Atmospheric Remote Sensing

Climate Applications and Remote Sensing (CARS) and Tropospheric Remote Sensing and Air Quality (TRAQ)

M. Patrick McCormick

Hampton University

NOAA CREST Technical Meeting

December 7- 8, 2009

Silver Spring, MD

NOAA's Strategic Initiative

- The atmosphere remote-sensing research projects specifically pursue answers to questions that are related to this NOAA strategic initiative
    - How is stratospheric ozone changing as the abundance of ozone-destroying chemicals decreases?
    - How do atmospheric constituents respond to climate and chemical change?
    - To what extent can future atmospheric chemical impacts be assessed?

- These projects support the NOAA-NESDIS “Climate Observations and Analysis” program, which is executed to meet the NOAA’s Strategic Goal to: “Understand Climate Variability and Change to Enhance Society’s Ability to Plan and Respond”.

- These activities support NOAA’s remote sensing technology mission responsibilities, and provide applied research to ensure the quality, reliability, and accuracy of current and future satellite products and services to support the NOAA mission goals.

Climate Applications and Remote Sensing Participants

CREST Researchers:		NOAA Scientists:	
John Anderson	HU	Lawrence Flynn	NESDIS
Stanislav Kireev	HU	Shobha Kondragunta	NESDIS
Robert Loughman	HU	Paul Menzel	CIMSS
M. Patrick McCormick	HU	Irina Petropavlovskikh	CERES
Hovakim Nazaryan	HU		
James M. Russell III	HU		
Bill Smith	HU		
Omar Torres	HU		

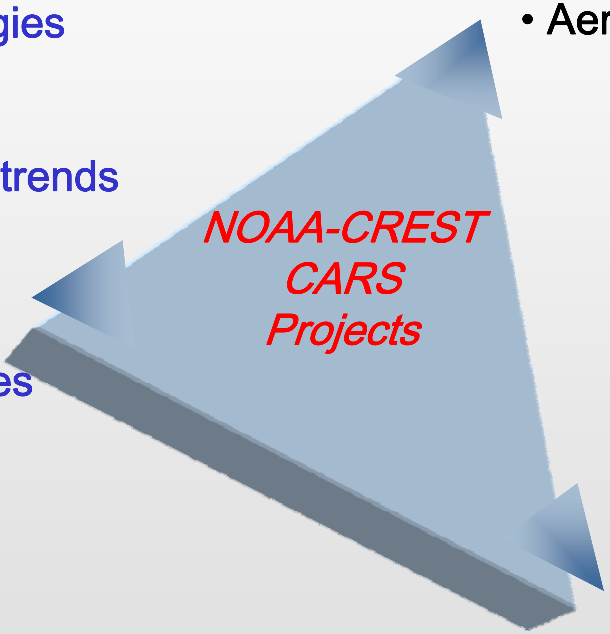
4 Post-docs

Mike Hill, Jia Su, Hiren Jethva, Ping-Ping Rong

Climate Applications and Remote Sensing

Satellite Validation :
- NOAA Aerosol Products
- CALIPSO
- Version 8 SBUV/2 Retrievals
- SBUV/2 ozone data
- Aerosol retrievals

Data Analysis:
- Develop trace-gas climatologies and determine trends
- Develop global aerosol climatologies and determine trends
- Develop global cirrus cloud climatologies
- PSC and PMC Studies
- CALIPSO and A-Train Studies



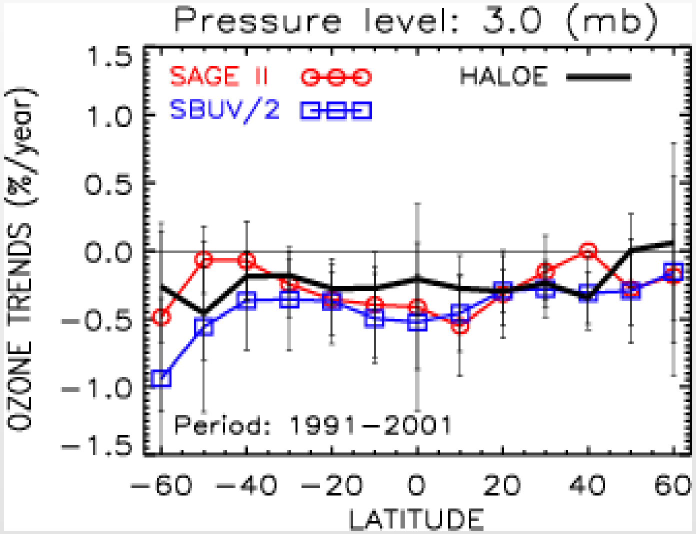
Algorithm Development :
- Limb Scattering
- Develop SBUV/2 operational algorithm
- Umkehr

