

- Exploring raw imager data
- PSCs , convective clouds and cirrus
- Retrieving total extinction profiles
- Retrieving aerosol extinction profiles from total extinction
- Retrieving temperature profiles using Zernike moments

Other activities related to ACE can be found in the chapter "Synergies between ground-based, balloon and satellite data"

SQWG/ SCIAMACHY SGP OL3.0 verification
(UVVIS)

Based on its acknowledged expertise in UV-visible trace gases retrieval and associated validation techniques, BIRA-IASB contributes to the maintenance and improvement of the SCIAMACHY operational data processing. This is undertaken in the framework of the SCIAMACHY Quality Working Group (SQWG), which gathers all activities related to the evolution and improvements of the operational processing chain from Level 0 to Level 2. The recent formation of the SQWG under the ESA umbrella follows from successful similar experience with other instruments onboard ENVISAT.

Activities:

- GDP 4.0 Algorithm transfer to SCIAMACHY level 1b-2 Off-line data processor:
- Adaptation of the GDOAS algorithm allowing the total O3, NO2 and other trace gases columns retrieval from GOME measurements to the SCIAMACHY instrument.
- Establishment of optimal settings for the retrieval of total O3 and NO2 columns from the SCIAMACHY measurements with an accuracy similar to GOME data processor (version 4.0).
- Support to the DLR-IMF for the adaptation of the original GOME operational processor, based on the BIRA/IASB algorithm, to the SCIAMACHY instrument. Comparison between the O3 and NO2 columns issued from the SCIAMACHY operational processor (SGP OL 3.0) and the BIRA-IASB software and evaluation of the transfer.
- Comparison of the different total ozone columns issued from the SCIAMACHY measurements using various scientific algorithms: SDOAS (BIRA-IASB), WF-DOAS (IFE_Bremen), TOSOMI (KNMI) and SGP (ESA operational processor). Characterization of the latitude, solar zenith angle, cloud fraction and temporal dependences of the retrieved ozone columns.

GODFIT/ GOME-2 Tools
(UVVIS)

GODFIT is an ESA-funded project focusing on the development of advanced high precision retrieval algorithms for the determination of total column ozone from nadir UV backscatter measurements, with direct application to the GOME instrument on board of ERS-2. This project is currently in its Phase B. A major achievement of GODFIT Phase A was the development of the so-called GDOAS algorithm, which has been selected by ESA in 2004 for implementation in the GOME operational ground segment (leading to version 4.0 of the GOME Data Processor - GDP), and later on for SCIAMACHY as well as GOME-2 onboard METOP. The aim of GODFIT Phase B is to further consolidate the quality of the GOME total ozone product, especially for polar regions under extreme conditions of ozone columns and solar zenith angles. The project is linked to the GOME-2 tools project, where a retrieval tool based on GDOAS is delivered to EUMETSAT for use in the METOP Cal/Val facilities.

Activities:

- Software developments:
    - Implementation of the earthshine spectrum fitting scheme during the retrieval procedure in the Direct Fitting part of the GODFIT software.
    - Development of an ECMWF temperature fields ingestion interface.
    - Implementation of a new OCRA/ROCCIN cloud properties derivation, as delivered from D. Loyola (DLR)
    - Implementation of an improved Rotational Raman Scattering correction scheme, based on look-up tables generated with the LIDORT-RRS radiative transfer code. This has been used to study the influence of rotational Raman scattering in the atmospheric trace gas retrieval with Godfit.
    - Programming of reading and processing interfaces for GOME-2
- Total ozone column sensitivity study for different auxiliary input data set as the ozone cross-sections, the temperature profile and the parameters issued from various cloud algorithms. Influence on the O3 columns of the retrieval settings such as the fitting window, a possible fit of the surface albedo and/or of the temperature profile, etc.
- Analysis of measurement data collected during the Sodankyla/SAUNA campaign and contribution to the SAUNA workshop in Tenerife (7-11 Nov) with four oral presentations.
- User manual for GDOAS and other documentation for GOME-2 Tools.
- Mid-term review (19 May – ESA/ESRIN) and second progress meeting (12 Dec – BIRA-IASB) of GODFIT-2 during which last developments and results were presented.

DAEDALUS-PROMOTE
(LRS)

This activity consists in the development of a sustained service for the delivery of stratospherical aerosol information, based on past and present data from remote sounding retrievals.

Activities:

- Preparation of a proposal for the PROMOTE project. This proposal concerns an extension service entitled “Stratospheric aerosol and gas (water vapour and methane) report”; collaboration with the modeling group (Q. Errera). The proposal has been accepted in December 2006.

STRATOSPHERIC AEROSOL MODELISATION
(LRS)

Starting from stratospheric particle size distributions derived from measured extinction coefficient profiles, our group has continued since many years a modelization activity in order to integrate an accurate description of the microphysics into a 3-D transport model.

Activities:

- Extensive study of parallel computing aspects, through a literature study and the participation to a course about optimization and parallelization (general principles and specific aspects for the parallel computer "zeno" of the IRM/IASB/ORB).
- Development of the MOSTRA model: Achievement of the serial version of the model, including transport and two microphysical modules (sedimentation, coagulation); optimization and development of the parallel version using OpenMP.

Modeling of Polar Stratospheric Clouds (PSCs)
(MOD)

The study of the Antarctic winter 2003 with online coupled detailed microphysics into a 3D Chemistry Transport Model (CTM) has been completed. The 3D CTM is the core of the 4D-VAR chemical data assimilation system BASCOE which has been developed at BIRA-IASB [Errera and Fonteyn, 2001; Fonteyn et al, 2002, 2004]. The microphysical model has been developed by Dr. N. Larsen of the Danish Meteorological Institute (DMI). It describes the formation and evolution of 4 types of PSC particles through a fixed binned size distribution.

This approach of coupling a detailed microphysical model to a global atmospheric model is the first in its kind. It allows for a proper implementation of sedimentation of the particles and for a detailed study of the effect of PSC formation on the chemical state of the polar stratosphere, in particular on the formation process of the ozone hole. Model results have been compared to satellite observations of aerosol and cloud extinction made by the instrument POAM III onboard Spot-4, and to observations of various chemical atmospheric constituents made by POAM III as well as by the instrument MIPAS onboard Envisat. The results of this comparison are excellent and are published in Daerden et al [2006].

Tropospheric composition, tropospheric ozone and its precursors; interactions with biosphere

➢ Model results

IBOOT (coordinated at IASB-BIRA)
(MOD)

The IBOOT project coordinated at IASB-BIRA and financed by Belspo in the framework of the "Science for a Sustainable Development" programme has started officially on December 15, 2005. A kick-off meeting with our partners, KULeuven and

Max-Planck Institute Mainz, was held at KULeuven in June 2006, with presentations from all partners. The IBOOT project combines laboratory, theoretical and modeling investigations aiming to understand the chemistry and quantify the role of biogenic volatile organic compounds in the atmosphere. We are in charge of the modeling tasks within IBOOT. Manuel Capouet, in charge of the project, completed his PhD Thesis in January 2006 at ULB, under the supervision of Guy Brasseur and J.-F. Müller.

In a first step within IBOOT, a parameterization of the vapor pressures of monoterpene degradation products was finalized and published in Atmos. Chem. Phys. This is a necessary step in order to provide state-of-the-art estimation of aerosol production from these compounds. Next, a large number of alpha-pinene photooxidation experiments have been simulated, as well as their associated aerosol production, based on our previous work on the gas-phase oxidation mechanism (in collaboration with team of J. Peeters in Leuven) and on the vapor pressures of the oxidation products (see above). A surprisingly good model/data agreement was found, contrasting with previous studies. An article is in preparation on these results.

The IBOOT project now has its web page:
http://www.oma.be/TROPO/IBOOT/Home.html

PRODEX project "Tropospheric ozone from satellites"
(MOD)

This project (2005-2007) aims to exploit satellite retrievals of tropospheric compounds in order to improve our knowledge of tropospheric ozone precursors and their emissions. It is a continuation of precious work at IASB in the field of inverse modeling of trace gases. Inverse modeling is a new technique developed to provide improved estimates of the emissions by the use of atmospheric chemical observations in a chemical/transport model (CTM). The techniques developed and used at IASB are among the most advanced to date. In 2006, we applied these techniques to infer the emissions of carbon monoxide (CO) based on the CO vertical columns retrieved from the MOPITT instrument. The method and the results have been published in J. Geophys. Res.

Next, we are now using the GOME and SCIAMACHY NO2 and HCHO data in order to investigate the variability and trends in the emissions of nitrogen oxides (NOx) and the non-methane volatile organic compounds (NMVOC). The formaldehyde data are obtained by the group of M. Van Roozendael, while the NO2 data are obtained from the TEMIS project, a KNMI/ IASB-BIRA collaboration. Our study shows the great potential of such data to validate and improve existing dataset for biomass burning and biogenic emissions.

ACCENT
(MOD)

Our role within this "network of excellence" (NoE) of the EU FP6 programme includes a contribution to model intercomparisons and exercises, as well as a participation in

the steering committees of the “Access to emission databases” activity within ACCENT. This activity aims to disseminate emission data as well as to enhance collaborative efforts within the emission community. In 2006, several papers have been published in the literature (see below) describing the results of the modeling exercises. An international workshop has been also organized and held in December 2006.

➢ Laboratory work

VOCCIMS
(MS)

VOCCIMS stands for Volatile Organic Compound measurements by Chemical Ionization Mass Spectrometry.
Activities:

- Selected Ion Flow Tube (SIFT) studies of ion/molecule reactions and SIFT-MS detection of wound compounds
  - SIFT-MS detection of “wound VOCs” (hexenal, hexenol, methanol, acetone,...), emitted after cutting leaves of Trifolium Repens, using a custom-designed leaf enclosure (including a cutting device). Study of the influence of water vapour (present in ambient air and emitted by the leaves in the enclosure) and of variable incoming airflows on the quantification of emitted acetone flows by SIFT-MS.
  - Product ion distributions of ion/molecule reactions of H_3O^+ ions with four sesquiterpenes (important biogenic volatile organic compounds with molecular formula $C_{15}H_{24}$) in view of their detection and quantification by SIFT-MS and PTR-MS.
  - Set-up of an inlet system for introducing controlled amounts of sesquiterpenes (low vapor pressure compounds) in a flow tube reactor, in view of future kinetic measurements. Preliminary tests of this system.
  - Absolute and relative rate constant measurements of ion/molecule reactions of H_3O^+ ions with four sesquiterpenes in view of their detection and quantification by SIFT-MS and PTR-MS.
  - Follow-up and analysis of quantumchemical (DFT) calculations of molecular parameters (electric dipole moment and polarizability), which are required for calculating ion/molecule collision rate constants (in collaboration with the quantum chemistry group of P. Bultinck at Ghent University).

- Transformation of the existing SIFT detection chamber into a differentially pumped chamber.
  - Aim:
    - To enhance lifetime and performance of the ion detector through more efficient pumping of the detector.
    - Creating the space required for housing a new detector type (with a conversion dynode) with a less pronounced mass discrimination at the high mass range.
  - Activities related to this transformation
    - Design of the new vacuum chamber, detector flange and detector mounting accessories (in cooperation with Jeroen Maes)

construction of the chamber, detector flange and detector mounting accessories (in the mechanics workshop of BIRA)
testing the vacuum performance of the new differentially pumped configuration
testing the new mass spectrometer configuration with the old SEM detector
testing the new mass spectrometer configuration with the new ion detector with a conversion dynode

- Activities related to the Triple Quadrupole Mass Spectrometer (TQMS)

  This new apparatus has been financed by the National Lottery (project "Tandem Quadrupooluitrusting voor de structuurbepaling van ionen in een flowing afterglow opstelling") and has been installed in May 2005. The TQMS-related activities in 2006 were:

  Further optimalisation of the electrostatic lens system for the introduction and transport of external ions into the apparatus
  First break-up tests (MS/MS) with external and internal ions
  Thorough literature study about TQMS instrumentation and study of protocols for obtaining instrument-independent MS/MS spectra
  Measurement of stopping potentials in order to derive the ion energy in the collision cell
  Calibration of pole bias voltages for the two mass filters and the octopole guide
  Optimization of the configuration files for studying internally and externally produced ions.

