NOAA Activities:

Volcanic Ash
Greenhouse Gases
Ozone CDRs
NOAA Program for CDRs

Mitch Goldberg, Chris Barnet, Larry Flynn (NESDIS/STAR)
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 the **Eyjafjallajökull eruption,** The UK VAAC requested NESDIS to provide our GOES-R Volcanic Ash a products routinely

Research to Operations in a Flash!!

For details on the algorithm or interest in collaboration please contact Mike.Pavolonis@noaa.gov

Early Role of the GOES-R Volcanic Ash Products

April 14: beginning of explosive ash producing eruption. ***We began regularly distributing the GOES-R ash products to the operational and research community via an e-mail list.***

April 15 - April 23: Significant airspace restrictions over Europe. ***The GOES-R products show the evolution of the ash cloud and are featured on NOAA web pages.***

April 19: ***UK Met Office requests real-time GOES-R volcanic ash products (using SEVIRI).***

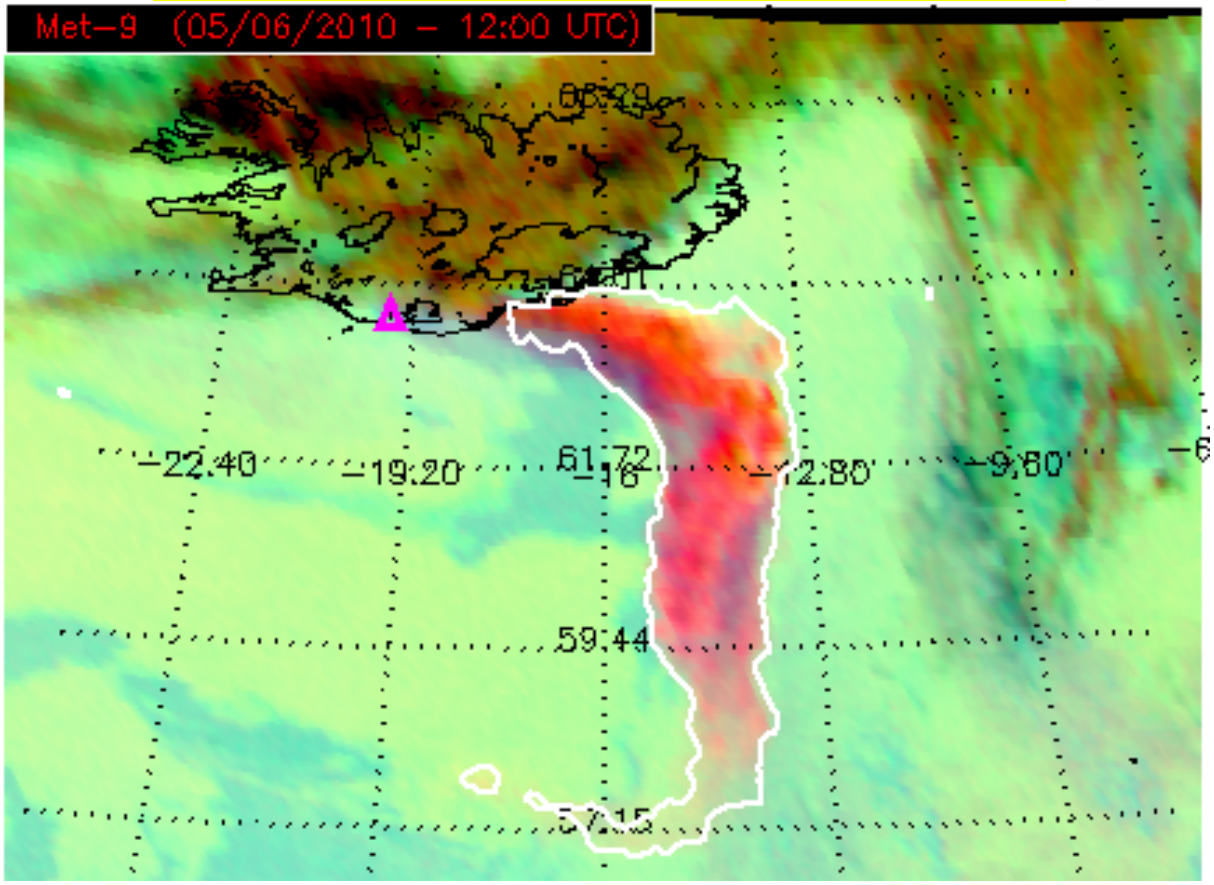
April 20: STAR submits statement on climate impact. ***The GOES-R products played a role in the assessment.***

April 21:GE Aviation releases preliminary safe operating threshold. ***The 2 mg/m^3 threshold is within the GOES-R algorithm sensitivity range.***

April 22: ***GOES-R ash products are generated in real-time and displayed on the web.***

