Evaluating NUCAPS CH$_4$ and CO

NOAA OAR ESRL: Gregory Frost, S. McKeen, L. Zhang, R. Ahmadov, W. Angevine, J. Brioude, Y. Cui, K. Froyd, C. Granier, G. Grell, S.-W. Kim, K. McKain, D. Murphy, T. Ryerson, J. Roberts, K. Rosenlof, J. Schwarz, C. Sweeney, M. Trainer , C. Warneke

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NOAA NESDIS STAR: R. B. Pierce

NOAA NESDIS NCEI: C. Elvidge

A JPSS Proving Ground/Risk Reduction Project

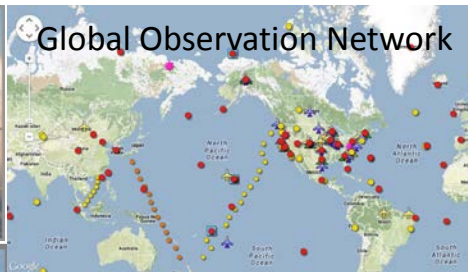**2017 STAR JPSS Annual Meeting**

Close collaboration of ESRL, NESDIS, and STC
➢ Critical to project's success
➢ Retrieval developers work directly with science users
➢ Leads to improved algorithms and products
➢ Adds value to PGRR investment
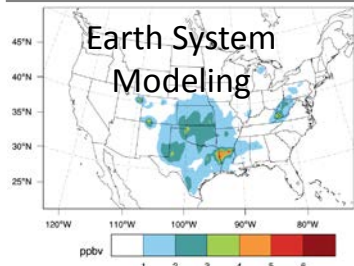
NOAA OAR's Atmospheric Composition Tools
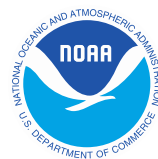
Aircraft

Global Observation Network

Satellite Data Analysis

Ships

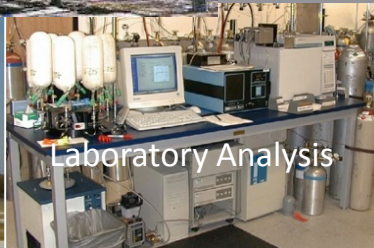Observatories

Sondes

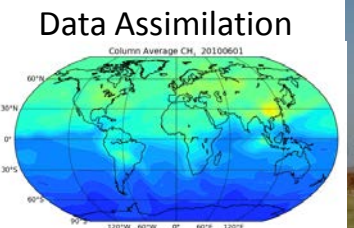Earth System Modeling

Mobile Laboratories

Wind Profilers

Data Assimilation

Instrumented Ground Sites

Laboratory Analysis

Tall Towers

Observing the atmosphere at multiple spatial and temporal scales with a suite of complementary approaches

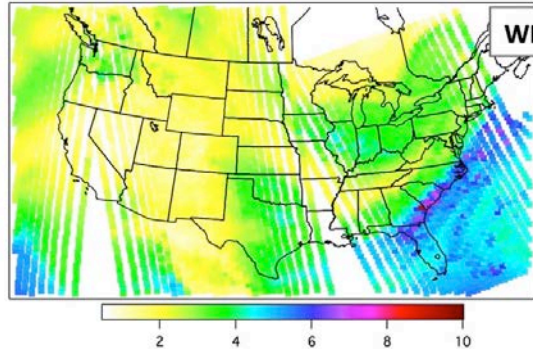State-of-the-art earth system modeling and data analysis

http://www.esrl.noaa.gov

Approach for this project

Aircraft data from field research studies are the basis of our NUCAPS evaluations, providing...
- high accuracy and precision
- fine horizontal and vertical resolution
- repeated sampling

SENEX 2013 Flights

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

6/29/13, 16:38-21:46 UTC, Total Precipitable Water (cm)

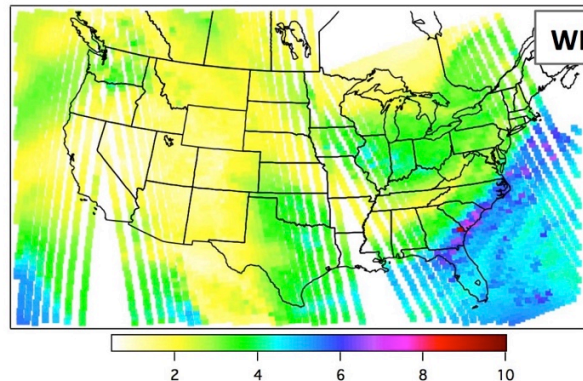6/29/13, 16:38-21:46 UTC, mid-trop. CH_4 (ppbv)