- Literature study on in situ measurements of biogenic volatile organic compounds and co-writing of several proposals for future BVOC measurements with a Proton Transfer Reaction Mass Spectrometer (PTR-MS) (Lotto 2005), which has been ordered at the end of December 2006.
- Performance tests of the new rootspump configuration, which will replace the one which is presently used to pump the SIFT apparatus. This new configuration has a higher pumping capacity and as a result the useful pressure range of the reactor will be extended towards lower pressures.
- Writing a paper on the results of a SIFT-MS study of H_3O^+, NO^+ and O_2^+ ions with a series of biogenic alcohols.

IMPECVOC
(MS)
(started on 15 December 2006)

Preparatory Activities:
intensive search for materials and instrumentation for branch cuvette construction
testing different configurations (including dry pumps, flowmeters, solenoid valves) to sample air from cuvettes through long Teflon tubes in a controlled way.
technical meetings (at Ghent University) with the IMPECVOC partners (10/10/2006 – 16/10/2006 – 23/11/2006)

Laboratory spectroscopy
(IR and UVVIS)

The following laboratory experiments have been carried out in collaboration with the Service de Chimie Quantique et de Photophysique (SCQP) of the ULB, for the measurements of new or improved spectroscopic parameters:

- Measurements and interpretation of isopotologues of NO_2 in the UV-visible region (collaboration with R. Jost, Grenoble)
- Measurement and interpretation of absorption cross sections of BTX (Benzene, Toluene and Xylenes) in the UV region; temperature and pressure effects
- Measurement campaign at Reims (H2O isopotologues) (in the frame of AGACC – see Section 'Ground-based observations of atmospheric composition -Long-term monitoring')

Atmospheric species and processes impacting air quality

PROMOTE/ TEMIS HCHO and NO2
(UVVIS; Isabelle.Desmedt@oma.be)

As part of the DUP-2 and GSE programmes BIRA-IASB develops advanced satellite data products for the global monitoring of the tropospheric composition, based on observations from the GOME, SCIAMACHY, OMI and GOME-2 instruments. This work is performed in collaboration with scientists from KNMI (The Netherlands) and DLR (Germany).

Activities:

- Update and maintenance of the NRT SCIAMACHY NO2 slant column service.
- Improvement of the GOME and SCIAMACHY formaldehyde products:
  - Optimization of HCHO retrieval settings in order to optimize the consistency of slant columns from both GOME and SCIAMACHY instruments.
  - Update of HCHO AMFs, using profiles from the IMAGES v2 model (J-F. Muller and J. Stavrakou, 2006). This model includes advanced treatment of VOC chemistry and emissions, adequate for accurate HCHO profile estimations.
- The GOME HCHO product has been used successfully into the IMAGES model to constrain VOCs emissions. (J-F Müller, T. Stavrakou).
- GOME HCHO columns generated for the 1997-2005 period + one year of SCIAMACHY HCHO data. Work in progress with KNMI to put these data on the TEMIS/PROMOTE web site.

TEMIS intercontinental transport
(IR and UVVIS)

The FLEXTRA and FLEXPART trajectory models were installed and implemented at BIRA-IASB. These models are used to determine accurate source-receptor relationships. Currently we are investigating the 2004 Reunion FTIR measurement results (in particular, signatures of biomass burning gases advected from

Madagascar), as well as intercontinental transport (e.g., of NO_2 towards Europe) in the frame of the TEMIS project.

PROMOTE/ SACS
(UVVIS; Jos.VanGeffen@oma.be)

The Support to Aviation Control Service (SACS) is one of the service from the GSE Atmospheric project PROMOTE. SACS is managed by BIRA, with CGS, DLR and KNMI as partners. It proposes a Near-Real-Time (NRT) volcanic warning tool based on satellite observations of SO_2 emissions based on SCIAMACHY, OMI and GOME-2 instruments. Additional information on volcanic dust is derived from analysis of MSG images. Further a dispersion model is used to monitor the plume extension and evolution. This service is meant to support European Volcanic Advisory Ash Centers (VAAC) and through them aviation control.

Activities:
- Coordination of SACS (service lead).
- SO2 retrieval and set-up of near-real-time (NRT) process for SACS, and accompanying web pages for showing results and product information.
- NRT processing of SO2 made public on 27 Sep. 2006.
- Service dedicated website set up: http://sacs.aeronomie.be/
- SACS workshop held at BIRA on 3 Oct. 2006.
- Started work on the automatic email notification of exceptional SO2 concentrations, e.g. as a result of volcanic eruptions.
- Archive of SO2 based on SCIAMACHY data (also for TEMIS project)

UAV
(UVVIS and IR; Alexis.Merlaud@oma.be)

In 2006, we have initiated a project aiming at the development of compact and light-weight spectrometer systems for remote sensing of pollution onboard an unmanned aerial vehicle, in collaboration with VITO and Unité de physique atomique, moléculaire et optique (PAMO), at UCL (De Mazière et al., 2006).
Activities:
- Participation to the workshop "Airborne Imaging Spectroscopy", October the 10th, in Bruges, Belgium
- Participation and presentation at the workshop "The future of remote sensing", October the 17th-18th, in Antwerpen, with paper entitled: "Regional Monitoring of tropospheric NO2 and CO using remote sensing from high altitude platforms-preliminary concept", De Maziere M, Van Roozendael M., Merlaud A.
- Meeting with VITO to define collaboration for the UAV project; preparation of a meeting with Belgian Science Policy
- Initial studies regarding the UAV payloads (Phase A)

Greenhouse gases

UFTIR
(IR)

In the frame of the European UFTIR project, coordinated at BIRA-IASB (Time series of Upper Free Troposphere observations from a European ground-based FTIR network, http://www.nilu.no/uftir) we finalised the analysis of the 1995-2005 time series of O_3 vertical profiles from FTIR ground-based measurements at the Jungfraujoch. The O_3 data at all UFTIR stations have been collected and verified, validated against independent correlative data from ozone sondes, Brewer, Dobson or UV-visible spectrometers, and the long-term trends over the last decade have been investigated. A publication is in preparation.
The UFTIR project ended officially end of January 2006, and the final report has been delivered to EU. In addition, there will be common publications concerning each target gas in the project (O_3, N_2O, CH_4, CO, C_2H6, HCFC-22), and the associated model and trend studies, in a Special Issue in the Atmosperic Chemistry and Physics (ACP) Journal, in 2007.

HYMN
(IR)

The close collaboration with the European FTIR teams will be continued in the frame of a new European project called HYMN (Hydrogen, Methane and Nitrous oxide: Trend variability, budgets and interactions with the biosphere http://www.knmi.nl/samenw/hymn) that started on September 1, 2006 (KO meeting at KNMI on October 10-11, 2006). We will contribute with retrieval strategies and data for CH_4 at Réunion Island.

Evergreen
(IR)
The work regarding the validation of the greenhouse gases retrieved from SCIAMACHY in the near-infrared channels (CO, CH_4, CO_2, and N_2O) with the algorithms WFM-DOAS, IMAP-DOAS and IMLM, which was performed in the frame of the European Evergreen project (http://www.knmi.nl/evergreen), has been presented at the Final International Evergreen Workshop, in January 2006, and published by Dils et al., (2006). It has been continued afterwards, for validating the CO and CH_4 products from the latest versions of the WFM-DOAS algorithm. The results have been presented at the ACVE-3 meeting and will be published in the Proceedings (Dils et al., 2007).

IASI (PRODEX)
(IR)

The Infrared Atmospheric Sounding Interferometer (IASI; http://smsc.cnes.fr/ IASI) has been launched onboard METOP-1 on October 19, 2006. The spectral data will be distributed from March 2007 onwards. An EUMETCAST reception system is being setup at the institute, for the reception of IASI and GOME-2 L1 and L2 data.

It is our intention to contribute to the retrieval of scientific data products for some gases, CH_4 and N_2O in particular, and aerosol. To this end, a new line-by-line spectral modeling and retrieval algorithm called ASIMUT has been developed. It is a modular

and flexible code, that can handle several observation geometries. It has been tested on ground-based, IMG and ACE spectra.
In parallel, an algorithm developed previously to retrieve boundary-layer aerosol optical depths above the ocean from IASI-like spectra (nadir high-resolution radiance spectra in the thermal infrared) has been extended to both low-altitude and higher-altitude tropospheric aerosols (such as transported biomass burning aerosols and Sahara dust). It has been verified thoroughly using the well-known LBLRTM and CHARTS codes, and will now be coupled to ASIMUT.
We have also started the preparation of a coordinated validation activity, using a network of ground-based FTIR data, as well as the preparation of an FTIR measurement campaign at the Ile de La Réunion for contributing to this validation activity.

Ground-based observations of atmospheric composition:
➢ Long-term monitoring

NDACC
(IR and UVVIS)

BIRA-IASB is strongly involved with the Network for the Detection of Atmospheric Composition Change (http://www.ndacc.org, formerly called NDSC, Network for the Detection of Stratospheric Change). It operates UV-Vis (MAX)DOAS instruments at the Jungfraujoch in the Swiss Alps, at the Observatoire de Haute Provence, and at Harestua in Norway. Since 2002 it has performed FTIR and UV-Vis MAXDOAS campaigns at the Ile de La Reunion in the southern subtropics, in preparation of permanent monitoring activities at this complementary NDACC site.
Activities:

- Maintenance of the BIRA-IASB instruments at the three NDACC stations (Harestua, OHP, Jungfraujoch) and operational data retrieval. NO2 and O3 column results are regularly submitted to the NDACC data base.
- The FTIR spectra taken at Ile de La Réunion (21°S, 55°E) during 2 campaigns in 2002 (October) and 2004 (August to end of October) have been further analysed. The retrievals have been optimized for the direct greenhouse gases methane (CH4), nitrous oxide (N2O) and ozone (O3), the gases carbon monoxide (CO) and ethane (C_2H_6) that are indirect greenhouse gases, as well as for hydrogen cyanide (HCN) and the stratospheric species hydrogen chloride (HCl), hydrogen fluoride (HF) and nitric acid (HNO3). All retrievals have been executed using version 3.92 of the inversion tool SFIT2, that was implemented in the beginning of 2006.
  The retrievals have been characterized, the error budgets have been evaluated, and the retrieval results have been validated against independent balloon-borne or space-based data. In particular, comparisons have been made with data from the Canadian ACE satellite. Some geophysical interpretation of the data is ongoing. A publication is in preparation (Senten et al., 2007).
  This work is the first part of the research project ‘Development and evaluation of a modified Optimal Estimation Method inversion algorithm for ground-based FTIR spectra. Application to spectra recorded at Réunion Island’, funded by Belgian

Science Policy. The next part of this project will focus on the improvement of the retrieval algorithm.

Preparations are ongoing for a new, long-lasting campaign for FTIR observations at Ile de La Réunion that is planned between April and end of 2007.

