Retrieval of Trace Gases using CrIS Full Spectrum Data

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Outline

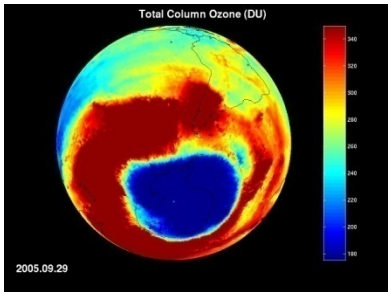
- **Part I: Lessons Learned from AIRS and IASI Trace Gases Retrievals**
  - AIRS and IASI provide measurements of trace Gases (O_3, CO_2, CO, CH_4, N_2O since 2002);
  - Valuable information of gases distribution in Mid-Upper troposphere can be observed (examples) :
    1) Enhancement of upper troposphere CH_4 over south Asia during Monsoon season;
    2) Stratospheric Intrusion and its impact to CH_4 and O_3;
  - One more study to examine the possibility to combine AIRS and IASI data to make a long-term product;

- **Part II: Preliminary Assessment to CrIS Trace Gases Retrievals and Improvements**
  1) Preliminary assessment to current trace gases retrieval in NUCAPS (DOF, Averaging Kernels) and Improvements;
  2) Monitoring the leakage of CH_4 from California **Aliso Canyon Oil Field and Gas Storage Facility;**

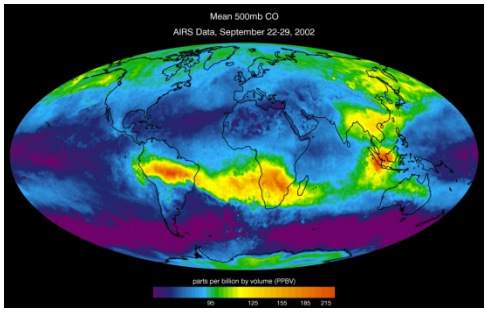
- **Summary and Future Works**

Trace Gases Products

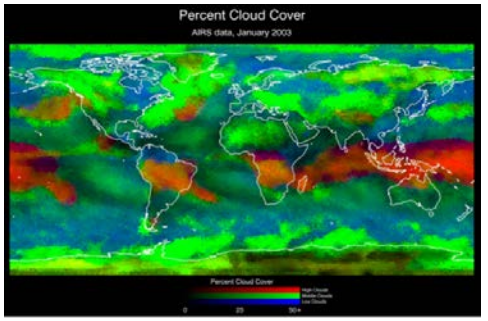
Ozone



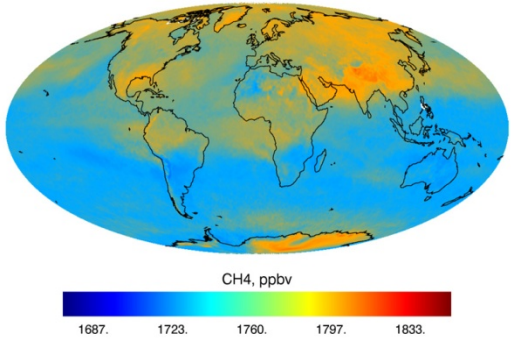
CO



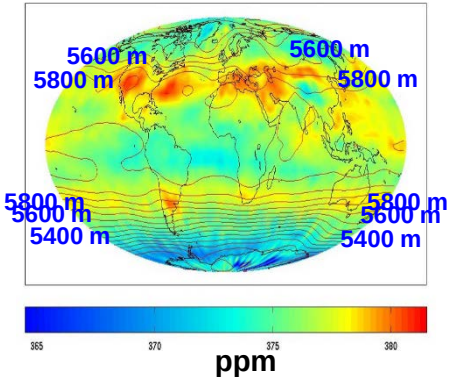
Clouds



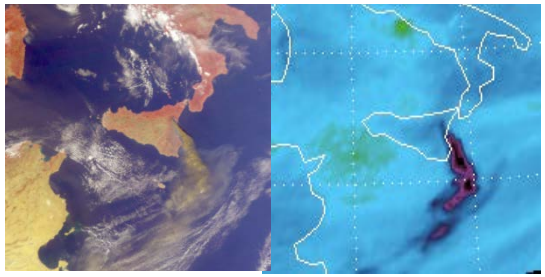
Methane



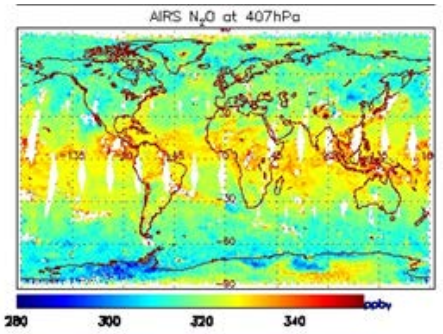
CO2



SO_2

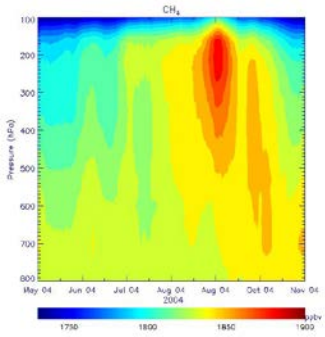


N_2O

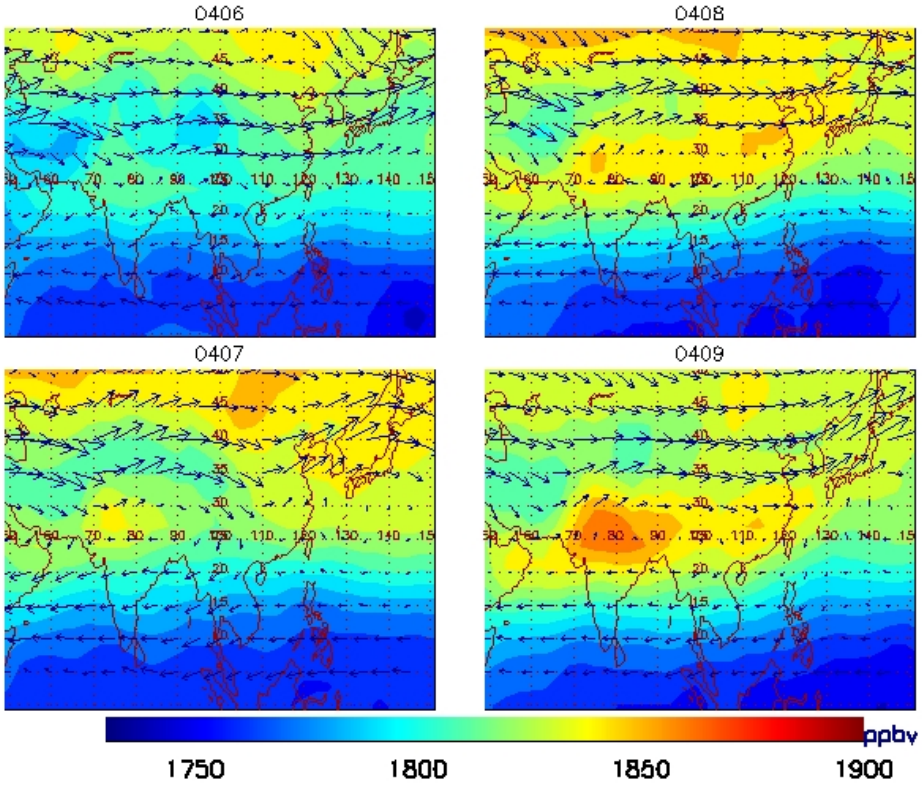


CO_2, CO and CH_4 are listed as Level-1 requirement of products of JPSS

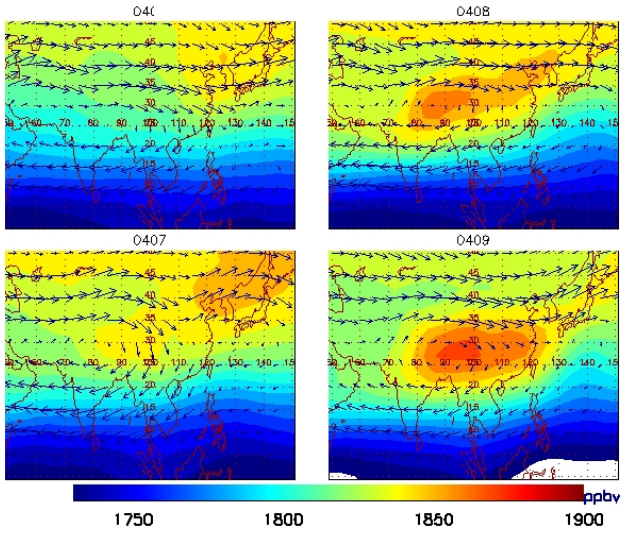
1. AIRS Observed CH_4 Enhancement over South Asia During Monsoon Season (JJAS)