WRF-Chem
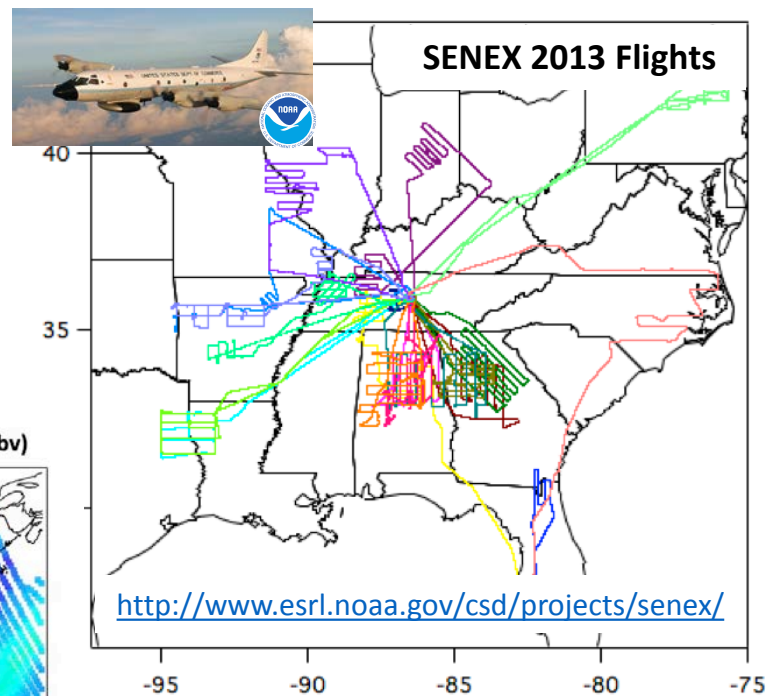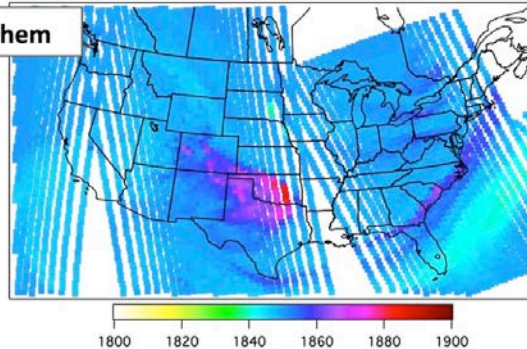
Atmospheric chemical-transport models evaluated and improved by aircraft data enable direct assessment of NUCAPS trace gases and meteorological products, by...
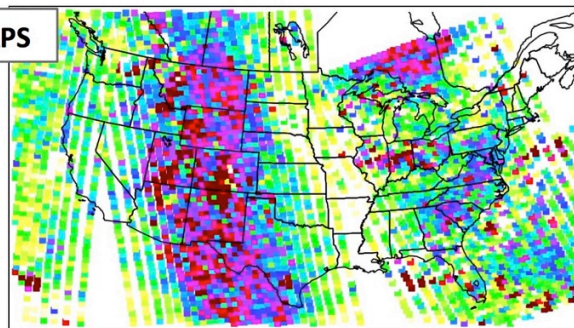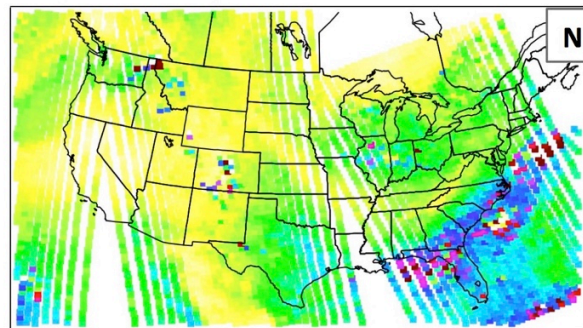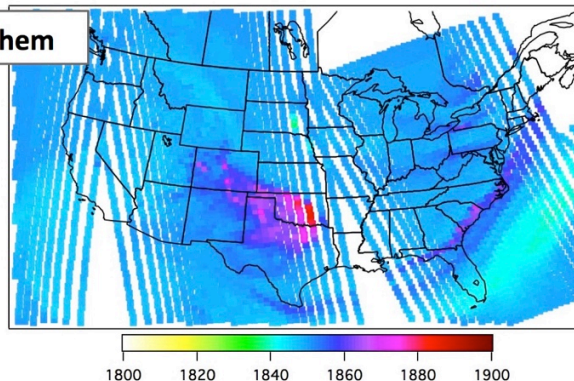- Extending temporal and spatial domain beyond sparse aircraft sampling
- Simulating atmospheric quantities to match NUCAPS retrievals

NUCAPS - Model Comparisons ➔ Improved Retrievals

6/29/13, 16:38-21:46 UTC, Total Precipitable Water (cm)

6/29/13, 16:38-21:46 UTC, mid-trop. CH_4 (ppbv)

WRF-Chem

NUCAPS

Initial comparisons of NUCAPS data suggested issues with NUCAPS CH_4

- NUCAPS trace gas retrievals used quality control (QC) thresholds optimized for meteorological variables

STC refined its NUCAPS retrieval algorithms

- Updated, more restrictive QC thresholds specific to CH_4 and to 7 other trace gases

Assessing NUCAPS Scale Variance

How do we characterize NUCAPS true signals versus noise?

• Assess spatial averaging needed to produce meaningful NUCAPS trace gas data

Decomposition of time series into orthogonal functions has previously been used to analyze the temporal or spatial variance of a measurement

- Dynamic turbulence within the atmosphere is known to be the determining factor in the scale dependence of variance

- Chemical constituents display same scale dependence as thermodynamic and momentum-based quantities (Tuck and Hovde, 1999)

➢ Use power spectrum analysis of scale variance to determine the quality of NUCAPS retrievals

