SATELLITE REMOTE SENSING ATMOSPHERIC COMPOSITIONS, PRODUCTS VALIDATION AND DATA APPLICATION IN CHINA

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Abstract – This paper summarizes the achievements related to atmospheric compositions remote sensing from the bilateral cooperation under the framework of MOST-ESA Dragon Programme. The algorithms to retrieve Aerosol, ozone amount and profile, NO_2, SO_2, CH_4, CO_2, etc. have been developed since 2004. Such algorithms are used to process FY-3 series (Chinese second generation polar orbit satellites) observation and ground based FTIR observation. The results are validated with in-situ measurements. Aerosol, total ozone amount shows the very good consistent with the ground measurements. Some satellite derived products, such as NO_2, SO_2 etc., have been utilized to analyse the environmental and climate change in China. These works demonstrate the satellite's capacity on environment monitoring and climate change research.

Keywords: atmospheric composition, remote sensing, satellite, Dragon Programme, validation

1. INTRODUCTION

A great progress has been achieved since 2004 on satellite remote sensing atmospheric compositions, products validation and data application by the bilateral cooperation under the framework of MOST-ESA Dragon Programme.

Concerning satellite retrieval algorithms, the method to retrieve atmospheric aerosol, total ozone amount, ozone profile, NO2 concentration, SO2 concentration, CH4 concentration and CO2 concentration have been developed (Yang, et al., 2010). Typically, the retrieval algorithms for atmospheric aerosol, ozone amount and ozone profile have become the operational algorithm to process FY-3A satellite data, which is the first satellite of second generation of Chinese Meteorological Satellite, and to generate relative products on the daily basis.

Concerning satellite products validation, most of atmospheric compositions have been compared with the observations from MAX-DOAS and FTIR Bruker, ground station in-situ network, sun-photometer network, etc. The results show that atmospheric aerosol, total ozone amount and ozone profile are comparable with the relative ground-based remote sensing products in a very good consistent. On the other hand, it is very hard to validate the satellite products with in-situ measurements directly because the in-situ measurements reflect to the situation near the ground level. However, the long data records show there is very high correlation between in-situ measurements and satellite products. It shows satellite products have the distinguish advantage to investigate the spatial and temporal characteristics of atmospheric compositions.

With the satellite products, the spatial and temporal characteristics of atmospheric aerosol, ozone, NO2, SO2, CO, CO2, CH4, etc have been investigated over China. A number of papers have been or will be published. These works demonstrate the satellite's capacity on environment monitoring and climate change research.

2. RETRIVAL ALGORITHM

Fengyun 3 series (hereafter FY-3) are the second-generation polar-orbiting meteorological satellites of China. FY-3A was launched on May27, 2008. It is morning orbiting satellite. FY-3B was launched on Nov 5, 2010. It is afternoon orbiting

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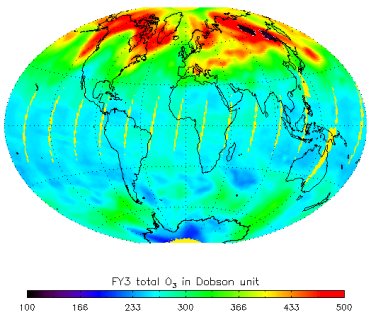
satellite.

FY-3A and FY-3B have the same payloads onboard. There are 11 instruments to monitor the earth and the space weather. These instruments are the visible and infrared radiometer (VIRR), infrared atmospheric sounder (IRAS), microwave temperature sounder (MWTS), microwave humidity sounder (MWHS), medium resolution spectral imager (MERSI), microwave radiation imager (MWRI), solar backscatter ultraviolet sounder (SBUS), total ozone unit (TOU), earth radiation measurement (ERM), solar irradiance monitor (SIM), and space environment monitor (SEM). Among them, the IRAS, MWTS, and MWHS make up the vertical atmospheric sounding system (VASS) (Zhang, et al., 2009).

The aerosol retrieval algorithm of MERSI is similar with the algorithm used by MODIS/EOS. 0.47, 0.65 and 2.1 μm band information is used to retrieve aerosol over ocean and land respectively (Li, et al., 2009).

The total column ozone retrieval algorithm of TOU is similar with the algorithm used by TOMS/NIMBUS-7, OMI/AURA. The total column ozone is derived from a pair of measurements of backscattered solar ultraviolet radiation at two wavelengths where ozone absorption has apparent difference (Wang, et al., 2010).

The ozone profile retrieval algorithm of SBUS is similar with the algorithm used by BUV/NIMBUS-4 and SBUV on NOAA series. The ozone profile is deduced from 12 wavelengths in ozone ultraviolet absorption spectrum with the iterative method of calculation of the radiation transfer equation (Huang, et al, 2010).