The GOES-R Volcanic Ash Products

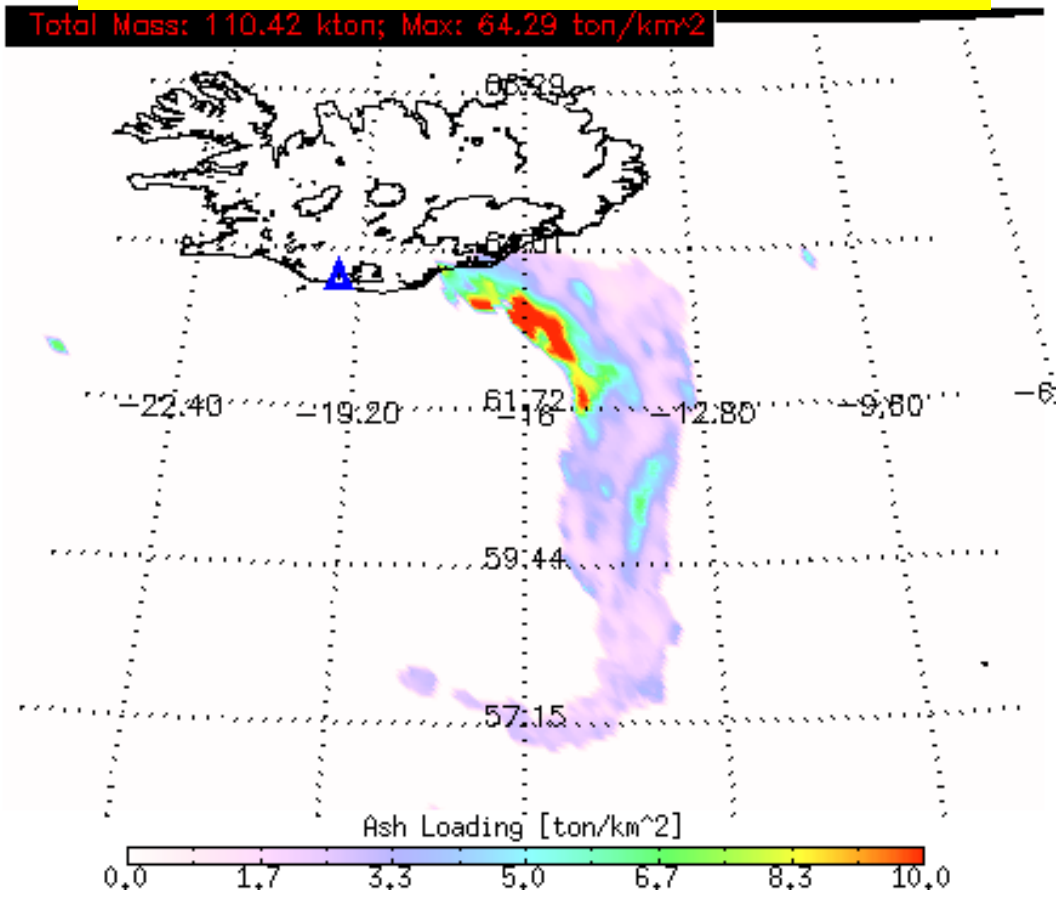
Quantitative Ash Detection



- 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

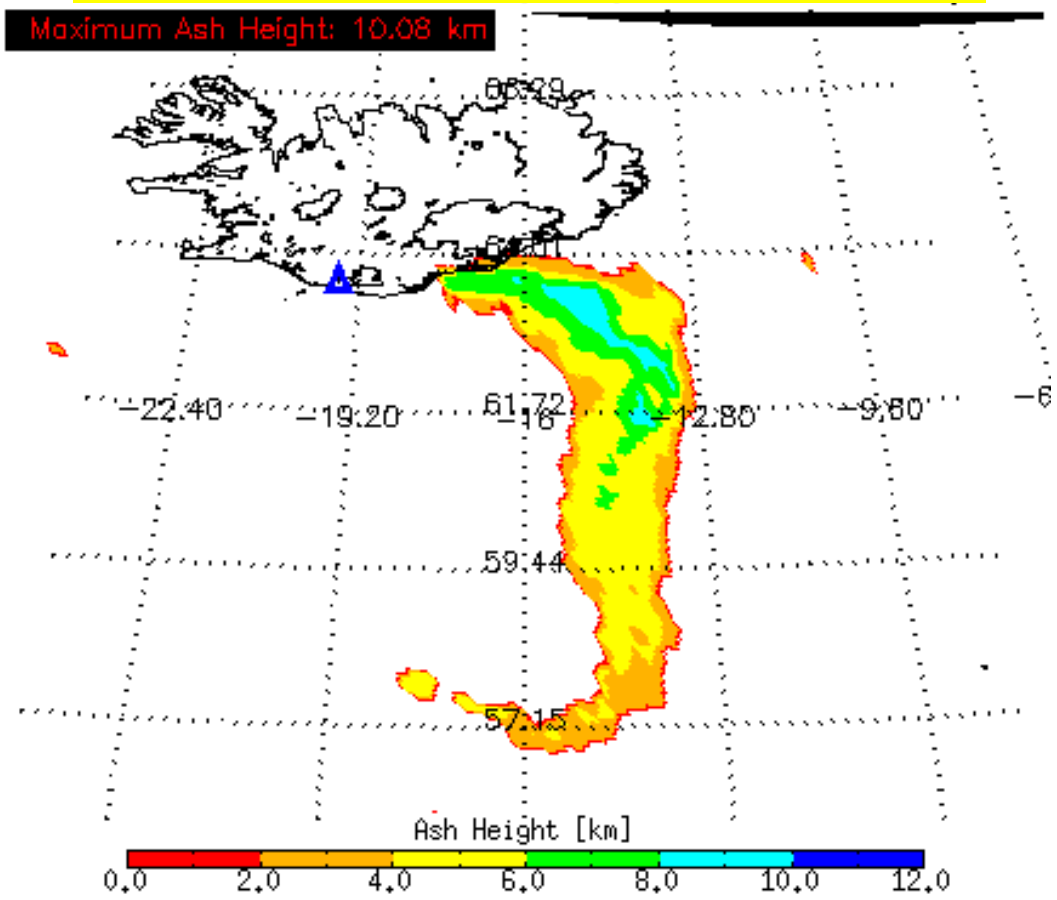
Ash Mass Loading



- Ash mass loading (ton/km^2) 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^3.

The GOES-R Volcanic Ash Products

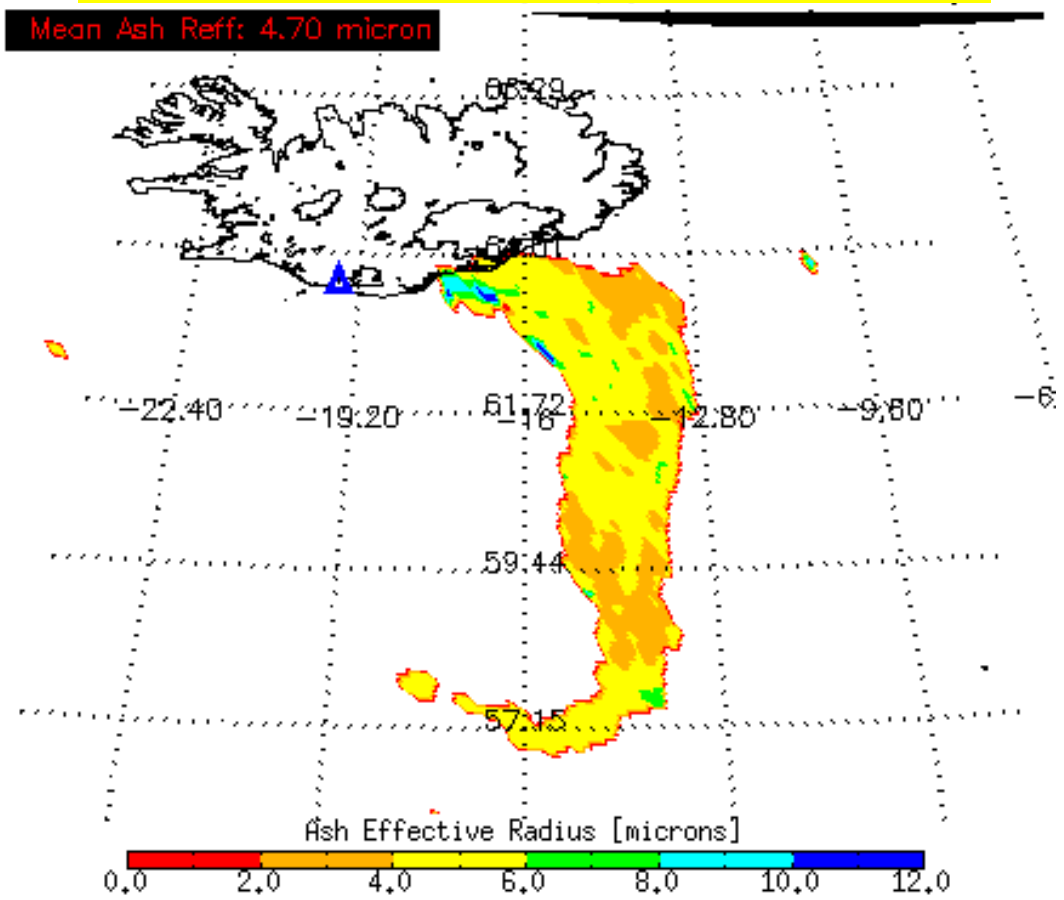
Ash Cloud Height



- 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).