Time series of aircraft and model CO
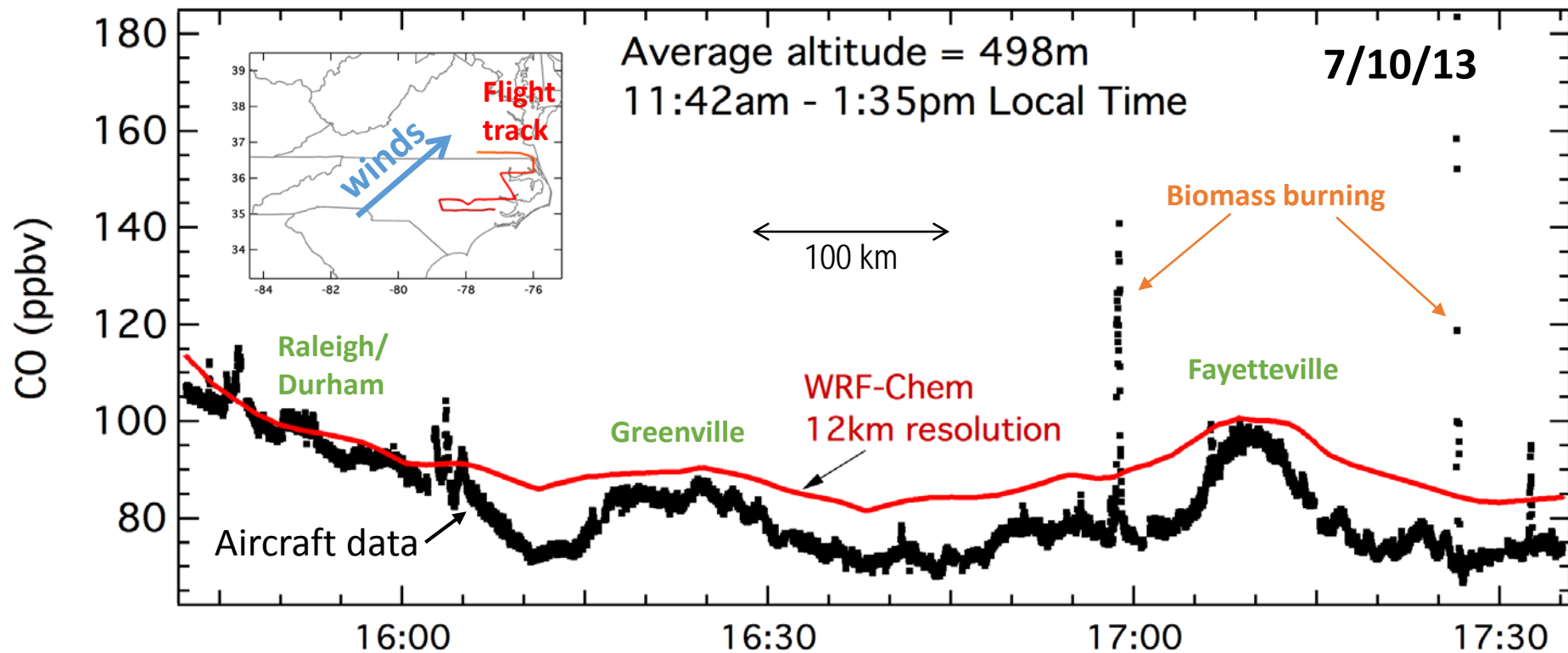
Power spectra of aircraft and model CO
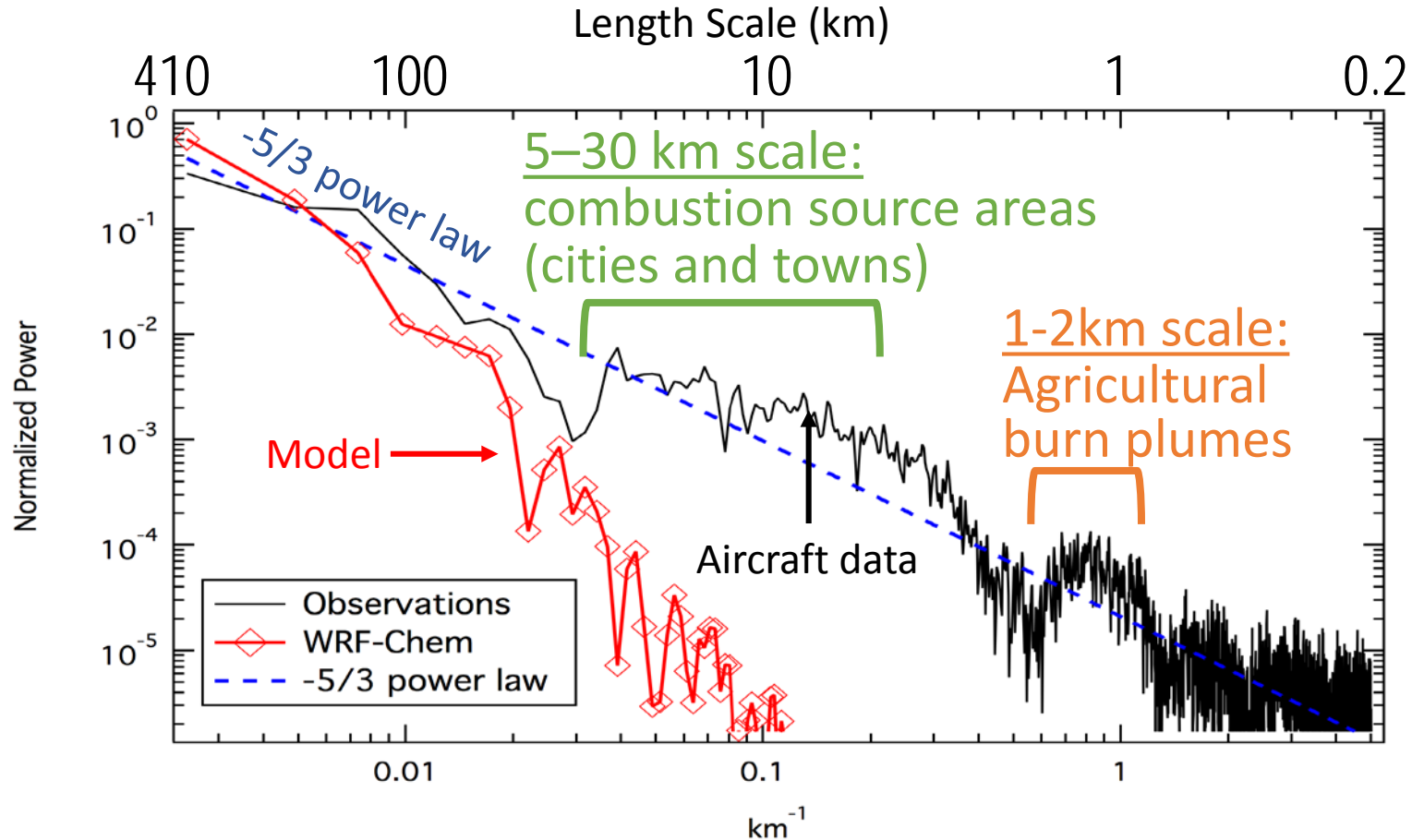