Understanding Emissions and Tropospheric Chemistry using NUCAPS and VIIRS

A JPSS Proving Ground/Risk Reduction Project

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Project Overview

Goal: Use aircraft data and atmospheric models to characterize NUCAPS CH_4 and CO retrievals

Objectives:

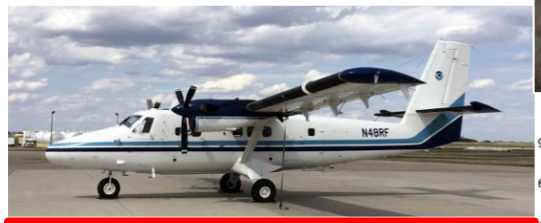
- Validate atmospheric chemical-transport models with aircraft observations
- Simulate spatial and temporal variability of CH_4 and CO
- Evaluate NUCAPS CH_4 and CO retrievals with validated model
- Assess ability of JPSS datasets to constrain modeled CH_4 and CO

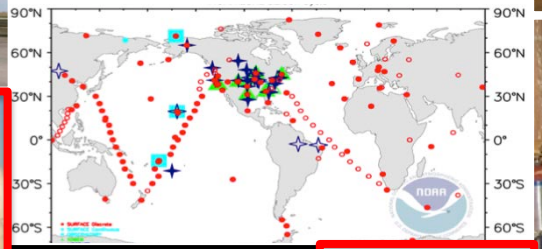
End Users: Researchers and forecasters at NOAA and elsewhere

Close collaboration of NOAA ESRL team with STC NUCAPS retrieval team and NESDIS STAR analysis team is absolutely critical to this project's success and adds value to PGRR investment

ESRL Research Assets

ESRL employs unique combination of observational platforms, analysis approaches, and human expertise