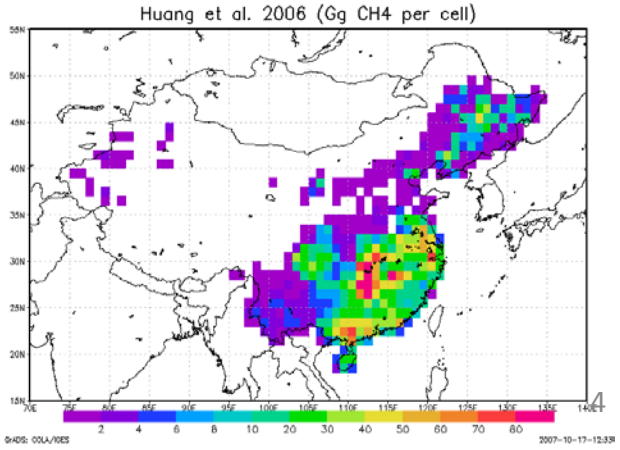
AIRS



Model

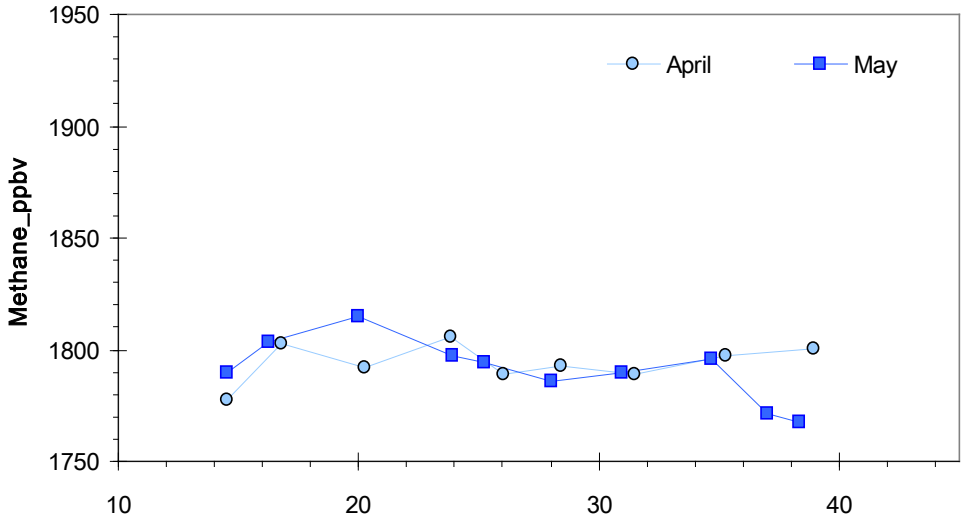


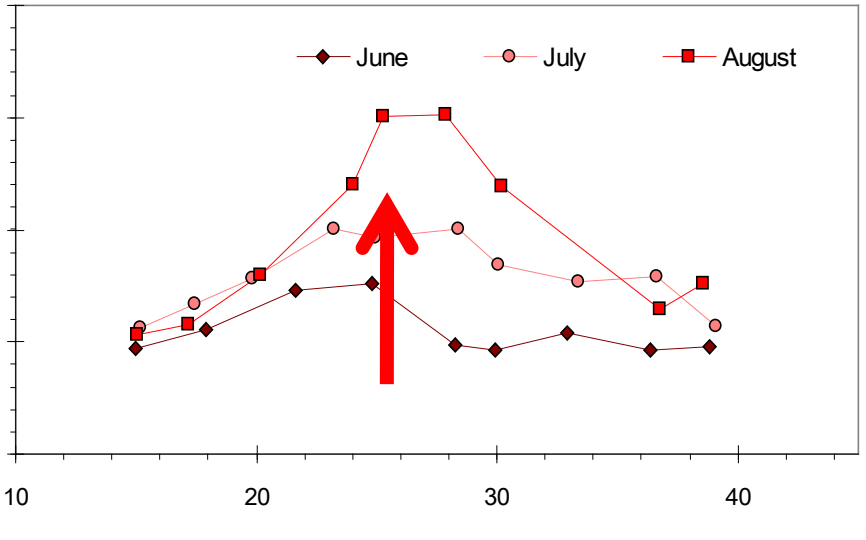
CH4 emission from rice paddies

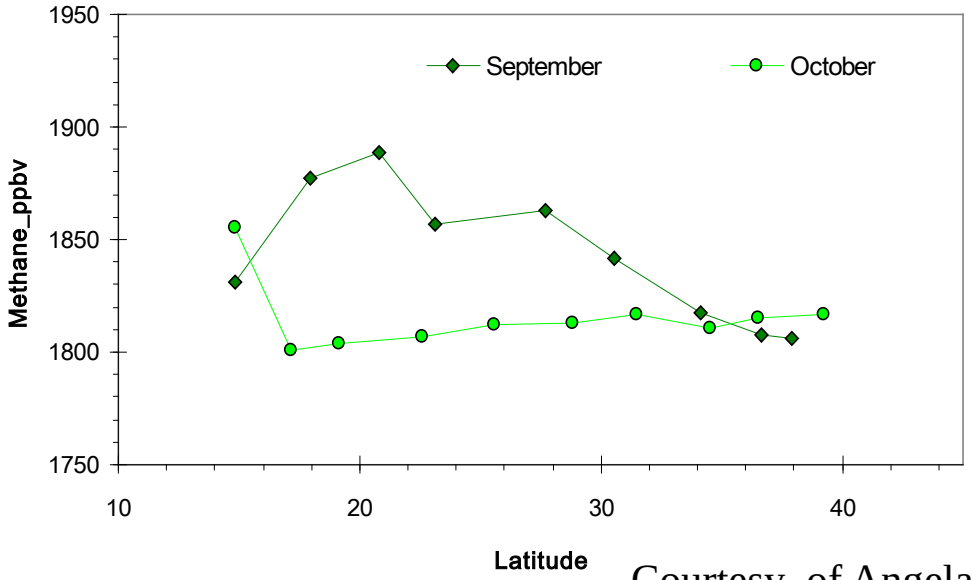


Xiong et al., Methane Plume over South Asia during the Monsoon Season: Satellite Observation and Model Simulation, *ACP.*, 9, 783-794, 2009 .

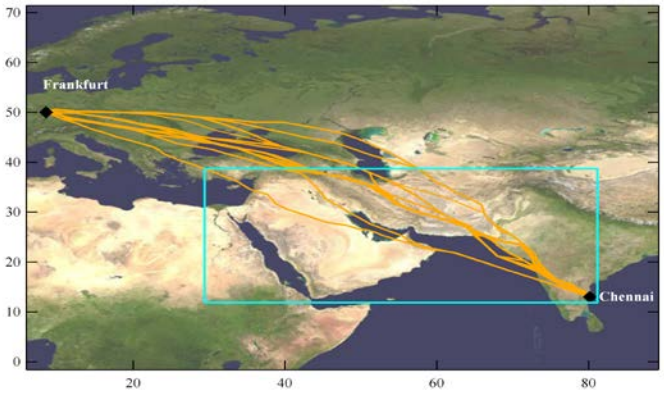
CARIBIC aircraft measurements proved significant increase of CH_4 as AIRS observed in the same time over South Asia







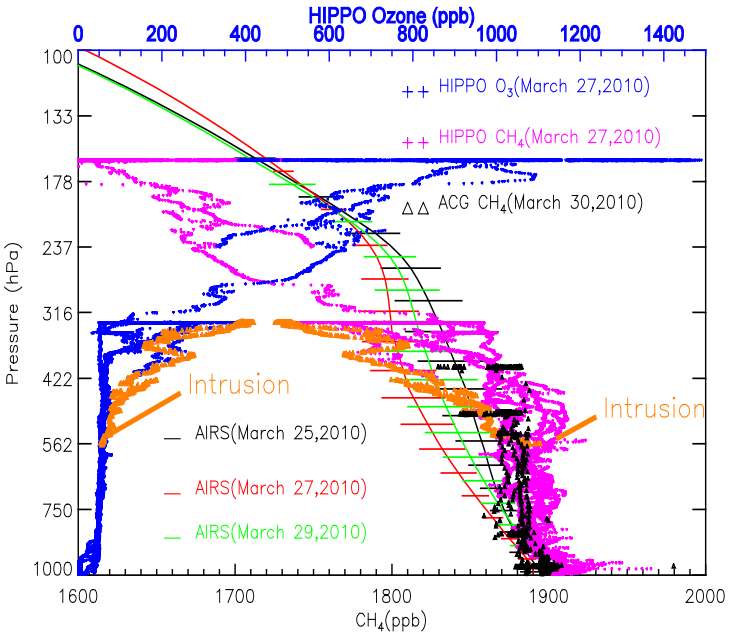
CARIBIC



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

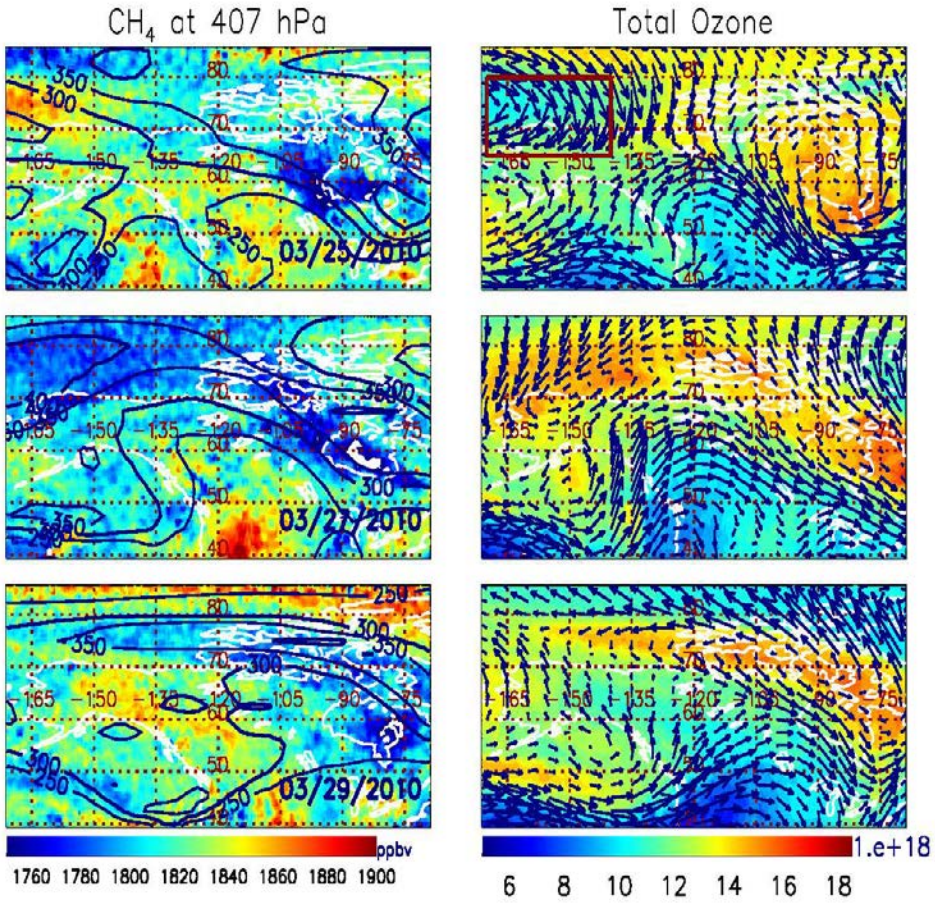
2. AIRS Observed the Impact of Stratospheric Intrusion to CH_4 and O_3

Aircraft Measurements



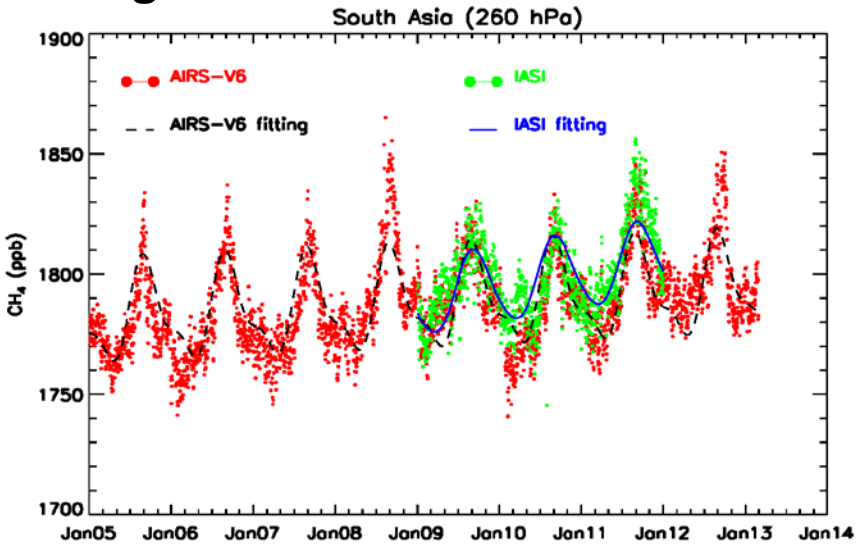
Xiong, X. , Barnet, C. D., Maddy, E., et al., 2013, Detection of Methane Depletion Associated with Stratospheric Intrusion by Atmospheric Infrared Sounder (AIRS), *GEOPHYSICAL RESEARCH LETTERS*, VOL. 40, Issue 10, Pages: 2455–2459, doi:10.1002/grl.50476, 2013.

