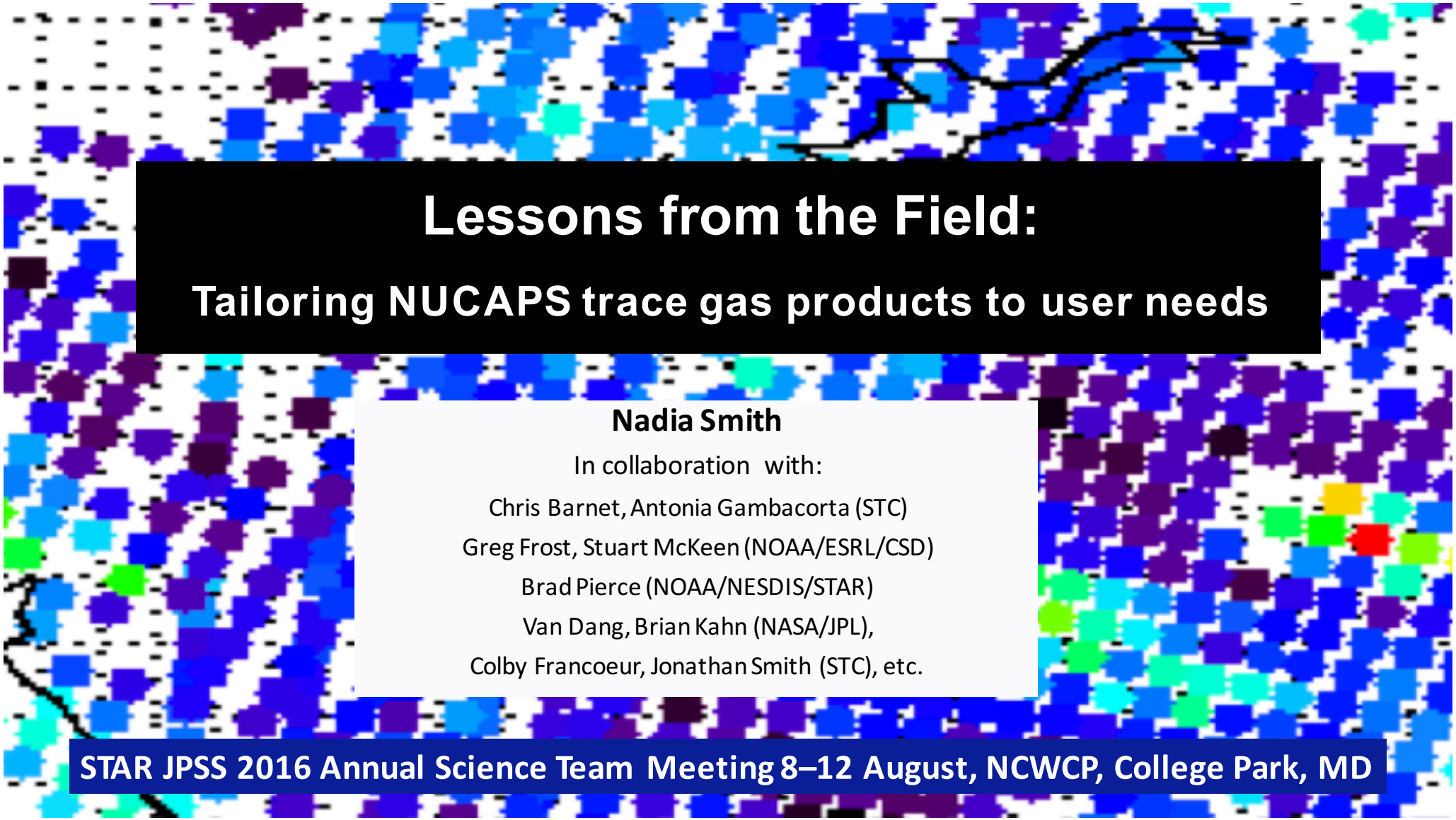


Lessons from the Field:

Tailoring NUCAPS trace gas products to user needs

Nadia Smith

In collaboration with:

Chris Barnet, Antonia Gambacorta (STC)

Greg Frost, Stuart McKeen (NOAA/ESRL/CSD)

Brad Pierce (NOAA/NESDIS/STAR)

Van Dang, Brian Kahn (NASA/JPL),

Colby Francoeur, Jonathan Smith (STC), etc.

STAR JPSS 2016 Annual Science Team Meeting 8–12 August, NCWCP, College Park, MD

Doing Science within an Operational Framework

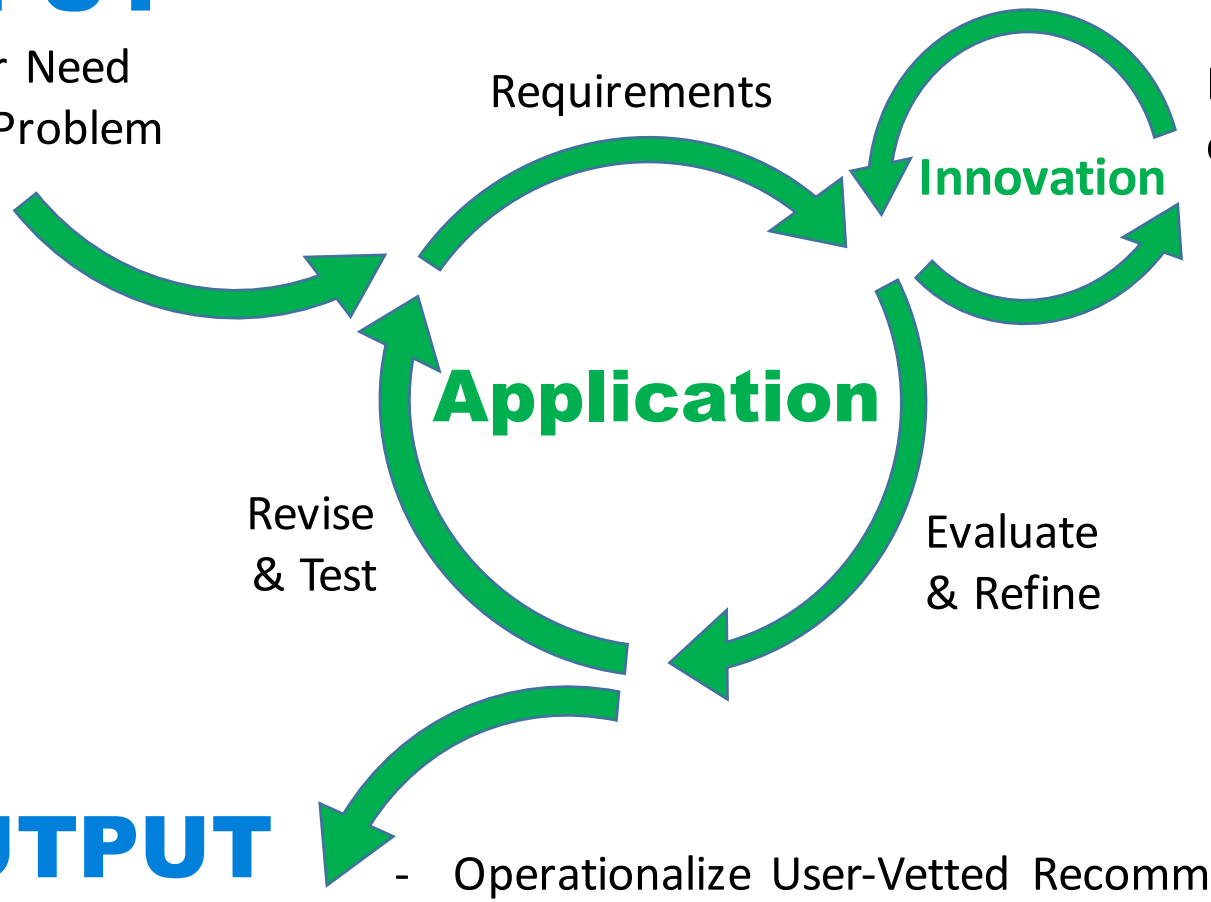
- Who cares about this problem?
- Can we find a **robust**, **stable** scientifically credible solution?
- Is the solution **operationally viable**, i.e. cost effective?