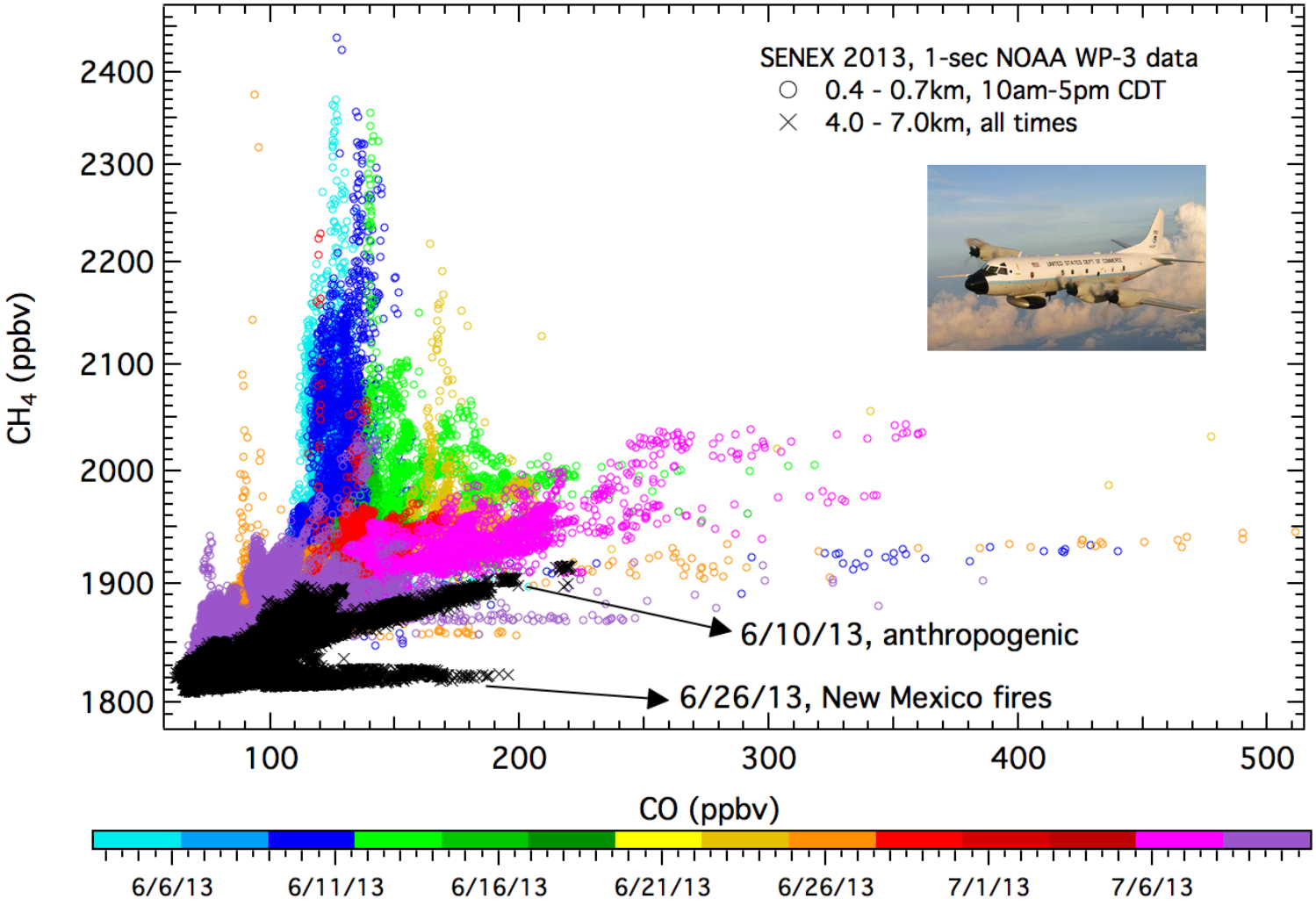


http://www.esrl.noaa.gov

SENEX 2013 NOAA WP-3 Flights

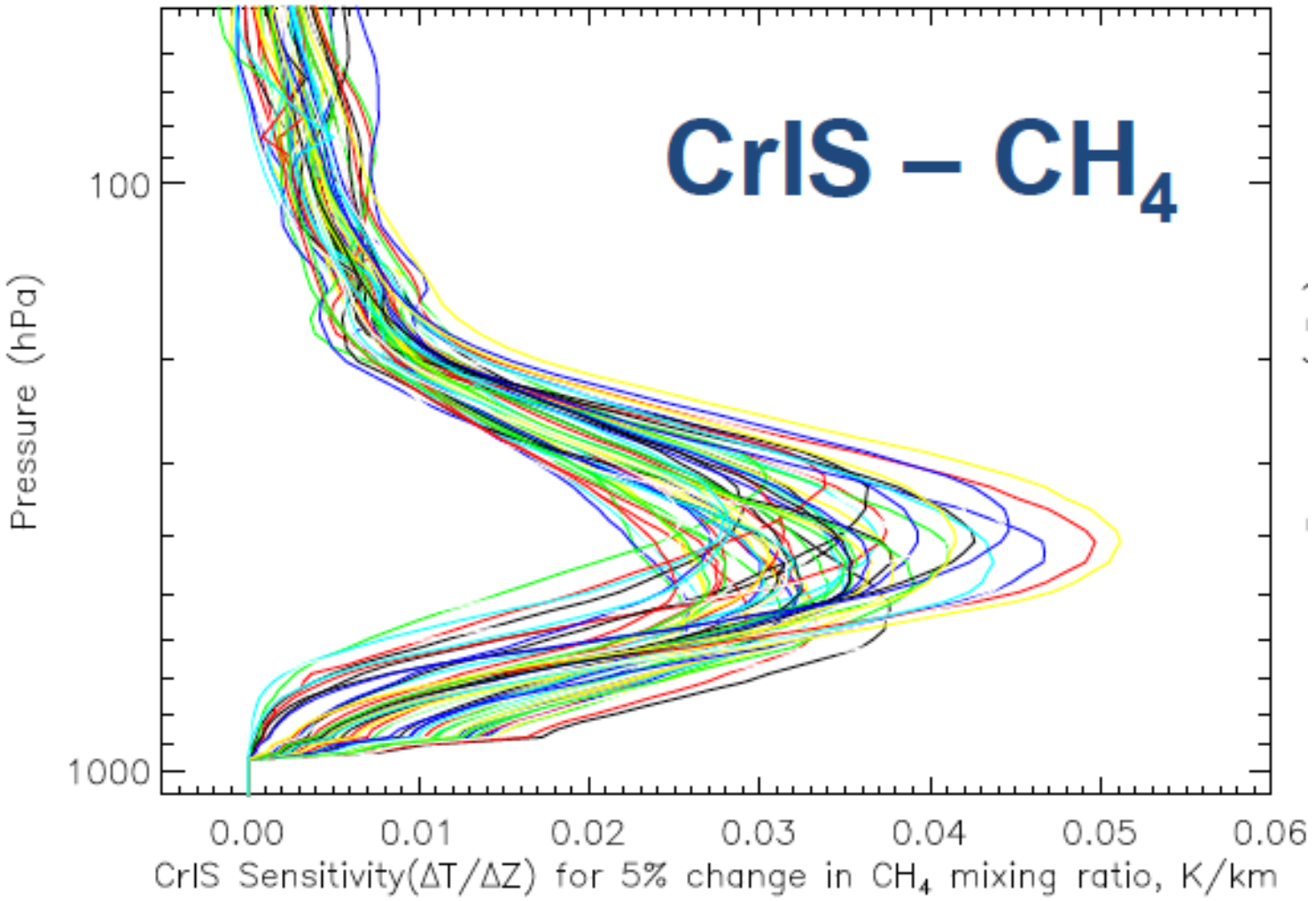
http://www.esrl.noaa.gov/csd/projects/senex/