3/25, 3/27, 3/29/2010, Alaska

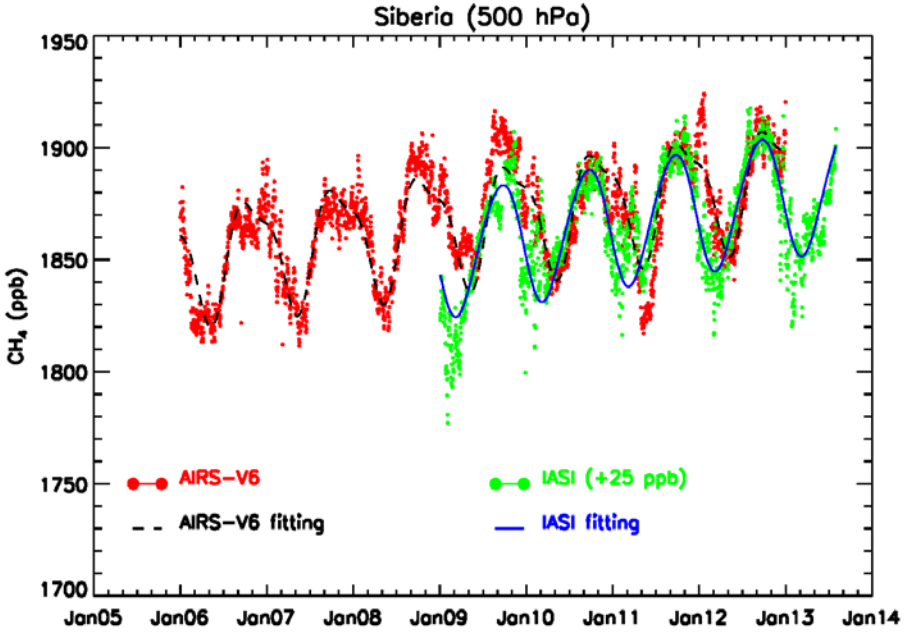


One more study: to make a long-term product by combing AIRS and IASI CH_4 Products

South Asia: repeatable increase of CH_4 during Monsoon Season



Arctic: similar seasonal cycles from AIRS and IASI but has large difference in the cold season



Xiong et al., 2016, Comparison of Atmospheric Methane Retrievals from AIRS and IASI, IEEE JSTARS, 10.1109/JSTAR.2016.2588279

- The above examples shows that AIRS and IASI can be used to observe gases distribution in Mid-Upper troposphere, and it is likely to combine AIRS and IASI data to make a long-term product;

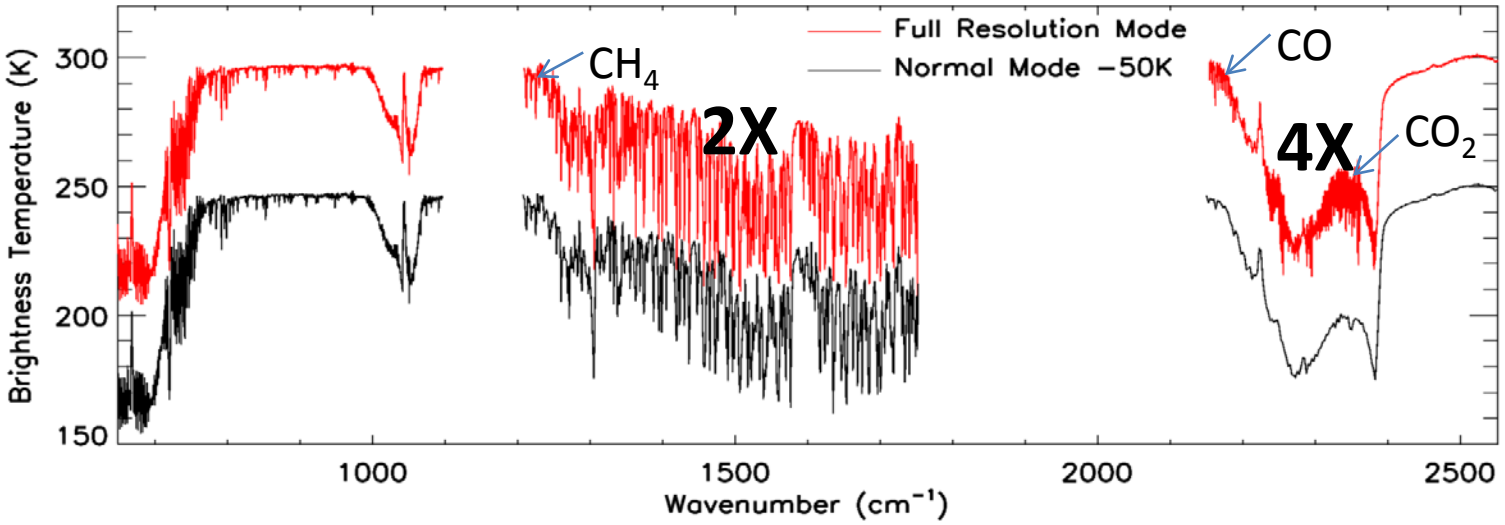
- **CrIS started to operate in the full spectral resolution (FSR) mode since Dec.4, 2014 → making it possible to retrieve trace gases .**

CrIS Normal Resolution and Full Resolution SDR

- CrIS FSR data are available from NOAA/NESDIS/STAR, and it has 2211 channels as compared to 1305 channels in normal mode

ftp://ftp2.star.nesdis.noaa.gov/smcd/xxiong/ **Red: Full resolution**

Frequency Band	Spectral Range (cm^{-1})	Number of Channel (unapodized)	Spectral Resolution (cm^{-1})	Effective MPD (cm)
LWIR	650 to 1095	713* (717)	0.625	0.8
MWIR	1210 to 1750	433* (437)	1.25	0.4
		865* (869)	0.625	0.8
SWIR	2155 to 2550	159* (163)	2.5	0.2
		633* (637)	0.625	0.8



Part 2: Preliminary Assessment to CrIS Trace Gases Retrievals and Improvements

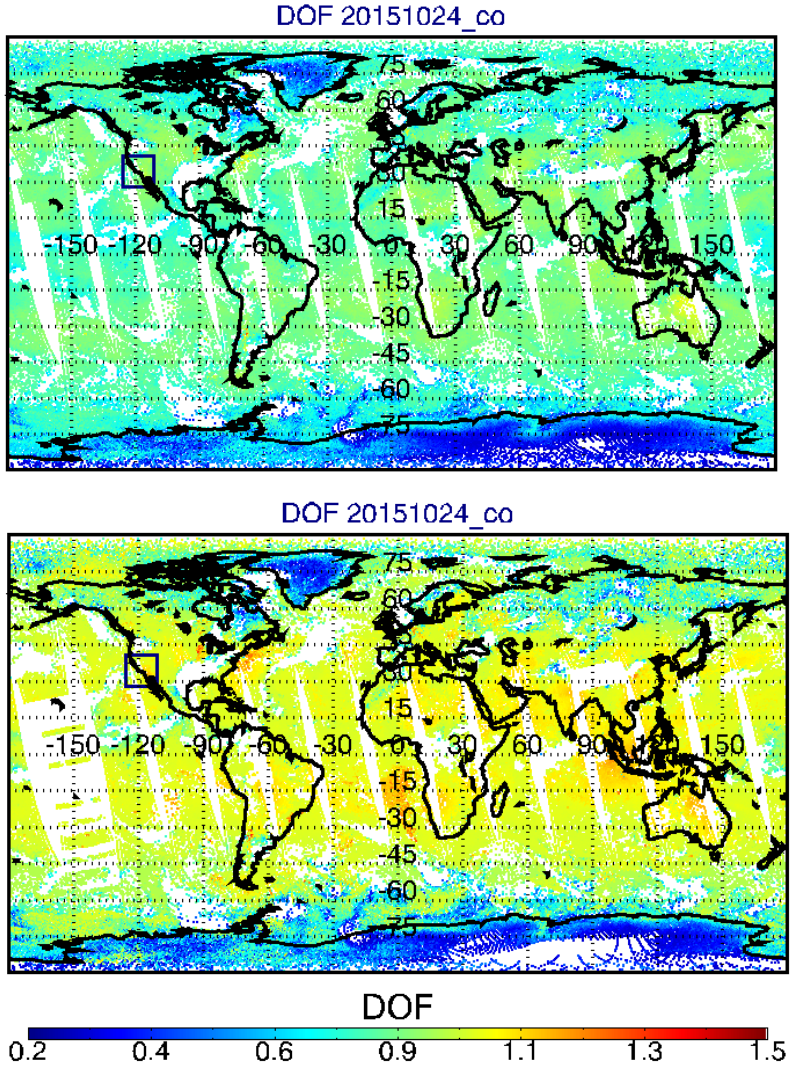
- **First check to NUCAPS trace gases retrieval averaging kernels and DOFs indicated the DOFs are much lower than AIRS and IASI;**

- **Improvements can be made after re-selection of channels, as well as the update to QC;**

- **Historically largest gas leakage in California provides a good case to test if NUCAPS can capture this leakage;**

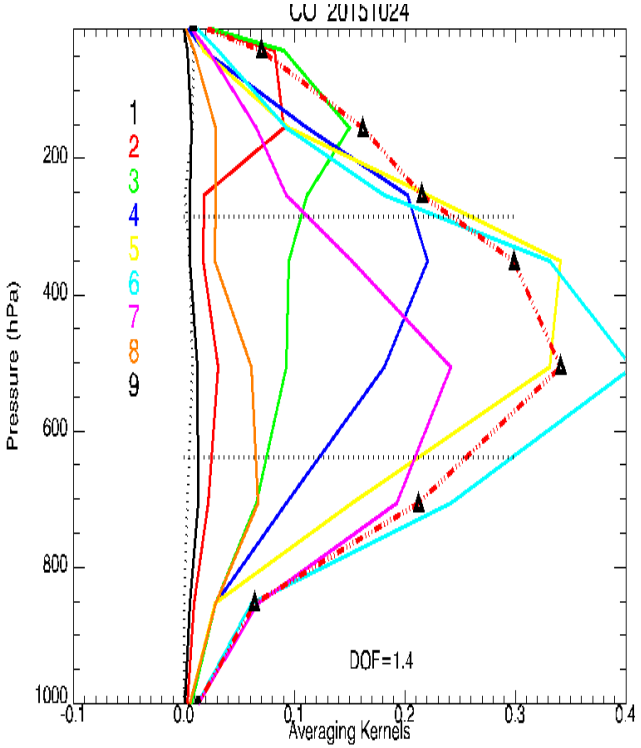
Averaging Kernels and Degree of Freedoms (DOFs) before and after Improvement for CO

Major Sensitivity: 300-650 hPa



current

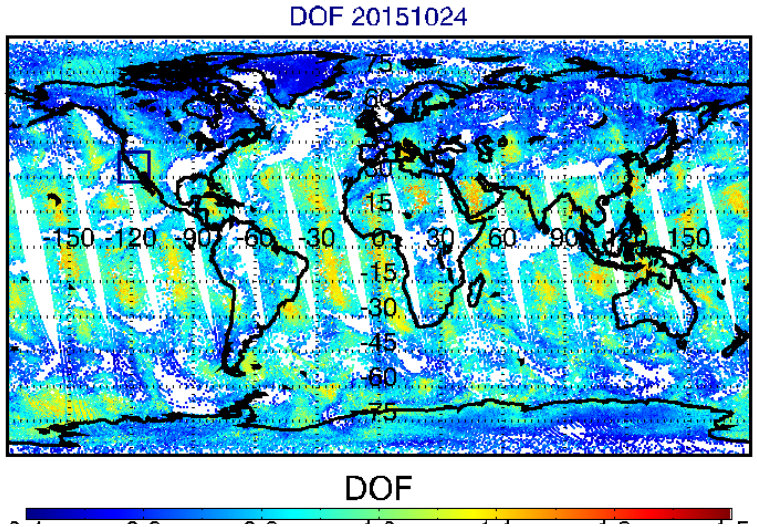
after



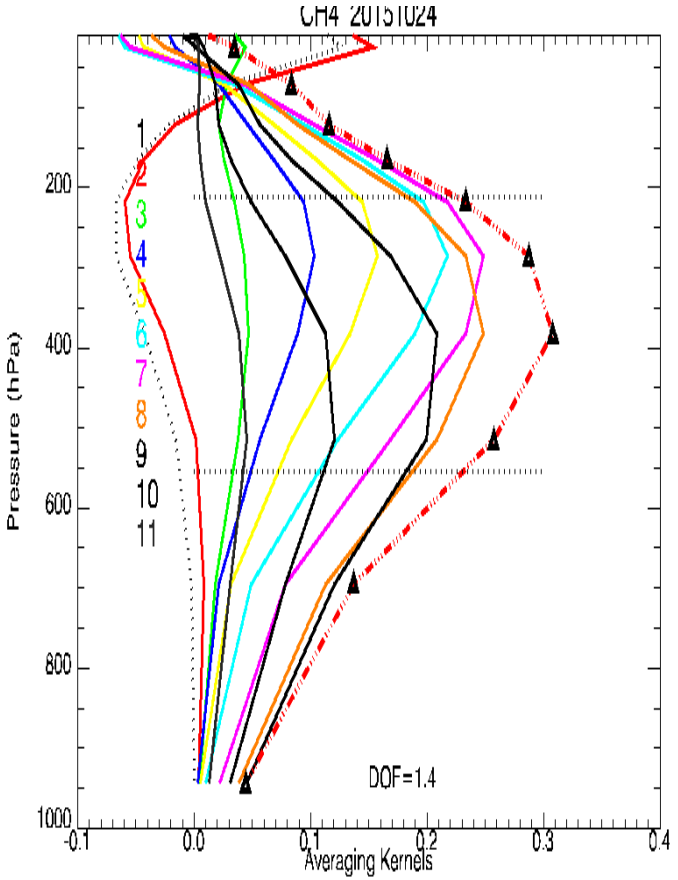
DOFs increase after the re-selection of channels

