Retrieval of CH_4 and N_2O using NUCAPS and Applications

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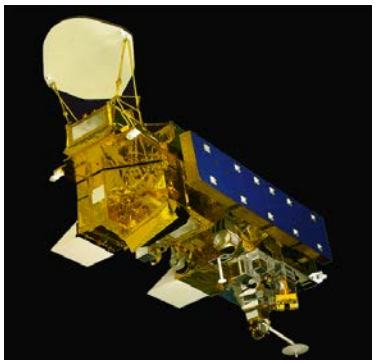
College Park, Sept 18, 2014

Outline

- **NUCAPS and Trace Gases Retrieval from AIRS, IASI and CrIS**
- **L1 Requirement of Trace Gases in JPSS-1 and status of CH_4 and N_2O retrieval from S-NPP**
- **Some Results of N_2O Retrieval using AIRS**
- **AIRS CH_4: Validation and Applications**
  1. **CH_4 Plume over South Asia during Monsoon Season;**
  2. **CH_4 depletion during stratospheric Intrusion;**
  3. **Arctic CH_4 monitoring;**
- **Summary**

NUCAPS and Trace Gases Retrieval using Hyper Spectral Infrared Sounders: AIRS, IASI, CrIS



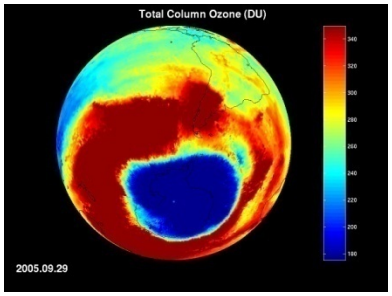
AIRS on NASA/Aqua 1:30 pm orbit (May 4, 2002)

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

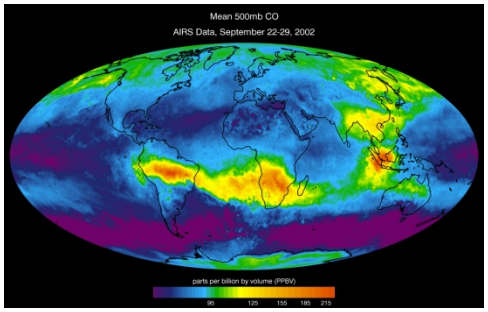
CrIS on NPP 1:30 pm orbit (Oct.28,2011) and JPSS

AIRS Trace Gases Products

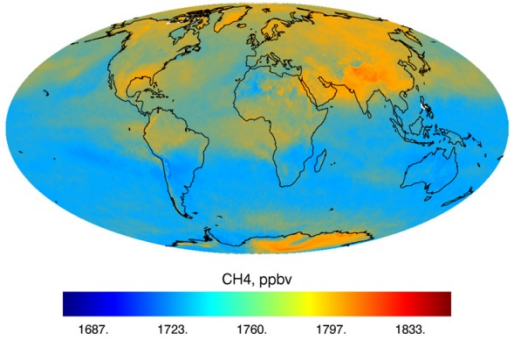
Ozone



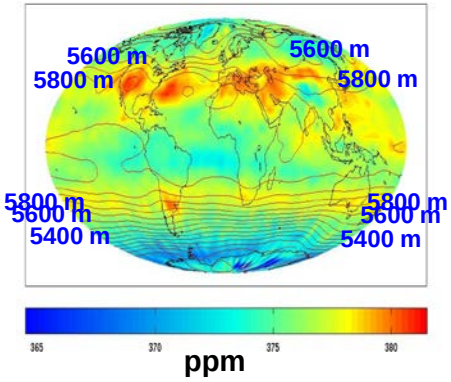
CO

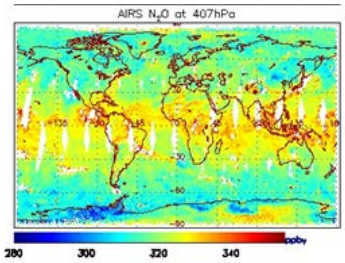


Methane



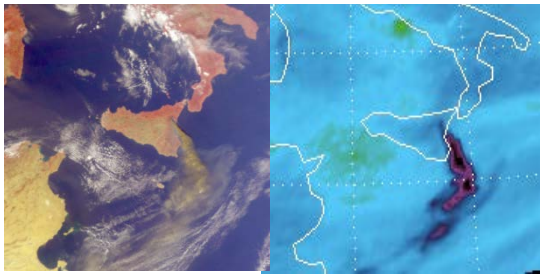
CO2





N_2O

SO_2



HNO3

4

JPSS-1 Requirements

EDR Attribute	CO	CO_2	CH_4
Vertical Coverage	Total Column	Total Column	Total Column
Horizontal Resolution	100 km	100 km	100 km
Mapping Uncertainty, 3 sigma	25 km	25 km	25 km
Measurement Range	0 – 200 ppbv	300 – 500 ppmv	1100 – 2250 ppbv
Measurement Precision	35%	0.5% (2 ppmv)	1% (~20 ppbv)
Measurement Accuracy	±25%	±1% (4 ppmv)	±4% (~80 ppbv)
Refresh	24 h	24 h	24 h
Note			

NUCAPS Sounding Products Released at NOAA CLASS since April 8, 2014

- Atmospheric Vertical Temperature Profile
- Atmospheric Vertical Moisture Profile
- Infrared Ozone Profile

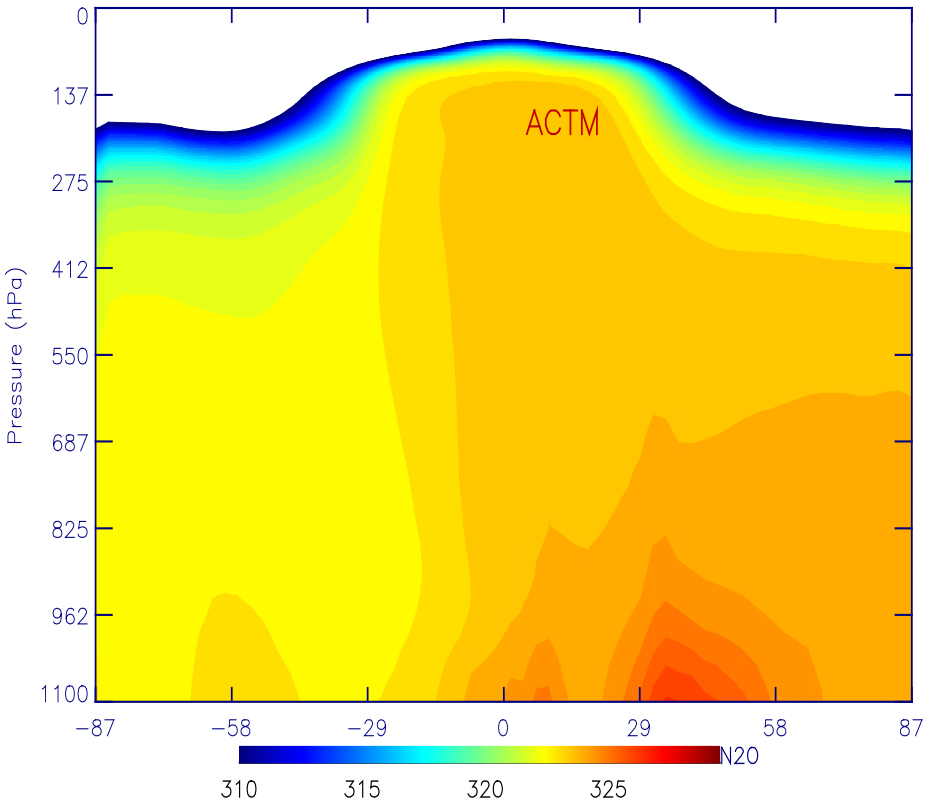
- (requirement: total column)
- Vertical CO Profile
- Vertical CO_2 Profile
- Vertical CH_4 Profile
- Outgoing Longwave Radiation (OLR)

- (new)
- Vertical HNO_3 Profile
- Vertical N_2O Profile
- Vertical SO_2 Profile
- A flag indicating the presence of dust and volcanic emissions
- Cloud-Cleared Radiances

