



# NOAA Activities:

## **Volcanic Ash Greenhouse Gases Ozone CDRs NOAA Program for CDRs**

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John Bates, Jeff Privette (NCDC CDR Program)



# NESDIS Satellite Activities for Volcanic Ash

The GOES-R Volcanic Ash Product (by Mike Pavolonis) was developed and tested using MSG SEVIRI data.

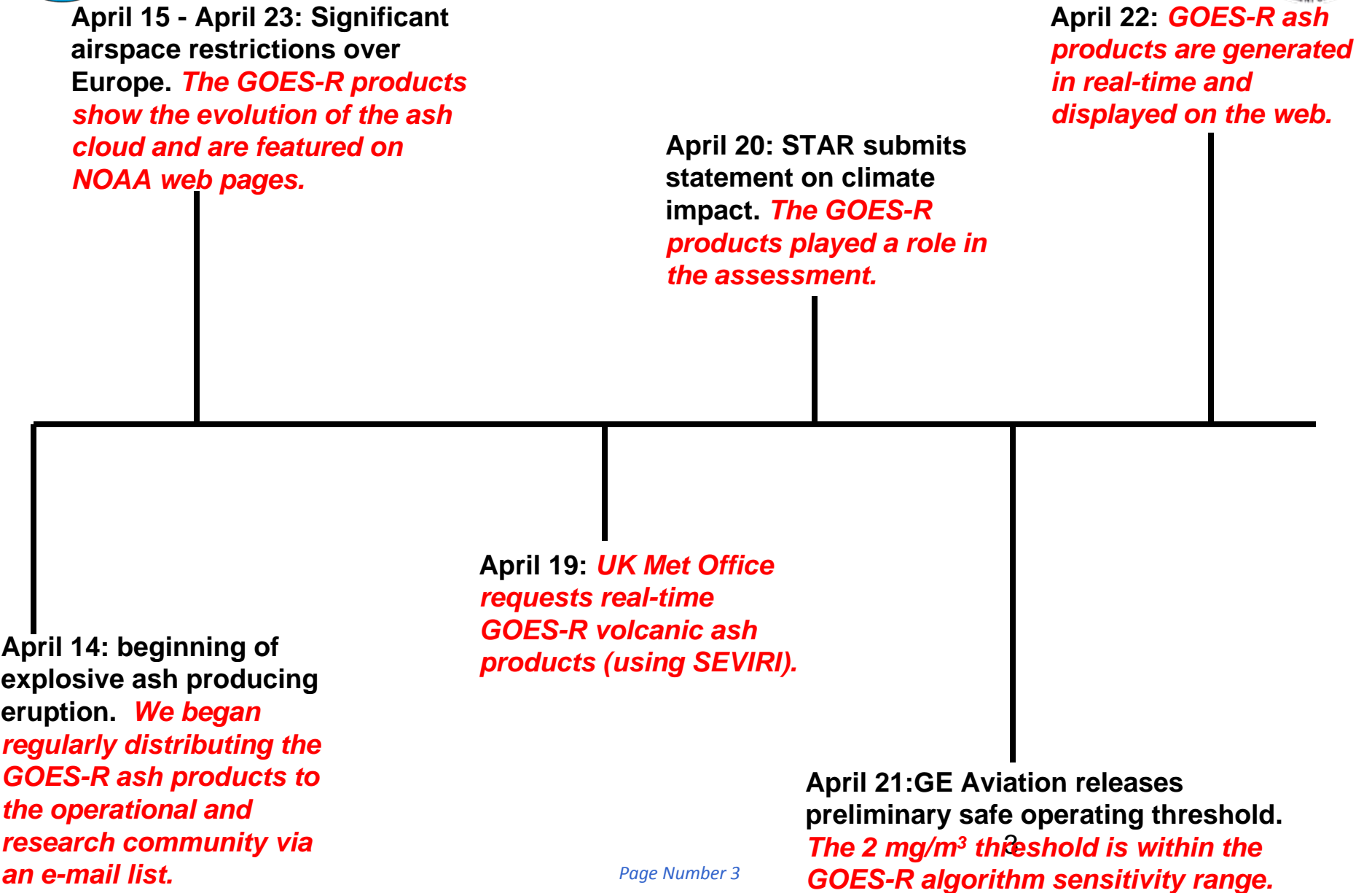
Shortly after the **Eyjafjallajökull eruption**, The UK VAAC requested NESDIS to provide our GOES-R Volcanic Ash products routinely

Research to Operations in a Flash!!

For details on the algorithm or interest in collaboration please contact [Mike.Pavolonis@noaa.gov](mailto:Mike.Pavolonis@noaa.gov)

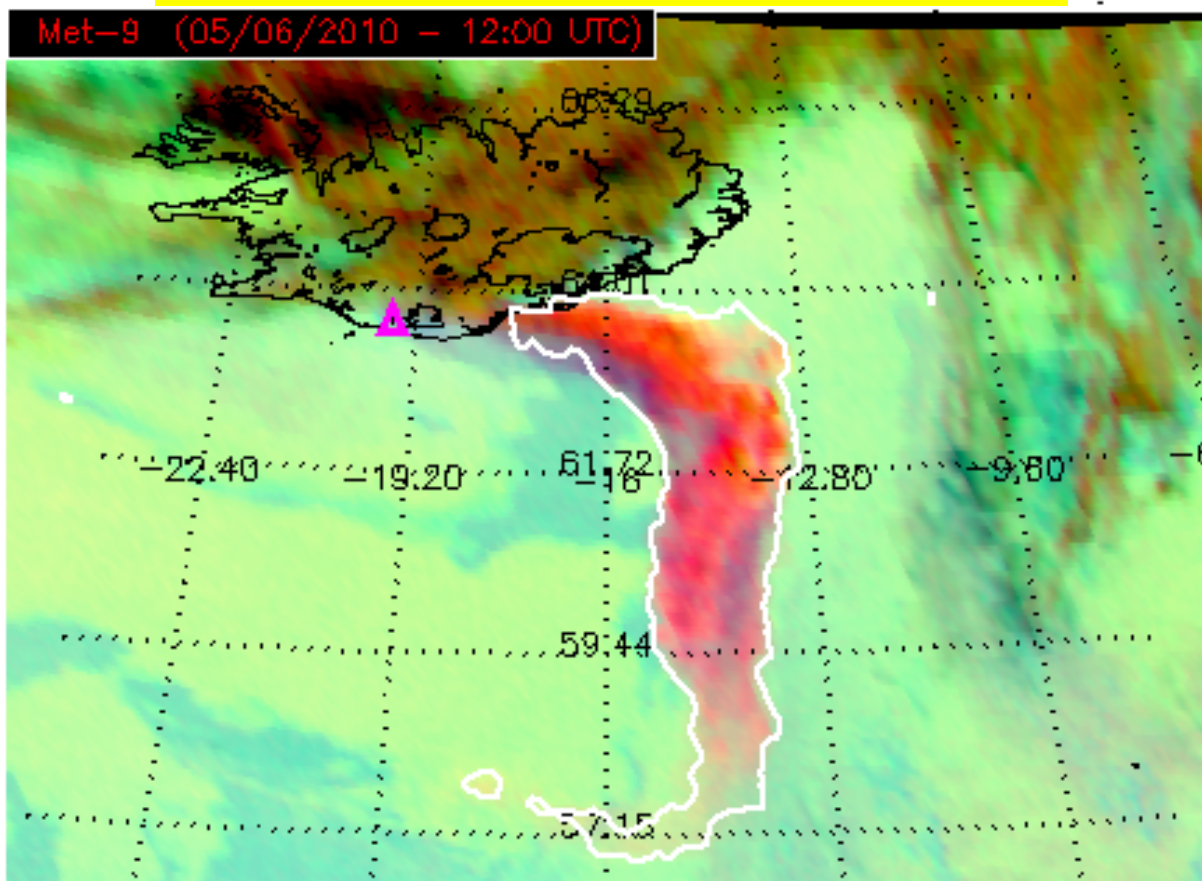


# Early Role of the GOES-R Volcanic Ash Products



# The GOES-R Volcanic Ash Products

## Quantitative Ash Detection

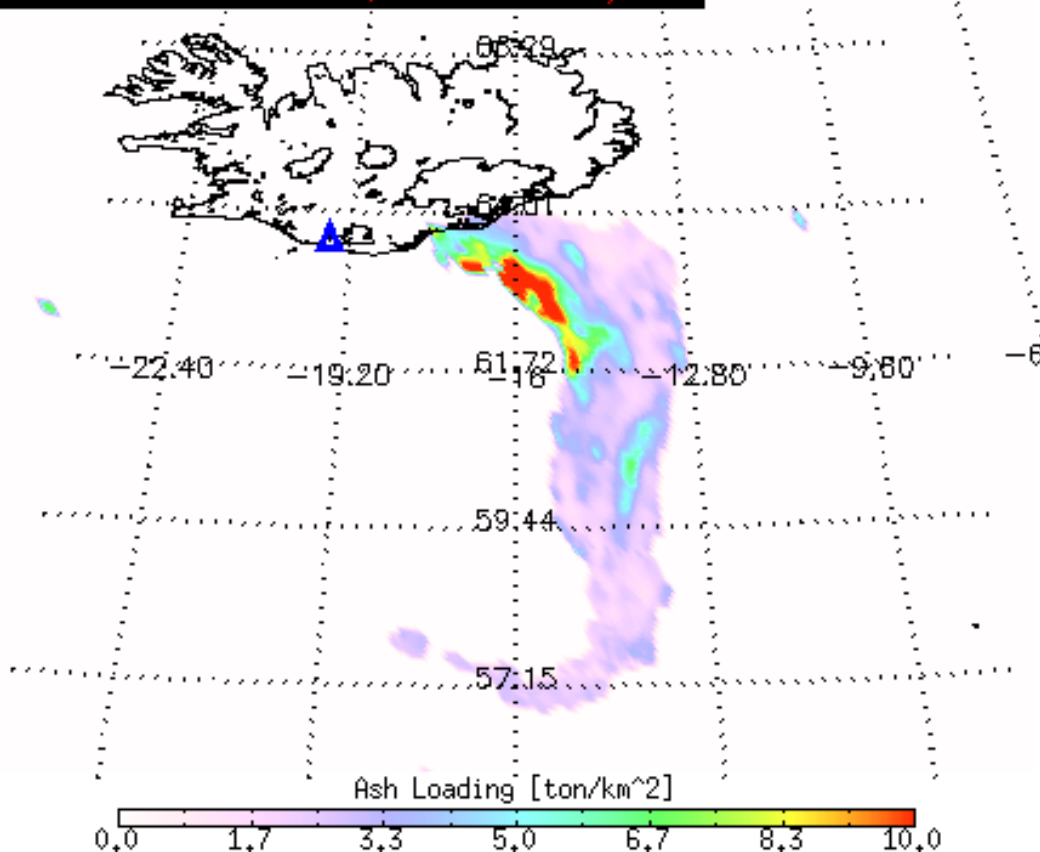


- Quantitative ash detection is expressed as an ash confidence.
- Ash detection results can be overlaid on false color imagery to give the user perspective.
- The ash detection can be used to provide automated ash alerts.