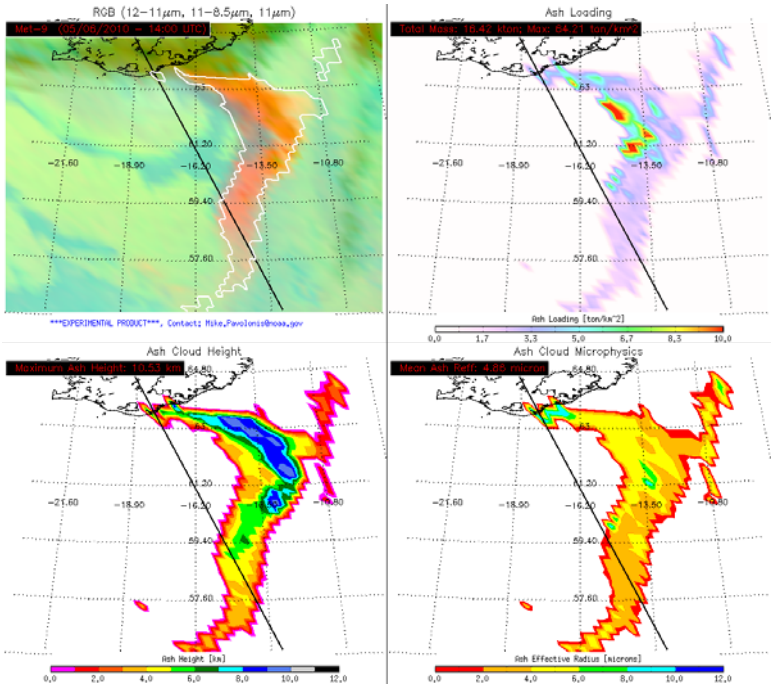
The GOES-R Volcanic Ash Products

Ash Effective Radius



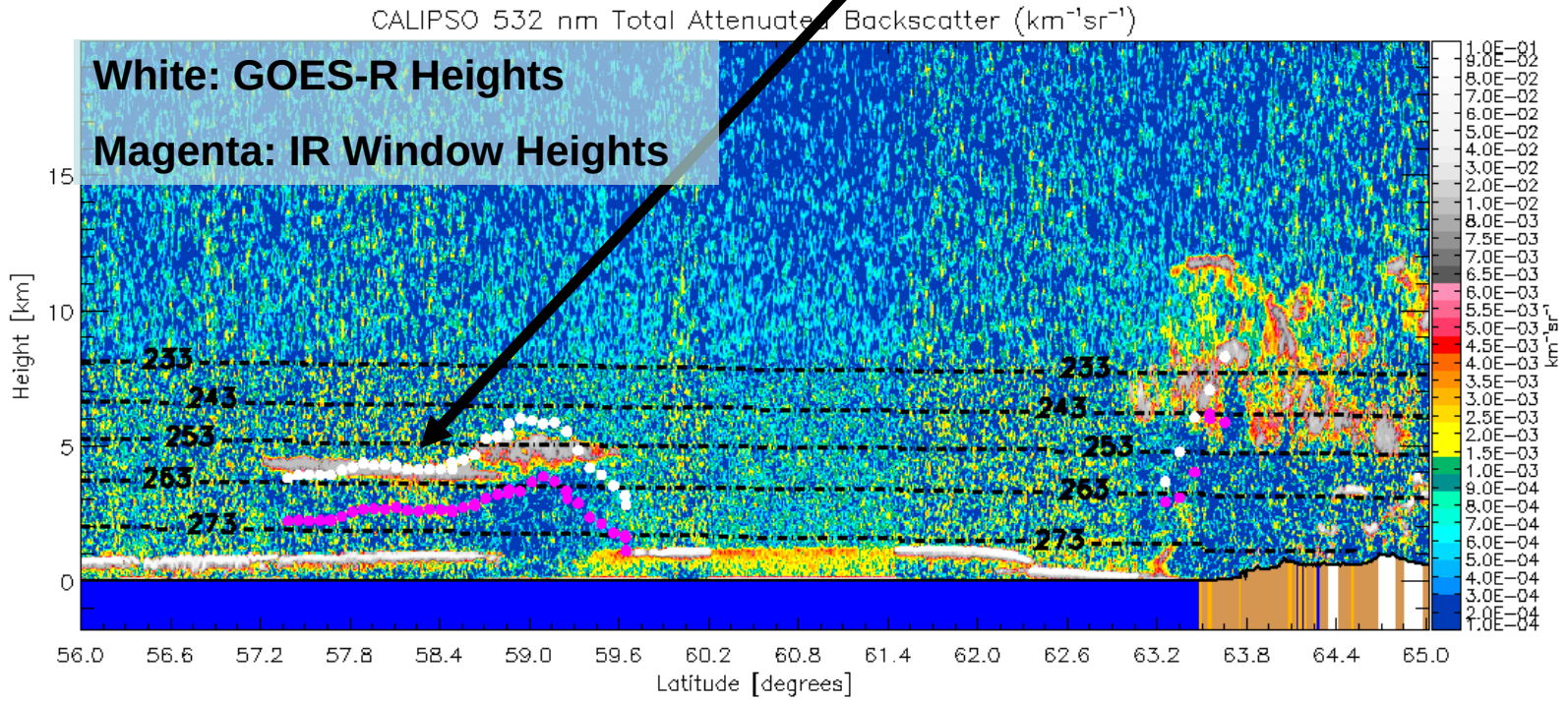
- The ash cloud effective particle radius is not a required product, but it is automatically generated as part of the ash retrieval.
- Since the effective particle radius is well correlated with ash residence time, we will retain this information in quality flag form.

May 6, 2010 (14:00 UTC)

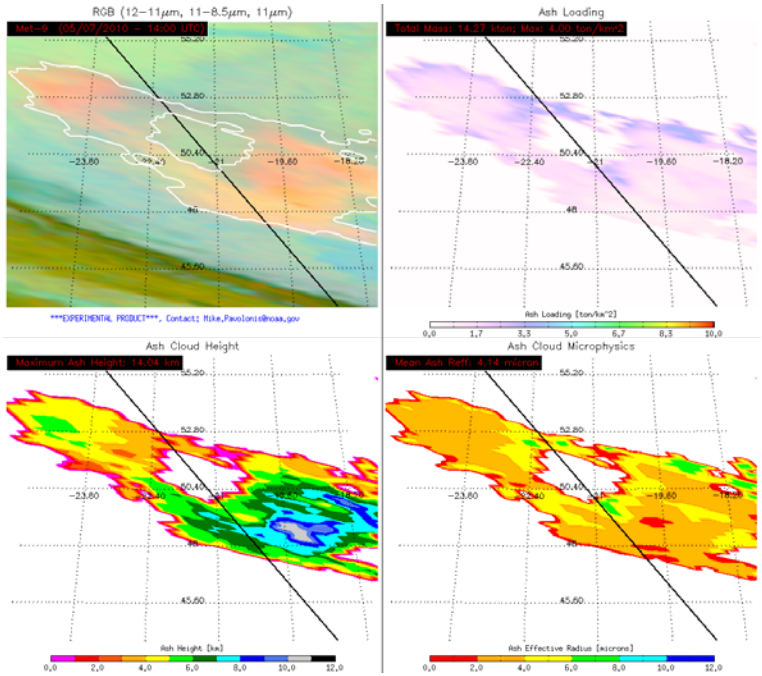


The GOES-R ash cloud heights closely match the CALIPSO cloud top boundary.