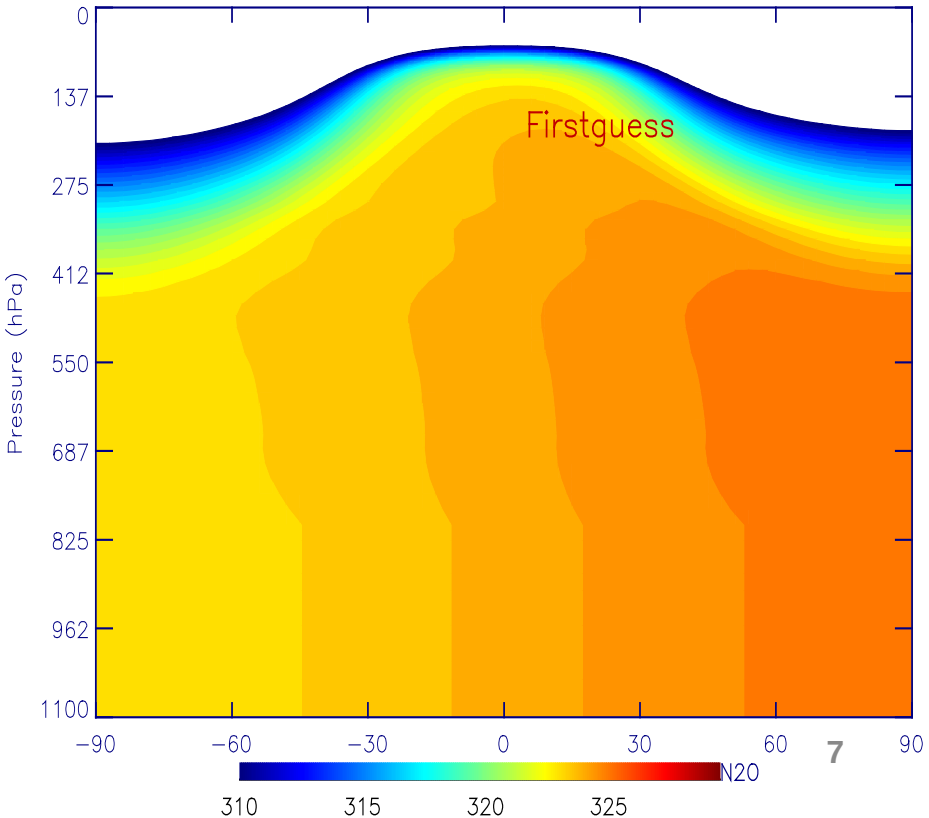
Set-up of CH_4 and N_2O retrieval

First guess of CH_4 and N_2O is updated

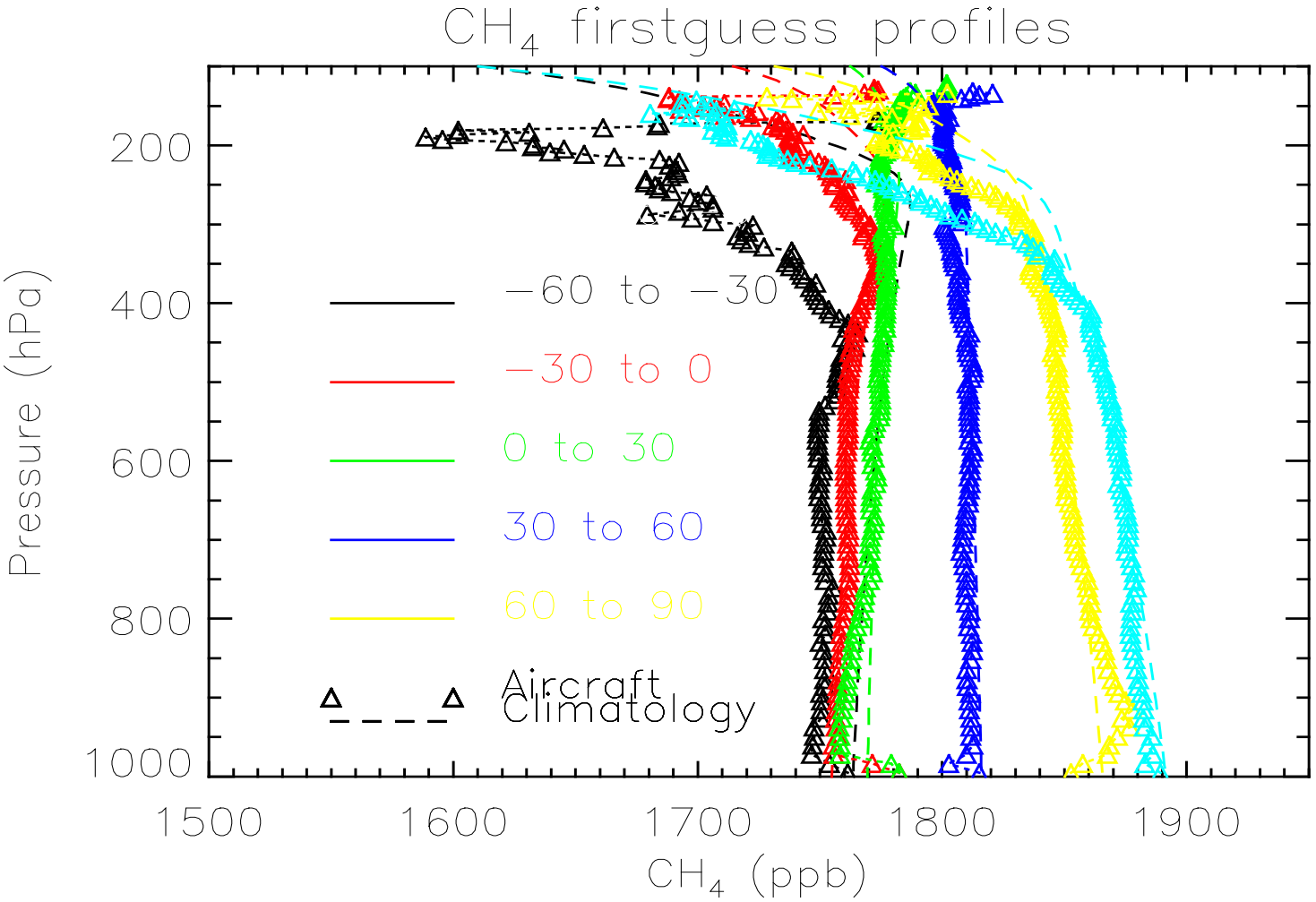
N_2O from Model



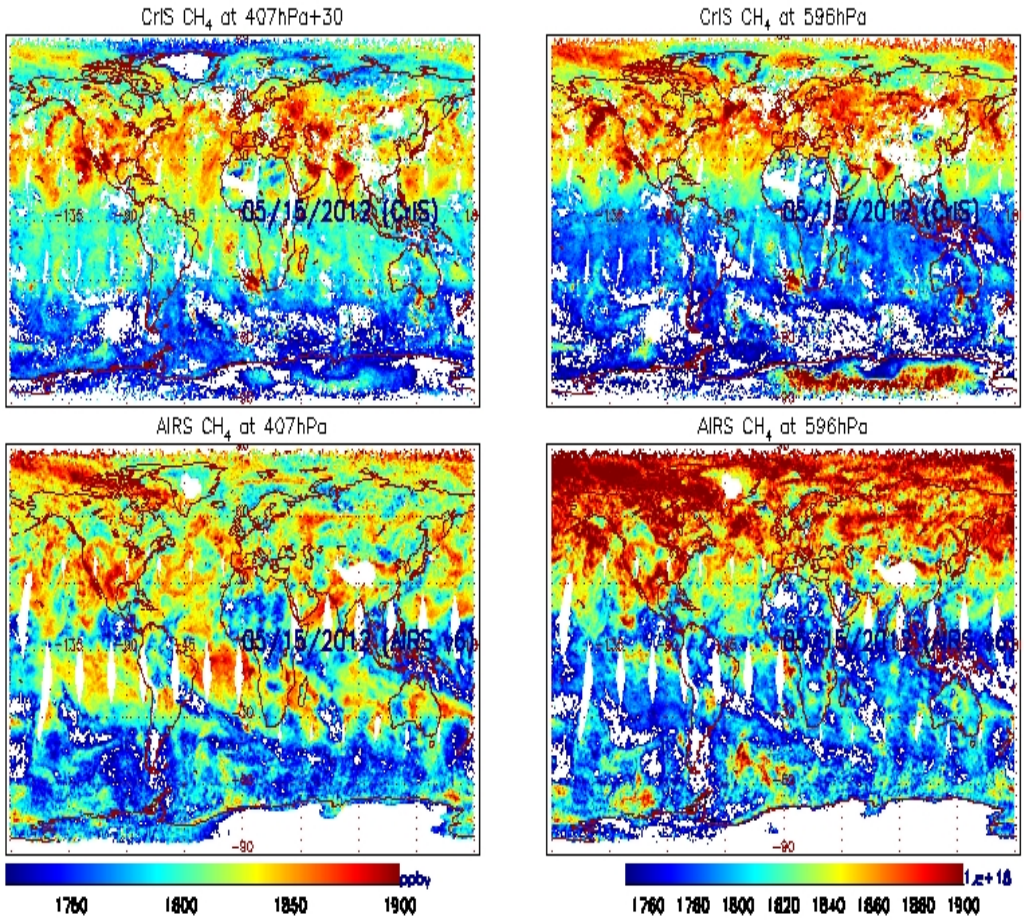
N_2O firstguess

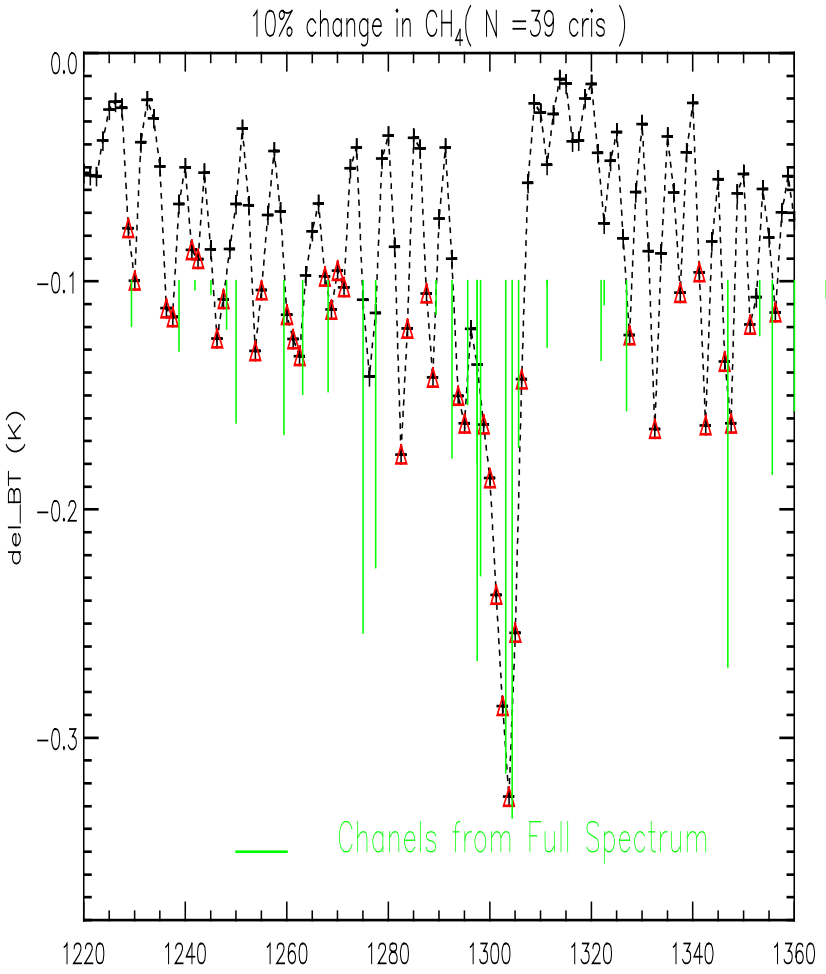


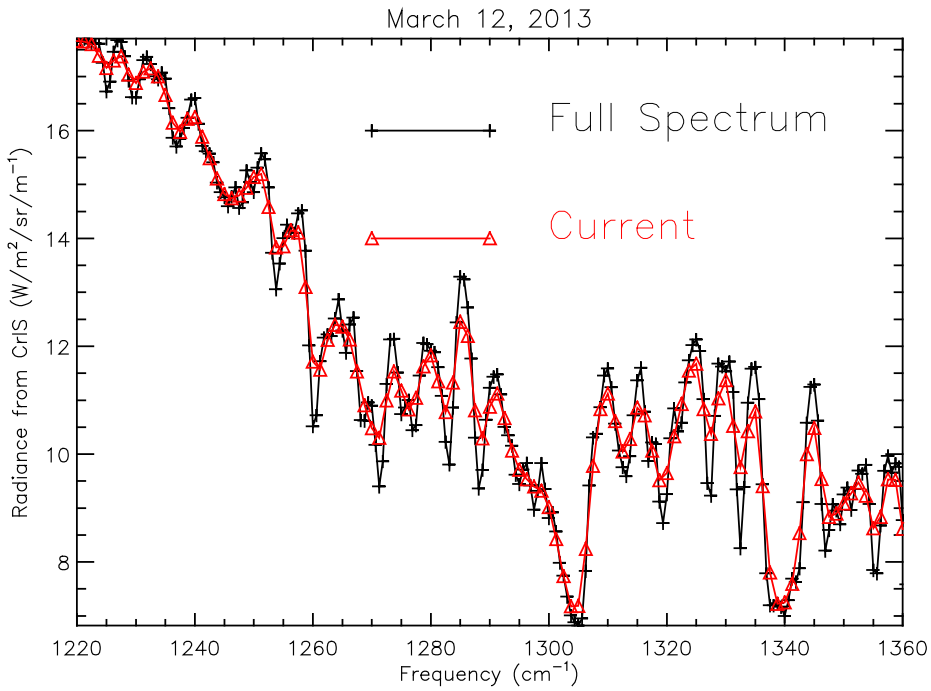