Data Analysis

Continued Trend Analysis of the Ozone Retrievals Obtained by SBUV/2 Experiments

Dr. Hovakim Nazaryan

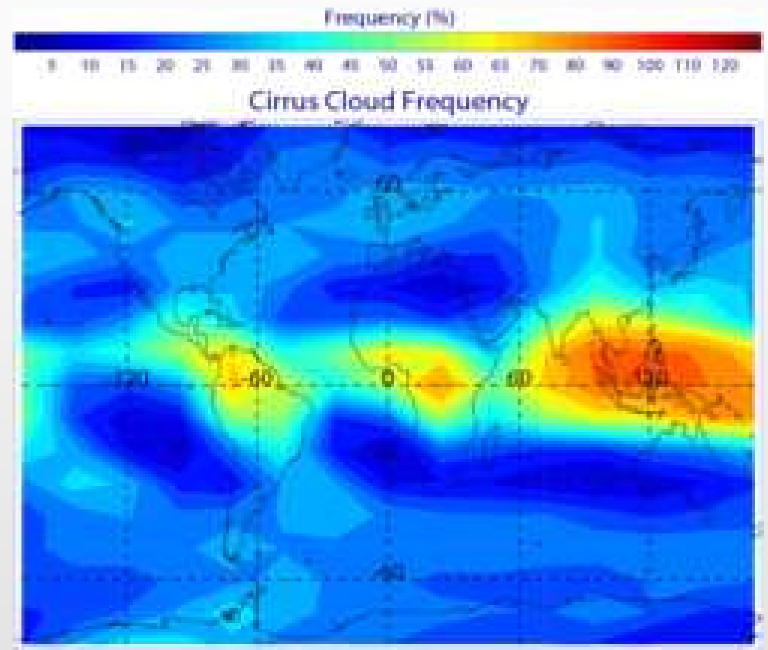
- Trend analysis of the ozone profiles obtained by the SBUV/2, SAGE II, and HALOE instruments
- Compare ozone trends obtained from different experiments
- Examine performance of the NOAA SBUV/2 instruments
- NOAA Collaborators: Lawrence Flynn