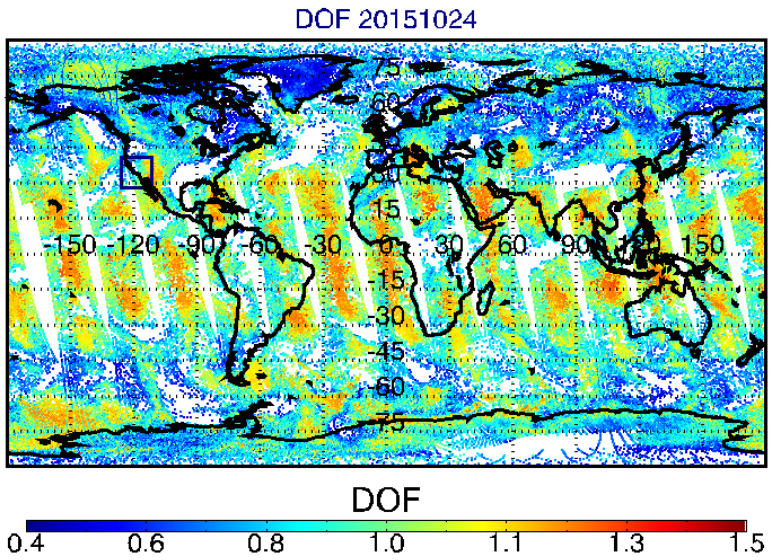
Averaging Kernels and DOFs Changes for CH_4

Major sensitivity: 200-550 hPa



current

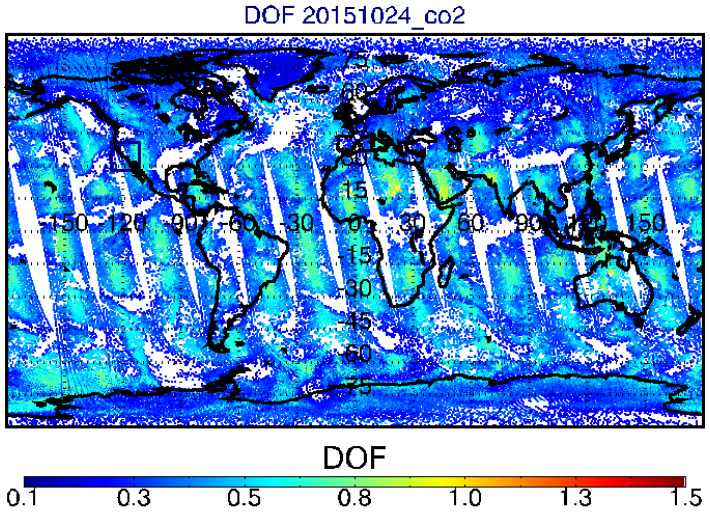


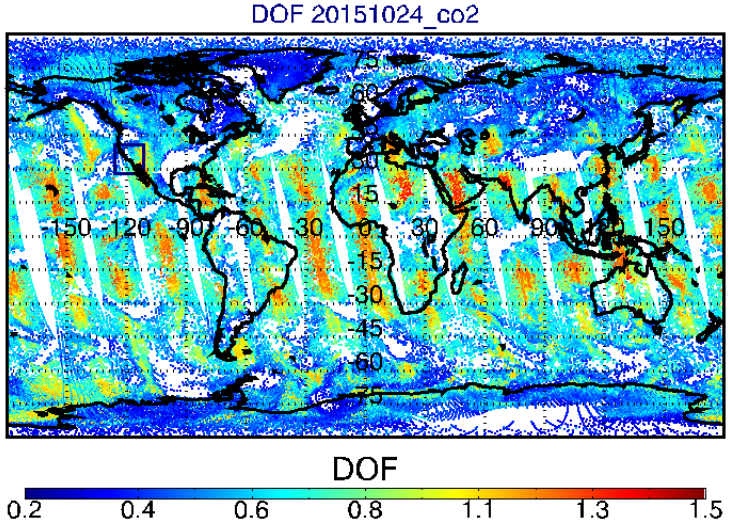


after

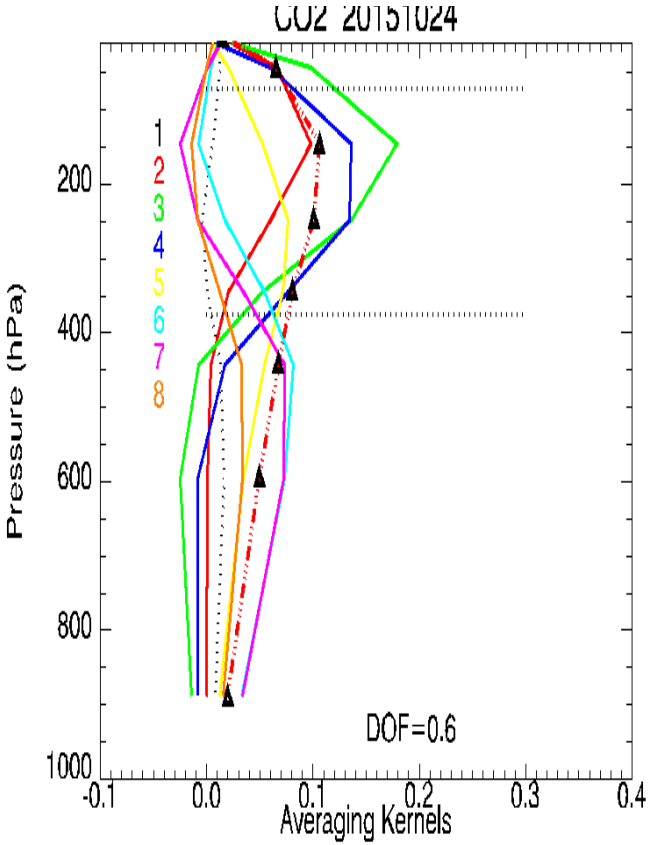
DOFs increase after the re-selection of channels

Averaging Kernels and DOFs – CO_2



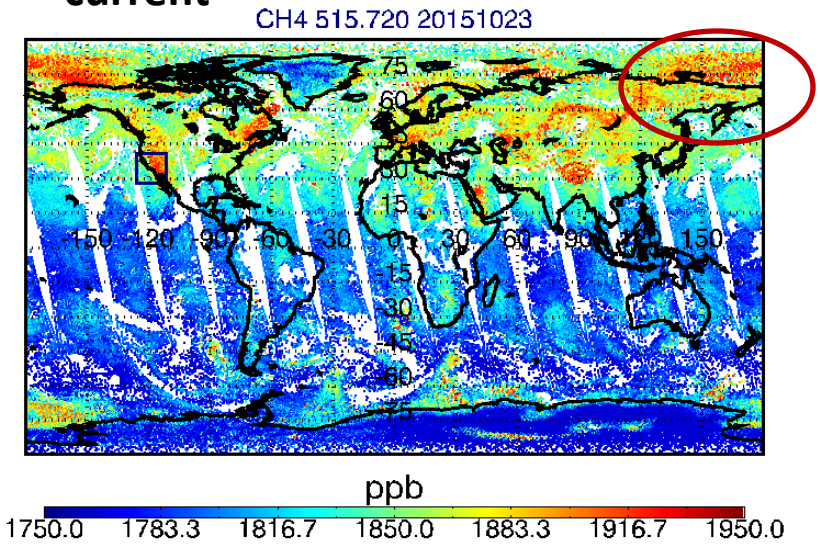


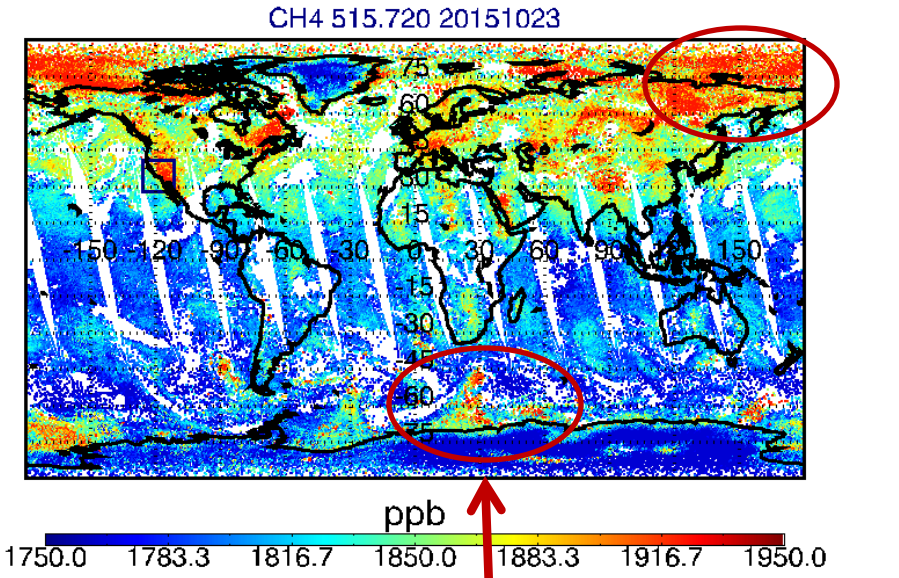
More works need to be done for CO_2



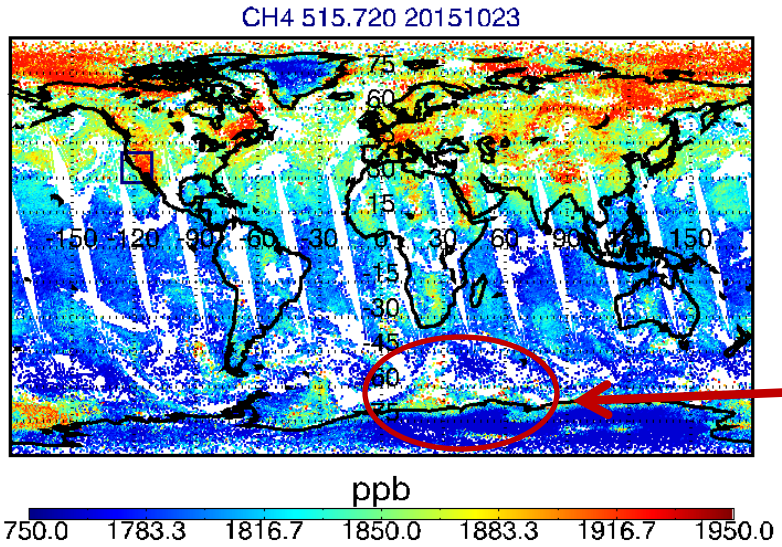
Changes of CH_4 Distribution after the re-selection of channels and update of QC (+10 ppb)

