N$_2$O and CH$_4$ Profile Observation using Thermal Infrared Sounders AIRS, IASI and CrIS

Xiaozhen (Shawn) Xiong*, Chris Barnet
Eric Maddy, Antonia Gambacorta, Thomas S. King,
Thomas S. Pagano, Prabir Patra

*IMSG @ NOAA Center for Satellite Applications and Research (STAR), College Park, Maryland, USA

IWGGMS-9, Yokohama, Japan
May 30, 2013
AIRS, IASI, CrIS
(can provide daily profile observation for 20+ years)

AIRS on NASA/Aqua 1:30 pm orbit (May 4, 2002)

comparison

IASI on METOP-A (Oct. 19, 2006) METOP-B (Sept 27, 2012) 9:30 am orbit

CrIS on NPP 1:30 pm orbit (Oct. 28, 2011) and JPSS
Outline

Part I: Update the status of AIRS-V6, IASI and CrIS CH₄:

Part II:
1. NOAA plans to develop 20+ years CH₄ data record in the Arctic using AIRS, IASI and CrIS for monitoring CH₄ emission from permafrost;
2. N₂O retrievals from AIRS, IASI - a new product;
3. Recent paper: CH₄ depletion during one stratospheric intrusion on Match 27, 2010 (GRL, 2013);

Summary
Part I

Current status of CH₄ from AIRS, IASI and CrIS
AIRS-V6 CH$_4$

- Released two months ago, and CH$_4$ is one of the standard products (research product in V5);

- Benefit from significant improvement in temperature and water vapor retrievals

- Compared to V5, we added more layers, new tuning, better QC
Preliminary Validation to AIRS-V6

1. Within 200 km
2. Same day
3. ACTM model data are used to extrapolate the Aircraft measurement
4. Averaging Kernels are applied
AIRS-V6 CH₄ vs Aircraft Measurement

- 300–374 hPa
  \[ R = 0.81 (0.61 \text{ Not conv.}) \]
  \[ \text{Bias} = -1.67 (-1.13)\% \]
  \[ \text{rms} = 2.02 (1.96)\% \]

- 374–477 hPa
  \[ R = 0.83 (0.71 \text{ Not conv.}) \]
  \[ \text{Bias} = -1.01 (-0.61)\% \]
  \[ \text{rms} = 1.58 (1.70)\% \]

- 477–596 hPa
  \[ R = 0.87 (0.81 \text{ Not conv.}) \]
  \[ \text{Bias} = -0.04 (0.040)\% \]
  \[ \text{rms} = 1.18 (1.43)\% \]

- 596–753 hPa
  \[ R = 0.94 (0.89 \text{ Not conv.}) \]
  \[ \text{Bias} = 0.560 (0.400)\% \]
  \[ \text{rms} = 1.03 (1.21)\% \]
More Improvement in tuning CH$_4$ Spectroscopy (from V5.9, NOAA version)

The “truth” data can be shared for GOSAT tuning and explore the CH4 absorption uncertainty
IASI and CrIS CH$_4$ data → NOAA CLASS
http://www.nsof.class.noaa.gov/saa/products/
IASI CH$_4$ Validation
(published in AMTD, 2013)
Update of CH$_4$ retrieval from CrIS on Soumi NPP

- Using NOAA Unique CrIS ATMS Processing System (NUCAPS)
- Similar algorithm as IASI and AIRS (v5) retrieval

Xiaozhen.Xiong@noaa.gov
Comparison of CH$_4$ at 400 hPa from CrIS, AIRS, IASI (5/15/2012)

Xiaozhen.Xiong@noaa.gov
DOFs from CrIS are lower than AIRS and IASI (5/15/2012)

Xiaozhen.Xiong@noaa.gov
More channels available from full spectrum data

1. The current spectral resolution can not get a good CH$_4$ data as IASI and AIRS;

2. Test of full spectrum data was made on 3/12/2013 and full spectrum data will be available later this year;

Xiaozhen.Xiong@noaa.gov
Part II

Generation of mid-tropospheric CH$_4$ data record in the Arctic from AIRS, IASI and CrIS – an important work for climate change study and needs more collaboration with GOSAT team and modelers;

N$_2$O retrieval from AIRS and IASI
CH$_4$ leakage in the Arctic and its impact on Global CH$_4$ distribution - mystery

- Observation by SWIR is almost limited in summer;
- Inverse modeling using TIR data will be very helpful;

Xiaozhen.Xiong@noaa.gov
To generate a long-term record for monitoring the polar CH$_4$ emission under the impact of global warming,

- Current algorithm is not optimized in the polar;
- Information of multiple observations per day has not been well used in L3 product;
- We are investigating to better characterize the retrieval in the polar and use better first guess.

Multiple observations from AIRS per day over the polar regions

Xiaozhen.Xiong@noaa.gov
CH$_4$ release from wetland and thawing permafrost are very sensitive to global warming. Its trigger will be a disaster.
$N_2O$ is keeping increasing

Barrow, Alaska, United States (BRW)

Mauna Loa, Hawaii, United States (MLO)

Xiaozhen.Xiong@noaa.gov
N$_2$O Retrieval using AIRS

Retrieval layers

➢ will improve the CH$_4$ retrieval since their absorption bands overlap;

➢ Can be used to improve the quality control;

➢ Monitoring the N$_2$O trend.
AIRS is successful in capturing the N$_2$O trend.

N$_2$O increase rate is 0.75 ppb yr$^{-1}$ from 1977 to 2005 (see Ricaud et al., 2009).

A paper is in preparation, 2013.
Detection of methane depletion associated with Stratospheric intrusion by Atmospheric Infrared Sounder (AIRS)

Xiaozhen Xiong¹,²,*, Chris Barnet², Eric Maddy²,³, S.C. Wofsy⁴, Liangfu Chen⁵, Anna Karion⁶, Colm Sweeney⁶

DOI: 10.1002/grl.50476, 2013
Summary

1. AIRS-V6 was released two months ago, and I welcome all interested users to analyze this data, use it in inverse modeling, and will be glad to provide any help if needed;

2. IASI CH$_4$ is an operational product in NOAA CLASS system and recent validation results was published at AMTD (2013).

3. CH$_4$ retrieval from CrIS on Suomi NPP is still under testing and wait for the use full spectrum data;

4. A unique CH$_4$ dataset of Arctic mid-tropospheric CH$_4$ is important for climate change study and call for the collaboration with TIR measurements from different group and support of inverse modeling;

5. N$_2$O is a new product that will be added in the system.
Thank You