


A vertical orange line is positioned to the left of the text. The background is a photograph of Earth from space, showing the horizon and a bright sun in the upper left corner with lens flare.

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

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2006
Overzicht van de activiteiten

Activiteitenverslag 2006

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Voorwoord

2006 was voornamelijk een jaar van bestendiging van de internationale erkenning van de wetenschappelijke activiteitsdomeinen 'Scheikunde en fysica van de atmosferen' en 'Ruimteplasma'. Eén van de belangrijkste interne opdrachten was meer synergie en kritische massa te bereiken, onder gezamenlijke onderzoeks- en dienstverleningsthema's.

Een belangrijke groepsdynamiek werd gecreëerd naar nieuwe projecten welke de brug slaan tussen wetenschappelijk onderzoek en dienstverlening.

Enkele van de voornaamste realisaties voor 2006 zijn:

- Het uitbouwen van de wetenschappelijke dienstverleningsactiviteiten in de 2 inhoudelijke thema's (Scheikunde en fysica van de atmosferen of 'Chemical Weather', en Ruimteplasma – 'Space Weather').
- De goedkeuring door de Federale Ministerraad van de financiering van het Solar-Terrestrial Center of Excellence van de Pool Ruimte en de oprichting van het Ideeënfonds voor de Wetenschappelijke Instellingen op 22 maart 2006.
- De 'in-orbit commissioning' van het Belgisch experiment SOIR voor het onderzoek van de Venusatmosfeer, en het opstarten van de wetenschappelijke diensten en activiteiten van de Venusexperimenten. De spectra gemeten door SOIR zijn van zeer goede capaciteit.
- COSPAR kende aan Viviane Pierrard de Zeldovich Medal toe. De overhandiging vond plaats tijdens de COSPAR Scientific Assembly in Beijing (17 juli 2006).
- GMES: de Europese Unie heeft beslist om een pilootproject op te zetten rond atmosferische diensten. Het BIRA zal hierbij, samen met het KMI en het VITO, een sleutelrol spelen voor de wetenschappelijke dienstverlening rond klimaat en milieu.
- PromISS-4 is een Belgisch experiment in het Internationale Ruimtestation (ISS), gelanceerd met de Progress 20P. Het B.USOC was in samenwerking met NASA verantwoordelijk voor de operaties.
- De ondertekening van een samenwerkingsakkoord met Canada (Air Quality Branch/MSO) ter gelegenheid van de Economische Missie van 5-11 november voor het onderzoek, de productontwikkeling en de operationele dienstverlening in het domein van de 'Chemical Weather'-diensten binnen de stratosfeer en troposfeer
- ALTIUS atmosferische minisatelliet op basis van PROBA: de fase-A-studie is opgestart (wetenschappelijke en technologische aspecten), in samenwerking met ESTEC (Concurrent Design Facility), OIP en Verhaert.

- Een indrukwekkend aantal wetenschappelijke publicaties, deelnames aan internationale conferenties/symposia en nationale/internationale projecten.

Naar operationele aspecten kunnen we stellen dat een volledig analytisch projectbeheerssysteem is uitgewerkt dat toelaat een dynamisch en strategisch beleid te voeren vanuit competenties en doelstellingen.

Beleidsorganen zoals de Wetenschappelijke Raad, de Commissie voor Werving en Bevordering, de Beheerscommissie en het Basisoverlegcomité hebben hun waarde naar behoren bewezen.

Een dynamisch personeelsbeheer laat toe optimaal in te spelen op de behoeften, maar dient verder uitgebouwd te worden naar carrièreplanning.

Voor 2006 zijn spijtig genoeg de zo noodzakelijke renovatie- en infrastructuurexpansieplannen nog niet opgestart kunnen worden.

Verder heeft het Instituut zijn internationale erkenning kunnen versterken, door betrokkenheid bij de uitbouw van netwerken en deelname aan internationale programma's.

De kracht van het Instituut is en blijft zijn kennis, waarin blijvend geïnvesteerd zal worden.

N. Parmentier

Deel 1: Activiteiten in 2006

1.1. Scheikunde en fysica van de atmosferen

De activiteiten van de verschillende groepen binnen de zuil 'Scheikunde en fysica van de atmosferen' situeren zich in verschillende deelgebieden van de aeronomie, enerzijds gaande van de aardse mesosfeer tot de troposfeer en de verbinding met de biosfeer, anderzijds de planetaire aeronomie met de studie van atmosferische verschijnselen op Mars en Venus. De onderzoeksmethodes omvatten waarnemingen vanaf verschillende platforms, modelberekeningen en data-assimilatie, alsook ondersteunende laboratoriumexperimenten.

1.1.1. Fundamenteel onderzoek van de aardatmosfeer

De gegevens van de instrumenten voor atmosferische chemie GOMOS, MIPAS en SCIAMACHY aan boord van **Envisat** zijn verder uitgebreid verwerkt. Ten eerste heeft men een beter begrip gekregen van hun waarde (inhoud aan informatie, precisie, accuratesse) door deel te nemen aan verschillende validatieoefeningen,



deels als productcoördinator, en door de inhoud aan informatie van de verschillende metingen beter te karakteriseren. De synergie tussen waarnemingen vanaf verschillende platforms is geëxploiteerd, bv. in de ontwikkeling van een klimatologie voor NO₂-profielen, en het gebruik van grond-, ballon- en satellietwaarnemingen van BrO voor een beter begrip van de troposferische hoeveelheid BrO. Ten tweede zijn algoritmes ontwikkeld om de satellietproducten te bepalen met verhoogde precisie, bv. voor de afleiding

van aerosolgegevens uit GOMOS en de bepaling van ozon, NO₂ en andere sporengassen (BrO, H₂CO, ...) uit SCIAMACHY en zijn voorloper GOME.

Parallel met deze laatste activiteit zijn voorbereidingen getroffen voor de verwerking van de gegevens van GOME-2, gelanceerd in oktober 2006 aan boord van **METOP-1**. Het tweede instrument dat ons interesseert aan boord van METOP-1 is IASI: het BIRA heeft een nieuwe code, ASIMUT, ontwikkeld voor de bepaling van chemische bestanddelen en aerosols uit de thermisch-infrarode stralingsspectra van IASI, en heeft de validatie van de IASI-producten voorbereid.

Het BIRA is wereldwijd erkend voor zijn expertise in satellietdatavalidatie en -retrieval. Deze erkenning uit zich o.a. in het feit dat het Instituut het vicevoorzitterschap bekleedt van de **CEOS** (Committee for Earth Observation Satellites) Working Group on Calibration and Validation/Atmospheric Chemistry Sub Group, die deel uitmaakt van verschillende Satellite Quality Working Groups en SAFs (Satellite Application Facility) en coördinator is van het project **TASTE** (Technical Assistance To Envisat), dat gebruik maakt van spectrometers, radiometers en ozonsondes.

Als lid van het **ACE** Science Team is het BIRA ook sterk betrokken bij dataretrieval en -validatie van verschillende producten van ACE-FTS en MAESTRO, deels als productcoördinator. Eén van de producten door het Instituut verwerkt zijn wolken (cirrus, convectieve wolken, en Polar Stratospheric Clouds (PSC)) uit de ACE-imagerbeelden.

In aansluiting op de afleiding en validatie van atmosferische satellietgegevens is gewerkt aan hun exploitatie, in combinatie met modellen.

Een nieuw model, **MOSTRA**, is in ontwikkeling om een nauwkeurige beschrijving van stratosferische aerosolmicrofysica te integreren in een 3D-transportmodel. Tegelijkertijd is gewerkt aan de integratie van een **microfysisch model voor PSC** in een 3D Chemistry Transport Model (CTM). Het model is succesvol toegepast op een studie van de winter 2003 boven Antarctica en toont een goede overeenstemming met satellietwaarnemingen (POAM III en MIPAS).

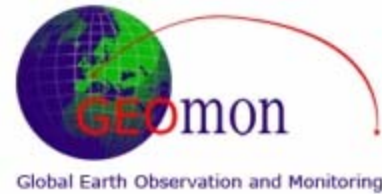
De stratosferische satellietdata, in het bijzonder de Envisat-data, zijn uitgebreid gebruikt in **BASCOE**, het BIRA-IASB 4D Var data-assimilatiesysteem (Belgian Assimilation System for Chemical Observations from Envisat). BASCOE heeft deelgenomen aan validatieoefeningen en aan het Europees project ASSET, waarin het vergeleken is met andere bestaande assimilatiemodellen.