- The BARCOS, Bruker Automation and Remote Control System for atmospheric observations (Neefs et al., 2006) has been further improved. The development of an operational version, for implementation at the Reunion Island during the FTIR campaign that is planned in 2007, is ongoing. The BARCOS manual is being updated as well.
- A new solar tracker for the FTIR experiment is being designed and built at the BIRA mechanical workshop (collaboration with E. Neefs and J. Maes)
- The concentration of CO at Jungfraujoch is measured on a continuous basis at the surface by in-situ observations, with a non-dispersive infrared detection method. It is also observed regularly by FTIR remote-sensing methods in the boundary layer. The comparison between both data sets, and its interpretation using trajectory modeling, is ongoing, in collaboration with colleagues from the University of Liège and EMPA in Switzerland. A publication is planned early 2007. This activity will be continued in the frame of the project GEOMON.

GEOMON
(IR, UVVIS and SYN)

In 2006, we have contributed to the preparation of the European Integrated Project GEOMON that will start in February 2007. The overall goal of the GEOMON project is to sustain and analyse European ground-based observations, complementary with satellite measurements, in order to identify, quantify and understand the ongoing changes in atmospheric composition that impact climate, ecosystems and human health. GEOMON will support the monitoring of atmospheric composition in Europe as a contribution to GMES (Global Monitoring for Environment and Security), the European element of GEOSS (Global Earth Observation System of Systems). BIRA-IASB is Activity Leader of the 'Stratospheric Ozone and Climate' Activity, and contributes with its NDACC activities for stratospheric composition monitoring and detection of reactive gases. It is also leader of the work package 'about the integration of GEOMON data with satellite observations', for which we refer to the Section 'Synergies between ground-based, balloon and satellite data'

AGACC
(IR and UVVIS)

The AGACC project (Advanced Exploitation of Ground-based measurements for Atmospheric chemistry and climate applications; http://www.oma.be/AGACC/Home.html) is coordinated at BIRA-IASB and financed by Belgian Science Policy in the framework of the "Science for a Sustainable Development" programme; it started officially on December 15, 2005. The Kick-Off meeting was held in February 2006.
In the frame of this project , we have been looking specifically at the retrieval strategy for HCN, in collaboration with our colleagues from Liège University (GIRPAS team).
Also in the frame of AGACC, we have performed an FTIR measurement campaign at Ukkel in the 2nd half of 2006, focusing on the observation of water vapour and its isotopologues and on formaldehyde. This campaign also involved a UV-VIS MAXDOAS instrument targeting the measurement of formaldehyde. The spectral

data analysis is ongoing. The aim is to compare UV-Vis and FTIR measurements of the same species (formaldehyde), in view of near-future measurements at the Jungfraujoch.

NOVAC
(UVVIS)

The Network for Observation of Volcanic and Atmospheric Change (NOVAC) is an EU FP6 project the aim of which is to establish a global network of stations for the quantitative measurement of volcanic gas emissions based on UV absorption spectroscopy. Coordinated by Bo Galle from the Chalmers University in Goteborg, this project relies on a novel type of instrument, the Scanning Dual-beam miniature – Differential Optical Absorption Spectrometer (Mini-DOAS), which has been developed within the precursor EU-project DORSIVA. As part of NOVAC, Mini-DOAS instruments will be installed in 15 volcanic observatories and used to provide new parameters in the toolbox of the observatories for risk assessment, gas emission estimates and geophysical research on the local scale. In addition to this, data will be exploited for other scientific purposes than local volcanic gas emissions, e.g. global estimates of volcanic gas emissions, large scale volcanic correlations, studies of climate change, studies of stratospheric ozone depletion. In particular large scale validation of satellite instruments for observing volcanic gas emissions will be possible for the first time, allowing to bring observation of volcanic gas emissions from space a significant step forward. The contribution from BIRA-IASB to the project is related to the optimization of the spectroscopic measurements including instrumental characterization and retrieval algorithm development, as well as to establishing the link with satellite measurements (e.g. as part of SACS activities).

Activities:
- Participation to the First Annual Meeting at La Granada, Nicaragua and contribution to the training courses with a talk on DOAS algorithms (4-9 Dec).
- Characterization of the Ocean Optics S2000 spectrometer (wavelength calibration, dependency of the slit function in temperature, stray-light measurement) in the laboratory of the Institute
- MiniDOAS characterisation, with focus on the temperature effect on the calibration and on the detector (dark current and offset), and the stray-light issue.
- Participation to the first two NOVAC Spectroscopy meetings in Heidelberg (4 August and 21 December 2006), with key contribution on data analysis and SO2 retrieval issues.

➢ Observation campaigns

SAUNA and DANDELIONS
(UVVIS)

- Participation to the SAUNA intercomparison campaign in Sodankyla, Finland (20 March – 12 May 2006) with three ground-based DOAS instruments. The aim of the campaign is to establish a baseline for accurate total ozone measurements for use in satellite validation. The SAUNA campaign was linked to the GODFIT-2 project.

- Participation to the DANDELIONS-2 campaign for the validation of OMI and SCIAMACHY troposheric NO2 measurements, in Cabauw, the Netherlands (1-30 September 2006). Three ground-based DOAS instruments have been operated, and used for OMI and SCIAMACHY NO2 validation. Papers are in preparation for the JGR special issue on AURA validation (Deadline March 2007).
- Design of an OMI Level 1 data ingestion procedure for the WinDOAS software in view of test OMI retrievals of BrO and HCHO in the OMI validation context (contribution to ESA OMI AO)

Synergies between measurement systems; synergies with modeling (data assimilation)

➢ Synergies between measurement systems

Research undertaken at the institute often relies on the integrated use of multi-platform atmospheric composition measurements. Several projects are based directly on the integrated use of data, while others aim at the development of the needed synergistic techniques. Integrated use of data has played a major role in the following main activities:

- Geophysical validation of level-2 data products retrieved from satellite measurements using ground-based network data: ACE (FTS, MAESTRO), Envisat (GOMOS, MIPAS, SCIAMACHY), EOS-Aura (OMI), ERS-2 (GOME-1), MetOp-1 (GOME-2, IASI)
- Diagnostic, maturation and verification of related satellite retrieval algorithms using ground-based network data
- Integrated use of data acquired by complementary ground-based networks and satellites: characterisation of the measured information content associated with each measurement technique; development of physically-based comparison methods and related error budgets; study of observation operators needed by assimilation models to ingest measurements
- Multi-platform studies of stratospheric and tropospheric species

Using our technical, scientific and management experience gained in satellite validation and synergistic studies, we have also contributed to the following planning and coordinating activities:

- Co-chair of the NDACC Satellite Working Group, fostering collaboration among atmospheric scientists involved in the NDACC and in satellite missions
- Vice-chair of the CEOS Working Group on Calibration and Validation (WGCV)/Atmospheric Chemistry Sub Group (ACSG), a high-level body of the space segment of GEOSS dedicated to ensuring accurate and traceable calibration of remotely-sensed atmospheric chemistry radiance data and validation of higher level products at interagency level, and to improving exchange of validation resources and expertise
- International coordination of validation projects for ACE, GOME-1, GOME-2, GOMOS, IASI, MIPAS, OMI and SCIAMACHY
- Operation of the QA/Val Office of the GMES Service Element PROMOTE project
- Preparation of the EC FP6 GEOMON project (see introduction above and description below), among others as leader of WP 4.2 “about the integration of

GEOMON data with satellite observations" and as member of the "GEOMON Satellite Working Group"

CINAMON (PRODEX)
(IR, UVVIS and SYN)

The PRODEX CINAMON project covers research activities carried out in the framework of three ESA AO projects plus two ESA/EUMETSAT RAO joint projects and one ESA/NIVR joint project, all approved by ESA and all coordinated at BIRA-IASB. The overall objective of these projects is to contribute to the characterization, maturation and interpretation of satellite data products from several platforms: ERS-2 (GOME-1), Envisat (MIPAS, GOMOS, SCIAMACHY), Earth Probe (TOMS), EOS-Aura (OMI), and MetOp-1 (GOME-2 and IASI). These projects addresses the following subjects which, put end to end, improve the quality and the use of the considered satellite data products:

- Development of physically based tools to characterise the multi-dimensional information content available from a satellite measurement
- Adaptation of those tools with a view to performing comparisons between satellite data and NDADC data, and to derive error budgets including the smoothing of natural variability
- Exploration of existing atmospheric composition measurement techniques as satellite validation tools, e.g., about the use of MAX-DOAS instruments for the validation of tropospheric measurements by GOME-like instruments
- Geophysical validation of level-2 data products by confrontation with pole-to-pole measurements acquired by the NDACC and WMO/GAW networks
- Verification of satellite data using independent/prototype retrieval algorithms
- Support to the implementation of prototype retrieval algorithms to the operational environment established at DLR on behalf of ESA
- Further development of tools to explore the possible integration of complementary long-term data records acquired by the different satellites, among others through the use of chemical data assimilation systems

Regarding the tools and techniques developed, a special care has been given in 2006 to:

- Line-of-sight issues of total ozone remote sensing by NDACC-certified instruments and by major satellite systems; participation to the SAUNA campaign organized at Sodankylä in Finland by NASA, FMI and ESA (see "Observation campaigns"); results presented during the SAUNA workshop held in Puerto de la Cruz and the GODFIT meeting held at BIRA-IASB, both in November 2006
- Line-of-sight issues of limb emission measurements with application to MIPAS and the impact on validation studies and data assimilation; results reported during the Atmospheric Chemistry Conference in Frascati in May and to be published, for O_3 and temperature, in the MIPAS ACP Special Issue
- Development of a novel technique to validate NO_2 profile satellite data using NO_2 column data from the NDACC; this technique uses BASCOE analyses to assess the contribution of the lower stratospheric column not seen by the satellite

- Exploration of MAX-DOAS measurements for the validation of tropospheric data by GOME-like instruments; participation to the DANDELIONS campaign organized in the Netherlands by KNMI, and also to SAUNA (see “Observation campaigns”)
- Development of a cross-correlation technique relying on NDACC data to study satellite error pointing issues of SCIAMACHY limb profile data; results have been reported during the SCIAMACHY limb pointing error meeting held at IFE/IUP-Bremen, and ACVE-3 in Frascati, both in December 2006

Tools, methods and techniques have been instrumental in preparing WP 4.2 of the EU FP6 integrated project GEOMON, ‘about the integration of GEOMON data with satellite observations’, and in defining the PROMOTE Validation Protocol (see below). They have also been valuable to establish guidelines for the routine validation of Envisat data products in the framework of TASTE (see below).

Regarding satellite validation activities contributing to the characterisation and improvement of satellite data products and related algorithms (as opposed to routine validation which contributes more to the monitoring of the instrument performance), ground-based FTIR data from a subset of NDACC have been used for a coordinated validation of MIPAS profile data (ESA products v4.61) for N_2O and HNO_3 in the year 2003. The validation included comparisons of the FTIR data with results from the BIRA-IASB 4D VAR data assimilation system BASCOE, to verify their usage as proxies of the MIPAS profiles. This work has been published in ACP (Vigouroux et al., 2007). Ground-based lidar, microwave radiometer and UV-visible data, as well as small-balloon ozonesonde/radiosonde data, at all NDACC stations plus additional WMO/GAW sites have been used for a coordinated validation of MIPAS 4.61 profile data for temperature, O_3 and NO_2. Here, analyses provided by BASCOE have not been used for comparison with MIPAS data, but rather for the estimation of vertical and horizontal smoothing errors of MIPAS data and their impact on comparisons with NDACC data. The work for NO_2 has been submitted to ACP (Wetzel et al., 2007). We also contributed intensively to the coordinated validation exercise that was set up by the MIPAS team at Forschungszentrum Karlsruhe, for temperature, N_2O, NO_2, CH_4, HNO_3, and O_3 profile data delivered by ESA (v4.61). In this exercise, we have collected all contributing ground-based data (FTIR, lidar, microwave radiometer, ozonesonde/radiosonde, UVVIS); we have carried out correlative studies of the MIPAS data; and we have exchanged the results with the contributing teams. The papers for temperature, O_3 and HNO_3 will be submitted by the product coordinators (M. Ridolfi for temperature, U. Cortesi for O_3, Wang for HNO_3) early 2007.