Sounding Initiative: A User-Oriented Approach to Development

See NOAA Test Bed Concept in Ralph et al. 2013 BAMS

INPUT

User Need
Data Problem



Loops are maintained by active & collaborative **User-Developer Partnerships**

This leads to:

(1) Improved user/developer understanding

(2) Products tailored to user applications

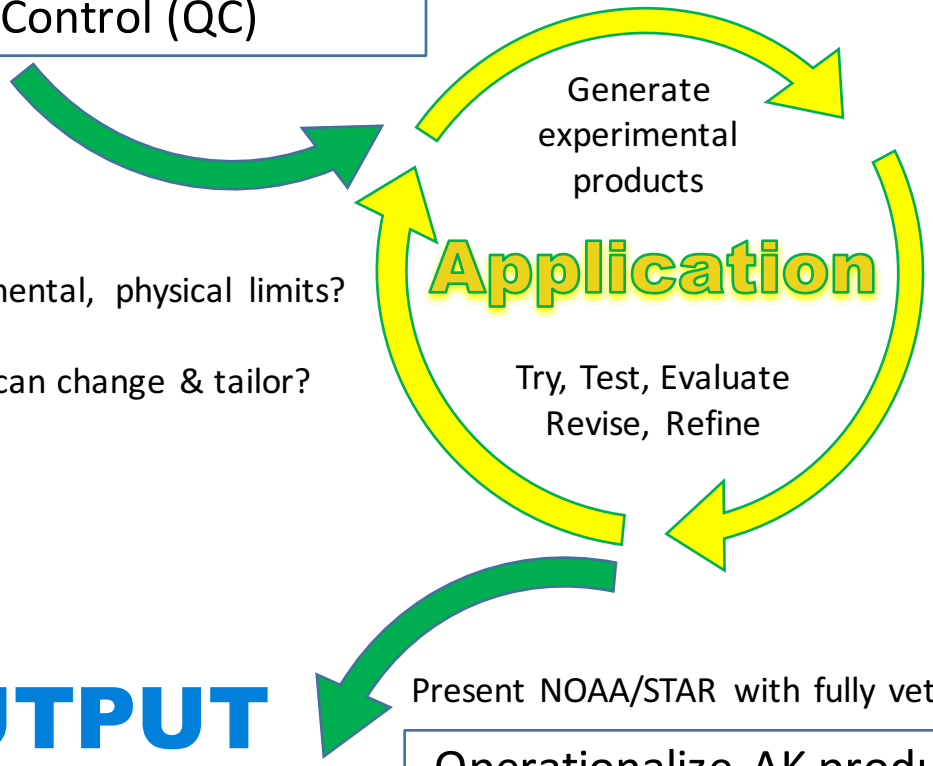
OUTPUT

- Operationalize User-Vetted Recommendations
- Develop/Enhance Applications

NOAA PGRR Sounding Initiative: NUCAPS CO and CH4

INPUT

Need for Averaging Kernels (AK) and Quality Control (QC)



What are the fundamental, physical limits?

What are things we can change & tailor?

STC NUCAPS Team in collaboration with:

NESDIS/STAR
NOAA/ESRL/CSD
CIRES + CIMSS

Working with multiple users in multiple applications to ensure that everyone benefits

OUTPUT

Present NOAA/STAR with fully vetted recommendations and solutions

Operationalize AK product and QC changes

Auxiliary Data Distribution – Averaging Kernels

Our primary partners in this initiative:

Brad Pierce (PGRR PI): High resolution trajectory-based smoke forecasts

Greg Frost (PGRR PI): Understanding emissions and tropospheric chemistry using NUCAPS and VIIRS

- At present, the NUCAPS trace gas user community is largely made up of scientists, not forecasters or air quality monitoring agencies yet
- Users have need for Auxiliary products that are not available in Operational CLASS product to cast light on the quality of products and aid in evaluation/characterization – Specifically the Averaging Kernels (AK) and Degrees of Freedom (DOF), both metrics of uncertainty and information content
- We developed the capability to distribute AK and DOF to users in netCDF files.

  NUCAPS stores all the building blocks with which to calculate AK and DOF in binary files (that are currently discarded for operational products, but available when run off-line)

  For each granule of measurement and a target parameter (e.g., CO, CH4), we generate a netCDF file that contains all the relevant retrieval and auxiliary information that enables users to do meaningful characterization.