Troposferische data voor CO van MOPITT en voor NO₂ en H₂CO van SCIAMACHY zijn met succes gebruikt in **inverse modellering**, gebaseerd op het model IMAGES voor het verbeteren van emissiegegevens, in het bijzonder afkomstig van verbranding van biomassa en van biogene oorsprong. Een deel van dit werk kadert in de bijdrage van BIRA-IASB tot het Europees netwerk **ACCENT**, als lid van het Steering Committee van de 'Access to Emission Databases'-activiteit.

Er is fundamenteel onderzoek verricht naar de scheikunde en de rol van biogene vluchtige organische stoffen (VOS) in de troposfeer, op basis van theoretische en modelberekeningen en laboratoriumexperimenten, in het kader van het nationale project **IBOOT**, gecoördineerd door BIRA-IASB. Ondersteunende laboratoriumexperimenten **VOCCIMS** (Volatile Organic Compound measurements by Chemical Ionization Mass Spectrometry) omvatten Selected Ion Flow Tube (SIFT)-studies van ion-moleculereacties en SIFT-MS-detectie van componenten uitgestoten door verwondingen van planten (hexenal, hexenol, methanol, aceton, ...). Er is gewerkt aan het operationeel maken van een Triple Quadrupole Mass Spectrometer (TQMS), aangeschaft in 2005. En een nieuwe Proton Transfer Reaction Mass Spectrometer (PTR-MS) zal in gebruik genomen worden in 2007 in het kader van het nationale project **IMPECVOC** (Impact of Phenology and Environmental Conditions on BVOC Emissions from Forest Ecosystems), o.l.v. de Universiteit Gent, o.a. om studies in het veld en in het laboratorium te maken van biogene emissies van VOS.

Lange-termijngrondwaarnemingen van de atmosferische samenstelling met Fourier Transform Infrarood (FTIR) en UV-visible-DOAS-spectrometers zijn voortgezet in het kader van **NDACC** (Network for the Detection of Atmospheric Composition Changes) en Europese en nationale projecten, in de stations Jungfraujoch en Observatoire de Haute Provence, Harestua, en sedert 2002 op het eiland Réunion. BIRA-IASB's expertise in dit verband werd erkend door de benoeming en bevestiging van de co-voorzitters van de NDACC UV-visible, Infrared, en Satellite Working Groups. BIRA-IASB heeft ook de leiding gekregen van de Stratospheric Ozone and Climate-

activiteit binnen het Europees Integrated Project **GEOMON** dat in februari 2007 van start is gegaan.

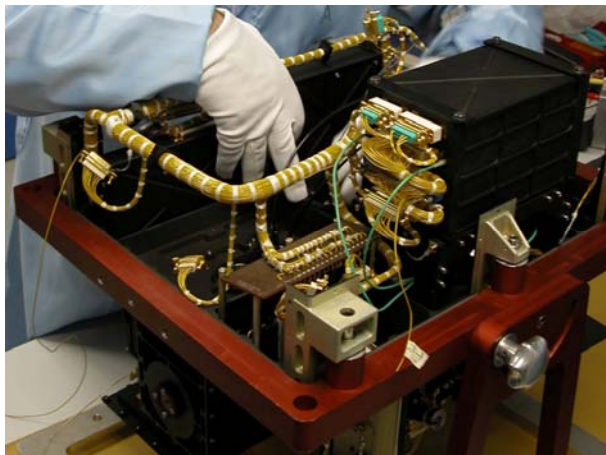


Er is ook deelgenomen aan verschillende waarnemingscampagnes met UV-visible-DOAS-instrumenten, ter validatie van SCIAMACHY/Envisat- en OMI/Aura-gegevens van ozon en NO₂.

Een nieuw instrument voor de meting van aerosolparameters, nl. een CIMEL zonfotometer, is in gebruik genomen in Ukkel en geïntegreerd in AERONET. Een campagne met CIMEL-, UV-vis-DOAS- en FTIR-waarnemingen vond plaats in Ukkel in de tweede helft van 2006, in het kader van het nationale project **AGACC**, gecoördineerd door BIRA-IASB.

BIRA-IASB is ook betrokken bij het Europees project **NOVAC** dat een grondnetwerk van UV-visible-DOAS-spectrometers zal creëren voor de waarneming van vulkanische emissies (BrO, SO₂, ...).

Het Belgisch netwerk voor de meting van de **spectrale UV-zonnestraling** is aangevuld met een station in Oostende, om het Belgisch kustgebied op te volgen. Er



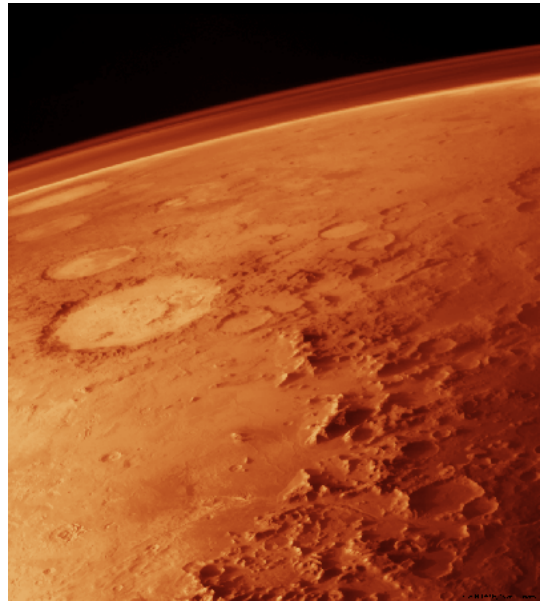
zijn studies gemaakt naar de invloed van ozon en wolken op de UV-straling, en ter bepaling van de langetermijntrends (19 jaar). Het ruimte-experiment **SOLSPEC**, dat beschouwd wordt als een referentie voor de meting van het absolute buitenaardse zonnenspectrum tussen 180 en 3000 nm, en dat gepland is voor installatie aan boord van het Internationaal Ruimtestation (ISS), heeft in 2006 verschillende tests ondergaan (EMC, thermisch, optisch). Het zal in 2007 geleverd worden aan Alenia.

Ter ondersteuning van de optische teledetectiewaarnemingen worden de **spectroscopische parameters** van atmosferisch relevante gassen in het laboratorium opgemeten. In 2006 lag de nadruk op H₂O en zijn isotopen, NO₂ en zijn isotopen in het UV-zichtbaar-lichtgebied, en op werkzame doorsneden voor absorptie van benzeen, toluen en xylenen.

Twee belangrijke nieuwe projecten zijn gelanceerd, nl. **ALTIUS** en **UAV**. ALTIUS is een ruimteinstrument dat zal gelanceerd worden in het kader van het Belgisch microsattelietprogramma, voor de observatie in UV-Vis-NIR limb scattering mode van de samenstelling van de hoge troposfeer en stratosfeer, na Envisat. Het project UAV beoogt de ontwikkeling van ultralichte en compacte spectrometers aan boord van een Unmanned Aerial Vehicle (UAV) voor de waarneming van de luchtkwaliteit, i.h.b. NO₂ en CO.

1.1.2. Fundamenteel onderzoek van de Mars- en Venusatmosferen

De **SPICAM**-data werden geëxploiteerd voor de bepaling van de optische eigenschappen van (stof)wolken op Mars en voor de ontwikkeling van een wolkenklimatologie en een kaart met het oppervlaktealbedo op Mars. Het Global Mars Multiscale Model is een 'general circulation'-model dat ontwikkeld werd voor de Marsatmosfeer en dat op BIRA-IASB geïmplementeerd werd met de bedoeling hierin een microfysisch model voor ijs- en CO₂-wolken te implementeren. Een ander 2D-model van de Marsatmosfeer is geïmplementeerd om de temperatuur, druk en chemische samenstelling van de Marsatmosfeer af te leiden uit de SPICAM UV-data en een klimatologie te maken van de UV-straling op het Marsoppervlak.



Er is tevens gestart met de verwerking van de **SPICAV/SOIR**-spectra, voor de bepaling van de chemische samenstelling van de Venusatmosfeer. Hiertoe is een aangepaste versie van de ASIMUT-code ontwikkeld.

1.2. Interplanetair milieu en plasma

In 2006 telde de groep 'Plasma' van het Belgisch Instituut voor Ruimte-Aeronomie 8 wetenschappers (3 statutairen en 5 contractuelen). Deze groep was in 2006 goed voor 39 publicaties.

De groep Plasma heeft onderzoek gedaan naar verscheidene aspecten van de fysica van ruimteplasma's en naar de verhoudingen tussen Zon en Aarde.

De studies over de wisselwerking tussen stofdeeltjes en het coronale plasma zijn in 2006 voltooid. Het ablatiemodel dat was ontwikkeld voor de aardatmosfeer werd uitgebreid tot de zonnearmosfeer, rekening houdend met de plasmatoestand van deze omgeving.