current

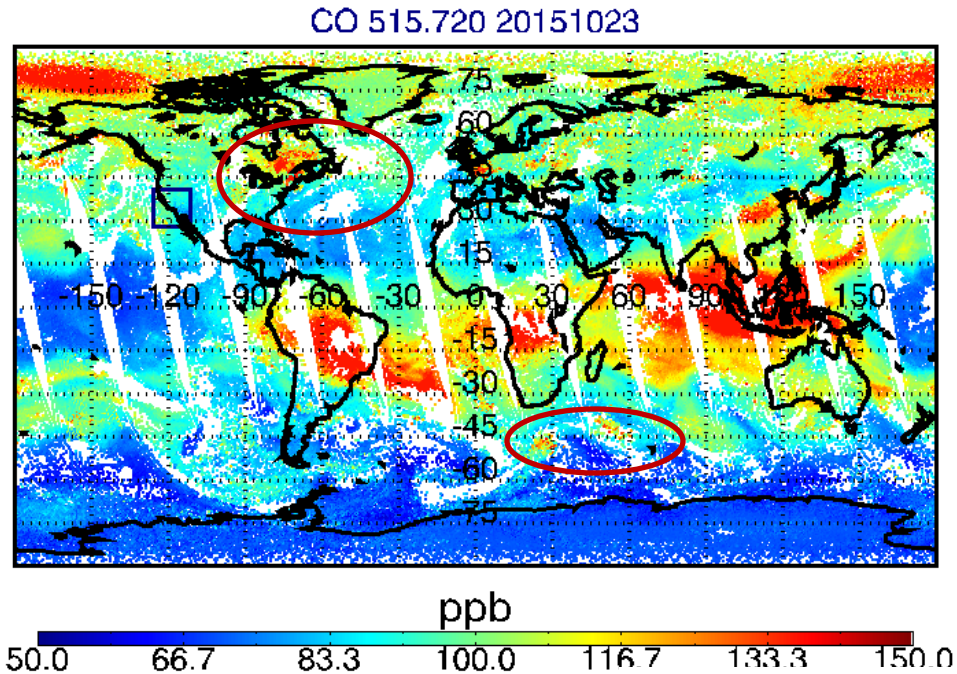




after the re-selection of channels

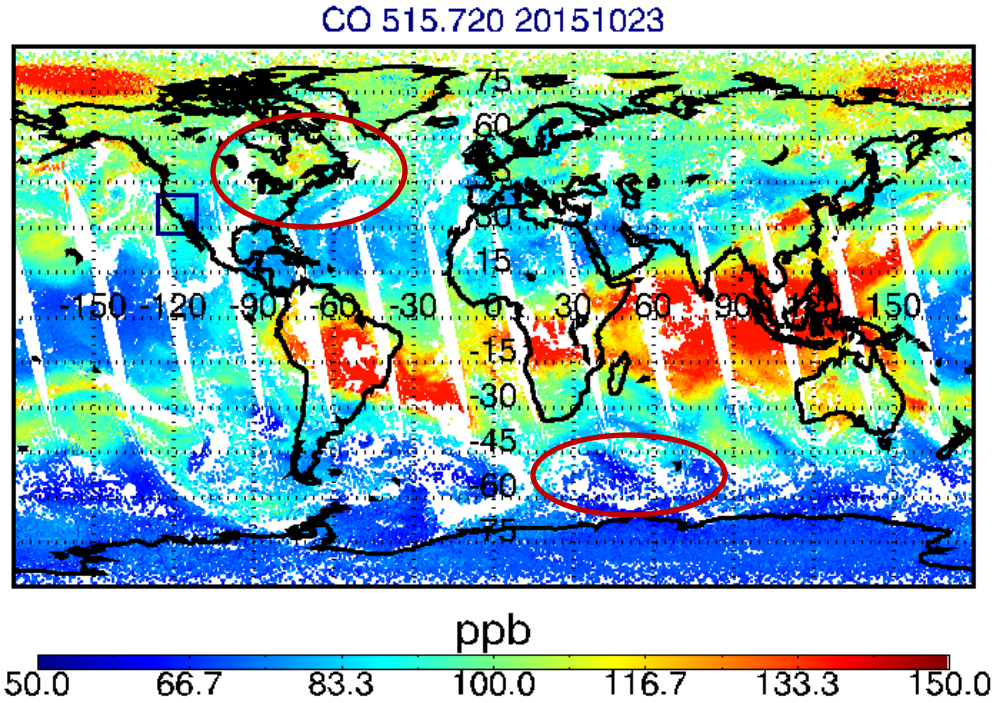


New QC



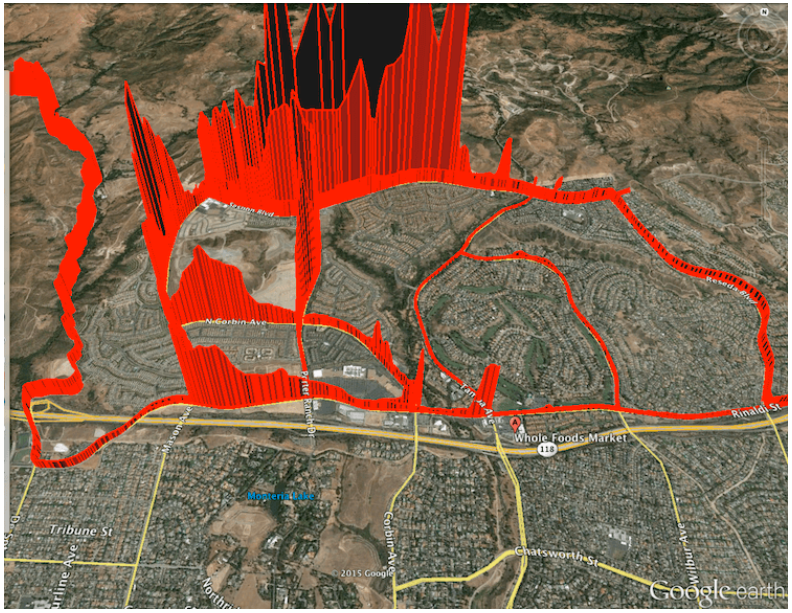
Change of CO distribution after re-selection of channels and update of QC

After



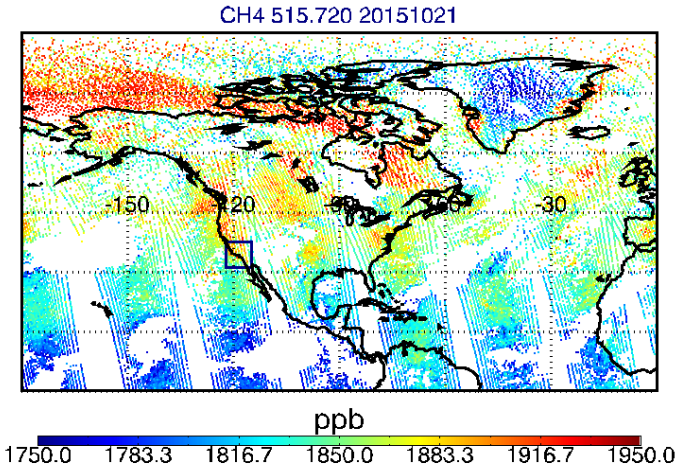
Aliso Canyon Gas Leakage (10/23/2015- 2/18/2016)

CH_4 increase from ground measurement

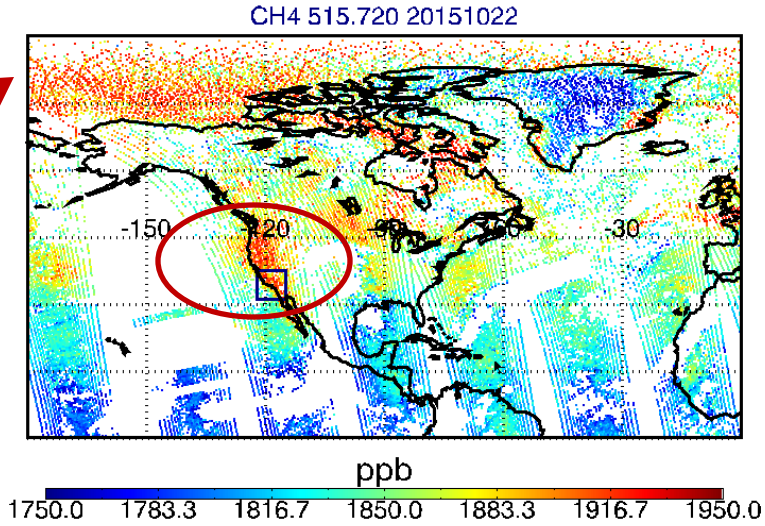


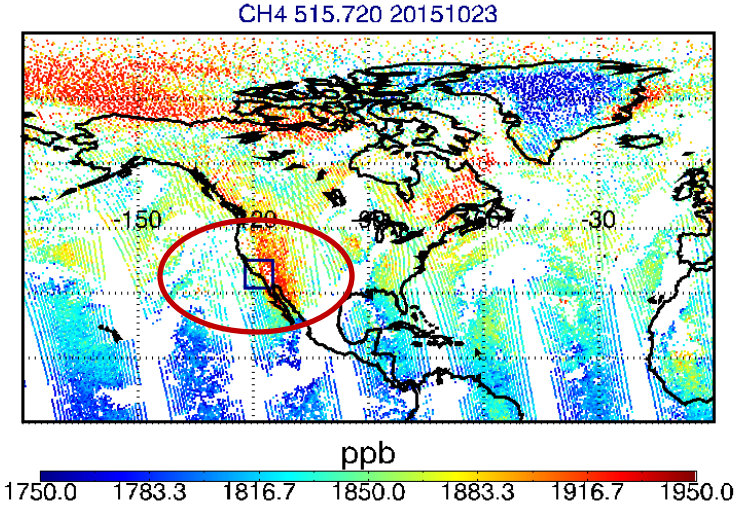
- Historically largest gas leakage -- a good case to test if NUCAPS can capture this leakage;
- CrIS retrievals for two days before the leakage (10/23/2015) and 1 week after have been made in this analysis;

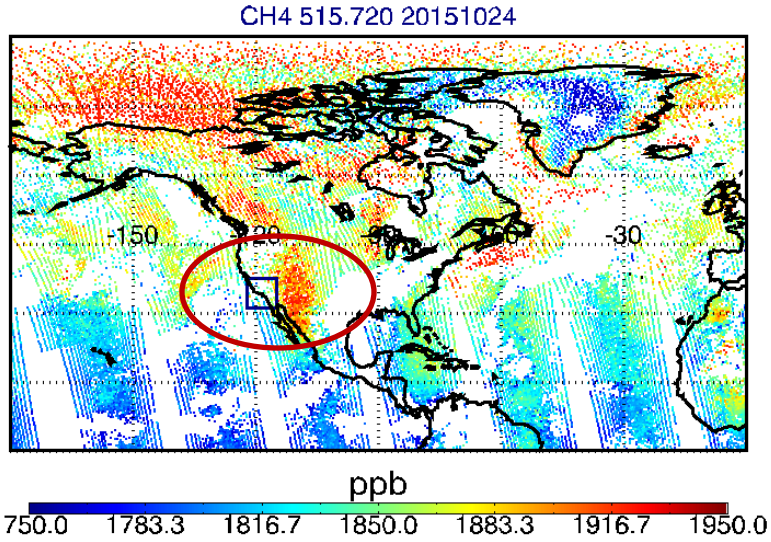
CH_4 from Ascending Node – enhanced CH_4 started in Oct.22,2015