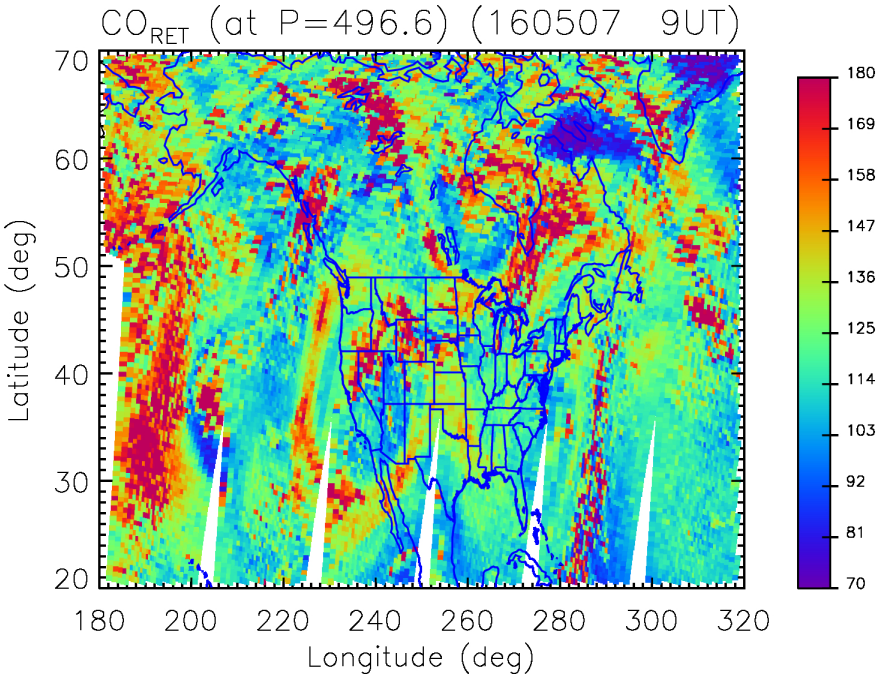
  Each netCDF files is ~2.5MB in size

  These netCDF files are experimental products and available only upon user request.

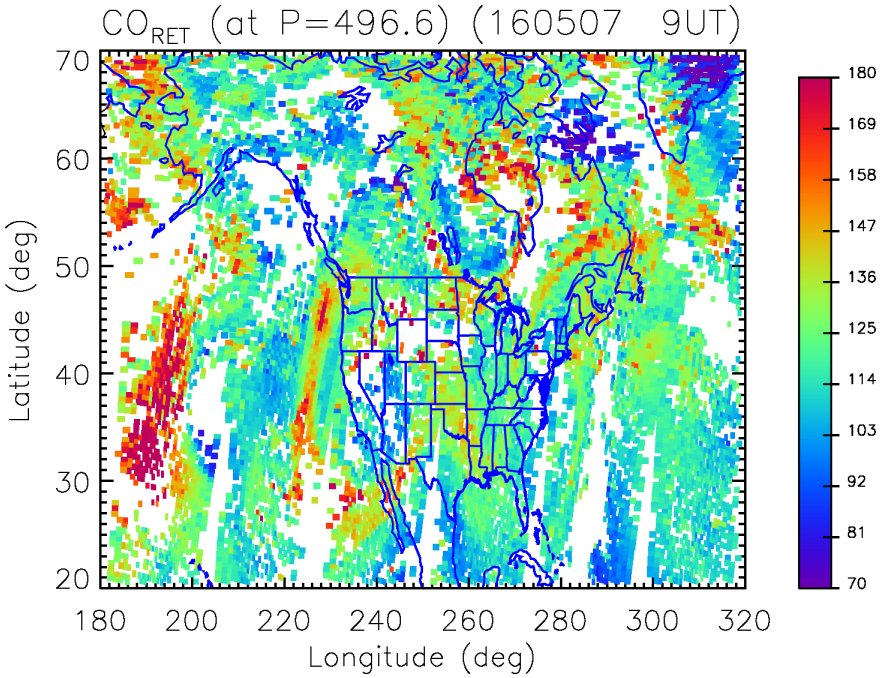
  We will evaluate product value, fine tune its design and eventually make recommendations for operationalization

Quality Control – A necessary step in using Satellite Data

NUCAPS CO without QC



NUCAPS CO with QC



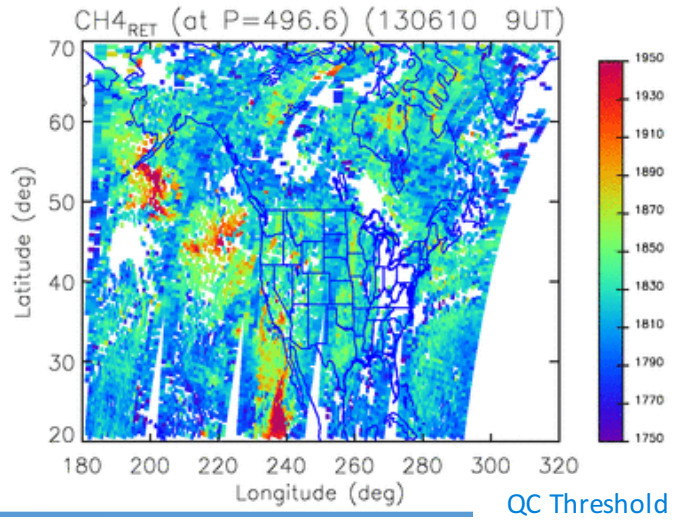
NUCAPS QC indicates quality of T/q from IR and MW retrieval steps

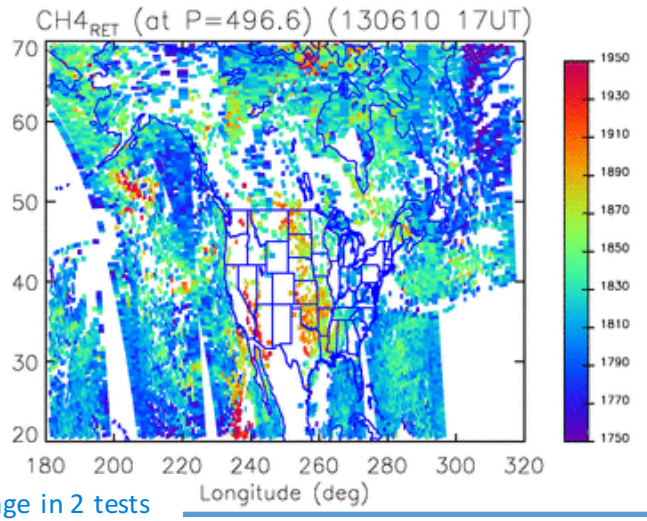
Designed to meet system requirements for global retrieval statistics; 1K T and 10% q

Can we adjust NUCAPS QC and improve Retrieval Yield?