Development of Cirrus Cloud Climatology

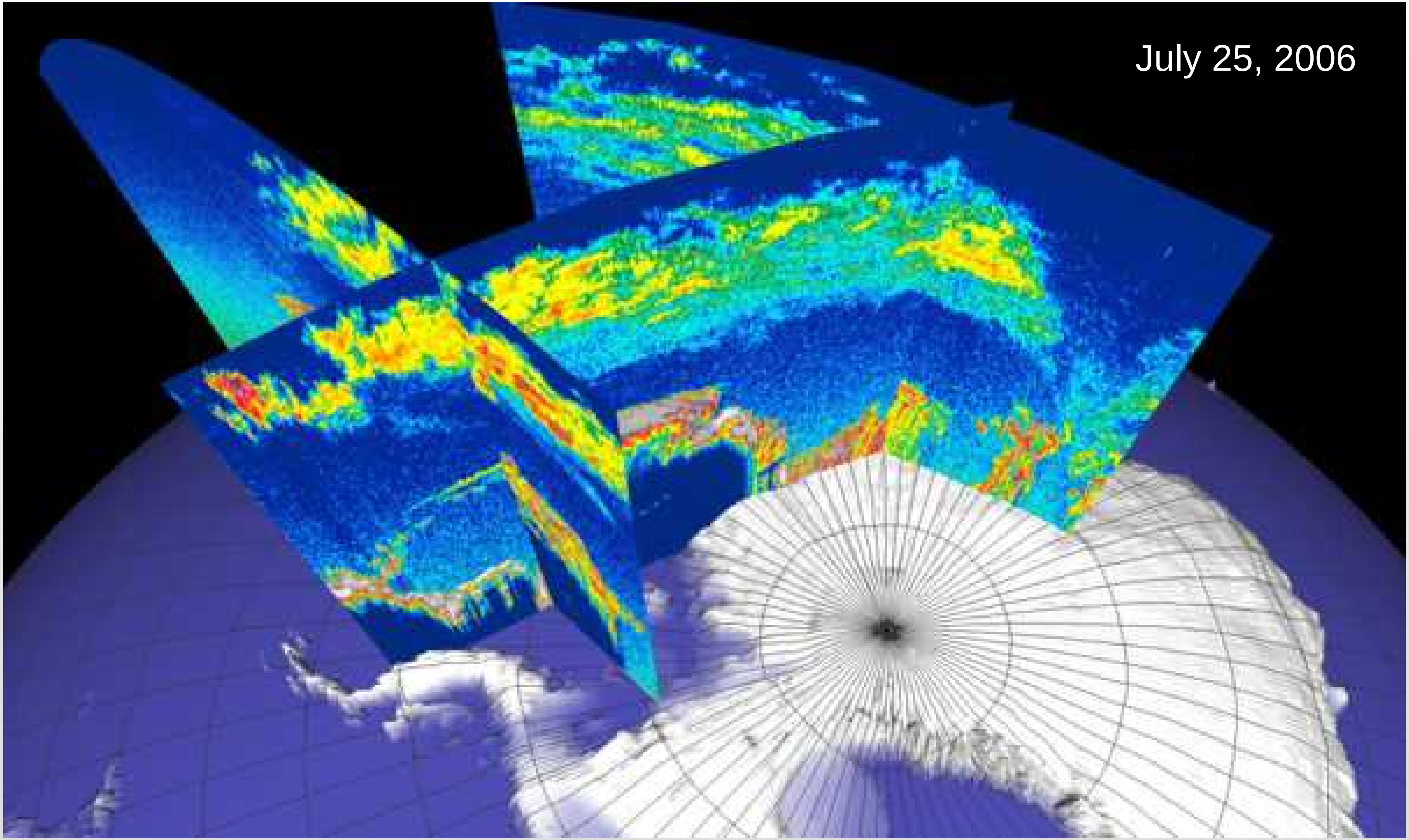
Dr. Hovakim Nazaryan

- Construction of cirrus cloud climatology using CALIPSO data
- Study of the vertical distribution of cirrus clouds
- Investigation of the Latitude – Longitude distribution of cirrus clouds
- Investigation of the cirrus cloud geometrical thickness

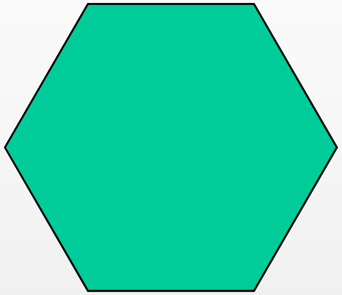


- Collaborators: Paul Menzel
- Students: Sydney Paul

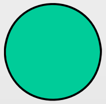
CALIPSO PSC Observations Along Multiple Orbits