CH_4 Firstguss and its Comparison with HIPPO data



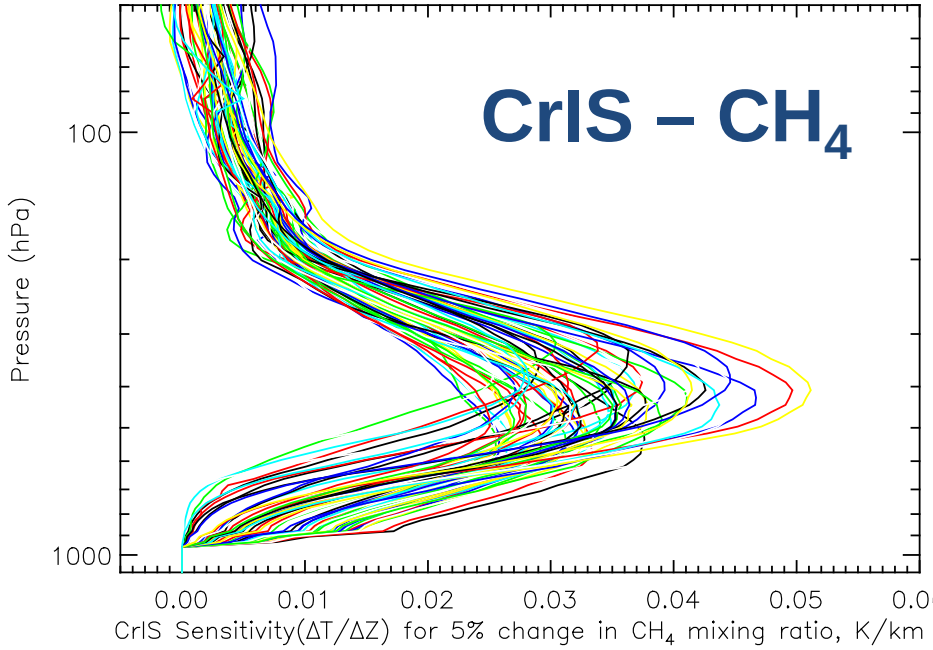
Comparison of CH_4 from CrIS and AIRS

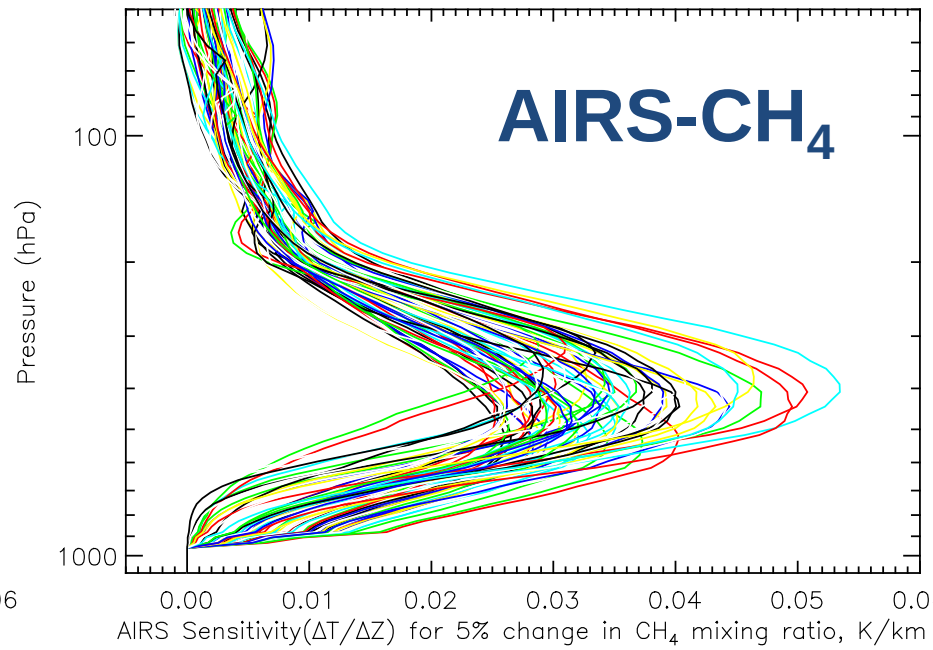






- **Full spectrum data from CrIS on NPP and JPSS can be used to obtain similar N_2O and CH_4 products like AIRS**