Night Time
AM orbit
(~01h30)

NUCAPS has 17 QC tests throughout retrieval process

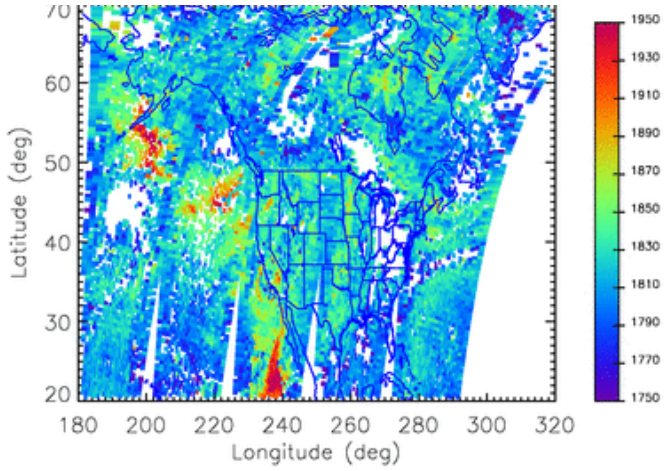


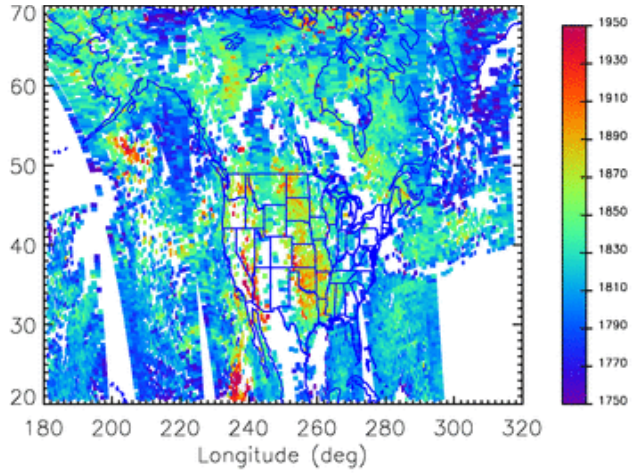


Day Time
PM orbit
(~13h30)

QC Threshold Change in 2 tests

~4% increase in retrieval yield





~12% increase in retrieval yield

Can we tailor QC to specific parameters? – CO

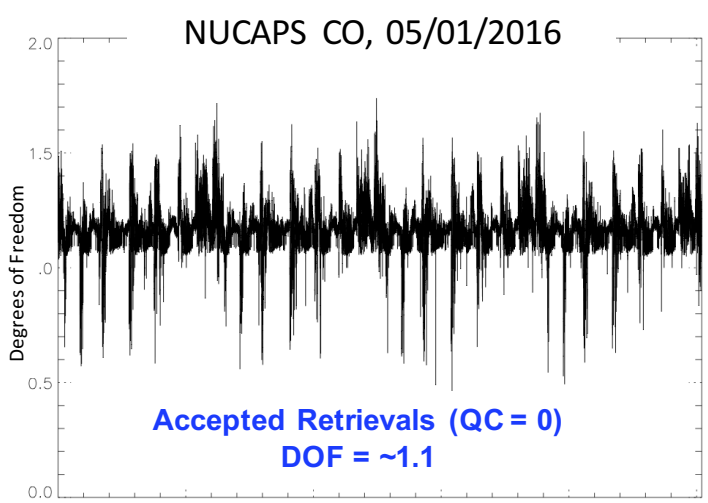
Night Time
AM orbit
(~01h30)

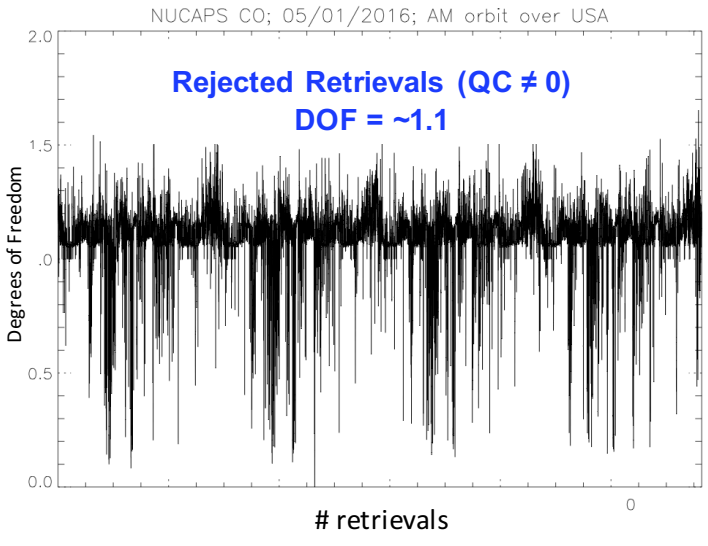
Night time DOF for accepted cases has less variation

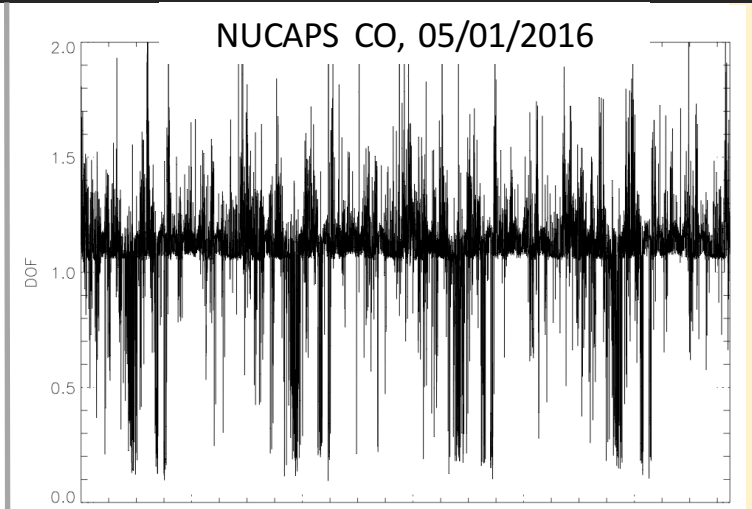
There is a clear difference between night time DOF for accepted vs rejected cases

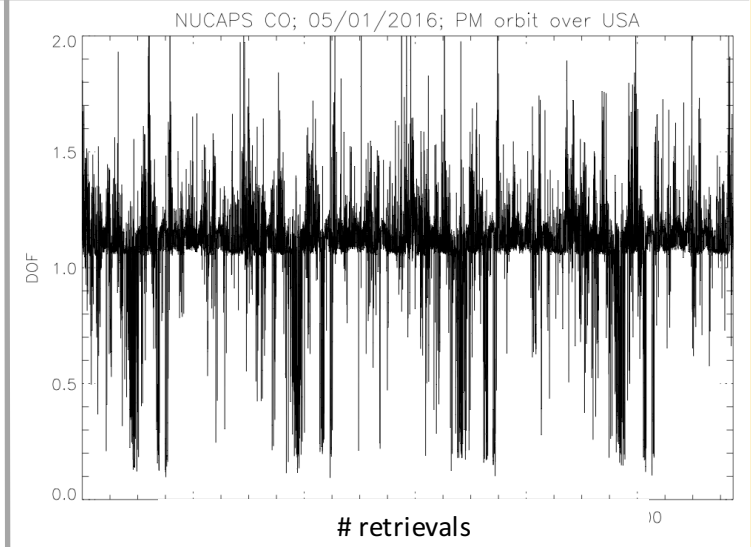
QC should typically filter out those retrievals with low DOF (or quality) and retain those with high DOF