Anderzijds is de groep 'Plasma's' sterk betrokken geweest bij de analyse en interpretatie van de gegevens van de CLUSTER-missie van de ESA. Deze missie bestaat uit vier satellieten die in 2000 zijn gelanceerd. Ze zal minstens tot 31 december 2009 operationeel blijven. BIRA-IASB is namelijk Co-I voor twee CLUSTER-experimenten. Deze missie heeft als doelstelling een driedimensionale, niet-stationaire cartografie tot stand te brengen van de sleutelgebieden waar de interactie tussen magnetosfeer en zonnwind het zichtbaarst is. De vier satellieten van de CLUSTER-missie, die zich in een dichte formatie voortbewegen, hebben BIRA-IASB in staat

gesteld om het gebied van de plasmasfeer in detail te bestuderen (de plasmasfeer is het verlengde van de ionosfeer op lage en middelhoge breedtegraden). BIRA-IASB heeft de ontwikkeling van bijzondere structuren zoals 'pluimen', 'schouders' en 'kanalen' aan het licht gebracht. Al deze structuren werden geanalyseerd. Hun tijd-ruimtelijke ontwikkeling werd in model gebracht en vergeleken met de gelijktijdige metingen van de instrumenten EUV (aan boord van de IMAGE-satelliet) en WHISPER (aan boord van CLUSTER). In 2006 zijn de recentste metingen van CLUSTER en IMAGE geanalyseerd en vergeleken met de simulaties. Het model voor de plasmasfeer is online gezet op de portaal-site van 'European Space Weather'. BIRA-IASB heeft eveneens een nieuw, zeer krachtig algoritme ontwikkeld dat ons in staat stelt de ruimtelijke en tijdelijke gradiënten te berekenen op basis van meerpuntige metingen, zoals degene die door de vier CLUSTER-satellieten geleverd worden.

Eén van de doelstellingen van de groep 'Plasma's' is om het onderzoek naar de verbinding tussen ionosfeer en magnetosfeer te herwaarderen. Eén van de meest spectaculaire gevolgen van deze verbinding is het ontstaan van poollicht, met de discrete poollichtbogen als één van de meest intense vormen. BIRA-IASB wil twee dimensies beschrijven van de verbinding ionosfeer-magnetosfeer, vertrekkend van de basisprincipes die de beweging van geladen deeltjes regelen en gebruik makend van

relevante grensvoorwaarden op het vlak van de ionosfeer en de magnetosfeer. Studies hebben de oorzaak aangesneden van het elektrisch potentiaalverlies dat verantwoordelijk is voor de versnelling van de poollichtelektronen boven de discrete bogen. In 2006 heeft BIRA-IASB eveneens de methodes van de poollichttomografie gebruikt om de driedimensionale



structuur van de discrete poollichtbogen te reconstrueren in het gebied van de golflengten overeenkomstig de drie meest intense lijnen van de poollichtemissie (de groene, rode en blauwe lijnen).

De groep Plasma ontwikkelt verder een zeer krachtig softwareprogramma. Het bestaat uit interactieve modules die het mogelijk maken de satellietgegevens te visualiseren en te analyseren en om verschillende hulpmiddelen te gebruiken, zoals bijvoorbeeld de module om de gradiënten in de plasmasfeer te berekenen. Dit programma werd MIM genoemd (Manager of Interactive Modules).

De komeet- en planeetwetenschappen werden in 2006 niet vergeten. Enerzijds heeft BIRA-IASB, ter voorbereiding van de ROSETTA-missie, hulpprogramma's en databanken ontwikkeld met betrekking tot de chemische reacties in kometen. Deze onderzoeken zullen dienen voor de analyse van de gegevens van het ROSETTA-instrument, waarvoor BIRA-IASB de verantwoordelijkheid draagt van Co-I. De

ROSETTA-sonde werd gelanceerd op 2 maart 2004 met als bestemming de komeet 67P/Churyumov-Gerasimenko, die ze zou moeten bereiken in mei 2014. Anderzijds heeft BIRA-IASB een PRODEX-voorstel ingediend voor deelname aan het bouwen van instrumenten die zullen worden geïnstalleerd aan boord van de MMO orbiter (MSA-instrument) en van de MPO orbiter (PICAM-instrument) in het kader van de verkenningsmissie BepiColombo. Deze ESA-missie heeft als doelstelling de bestudering van de omgeving van de planeet Mercurius.

De atmosferische elektriciteit is een domein in volle expansie. Daarom heeft BIRA-IASB zich gebogen over de studie van de verhouding tussen de tijdelijke lichtfenomenen (sprites, blue jets en elves) en verscheidene aspecten van het atmosferische systeem, waaronder het klimaat.

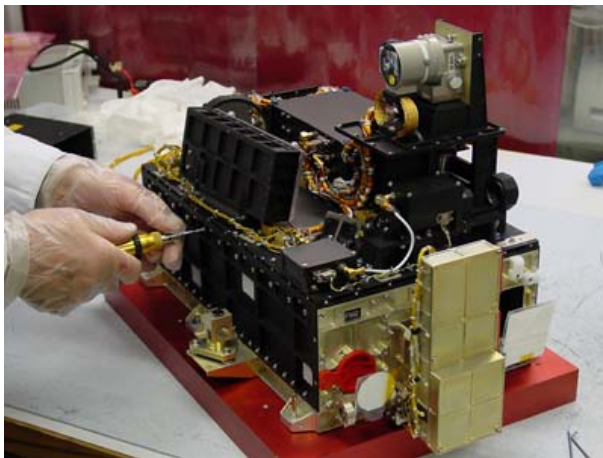


Vanuit organisatorisch oogpunt heeft de groep Plasma bijgedragen tot het uittekenen van de structuren van het toekomstige Solar-Terrestrial Center of Excellence (STCE). Meerdere leden zijn actief geweest in het inrichten van conferenties en workshops van internationaal niveau. **Viviane Pierrard** heeft de prestigieuze **Zeldovichmedaille** ontvangen voor de voortreffelijkheid van haar werk. Verschillende leden van t Belgisch Instituut voor Ruimte-Aeronomie maken deel uit van comités en/of verenigingen die op internationaal vlak werkzaam zijn.

1.3. Instrumentatie

1.3.1. VENUS EXPRESS – SOIR

Vanaf de lancering in november 2005 en doorheen gans 2006 is het Belgische SOIR-instrument (Solar Occultation in the InfraRed), een onderdeel van SPICAV (Spectroscopy for the Investigation of the Atmosphere of Venus), actief geweest tijdens alle fases van de Venus Express-missie. Een aantal tests werden uitgevoerd tijdens de commissioningperiode, bv. een eerste pointeringstest (nov 2005, jan 2006) om de uitlijning van het gezichtsveld van SOIR tegenover de satellietassen te verfijnen. Er werden ook een aantal check-outs uitgevoerd (feb 2006) om het instrument optisch te kalibreren. SOIR nam ook deel aan de Venus-commissioningfase waarin het onder meer het eerste absorptiespectrum mat van de Venusatmosfeer (mei 2006).



Sinds einde mei 2006 is de satelliet in zijn nominale baan. Op regelmatige tijdstippen worden kalibrerings- en pointeringstests uitgevoerd.

De operationele taken van het SOIR-instrument bestaan uit: het plannen van de observaties in samenwerking met de partners in het SPICAV-team, het definiëren van correcte pointing, rekening houdend met lichtbreking in de Venusatmosfeer (in huis ontwikkelde softwareroutines), het samenstellen van telecommando's voor elke observatie, het uittesten van de telecommando's op het reservemodel van SOIR in de testruimte van het BIRA-IASB, het uitwisselen van gegevens (observatieplanningen, telecommandosequenties en telemetingdata) met het Venus Express Science Operations Team (VSOC in ESTEC) en het Venus Express Mission Operations Team (VMOC in ESOC), deelnemen aan wekelijkse teleconferenties voor planning en operationele aspecten, ...

Data van het SOIR-instrument worden opgevraagd in het Data Dispositioning System (DDS) in ESOC en opgeslagen op een BIRA-IASB-server. Een eerste databehandeling wordt uitgevoerd, waarbij de niet-lineariteit van de detector wordt gecorrigeerd, de golflengteschaal wordt gekalibreerd, roosterordes worden gescheiden en referentiespectra worden gemaakt en toegepast. Al deze eerstelijns-kalibreringsstappen werden verzameld in een gebruikersvriendelijk softwarepakket dat kan gebruikt worden door het wetenschappelijk team bij verdere diepgaande analyse van de gegevens.