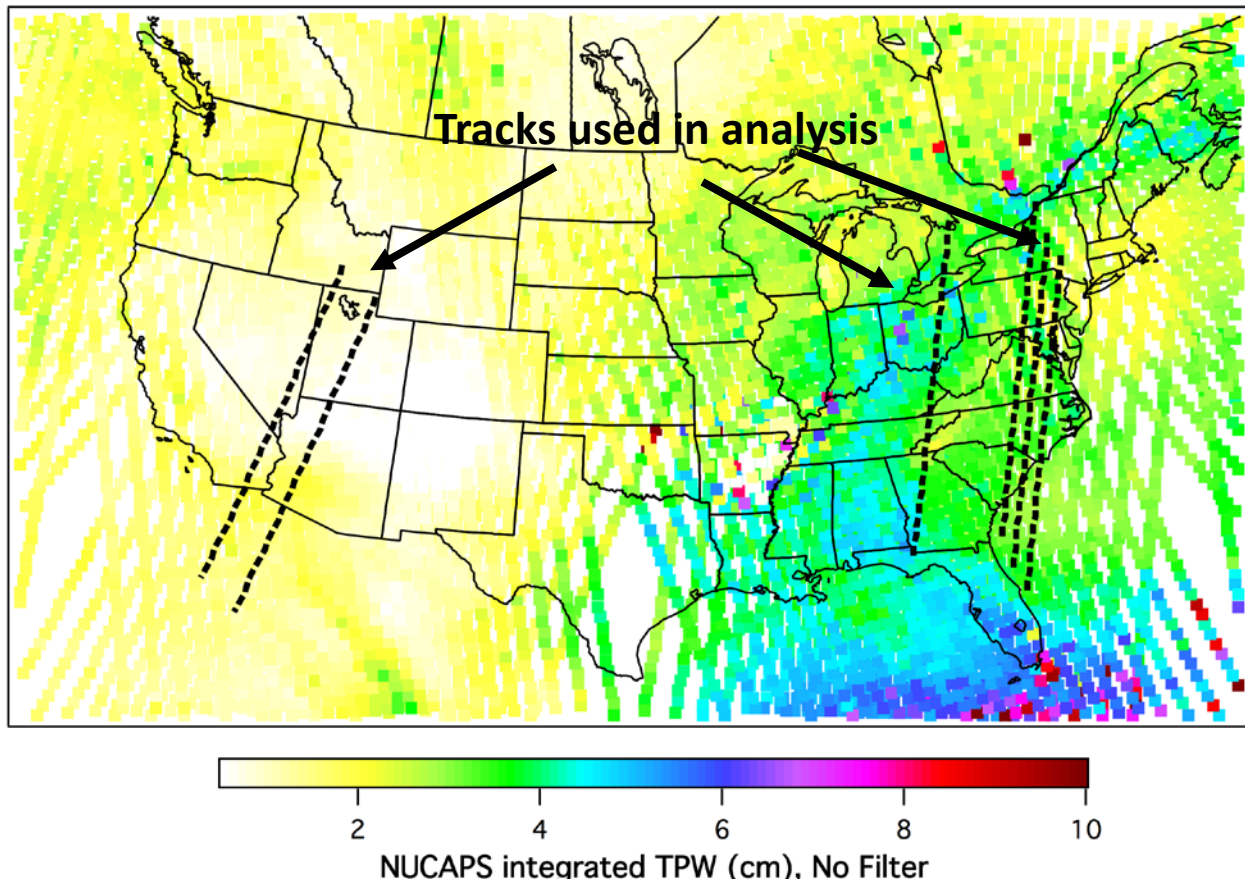
Domain for comparisons of NUCAPS to model
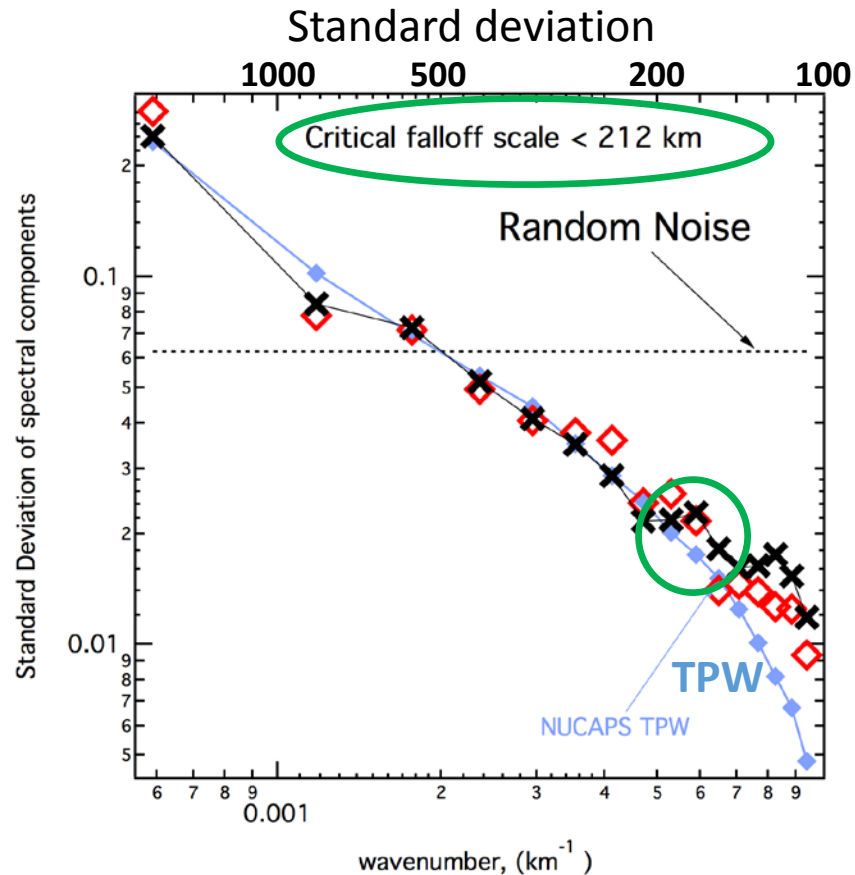