# The GOES-R Volcanic Ash Products

## Ash Mass Loading

Total Mass: 110.42 kton; Max: 64.29 ton/km<sup>2</sup>



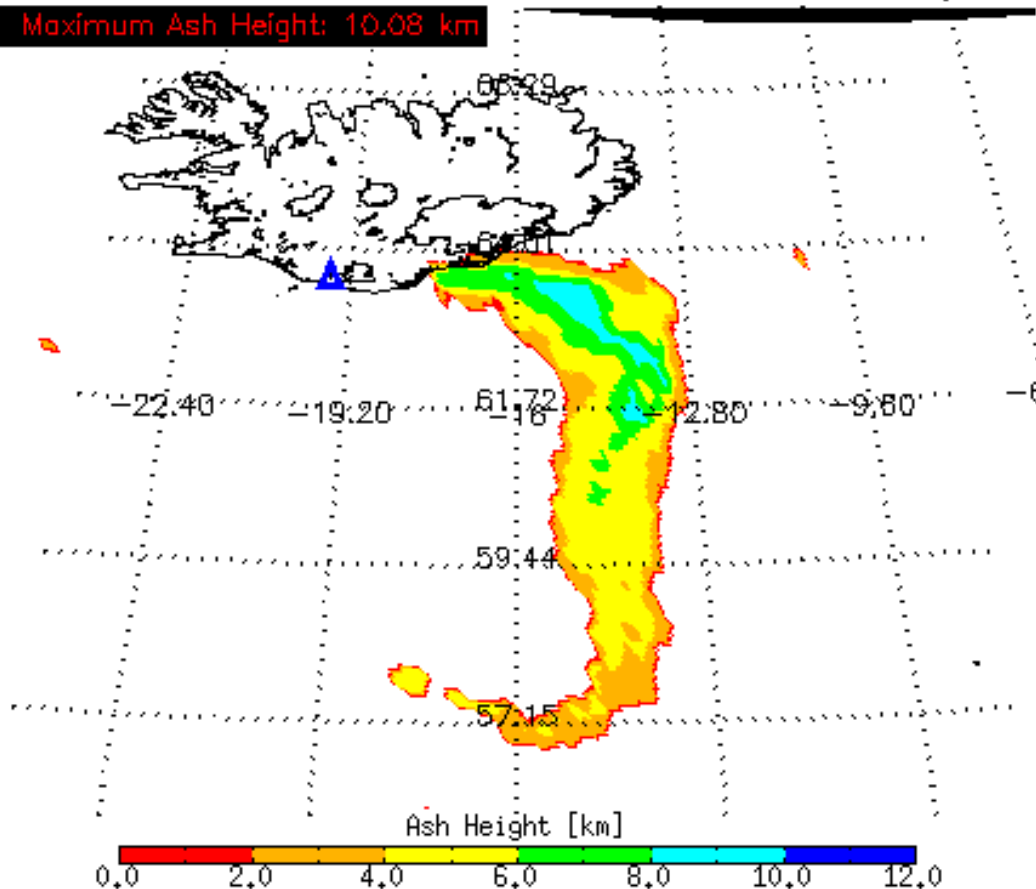
- Ash mass loading (ton/km<sup>2</sup>) is needed to determine if jet engine tolerances are exceeded and to initialize models.

- If a 1 km cloud thickness is assumed, the mass loading is numerically equivalent to ash concentration in mg/m<sup>3</sup>.

# The GOES-R Volcanic Ash Products

## Ash Cloud Height

Maximum Ash Height: 10.08 km

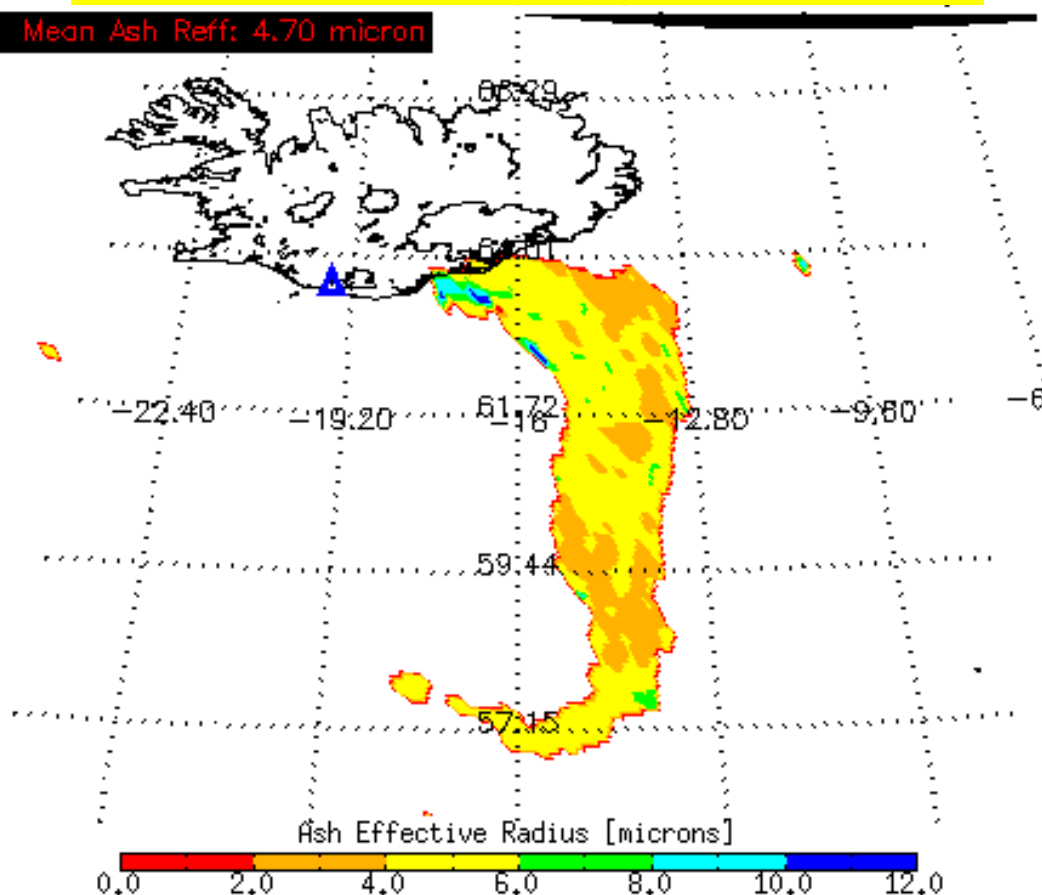


- The ash cloud top height is critically important for determining if ash is at jetliner cruising altitudes (nowcasting component).
- In addition, the ash cloud height is a very important parameter for initializing dispersion models (forecasting component).

# The GOES-R Volcanic Ash Products

## Ash Effective Radius

Mean Ash Reff: 4.70 micron

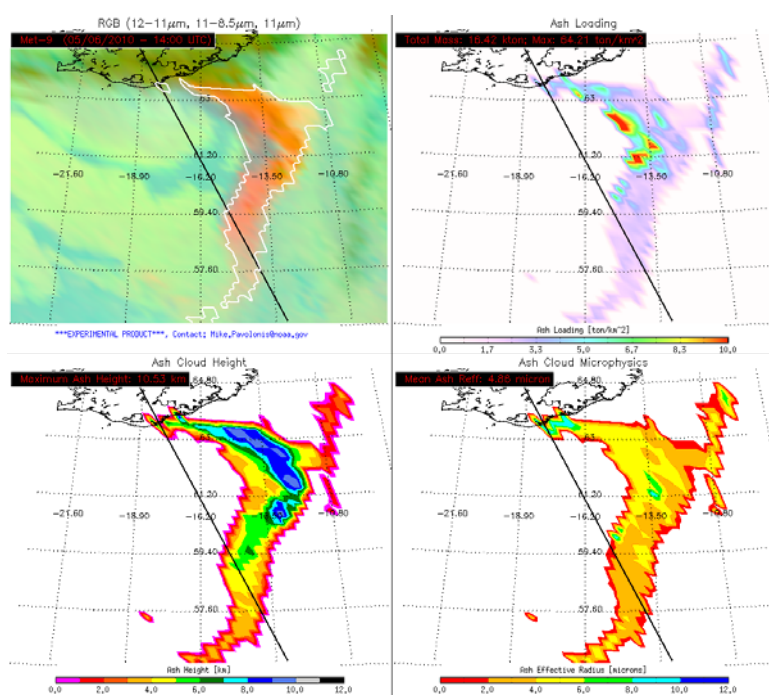


- The ash cloud effective particle radius is not a required product, but it is automatically generated as part of the ash retrieval.
- Since the effective particle radius is well correlated with ash residence time, we will retain this information in quality flag form.