Er werd een volledig PSA (Planetary Science Archive)-archief opgebouwd dat up to date wordt gehouden telkens nieuwe data van SOIR worden geregistreerd.

1.3.2. BEPICOLOMBO

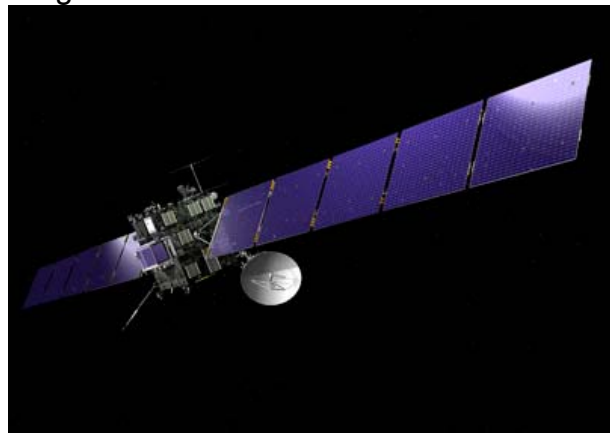
BIRA-IASB heeft onder andere deelgenomen aan de BepiColombo-missie, een 'cornerstone mission' van de ESA naar de planeet Mercurius met het instrument

PICAM (Planetary Ion Camera) dat deel zal uitmaken van de nuttige lading van MPO (Mercury Planetary Orbiter), het Europese deel van de BepiColombo-missie. PICAM is een hoge-resolutiecamera die de gehele hemisfeer afspeurt naar geladen deeltjes en zo toelaat de driedimensionale snelheidsverdeling en het massaspectrum van ionen te bepalen in een volledig gezichtsveld van 2π -radialen.

In 2006 werd een fase-A-studie opgestart tussen BIRA-IASB, CETP-IPSL en IMEC, waarin de haalbaarheid van de levering van hardwarecomponenten (ASIC's) werd bestudeerd.

1.3.3. ROSETTA – ROSINA/DFMS

De Rosetta-satelliet werd gelanceerd in 2003 en verwijdert zich sindsdien steeds verder weg in het zonnestelsel. Er werd vastgesteld dat de instrumenten aan boord van Rosetta sneller afkoelen dan oorspronkelijk voorzien. Indien de huidige trend zich zou voortzetten, zou dat tot extreem lage temperaturen leiden bij aankomst aan de komeet Churyomov-Gerasimenko.



Vooraf aan de detectormodule van de DFMS (Double Focussing Mass Spectrometer) worden zeer lage temperaturen (beneden -60 °C) verwacht. Om er zeker van te zijn dat de detector en de bijhorende RDP-elektronica (Remote Detector Pack) in staat zijn deze lage temperaturen te overleven en, zo ja, of het aanvaardbaar is de detector- en de elektronicamodules in deze omstandigheden op te starten, werden een aantal thermisch-vacuümtesten uitgevoerd (in de propere kamer van BIRA-IASB) in samenwerking met onze Franse partner (CETP-IPSL).

De testresultaten tonen aan dat de detector in staat is op te starten en te functioneren bij temperaturen tot -60 °C. Meer tests zullen uitgevoerd worden in de loop van 2007.

1.3.4. Ondersteuning bij het IMPECVOC-project

BIRA-IASB ontwikkelde en testte Labview software, ter ondersteuning van het IMPECVOC project waarin een PTR-MS massaspectrometer zal worden gebruikt voor het meten van biogene vluchtige organische stoffen. Dit softwarepakket is opgebouwd rond een schakeleenheid en een datalogger die in staat is een groot aantal omgevings- en instrumentparameters te monitoren (temperaturen, lichtintensiteit, debieten, ...). Het geheel is voorzien van een flexibele, gebruikersvriendelijke interface, die toelaat alle parameters in te stellen en te observeren. De gebruiker heeft ook de mogelijkheid om scripts te gebruiken. In de mechanische werkplaats ontwikkelde BIRA-IASB een prototype van de containers die in dit project worden gebruikt, 'cuvettes' genaamd.

1.3.5. Ondersteuning bij het BRUKER-project

Ter ondersteuning van het BRUKER-project ging BIRA-IASB verder met de ontwikkeling van de LabView-software voor het besturen van de spectrometer en de bijhorende zonnevolger; met de verbetering van de mechanica (scheiden van de zonnevolgfunctie van het afsluitsysteem van de zonnevolger door middel van een pneumatisch afsluitsysteem, vervangen van de 45°-spiegel in het optisch pad) en de elektronica (combineren van een CCD-camera en een 4-kwadrantsdetector in de zonnevolglus) van het instrument. BIRA-IASB is ook begonnen met het ontwerp en de constructie van een volledig nieuwe, compacte zonnevolger.

1.3.6. Engineeringsondersteuning voor het EPT-project

BIRA-IASB ontwierp de volledige mechanische structuur voor het EPT-instrument (Energetic Particle Telescope), in samenwerking met de UCL – Université Catholique de Louvain. BIRA-IASB bouwde hulpstukken en een transportcontainer voor de vibratietests in 2007 (ESTEC). Tussen 4 en 8 mei 2006 voerde BIRA-IASB thermisch-vacuÛmtesten uit in haar testkamer.

1.4. B.USOC

1.4.1. Inleiding

Tijdens de voorbereidingsfase van het gebruiksprogramma voor de Columbusmodule van het Internationaal Ruimtestation is het B.USOC verantwoordelijk voor activiteiten zoals de implementatie van het grondsegment, de operaties met de verschillende grondmodellen, de ontwikkeling van de operationele experimentprocedures, de optimalisering en de kalibrering van de operaties met de nuttige ladingen en experimenten, en de ondersteuning van de vormings- en trainingsactiviteiten van de wetenschappelijke en operationele teams. Tijdens de operaties met de nuttige ladingen in een baan om de aarde zal het B.USOC de experimentgegevens ontvangen en ondersteuning bieden aan het Columbus Control Center (COL-CC) door de operaties te verzekeren met de nuttige ladingen waarvoor het B.USOC verantwoordelijk is. De globale voorbereiding en uitvoering van de gebruiksactiviteiten is een gedeelde verantwoordelijkheid van de ESA, het B.USOC en de industrie (deze laatste omvat de industriële operatoren die de nuttige ladingen hebben ontwikkeld).

1.4.2. Harmonisering van de contractsstructuur

In deze context was het jaar 2006 een beslissend jaar voor de afronding van de implementatie van de infrastructuur, evenals voor de evolutie van de managementsstructuur.

Op louter organisatorisch vlak heeft ESA aanvaard om het B.USOC Steering Committee (samengesteld uit vertegenwoordigers van Belpo, BIRA-IASB, het B.USOC en de industriële operator belast met de implementatie) de rol te laten spelen van beslissingscentrum, opdat het B.USOC formeel gezien over een

organisatorisch schema zou kunnen beschikken dat vergelijkbaar is met de andere USOC's van het netwerk.

De vanzelfsprekende tegenprestatie vanwege ESA was dan ook een omvorming van de contractuele relaties met de industrie om het B.USOC de verantwoordelijkheid voor management en onderaanneming naar de industrie toe te kunnen geven (in de praktijk wordt de industriële operator dus onderaannemer van het B.USOC).

1.4.3. De PromISS-4-missie

Begin 2006 was het B.USOC het Europees missiecentrum, verantwoordelijk voor het uitvoeren van het PromISS-4-experiment. Dit Belgisch experiment van eiwitkristallisatie werd gerealiseerd in het Internationaal Ruimtestation, meer bepaald in de 'Microgravity Science Glove Box' (MSG), die zich in het Amerikaans laboratorium bevindt. Het experiment werd geactiveerd in de nacht van 19 januari en het B.USOC heeft de real-timeoperaties gedurende meerdere weken geleid.

1.4.4. Voorbereiding van de COLOMBUS-operaties



Op 6 december 2007 zal de Europese COLOMBUS-module in een baan om de Aarde worden gebracht en vastgehecht aan het Internationale Ruimtestation. In de context van dit programma en van de gedecentraliseerde visie van de ESA werd aan België de verantwoordelijkheid toegewezen van missiecentrum van het zonnelaboratorium (SOLAR) en van de 'Protein Crystallization Diagnostic Facility' (PCDF). In deze context werd het jaar 2006 gekenmerkt door:

- de voltooiing van de implementatie van het ISS-grondsegment in het kader van het FRC SOLAR en van het FSC EDR/PCDF
- de ontvangst van de Columbus Emulator
- het uitvoeren van de tests met de procedures en het ISS-grondsegment
- de training en vorming van het personeel (B.USOC en SAS) voor het uitvoeren van de increment-1E-operaties
- de afwerking van de contractuele documentatie voor het ESA 'Check point' (16/10/2006)
- de uitrusting van het PCDF-laboratorium, de ontwikkeling van software ter ondersteuning van de wetenschappers in het kader van de voorbereiding van het EDR/PCDF-experiment en voor zijn implementatie in microzwaartekracht.