The larger the DOF, the more information is available in the radiances









Day Time
PM orbit
(~13h30)

Degrees of Freedom (DOF) as indicator of information content

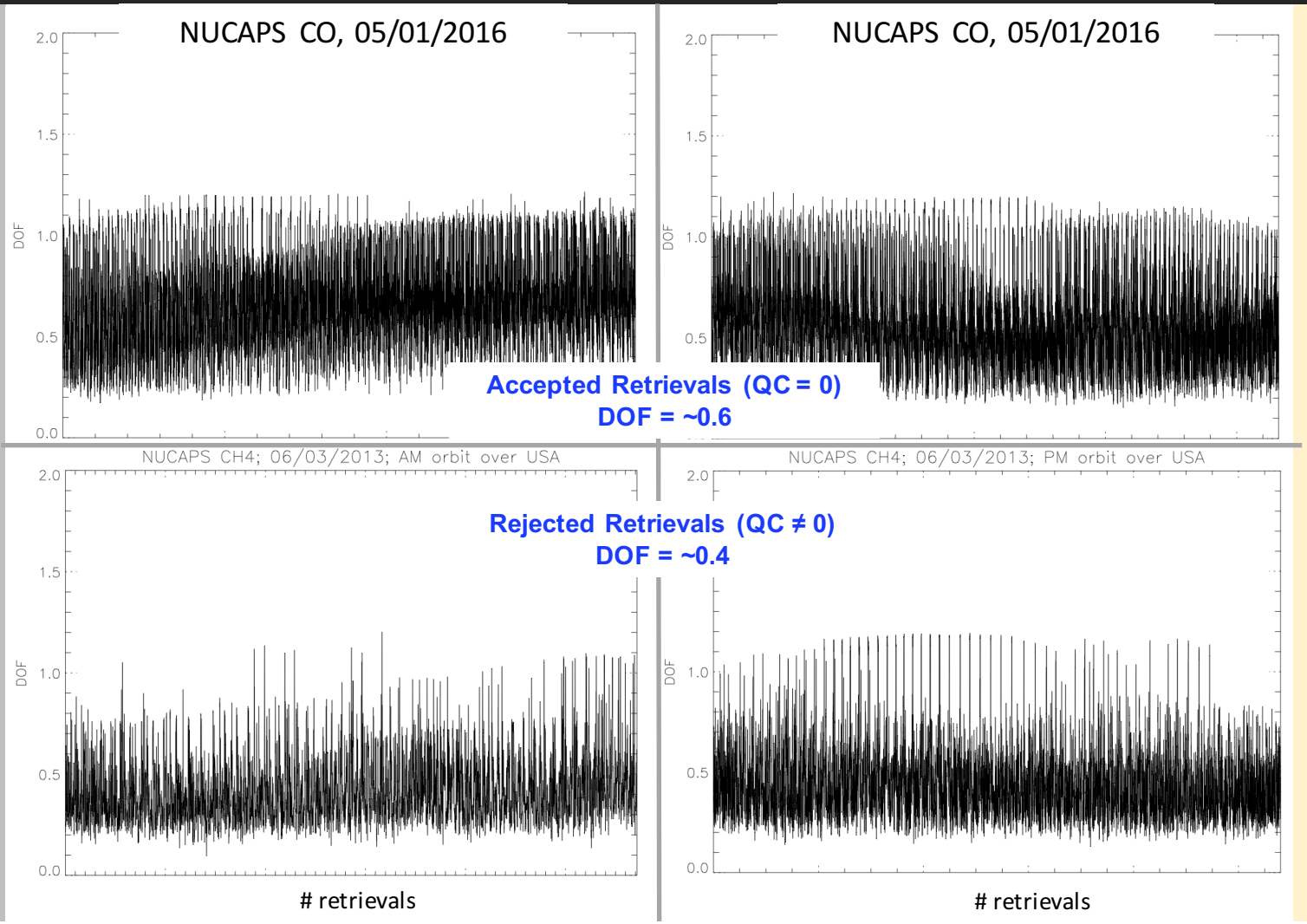
Mean DOF = 1.2
No matter what the time of day or QC

Daytime DOF has the same variation and systematic patter irrespective of QC

There are many CO retrievals with DOF > 1 in rejected cases (and vice versa) suggesting opportunity to develop CO-tailored QC. The quality of NUCAPS CO appears to be largely independent of T/q QC

Can we tailor QC to specific parameters? – CH4

Night Time
AM orbit
(~01h30)



DOF for rejected cases has less variation and the average is lower than the DOF for accepted cases suggesting that current QC successfully filters out the low quality CH4 retrievals

Day Time
PM orbit
(~13h30)

Accepted retrievals have higher DOF than rejected cases for both day and night time suggesting a stronger dependence of CH4 on T/q QC