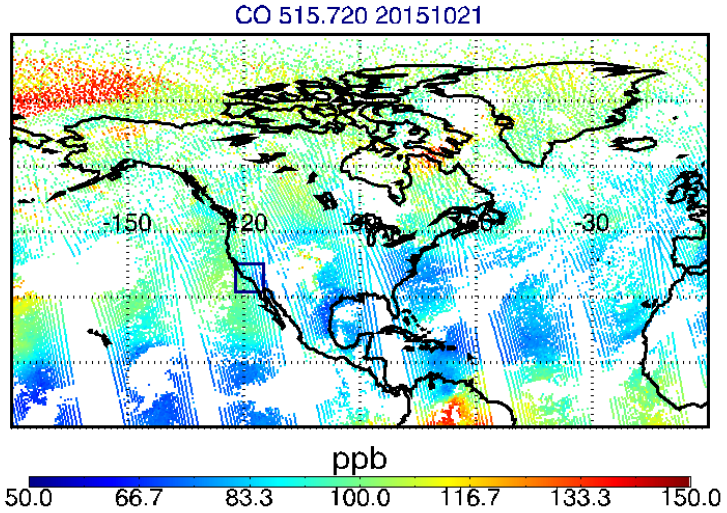
Unknown sources

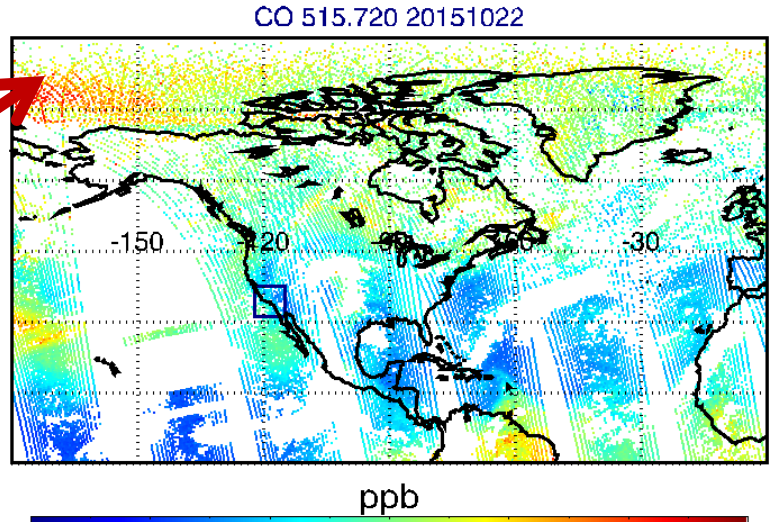


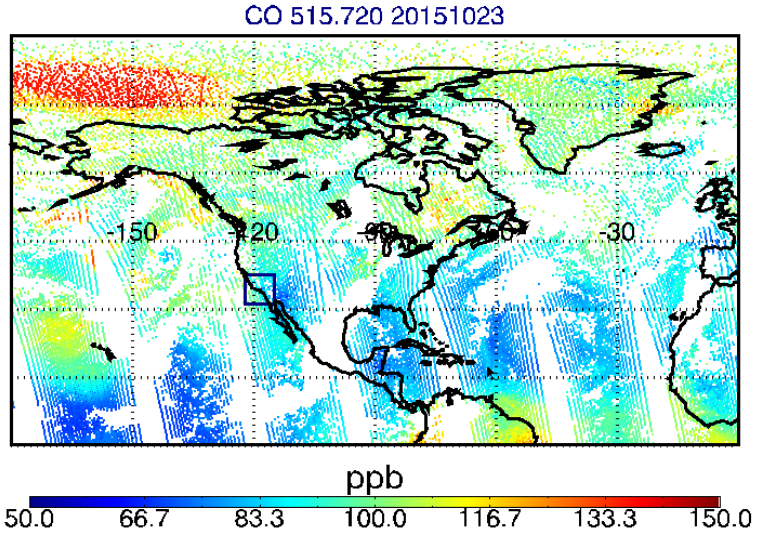


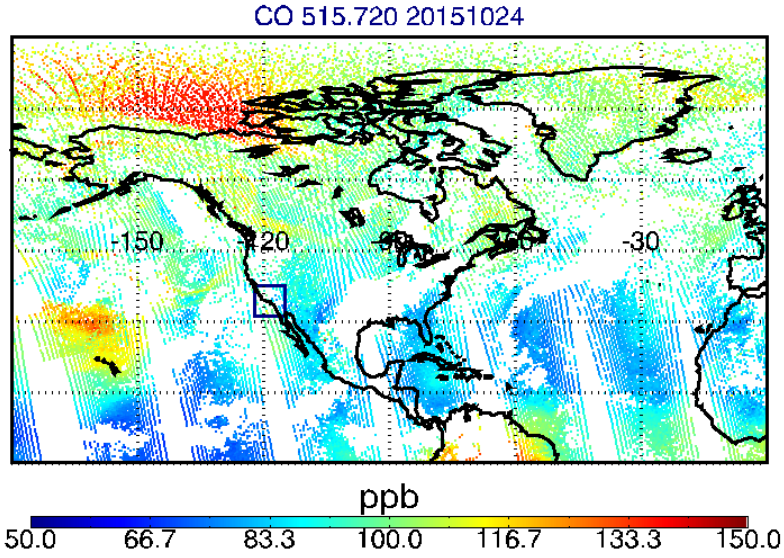


CO from Ascending Node – similar transport of CO, but sources are unknown

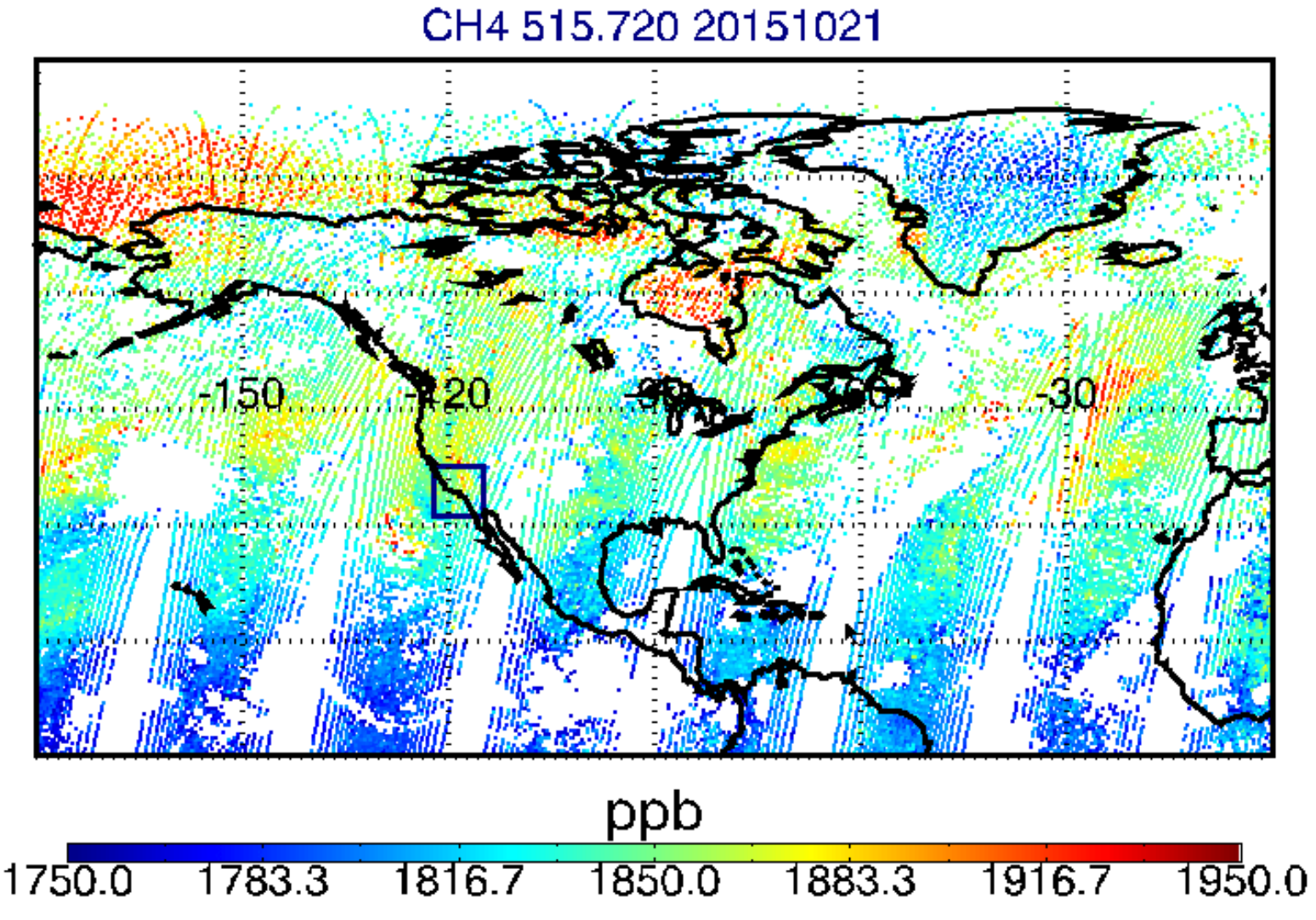




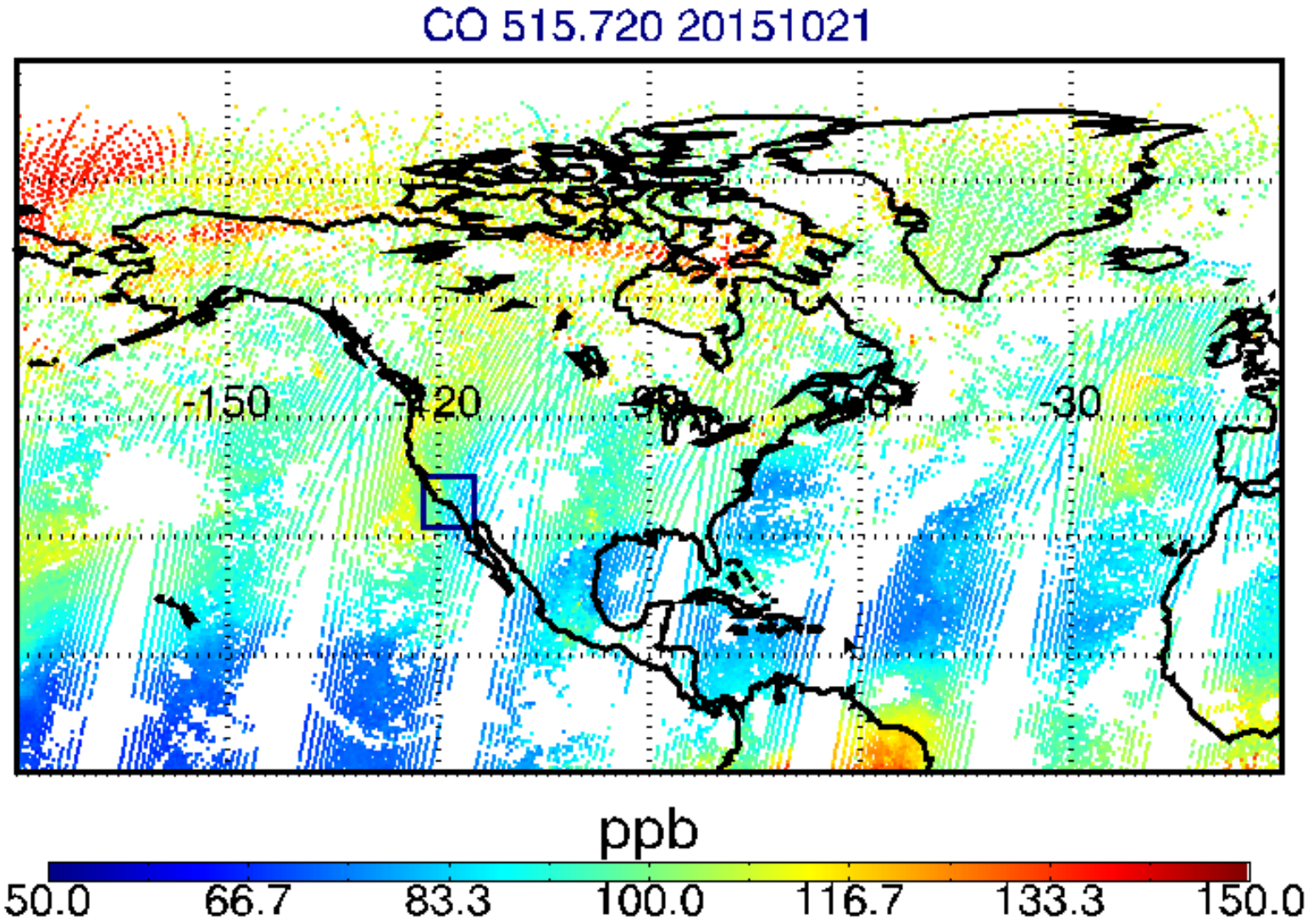




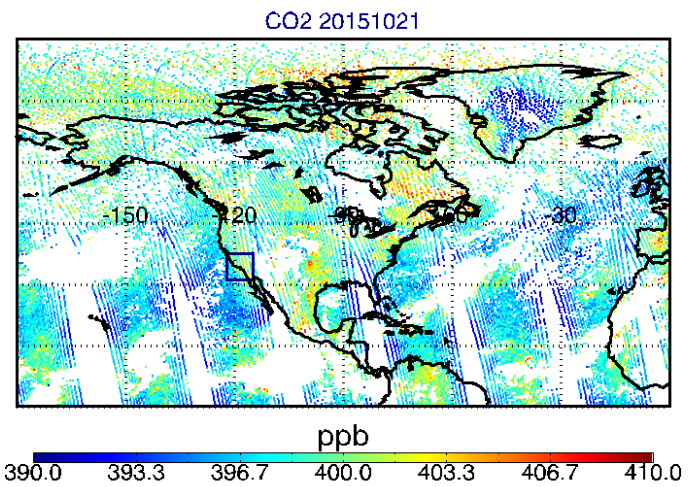
CH_4 from 10/21 – 10/29/2015

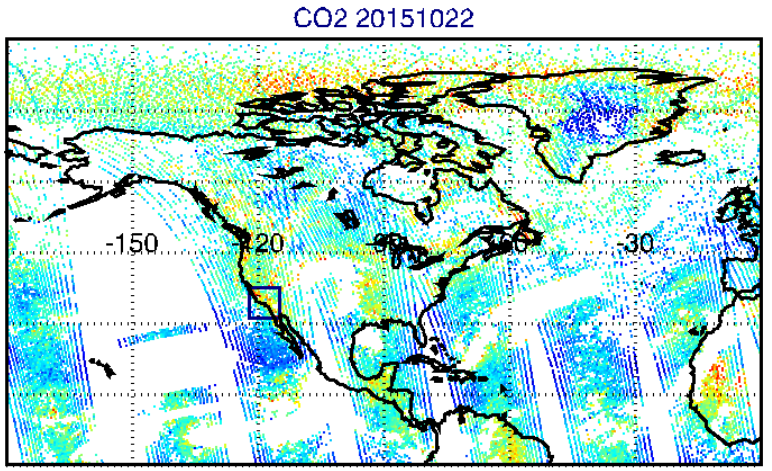


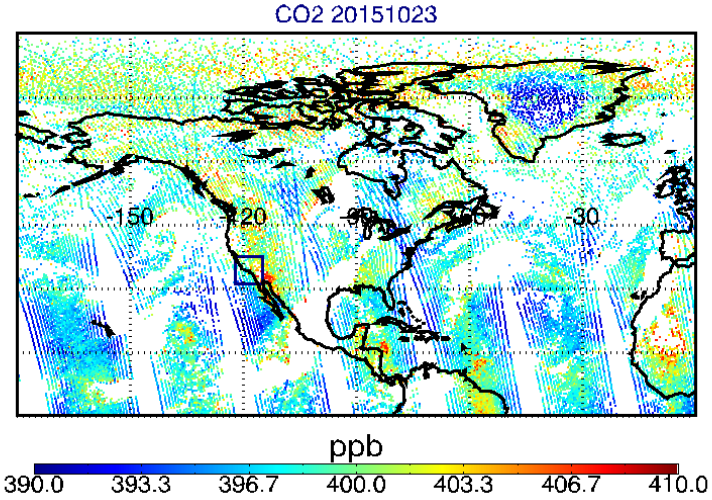
CO from 10/21 – 10/29/2015

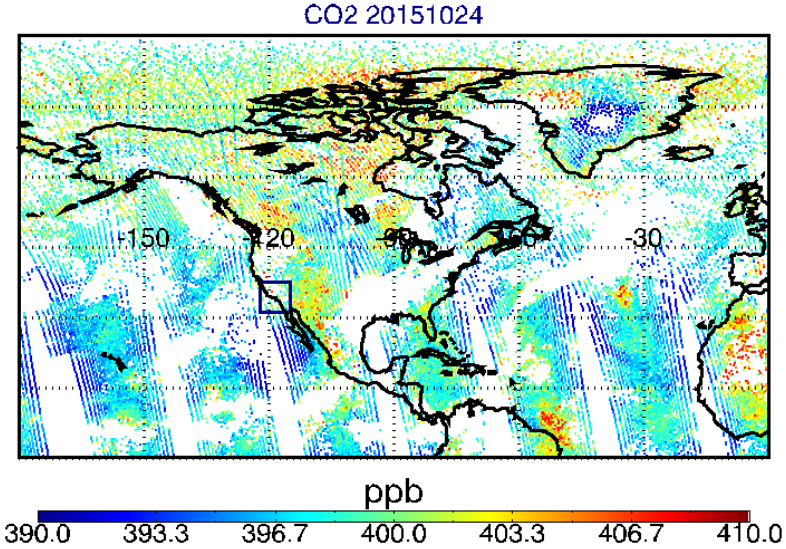


CO_2 from Ascending Node









Summary and Future Works

1. CrIS full spectrum data can be used to retrieve trace gases with similar DOFs as AIRS and IASI, with its major sensitivity in the ***mid-upper troposphere***; however, to combine these three sensors to make a consistent product from 2002 to beyond need more works (***larger disparity existed in the Arctic between AIRS and IASI retrievals***);