1.4.5. Inrichting van het wetenschappelijk missiecentrum van PICARD (CMS-P)

De PICARD-missie past in het kader van de MYRIADE-reeks van het CNES. Het gaat om een wetenschappelijke microsatteliet met aan boord 3 instrumenten voor de beschrijving van de Zon (diameter,

limbe, activiteit).

De betrokken laboratoria zijn Frans (Service d'Aéronomie du CNRS, voor het SODISM-instrument), Belgisch (Koninklijk Meteorologisch Instituut, voor het SOVAP-instrument) en Zwitsers (World Radiation Center, voor het instrument PREMOS).

De lancering is gepland voor 2009 en de missie is voorzien voor een nominale duur van 3 jaar.

Het CNES is verantwoordelijk voor het globaal technisch en financieel beheer van de PICARD-missie, en de dienst DCT/PS/CMI is bevoegd voor de ontwikkeling van het wetenschappelijk missiecentrum van PICARD (CMS-P). De financiering van het CMS-P wordt verzekerd door de Belgische staat via het PRODEX-programma van de ESA.

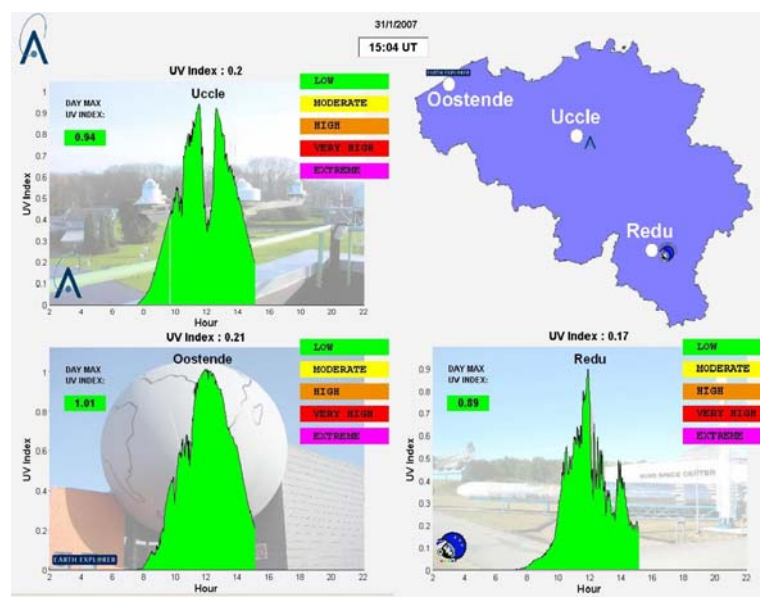
Tijdens het jaar 2006 werden ook de technische specificaties van het wetenschappelijk missiecentrum van PICARD definitief op papier gezet. Na een openbare aanbesteding bij 4 Belgische bedrijven in juni 2006 werd de uitvoering ervan toevertrouwd aan het bedrijf SPACEBEL.

1.5. Valorisatie

BIRA-IASB heeft zijn activiteiten van wetenschappelijke dienstverlening uitgebreid.

1.5.1. UV-index

In 2006 beheerde BIRA-IASB drie automatische stations om de UV-straling continu te meten. De combinatie van de verschillende meettechnieken maakt het mogelijk de UV-klimatologie van de waarnemings-site te bepalen en de invloed te bestuderen van het ozon, de aerosols, het wolkendek enz. op de penetratie van de UV-straling tot op het aardoppervlak. Een bijzondere inspanning werd geleverd om deze gegevens voor het grote publiek zichtbaar en toegankelijk te maken. Daarvoor is er een **UV-indexservice** opgezet via de BIRA-IASB-webpagina's die in reële tijd de UV-index en bijhorende informatie aangeeft in de 3 Belgische UV-metstations: Ukkel, Oostende en Redu. Deze gegevens zijn reeds beschikbaar en worden voorgesteld op <http://www.aeronomie.be>



1.5.2. BACCHUS

Het BIRA-IASB en het Directoraat voor Atmosfeerwetenschappen van Environment Canada sloten in 2006 een samenwerkingsovereenkomst om diensten zoals het voorspellen van de luchtkwaliteit en de vervuiling te ontwikkelen en te leveren aan onze samenleving. In aanwezigheid van Prins Filip en het federaal Ministerie van Wetenschapsbeleid ondertekenden vertegenwoordigers van beide onderzoeksinstituten een verklaring tot nauwe samenwerking op het vlak van de atmosfeerchemie.



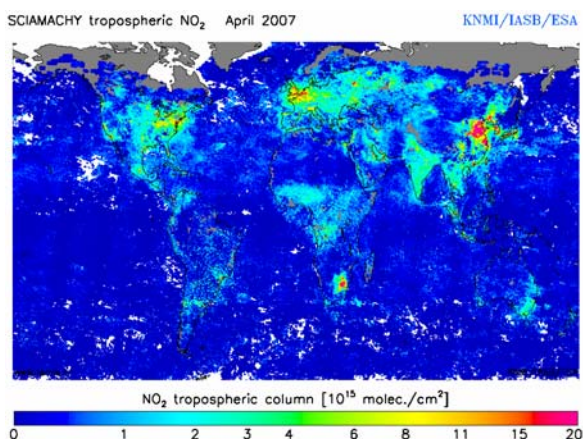
Heel concreet gaat het over afgeleide producten als:

- een verbeterde voorspelling van de luchtkwaliteit
- chemische voorspellingen in de lage atmosfeer
- langetermijnanalyses van troposferische vervuiling en de schade aan landbouwgewassen
- controleren van de uitstoot van broeikasgassen en chemische samenstellingen die een belangrijke rol spelen in ozonafbrekende processen (ozonprecursoren)
- voorspelling (3 dagen) van de UV-index.

Het onderzoek kadert binnen het GEOSS, het Global Earth Observation System of Systems, en meer bepaald de Europese bijdrage GMES, Global Monitoring for Environment and Security. Gebruik makend van de expertises ontwikkeld in BASCOE en het project **ACHEDYRE** ontwikkelt het BIRA-IASB dus, in samenwerking met de Meteorological Service of Canada, een nieuw operationeel data-assimilatiesysteem dat zowel de troposfeer als de stratosfeer, en zowel dynamica als chemie, zal voorstellen. Dit is het onderwerp van het project **BACCHUS**, Belgium And Canada for CHemical weather User-oriented Services.

1.5.3. TEMIS

Het Instituut speelt een belangrijke rol in het ESA DUE-project **TEMIS**, in samenwerking met het KNMI, waarin het geavanceerde troposferische satellietproducten aanbiedt voor H_2CO en NO_2 , en onderzoek doet naar de mogelijkheid om lange-afstandstransport te karakteriseren op basis van satellietgegevens, eventueel op operationele basis. Voor deze laatste studies zijn de trajectmodellen FLEXSTRA en FLEXPART geïmplementeerd aan het BIRA-IASB en met succes geëxploiteerd.



1.5.4. GMES – PROMOTE

BIRA-IASB neemt bovendien deel aan het GMES Service Element project **PROMOTE**, met de 'Stratospheric Aerosol and Gas'-dienst, de 'Ozone Record Profiles'-dienst (voortzetting van BASCOE), de 'Support to Aviation Control'-dienst, de productie van hoge-kwaliteits-satellietproducten voor H₂CO en NO₂ uit GOME, SCIAMACHY, OMI en GOME-2, en de 'PROMOTE Quality Assessment/Validation Office'.

BIRA-IASB neemt deel aan het tweede speerpuntproject van de Europese Commissie: **GMES** (Global Monitoring for Environment and Security), waarvan het vierde pilootproject, dat draait rond de atmosfeer, het mogelijk zou moeten maken om aan de politieke leiders en aan het grote publiek diensten aan te bieden met de meting van ozon, aerosols, de UV-index, de luchtkwaliteit...

BIRA-IASB ontwikkelt nu reeds deze producten in samenwerking met de industrie en met talrijke Belgische universiteiten (Université de Liège, UCL, KU Leuven, de universiteiten van Gent en Antwerpen...).

De aanwezigheid van BIRA-IASB in de GMES-gerelateerde projecten **GEMS**, **PROMOTE** en **GEOMON** is belangrijk voor een goede positie binnen de toekomstige EU GMES Atmospheric Service (**GAS**).