Classification of PSC Particles

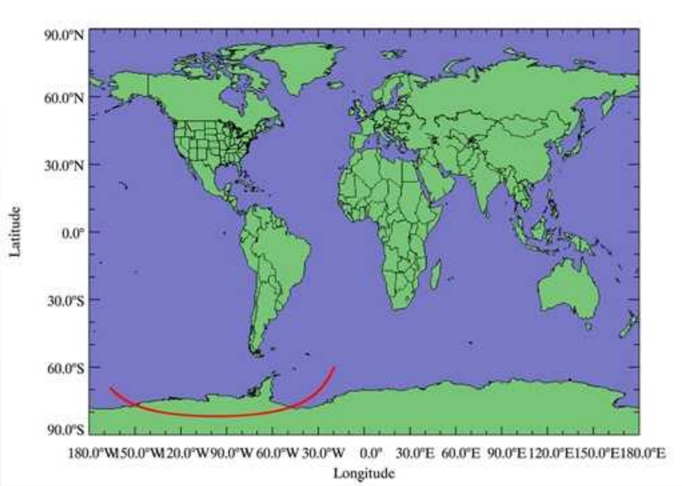


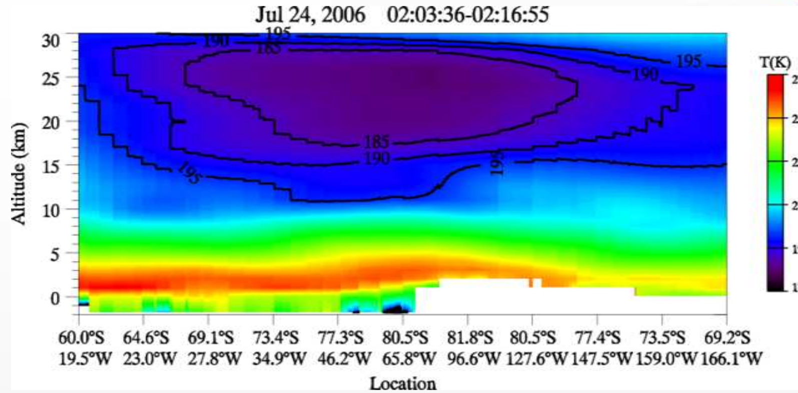
Solid nitric acid trihydrate (NAT), T < 190 – 195 K, “Type 1a”



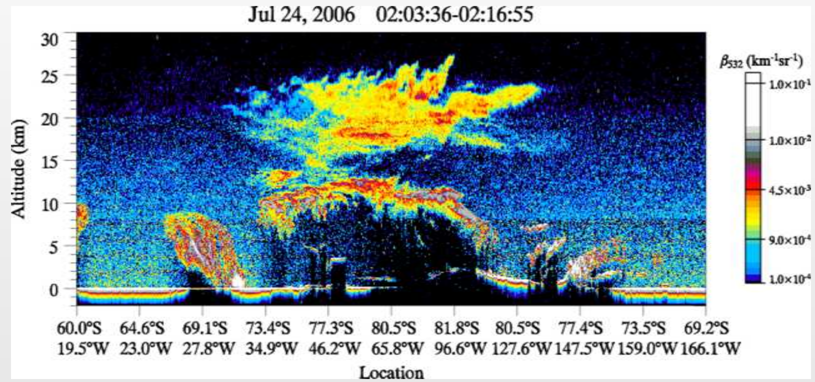
Supercooled ternary (H_2SO4-H_2O-HNO_3) solution (STS or LTA), T < 186 – 191 K, “Type 1b”

H_2O ice, T< 185-188 K, “Type 2”





Full Resolution



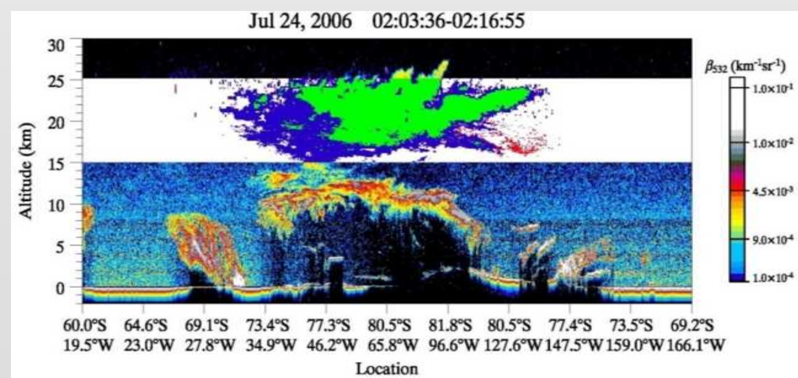
PSC Classification (15-25 km):

Blue = type 1a

Red = type 1b

Green = type 2

White = no PSC detected



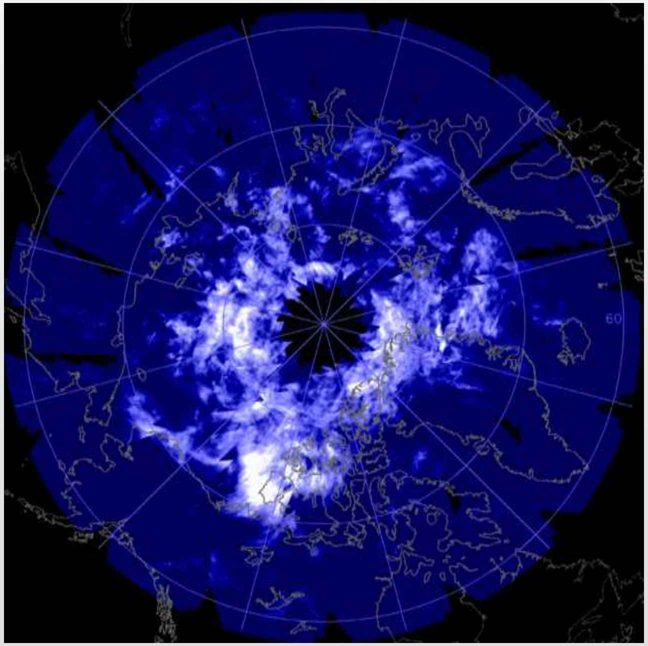
AIM is observing ice clouds that exist more than 60 km above tropospheric clouds