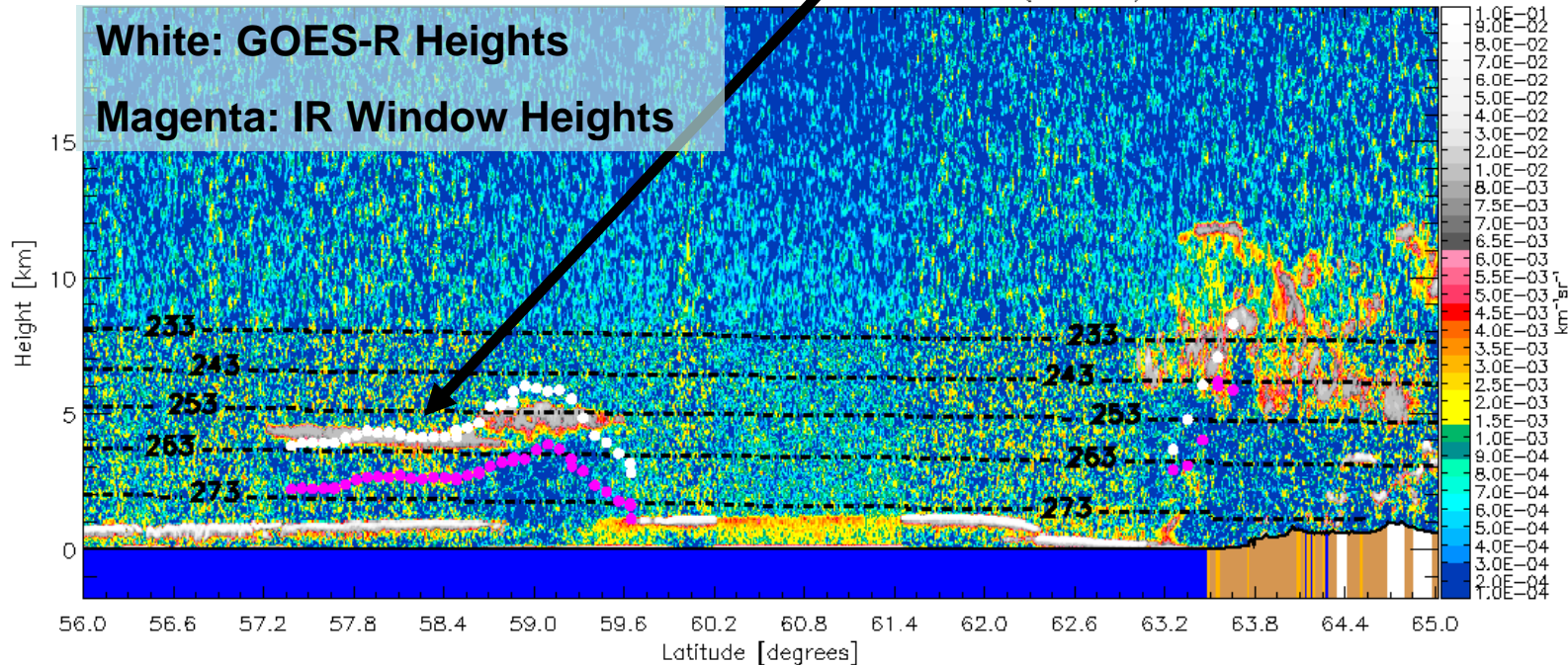
May 6, 2010 (14:00 UTC)

*The GOES-R ash cloud heights closely match the CALIPSO cloud top boundary.*



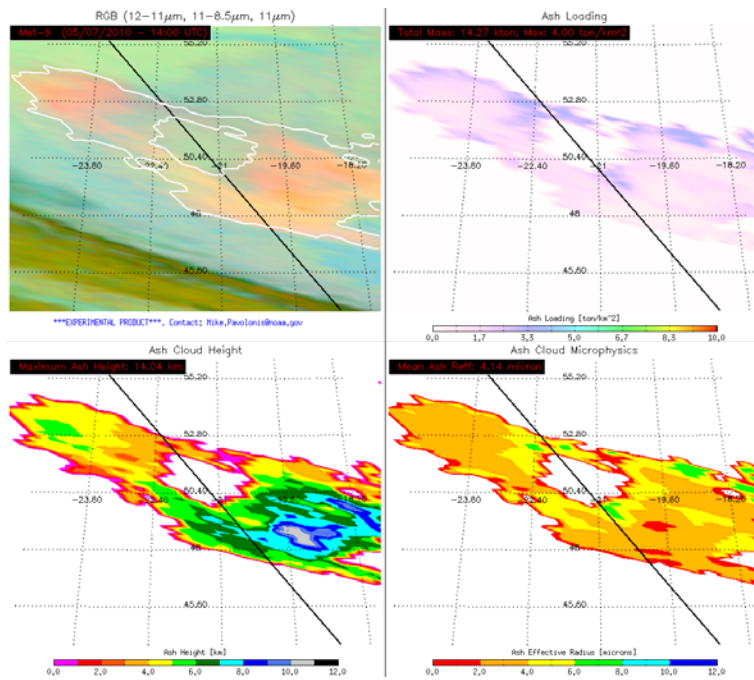
Ash cloud

CALIPSO 532 nm Total Attenuated Backscatter ( $\text{km}^{-1}\text{sr}^{-1}$ )



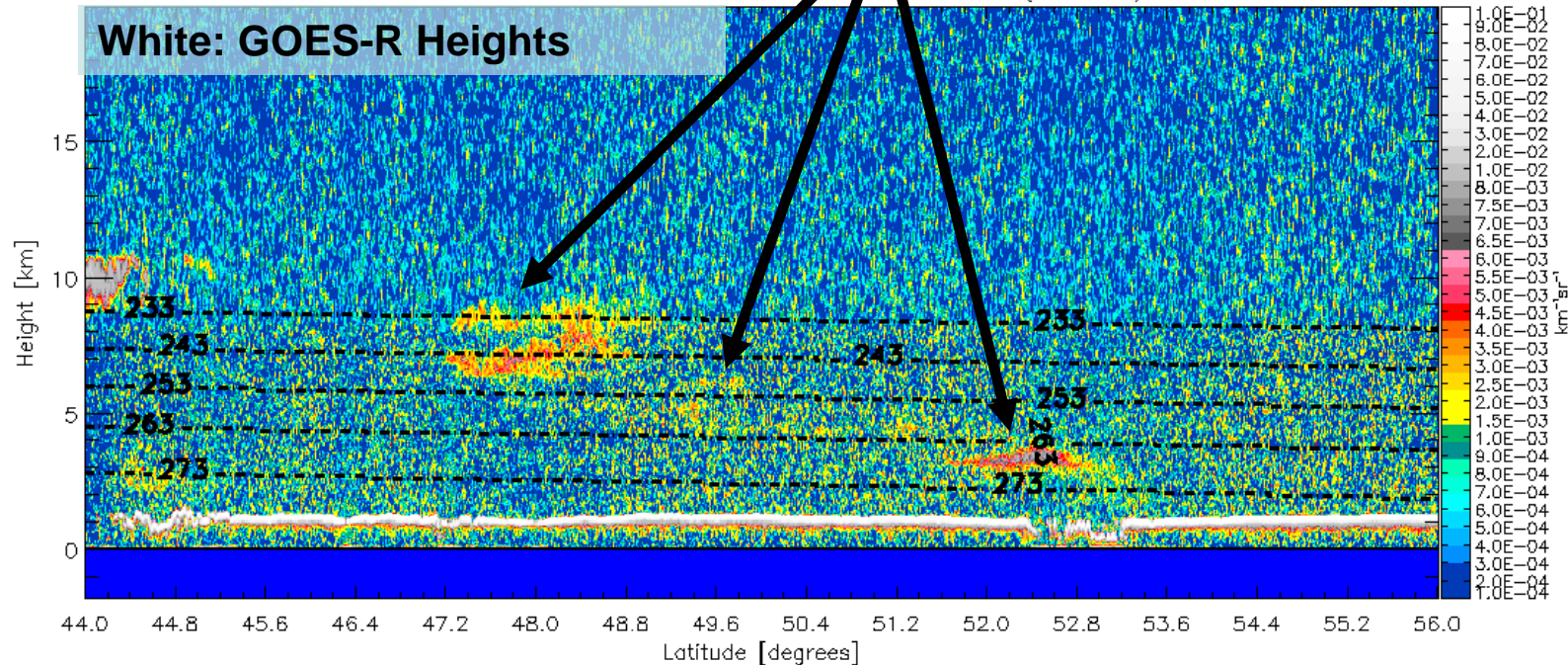


May 7, 2010 (14:00 UTC)