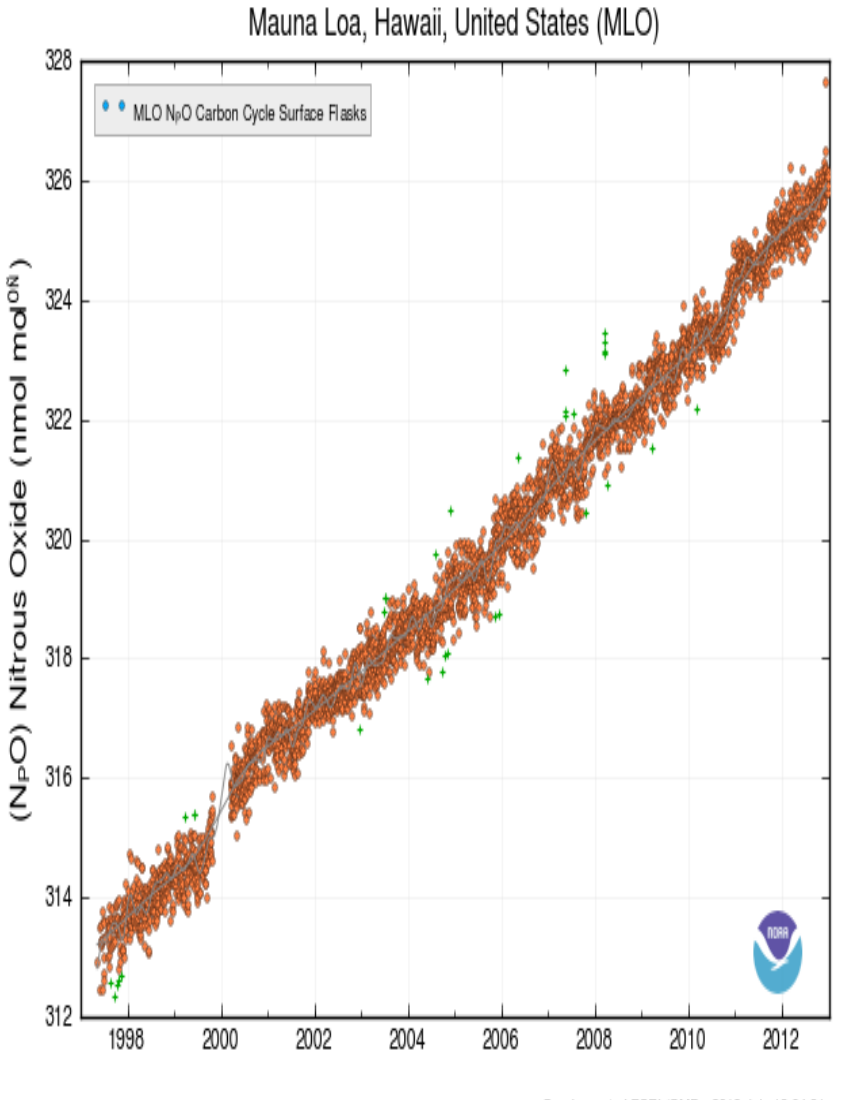




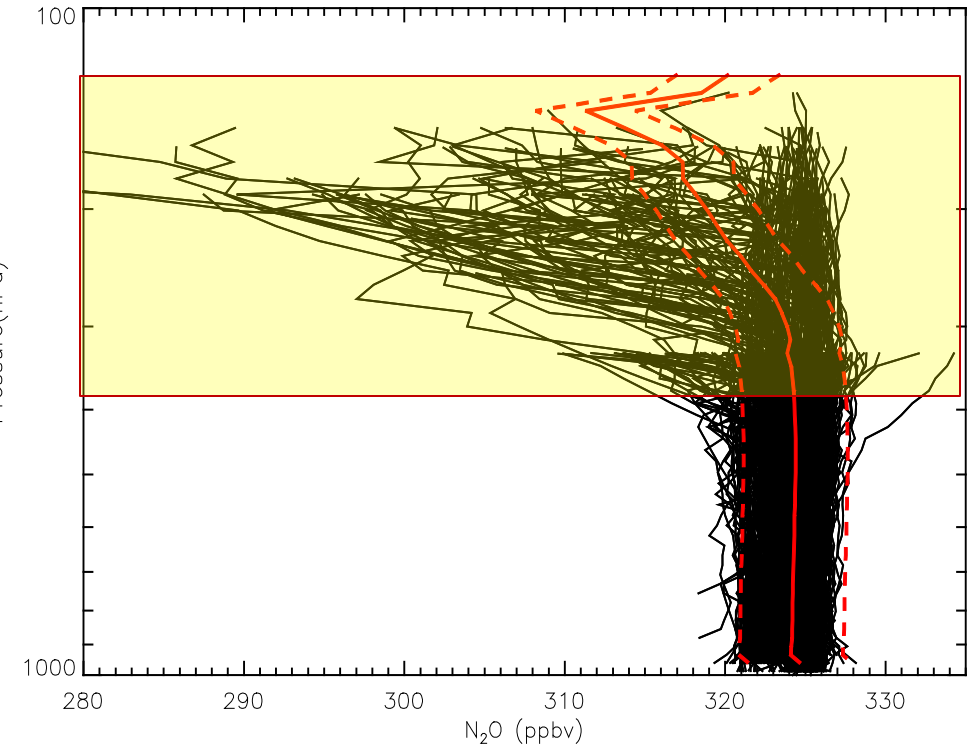
Monitor global N_2O trend

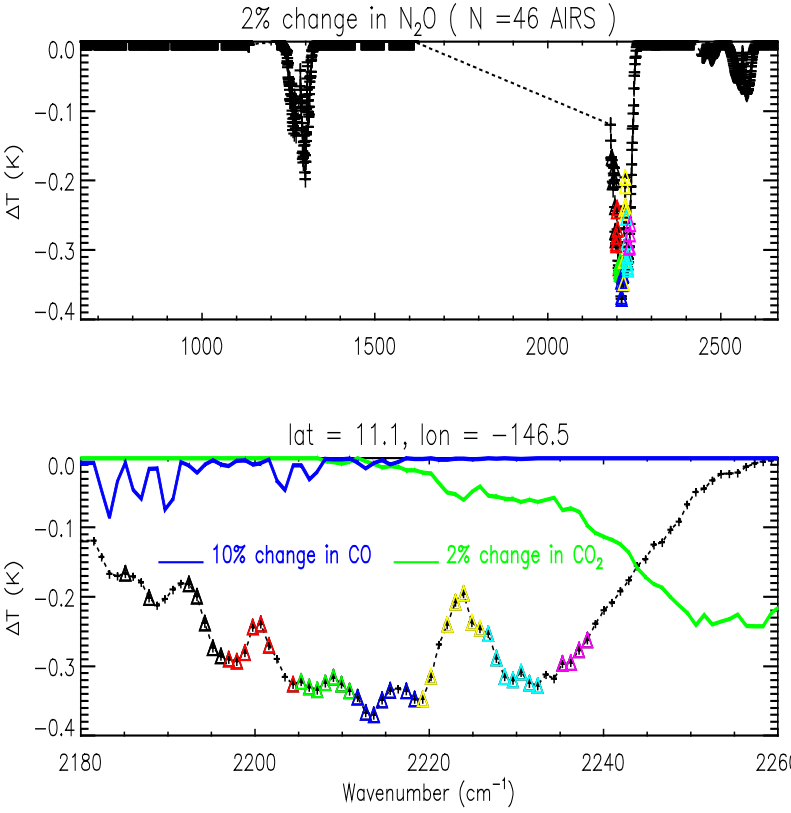
Why is it important ?

- One important greenhouse gases: life time 120 years,
- Warming potential is 300 times of CO_2;
- has a nearly linear increase of 0.26% yr^{-1} over the last three decades [IPCC, 2007].
- N_2O is recognized as the single most important anthropogenically emitted stratospheric ozone depleting substance [Ravihsankara et al., 2009].