Detecting Source Signatures with Aircraft Data



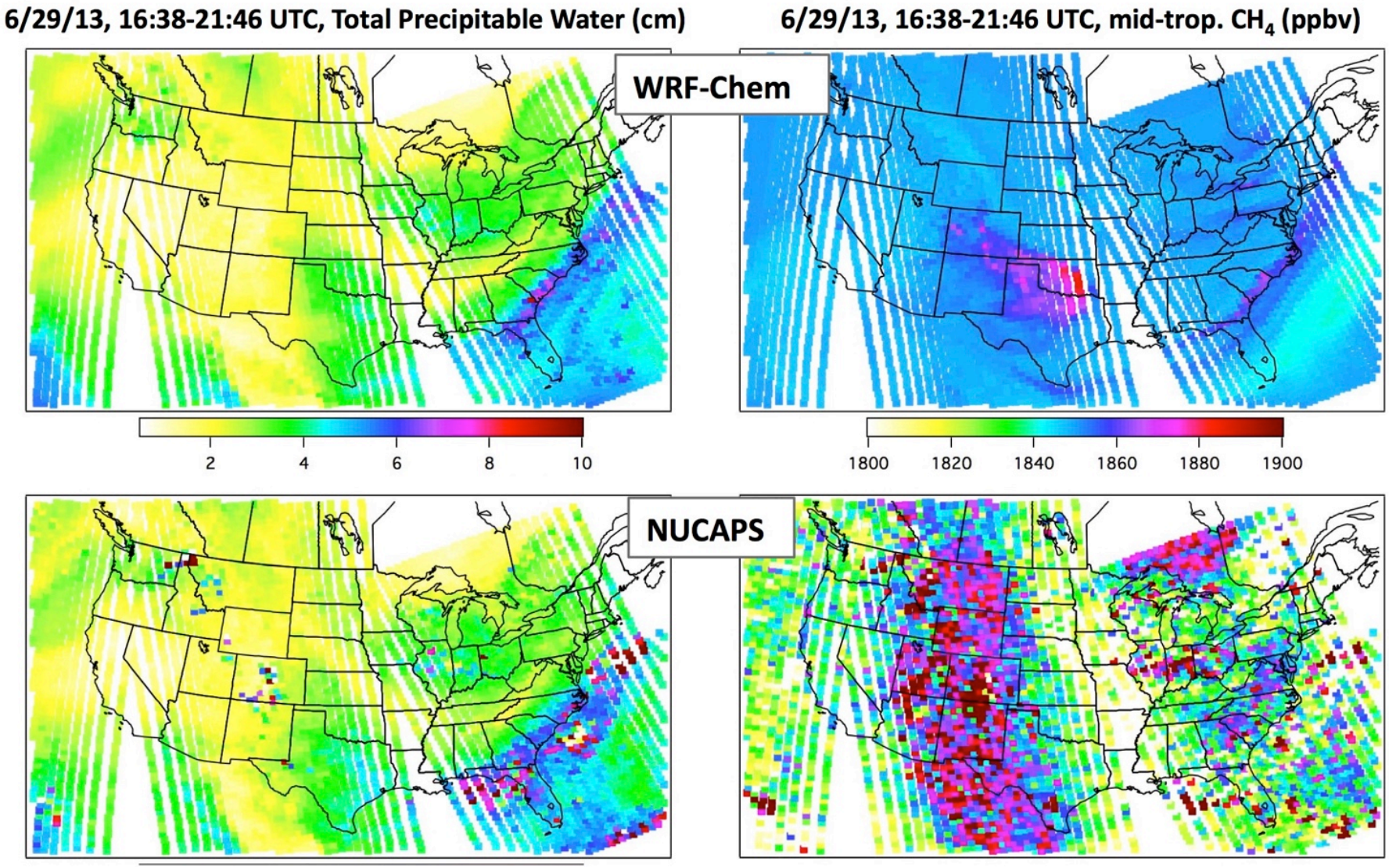
Stuart McKeen

CrIS CH_4 Vertical Sensitivity



Xiaozhen Xiong et al., CrIS Trace Gas Data Users Workshop, 18 Sept 2014

NUCAPS vs. WRF-Chem Model Comparison



Brad Pierce, Stuart McKeen

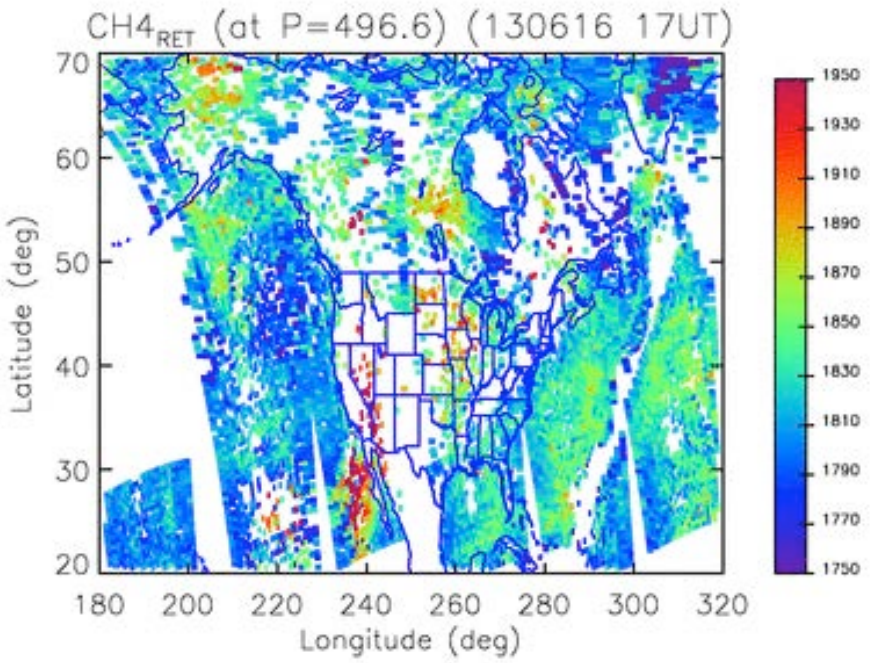
NUCAPS CH_4 Science Retrievals: Initial Data Processing Issues

- Many granules not processed due to failures in pre-processor code, possibly from too stringent ATMS QC threshold
- "Acceptable" QC (QC = 0): Daytime data rejection >> nighttime over land, likely from too stringent CrIS QC threshold
- Very noisy CH_4 signal. Noise filter or averaging may be needed.
- CrIS averaging kernels not initially available

