Evolution of SST and XCO_2 in the summer ice free Arctic Ocean: is IASI able to contribute to climate change studies?

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ABSTRACT

The Arctic Ocean is a very important region of the globe in which the effect of climate change can be detected over short time periods. We have used the possibility provided by the two infrared sounders IASI-A and IASI-B on the MetOp platforms to retrieve the sea surface temperature (T_{surf}) and the column averaged mixing ratio of several trace gases including CO_2. A strict filtering based on the AVHRR cloud fraction and the radiance analysis within the IASI footprints lead to a large number of spectra for which a 1D-var inversion (T_{surf} and XCO_2 as the main parameters in the state vector, plus scaling factors for the profiles of H_2O and O_3) has been performed. For this purpose, we used during retrieval the atmospheric window between 940 and 980 cm-1 (CO_2 laser band) for which the sensitivity to the surface is maximum. The statistics of the comparison between IASI-A and IASI-B retrievals will be presented and compared to the corresponding Eumetsat L2 products. The months of July, August and September for the years 2013 to 2015 have been considered since in these Arctic summer conditions the ice pack coverage is reduced. The monthly climatology for the consecutive years from 2010 (for which only IASI-A was in orbit) to 2015 is confirming that IASI can indeed be used for climate change studies.

Climatology of infrared radiance spectra from IASI-A has been continued since June 2010. Monthly averaged radiances spectra for the globe or for specific areas are computed and archived. Similar statistics of IASI-B radiances are also established but slight differences in cloud mask generates small radiometric differences and a discontinuity in the time series. As long as IASI-A is working well, it thus remains the reference to monitor climate change. Full spectra are compared month to month since 2010 and annual mean spectra are compared for all pixels and only sea pixels. The year to year differences are then inverted to retrieve CO_2, CH_4, O_3, N_2O variations, surface temperature, and mean troposphere, mean stratosphere temperature and humidity. The figures are then compared to NCDC with a good agreement. On another hand, proxies are defined for the SST, for surface temperature (land and sea in daily conditions) or other ECV signatures and plotted for all cloudfree (0%) or cloudy (>95%) and also for land or sea pixels. Surface temperature for Tropical ocean (20S-20N) and ENSO 34 or Pacific west zone are also extracted and plotted. The time series shows a continuous increase of global sea surface temperature while global temperature first decreases before strongly increasing in 2014 and 2015. The slope of increase of tropical SST is very strong since 2010, about 0.1C/year. This is further amplified by the ENSO event of 2015 but the trend is there. In this paper, the difference of heating rate between land and sea temperature is discussed according the different assumptions.

Defining IASI as the Primary Reference for the Global Space-based Inter-Calibration System (GSICS)

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ABSTRACT

The Global Space-based Inter-Calibration System (GSICS) aims to ensure consistent accuracy among satellite observations worldwide for climate monitoring, weather forecasting, and environmental applications. To achieve this, algorithms have been developed to correct the calibration of meteorological geostationary imagers to be consistent with community-defined reference instruments. For inter-calibration of channels in the thermal infrared, Metop-A/IASI has been defined as the *primary GSICS reference*. Comparisons with other reference instruments may also be used and transferred back to this primary reference through a series of double-differences, which can be combined according to their associated uncertainties. This approach ensures traceability to a community reference, while allowing comparisons with reference instruments on different satellites to characterise any diurnal calibration variations of the monitored instrument.

This paper describes the process of selecting Metop-A/IASI as the primary GSICS reference for the thermal infrared. This analysis is based firstly on an analysis of the coverage provided by the reference instrument (geographically, temporally, geometrically and spectrally). This is supplemented by an analysis of the accuracy of the instruments' performance radiometrically, spectrally and in geolocation. These factors are weighted, according to their perceived contribution to the overall uncertainty of the GSICS Corrections, which in turn is based on a rigorous uncertainty analysis of the inter-calibration algorithm.

Error budgets of the instruments' calibration systems are also reviewed to provide the key variables relating to the accuracy and stability of their radiometric calibration, and its traceability to international standards.