- Called “noctilucent” or night shining clouds (NLCs)
- From the ground, seen at twilight, just after sunset or before sunrise
- Over the last 27 years they have been getting brighter, occurring more frequently and seem to be appearing at lower latitudes

Why do these clouds form and vary?

Why are long-term changes occurring?

Is there a global change connection?



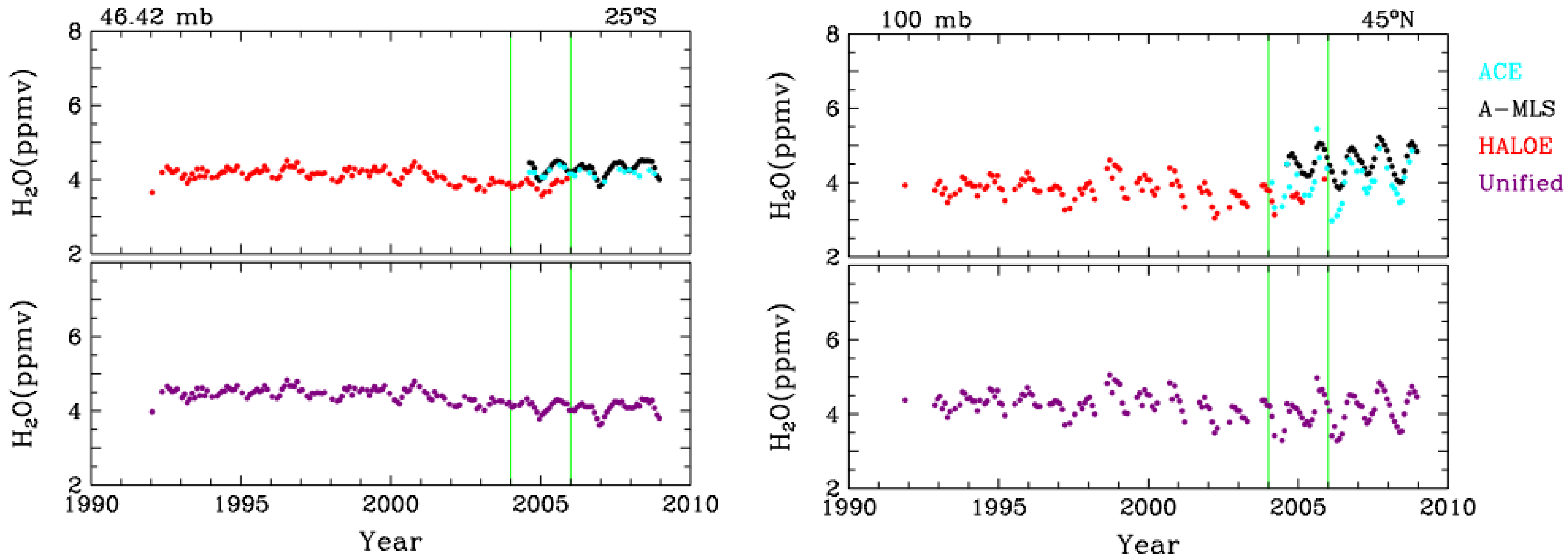
AIM July 4, 2008

Unifying Stratospheric Data Records

NOAA CREST

Time-Series 'Splicing' Procedure:

1) Means of co-located points between AURA MLS, ACE FTS and HALOE were first calculated.
2) A reference was then calculated by averaging all of the co-located means.
3) Each time-series was then adjusted to the reference by applying the derived constant offset.
4) Final time-series is calculated by averaging the available adjusted data sets.