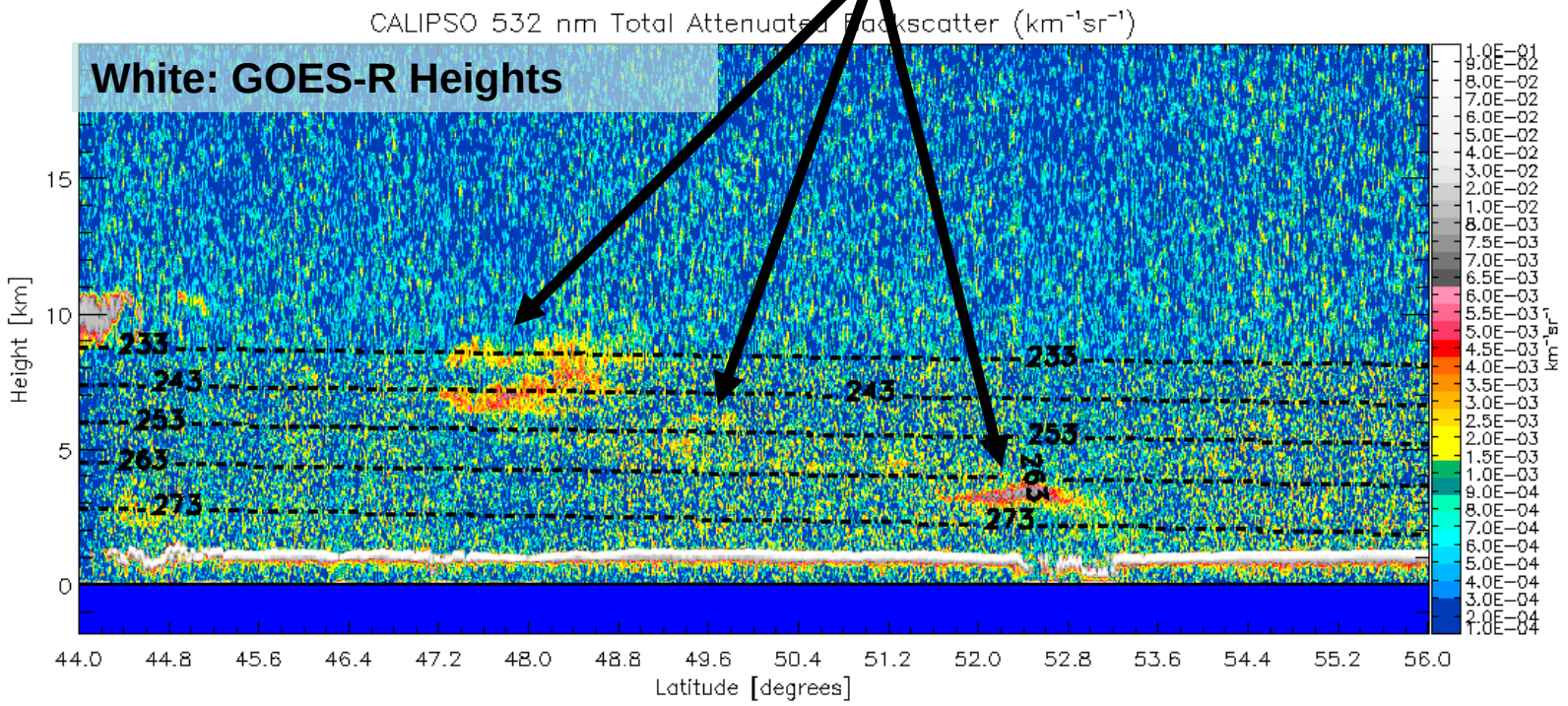
Ash cloud



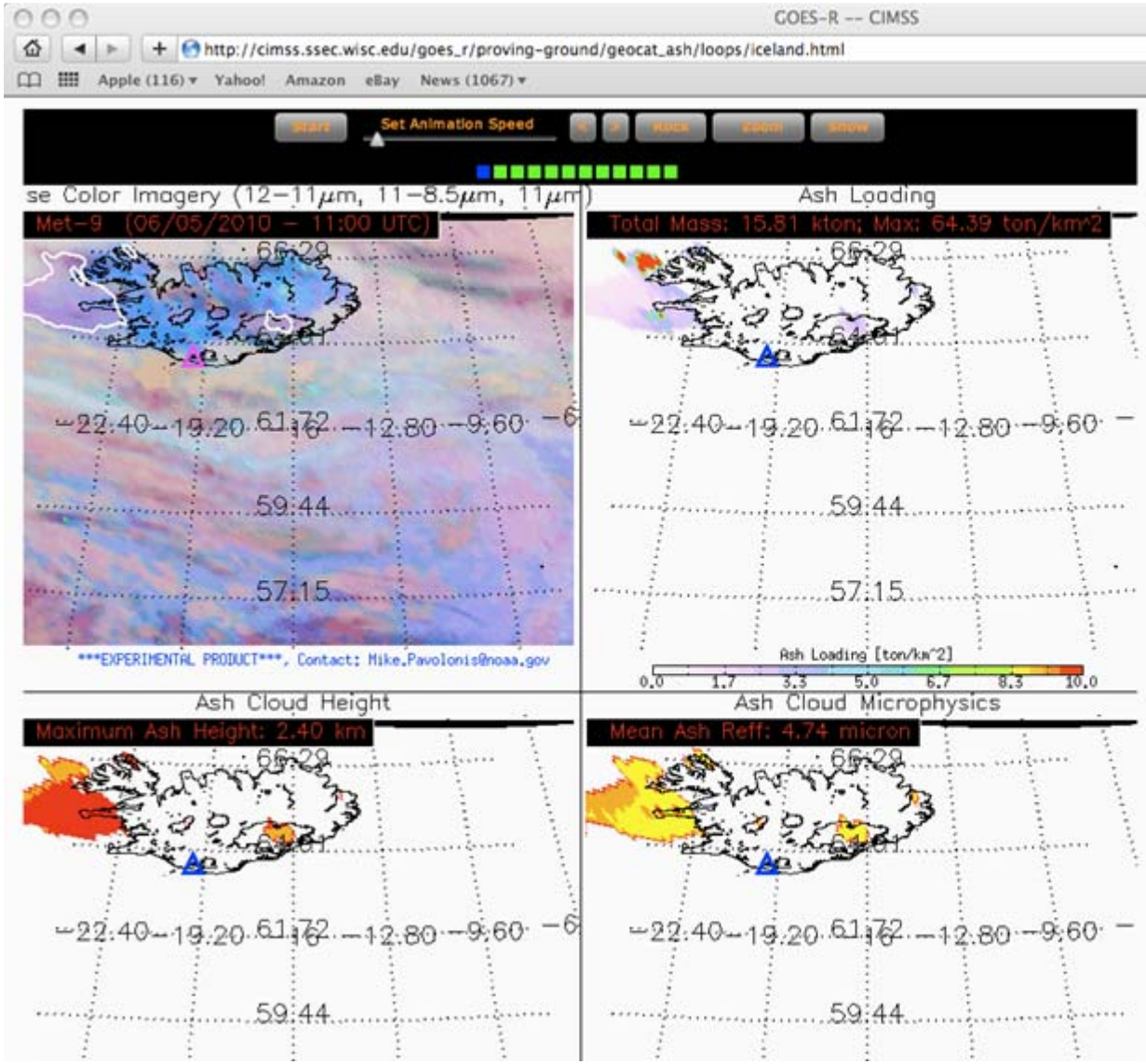
May 7, 2010 (14:00 UTC)