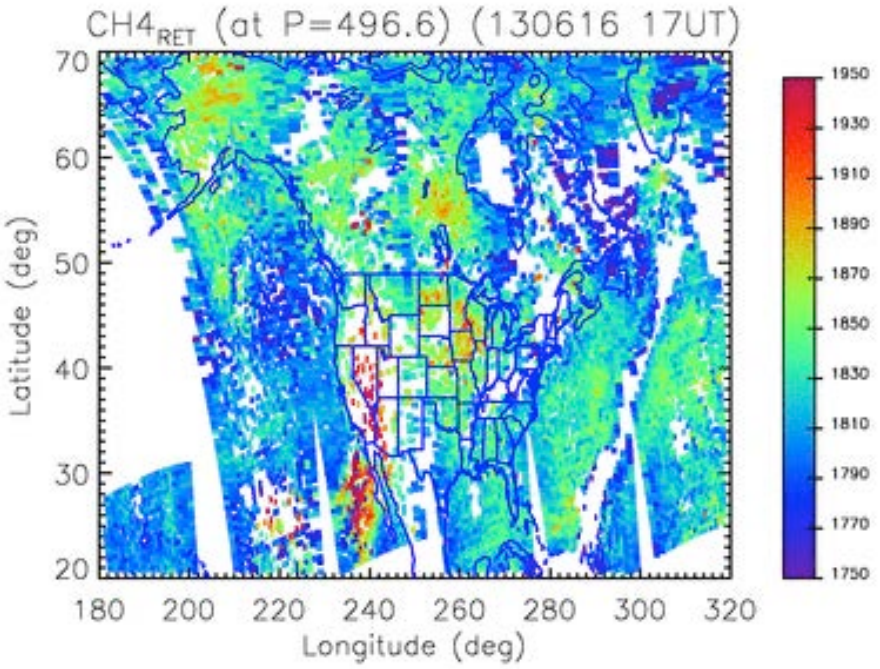
Chris Barnet

Improved NUCAPS Science Code Quality Control Thresholds

Before QC Changes



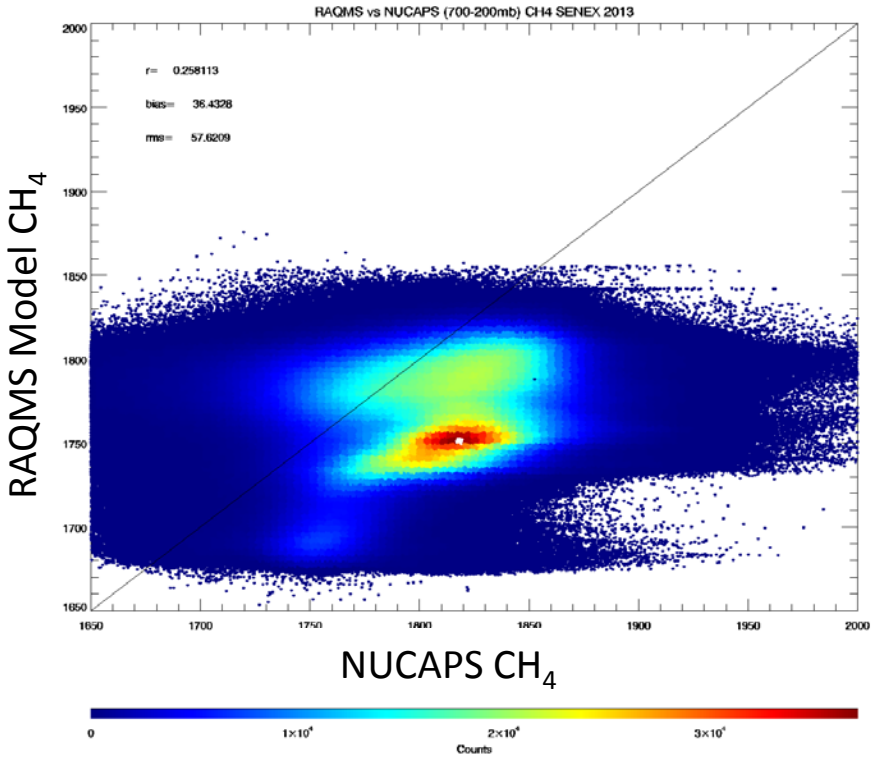
After QC Changes



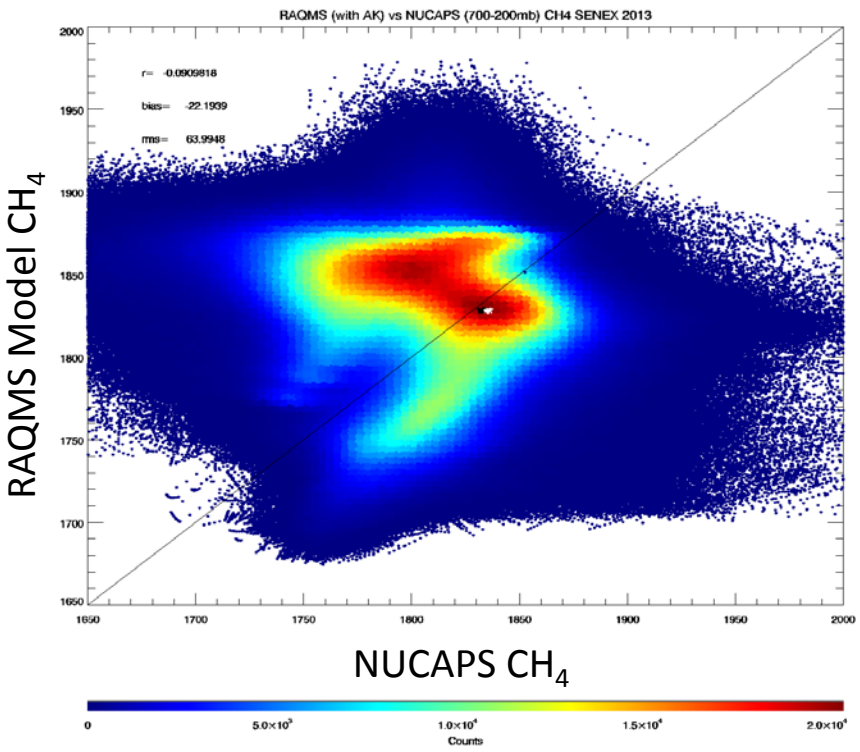
Nadia Smith

CrIS Averaging Kernels Now Available in Science Code Output

Model without AKs



Model with AKs

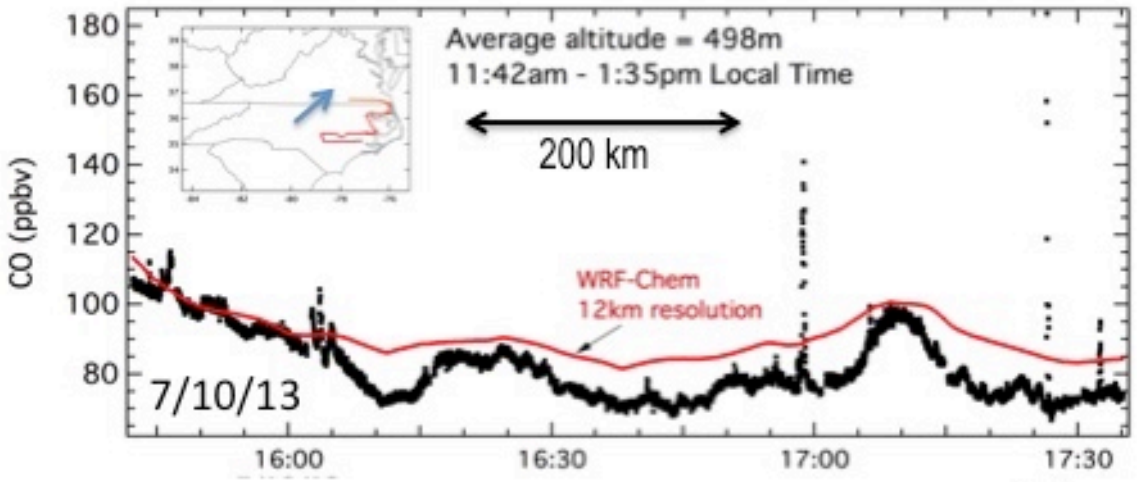


Brad Pierce

Analyzing Scale Dependence of Variance

Compare SENEX-2013 aircraft and WRF-Chem model CO

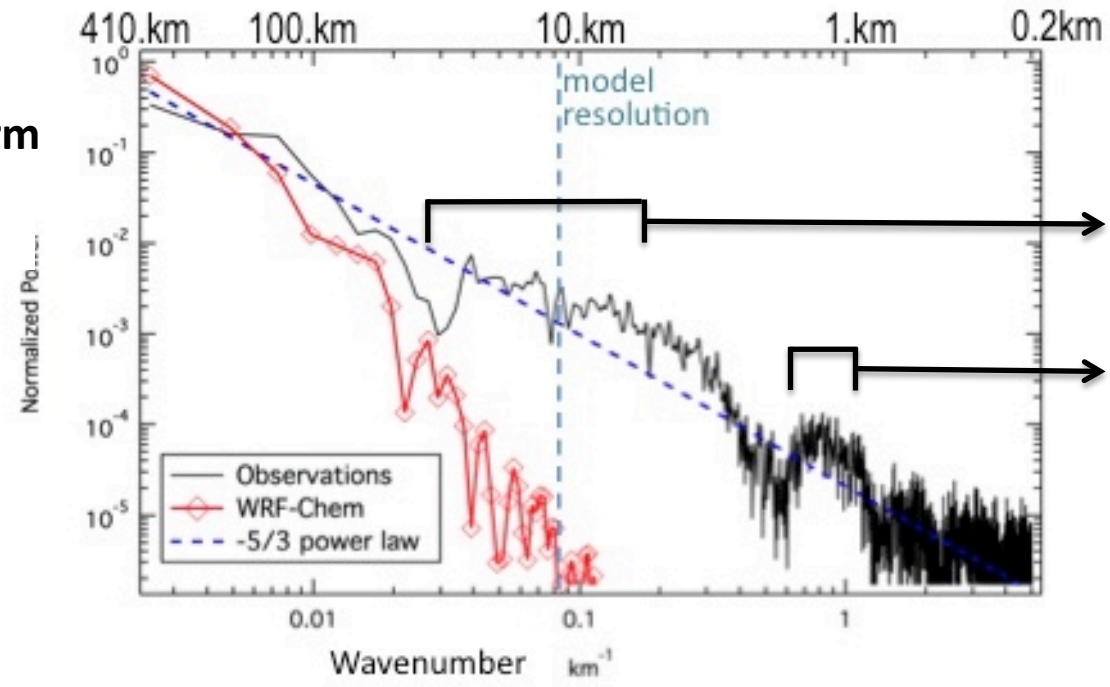
Time Series



Urban Plumes:
15:50 Raleigh/Durham
16:20 Greenville
17:10 Fayetteville

Burning Plumes:
Throughout transect

Fourier Transform Power Spectra



5–30 km scale:
combustion source areas (cities and towns)