NUCAPS total precipitable water
1 June 2013 shown
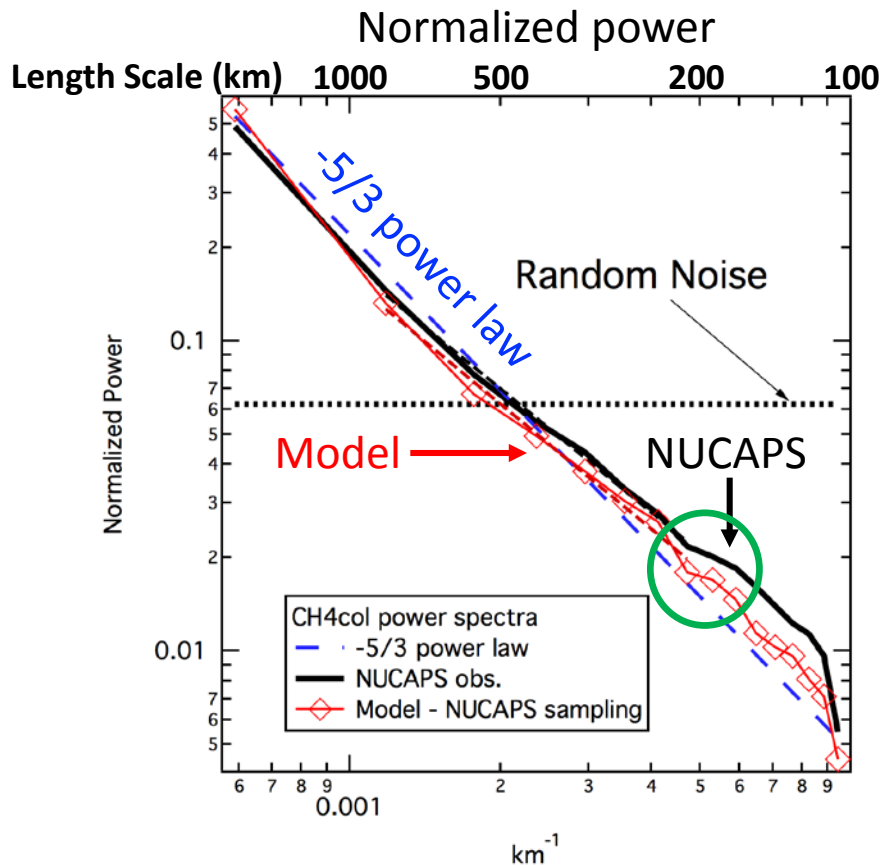1 June – 15 July 2013 data were analyzed