The new processors GOMOS IPF 5.00 and SCIAMACHY SGP 3.0 have also been validated against NDACC network measurements (lidar, ozonesonde and microwave radiometer for the O_3 profile, UV-visible spectrometers for O_3, NO_2 and BrO columns, Brewer and Dobson spectrophotometers for O_3 columns). The team has provided particular support to the implementation of the prototype algorithm SDOAS into the operational environment at DLR (see above description of SQWG activities). Based on our expertise regarding the validation of SCIAMACHY O_3, NO_2, BrO, CO, CH_4, and N_2O columns (see also Section ‘Greenhouse Gases – Evergreen’) we have performed the coordination of the validation of these products within the SCIAVALIG team (http://www.sciamachy.org/validation). SCIAMACHY results have been reported during the SCIAMACHY Pre-validation Meeting held in September 2006 at KNMI.

GOMOS, MIPAS and SCIAMACHY results have been reported during ACVE-3, including various oral and poster presentations and paper proceedings. The team has also contributed to the organisation of the SCIAMACHY sessions on radiances and irradiances, O_3 and NO_2 columns, and cloud data products.

We have also carried out a preliminary validation of OMI O_3 and NO_2 columns based on retrievals performed at NASA/GSFC. Results have been summarised in a general OMI Validation Report coordinated by KNMI and will be published in the JGR Aura Special Issue for which contribution must be submitted by April 2007.

Finally, plans for the upcoming validation/maturation of GOME-2 retrieval algorithms and data products have been presented to ESA and EUMETSAT during the First EPS/MetOp RAO Workshop held in Frascati in May 2006.

Characterisation and maturation of O_3 profiling algorithms for GOME (CHEOPS)
(SYN)

Built upon the outcome of the GOME-1 Ozone Profiling Working Group (http://earth.esa.int/gome1/) set up in 2001 by ESA and coordinated jointly by IASB-BIRA (J-C Lambert) and NASA/GSFC (J. Gleason), CHEOPS-GOME aims at further developing two ozone profile retrieval algorithms for ERS-2 GOME-1: a physically based algorithm retrieving O_3 profiles from GOME-1 spectra using the Optimal Estimation technique (OPERA, operated at KNMI), and a fast algorithm based on a neural network trained on several ground-based and satellite profile measurement data records (NNORSY, operated at ZSW). The overall project consists of five main tasks:

- Level-0-to-1 data processing issues (calibration, degradation, polarisation…)
- Ozone profile retrieval with OPERA
- Ozone profile retrieval with NNORSY
- Evaluation of retrieval techniques and characterisation of measured information content /geophysical validation of data products
- Development of new ozone profile climatologies for 1995-2005

Activities:

- Further development of diagnostic and characterisation methods developed within the PRODEX CINAMON project, based on the combined analysis of averaging kernels, co-variances, a priori constraints, and comparisons with NDACC and satellite observations
- Independent evaluation of OPERA Optimal Estimation algorithm and related GOME-1 ozone profile data records retrieved at KNMI
- Independent evaluation of NNORSY neural network algorithm and related GOME-1 ozone profile data records retrieved at ZSW

Maturation of O_3 and NO_2 retrieval algorithms for nadir-looking UV-visible satellites
(SYN and UVVIS)

Based on its acknowledged expertise in UV-visible trace gases retrieval and associated validation techniques, BIRA-IASB has continued his long-lasting contribution to the improvement of O_3 and NO_2 column retrieval algorithms for nadir-looking UV-visible satellites like GOME-1, GOME-2, OMI and SCIAMACHY.

Activities in 2006:

- Completion of the JGR validation paper of GOME Data Processor (GDP) version 4.0 for GOME-1 O_3 column processing
- After improvement at DLR of the level-1 calibration of the entire GOME-1 time series, organisation of and contribution to: (a) a verification exercise of the new level-2 O_3 column data version 4.1, and (b) geophysical validation of the entire GOME-1 GDP 4.1 data record (1995-2006) of O_3 and NO_2 column data using NDACC and WOUDC ground-based network data archives
- GDP 4.0 algorithm transfer to SCIAMACHY level 1b-2 Off-line data processor SGP 3.0: first verification of a small data set in August-September 2006, followed by the geophysical validation of an extended data set of SCIAMACHY data using NDACC and WOUDC ground-based network data archives
- Preliminary validation of OMI O_3, NO_2 and BrO column data retrieved at NASA and at KNMI
- Preparation of an end-to-end GOME-2 validation based on different types of retrieval and the integrated use of ground-based network data

Technical ASsistance To Envisat (TASTE) using spectrometers, radiometers and ozonesondes
(SYN, IR and UVVIS)

This project consists of essential activities being performed to ensure proper validation of Envisat atmospheric chemistry data products and evaluation of related algorithms improvements. TASTE ensures that correlative measurements acquired by ground-based systems and ozonesondes are available to the geophysical validation and algorithm maturation for data products of the Envisat atmospheric chemistry payload (GOMOS, MIPAS and SCIAMACHY). Tasks include the collection and regular delivery of NDACC correlative data (about 20 stations) to the Envisat Cal/Val database operated at NILU on behalf of ESA; delivery includes the conversion to the agreed format HDF 4.1.3. Systematic and random differences between Envisat and ground-based data sets are determined and discussed by the consortium. Consolidated results are reported to concerned parties and valorised through public presentations, web articles, and massive contributions to ESA's ACVE conferences. Results are an important input to ESA's GOMOS, MIPAS and SCIAMACHY Quality Working Groups, and are also used as input in projects like CINAMON and GEOMON.

Activities in 2006:

- Coordination of Envisat validation activities carried out by the TASTE consortium
- Upload to Cal/Val database of ground-based UV/Vis and FTIR data acquired by IASB-BIRA at the NDACC stations of Harestua and the Jungfraujoch

- Routine validation of several Envisat atmospheric chemistry data products (O_3, NO_2, CH_4, N_2O, HNO_3, BrO, temperature) generated by the operational processors MIPAS IPF 4.61 and 4.62, GOMOS GOPR 6.0cf and IPF 5.0, and SCIAMACHY SGP 3.0.
- Contribution to SCIAMACHY Pre-validation Meeting in September at KNMI
- Contributions to ACVE-3, including various oral and poster presentations and paper proceedings as well as the organisation of the SCIAMACHY sessions on radiances and irradiances, O_3 and NO_2 columns, and cloud data products

ACE (PRODEX)
(IR and SYN)

Being coordinator of the validation of the CH_4 data from ACE, we have started collecting the correlative data and validation results by independent teams. In 2006, we have mainly looked at the correlative data from ground-based FTIR instruments. The preliminary validation results based hereupon have been presented at the 14th ACE Science Team meeting. Additional data sets and results will be integrated in the validation exercise early 2007, with the objective of making an assessment of the quality of the ACE CH_4 data based on an extended set of correlative data, before mid 2007.

The SYN group has worked on the geophysical validation of temperature profile data from ACE-FTS, and of O_3 and NO_2 data from both ACE-FTS and ACE-MAESTRO. Temperature studies were based on correlative measurements collected from about 30 radiosonde and 10 lidar stations of the NDACC. Ozone studies were based on correlative measurements collected from about 40 ozonesonde, 10 lidar and 4 microwave radiometer stations of the NDACC, and NO_2 studies on correlative measurements collected from about 30 UV-visible spectrometers. A first round of studies will be finalized in 2007 in order to contribute to coordinated validation effort and related papers.

PRODEX NOy-Bry
(UVVIS)

- Study of the seasonal variation and trends of tropospheric and stratospheric BrO at the NDACC station of Harestua using ground-based DOAS profiling
- Start of a comparison exercise between the tropospheric BrO vertical columns retrieved at Harestua and the p-TOMCAT tropospheric model (University of Cambridge)
- Validation of MIPAS-ENVISAT version 4.61 NO_2 data using ground-based DOAS profiling at Harestua
- Validation of the Canadian ACE-FTS and ACE-MAESTRO NO_2 profiles using ground-based UV-vis profiles retrieved at Harestua and Reunion Island
- Validation of SCIAMACHY NO2 and BrO limb and nadir products (OL 3.0 and scientific products) using ground-based UV-vis profiles retrieved at Harestua and Reunion Island
- Contribution to the retrieval of CNRS/SA SAOZ balloon BrO profiles through model simulations of the BrO diurnal variation

- Analysis of tropospheric and stratospheric BrO data at Reunion Island and Observatoire de Haute-Provence, based on a two-layer inversion technique designed for multi-axis DOAS observations.
- Development of a new stratospheric BrO column and profiles climatology based on chemical and dynamical indicators, obtained through analysis of 3D-CTM calculations from the BASCOE model
- Refinement of the first global climatology of stratospheric NO_2, built upon the harmonic integration of measurements from the HALOE, POAM-III and GOME-1 satellites and the NDACC/UV-visible network.
- Intercomparison of radiative transfer tools for NO2 and BrO nadir observations in the framework of the O3-SAF visiting scientist project
- Intercomparison of the IASB-BIRA and University of Toronto NO_2 profiling tools.

PROMOTE – Quality Assessment/Validation Office
(SYN)

PROMOTE, an ESA-funded project standing for PROtocol MOniToring for the GMES Service Element on Atmospheric Composition, delivers sustainable geo-spatial information services relevant to atmospheric ozone, surface UV exposure, air quality, and climate change. Services are directed to a wide spectrum of users including public authorities, governmental and intergovernmental agencies, industries active in the energy and health sectors, as well as the general public. Services usually make integrated use of ground-based monitoring capacities, airborne and space-based Earth observation, and numerical models. PROMOTE is a major element of Global Monitoring of Environment and Security (GMES), the European contribution to the international Global Earth Observation System of Systems (GEOSS). As PROMOTE services are to support informed decisions with societal and economical impact, it is crucial to establish and verify the “fitness for purpose” of each service and its sustainability through rigorous validation. This implies efficient cooperation with service developers and end-user organisations. GMES/GEOSS commitments also call for establishing general standards and working practices. To ensure appropriate, user-driven validation of PROMOTE services, compliant with GMES requirements of standardization and sustainability, we have established a dedicated office for the coordination of PROMOTE services validation and quality assessment.
A main task of the PROMOTE QA/Val Office is to manage the top-level definition of applicable standards and validation approaches for all constituents of the Service Portfolio, in order to generate the Service Validation Protocol that will be applied consistently across the services network. Where relevant, the office seeks for consistency with standards and best practices discussed at the international level in interagency groups like CEOS and its Working Group on Calibration and Validation (WGCV), and at the European level through the INSPIRE directive of the EU Environment policy, another contribution of Europe to GEOSS. Other tasks of importance are to coordinate validation carried out through a series of mechanisms within PROMOTE and external supporting projects, and to organise the validation against components of long service lines based on a variety of intermediate modules, a hierarchy of models and a wide panel of data sources.
Activities in 2006:

- Set up of the PROMOTE QA/Val Office
- Design, implementation and operation of the PROMOTE validation web pages
- Issue of the first version of PROMOTE Services Validation Protocol

- Organisation of the PROMOTE Services Validation Report

➢ Synergies with modeling: Data assimilation

BASCOE – applications
(MOD; Quentin.Errera@oma.be **and** Frank.Daerden@oma.be**)**

The Belgian Assimilation System for Chemical Observations from Envisat (BASCOE) is a 4D-Var systems that optimize the initial condition of a Chemical Transport Model in order to reproduce Satellites observations and is based on Errera and Fonteyn (2001). During 2006, this system has been used mainly to assimilate MIPAS observations. The CTM of BASCOE has also been used to study PSC (see 'Mesospheric and stratospheric ozone and related species; stratospheric aerosol and PSC'). The BASCOE system took part to several project in 2006: the Assimilation of Envisat Data project (ASSET), one of the PRODEX projects and the PROMOTE project.