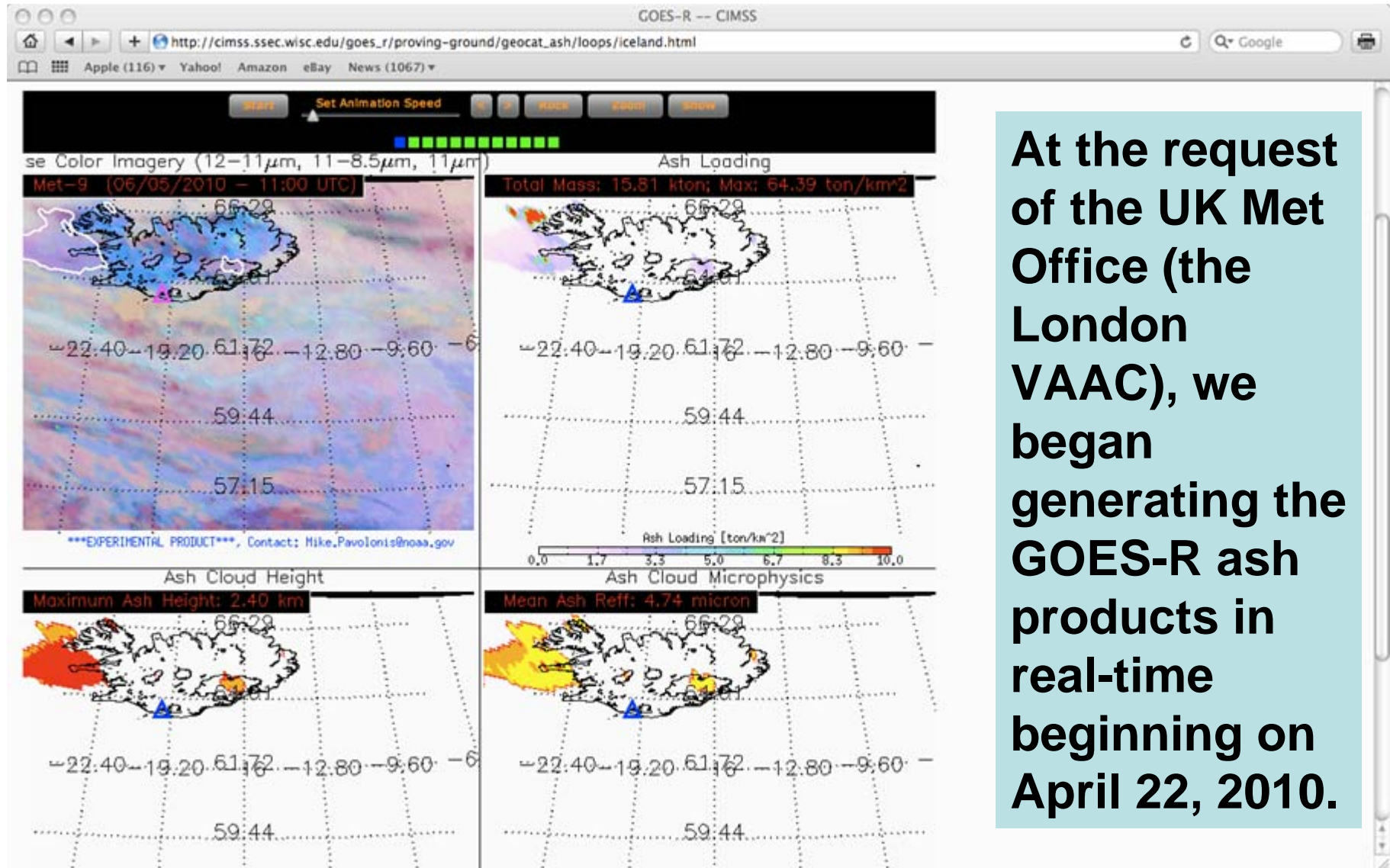


## Ash clouds

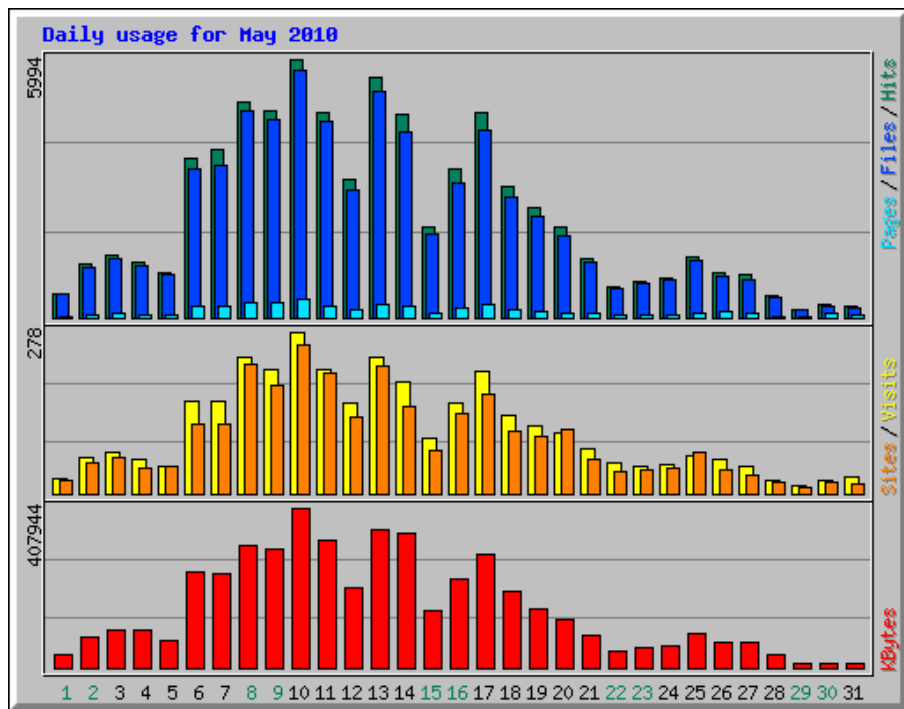
CALIPSO 532 nm Total Attenuated Backscatter ( $\text{km}^{-1}\text{sr}^{-1}$ )



[http://cimss.ssec.wisc.edu/goes\\_r/proving-ground/geocat\\_ash/](http://cimss.ssec.wisc.edu/goes_r/proving-ground/geocat_ash/)



At the request of the UK Met Office (the London VAAC), we began generating the GOES-R ash products in real-time beginning on April 22, 2010.



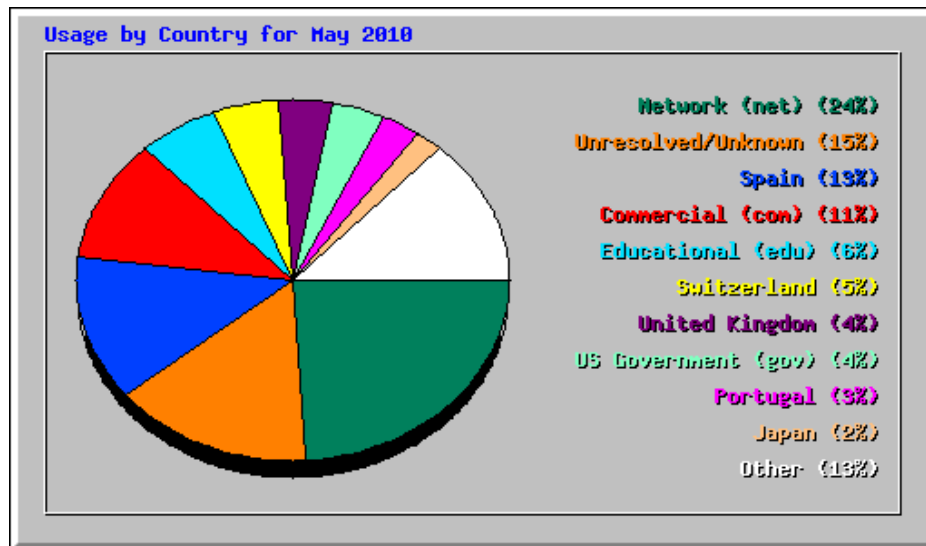
**~74,000 hits in May 2010, despite being a “hidden” site.**

•The web site attracted visitors from a wide range of countries.

•***\*\*\*The UK Met Office (London VAAC) registered the most hits out of all visitors.***

•The UK Met Office confirmed that they use the products daily.

•Stan Benjamin’s group has been using the ash heights to initialize the FIM.





# Known Users and Data Requests

- AFWA
- Airline Pilots Association
- Aviation Weather Testbed
- CALIPSO Science Team
- Deutscher Wetterdienst Remote Sensing Division
- NOAA OAR ESRL
- Iceland Met Office
- Italian Civil Protection
- MISR Science Team
- Norwegian Institute for Air Research
- Norwegian Meteorological Institute
- UK Met Office
- University of Alaska - Fairbanks
- University of Buffalo
- USGS
- WMO



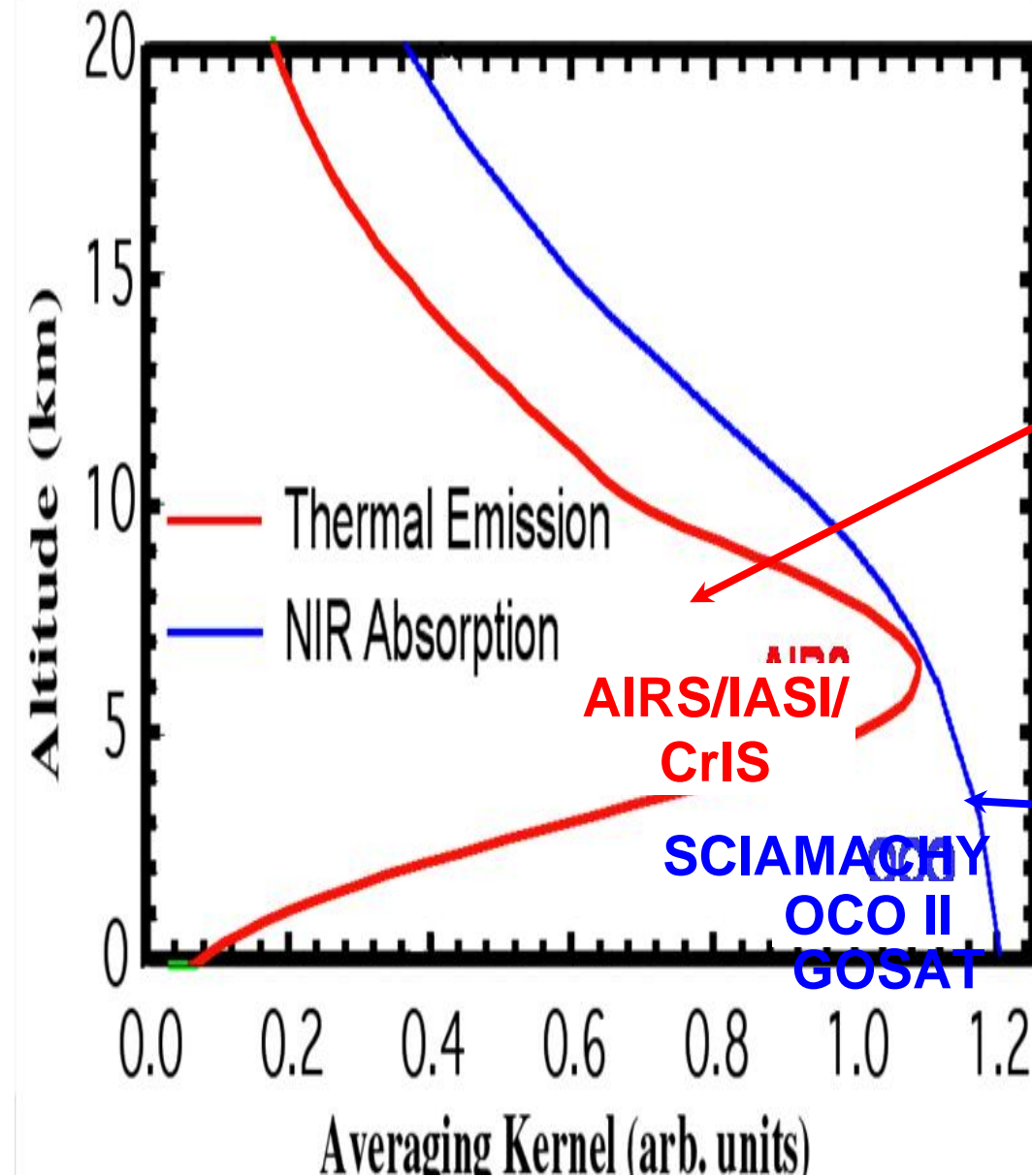
Marco Fulle - [www.stromboli.net](http://www.stromboli.net)