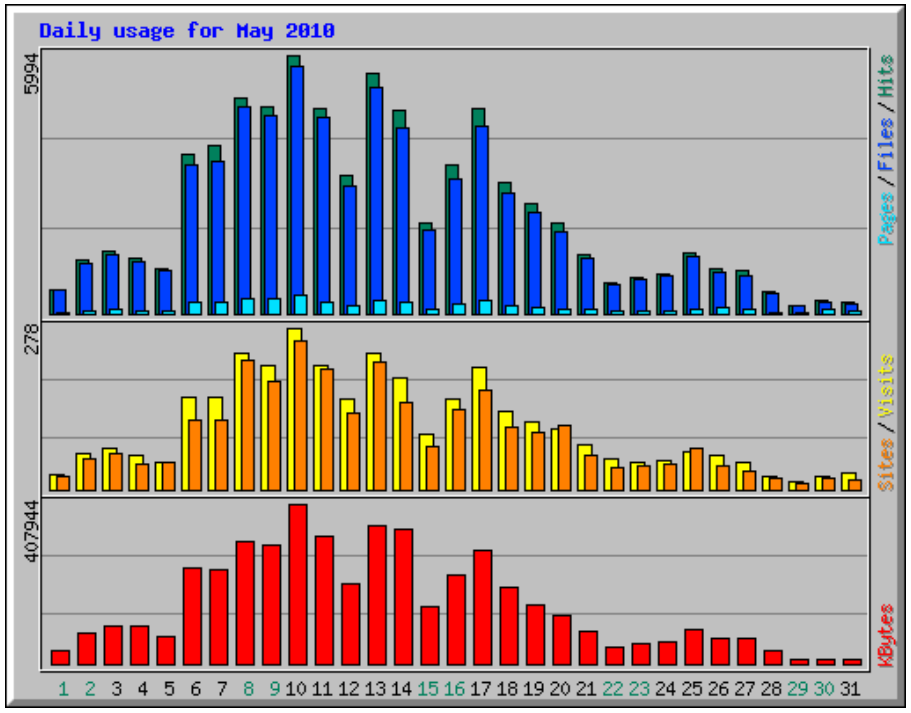
Ash clouds

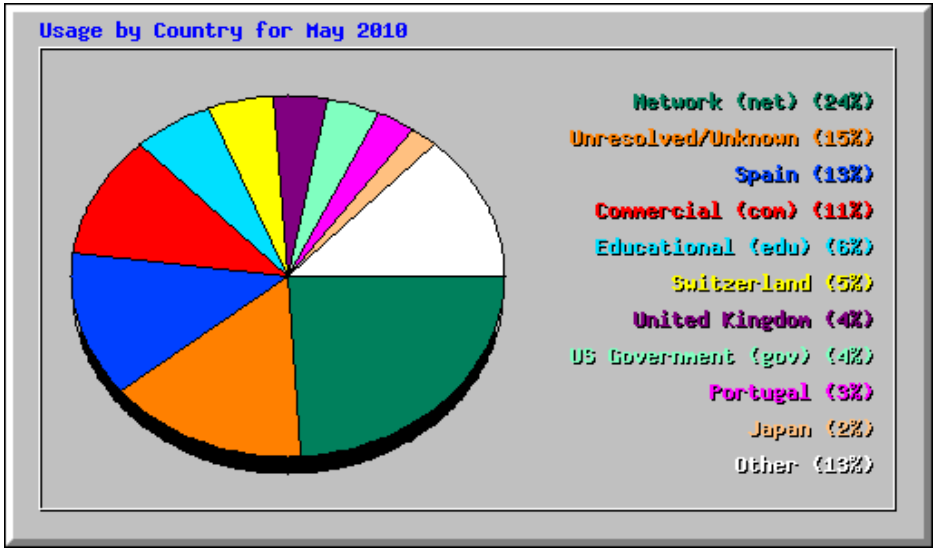


http://cimss.ssec.wisc.edu/goes_r/proving-ground/geocat_ash/



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

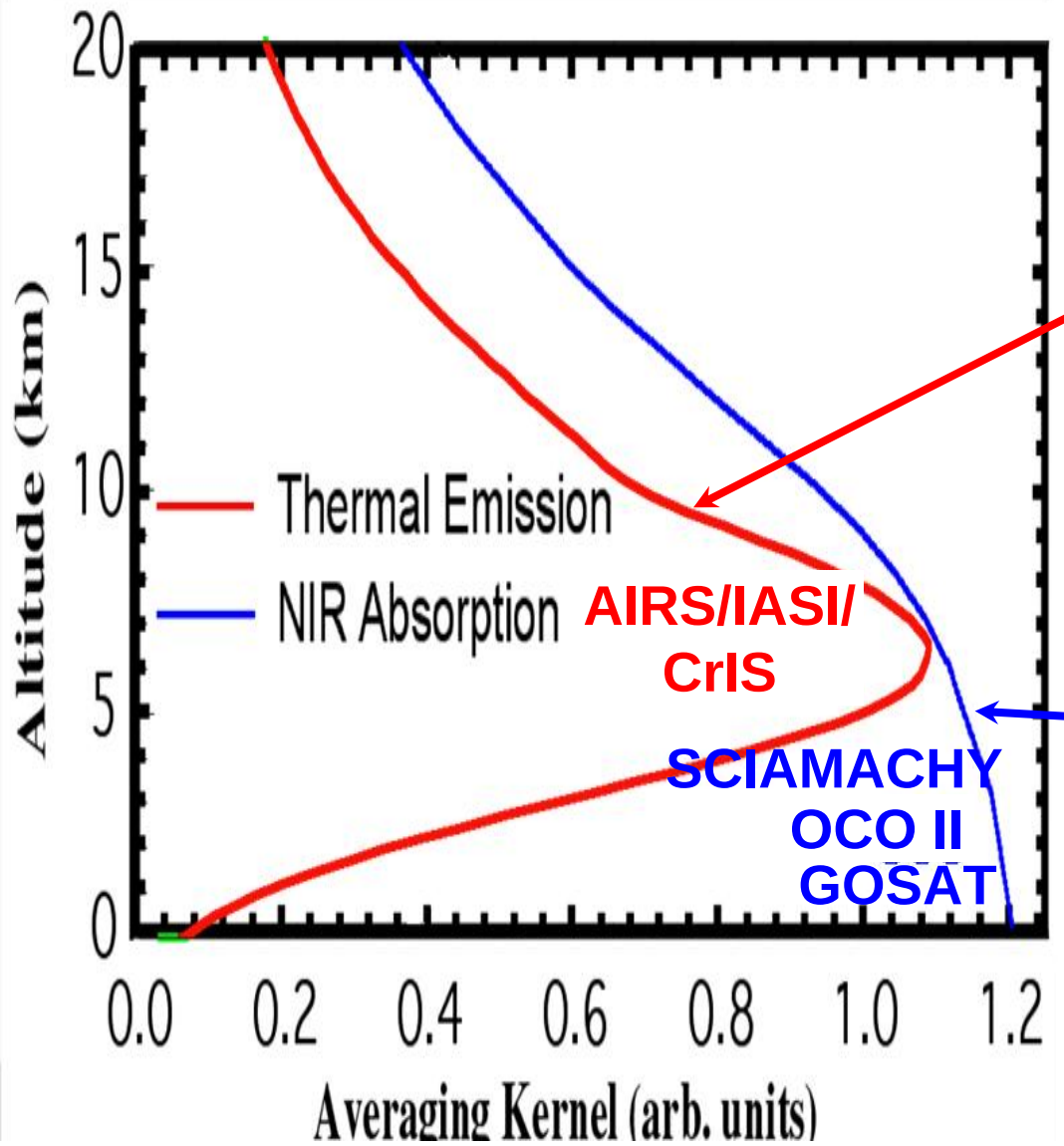
- AFWA
- Airline Pilots Association
- Aviation Weather Testbed
- CALIPSO Science Team
- Deutscher Wetterdienst Remote Sensing Division
- NOAA OAR ESRL
- Iceland Met Office
- Italian Civil Protection
- MISR Science Team
- Norwegian Institute for Air Research
- Norwegian Meteorological Institute
- UK Met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

Marco Fulle - www.stromboli.net

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

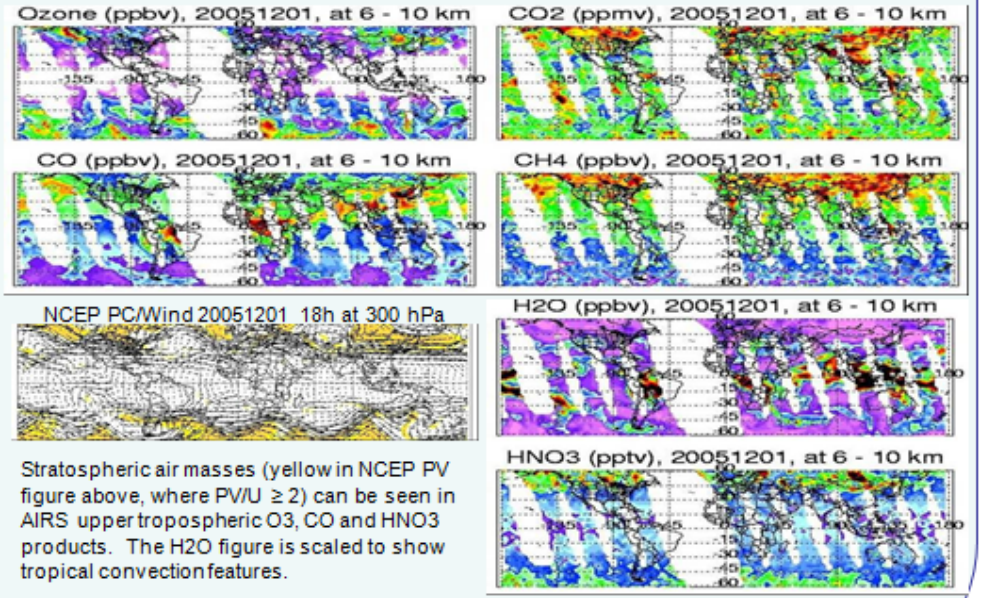


- Thermal instruments (e.g., AIRS, IASI, CrIS) measure mid-tropospheric column
  - Peak of vertical weighting is a function of T profile and water profile and ozone profile.
  - Age of air is on the order of weeks or months.
  - Significant horizontal and vertical displacements of the trace gases from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

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_2O	15%	4-6	NASA DAAC	NGDC/CLASS
O_3	10%	1+	NASA DAAC	NGDC/CLASS
CO	15%	≈ 1	NASA DAAC	NGDC/CLASS
CH_4	1.5%	≈ 1	NASA DAAC	NGDC/CLASS
CO_2	0.5%	≈ 1	NOAA NESDIS	NGDC/CLASS
Volcanic SO_2	50% ??	< 1	TBD	TBD
HNO_3	50% ??	< 1	NOAA NESDIS	NGDC/CLASS
N_2O	5% ??	< 1	NOAA NESDIS	NGDC/CLASS



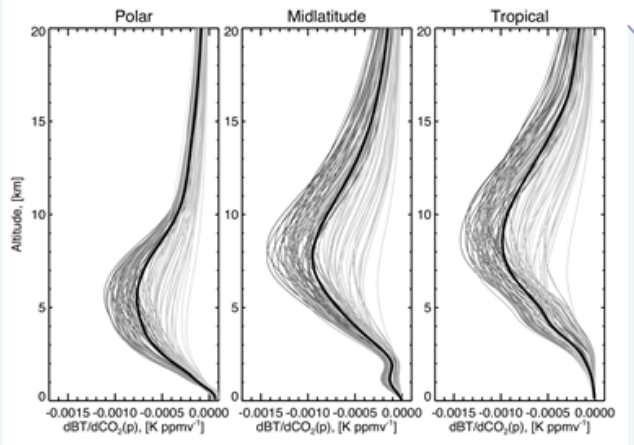
Stratospheric air masses (yellow in NCEP PV figure above, where PV/U ≥ 2) can be seen in AIRS upper tropospheric O3, CO and HNO3 products. The H2O figure is scaled to show tropical convection features.

NOAA Proposal to JAXA Second Research Announcement

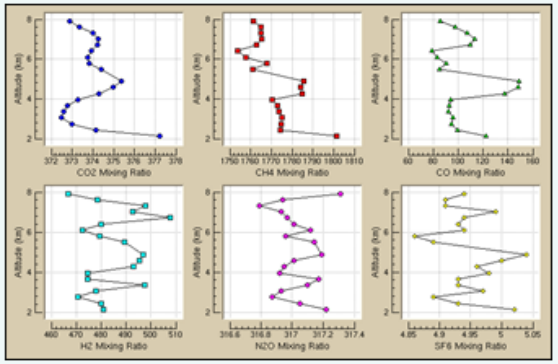
- To provide cross-validation of GOSAT/TANSO products with NOAA/NESDIS/STAR operational AIRS and IASI products (waiting for go-ahead from JAXA on readiness of their products)
- To improve the retrieval of total column of CH_4 and CO_2 based solely on TIR measurements.
- To enable a better understanding of the strengths and weaknesses of TIR, SWIR and combined TIR/SWIR retrieval strategies in determining the spatial-temporal variation of CO_2 and CH_4 in the atmosphere.