ASSET project

The FP5 ASSET project ended in June 2006. This project has focused on the assimilation of constituents observed by Envisat instruments. BASCOE was one of the involved systems. In 2006, the main activity of BIRA-IASB in ASSET was to write the final report and to contribute to scientific publications. Assimilation of ozone data from different assimilation systems, including BASCOE/MIPAS, have been intercompared and published in ACP (Geer et al., 2006). Another publication that summarized the ASSET project has been published in ACPD (Lahoz et al., 2006). In this publication, the BASCOE analyses of MIPAS H2O are compared with the ECMWF analyses.

BASCOE/PRODEX

In 2006, PRODEX has extended the funding of the BASCOE project but with the restriction to focus on research only (no more operational). Within PRODEX, BASCOE mainly focused on assimilation of MIPAS data (O3, NO2, HNO3, N2O, CH4, and H2O). For this task, work has been done to evaluate the analyses, mainly using independent observation like HALOE and ground based instruments. In the later case, BASCOE analyses have been involved in the validation of MIPAS N2O and HNO3 (Vigouroux et al., 2007).

Assimilation of GOMOS data (O3 and NO2) has also been done for a limited period of observations, from Sep. to Oct. 2003. These analyses will be used to make an intercomparison with MIPAS analyses. One of the first tasks of this study was to evaluate GOMOS data. It was found that some stars were producing wrong profiles that could not enter in the BASCOE system and a blacklist of occultations has been made.

Last but not least, some work has been done to improve the BASCOE chemical system and its adjoint. This work was based on the Kinetic PreProcessor (KPP) v2.1. This program built a chemical equation system in Fortran90 from a list of reactions

and rate constants. In 2006, KPP has been upgraded (Sandu and Sander, 2006) and now is able to generate the adjoint of the chemical system. In BASCOE, this adjoint is based on some approximation that could prevent the minimization. Using KPP-2.1, we try to solve this problem but new issues emerged since the Fortran90 code produced by KPP is not completely in agreement with our Fortran True64 complier. Therefore, the previous version of the adjoint of the chemistry in BASCOE is still in use.

BASCOE/PROMOTE

The GSE-PROMOTE Stage-II project starts in autumn 2006. BASCOE is involved in two extensions services: “Ozone Record Profiles” (Lead. F. Baier, DLR) and “Stratospheric Aerosols and Greenhouse Gases” (Lead. C. Bingen, BIRA-IASB). Within PROMOTE, the major work done during 2006 was writing the proposal describing the services that will provide BASCOE.

For the first service, BASCOE will provide analyses of ozone and chlorine species from UARS/MLS and ESA/MIPAS assimilation. The covered period, defined by the data availability from these two instruments, is from 1992-1999 and from Oct 2002-Mar 2004, respectively. The final products are due at the end of PROMOTE, *i.e.* autumn 2008.

For the second service, BASCOE will provide analyses of water vapor and methane from UARS/HALOE and ESA/MIPAS assimilation. The covered period is the same as for the first service. Due to a reduction in the funding, this service will only start in 2007 for two years duration.

GEMS: Global and regional Earth-system (Atmosphere) Monitoring (EU FP6 IP)

In October 2006 BIRA-IASB started its participation in the E.U. FP6 Integrated Project “GEMS: Global and regional Earth-system (Atmosphere) Monitoring”. The goal of this project is to create a new European operational system for operational global monitoring of atmospheric chemistry and dynamics and an operational system to produce improved medium-range & short-range air-chemistry forecasts, through much improved exploitation of satellite data.

BIRA-IASB’s task in this project is mainly to validate the GEMS model and the operational system with analyses from the assimilation of observations from Envisat/MIPAS by the chemical data assimilation system BASCOE [Errera and Fonteyn, 2001; Fonteyn et al, 2002, 2004].

ACHEDYRE

(MOD; Simon.Chabrillat@oma.be)

Most of year 2006 has been devoted to the ACHEDYRE project, *i.e.* processing chemical and dynamical observations of the atmosphere into the same data assimilation system, which is an extension of the system used operationally by the Meteorological Service of Canada for Numerical Weather Prediction (NWP).
From July 2005 to April 2006, the tasks of ACHEDYRE under BIRA-IASB responsibility were realized by S. Chabrillat at the Meteorological Service Center (MSC) in Dorval, Canada as part of a long-term mission. The year started with the

first complete simulation of stratospheric chemistry online in an operational NWP model. The results turned out to compare extremely well with observations of stratospheric chemistry, not only qualitatively but quantitatively, opening the way to simultaneous assimilation of dynamical and chemical observations.
In April 2006, these results were presented in a series of seminars given at MSC, at the HeadQuarters of Environment Canada (Toronto) and at the MacGill University (Montreal). This provided maximal visibility to the Belgian-Canadian collaboration in ACHEDYRE, and led to the preparation of a longer-term collaboration with Environment Canada (see below).
During the Summer 2006, new tools were created to allow quantitative intercomparisons between several modelling/assimilation systems and several observational datasets. During the SPARC Data Assimilation workshop (ESTEC, September 2006), we presented a comparison of analyses (or forecasts) by BASCOE, ECMWF and the new Belgian-Canadian system. It was shown that our dynamical results were not yet as good as ECMWF products, and that our chemical results were almost as good as the BASCOE products – but the point was made that the new system processed both types of observations simultaneously.
Our Canadian partners also showed the important impact of the interactive calculation of ozone on the predictability of temperature in the lower stratosphere, and the possibility to optimize directly the wind fields through 4D-VAR assimilation of chemical tracer observations. These advances, allowed by the online calculation of chemistry in the NWP model, open entirely new applications for operational satellite observations of atmospheric chemistry.
During the Summer of 2006, planning and negociations took place in order to create a longer-term and broader collaboration: the BACCHUS project (Belgium And Canada for CHemical weather User-oriented Services). These negociations resulted in a Memorandum of Understanding which was signed on November 9, by N. Parmentier and K. Puckett, head of research for air quality at Environement Canada, in the presence of H.H. Prince Philippe.
Finally, the *a posteriori* evaluation of observation and first guess variances demonstrated that MIPAS-ESA chemical observations were too noisy to allow optimal assimilation in the high-resolution NWP system. Hence we decided to try instead the assimilation of the IMK retrieval of MIPAS observations. In collaboration with T. Von Clarmann, who joined the ACHEDYRE study, S. Chabrillat started studying the best ways to assimilate a new, tailor-made MIPAS-IMK dataset which includes averaging kernel and error covariance matrices for each retrieved profile.

Solar irradiance and spectral UV

Introduction

Since the end of the 80's, the Belgian Institute for Space Aeronomy (IASB) has developed an automatic station to measure continuously the UV (UV-B & UV-A) – Visible Solar irradiance (280-600 nm) at the Earth's surface.
The IASB monitoring station consists in a combination of instruments including spectro-radiometer, filter-radiometers and broadband radiometers providing absolute values of the total, direct and diffuse components of the solar irradiance. The IASB data set is completed by ancillary measurements e.g. Ozone and SO_2 total column, Ozone concentration profiles, meteorological conditions…mainly provided by the Royal Meteorological Institute of Belgium (KMI/IRM). From the available 14-years

period of continuous measurements, it is possible to define the major characteristics of the UV climatology in Belgium and by extension in the 50° - latitude area.

The penetration of solar UV radiation through the atmosphere depends on the solar zenith angle (SZA), the ozone overhead column and other atmospheric absorbers and scatters such as clouds and aerosols. In particular, clouds are responsible for a great deal of the observed irradiance variability. The interpretation of observed UV-B time series, and e.g. the detection of possible trends due to human activity, requires the correct understanding of the effects of these different 'factor of influence' and a detailed study of their evolution with time.

Ground based monitoring stations (SOL)

The IASB automated station is located at Uccle, a residential area in the Brussels suburbs (lat.: 50°47'54''N, long: 4°21'29''E, Alt.: 105m asl). It is operational since mid-march 1993. The 2 core instruments of the main station are a calibrated double monochromator (modified HD10, Jobin-Yvon and Bentham).
It includes also 5 filter radiometers (SPUV-10, UVMFR-7, MFR-7 from Yankee Environmental System, YES and GUV 511C and GUV 2511 from Biospherical Instruments) and four pyranometers (YES), two in the UV-B range (UVB-1), one in the UV-A (UVA-1) and the last covering the wavelength range from the UV-A up to the near IR (TSP-700).

The spectro-radiometer, with its optical axis pointing the zenith direction, is fitted with a Lambertian Teflon diffuser with a 2πsr field of view, measures the total solar irradiance (diffuse + direct), and a nearly perfect cosine response. One scan is performed every 15 minutes for SZA smaller than 100°.

In addition, 2 complementary stations were deployed respectively in Transinne (Euro Space Center) in 2004 and in Oostende (Earth Explorer) in 2006. They consist in a set of 3 pyranometers (UVB, UVA and TSP), a filter radiometer (GUV 2511), a meteorological station and a "cloud infrared radiometer".

Time series of measurements

Erythemal doses at noon in Uccle are evaluated from both sets of spectral UV-Visible measurements, by weighting each spectrum by the CIE action spectrum.. The KMI/IRM data set is corrected to take into account the lack of spectral measurements between 325 and 400 nm. The comparison of the two data sets gives a good agreement (within 5%) for most of the cases over the overlap period (1993-1999). Nevertheless, in some occasions, the discrepancy can reach 20-25%. This is probably due to 1) the unperfected synchronism between the measurements and 2) the correction of the Brewer measurements which does not take into account the modification of the cloud cover during one scan duration.

Study of the factors of influence

Ozone.

The anti-correlation between ozone total column and UV-B integrated irradiance corrected for the effect of cloud cover is well established and confirned for the 2005-2006 period.

Clouds

In order to investigate the role of clouds, a set of 2 instruments has been deployed in Uccle. Based on optical measurements in the visible range and in the thermal IR wavelength range, they provide accurate measurement of cloud cover and a good estimation of cloud ceiling (altitude of cloud base). A simplified version of the IR equipment equipped the Redu and Ostende stations
To study the impact of cloud cover, as a function of wavelength, on the UV penetration, average spectra for well-defined cloudy conditions (complete overcast, similar zenith angles…) have been derived from the observations, and compared with a corresponding clear sky spectrum. Different 'action spectra have been derived and can be used to predict the UV index in various cloudy conditions. A parametric model has also been developed to characterise the broken cloud situations.

Finally, the average attenuation of sunlight by different type of clouds can be also directly estimate from the pyranometers data. As expected, the attenuation by cirrus clouds (high altitude) is found to be very small. In contrast, low clouds (mainly stratocumulus) reduce solar irradiance by about a factor 5 on average.

Trends

The bring to light of potential trends of UV-B radiation at the Earth's surface due to human activity is of high interest for the public health medical community as well as for all the scientists interested in the effects of UV-B on biology and material sciences. The aim of this study was just to illustrate what can be deduced from an 19-years period of UV-B monitoring. Ozone negative trends and UVB positive trends have been clearly established and are confirmed to be valid during the 2005-2006 period.

UV index service

A special effort has been done to improve the accessibility and visibility of the data set to the general public by modifying the Web site UV items:
Real time UV index at the 3 Belgian stations are presently accessible directly and presented on an interactive display.
Each graph being a gate to more specific information on each station of the network; e.g. real-time UVB, UVB and solar irradiance measurements, yearly representations of different parameters as UV index, Erythemal doses, ozone,…
Specific displays have also been developed for site purposes as the 'Meteorological parameters' display in Redu and Oostende and the 'SPUV-10' display in Brussels.