This analysis is supported by a series of inter-comparisons between different hyperspectral infrared spectrometers, including Metop-A/IASI, Metop-B/IASI, Aqua/AIRS and Suomi-NPP/CrIS. Various inter-comparison methods are reviewed, including Polar Simultaneous Nadir Overpasses (SNOs), Quasi SNOs, double differences against geostationary satellite and aircraft instruments as well as Numerical Weather Prediction (NWP) models, and statistics over extended geographical areas. Results from different methods under the same range of conditions are compared to assess their relative calibration, long-term stability and ultimately, the overall uncertainty of the instruments as inter-calibration references for GSICS.

Climate Level Retrievals of Trends, Anomalies and PDFs from AIRS/IASI Radiance Time Derivatives

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ABSTRACT

The time rate of change of a wide variety of geophysical variables (atmospheric temperature, humidity, clouds, etc.) can be derived from hyperspectral infrared sensors such as AIRS/IASI, now in operation for more than 13/8 years. Traditional approaches retrieve geophysical variables on a per-footprint basis using some sort of non-linear inversion scheme that is inherently dependent on a-priori information. Trends of interest to the climate community are then derived from time and space averaging of these 1D-var retrievals. For climate applications, a clear understanding of the error characteristics of these products is required, but the complexity (and non-linearity) of these retrieval systems is extremely problematic. We introduce here an approach to measuring climate-level variability with AIRS and IASI by instead doing time and space averaging in the radiance domain, and then converting to geophysical trends directly from averaged radiance trends. This approach makes error estimation much more straightforward since the final geophysical measurement is more directly related to the instrument stability (and inter-calibration if using more than one instrument). We will show results using this approach for all-sky retrievals of AIRS/IASI 13/8-year variability, and compare our results to the AIRS Level 3 data, the ECMWF ERA-Interim re-analysis and the NASA MERRA re-analysis. In addition we will compare radiance probablity distribution functions (PDFs) observed with AIRS/IASI and compare to PDFs simulated from re-analysis models.

Ozone instantaneous longwave radiative effect from IASI and TES observations

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ABSTRACT

Ozone is one of the most important greenhouse gases in terms of radiative forcing as a result of increases in its precursor emissions since pre-industrial times. Until recently, the ozone radiative forcing calculations were entirely model based, exhibiting high uncertainties and a large spread in model values, as shown in the IPCC AR5. Satellite sounders operating in the infrared now offer the possibility to infer directly the longwave radiative effect (LWRE) of ozone in the 9.6 μm band, with respect to its vertical distribution, allowing to better constrain model estimates of the ozone radiative forcing and its future predictions. In this presentation we calculate the ozone LWRE by exploiting the measurements of IASI/MetOp-A. We briefly describe a new method for calculating the ozone LWRE and the flux sensitivity with respect to the ozone profile, known as instantaneous radiative kernel (IRK), and we demonstrate that it is more accurate than previous existing methods by up to 30%. We also show a first comparison with similar quantities derived from measurements of TES/Aura and report a very good agreement overall. Finally, we present the application of such calculation, made at unprecedented resolution and sampling with IASI, in climate models and the ability of assessing the biases of the latter in terms of radiative effect.

The BIRA-IASB IASI CH_4 product

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In recent years the IR team of BIRA-IASB has developed an automatized processing chain for the fast retrieval of tropospheric IASI CH_4 profiles with the ASIMUT Optimal Estimation Method retrieval software.

In this presentation we will give a quality assessment of the new BIRA-IASB IASI CH_4 product and results of its validation with co-located NDACC ground-based observations. It will be demonstrated that one independent piece of information is retrieved in the altitude range 4-17 km for daytime and nighttime observations.

In addition, we will discuss first results of a comparison, on a global scale, between the IASI upper tropospheric CH_4 product from Laboratoire de Météorologie Dynamique and the new BIRA-IASB IASI CH_4 product, that have been obtained as part of the ESA Climate Change Initiative Greenhouse Gas project.

An Infrared Radiance Climate Record Combining AIRS, IASI, and CrIS

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ABSTRACT

A continuous hyperspectral infrared radiance record of the Earth's emission started with AIRS in 2002 in the 1:30 orbit, followed by IASI in 2007 in the 9:30 orbit. The follow-on to AIRS, CrIS, began operation in early 2012, also in the 1:30 orbit. The AIRS record will soon span 13 years, long enough to start providing climate-level information. Both Cris and IASI are operational programs, slated to continue for 15+ years or more, so the importance of these sensors for climate studies will continue to grow. We discuss here the utility, and construction, of an homogenous radiance record from these sensors that could provide a well understood climate record with known error characteristics. Issues reviewed will include spectral response normalization, inter-calibration, and data sub-setting. Approaches to independently access individual instrument stability at the climate level will be introduced using optimal estimation retrievals of geophysical variability from radiance time derivatives taken over decadal time periods.