1-2km scale:
Agricultural burn plumes

Power Spectra of CO depends on both emissions and transport

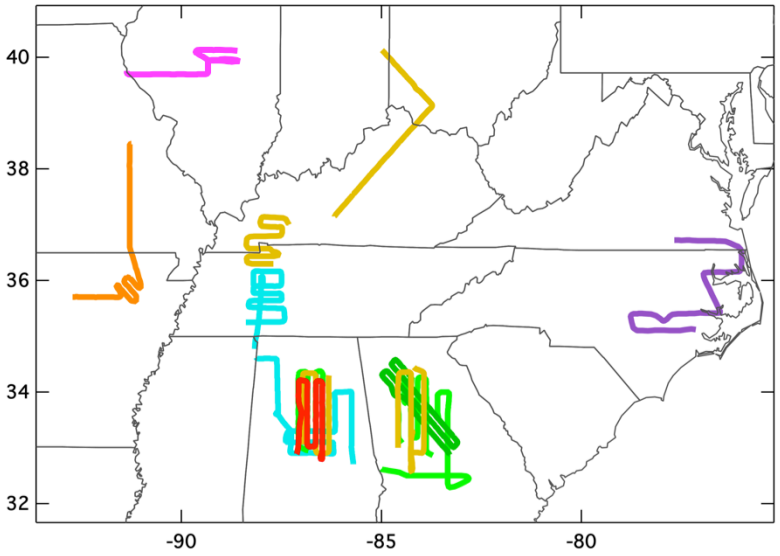
Model spectra somewhat similar to observations for length scales > 4ΔX

Stuart McKeen

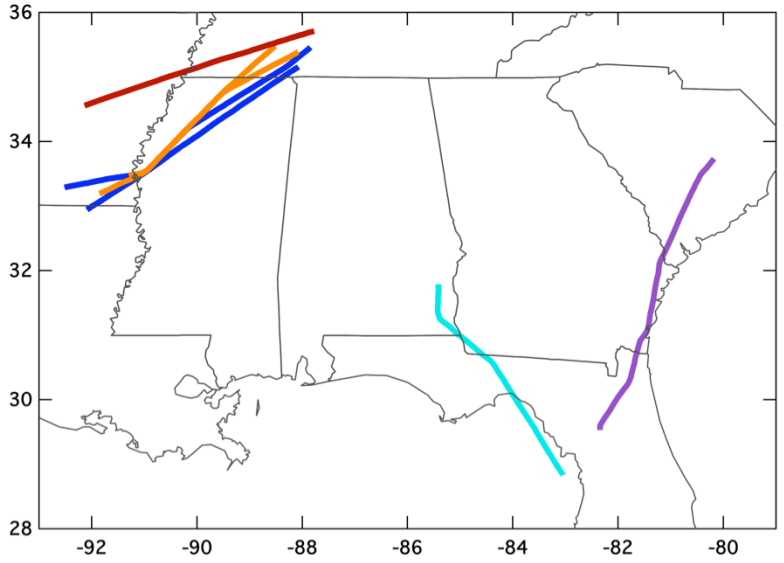
Comparing Average Power Spectra: Aircraft and Model

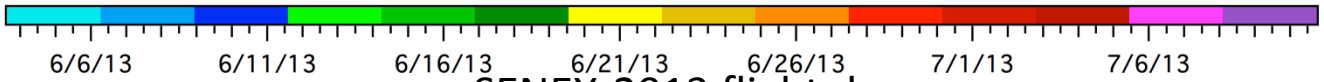
SENEX 2013 flights within the boundary layer and at high altitude (~500mb)