Colored pixels = No QC flag filtering
Dotted lines = 6 NUCAPS tracks that meet QC criteria

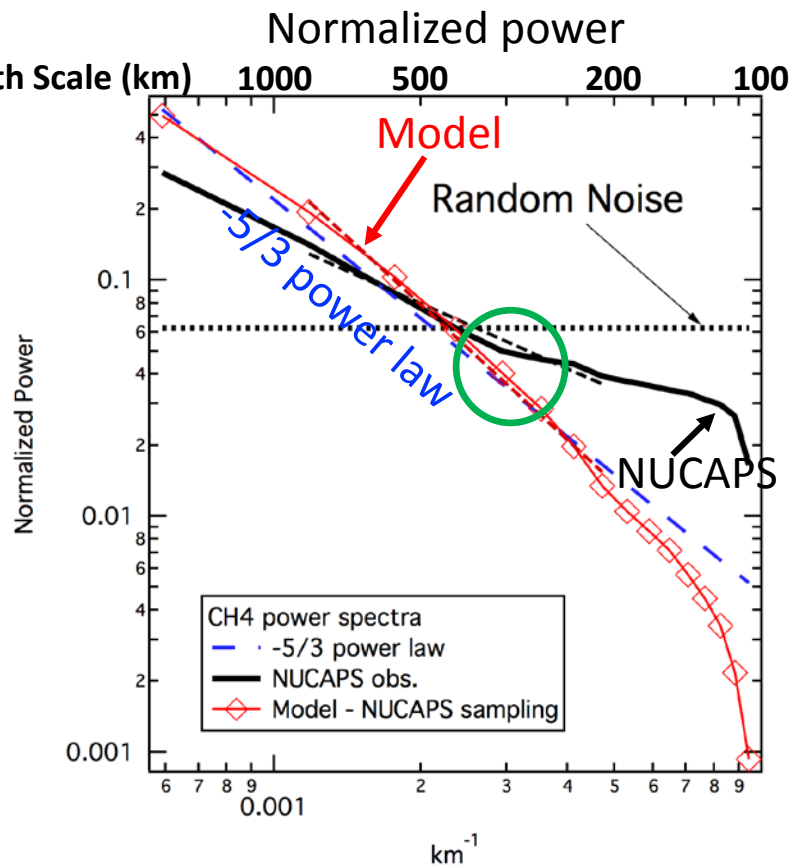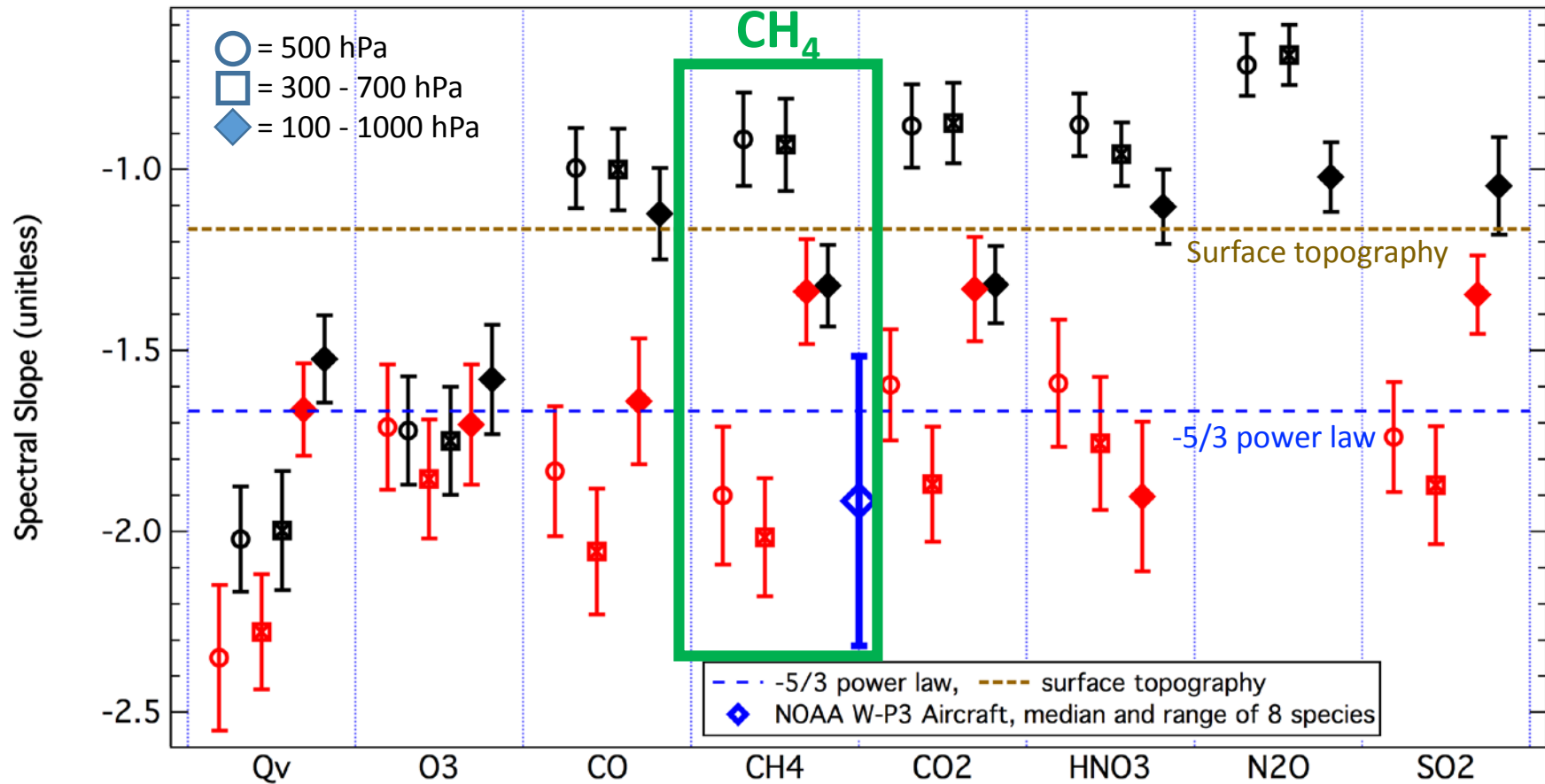Tracks used in analysis