TOWARDS HOMOGENEOUS REFERENCE DATASETS FOR LONG-TERM CLIMATIC VARIABLE TIME SERIES FROM METOPA AND METOPB VALIDATED OBSERVATIONS

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For the validation of satellite level1 and level2 products, for our in house applications as well within the frame of the GSICS programme through our cooperation with CNES, we have developed and applied, for a long time, physically coherent quality control tests to detect errors in satellite and atmospheric/surface observations: among many others are errors related to format problems, spurious trends, degradation of the instruments, cross-track asymmetry problems, physically unrealistic values, temporal and vertical inconsistencies in temperature, dew point temperatures profiles, … .

Based on one or several instruments on board the same or different platforms, these quality controls as well as the required spatial, spectral, temporal and viewing geometry matchings have been already described in former presentations as part of our "stand alone" and "relative" validation approaches. These quality control and validation activities keep going on for IR and microwave instruments on board satellites operated e.g. by CNES and/or Eumetsat, NASA. Among them, not only IASI, AMSU, HIRS, MHS on board MetOp A and B but also IIR/Calipso, Modis/Aqua, Seviri/MSG.

All these validation activities (satellite observations, ARSA (Analyzed RadioSoundings Archive) data base) *have led us to build a robust, global sample of MetOp - clear and not clear- observations collocated in space and time with ARSA. This dataset, so far dedicated to the MetOp – and possibly to post MetOp - era now represents years of information with product updates at approximately 3 month delay from real-time.*

The interest for such datasets (e.g. Reale and Thorne, 2004) has been clearly expressed by GSICS/WMO a long time ago. Due to the especially high stability of the IASI radiances and, equally important, to the careful validation of every atmospheric profile accepted in ARSA (more 5,000,000 profiles from 1979-2015 onwards) , our dataset may offer a high degree of homogeneity and, as such, be used for assessing the trends and/or variability of other datasets (satellite observations, raw radiosonde reports, level 2 products).

The goal of this talk is to present how the high stability of IASI radiances (demonstrated from our ongoing work on the validation of IASI/MetOp A and B level1 data) may help the validation of other instruments not only onboard MetOp but also as IIR/Calipso and Modis/Aqua. Characteristics and description of the collocated MetOp/ARSA dataset will be given as well as will be discussed the capability of such a dataset to help homogenizing other simple or composite datasets.

http://ara.abct.lmd.polytechnique.fr/index.php?page=calibration-validation
http://ara.abct.lmd.polytechnique.fr/index.php?page=arsa-database

Long time series of Essential Climate Variables from IASI – Almost a decade!

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ABSTRACT

Since its launch onboard Metop-A in October 2006, and the onboard Metop-B in September 2012, IASI contributes to the establishment of robust long term data records of several essential climate variables. Here, we will focus here on 4 of them that are retrieved at LMD: (i) clouds: physical and microphysical properties; (ii) greenhouse gases: mid-tropospheric integrated content of CO_2, CH_4 and N_2O; (iii) dust aerosols: AOD, altitude, and radius; (iv) continental surface characteristics: skin temperature and spectral emissivity. We will show that IASI has the potential to monitor the evolution of these variables on the long-term, to assess potential trends, and to detect signatures of specific climate events, such as ENSO or other sources of climate variability.

All these activities rely on a processing chain of satellite observations that has been developed for many years at LMD and that includes: permanent validation and improvement of the GEISA spectroscopic database and of the radiative transfer code 4A (which are respectively the official database and code for IASI Cal/Val activities at CNES), development of dedicated cloud and aerosol detection schemes, retrieval processes, and validation activities. In particular, in close collaboration with CNES, LMD contributes to the monitoring and intercomparison of IASI radiances with companion instruments in the framework of the Global Space-based Inter-Calibration System (GSICS) of WMO.

The suite of long time series of climate variables retrieved from IASI continues to expand. Based on both its exceptional spectral and radiometric stability and its ability to characterize simultaneously several climate variables, IASI has already demonstrated that it can and will play a major role in the monitoring and understanding of climate evolution and variability in the coming years.

Presentation preference: *POSTER.*