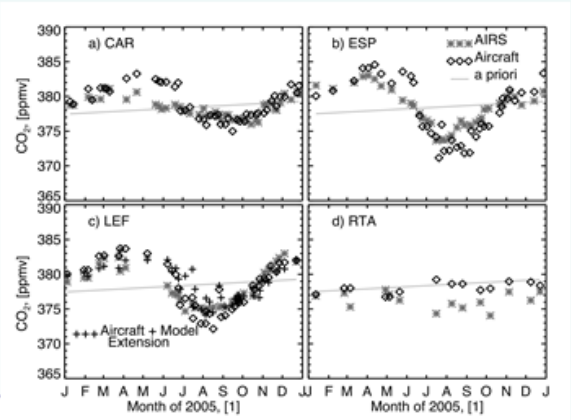
Validation

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 CO2



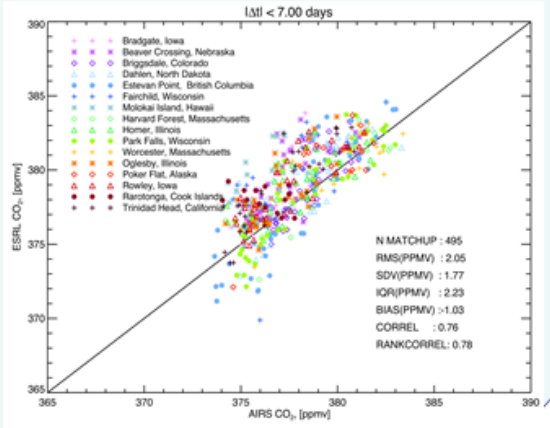
The best in-situ validation products are gas flask samples taken during aircraft flights. The NOAA/ESRL monitoring network provides high precision vertical profiles for a number of locations



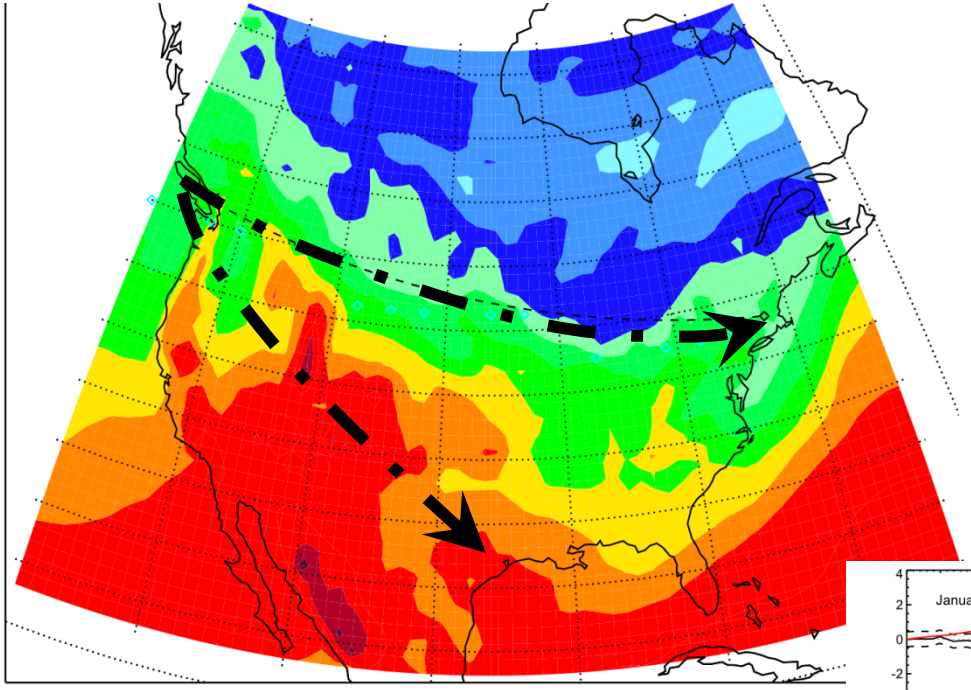


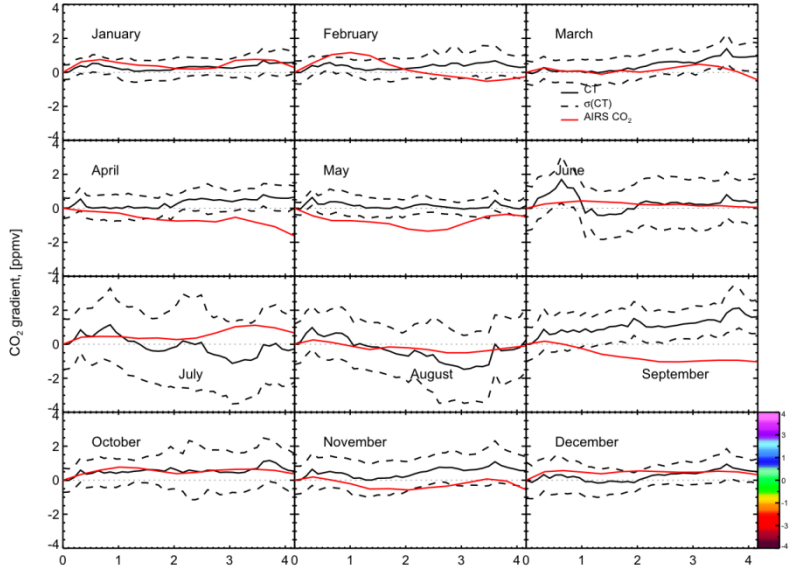
Comparison of AIRS CO2 product with aircraft measurements at 4 ESRL sites shown as a function of time (left)

and as a scatter plot for all ESRL sites (right)



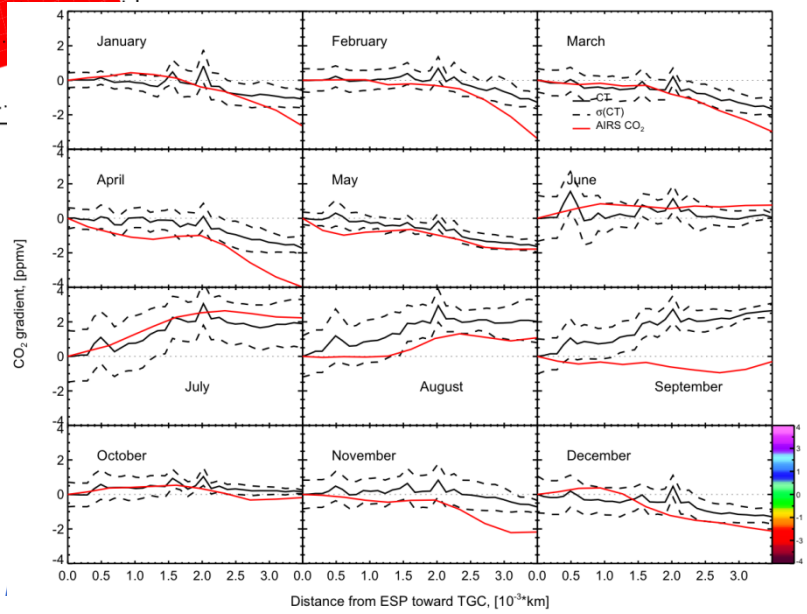
NOAA CarbonTracker Upper Troposphere CO2 Gradient Over N. America Relative to NW US For July