***There were also features on NPR, Weather Network TV (Canada), On Wisconsin Magazine, and Physorg.com***



# NESDIS Satellite Activities for Greenhouse Gases

# AIRS/IASI/CrIS thermal IR measurements complement the solar/passive measurements by providing an independent upper boundary condition



- Thermal instruments (e.g., AIRS, IASI, CrIS) measure mid-tropospheric column
  - Peak of vertical weighting is a function of T profile and water profile and ozone profile.
  - Age of air is on the order of weeks or months.
  - Significant horizontal and vertical displacements of the trace gases from the sources and sinks.
  - Excellent global coverage
- Short-wave infrared (SWIR) instruments (SCIAMACHY, OCO 2, GOSAT) & Laser) measure the total column average, weighted in the lower troposphere.
  - Mixture of surface and near-surface atmospheric contribution
  - Age of air varies vertically.
  - Limited global coverage (nadir)

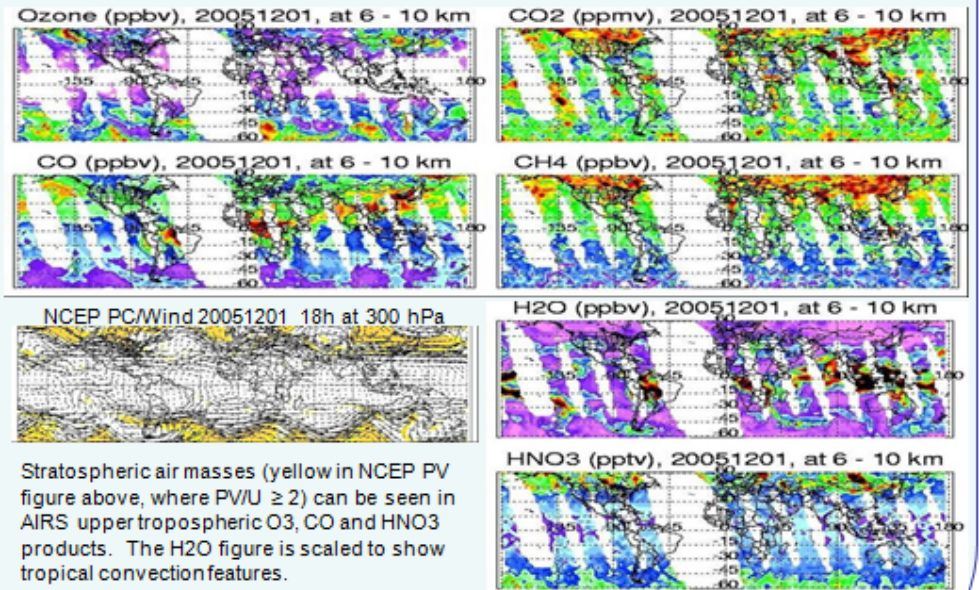


*AIRS Science Team Algorithm employs cloud clearing using 9 AIRS (or 4 IASI) fields of view to remove the effects of clouds with 4 parameters. Approximately 50-80% of the scenes in a given day satisfy the assumptions of cloud clearing.*

NOAA/NESDIS/STAR has led the development of trace gas products from AIRS and IASI

- Experimental trace gas products were developed in collaboration with the NASA's AIRS Science Team
- AIRS Science Team algorithm was transitioned to operations for the IASI instrument.

gas	Precision	d.o.f.	AIRS	IASI
T	1K/km	6-10	NASA DAAC	NGDC/CLASS
H <sub>2</sub> O	15%	4-6	NASA DAAC	NGDC/CLASS
O <sub>3</sub>	10%	1+	NASA DAAC	NGDC/CLASS
CO	15%	≈ 1	NASA DAAC	NGDC/CLASS
CH <sub>4</sub>	1.5%	≈ 1	NASA DAAC	NGDC/CLASS
CO <sub>2</sub>	0.5%	≈ 1	NOAA NESDIS	NGDC/CLASS
<u>Volcanic</u> SO <sub>2</sub>	50% ??	< 1	TBD	TBD
HNO <sub>3</sub>	50% ??	< 1	NOAA NESDIS	NGDC/CLASS
N <sub>2</sub> O	5% ??	< 1	NOAA NESDIS	NGDC/CLASS



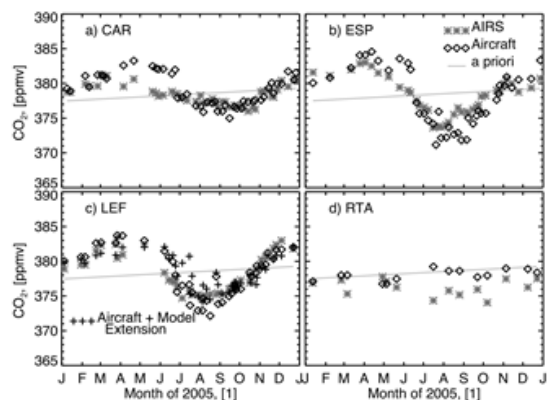
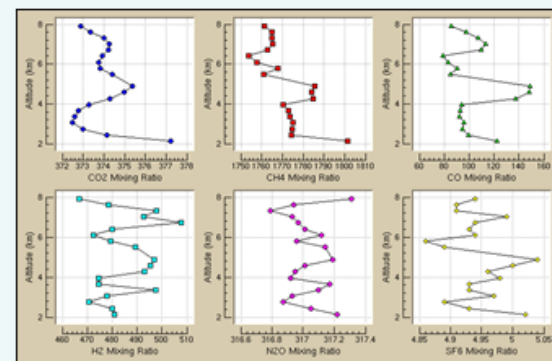
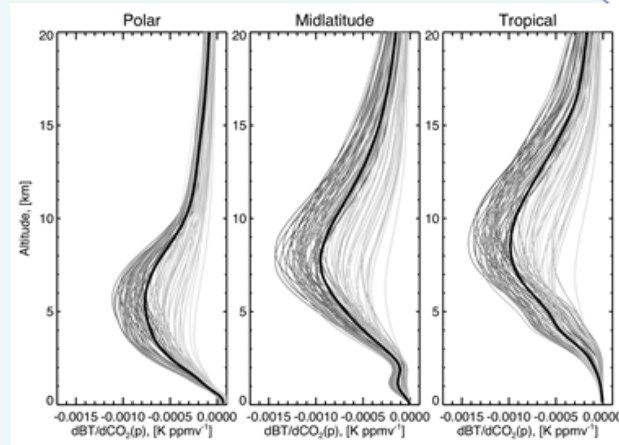
# NOAA Proposal to JAXA Second Research Announcement

- To provide cross-validation of GOSAT/TANSO methane products with NOAA/NESDIS/STAR operational AIRS and IASI products (in-work)
- To improve the retrieval of total column of CH<sub>4</sub> and CO<sub>2</sub> based solely on TIR measurements.
- To enable a better understanding of the strengths and weaknesses of TIR, SWIR and combined TIR/SWIR retrieval strategies in determining the spatial-temporal variation of CO<sub>2</sub> and CH<sub>4</sub> in the atmosphere.

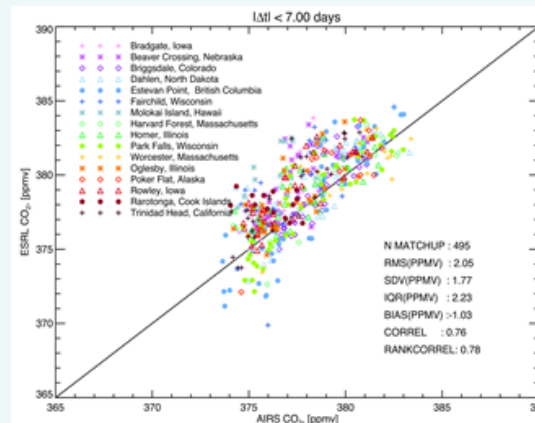
## Validation

Thermal sounders, such as AIRS, IASI, and CrIS, measure traces in a thick tropospheric column averages. The vertical region sounded is a function of the atmospheric state as shown at right for CO<sub>2</sub>

The best in-situ validation products are gas flask samples taken during aircraft flights. The NOAA/ESRL monitoring network provides high precision vertical profiles for a number of locations

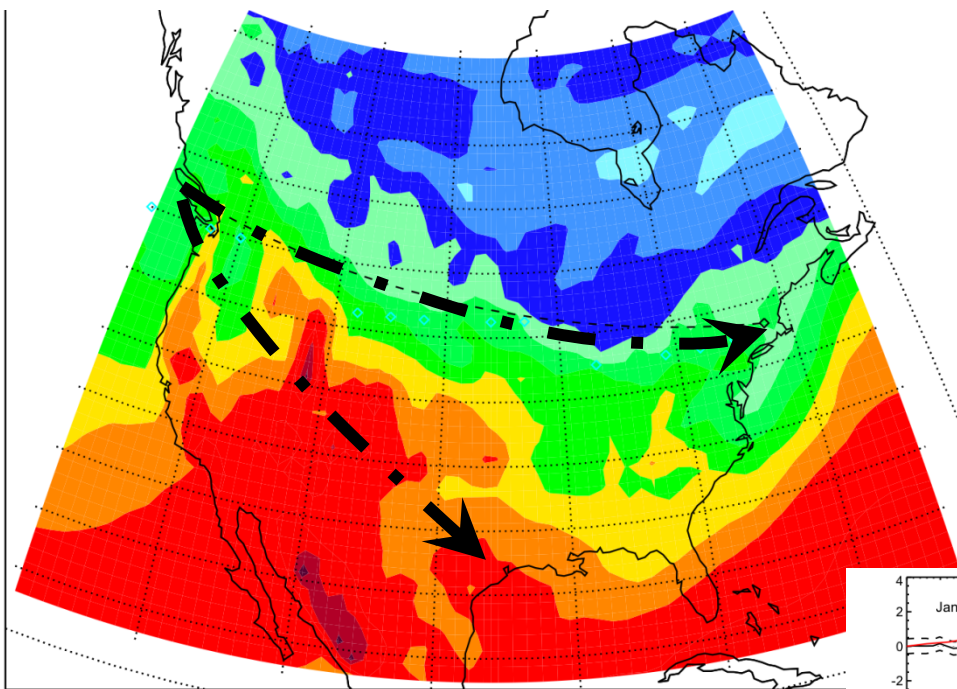


Comparison of AIRS CO<sub>2</sub> product with aircraft measurements at 4 ESRL sites shown as a function of time (left) and as a scatter plot for all ESRL sites (right)