PLAN FOR THE FUTURE

In a next future, we hope to be able to equip 2 extra measurement site in “Campine” and “Gaume” regions (probably respectively at Mol and Virton), in order to cover the 5 climatic Belgian regions: namely, low Belgium an Coast with the Oostende station, medium Belgium with the Uccle station, high Belgium and Ardennes with the Redu station, Gaume with the Virton station and Campine with the Mol Station.

The improvement of the “UV INDEX” service will also be continued in parallel by initiating the prediction of UV INDEX in real conditions.

Contacts are taken with different organization (e.g., CELINE) to increase the diffusion of the UV data; these contacts need to be intensified in the future.

SOLPEC ON ISS (SOL)

This programme initiated in 1998 is supported by PRODEX

Introduction

SOLSPEC (SOLar SPECtrum) is a space-qualified spectro-radiometer dedicated to the measurement of extraterrestrial solar spectral irradiance in absolute radiometric units from 180 to 3000 nm. It was designed in the years 70’s through collaboration between IASB, CNRS/SA (France, PI G. Thuillier) and Heidelberg Observatory (Germany, D. Labs). The most important scientific objectives are:

1. The climatology of the solar UV, VIS and IR radiation during one solar cycle. The UV integrated irradiance is subject to changes of about 10 % during one solar cycle and a monitoring is required.

2. Contribution to atmospheric chemistry. The photochemical processes induced by the solar UV radiation in the stratosphere are wavelength dependant. Thus, absolute measurements of solar UV spectral irradiance with high accuracy (2 %) are of critical importance. Any change of incoming UV radiation is able to modify the actual chemical equilibrium due to catalytic reactions.

ESA research program for ISS.

Since 1983, SOLSPEC has participated to 5 NASA and ESA space missions (SPACELAB 1, ATLAS 1, 2 and 3, and EURECA). It is now one of the reference instrument selected by the international scientific community for the definition of a standard solar extraterrestrial spectrum. Different external payloads for space research will be launched and transferred to the International Space Station (ISS) during the next years. One of them (the payload SOLAR) has been dedicated to solar physics. SOLAR is a grouping of three solar spectral and photometric instruments that will be installed on a pointing device (CPD) on the module COLOMBUS for a duration of 18 months: SOLSPEC, SOVIM and SOL-ACES. This selection offers the opportunity to deeply modernize the SOLSPEC instrument. The electronic has been upgraded, the mechanical interface has been

adapted to the ISS payloads requirements and the internal optical design has been modified.

SUMMARY OF THE PRESENT STATUS OF THE INSTRUMENT (end 2006).

General devices

- The prototype flight of SOLSPEC has been completed
- The vibration test have be held successfully
- The thermal model is completed and re-actualised for any major modification
- Major Optical tests an characterisation are completed.
- Interface for calibration in front of black body (Heidelberg, Germany) completed.
- Pre-calibration campaign in Heidelberg performed in January 2007.

TESTS PERFORMED IN 2006

EMC tests

- Experimental work at IASB for finding the origin of the EMC sensitivity at 125 MHz and to remove it. Environmental EMC tests at ESTEC in June

Thermal tests

- Change of some internal thermostats. Thermal vacuum tests at ESTEC during November.

Optical tests

- Experimental work for finding the origin of the instabilities of the SOLSPEC VIS channel. Change and fixating of the intermediate slit.
- Experimental work for finding the origin of the instabilities of the SOLSPEC wavelength scale. Modification of the internal optical encoder of the motor controlling the wavelength scale.
- Change of the HCL internal lamp and analyse of its Ar spectrum.

Optical characterisation of SOLSPEC :

- Accurate wavelength calibration of the 3 channels using He-Ne lasers and spectral lamps.
- Measurements of the slit function for each channel and the entire wavelength scale.
- New determination of the default parameters of the flight software controlling the whole optical characterization (filters, HCL lines …).
- Analyse of the temperature effects on the DC of the VIS channel
- Analyse of the IR response stability
- Determination of non-linearity of the UV and VIS channels.
- Analyse of the second order rejection for the UV and IR channels.
- Absolute calibration in spectral irradiance of the UV, VIS and IR channels.
- Simulation of solar extraterrestrial measurements with NIST FEL and deuterium lamps.

SUMMARY OF THE TASKS FOR THE PERIOD mid 2006-launch

- Operational tests of the instrument are planned at OHP (Observatoire de Haute Provence) if time is available.

- Absolute calibrations of the instrument will be performed in front of the black body at Heidelberg (Germany) and in front of the NIST standards lamps at IASB (beginning 2007) maximum 6 months before launch.
- Absolute calibrations are also planned after delivery to Alenia in Torino (Italy)
- After delivery, the ground segment of the acquisition programmes will be tested under pseudo real conditions during simulations.

Planetary atmospheres

SPICAM on MARS EXPRESS: observations and interpretation
(LRS)

The Martian cloud climatology was built using the measurements by UV channel of the spectrometer in nadir mode.
The properties of the Martian ground albedo were derived from the measurements and a ground albedo map in the UV was built.
The Martian dust clouds were detected and the optical properties of Martian dust were derived from the detailed investigation of the regional Martian dust storm observed in October 2005.

SPICAM on MARS EXPRESS: Modeling the Chemistry of the Atmosphere of Mars and Assimilation of the SPICAM Light (Mars Express) Observations
(MOD; Frank.Daerden@oma.be)

The Global Mars Multiscale Model or GM3 is a newly developed three-dimensional General Circulation Model (GCM) for the atmosphere of Mars [Moudden, 2005; Moudden and McConnell, 2005]. In 2006 a narrow collaboration was set up between F. Daerden/BIRA-IASB and the team which developed GM3 at York University in Toronto (Canada) under the leadership of prof. dr. J. McConnell. A work visit at York University was held in April 2006 and other meetings took place on various occasions.

Main focus of the work in 2006 lied on the introduction to - as well as operation of - GM3, and the handling of the output. Routines have been developed to translate the standard GM3 output into hdf format, and Matlab routines and a Graphical User Interfaces (GUI) have been developed to view and handle the output.

Starting from the experience in the detailed microphysical modeling of polar stratospheric clouds [Daerden et al, 2006], work has started in 2006 to transform the detailed microphysical PSC model into a model that can describe Martian water ice as well as CO_2 clouds. This work is planned to lead to an offline or even online coupling of the microphysical module to GM3. Using these models we will hopefully allow us to interpret and reproduce the detection of Martian clouds in the Spicam UV nadir observations by dr. N. Mateshvili [Mateshvili et al, 2006], giving rise to an interesting collaboration between two research groups within the institute.

SPIDEX : SPICAM DATA EXPLOITATION.
(**SOL)**

Since October 2005, a new software was developed for the visualization of SPICAM activities and calibrated spectrum were obtained from the existing set of SPICAM data covering the first Martian year (two earth years), a 2 dimensional model of the Martian atmosphere is currently used to interpret the data in terms of surface UV and atmospheric ozone. A preliminary result is that during this first Marian year, neither Martian ozone nor Martian dust was ever in a sufficient amount to constitute a UV screen on the surface confirming that a putative Martian life has to be either subterranean of UV-resistant.

According to the work of Joop M. Houtkooper and Dirk Schulze-Makuch, it is possible to reinterpret the results of the Vicking lander in term of a possible biogenic origin for hydrogen peroxide on Mars.

In order to confirm or infirm such hypothesis and without waiting for a new lander, we need to determine the concentration of H_2O_2 on the Mars surface. The SPICAM spectrometer on board of Mars Express used a UV channel which accessible wavelength may contain absorption band of H_2O_2. So it is theoretically possible to determine, first qualitative and next a quantitative, the H_2O_2 absorption.

In 2006, we have received the major part of the SPICAM UV raw data. We successfully attempted to calibrate these data and present the corresponding spectra. We've realized an interface to monitor the orbit/spectra. We easily observe a lot of absorptions coming from CO_2 and O_3.

Dr. Moreau's 2D model will be used to characterise the temperature, pressure and chemical composition of the atmosphere at spectra recording time. So we could get access to the abundance of the different gas species in the atmosphere and establish a UV climatology of Mars surface.

From the knowledge of the quantities of major constituents of atmosphere, we'll try to detect minor constituents as H_2O_2 and their abundance.

SOIR instrument on board Venus Express
(IR; A-C.Vandaele@oma.be**)**

- Modification of ASIMUT to be able to read and analyze SOIR spectra, to simulate radiative budget through the Venus atmosphere
- Development of tools (matlab) for the interpretation of the data
- Participation to ESA SWTs

Annexe 2 : Milieu interplanétaire et plasma (rapport détaillé en anglais)

Contributions from M. Roth, J. De Keyser, V. Pierrard, N. Crosby, F. Darrouzet, H. Lamy, M. Echim and S. Delanoye

1. Space Plasma

1.1. Solar wind and interplanetary space

a) Dust-solar corona interaction (Action 1 project) :

The ablation model of the Earth's atmosphere has been extended to the case of the solar corona taking into account additional effects/forces due to the fact that the solar corona is a plasma.

1.2. Magnetospheric physics

a) Prodex/ Cluster

The development of plasmaspheric plumes as observed by Cluster during several geomagnetic storms and substorms was studied. We compared the CLUSTER observations with IMAGE/EUV data to identify typical characteristics: development of the plume in the afternoon-dusk sector, rotation velocity of the basis and the end of the plume, duration and transformation of the plume. A paper has been published on this topic. Another paper has also been published about the comparison between the results of the simulations of plume formation during geomagnetic substorms and the observations of IMAGE.

The statistical position of the plasmapause given by CRRES as a function of Kp in different magnetic local time sectors were compared with observations of Cluster. These positions were also compared with results of the model of plasmapause position developed at IASB-BIRA.

The model of plasmapause position was improved to simulate different mechanisms proposed for the formation of the plasmapause: the interchange instability mechanism and the MHD drifts. Simulations were provided for typical dates to show the differences and similarities obtained with these mechanisms. We analyzed CLUSTER density profiles to determine whether the plasmasphere is compressed (MHD model) or eroded (instability model). The CLUSTER observations are compared with the results of the simulations and with the model of Carpenter and Anderson. The effects of different models for the electric field (E5D, Volland-Stern, Weimer) and for the magnetic field (dipole, M2) were also analyzed.

Data of the satellite IMAGE were analyzed to study the time-evolution of the plasmapause with Kp when formation of typical structures are observed: "plumes",

"notches", "shoulders" and "crenulations". These study cases were simulated with the model to interpret these structures in terms of geomagnetic activity and the position of the Roche limit. The results were also compared with CLUSTER/WHISPER observations.

Study cases with double plasmapause observations in Cluster measurements were compared with the predictions of numerical modelling. A 3D model of the plasmasphere based on the exospheric model and on the model for the position of the plasmapause is in development.

The model simulation using the McIlwain convection electric field E5D, the magnetic field model M2 and the mechanism of interchange instability for the formation of the plasmapause has been made available on line on the European Space Weather Portal: www.spaceweather.eu .

We have made a study of the overall spatial gradient in the plasmasphere, concerning the magnetic field and the electron density. We also have completed a study of plasmaspheric plumes, with the combination of data from CLUSTER, IMAGE and numerical simulations. Furthermore, a statistical study of the occurrence of plasmaspheric plumes has been initiated in 2006. The two above tasks have been included in a PhD thesis written and defended during the year 2006 (http://www.oma.be/plasmasphere/Articles_PDF/Darrouzet_PhDThesis_UniversityOrleans_20060607.pdf). This work also made it into an ESA Press Release (F. Darrouzet and J. De Keyser, *Cluster takes a new look at the plasmasphere*, November 2006).