Advantage of TIR in N_2O Observation

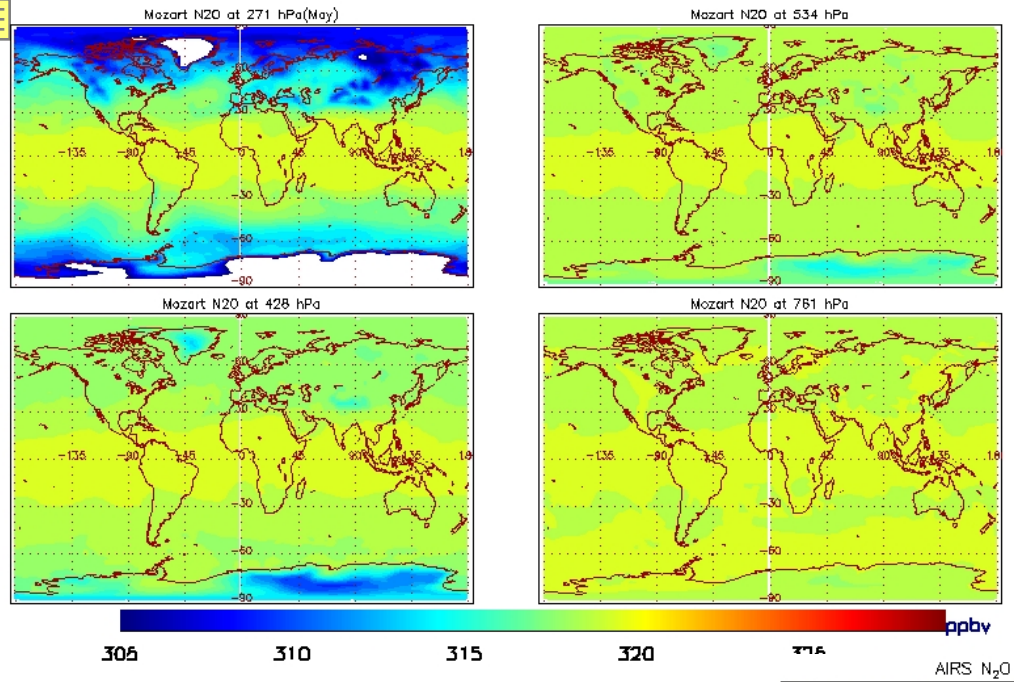




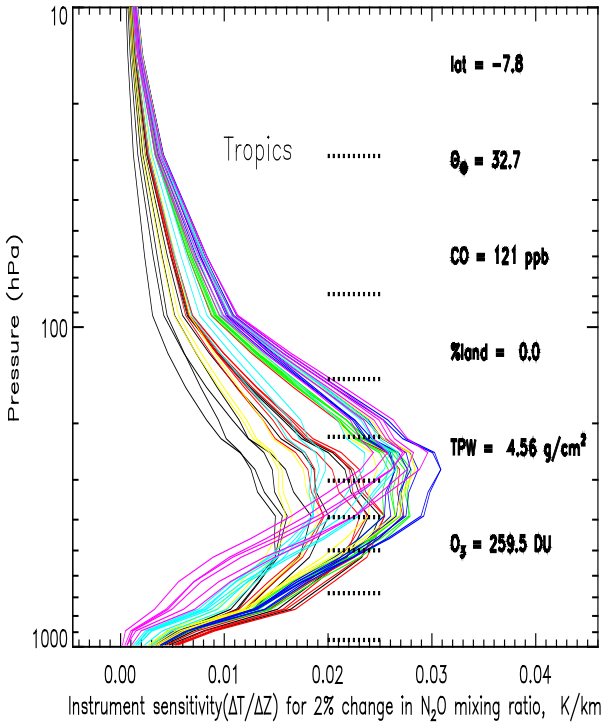
Largest variability is in the Mid-Upper troposphere from HIPPO aircraft measurements