14 Daytime PBL transects (300-700 m AGL)



7 Hi Altitude transects (480-530 mb)





SENEX-2013 flight day

14 transects, 10:00am-6:00pm EDT,
with N > 4096 for 1-Hz data

21.6 Hours of flight time

7 transects, day and night,
with N > 2048 for 1-Hz data

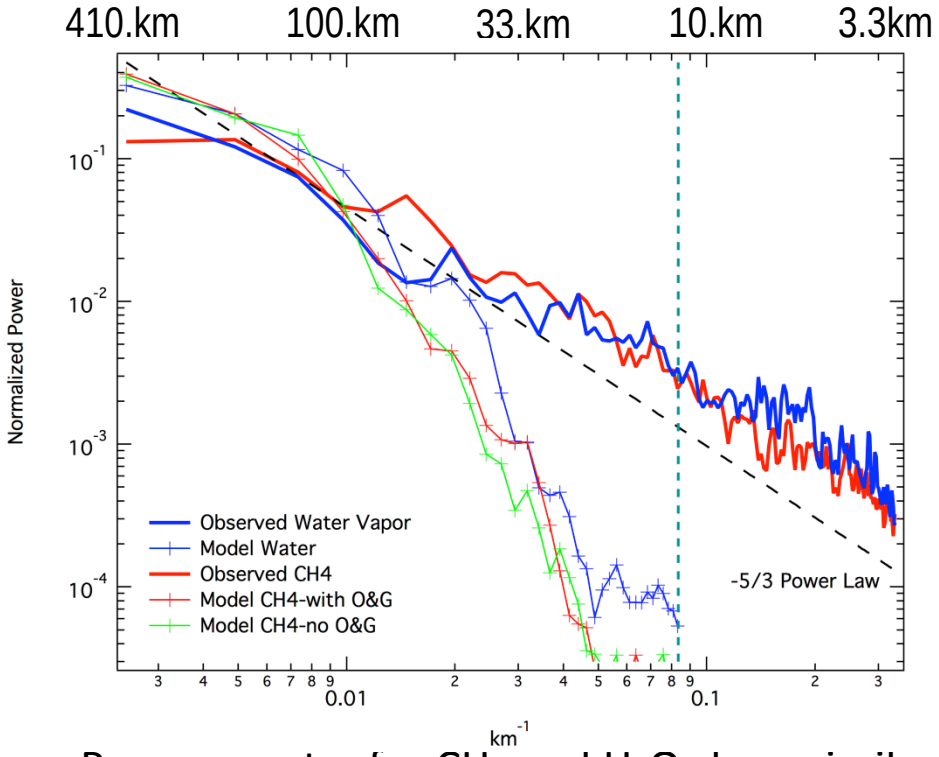
5.4 Hours of flight time

Stuart McKeen

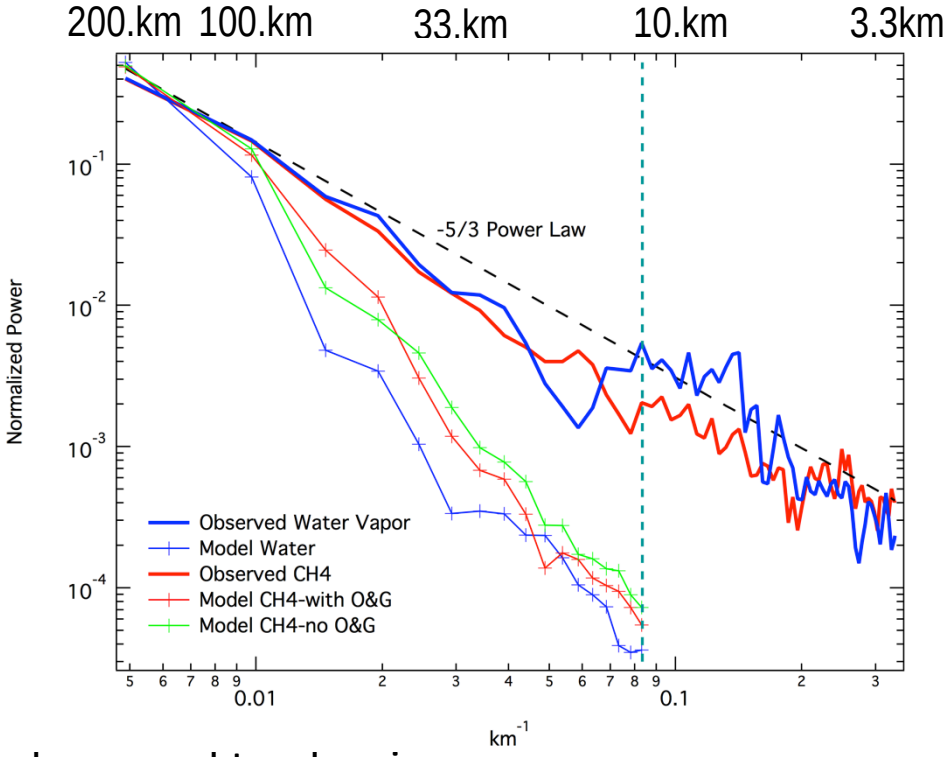
Comparing Average Power Spectra: Aircraft and Model

CH_4 and H_2O mixing ratios within the boundary layer and at high altitude (~500mb)

14 Daytime PBL transects (300-700 m AGL)



7 Hi Altitude transects (480-530 mb)



Power spectra for CH_4 and H_2O show similar slopes and tendencies.
At high altitude the slope is about -5/3 for longer (>50 km) length scales.

Model H_2O vapor captures variability for length scales > 3ΔX in the PBL, > 7ΔX at 500mb.

Adding/Removing model Oil/Gas emissions impacts CH_4 power spectra for both the PBL and high altitude transects.

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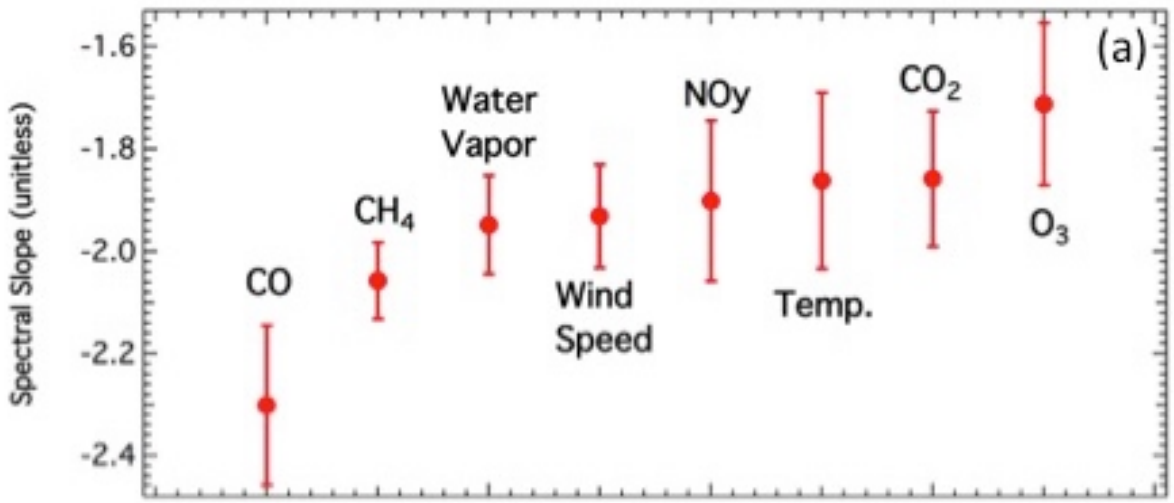
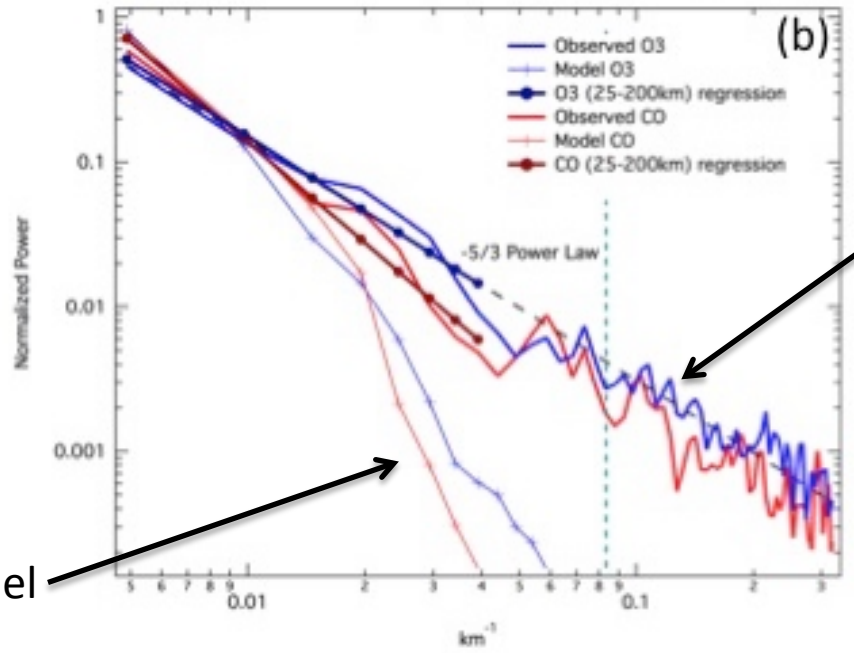
Comparing Average Power Spectra: Aircraft and Model

Data at high altitude (~500mb)