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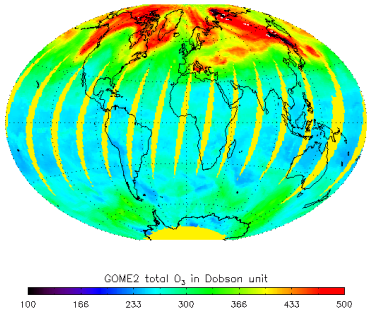

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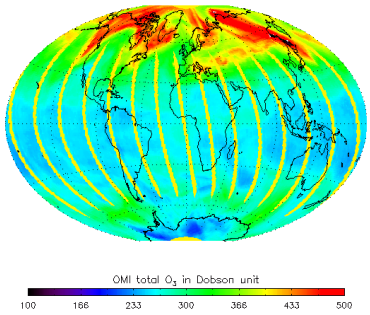

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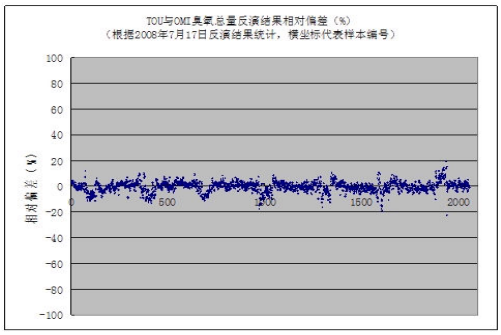

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Figure 1. Global total column ozone distribution monitored by TOU/FY-3A (a), GOME 2/Metop (b), OMI/Aura (c) and the bias between TOU and OMI (d). (Courtesy of W.H. Wang at NSMC)

3. GROUND-BASED REMOTE SENSING

To validate satellite derived products for atmospheric composition research, MAX-DOAS and FTIR were settled on the top of NSMC building, Beijing (39.9N , 116. 3E). Vertical tropospheric column contents of reactive trace gases, such as SO_2, NO_2, O_3 can be deduced from MAXDOAS measurements. Green house gases, such as CH_3, N_2O can be deduced from FTIR measurements (Zhang, 2009; Bai, 2010). Table 1 specifies the main parameters of these two instruments. Figure 2 shows an example. In the example, NO2 was deduced from ground-based FTIR measurements. The result keeps a good

consistence with IASI product.

Table 1. Main parameters of MAX-DOAS and FTIR

Instrument Type	MAX-DOAS	FTIR
Manufacture	Germany BRUKER	China AIOFM/CAS
Measured Spectrum	700 - 5000cm^{-1} (IR/NIR)	300 – 700nm (UV/VIS)
Spectral Resolution	0.0035 cm^{-1} (Max)	0.4 – 1.5 nm
Detected Target	O_3, NO_2, SO_2, OClO, BrO …	O_3, H_2O, NO, N_2O, NO_2, HNO_3, CO, CH_4, CO_2, HF, HCl, $ClONO_2$ ...

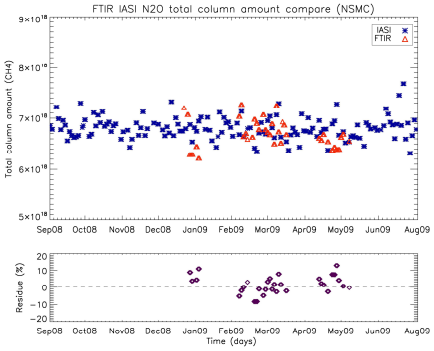

Figure 2. Comparison between N_2O derived from FTIR and IASI/EOS

4. APPLICATION

A lots of satellite derived atmospheric composition products have been utilized to investigate the temporal and spatial distribution characteristics over China (X.Y. Zhang, et al., 2007; Y. Zhang, et al., 2007; Bai, et al., 2010a; Bai, et al., 2010b). Such works prove the capability of satellite derived products on environmental change monitoring and climate change research. Figure 2 shows the he correlation-ship between NO_2 derived from Sciamachy/Envisat and vehicles population in Beijing (up) and Shanghai (down) during 1996 to 2006.

An website supported by FP6-2005-Space-1 can provide the research results to show the air quality monitoring and forecasting in China (http://www.knmi.nl/samenw/amfic/). The system uses satellite and in situ air quality measurements and modeling to generate consistent air quality information over China.

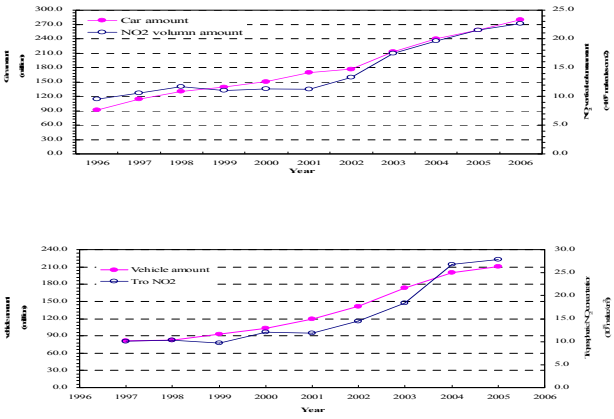

Figure 3. The correlation-ship between NO_2 derived from Sciamachy/Envisat and vehicles population in Beijing (up) and Shanghai (down) during 1996 to 2006.

5. SUMMARIZATION

The remote sensing instruments onboard on FY-3A and FY-3B provide the capability to monitoring atmospheric aerosol, total ozone amount and ozone profile. These products have the similar accuracy to the products derived from other space-based measurements.

In the second phase of FY-3 series, main green house gases and main reactive trace gases, such as CO_2, CH_4, NO_2, SO_2 will be measured by hyperspectral instruments in ultraviolet band, NIR band and thermal IR band respectively.

Some satellite derived products, such as NO2, SO2 etc., have been utilized to analyze the environmental and climate change in China. These works demonstrate the satellite's capacity on environment monitoring and climate change research.

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