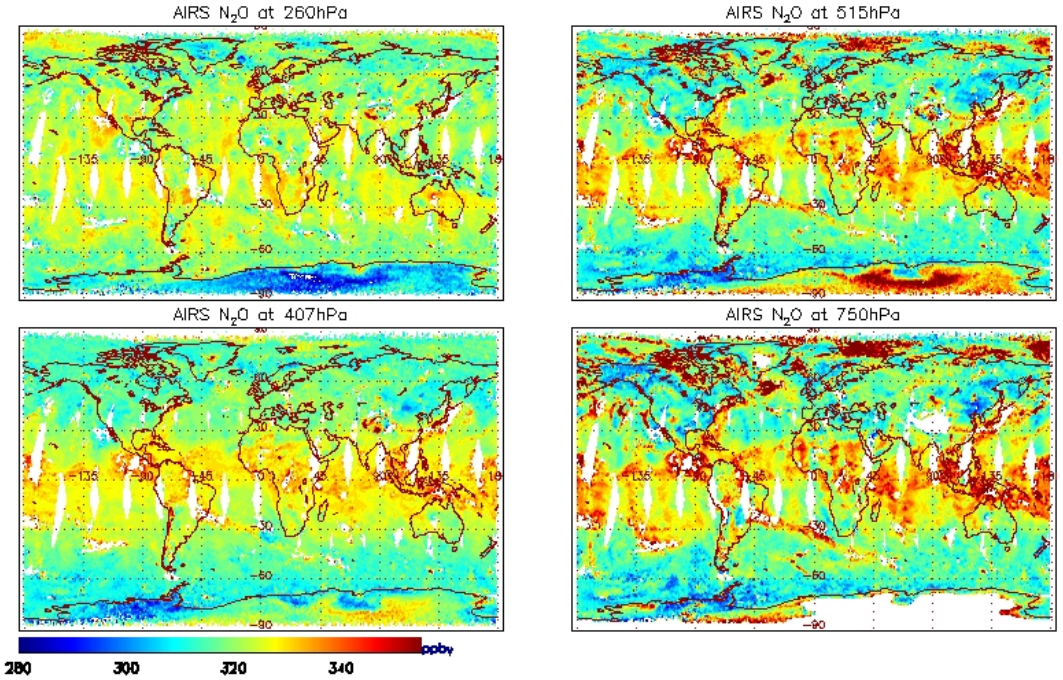
Selection of N_2O Channels

MOZART on May, 2004



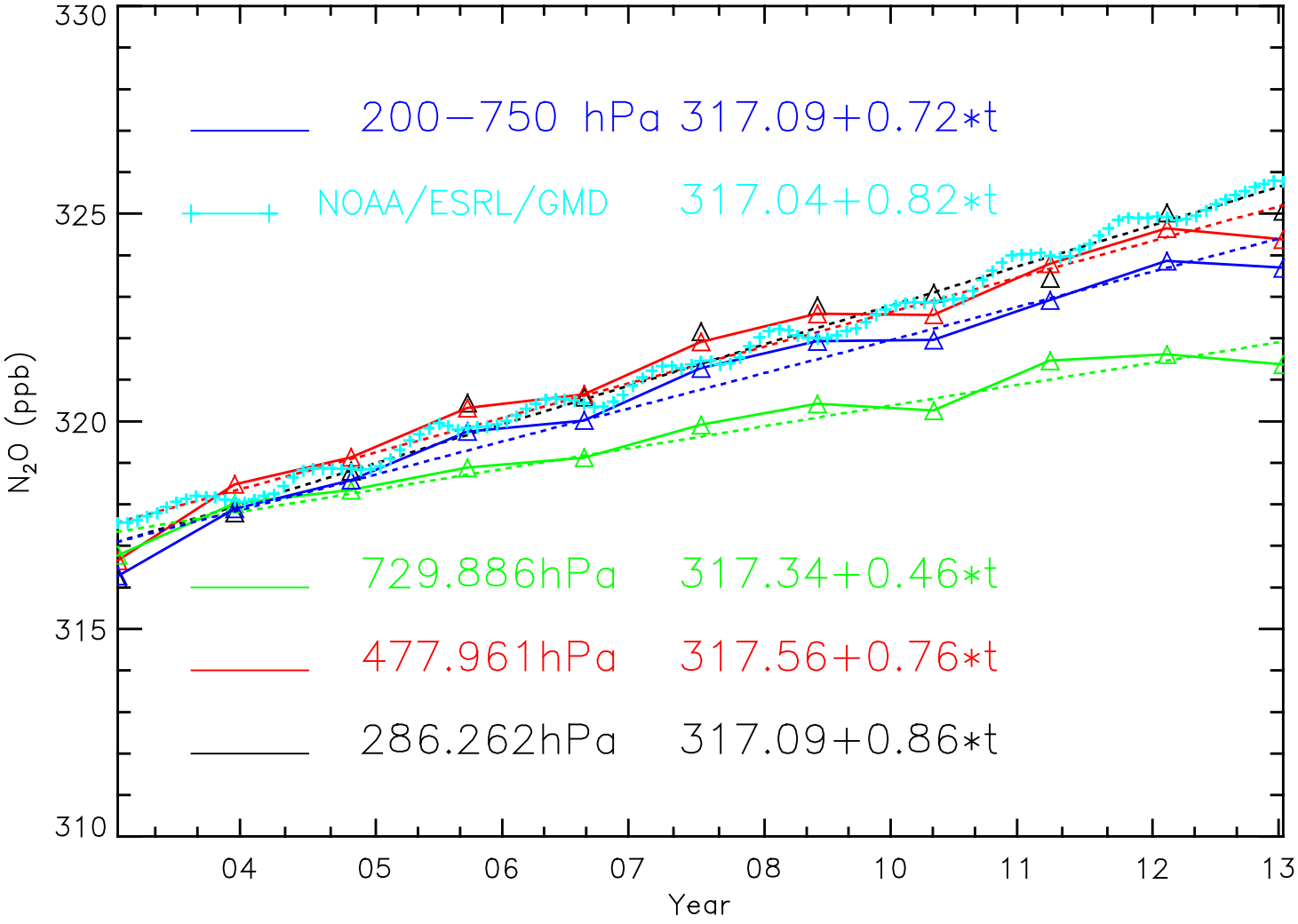
Enhancement of N_2O in the tropics





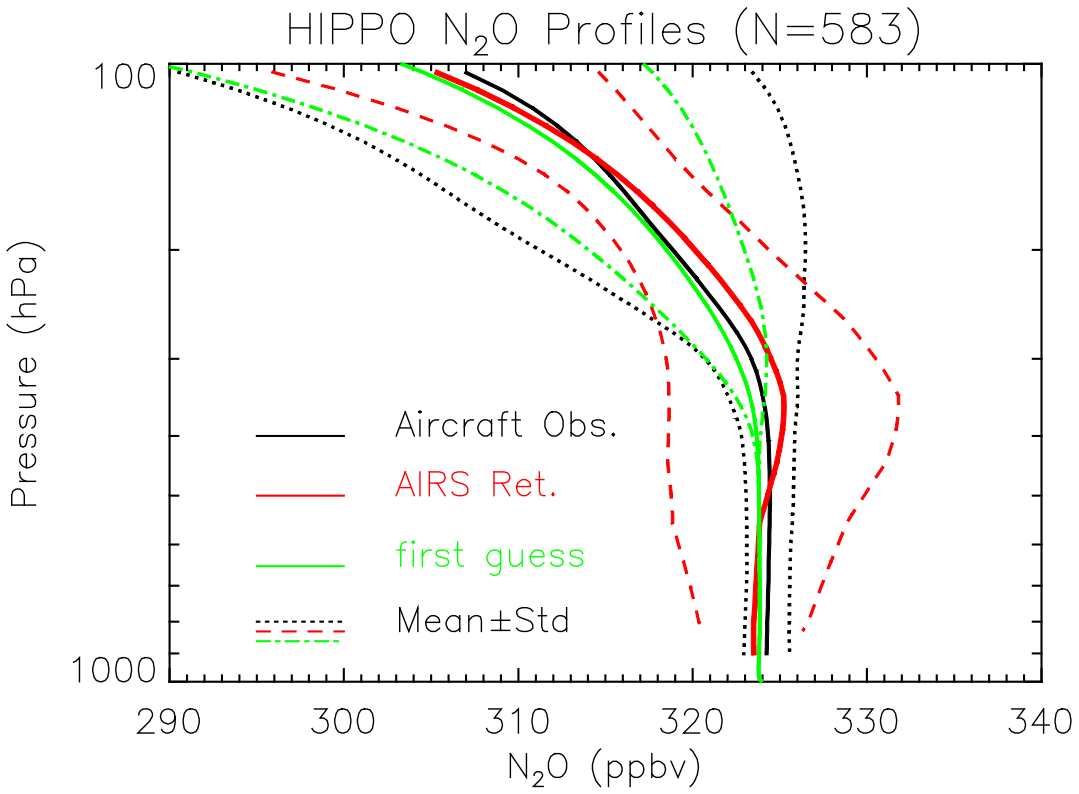
AIRS on 5/15/2012

Monitor the N_2O trend using TIR



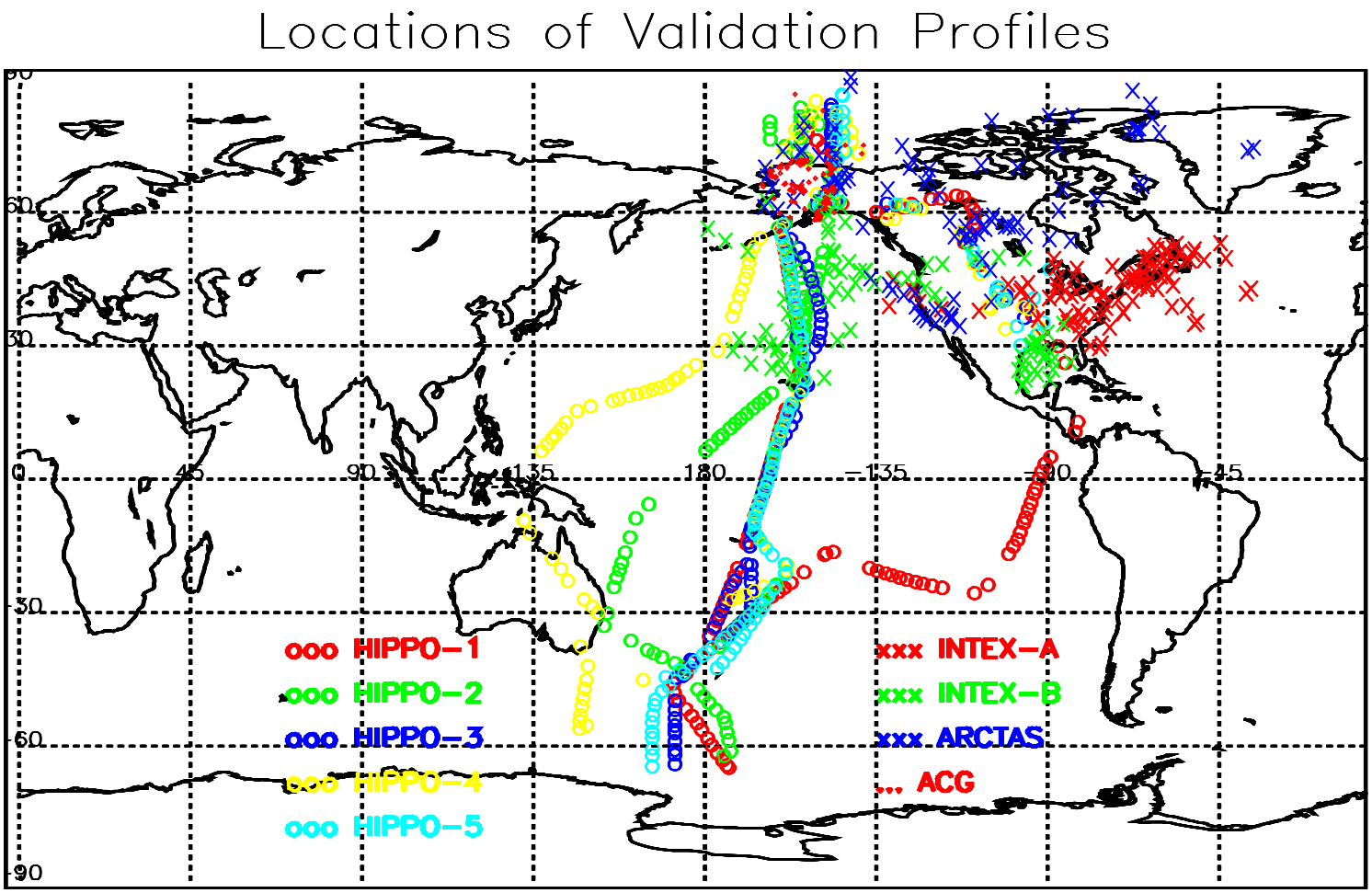
Xiong, X. et al., 2014, Retrieval of Nitrous Oxide from Atmospheric Infrared Sounder: Characterization and Validation, JGR-atmosphere (under revision).

A larger variation of N_2O in the mid-upper troposphere from AIRS than aircraft measurment