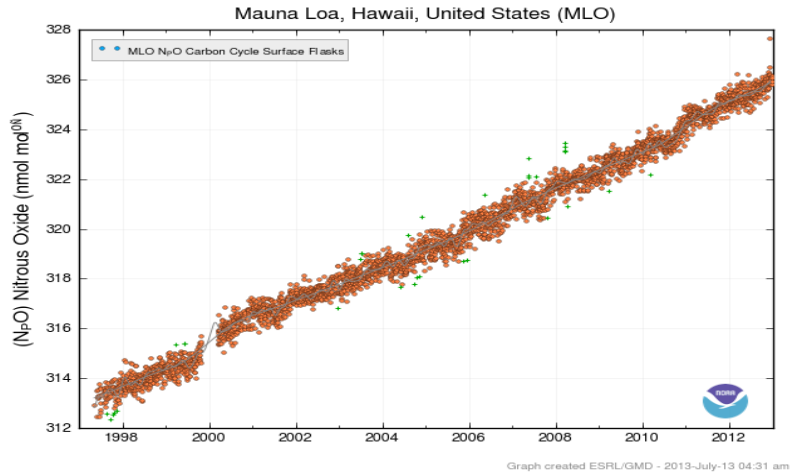
2. It is promising to use CrIS full Spectrum data to detect the leakage of CH_4 during the historically largest Gas leakage from **Aliso Canyon Oil Field and Gas Storage Facility in 2015. However,** more checks to other possible uncertainties need to be done (cloud-clearing, transport);

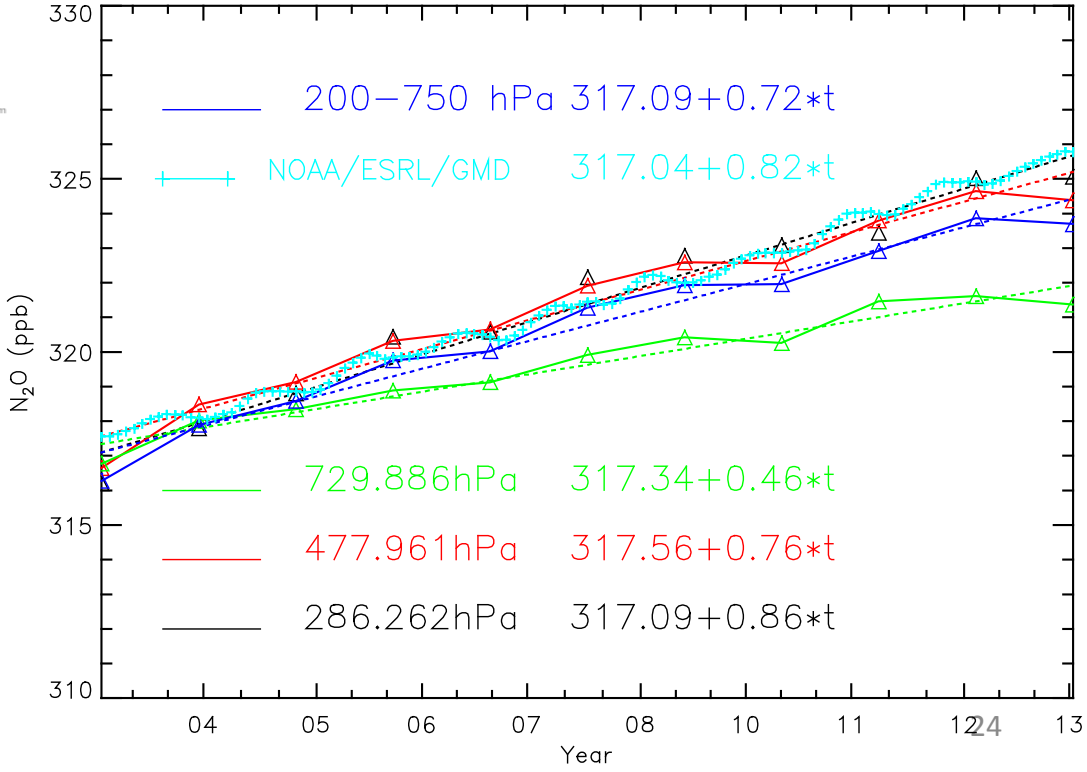
3. Preliminary improvements in channels selection and QC have been made, which show positive impacts to the retrieval products;

4. Validation is a key step but hampered due to lack of the measurements of trace gases profiles. Improvement to QC will be one focus of future works.

Questions/Suggestions

3. Monitoring of N_2O trend using AIRS

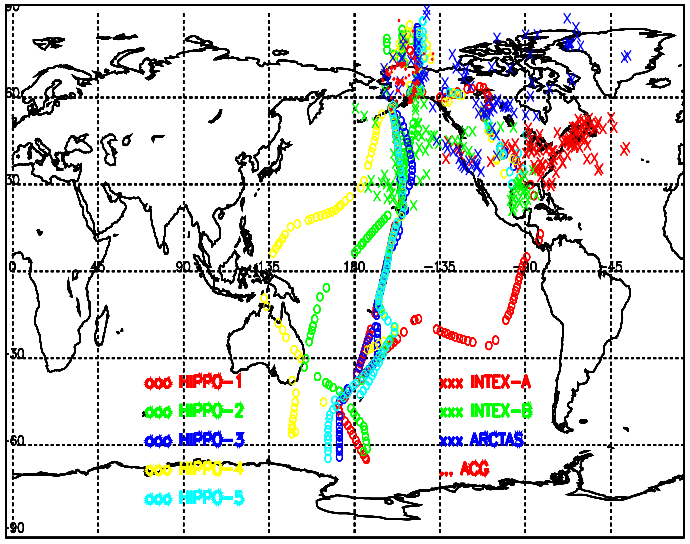




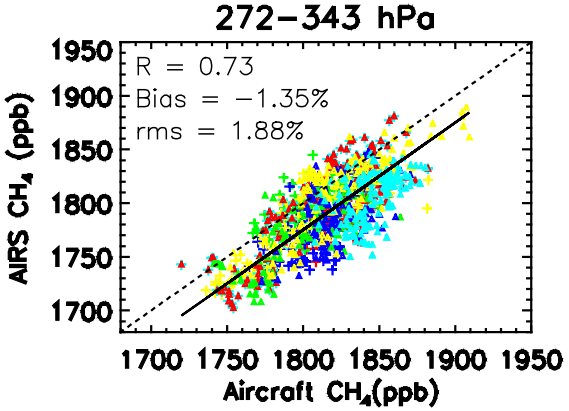
Xiong, X. et al., 2014, Retrieval of Nitrous Oxide from Atmospheric Infrared Sounder: Characterization and Validation, JGR-atmosphere, 119, doi:10.1002/2013JD021406.