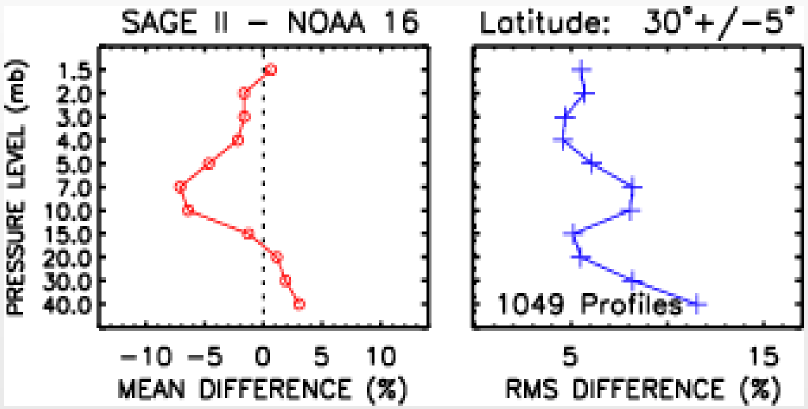


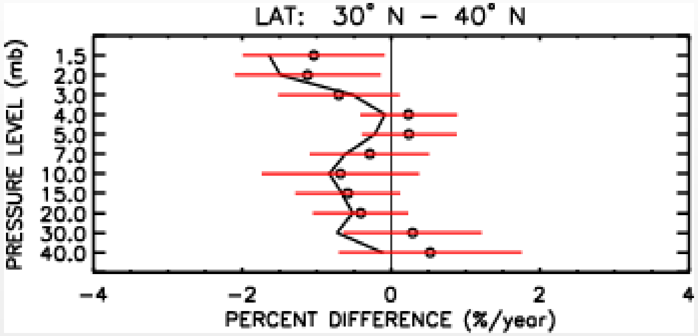
Top Panels: time series of monthly-zonal-averaged H_2O derived from AURA MLS, ACE FTS and HALOE. Bottom Panel: Merged H_2O time series from AURA MLS, ACE FTS and HALOE. The vertical green lines in all panels 'border' the overlap period of the 3 instruments. Anderson (HU), Froidevaux (JPL), Wang (GaTech) to create Earth System Data Records for GozCards.