NUCAPS integrated TPW (cm). No Filter

Power spectra: NUCAPS and model column CH$_4$

Normalized power

Standard deviation

Power spectra: NUCAPS and model 500-hPa CH₄
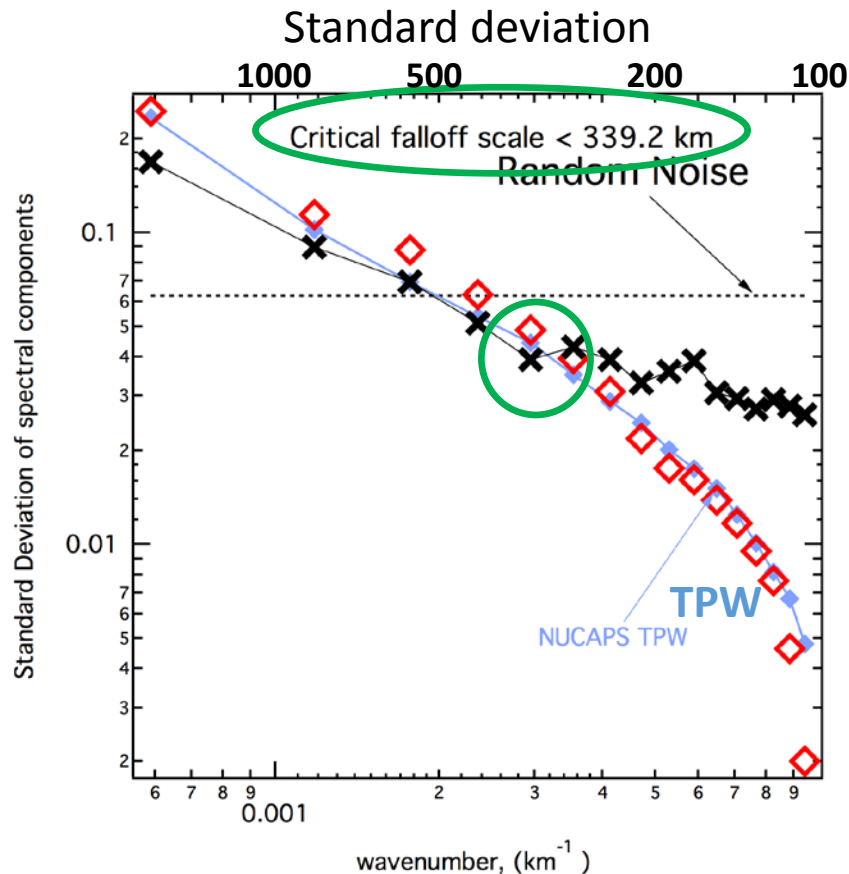
Power spectral slopes: NUCAPS, model, aircraft

Interim conclusions from the project

- Aircraft research observations provide evaluation of atmospheric model
- Evaluated model in turn provides comparison data for NUCAPS retrievals
- Aircraft-model-NUCAPS comparisons → customized trace gas QC thresholds
  - Improved NUCAPS retrievals
  - Larger NUCAPS science dataset compared with operational products
- Scale variance analysis helps distinguish NUCAPS true signals vs. noise
- NUCAPS CH_4 data are meaningful with adequate spatial averaging:
  - *vertically* over full tropospheric column + *horizontally* at scales ≥ 200 km
  - *vertically* in mid-troposphere + *horizontally* at scales ≥ 340 km
- Need full spectral resolution CrIS radiance products for similar analysis of NUCAPS CO
- In-situ observations should be averaged similarly for meaningful comparison to NUCAPS
  - Averaging limits direct comparison opportunities, thus necessitating use of evaluated chemical-transport models for understanding NUCAPS retrievals

Ongoing work: Atmospheric Tomography Mission
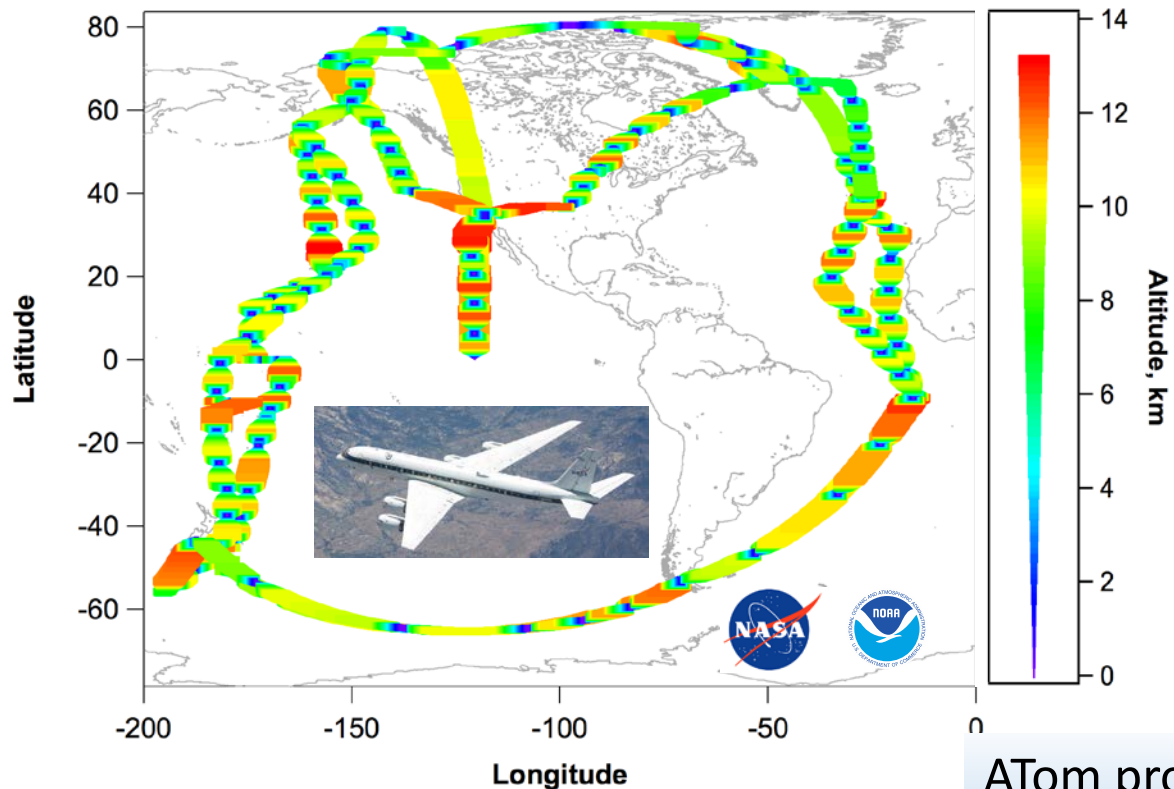
NASA's **A**tmospheric **Tom**ography Mission is conducting continuous pole-to-pole profiling from 0.2 to 12 km altitude in 4 seasons between 2016 and 2018.