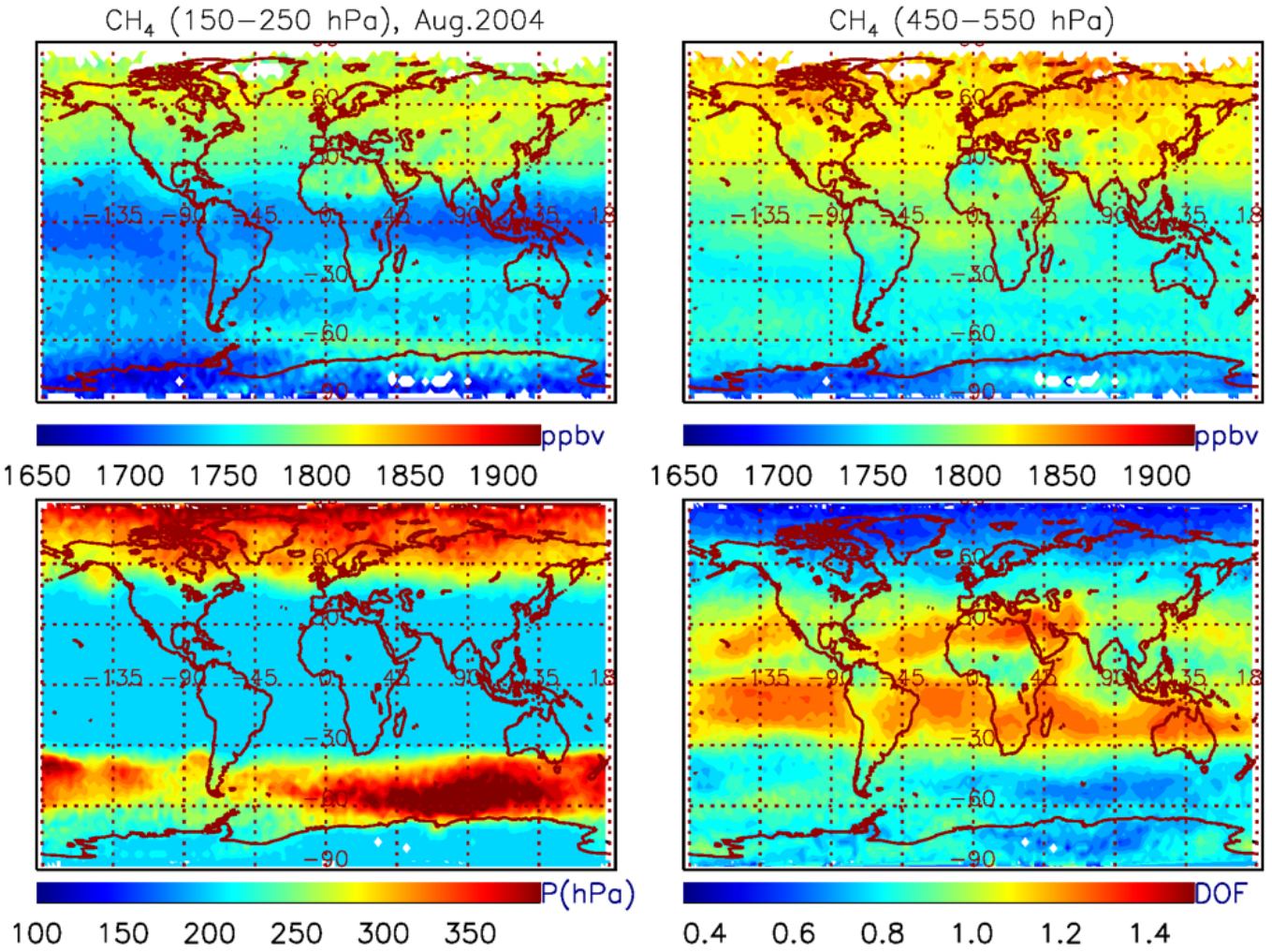


(Above) Comparison of Monthly Average **AIRS** and **CarbonTracker** Gradients From Northwest US to Massachusetts

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



AIRS Provides Middle/Upper Tropospheric CH4 Information



Peak Pressure of Sensitivity

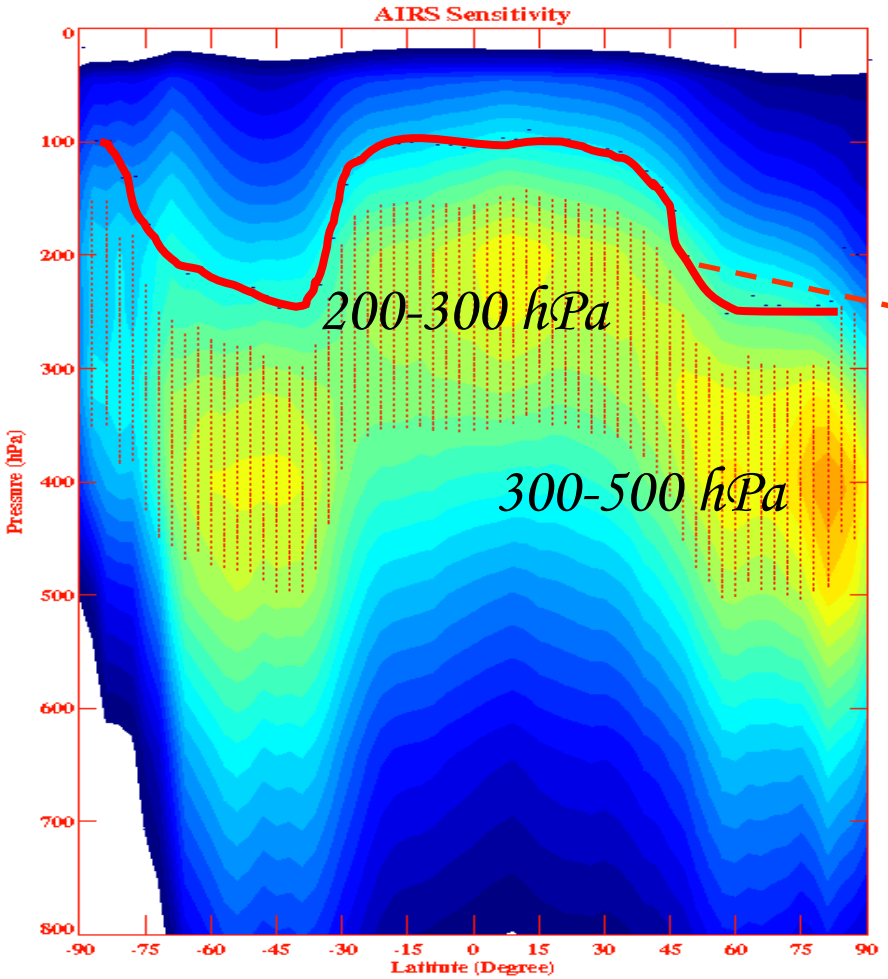
Degrees of Freedom

Xiong et al., JGR-B, 2007

Most sensitive layers of AIRS to CH4

(mapping based on area of averaging kernels)

AIRS CH_4
DOF ≈ 1



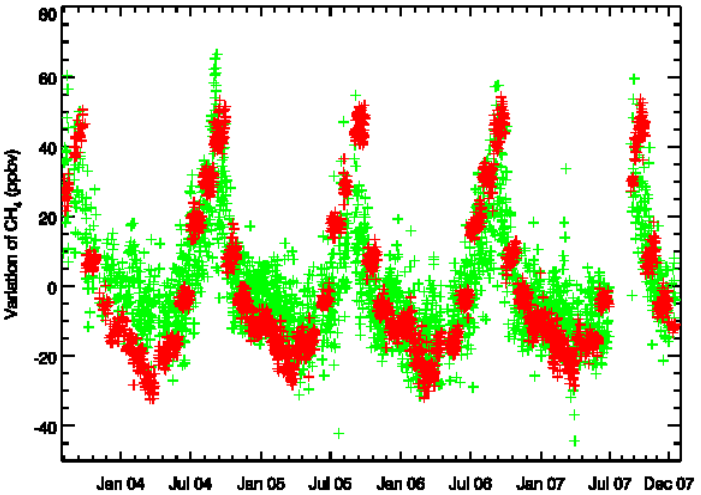
Thermal Tropopause

"Effective Layers"
50 ~ 250 hPa
below Tropopause

Xiong, X., C. Barnet, J. Wei, and E. Maddy, Information-Based Mid-Upper Tropospheric Methane Derived from Atmospheric Infrared Sounder (AIRS) and Its Validation, ACPD, V9, 4, 2009, pp.16331-16360

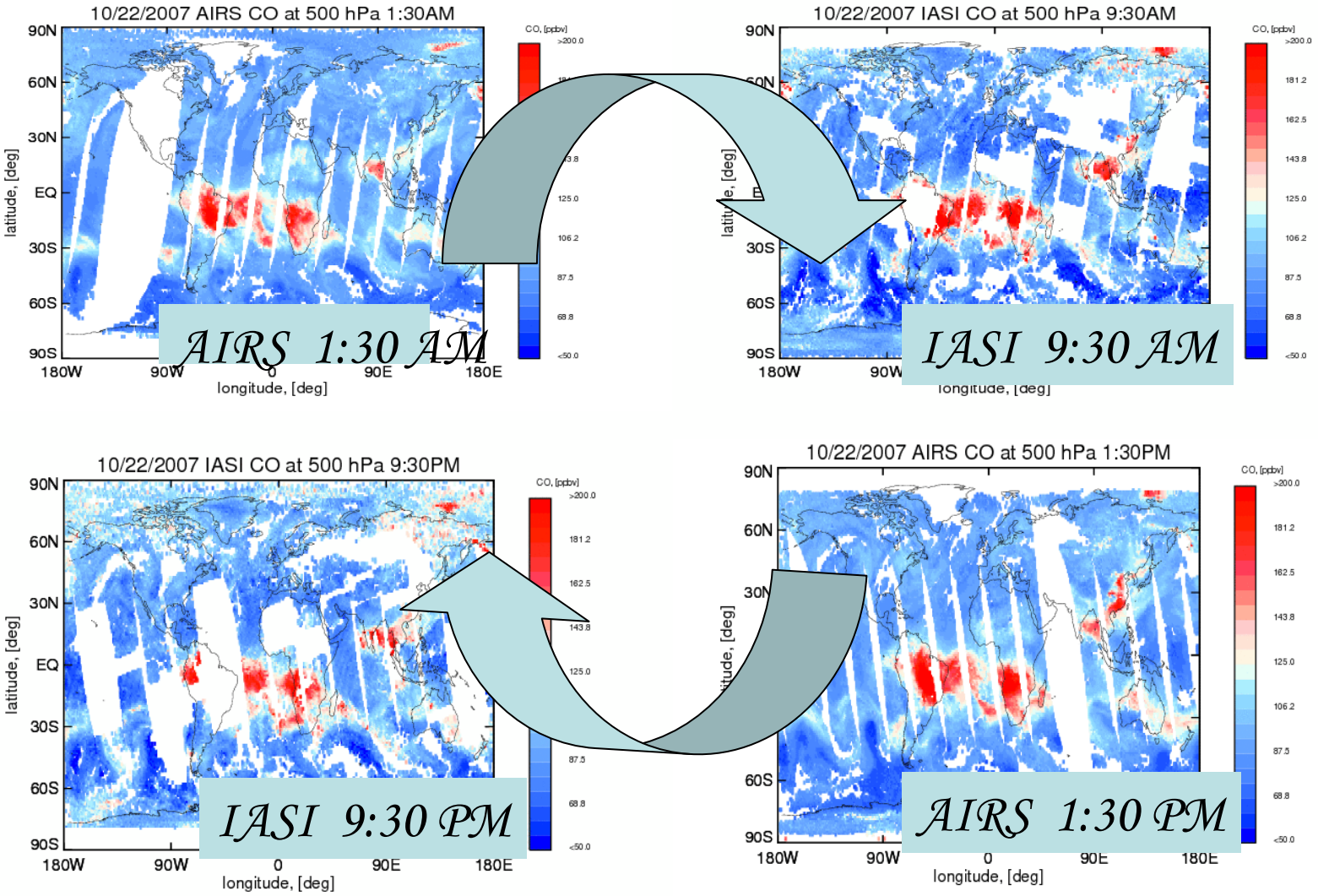
AIRS observes methane variability over Asia