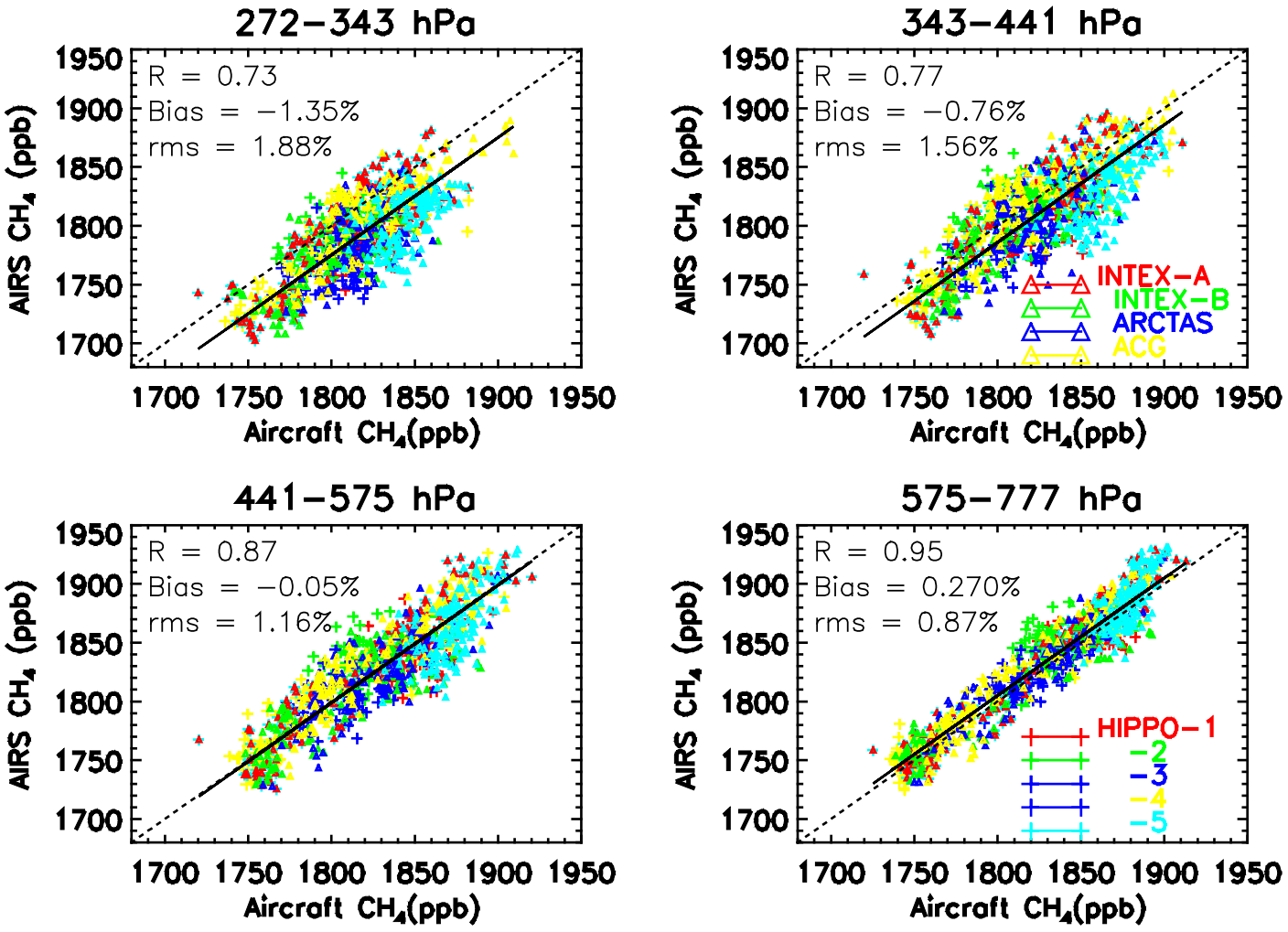
Xiong et al., JGR-atmosphere, 2014

Validation is important



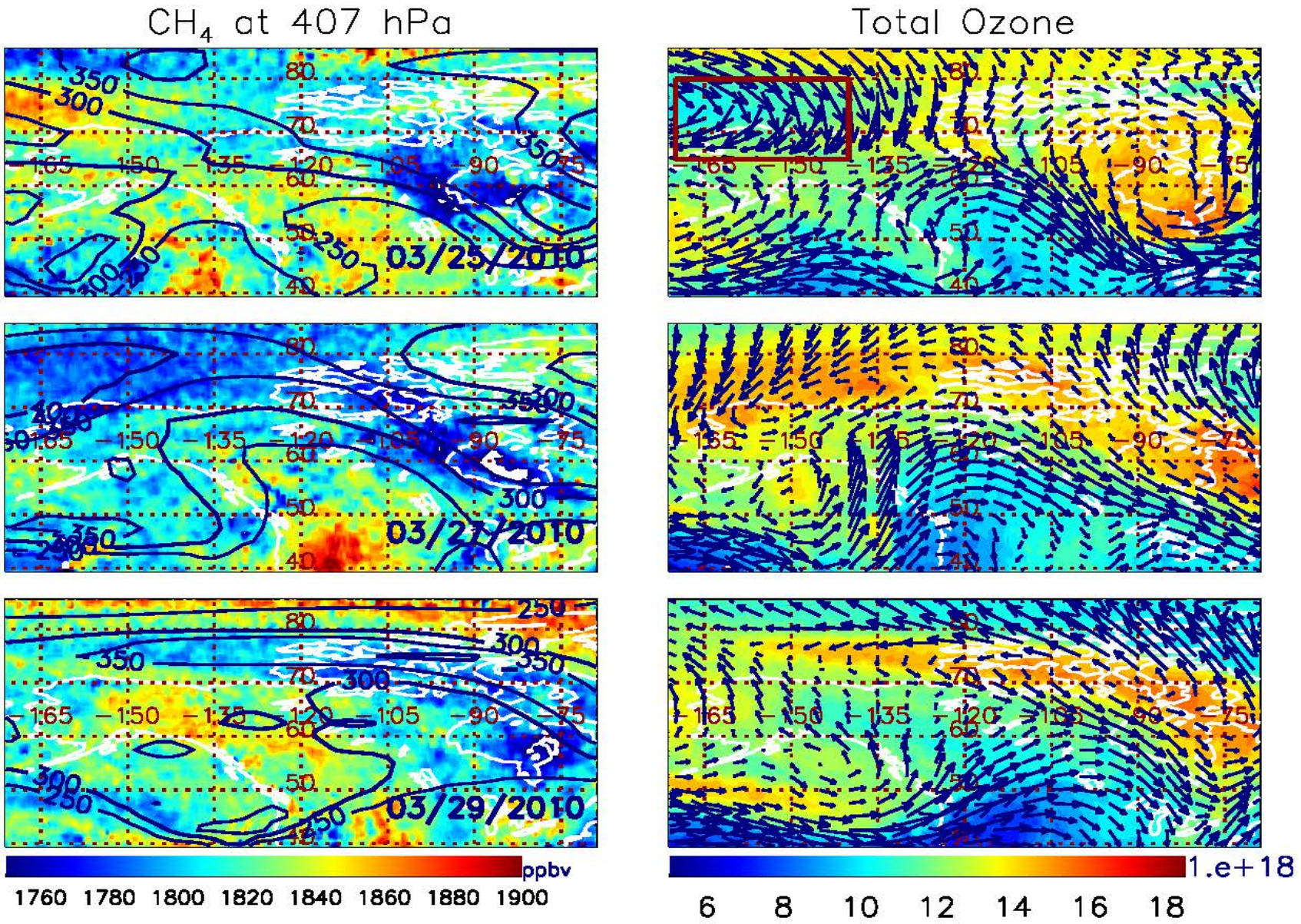
Validation Results : AIRS-V6 CH_4

(paper is to be submitted to AMT, 2014)



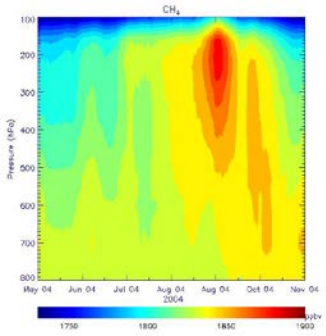
More Applications

-- Transport or Emission

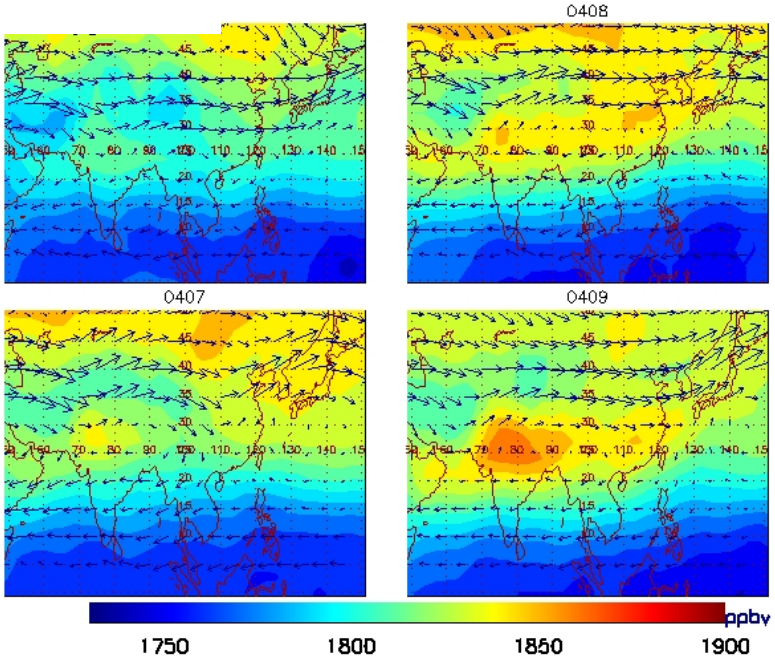


Xiong et al., GRL, 2013

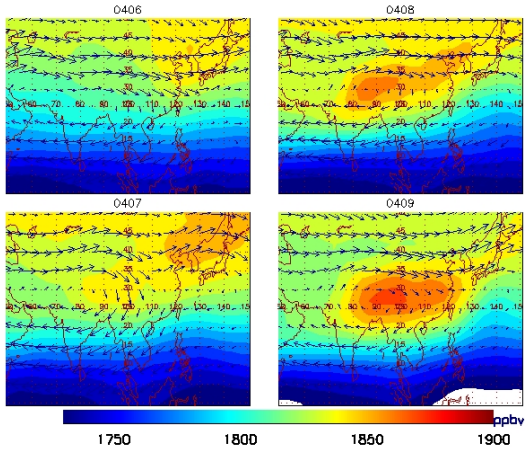
AIRS CH_4 over South Asia (JJAS)