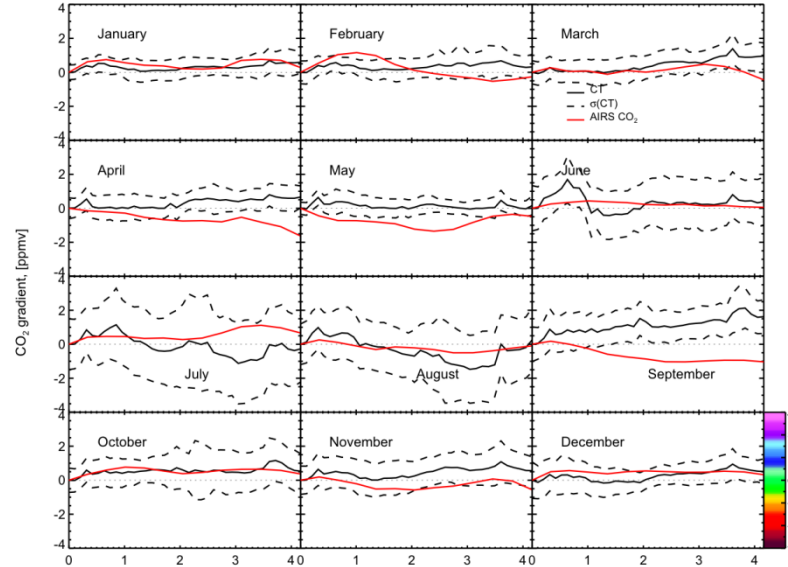


# NOAA CarbonTracker Upper Troposphere CO<sub>2</sub> Gradient Over N. America Relative to NW US For July

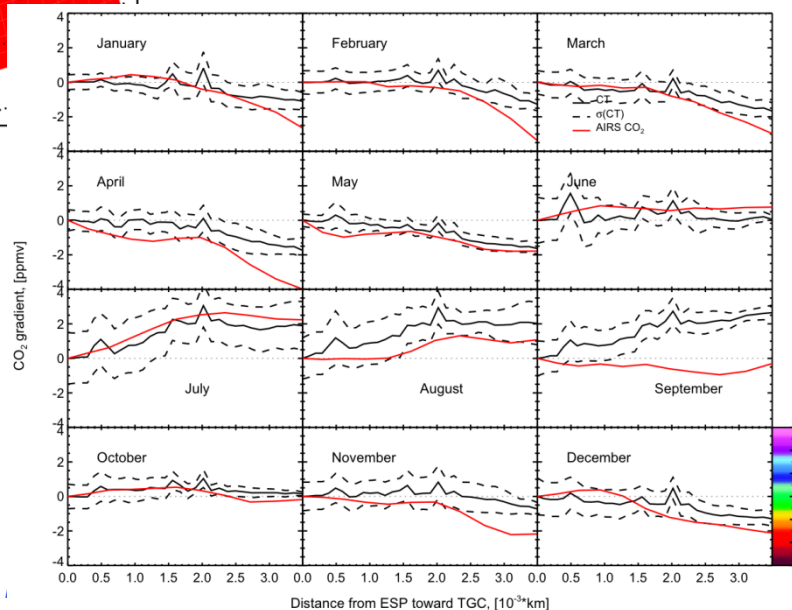


(Right) Monthly Average **AIRS** and **CarbonTracker** Gradients From Northwest US to Texas

*Validation has been used to identify and mitigate problems in the AIRS forward model.*



(Above) Comparison of Monthly Average **AIRS** and **CarbonTracker** Gradients From Northwest US to Massachusetts

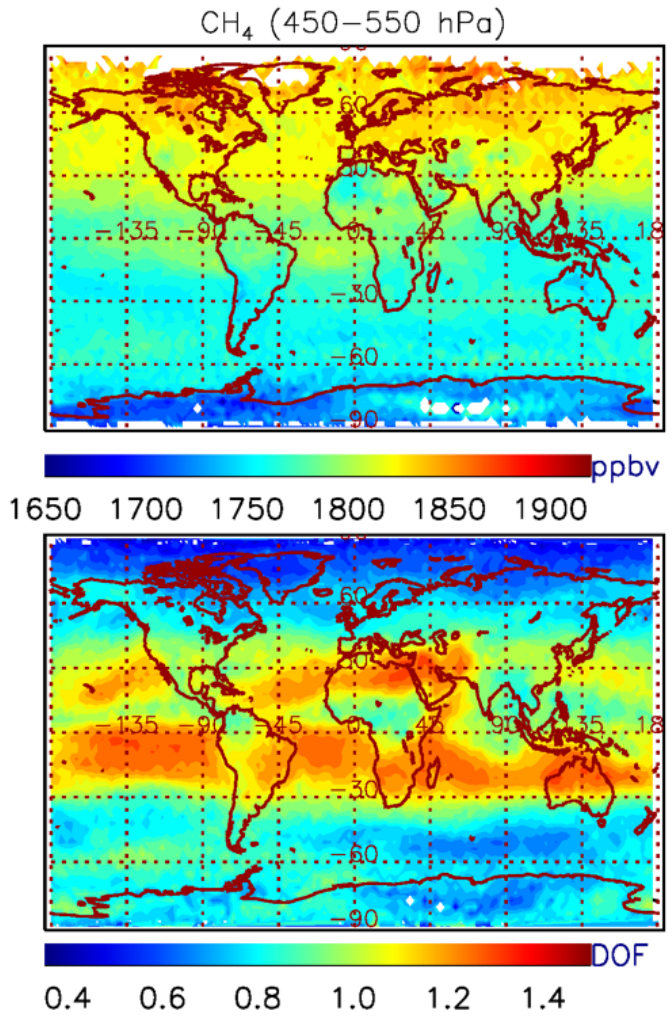
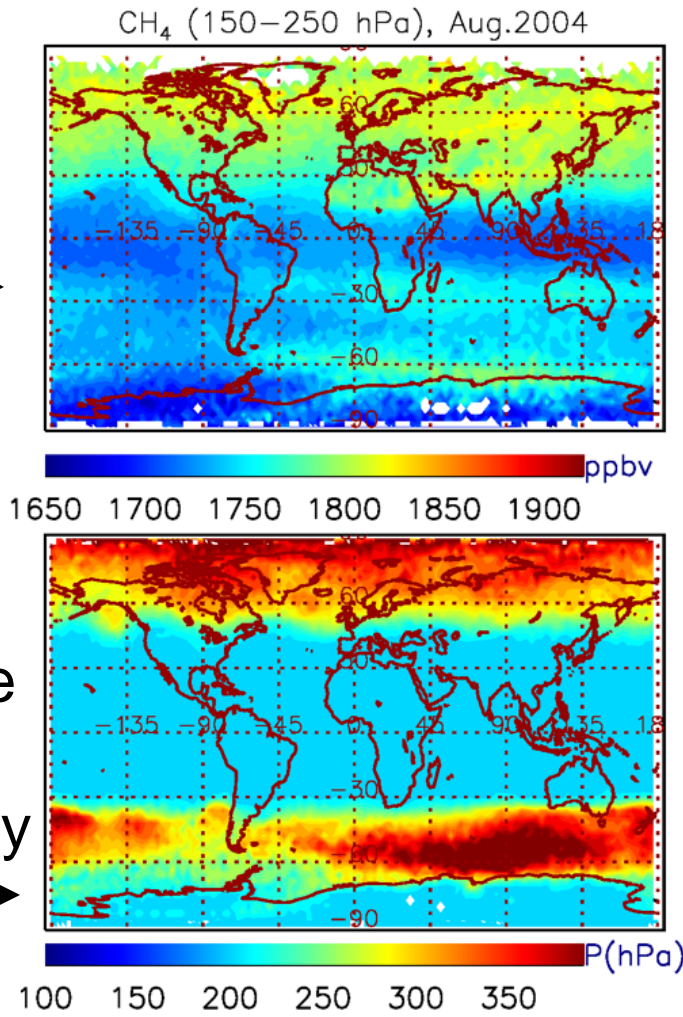