- 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.



Xiong, X., S. Houweling, J. Wei, E. Maddy, F. Sun and C. Barnet, 2008: *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 CO2) and measurement versus modeling uncertainty.
   - All traces gases are dependent on temperature.
   - CO2 and T(p) are intimately correlated since in the infrared CO2 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.

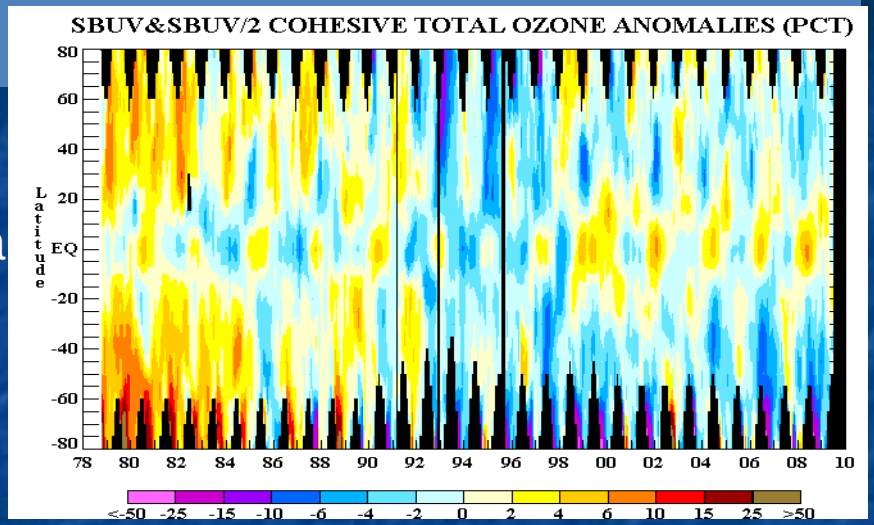


Figure from C. Long *et al.*, http://www.cpc.noaa.gov/products/stratosphere/sbuv2to/sbuv2to_cohesive.shtml

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

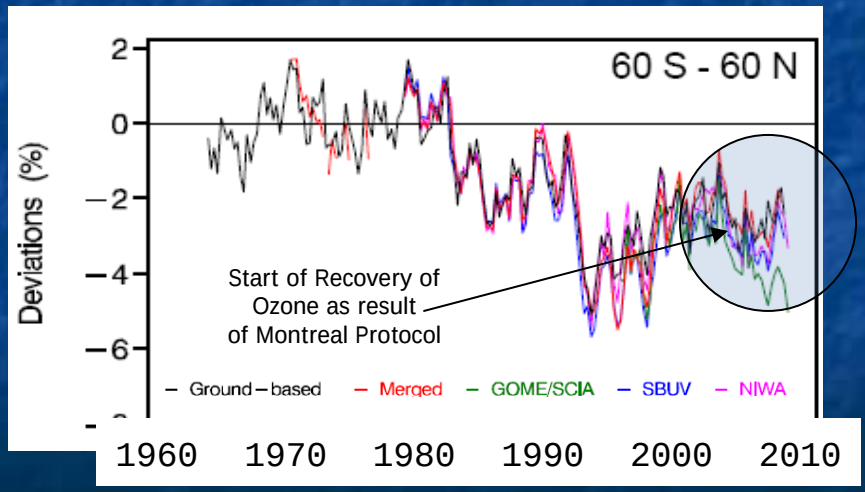


Figure from V. Fioletov et al. at the 2008 Quadrennial Ozone Symposium in Tromso Norway showing deseasonalized global mean ozone time series from SBUV(/2) and other sources.

Project Lead: Lawrence Flynn

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

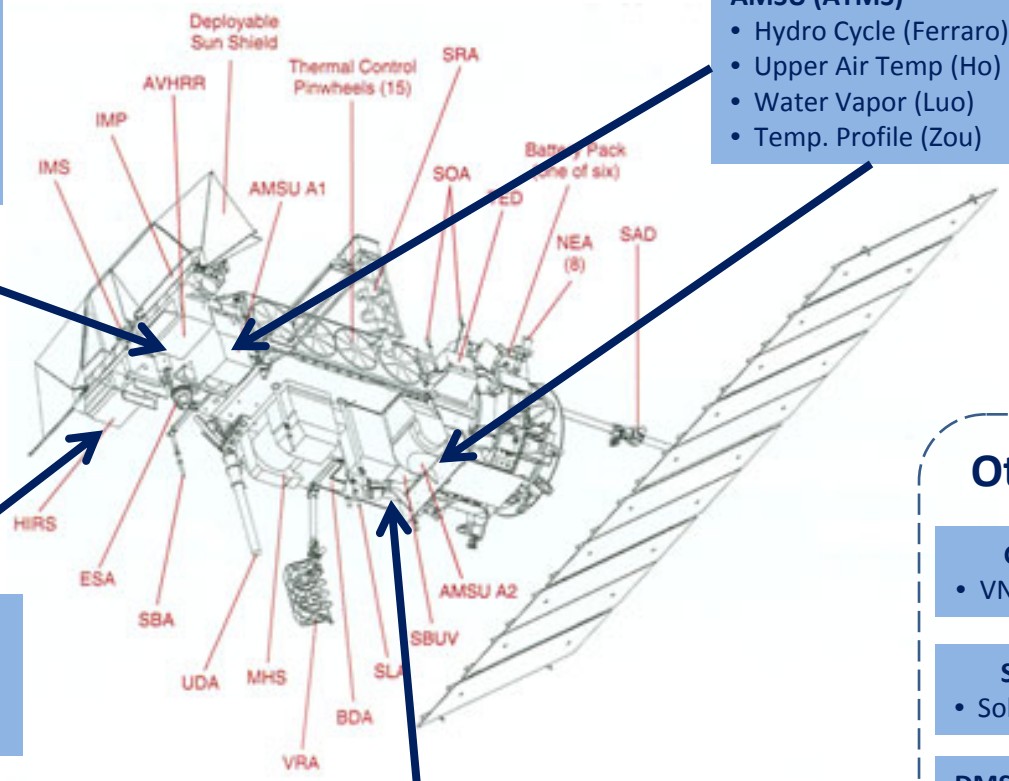
Planned CDRs Supported and Maintained by NOAA's CDR Program

- 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)

AVHRR (VIIRS)
- Cloud Properties (Kato)
- Snow/Ice (Key)
- VNIR Cal./Clouds Minnis)
- Thermal Calibration (Mittaz)
- Land/Carbon (Vermote)

AMSU (ATMS)
- Hydro Cycle (Ferraro)
- Upper Air Temp (Ho)
- Water Vapor (Luo)
- Temp. Profile (Zou)



HIRS (CrIS)
[Calibration development at STAR]
- Water Vapor (Luo)
- Cloud Properties (Menzel)

SBUV (OMPS)
- Ozone (Flynn)

Other Satellites

GOES: Imager (ABI)
- VNIR Cal./Clouds (Minnis)

SORCE, Glory (TSIS)
- Solar Irrad. (Pilewskie)

DMSP: SSM/I, SSMIS (MIS)
- Calibration (Kummerow)
- Snow/Ice (Key)
- Water Vapor (Luo)

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.