1.5.5. Effecten van de ruimtestraling (SPENVIS)

De wisselwerking tussen de heliosfeer en de magnetosfeer is onmisbaar voor de ruimtemeteorologie, de voorspelling van de impact van de heliosferische omstandigheden op de menselijke activiteiten.

De constructie van een satelliet bijvoorbeeld vereist dat men de hoeveelheid ioniserende straling kent die hij tijdens zijn levensduur zal opvangen. Men heeft dus behoefte aan modellen van de stralingsverdeling, inclusief hun evolutie met de zonneactiviteit. BIRA-IASB heeft hiervoor een hulpmiddel ontworpen: het SPENVIS-systeem (<http://www.spennis.oma.be/>).

1.5.6. Ruimteweerkunde

De software-infrastructuur van het Space Weather European Network (SWENET) is beschikbaar op <http://www.esa-spaceweather.net/swenet>, een portaal die toegang biedt tot diensten en data m.b.t. de ruimteomgeving en haar invloeden, waaronder:

- de voorspelling van poollicht
- de geomagnetische activiteit en GIC-voorspellingen
- de omstandigheden voor radiocommunicatie
- de kwaliteit van satellietnavigatiediensten
- afwijkingen van en operationele ondersteuning voor satellieten

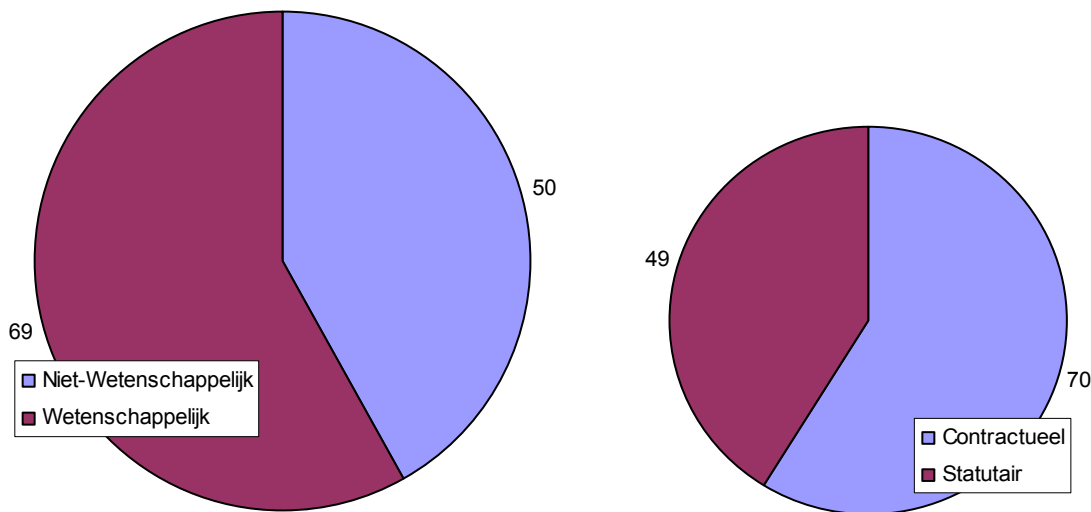
De SWENET-portaalsite biedt ook een breed gamma van data aan over de ruimteomgeving, die verzameld worden uit diverse externe bronnen en ter beschikking worden gesteld via een gemeenschappelijke databank. Gebruikers kunnen data opzoeken van specifieke tijdsperioden en daarbij verschillende bronnen combineren, dit dankzij een krachtig analyseprogramma. De resultaten kunnen dan worden weergegeven in de webbrowser, gedownload worden als tekstbestanden of grafisch worden geplot.

SWENET werd ontwikkeld in het kader van het ESA Space Weather Pilot Project, met de bedoeling Europese gebruikers te ondersteunen met informatie en diensten met betrekking tot de effecten van ruimteweer.

Cost 724, een EU-initiatief van 28 landen, heeft de wetenschappelijke basis gelegd voor de monitoring, modellering en voorspelling van ruimteweer. De resultaten worden nu ter beschikking van het publiek gesteld op een geïntegreerde website, de 'European Space Weather Portal'. Naast de functies die bedoeld zijn voor wetenschappers en ingenieurs (bv. toegang tot de modellen en databanken), legt de European Space Weather Portal sterk de nadruk op outreach en heeft hij een specifieke afdeling die hieraan gewijd is. De European Space Weather Portal kan geraadpleegd worden op het adres <http://www.spaceweather.eu>.

Deel 2: Werking

2.1. Personeel



2.2. Communicatie

2.2.1. Inleiding

BIRA-IASB heeft de opdracht wetenschappelijke en technologische expertise te verwerven op het gebied van de ruimte-aeronomie en deze informatie te verspreiden.

2.2.2 Didactisch materiaal

De algemene website van het BIRA-IASB (<http://www.aeronomie.be>) bestaat al sinds de creatie in het Nederlands en het Frans. In 2006 werd de site, naast het dagelijks beheer, bijna volledig vertaald naar het Engels en werd deze uitgebreid met databanken waarin de bezoekers wetenschappelijke projecten en wetenschappelijke publicaties van BIRA-IASB-personeelsleden kunnen opzoeken. Voor de Venus Express-missie werden in april 2006 nieuwe pagina's aangemaakt. Het BIRA-IASB zorgde er verder voor dat, naast de lange-termijnwaarnemingen in verband met UV, ook de UV-index gemeten in Ukkel, Oostende en Redu live (om de minuut!) te volgen is via de website. Naar aanleiding van de lancering van Metop-1 met IASI en GOME-2 aan boord creëerde het BIRA-IASB nieuwe pagina's. Op **de website van het B.USOC** (<http://www.busoc.be>) werden, naast het onderhoud, ook pagina's over PromISS-4 (januari 2006) gecreëerd.

De communicatiecel houdt zich bezig met het actualiseren van de quizvragen en het onderhoud van de **interactieve quizcomputers**.

Een groot aantal **posters voor tentoonstellingen** over de voor het Instituut relevante thema's werden gecreëerd. Er bestaan algemene posters en posters over de missies waaraan het BIRA-IASB deelneemt. Het accent ligt altijd op de Belgische bijdrage en meer bepaald op de bijdrage van het BIRA-IASB aan deze missies.

2.2.2.1. Evenementen en tentoonstellingen

Het BIRA-IASB installeerde een tentoonstelling met posters over **Venus Express**, **het instrument SOIR** en de bijdrage van het BIRA-IASB; het vluchtmodel van SOIR en een 3D-animatie van het instrument SOIR (dank aan het departement engineering!) in:

- het Planetarium van Brussel (*van april tot december 2006*)
- het Euro Space Center van Redu-Transinne (*van juni tot december 2006*).

De **Venus Express- en Mars Express-missies** werden belicht in het Centre de Culture Scientifique van Parentville (Charleroi) met posters, SpaceQuizComputers, maquettes,... (*van maart tot augustus 2006*).

Het BIRA-IASB nam deel aan het 'Forum des entreprises' van de Université du travail de Charleroi met **een algemene presentatie** over het Instituut aan de hand van posters, het ter beschikking stellen van twee quizcomputers en het animeren van de stand (*maart 2006*).

Een rondreizende tentoonstelling over de Hubbletelescoop in combinatie met een **algemene voorstelling van het BIRA-IASB** en 2 quizcomputers verhuisde om de 4 maanden van volkssterrenwacht Beisbroek (Brugge), naar volkssterrenwacht Urania (Hove), naar volkssterrenwacht Mira (Grimbergen).

Op de 'Wetenschaps-Expo-Science' van de Jeunesses Scientifiques van België gaf het BIRA-IASB **een algemene presentatie van het Instituut** aan de hand van posters en quizcomputers (*mei 2006*).

In het Koninklijk Paleis organiseerde het Federaal Wetenschapsbeleid een tentoonstelling, waarin o.a. het **BIRA-IASB** werd voorgesteld aan de hand van het schaalmodel van de **Rosettasonde**.

Het Wetenschapsbeleid organiseerde ook een evenement in het Kasteel van Seneffe met als centraal thema

'kleuren'. Het Instituut was aanwezig met een workshop over '**De kleur van aurora's**' (*september 2006*). Dezelfde workshop werd opgezet tijdens de Europese Researchers' Night diezelfde maand.





Het BIRA-IASB nam *in oktober* ook deel aan het Wetenschapsfeest in Flanders Expo Gent met een interactieve stand (4 quizcomputers) en een paneel over de **lagen van de atmosfeer**. De educatieve brochure van het BIRA-IASB werd er massaal verspreid.