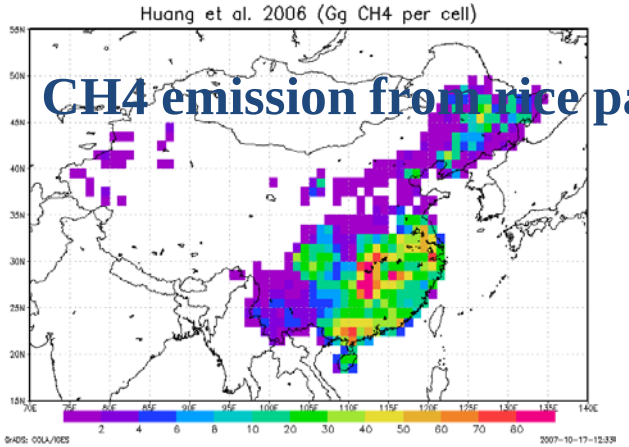


AIRS



Model

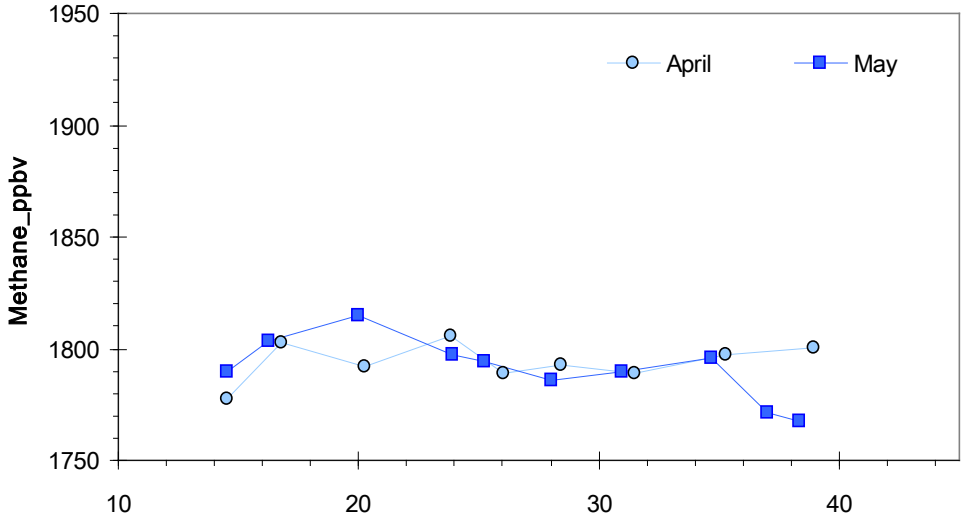


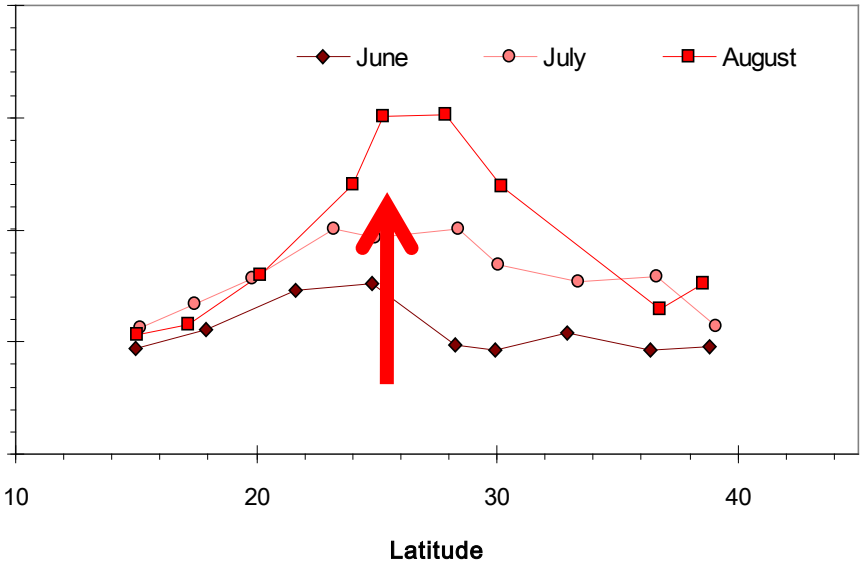


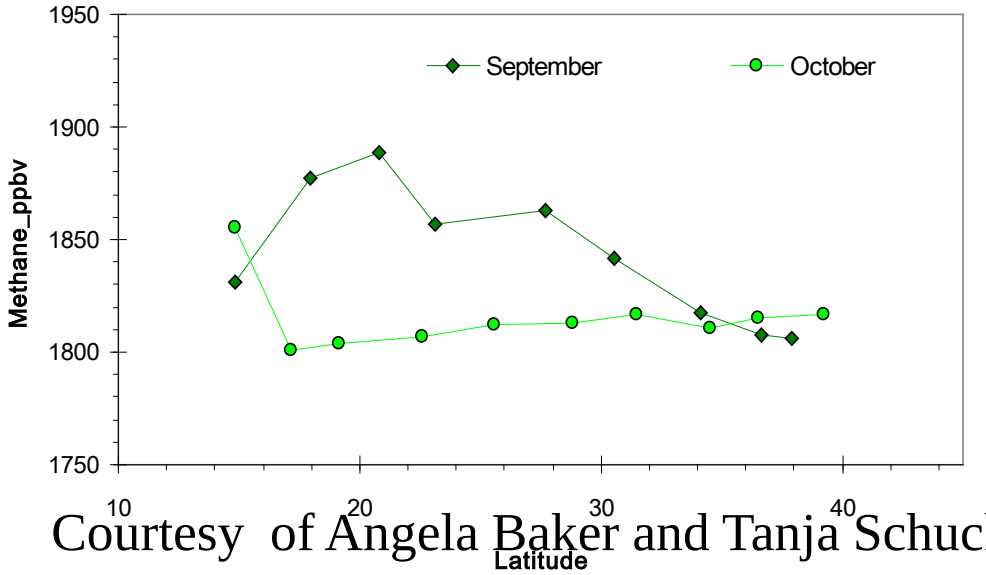
CH4 emission from rice paddies

Xiong et al., Methane Plume over South Asia during the Monsoon Season: Satellite Observation and Model Simulation, *ACP.*, 9, 783-794, 2009 .

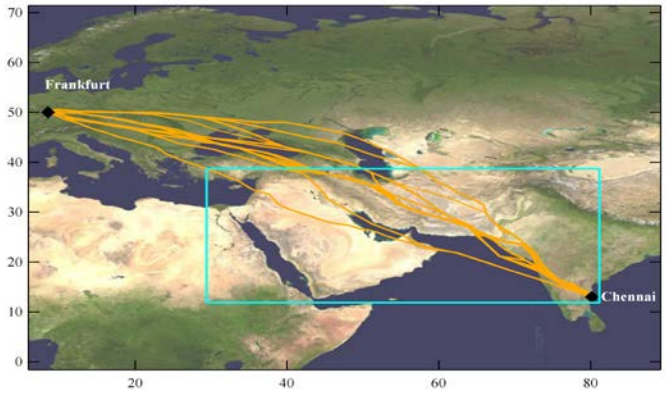
Agree with AIRS data, CARIBIC aircraft measurement also showed significant increase of CH4 during the monsoon season







CARIBIC



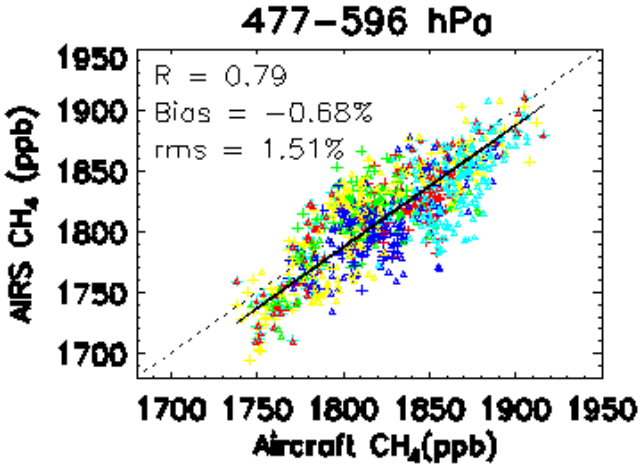
Courtesy of Angela Baker and Tanja Schuck **(Schuck et al., 2010, ACP)**

Monitor CH_4 emissions in the Arctic

- **Supporting the climate change study: CH_4 emissions from permafrost and hydrate leakage under the impact of global warming**

Ground-based observation network is sparse;

CH_4 remote sensing using NIR sensors (1.6 μm) is hampered by its low reflectivity over snow/ice/water surfaces and low solar angles in the Arctic;



Advantage of TIR sensors (all seasons, large swath)

Summary

Hyperspectral IR sounders from AIRS provide over 12 years data since 2002; Continued measurement will be made using CrIS on S-NPP and J-1, -2, as well as IASI.

The peak sensitivity of TIR is in the mid-upper troposphere with low sensitivity near the surface, so it is hard to distinguish the impact of transport or emission based on TIR products.

But, it is promising to monitor the trend of N_2O in the mid-upper troposphere;

We may provide valuable long-term measurement of CH_4 over the Arctic regions where no sensors available to make good measurements in the near future;

More validation and improvement to algorithm need to be done, especially for trend analysis;

– depending on the funding

Questions/Suggestions