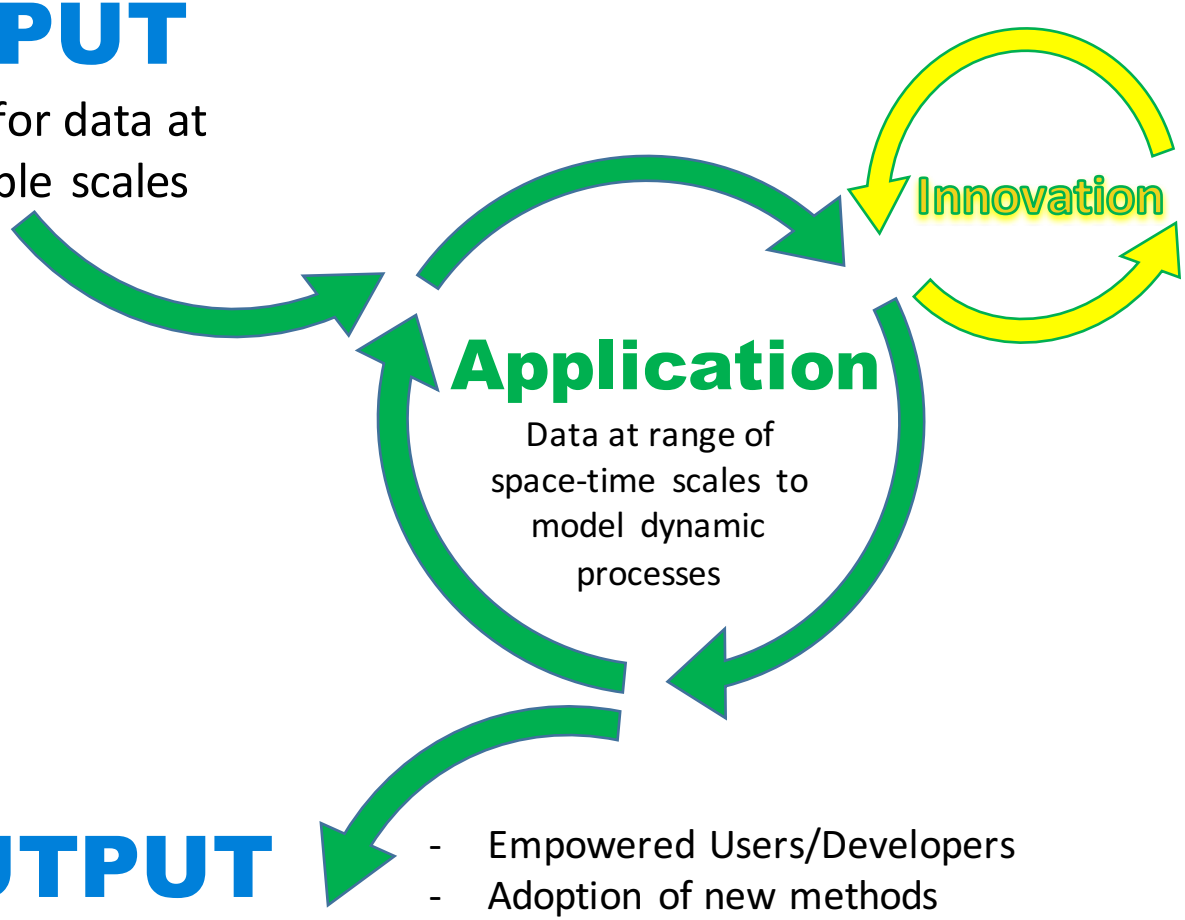
Accepted retrievals have high DOF variability suggesting a strong dependence on prevailing atm conditions

There are some CO retrievals with DOF > 0.5 in rejected cases suggesting opportunity to tailor QC for CH4

NOAA PGRR Initiative: NUCAPS CO and CH4

INPUT

Need for data at multiple scales



STC NUCAPS Team in collaboration with:

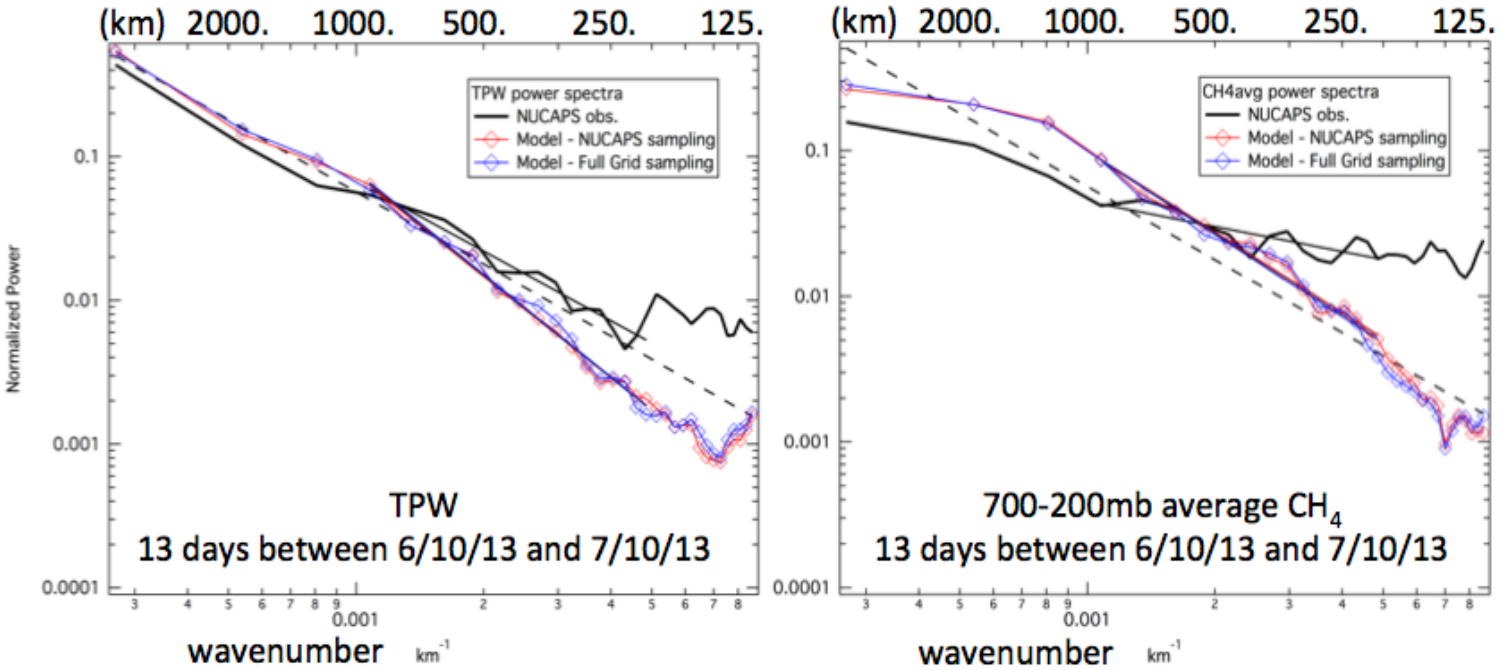
NOAA/ESRL/CSD
CIRES
NASA/JPL, etc.

OUTPUT

- Empowered Users/Developers
- Adoption of new methods
- Improved Trace Gas Climatologies, etc

Characterizing Atmospheric Chemistry

The objective is to understand how NUCAPS trace gases scale with respect to TPW in order to constrain the modeling of emission, chemistry and transport.



Average **normalized power spectra** for TPW (left) and 700-200 mb average CH_4 (right) for the NUCAPS data and the WRF-Chem model output. Dashed line is the -5/3 power law, and length scale is shown on the top axis. Thin lines are regression fits between 200 and 1000 km length scales.