In Earth Explorer Oostende werd een tentoonstelling geïnstalleerd over **UV-stralen**, de BIRA-IASB-waarnemingsstations, de **live-UV-index** en de **gevaren** voor de mens (*juni tot september 2006*). Er is een tentoonstelling voorzien over dit thema in het Euro Space Center in 2007.

Op de Vlaamse Ruimtevaarddagen in Oostende was het BIRA-IASB aanwezig met 4 SpaceQuiz-computers en de tentoonstelling over **Venus Express (SpicaV-SOIR)** die de rest van het jaar al opgesteld stond in het Planetarium van Brussel (*november 2006*). *Dezelfde stand werd enkele weken later geïnstalleerd op de Brussels Innova, Brussels Eureka, Innovatie beurs.*

Het BIRA-IASB was aanwezig op de tentoonstelling 'Découverte et conquête spatiale', met posters over Envisat, Mars en Venus Express, het broeikaseffect, de klimaatsveranderingen en een quizcomputer (*in november 2006*), georganiseerd door de Expo Espace et Environnement Mariemont, in het cultureel centrum van Manage.

2.2.2.2. Persrelaties

In 2006 werden persberichten verstuurd in verband met:

- de Sodankyla-campagne (SAUNA-project) (*maart*)
- de aankomst van Venus Express met instrument SOIR (*april*)
- het BIRA-IASB-onderzoek naar de UV-index (*juni*)
- de lancering van Metop-1 met IASI en GOME-2 aan boord (*oktober*)
- de wereldzondag (*september*)
- montage van allerlaatste onderdeel SOLSPEC instrument (*november*).

2.2.2.3. Tijdschrift 'Science Connection'

De cel communicatie ondersteunde wetenschappers van het BIRA-IASB bij het schrijven van (en/of schreef zelf) vulgariserende artikels voor het tijdschrift van het Federaal Wetenschapsbeleid 'Science Connection' over de volgende thema's:

- Envisat (Gomos), auteur Didier Fussen (*februari*)
- UV-stralen (*augustus*)
- Venus Express (SpicaV-SOIR) (*augustus*)
- Wetenschappers hebben ook een hobby: vb. gitarist (*september*)
- Lichtverschijnselen boven onweer (*december*)
- Onderzoeker Christian Hermans in Jungfrauoch (*december*).

2.2.3. Interne communicatie

De communicatiecel houdt zich ook bezig met interne communicatie via het dagelijks beheer van een groot deel van het intranet. Andere 'communicatie-evenementen' zoals het in groepsverband deelnemen aan de 20 km door Brussel zijn ook door deze cel georganiseerd.

2.2.4. Wetenschappelijke communicatie

Een vorm van communicatie waar de cel communicatie niet echt bij betrokken dient te worden, is de wetenschappelijke communicatie. Met deze term verwijzen we naar één van de basiselementen van het wetenschappelijk onderzoek: de communicatie tussen wetenschappers onderling. De onderzoekers van het BIRA-IASB publiceerden in 2006 samen een 40-tal aan experten voorgelegde publicaties in internationale vaktijdschriften of boeken, een 20-tal niet aan experten voorgelegde publicaties en 1 doctoraatsverhandeling. Ze gaven meer dan 75 presentaties (mondeling of in postervorm) op internationale symposia en tot 4 maal toe werd een spreker van het BIRA-IASB uitgenodigd, zelfs verzocht om een voordracht te komen geven. Tot slot kunnen we nog vermelden dat het BIRA-IASB ook betrokken is bij meer dan 40 nationale en internationale projecten, vaak met belangrijke verantwoordelijkheden als activiteitenleider of coördinator.

2.3. Budget

De budgettaire middelen van het Instituut kunnen op de volgende manier worden onderverdeeld:

- Personeelsenveloppe: de loonkosten van het statutaire personeel
- Dotatie van de federale administratie (sectie 0)
- Eigen inkomsten (sectie 1)
- Lotto, ministeriële onderzoeksprogramma's (sectie 2)
- Inkomsten vanwege derden, onderzoekscontracten (sectie 3)

Voor sectie 0 – dotatie van de federale administratie:

Inkomsten: het totaal, overschot inbegrepen, bedroeg 1.319.000 euro

Uitgaven:

Personeel: 153.430 euro

Algemene werkingsmiddelen voor het Instituut: 251.275 euro

Specifieke werkingsmiddelen, gekoppeld aan de projecten: 331.200 euro

Algemene uitrusting: 101.300 euro

Specifieke uitrusting: 457.500 euro

Voor sectie 1 – eigen inkomsten:

Personeel: 121.600 euro

Werking: 36.000 euro

Voor sectie 2 – inkomsten van Lotto, ministeriële onderzoeksprogramma's:

Inkomsten (subsidies): 849.275 euro, waarvan 233.000 euro van Lotto

Uitgaven:

Personeel: 564.800 euro

Werking: 47.750 euro

Uitrusting: 207.000 euro

Voor sectie 3 – fondsen vanwege derden (ESA, EC, ...):

Inkomsten: 2.965.700 euro

Uitgaven:

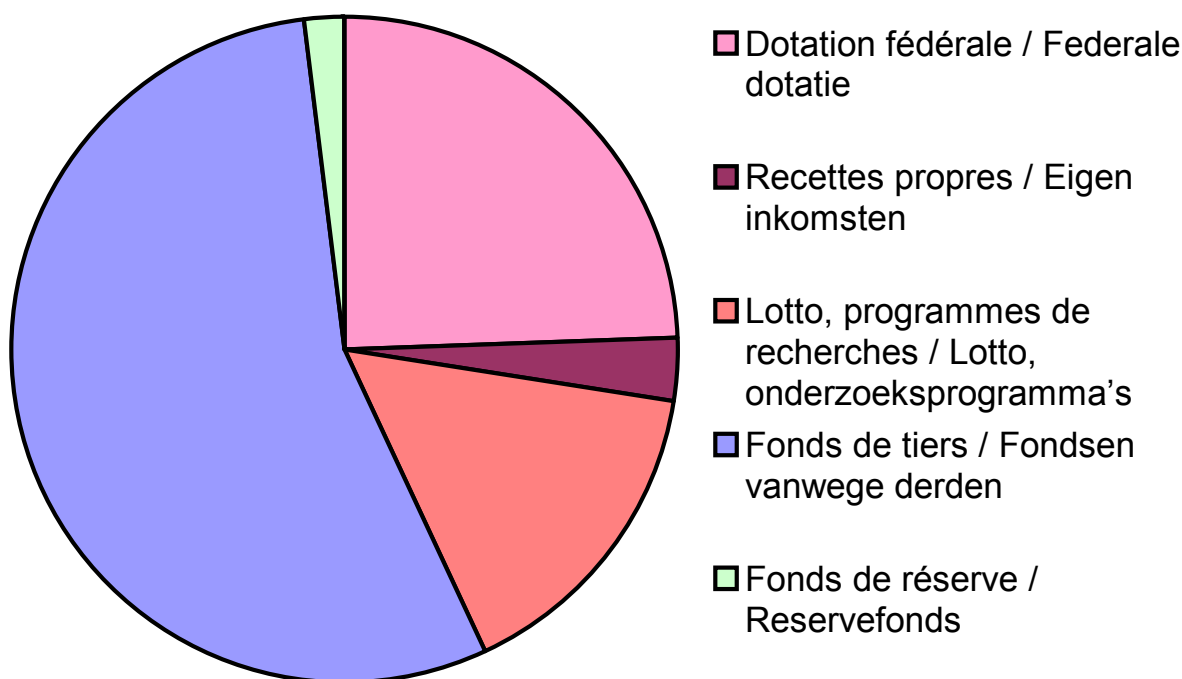
Personeel: 1.881.000 euro

Werking: 569.200 euro

Uitrusting: 78.500 euro

Voor sectie 4 – reservefonds:

Het huidige saldo van het reservefonds bedraagt 100.608 euro.



2.4. ICT

De activiteiten van het ICT-team van het BIRA-IASB kunnen opgesplitst worden in 2 categorieën: de dagelijkse activiteiten die het ganse jaar door uitgevoerd worden, en projectgebonden werk dat verband houdt met het bereiken van specifieke doelstellingen voor de gehele infrastructuur of voor bepaalde projecten.

Dagelijkse activiteiten

Dit zijn de activiteiten die ons het meest in contact brengen met onze gebruikers binnen het Instituut. De belangrijkste zijn:

- het operationeel houden van de basisinfrastructuur: onderhouden van de printers, vervangen of repareren van defect materieel, installeren van nieuwe versies van programma's of veiligheidsupdates, controleren van de goede werking van alle servers en diensten
- de ondersteuning van de gebruikers bij hun dagelijkse taken en het oplossen van specifieke problemen die ze kunnen hebben met programma's of diensten; dit omvat ook bijstand bij het ontwikkelen of aanpassen van hun eigen toepassingen
- de installatie van nieuwe gebruikers en afsluiten van gebruikersaccounts van mensen die vertrekken; er waren een 20-tal nieuwe gebruikers over het laatste jaar.