Aircraft power spectral slopes



Aircraft

Model

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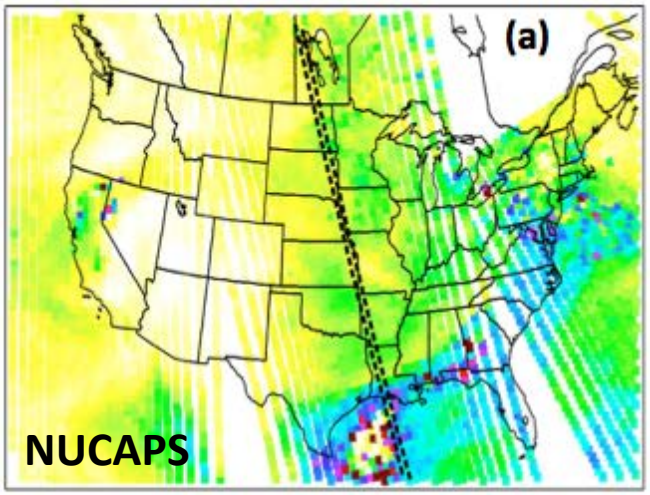
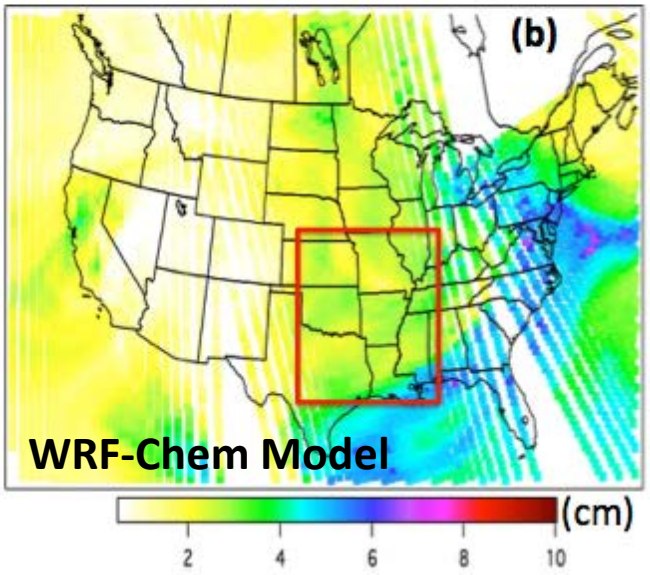
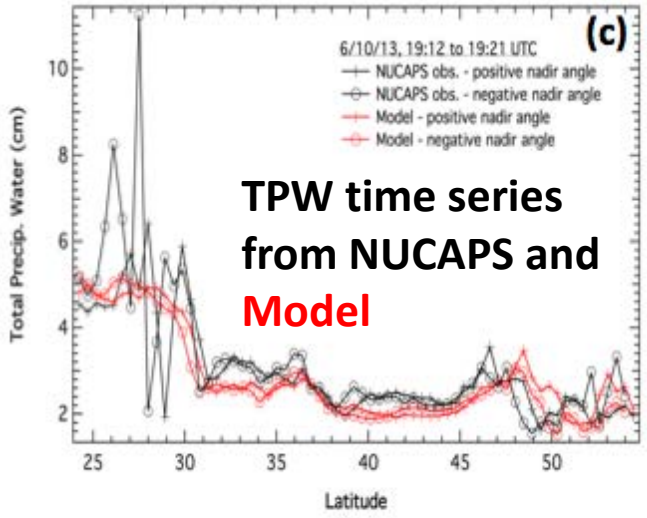
Comparing Average Power Spectra: NUCAPS and Model

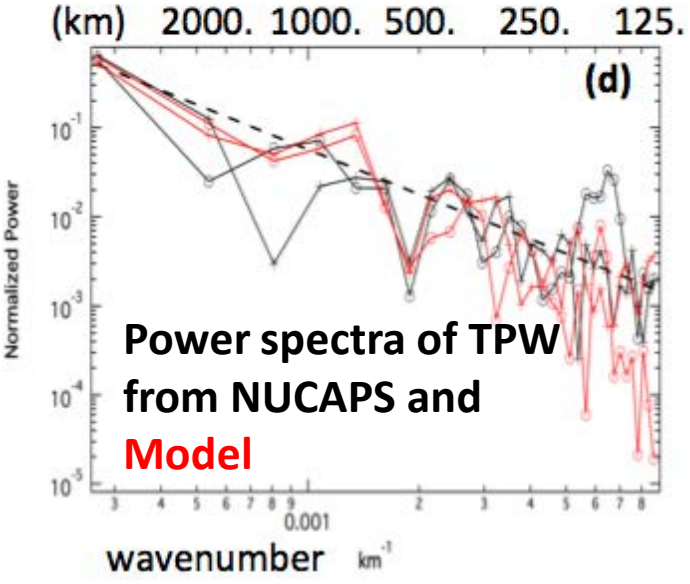
Total precipitable water (TPW) data, 6/10/13