# AIRS Provides Middle/Upper Tropospheric CH<sub>4</sub> Information



CH<sub>4</sub> at  
200 mb  
→  
  
Peak  
Pressure  
of  
Sensitivity  
→

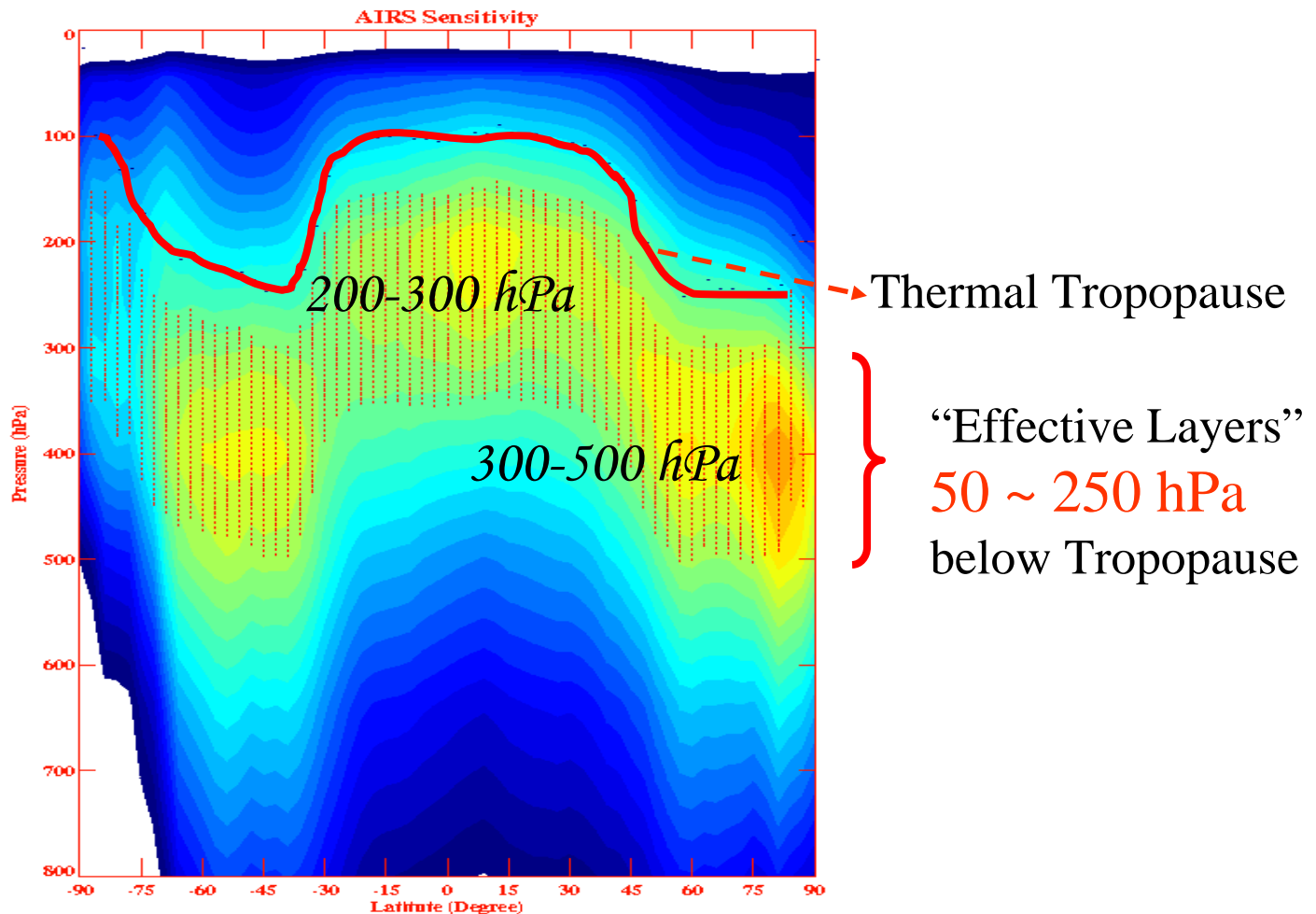


←  
CH<sub>4</sub> at  
500 mb  
  
←  
Degrees  
of  
Freedom

# Most sensitive layers of AIRS to CH<sub>4</sub>

(mapping based on area of averaging kernels)

AIRS CH<sub>4</sub>  
DOF  $\approx 1$

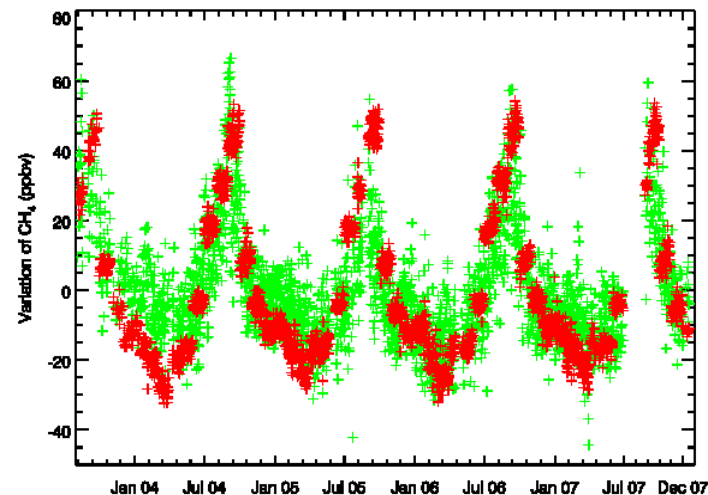


Xiong, et al. 2010 JGR doi:10.1029/2009JD013796 (In Press)



# AIRS observes methane variability over Asia

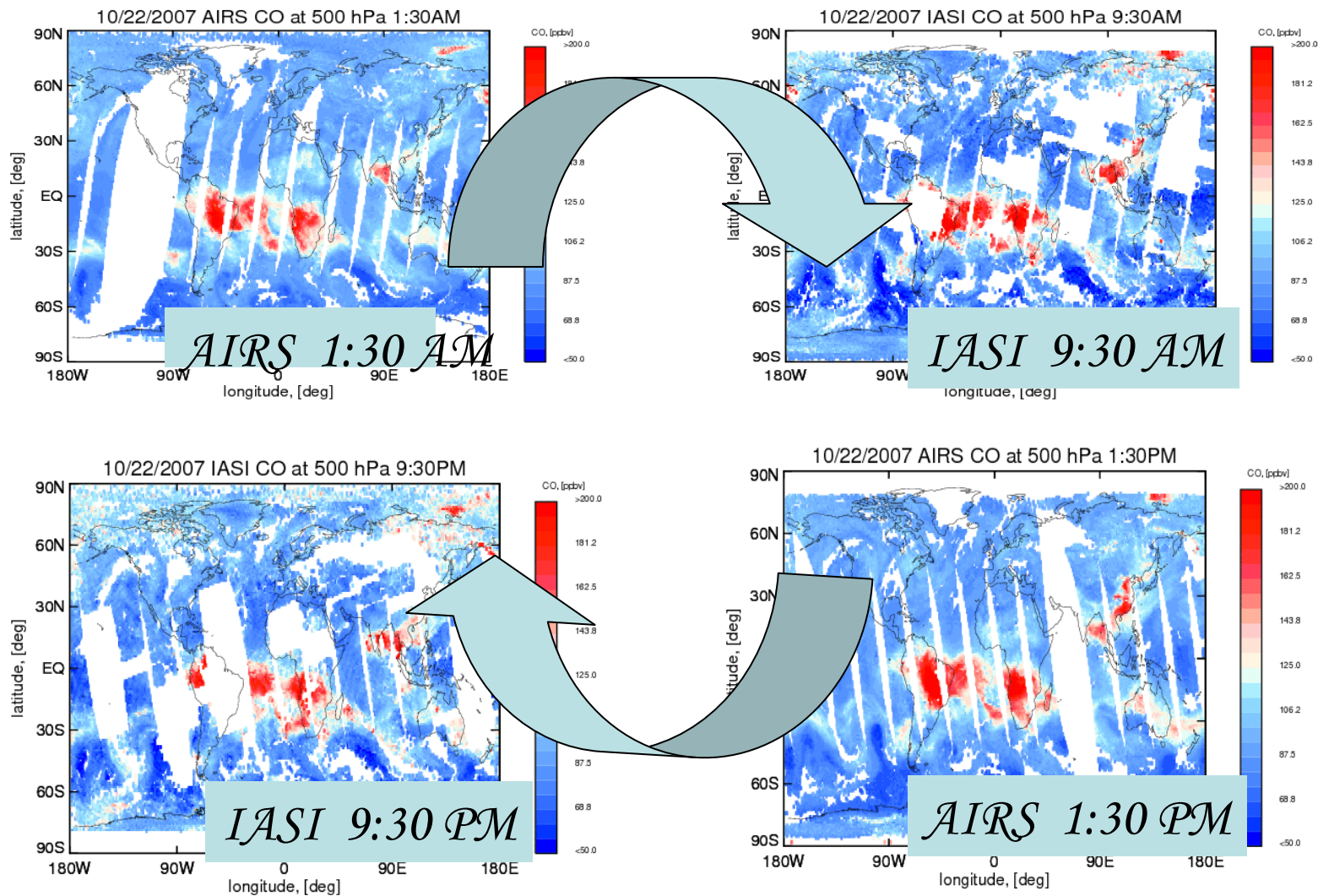
- Enhancement in AIRS methane product is seen in summer months over Asia.
  - Green points is the AIRS methane product
  - Red points are TM3 model provided by Sander Houweling, SRON
- Model agreement suggests methane is transport of local emissions during monsoon season.
- Evidence of strong transport from surface to mid-troposphere.
- AIRS observations confirmed by CARIBIC aircraft measurements
  - Schuck 2010 ACPD v.10 p.2031-2087



Xiong, X., S. Houweling, J. Wei, E. Maddy, F. Sun and C. Barnet, 2009:  
*Methane Plume over South Asia during the monsoon season: satellite observation and model simulation.*  
Atmos. Chem. Phys. 9, p.783-794.



# Interoperable algorithms allow time continuity of IASI & AIRS Carbon Monoxide products





## Challenges

1. Merging data records from satellite instruments with different spatial sampling, spectral samplings and noise characteristics is difficult.
2. Separation of geophysical signals (e.g. clouds, moisture, temperature and CO<sub>2</sub>) and measurement versus modeling uncertainty.
  - All trace gases are dependent on temperature.
  - CO<sub>2</sub> and T(p) are intimately correlated since in the infrared CO<sub>2</sub> absorption is used to derive temperature.
3. Provide assessment of the error characteristics and vertical resolution (information content) of products.
  - Especially important when the trace gas signals we are trying to measure are small.



# NESDIS Satellite Activities for Ozone Climate Data Records

# Climate Data Records for the SBUV(/2) measurement retrievals

The SBUV and SBUV/2 data since 1979 have been used to generate a climate data record more than 30 years in length - reaching true climatology (30 years).

Now we are planning to continue the time series with OMPS.