We have developed a new and innovative algorithm for computing the spatial and temporal gradients from multi-point measurements. This algorithm is a very robust one. The method provides reliable error estimates that include the effects of measurement errors and approximation errors due to structure at scales that are larger
and/or smaller than the physical scale of interest. The method provides diagnostics to assess the quality of the computation, in particular by monitoring the singular values of the problem as a generalization of the concepts of planarity or elongation of a 4-spacecraft configuration. The method has been found to be superior to the traditional instantaneous gradient computation. Its primary advantage is its generality. It correctly applies the principle of locality of information since only local data are used to compute the gradient at any given point, in accordance with the homogeneity condition. It also yields more stringent error margins on the obtained gradients. A disadvantage is the mathematical complexity. While the gradients obtained with this new method typically do not differ very much from those obtained with the traditional instantaneous gradient method, one now obtains a quantitative estimate of the total error on the results. We have successfully applied the method with Cluster 4-point measurements.

b) *Electrodynamic Coupling of the Auroral Ionosphere and Magnetosphere (Action 1 project)*

We have considered sheared flows in magnetospheric boundary layers of tangential discontinuity type, forming a structure that is embedded in a large-scale convergent perpendicular electric field. We have constructed a kinetic model that couples the magnetospheric structure with the topside ionosphere. The contribution of magnetospheric electrons and ionospheric electrons and ions is taken into account into the current-voltage relationship derived for an electric potential monotonically decreasing with the altitude. The solution of the current continuity equation gives the distribution of the ionospheric potential consistent with the given magnetospheric electric potential. Our new results obtained in 2006 can be summarized as follows:

- a sheared magnetospheric flow generates current sheets corresponding to upward field-aligned currents, field-aligned potential drops and narrow bands of precipitating energy, as in discrete auroral arcs.
- Higher velocity magnetospheric sheared flows have the tendency to produce brighter and slightly broader arcs.
- An increase in arc luminosity is also associated with enhancements of magnetospheric plasma density, in which case the structures are narrower.
- Finally, the model predicts that an increase of the electron temperature of the magnetospheric flowing plasma corresponds to slightly wider arcs but does not modify their luminosity.

We have obtained a follow-up for this Action 1 project for 2007 and 2008.

c) *Inversion methods for ground-based and satellite observations of aurorae (Action 1 project)*

With tomographic inversion techniques, the three-dimensional spatial distribution of auroral emissions can be inferred from simultaneous ground-based multi-station images. The ALIS (Auroral Large Imaging System) project is a multi-station system for spectroscopic ground-based imaging located in northern Scandinavia. Each station is equipped with a sensitive high-resolution (1024 x 1024 pixels) CCD-imager. It belongs to the research programme Solar Terrestrial Physics at the Swedish Institute of Space Physics (IRF) in Kiruna. One of its main scientific objectives is to apply tomographic inversion methods to optical aurorae. Our study is made in close collaboration with the ALIS team. In particular their expertise with inverse technique methods is of great importance.

We familiarized with the optical tomographic inversion techniques performed with ground-based multi-station systems such as ALIS i.e. how a 3D auroral emission distribution can be retrieved from a set of wide angle CCD images simultaneously obtained from different views. Two aspects have been considered: first, we have learned about the different computational methods available to solve this inverse problem. Then, we have considered the so-called « forward model ». This model describes the geometry of the system, i.e. how the auroral distribution is projected down onto the images. It also includes the sensitivities of the detectors, the transmission of optics and the atmospheric absorption. For that task, we have benefited from the experience of the ALIS team.

We also have studied the complex auroral model of Janhunen that describes how an auroral volume emission rate is produced under the assumption of a given electron energy spectrum incident at the top of the ionosphere.

d) Study of the F region trough (International S & T cooperation)

The Federal Science Policy has selected the following new project in the framework of the International S & T cooperation by granting a post-doc fellowship to Dr. Mirela Voiculescu from Romania

The coupling between the Earth's hot tenuous magnetosphere and the cold dense ionosphere is an important subject of investigation due to the consequences it has on radio communications and navigation systems. Over the next decade, a revolutionary new view of the dynamical behavior of the solar wind-magnetosphere-ionosphere system as it responds to energy inputs from the Sun is expected.

With the new project starting in May 2007, we will now investigate the ionosphere at high latitudes. High levels of geomagnetic activity are known to produce depletions of the ionospheric density during the recovery phase of a geomagnetic storm. These ionospheric troughs have an impact on the propagation of HF radio waves and on navigation technologies, like the global positioning system (GPS).

e) Prodex/Solar Drivers of Space Weather

We have continued the development of the MIM (Manager of Interactive Modules) software package. To introduce users on how to use the MIM software numerous scripts have been written for the modules.

- Production of basic on-line documentation for the MIM software package
- We have created "examples" for various MIM applications. These are referred to in the documentation. They can also serve as templates, so that the user may create his own material more rapidly.
- Additional routines have been implemented to allow writing of demos and interactive documentation to illustrate various features of the MIM software package.

An immediate goal of the MIM software package was the extension of our data analysis algorithms for the magnetospheric boundary to multi-spacecraft observations so that we are now able to exploit the full richness of the Cluster instrument data sets.
We have also improved gradient calculation algorithms.

1.3. Planetary Science

a) Prodex-Rosina DFMS

We have extended our reaction database by including the UMIST astrochemistry reaction database; software has been written for this purpose. Our reaction database currently holds more than 4000 reactions.

During our participation in the Deep Impact symposium in August we have received interest from US for our Rosetta/ROSINA tools and databases concerning chemistry in comets.

We have acquired and reformatted the Anicich reaction database for cometary studies.

Our proposed reshuffled financial plan for Rosetta/Rosina instrument support during the cruise phase of the mission until end 2009 has been approved.

b) BepiColombo mission

A statement was written to identify the scientific goals of participating to the BepiColombo mission.

We have submitted a PRODEX proposal, together with BIRA-IASB's engineering team, for participation in the construction of BepiColombo MMO and MPO instruments.

We have received an approval from BELSPO for a scientist on BepiColombo for experiment design advice (radiation hazards, thermal effects, required sensitivities, telemetry modes, …) starting in 2007.

J. De Keyser and S. N. Delanoye have participated in the workshop in Ghent on the design of the MSA instrument onboard BepiColombo's MMO, especially concerning operational modes, data acquisition, storage and compression.

We have started a study concerning the environment of Mercury in support of PICAM on MPO and MSA on MMO.

1.4. Atmospheric electricity

Coupling of Atmospheric Layers (CAL project)

The four-year Coupling of Atmospheric Layers (CAL) research training network project ended on 31 October 2006. CAL was funded by the European Commission within the Marie Curie Actions to study unanswered questions relating to transient luminous events (TLEs) and their effects on the atmosphere. More specifically, CAL concerned thunderstorms, electrical and space radiation effects in the stratosphere, mesosphere and lower thermosphere. The research was also aimed at studying the

relation of TLEs with various aspects of the atmospheric system, and thus climate.

N. Crosby was lead for both the CAL Training Programme WP2 and the CAL Outreach Programme WP3. Furthermore statistical studies (frequency distributions) were performed on lightning and sprite data.

2. Space Plasmas: organizational

- Final discussions and preparations for the STCE, including contribution to the socio-economic cost/benefit analysis and preparations for engaging personnel.
- Preparatory activities for the International Heliospheric Year 2007. We have built a website for announcing the planned Belgian activities, at http://gauss.oma.be/ihy2007
- V Pierrard received the Zeldovich Award at the COSPAR 2006 meeting in Bejing, China.
- J. De Keyser has become vice-president of the Belgium National Committee of Geodesy and Geophysics of the Royal Academy of Belgium.
- M. Roth has become president of the FNRS board “Astrophysique, Géophysique et Dynamique du Climat”.
- Preparation of a short press communication concerning Cluster work on the plasmasphere for publication on the web site of ESA in the course of October.
- Visit of D. Carpenter (organization of 2 seminars about plasmaspheric physics)
- INTAS hosting of Ms. Natalia Romanova, a Russian Ph.D. student, September-October 2006 and two months in 2007.
- Visit by Ms. Rosalyn Pertzborn and Dr. Sanjay Limaye from the University of Wisconsin–Madison, U.S.A., 25-26 September 2006, with a talk "Venus Express Education and Public Outreach Program Workshop for school teachers", 25 September 2006, at BISA and the organization of space-related lectures to the school children at the International School of Brussels, 26 Sepetmber 2006.
- Visit of Dr. Farida Mazouz, LPCE, University of Orléans (France), 14 December 2006, with a talk “Natural Emissions in the Plasmasphere”
- Various people of the space plasma group are active as referees. N. Crosby has become Editorial board member for the journal "Sun and Geospace – the International Journal of research and Applications" and Editorial advisory board member for the journal "Space Weather: The International Journal of Research and Applications".

The team has been active in organizations of international meetings and conferences:

- Preparation of a workshop on plasmaspheric studies for autumn 2007 at IASB in Brussels (first contacts, email to editors for a publication, first

list of participants, edition of a dedicated web site: http://www.aeronomie.be/en/workshop/plasmasphere/overview.htm).

- Congrès Nord-Sud: La recherche et l'enseignement de la physique, Université Mohammed 1er, Oujda, Maroc, 9-13 avril 2007. Viviane Pierrard is member of the organization committee.
- Joint International Scientific Meeting of the Belgian Physical Society and the Dutch Physical Society, Leiden University, The Netherlands, 28 April 2006. Viviane Pierrard was co-organizer and convener of the session "Geophysics and meteorology" (800 participants).
- International Symposium "Solar-Terrestrial Interactions from microscale to global models that will be organized in Romania, June 21-24, 2007. Marius Echim is member of the organization committee (attended the LOC meeting in June 2006).
- First International Meeting on University Satellites and Space Science Education UNIVERSAT-2006", Moscow State University, Moscow, Russia, Mon. 26 – Fri. 30 June 2006. Norma Crosby is member of the International Advisory Committee and Convener of one of the special sessions.
- "Europlanet #1" European Planetary Science Congress 2006, Berlin, Germany, Mon. 18 – Fri. 22 September 2006. Norma Crosby is Convener of special session "MA4 Space Weather and its Planetary Connection (Workshop)".
- Norma Crosby is Convener of the session "ES8 Education and outreach in the geo- and space-physical sciences", European Geosciences Union, General Assembly 2006, Vienna, Austria, 2-7 April 2006.
- Norma Crosby is Convener of the session "ST5.8 Solar, heliospheric and external geophysical effects on ecosystems", European Geosciences Union, General Assembly 2006, Vienna, Austria, 2-7 April 2006.
- Viviane Pierrard is Convener of the session "Astrophysics, Geophysics and Plasma Physics", General Scientific meeting of the BPS 2007 that will be held at the University of Antwerp, 30 May 2007.

- Planning activities for
  - A workshop on plasmaspheric studies for autumn 2007 at IASB in Brussels (contacts with JASTP and Space Science Reviews for a publication).
  - The COSPAR Capacity Building Workshop "Solar Terrestrial Interactions: Instrumentation and Techniques" to be held in Romania in June 2007 (http://www.faculty.iu-bremen.de/jvogt/cospar/cbw6/).
  - The second international workshop on "Solar Terrestrial Interactions from global models to microscale" (STIMM-2) to be held also in Sinaia, Romania (http://iss30.nipne.ro/gpsm/ws_ro/stimm2/).