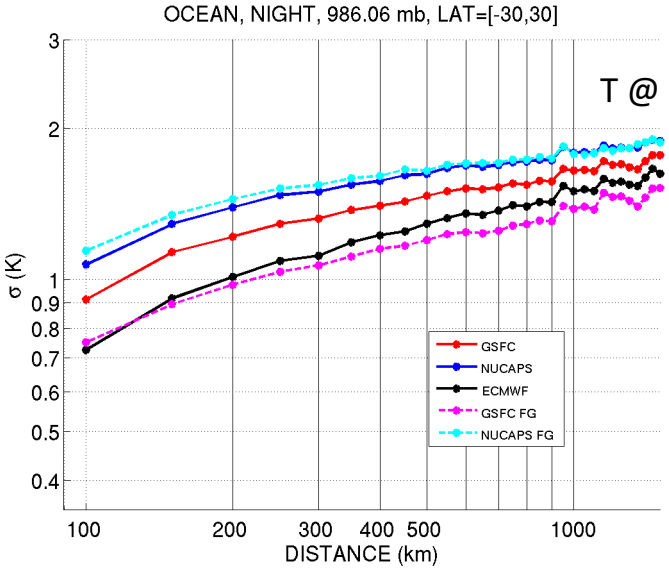
Figures by Stuart McKeen

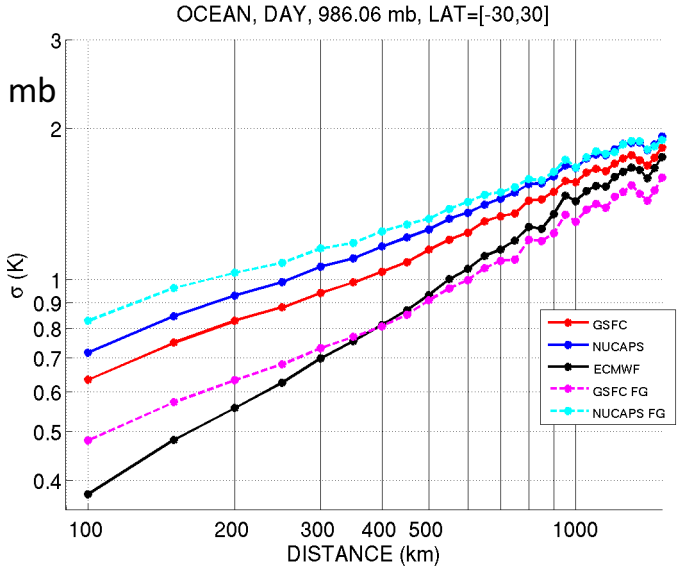
Spatial Variability in Satellite Data

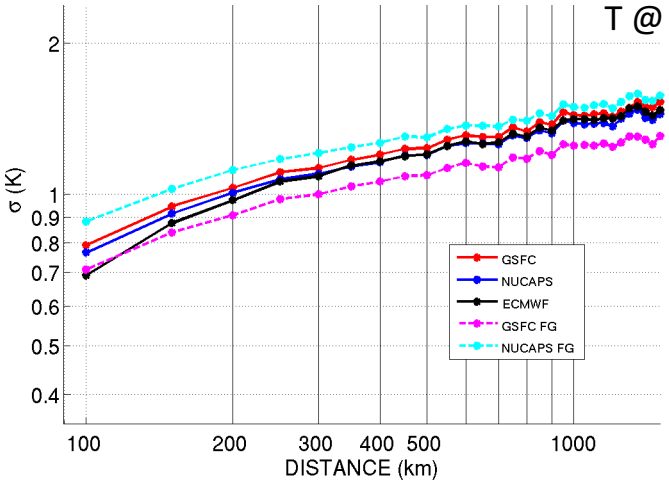
Night Time
AM orbit
(~01h30)

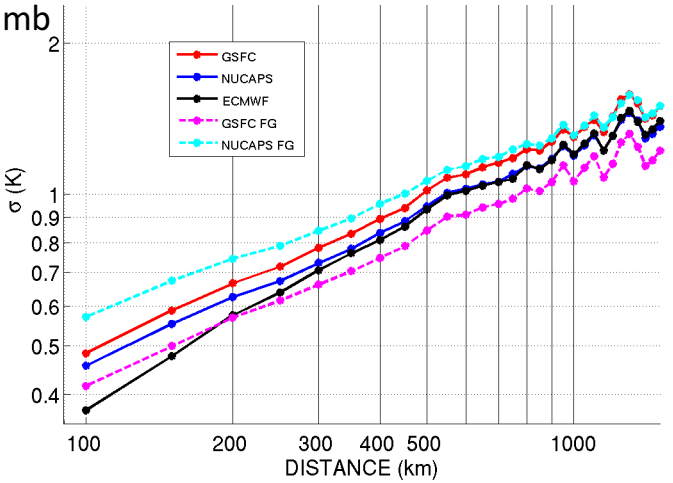
Standard deviation of NUCAPS T at different spatial scales

"Variance scaling" methods allow the characterization of nonlinear atmospheric processes and cross-scale energy transfer.









Day Time
PM orbit
(~13h30)

Satellite data have sampling challenges different to any other data source.

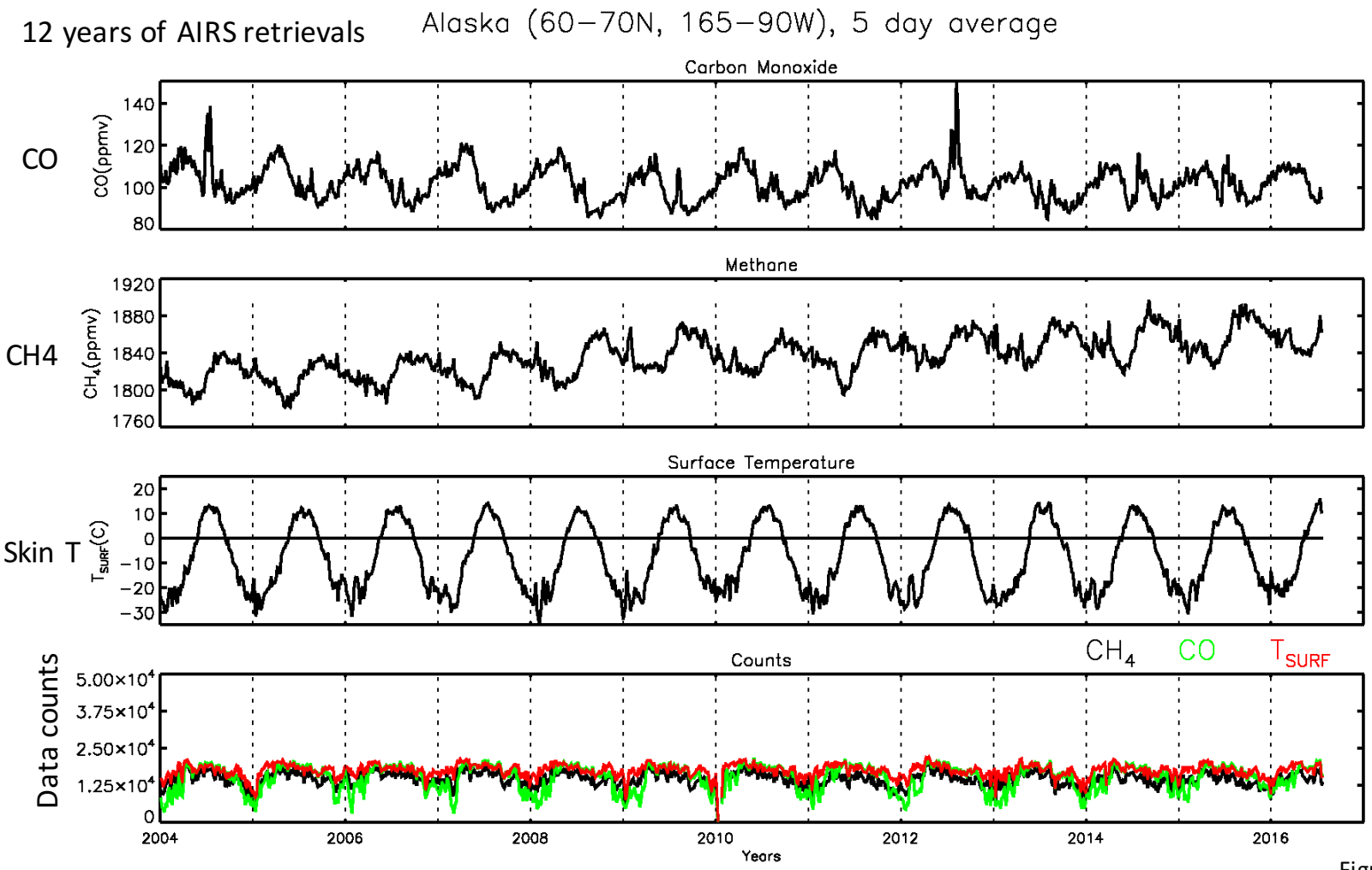
We need to find methods that aggregate spatially non-uniform data in objective manner and do not introduce systematic effects in end result.