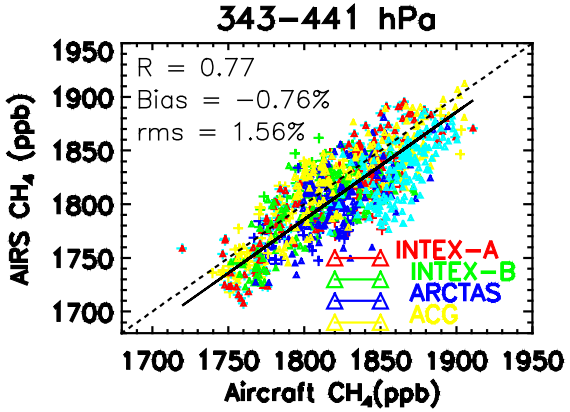
Validation: one Key step to evaluate the trace gases products

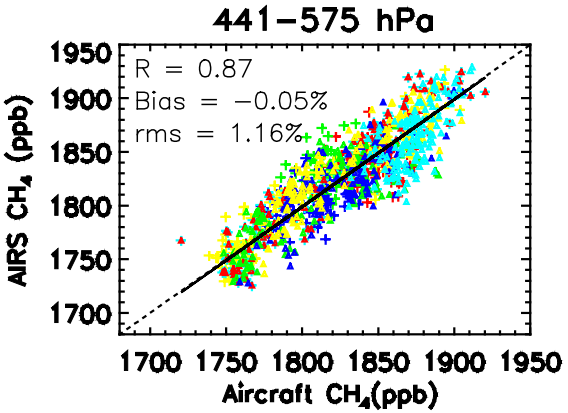
Locations of Validation Profiles

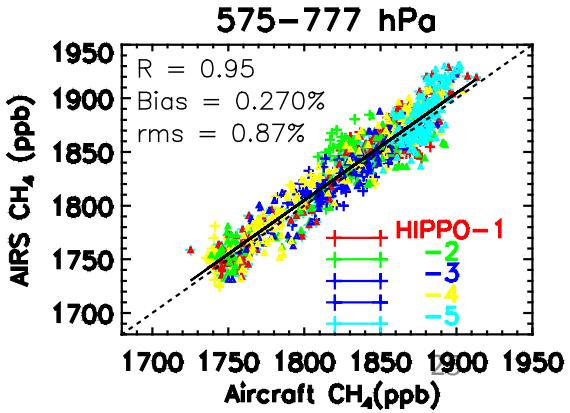


AIRS-V6 CH_4

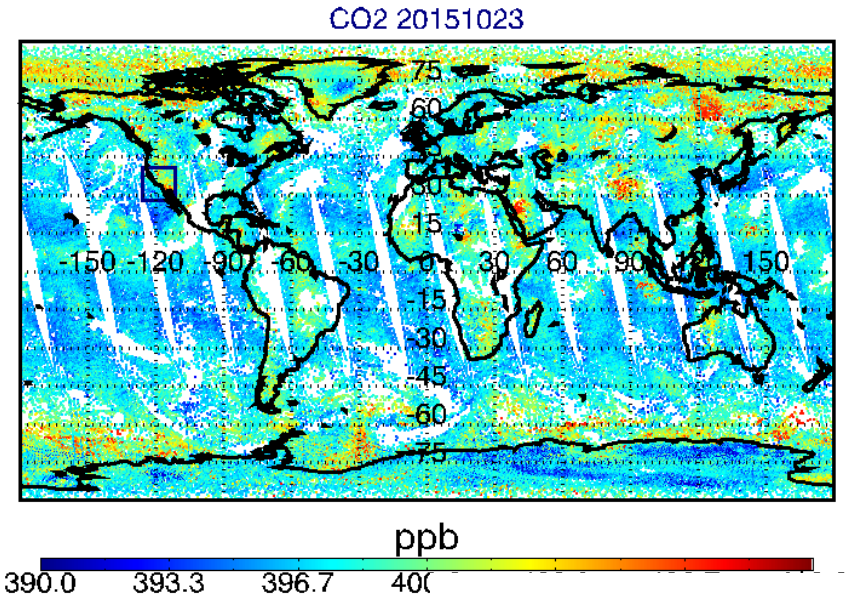


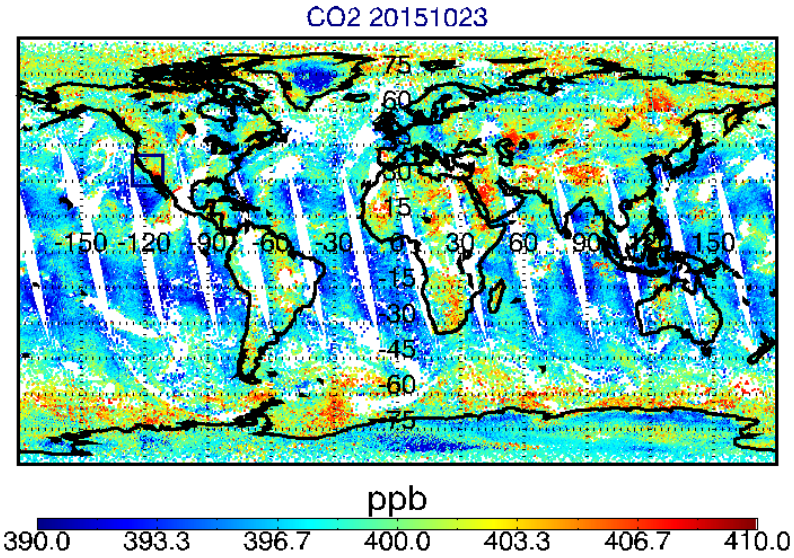


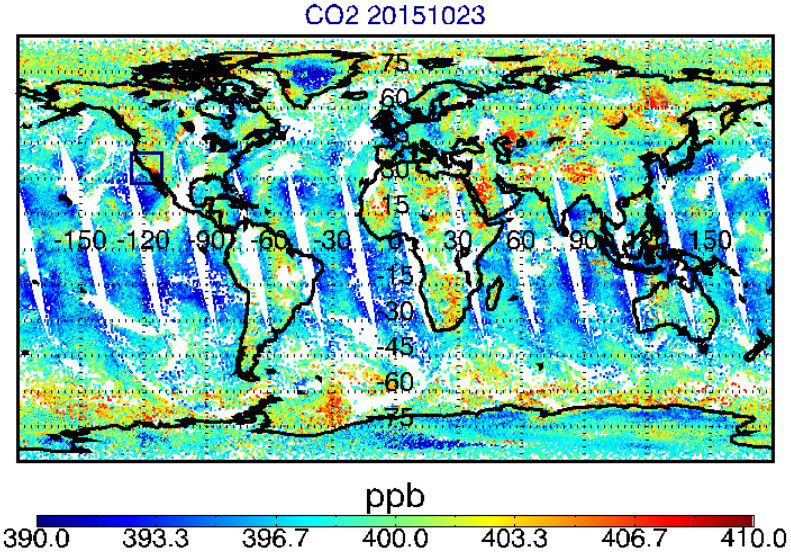




Change of CO_2

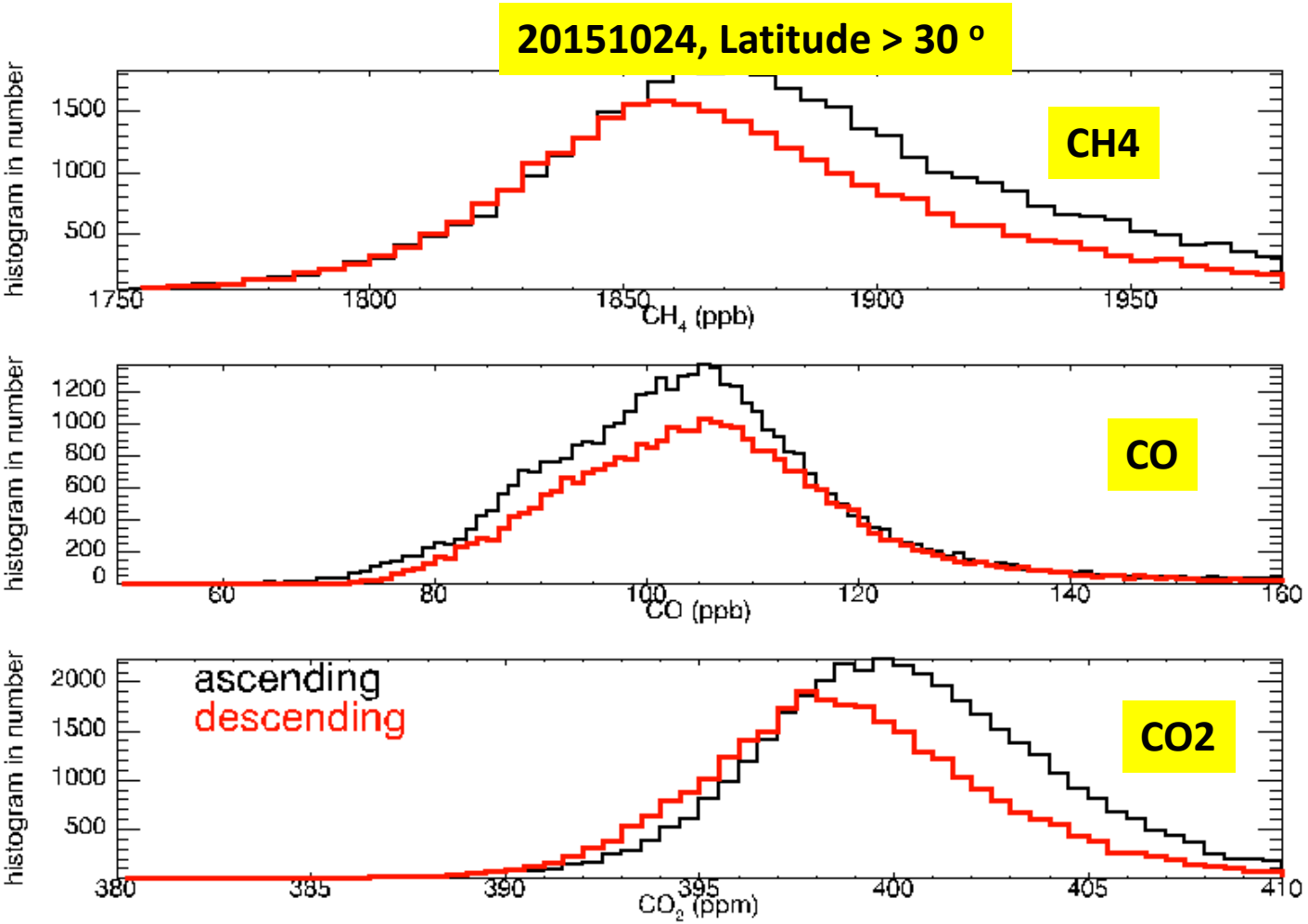






More works need to be done for CO_2

Day-night Difference



Daytime CH4 and CO2 are larger than night time, but not CO