De tijd die geïnvesteerd wordt in deze dagelijkse activiteiten groeit met het aantal gebruikers en stijgt ook met de toenemende diversiteit en complexiteit van de toepassingen en van het gebruikte materiaal.

Langs de andere kant proberen we deze permanente belasting onder controle te houden door een verdere uitbouw van het centrale beheer, een betere standaardisering en het maximaal automatiseren van courante taken.

Desondanks nemen deze kleinere taken een steeds groter deel van onze tijd in beslag.

Projecten

De grotere projecten die verleden jaar gestart en/of gerealiseerd werden, hebben voornamelijk betrekking op de vernieuwing en de uitbouw van de bestaande infrastructuur om beter te voldoen aan de steeds toenemende eisen en verwachtingen van de gebruikers. De belangrijkste zijn de volgende:

- Het opstarten, uitbrengen en opvolgen van een groot lastenboek (+/- 1 miljoen euro) voor de aankoop van een nieuwe centrale fileservers voor de Pool Ruimte. Een dergelijk lastenboek vraagt een belangrijke investering van tijd (o.a. marktonderzoek, onderzoek van de noden, definiëren van technische vereisten) om tot een goed einde gebracht te kunnen worden. De gunning is uiteindelijk gebeurd in januari 2007.
- Een belangrijke wijziging voor de Unix-gebruikers was de overstap naar een nieuwe Linux-gebaseerde login en applicatieserver. Dit werd gecombineerd met de installatie van een nieuwe generatie Unix/Windows-werkposten (thin clients) voor de gebruikers. De combinatie van deze 2 investeringen heeft een sterke verhoging van het gebruiksgemak voor de gebruikers opgeleverd.

- Bijkomende investeringen hebben de online opslagcapaciteit van de Envisat-server op 35TB gebracht.
- Een beveiligd draadloos netwerk is in bedrijf genomen om bezoekers van het Instituut een gemakkelijke toegang tot het internet te geven. Om veiligheidsredenen is dit netwerk volledig gescheiden van het interne netwerk van het Instituut.
- De configuratie van de centrale computerserver Zeno is verder verfijnd en een cursussenreeks werd gegeven om de gebruikers meer informatie te geven over het gebruik van deze machine.
- De firewall tussen het netwerk van de Pool Ruimte en het internet werd samen met de centrale routing switch uitgebreid als voorbereiding op de toekomstige upgrade van de internetverbinding en om extra bandbreedte te voorzien voor de nieuwe centrale fileserver.
- Bijkomend wordt er permanent geïnvesteerd in het betrouwbaarder maken van de gehele infrastructuur. Dit zowel door investeringen in fouttolerante hardware als in softwareoplossingen die een continue dienst garanderen. Dit blijft een permanent punt van aandacht daar meer en meer informaticadiensten als kritiek beschouwd kunnen worden voor de goede werking van het Instituut.

Deel 3: Besluiten en doelstellingen voor 2007

2006 was een eerste jaar van consolidatie naar wetenschappelijke en dienstverlenende activiteiten, maar eveneens een overgang naar een geoptimaliseerde organisatie en de bijhorende beheerssystemen voor projecten en financieel/contractueel beheer.

Voor 2007 worden de volgende doelstellingen naar voor geschoven:

- Het verder optimaliseren van de wetenschappelijke kennis naar een Center of Excellence in de domeinen van enerzijds de atmosferische fysica en chemie en anderzijds het ruimteplasma.
- Het uitbouwen, in samenwerking met de KSB en het KMI, van het Solar-Terrestrial Center of Excellence. Voor BIRA-IASB houdt dit onder andere in: het operationeel maken van de Europese Space Weather Portal en aanverwante diensten.
- De verdere integratie van de dienstverlenende activiteiten onder de noemer 'Service Center' van het BIRA-IASB. Hierbij zullen de B.USOC-activiteiten, zoals de exploitatie van experimenten aan boord van het Internationaal Ruimtestation ISS en het Mission Control Center integraal deel uitmaken van het BIRA-IASB.
- De positionering van het BIRA-IASB in het Pilootproject Atmosfeer van het Europees programma GMES (Global Monitoring for Environment and Security).
- Het openstellen van het 7^{de} kaderprogramma (2007-2013) is het platform waar actieve deelname zal nagestreefd worden in internationale programma's.
- Internationale structurele samenwerking, gezien het onderzoek aan het BIRA-IASB vooral een globale dimensie heeft. Samenwerking met andere continenten is een zeer belangrijke toegevoegde waarde.
- De rationalisatie van de samenwerking met Belgische universiteiten en onderzoeksinstituten.
- Een actieve bijdrage aan nationaal en internationaal beleid, bijvoorbeeld in de context van klimaat en milieu.

Bijlagen

Bijlage 1: Scheikunde en fysica van de atmosferen (uitvoerig verslag in het Engels)

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- Synergies between ground-based, balloon and satellite data
- Synergies with modeling: data assimilation

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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 Matashvili, 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 OCIO).

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 (NO_x) and the non-methane volatile organic compounds (NMVOC). The formaldehyde data are obtained by the group of M. Van Roozendaal, 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 $\text{C}_{15}\text{H}_{24}$) 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 optimisation 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 isotopologues of NO₂ 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 isotopologues) (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 NO₂ 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 SO₂ 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 Mazière M, Van Roozendaal 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 O₃ vertical profiles from FTIR ground-based measurements at the Jungfraujoch. The O₃ 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 (O₃, N₂O, CH₄, CO, C₂H₆, HCFC-22), and the associated model and trend studies, in a Special Issue in the Atmospheric 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 CH₄ at Réunion Island.

Evergreen **(IR)**

The work regarding the validation of the greenhouse gases retrieved from SCIAMACHY in the near-infrared channels (CO, CH₄, CO₂, and N₂O) 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 CH₄ 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://smc.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, CH₄ and N₂O 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 (C₂H₆) 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 Jungfrauoch.

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 tropospheric 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 O₃ and temperature, in the MIPAS ACP Special Issue
- Development of a novel technique to validate NO₂ profile satellite data using NO₂ 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 N₂O and HNO₃ 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, O₃ and NO₂. 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 NO₂ 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, N₂O, NO₂, CH₄, HNO₃, and O₃ 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, O₃ and HNO₃ will be submitted by the product coordinators (M. Ridolfi for temperature, U. Cortesi for O₃, Wang for HNO₃) 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 O₃ profile, UV-visible spectrometers for O₃, NO₂ and BrO columns, Brewer and Dobson spectrophotometers for O₃ 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 O₃, NO₂, BrO, CO, CH₄, and N₂O 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, O₃ and NO₂ columns, and cloud data products.

We have also carried out a preliminary validation of OMI O₃ and NO₂ 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 O₃ 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 O₃ 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 O₃ and NO₂ 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 O₃ and NO₂ 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 O₃ 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 O₃ column data version 4.1, and (b) geophysical validation of the entire GOME-1 GDP 4.1 data record (1995-2006) of O₃ and NO₂ 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 O₃, NO₂ 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 (O₃, NO₂, CH₄, N₂O, HNO₃, 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, O₃ and NO₂ columns, and cloud data products

ACE (PRODEX) **(IR and SYN)**

Being coordinator of the validation of the CH₄ 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 CH₄ 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 O₃ and NO₂ 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 NO₂ 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 NO₂ data using ground-based DOAS profiling at Harestua
- Validation of the Canadian ACE-FTS and ACE-MAESTRO NO₂ 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 NO₂, 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 NO₂ 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 compiler. 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.Chabrilat@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. Chabrilat 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 negotiations 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 negotiations 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 Environment 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 SO₂ 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 2π sr 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 confirmed 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 CO₂ 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. Matshvili [Matshvili 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 Martian 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 or UV-resistant.

According to the work of Joop M. Houtkooper and Dirk Schulze-Makuch, it is possible to reinterpret the results of the Viking 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

Bijlage 2: Interplanetair milieu en plasma (uitvoerig verslag in het Engels)

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 plasmopause 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 plasmopause position developed at IASB-BIRA.

The model of plasmopause position was improved to simulate different mechanisms proposed for the formation of the plasmopause: 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 plasmopause 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 plasmopause 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 plasmopause 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 plasmopause 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 Beijing, 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 September 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

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