Within NOAA's NGGPS (Next Generation Global Prediction System), ATom data are used to assess performance of global chemical-transport models.

ATom provides excellent evaluation opportunities for JPSS trace gas and aerosol products.

https://espo.nasa.gov/home/atom/content/ATom

Ongoing Work: Fire Influence on Regional and Global Environments Experiment (FIREX)

2019 NOAA & NASA aircraft studies

P3 aircraft max range for single flight

example flight

FIREX is NOAA's multi-faceted wildfire research program

- Emissions
- Chemical transformations
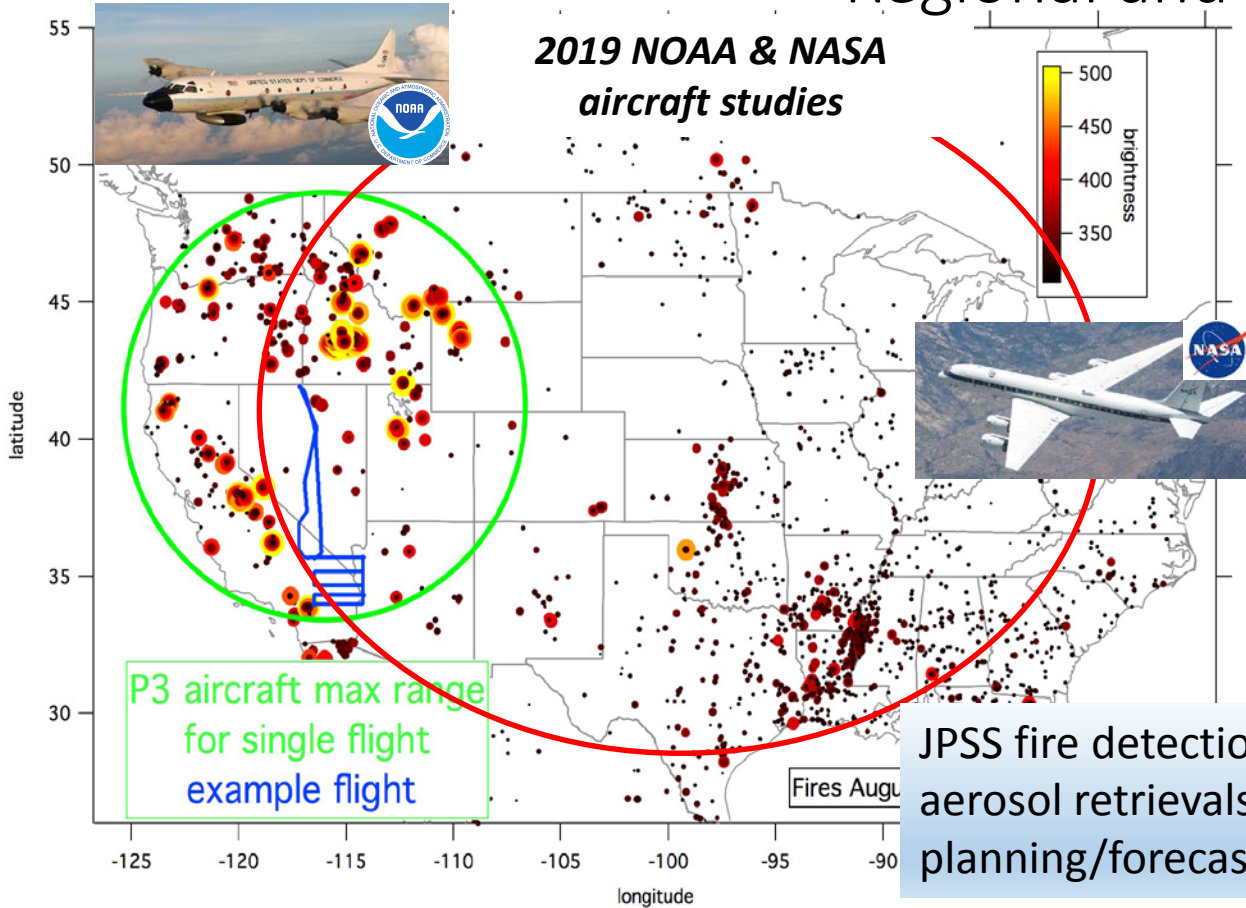- Model evaluation
- Coordinate with others:

FIRE-Chem   FASMEE   WE-CAN

JPSS fire detection products and trace gas and aerosol retrievals will be critical tools for mission planning/forecasting and analysis of aircraft data

Next Steps

- Finalize scale variance analysis

- Continue model validation with ATom data

- Analyze NUCAPS CH_4 and CO during ATom deployments
  - Need full spectral resolution CrIS CO data

- Begin planning for FIREX in 2019, and explore applications of JPSS fire-detection and trace gas products