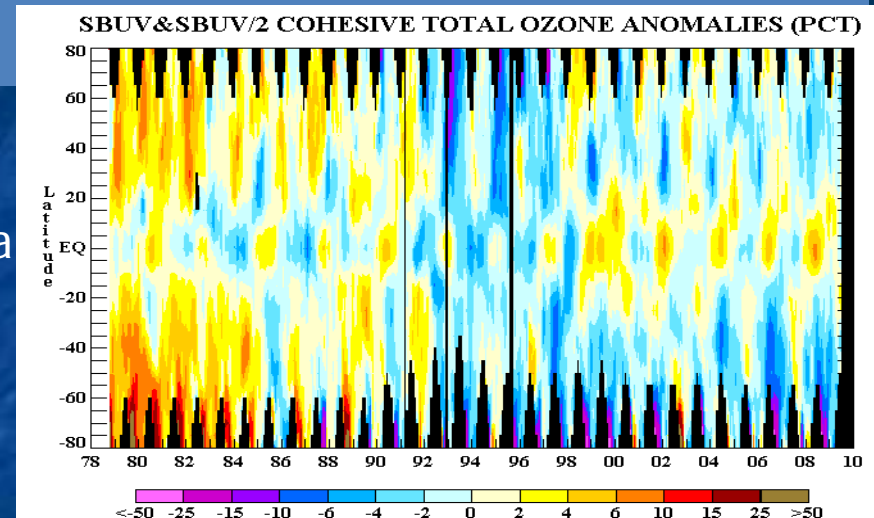


Figure from C. Long *et al.*, [http://www.cpc.noaa.gov/products/stratosphere/sbuv2to/sbuv2to\\_cohesive.shtml](http://www.cpc.noaa.gov/products/stratosphere/sbuv2to/sbuv2to_cohesive.shtml)

**Significance:** The SBUV(/2) ozone CDR's are used to determine and monitor **atmospheric ozone trends and variations**. These are compared to models and other results in creating the international ozone assessments.

The latest report is available at:

[www.esrl.noaa.gov/csd/assessments/2006/](http://www.esrl.noaa.gov/csd/assessments/2006/)

This new data set is being used in the preparing the next assessment due out in 2010.

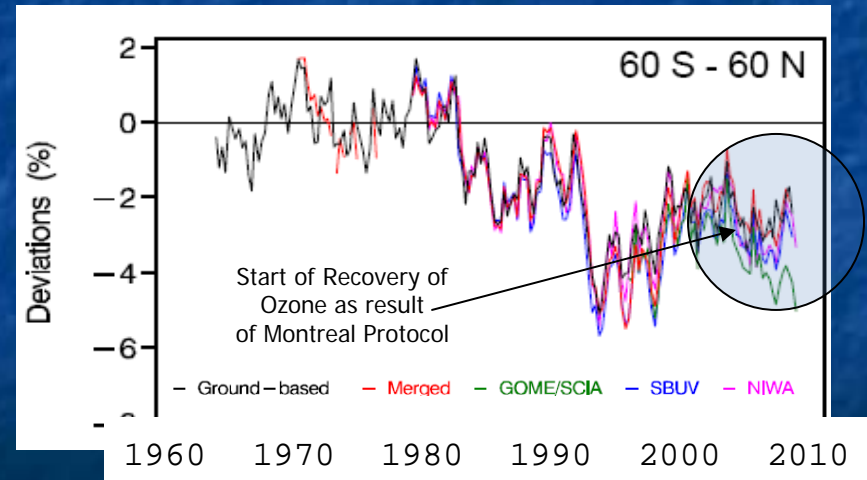


Figure from V. Fioletov *et al.* at the 2008 Quadrennial Ozone Symposium in Tromso Norway showing deseasonalized global mean ozone time series from SBUV(/2) and other sources.





# Extending Ozone Climate Data Records (CDRs) into the Ozone Mapping and Profiler Suite (OMPS) Era

- Source Data
  - OMPS RDRs (Level 0) and SDRs (Level 1) for NPP (L2011), JPSS J1 (L2015), and JPSS J2 (L2021)
- Deliverables
  - Algorithms and systems to reprocess OMPS SDRs and EDRs
  - Product validation and evaluation tools
  - Long-term monitoring of OMPS calibration and characterization
- ECVs addressed
  - Total Column Ozone ECV (+UV reflectivity)
  - Ozone Vertical Profile ECV (Nadir profile and Limb profile)
- Current/expected user communities
  - WMO Assessment, NOAA, EPA, NASA

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# Proposed international cooperation on Ozone CDRs from BUV measurements

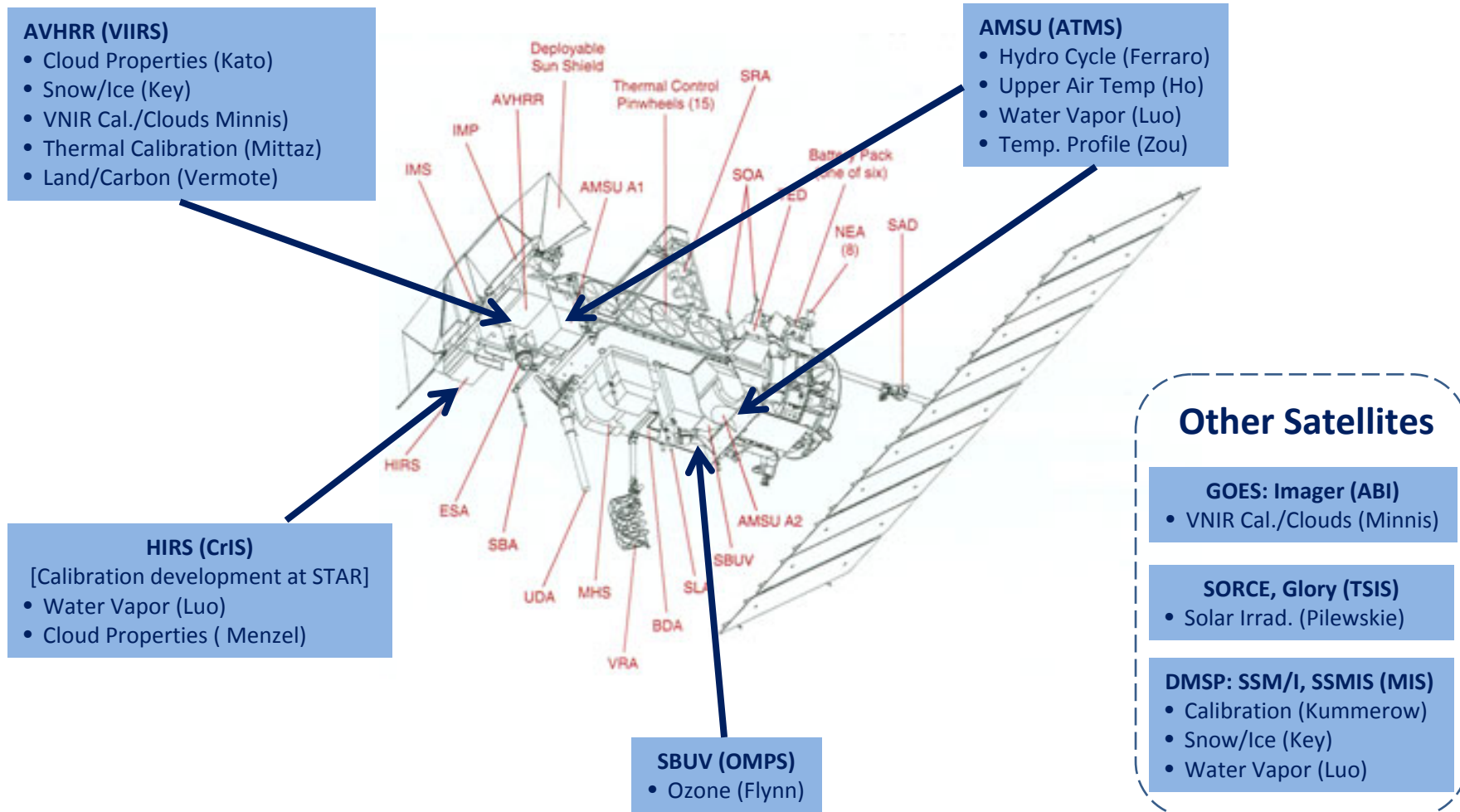
- Comparisons/homogenization of DOAS and TOMS-like total column ozone retrieval products
  - Need to use common sets of standard profiles or provide efficiency factors (column averaging kernels) and profiles
  - Need to revisit forward model comparisons
  - Check performance at high SZAs and large column amounts
- Identification of diurnal variations for profiles
  - Comparisons of profile products (and TOA) at no-local-time-difference latitudes to identify biases
  - Need to use common *a priori* profiles or provide averaging kernels and profiles

# NOAA Climate Data Records (CDR) Program

# Planned CDRs Supported and Maintained by NOAA's CDR Program

- Current
  - Sea Surface Temperature (Daily Optimum Interpolation)
  - CDR Microwave Imager Temperature Fundamental CDR (SSM/I)
  - Global Cloudiness Record Thematic CDR (POES/GOES ISCCP B1)
  - Shortwave Reflectance, Fundamental CDR (AVHRR, Top-of-Atmosphere)
  - Infrared Brightness Temperature, Fundamental CDR (Geostationary, Top-of-Atmosphere)
  - Thermal Sounder Radiance, Fundamental CDR (HIRS)
- Next set in 2011
  - Sea Ice CDR (Passive Microwave)
  - Surface Albedo, Thematic CDR (Geostationary, SCOPE-CM/Govaerts Alg.)
  - Atmospheric Temperature Profile CDR (Christy [A]MSU)
  - Precipitation Rate CDR (GPCP)
  - Aerosol Optical Depth CDR (GACP AVHRR)
  - Outgoing Longwave Radiation CDR (HIRS)
  - Sea Surface Temperature CDR (Pathfinder AVHRR)

# Climate Sensor Coverage CDR Program Grants (future operational CDRs)



Arrows identify key climate instruments

# What NOAA's CDR Program Can Offer to Support the Climate Goals of Other Agencies

1. FCDRs from historical NOAA and DMSP instruments
2. TCDRs (including algorithm theoretical basis documents (ATBDs) of selected historical data sets with initial focus on water and energy cycle CDRs
3. Participation in international efforts to improve climate data quality assurance through intercomparison studies.
4. Federation of data centers and standards for sharing of data and metadata

# What NOAA Would Welcome from Other Space Agencies for Climate Studies

- Coordinate identification of ECV to CRD mapping and evaluation of maturity
- Federated access to historical FCDRs and TCDRs, including ATBDs which describes the algorithm and uncertainties.