Collaboration with Stuart McKeen (ESRL, CIRES) Brian Kahn and Van Dang (NASA/JPL)

Figures by Van Dang NASA/JPL

Temporal Variability in Satellite Data

12 years of AIRS retrievals



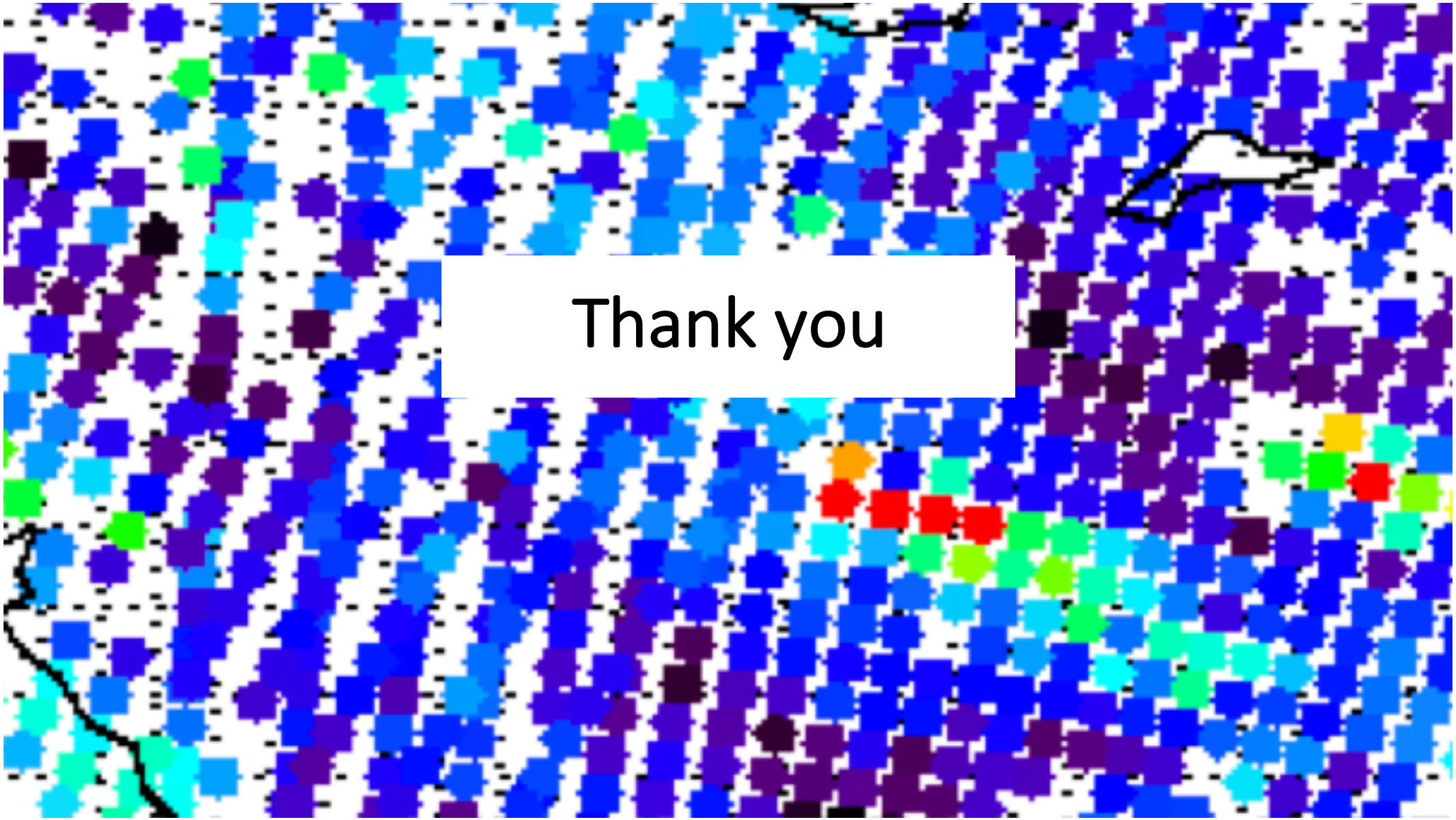
Experiments in temporal averaging.

Aqua and SNPP have repeat cycles of 16 days. How does the long term temporal pattern change when we average different sets of days together?

Figure by Colby Francoeur, STC

Lessons Learned

- The NOAA Sounding Initiative allows Users and Developers to collaborate and more effectively work towards solutions – we are all learning in the process
- There is a user need to not only improve the retrieval quality, but also the data product design, i.e., to to tailor the type of information made available in the data product files
- Given that QC removes data, we need to understand how the systematic patterns in data sampling affect analyses and propagate into applications, especially those that are concerned with dynamic, complex processes
- Our efforts will lead to products tailored to user needs AND applications tailored to satellite data


Thank you