6/10/13, 15:56:59-21:02:00, integrated TPW







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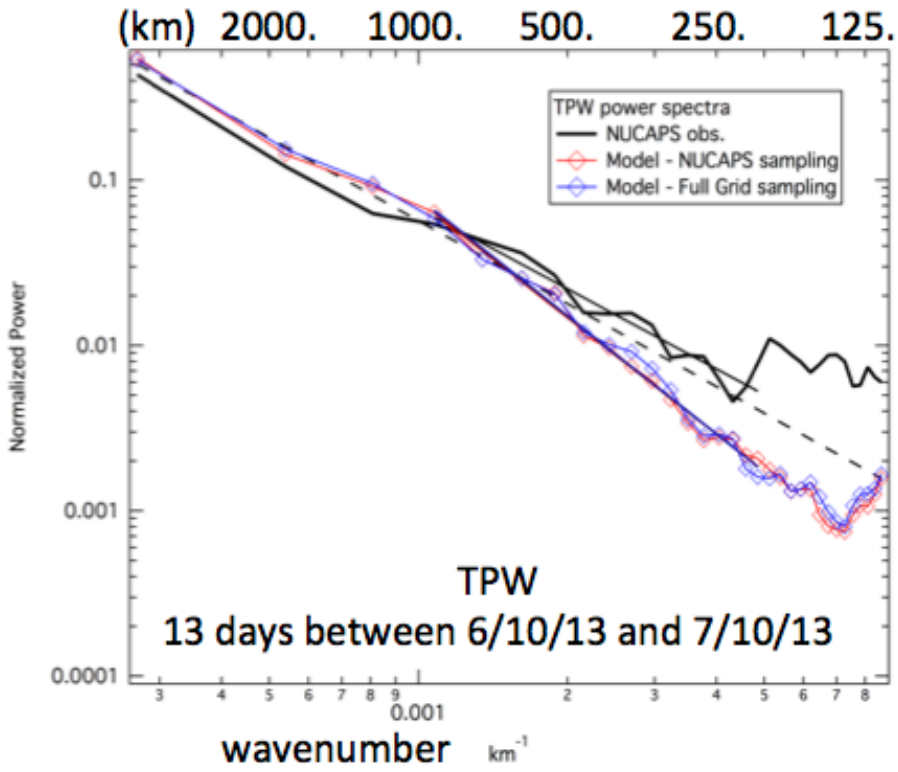
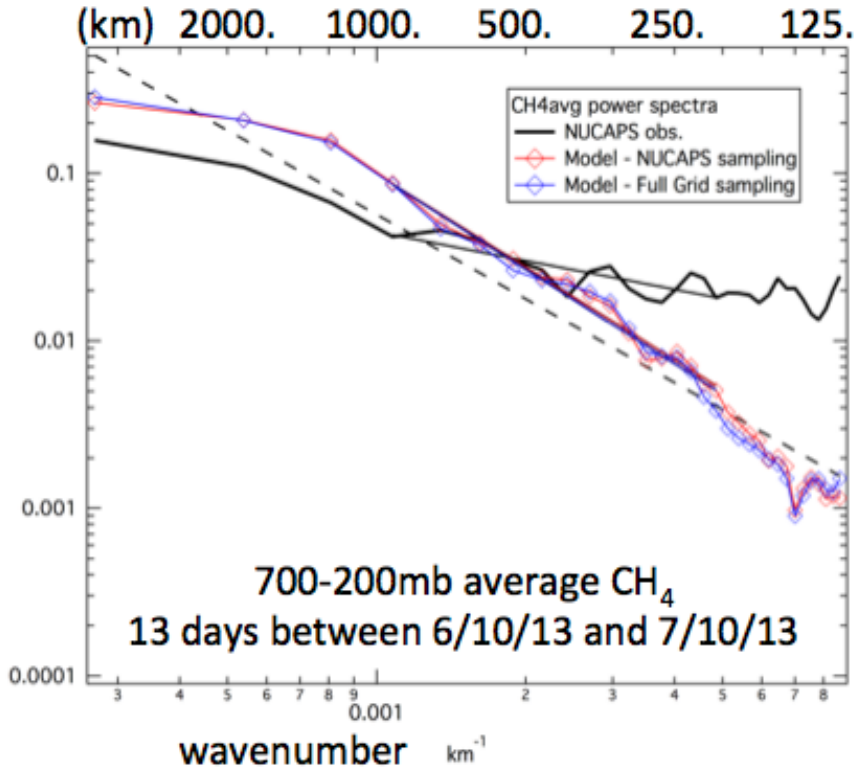
Comparing Average Power Spectra: NUCAPS and Model

TPW and CH_4 data, 13 days between 6/10/13-7/10/13





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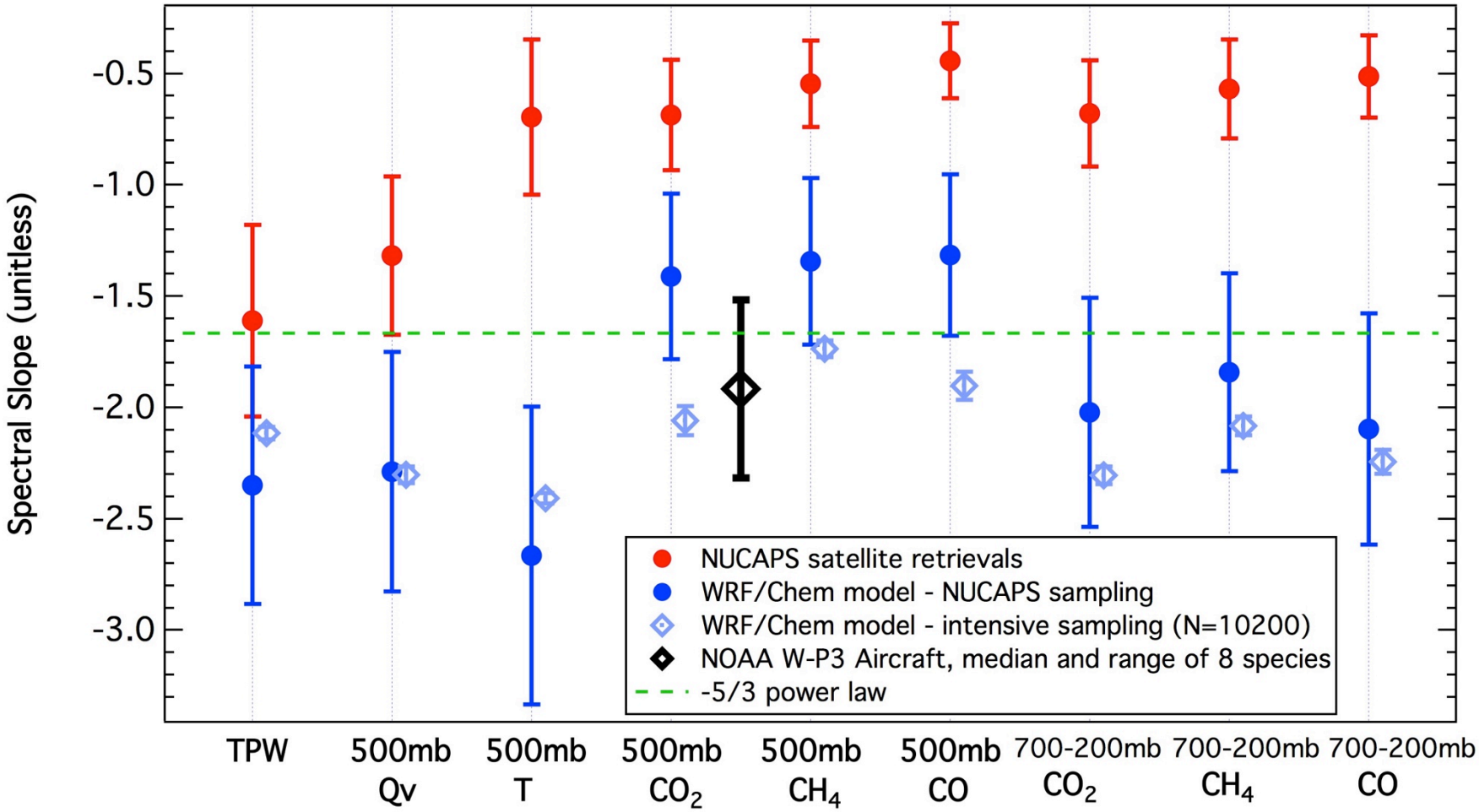
Comparing Average Power Spectra: NUCAPS and Model

6/10/13-7/10/13



Stuart McKeen

Some Next Steps

- Use averaging kernels to scale model vertical sensitivity to match CrIS
- Incorporate updated NUCAPS data from science code processing and filter with revised quality control flags
- Examine alternative scale variance approaches beyond Fourier analysis to evaluate NUCAPS data
- Examine NUCAPS CH_4 and CO during other recent aircraft field experiments (2015 and beyond)