3. Publications

α. *In international refereed journals/books*

- Published

1. Balsiger, H.., K. Altwegg, P. Bochsler, P. Eberhardt, J. Fischer, S. Graf, A. Jäckel, E. Kopp, U. Langer, M. Mildner, J. Müller, T. Riesen, M. Rubin, S. Scherer, P. Wurz, S. Wüthrich, H. Rème, C. Aoustin, C. Mazelle, J.-L. Médale, J. A. Sauvaud, E. Arijs, S. Delanoye, J. De Keyser, E. Neefs, D. Nevejans, J.-J. Berthelier, J.-L. Bertaux, L. Duvet, J.-M. Illiano, T.I. Gombosi, B. Block, G.R. Carignan, L.A. Fisk, F. Gliem, B. Fiethe, S.A. Fuselier, A.G. Ghielmetti, T. Magoncelli, E.G. Shelley, A. Korth, K. Heerlein, H. Lauche, S. Livi, A. Loose, B. Wilken, J. H. Waite and D.T. Young, H. Wollnik, Rosetta Orbiter Spectrometer for Ion and Neutral Analysis ROSINA, Space Sci. Rev., doi:10.1007/s11214-006-8335-3, 2007.
2. Crosby N., Book Review, K. Scherer, H. Fichtner, B. Heber, U. Mall (eds.), "Space Weather: The Physics Behind a Slogan, Lecture Notes in Physics", Surveys in Geophysics, Vol. 27, 4, 489-490, 2006.
3. Crosby N., Rycroft M., and Tulunay Y., "Overview of a Graduate Course Delivered in Turkey, Emphasizing Solar-Terrestrial Physics and Space Weather", Surveys in Geophysics, Vol. 27, 3, 319-364, 2006.
4. Crosby N.B., "Major Radiation Environments in the Heliosphere and their Implications for Inter-Planetary Travel", in "Space Weather: Physics and Effects", Eds. Bothmer V. and Daglis I., Springer Praxis Books, 2006.
5. Darrouzet, F., J. De Keyser, P. M. E. Décréau, J. F. Lemaire, and M. Dunlop, Spatial gradients in the plasmasphere from Cluster. Geophys. Res. Lett., 33, L08105, doi:10.1029/2006GL025727, 2006.
6. Darrouzet, F., De Keyser, J., Décréau, P. M. E., Gallagher, D. L., Pierrard, V., Lemaire, J. F., Sandel, B. R., Dandouras, I., Matsui, H., Dunlop, M., Cabrera, J., Masson, A., Canu, P., Trotignon, J. G., Rauch, J. L., and André, M., Analysis of plasmaspheric plumes: CLUSTER and IMAGE observations, *Ann. Geophys.*, 24, 1737-1758, 2006.
7. Darrouzet, F., Study of the terrestrial magnetosphere by multipoint data analysis with the CLUSTER mission. Contributions to the characterization of boundary layers and of the inner magnetosphere, *Planetary and Space Science*, 55(4**)**, 528-529, doi:10.1016/j.pss.2006.11.002, 2007.
8. De Keyser, J., The Earth's magnetopause: Reconstruction of motion and structure, Space Sci. Rev., 121, 225-235,doi:10.1007/s11214-006-6731-3, 2006.
9. Pierrard V. and Barghouthi I. A., Effect of wave-particle interactions on double-hump H+ velocity distribution in the polar wind, Astrophys. Space Sci., 302, 35-41, DOI: 10.1007/s/s10509-005-9002-y, 2006.
10. Pierrard V., The dynamics of the plasmasphere, in "Space Science: New Research", Nova Science Publishers, Nick S. Maravell Editor, ISBN 1-60021-005-8, 2006.

11. Pierrard V. and J. Cabrera, Dynamical simulations of plasmapause deformations, Space Science Reviews (WSEF), 122, Issue 1-4, 119-126, doi: 10.1007/s11214-005-5670-8, 2006.

- Accepted

1. Crosby N., Krasotkin S., Haubold H., "UNIVERSAT-2006 International Symposium: University Satellites and Space Science Education" meeting report, EOS, the American Geophysical Union (AGU) weekly newspaper, accepted, 2006.
2. Echim M., Lamy H., Multiscale transfer of the energy in the solar wind-magnetosphere system: evidence of intermittency, Advances in Space Research, accepted, 2006.
3. Grimald, S., Décréau, P. M. E., Canu, P., Suraud, X., Vallières, X., and Darrouzet, F., A quantitative test of Jones NTC beaming theory using Cluster constellation, *Ann. Geophys.*, accepted, 2006.
4. Pierrard V., G. V. Khazanov, and J. Lemaire, Current-voltage relationship, J. Atmosph. Sol. Terr. Phys., Special issue on the polar wind, accepted, 2006.
5. Tam S. W. Y., T. Chang, V. Pierrard, Kinetic modeling of the polar wind, in Atmosph. Sol. Terr. Phys., Special issue on the polar wind, accepted, 2006.
6. M. Echim, M. Roth, J De Keyser, Sheared magnetospheric plasma flow and discrete auroral arcs: a quasi-static coupling model, Ann. Geophys., accepted, 2006 (published: Ann. Geophys., 25, p. 317-330, 2007).

- Submitted

1. De Keyser, J., Darrouzet, F., Dunlop, M. W., and Décréau, P. M. E., Least-squares gradient calculation from multi-point observations of scalar and vector fields: Methodology and applications with Cluster in the plasmasphere, *Ann. Geophys.*, submitted, 2006.
2. Delanoye, S.N. and J. De Keyser, 'Comets and chemical composition', Space Science Reviews, Space Science Series of ISSI, vol. 27, submitted, 2006.
3. Magnus A. P. and V. Pierrard, Formulas for recurrence coefficients of orthogonal polynomials related to Lorentzian-like weights, Journal of Computational and Applied Mathematics, submitted, 2006.
4. Pierrard V. and J. Cabrera, Comparison between simulations of two mechanisms proposed for the formation of the plasmapause, Annales Geophysicae, submitted, 2006.
5. Schafer S., K. H. Glassmeier, P. T. I. Eriksson, V. Pierrard, K. H. Fornacon, and L. G. Blomberg, Spatial and temporal characteristics of poloidal waves in the terrestrial plasmasphere: A CLUSTER case study, Annales Geophys., submitted, 2006.

β. In non refereed journals

- International: published

1. Dandouras, I., V. Pierrard, J. Goldstein, C. Vallat, G. K. Parks, H. Rème, M. McCarthy, L. M. Kistler, B. Klecker, A. Korth, M. B. Bavassano-Cattaneo, Ph. Escoubet, and A. Masson, CLUSTER multipoint

observations of ionic structures in the plasmasphere by CIS and comparison with IMAGE-EUV observations and with model simulations, *Proceedings of the Cluster and Double Star Symposium, 5th anniversary of Cluster in Space*, (ESA ESTEC, Noordwijk, The Netherlands, 19-23 September 2005), 1-8, ESA SP-598, Jan. 2006.

2. Darrouzet, F., De Keyser, J., Décréau, P. M. E., Gallagher, D. L., Pierrard, V., Lemaire, J. F., Sandel, B. R., Dandouras, I., Matsui, H., Dunlop, M., Cabrera, J., Masson, A., Canu, P., Trotignon, J. G., Rauch, J. L., and André, M., Plasmaspheric plumes: Cluster, IMAGE and simulations, *Proceedings of the Cluster and Double Star Symposium, 5th Anniversary of Cluster in Space*, ESA SP-598, January 2006.
3. De Keyser, J., M. Roth, M.W. Dunlop, H. Rème, C.J. Owen, and G. Paschmann, Solar wind pressure and the position of the magnetopause: A Cluster perspective, *Proceedings of the Cluster and Double Star Symposium, 5th Anniversary of Cluster in Space*, ESA SP-598, January 2006.
4. Dunlop, M. W., Balogh, A., Shi, Q-Q., Pu, Z., Vallat, C., Robert, P., Haaland, S., Shen, C., Davies, J. A., Glassmeier, K.-H., Cargill, P., Darrouzet, F**.**, and Roux, A., The Curlometer and other gradient measurements with Cluster, *Proceedings of the Cluster and Double Star Symposium, 5th Anniversary of Cluster in Space*, ESA SP-598, January 2006.
5. El-Lemdani Mazouz, F., Grimald, S., Rauch, J. L., Décréau, P. M. E., Bozan, G., Le Rouzic, G., Suraud, X., Vallières, X., Trotignon, J. G., Canu, P., Darrouzet, F**.**, and Boardsen, S., Electrostatic and electromagnetic emissions near the plasmasphere. A case event: 27 May 2003, *Proceedings of the Cluster and Double Star Symposium, 5th Anniversary of Cluster in Space*, ESA SP-598, January 2006.
6. Rauch, J. L., Suraud, X., Décréau, P. M. E., Trotignon, J. G., Ledée, R., Lemercier, G., El-Lemdani Mazouz, F., Grimald, S., Bozan, G., Vallières, X., Canu, P., and Darrouzet, F**.**, Automatic determination of the plasma frequency using image processing on WHISPER data, *Proceedings of the Cluster and Double Star Symposium, 5th Anniversary of Cluster in Space*, ESA SP-598, January 2006.
7. Trotignon, J. G., Décréau, P. M. E., Rauch, J. L., Suraud, X., Grimald, S., El-Lemdani Mazouz, F., Vallières, X., Canu, P., Darrouzet, F**.**, and Masson, A., The electron density around the Earth, a high level product of the Cluster/WHISPER relaxation sounder, *Proceedings of the Cluster and Double Star Symposium, 5th Anniversary of Cluster in Space*, ESA SP-598, January 2006.

- <u>International: submitted</u>

1. Crosby N.B., V. Bothmer, R. Facius, J.-M. Griessmeier, X. Moussas, M. Panasyuk, N. Romanova, "Interplanetary Space Weather and its Planetary Connection", meeting report, AGU Space Weather Journal, submitted, 2006.
2. Delanoye, S.N. and J. De Keyser, 'Rosetta/ROSINA and chemistry in a cometary coma', ESO Astrophysics Symposia, submitted, 2006.

- National: published

1. Crosby N.B., "Entrez dans le monde des Sylphes, des Jets et des Elfes", Science Connection, December 2006, edition 14, (French version).
2. Crosby N.B., "Stap binnen in de wereld van sprites, jets en elves", Science Connection, December 2006, edition 14, (Dutch version).
3. Lamy H., and Pierrard V., Exospheric models of the solar wind, Physicalia Magazine, 28, 2, 103-116, 2006.
4. Roth M., V. Pierrard, J. De Keyser, H. Lamy, M. Echim, F. Darrouzet, N. Crosby, S. Delanoye, J. Lemaire, D. Heynderickx, K. Stegens and J. Wéra, Etude des plasmas de l'espace à l'Institut d'Aéronomie Spatiale de Belgique, Physicalia Magazine, 28, 2, 117-139, 2006.

- National: submitted

📂☞ Lamy H., "Applications spatiales de la tomographie", Ciel & Terre, submitted, 2006 (published, Ciel et Terre, 123, n°1, janvier – février 2007, 9 -23, 2007.)

χ. *Ph.D thesis*

1. Darrouzet, F., Etude de la magnétosphère terrestre par l'analyse multipoint des données de la mission CLUSTER. Contributions à la caractérisation des frontières et de la magnétosphère interne - Study of the terrestrial magnetosphere by multipoint data analysis with the CLUSTER mission. Contributions to the characterization of boundary layers and of the inner magnetosphere, PhD Thesis, University of Orléans, France, 7 June 2006

δ. *Others*

1. Darrouzet, F., and De Keyser, J., Cluster observes density structures in the plasmasphere, ESA Top Story, http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=40330, November, 2006.
2. Darrouzet, F., Magnétosphère Terrestre et Mission CLUSTER, *Le Mensuel de l'Université*, http://www.lemensuel.net/Magnetosphere-Terrestre-et-Mission.html, February 2007.