Satellite Validation

Validate the Ozone Retrievals Obtained by the SBUV/2 Experiment

Dr. Hovakim Nazaryan

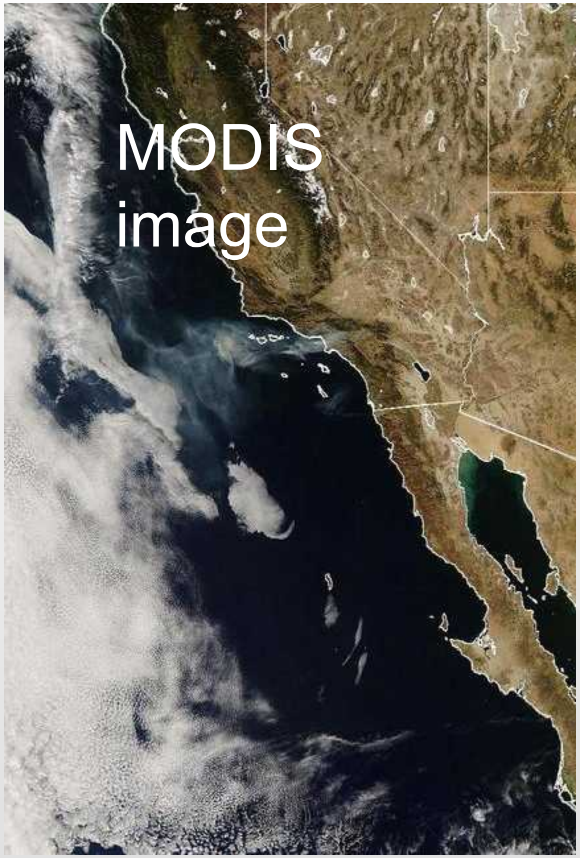


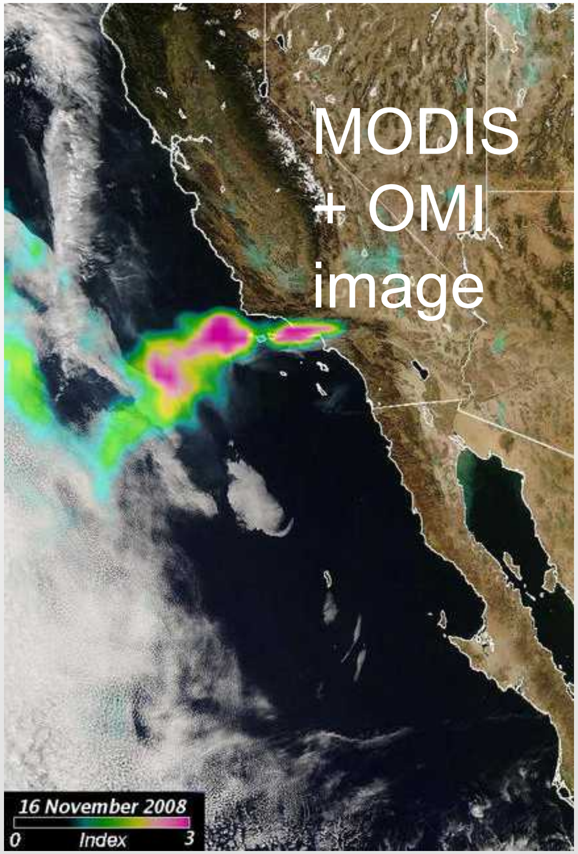


- NOAA Collaborators: Lawrence Flynn
- Students: Marion Greene

- Validate the SBUV/2 version 8 data sets
- Compare with SAGE II, HALOE, and OMI retrievals
- Operational validation of the data obtained from the NOAA-16, NOAA-17, and NOAA-18 SBUV/2 instruments

OMI's view of California Fires Nov. 2008:
Smoke observed drifting over low marine stratus clouds



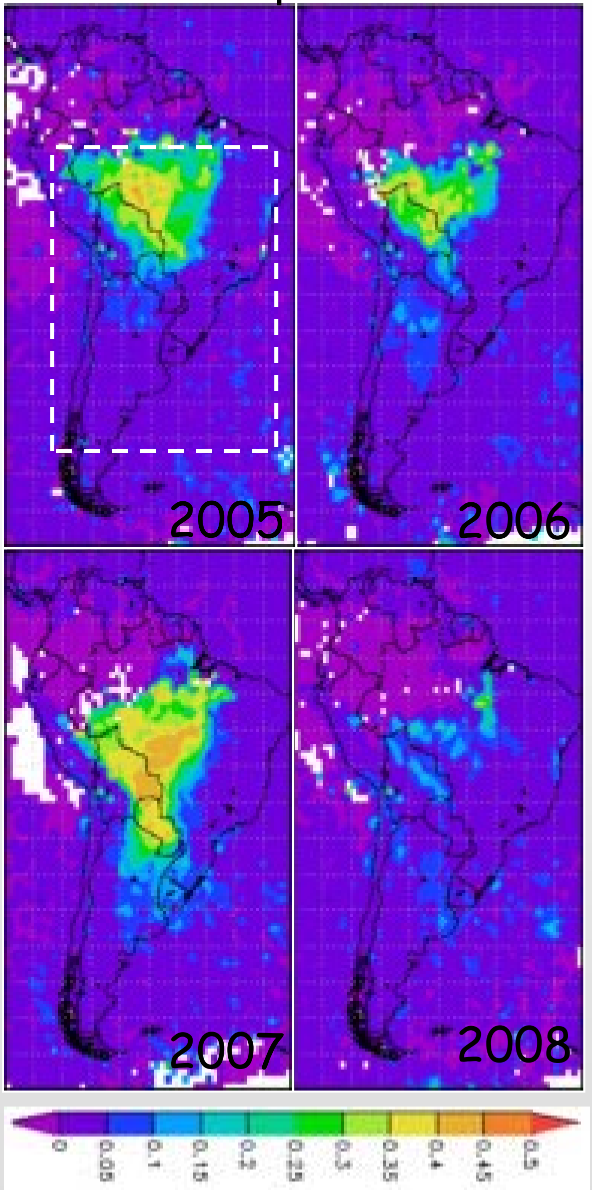


OMI aerosol index overlaid:
OMI is able to detect the absorbing smoke over clouds and bright land surfaces that are difficult to discern from MODIS imagery alone

O. Torres
Hampton University
P.K. Bhartia, GSFC
C. Seftor, SSAI

NOAA plans to produce near UV aerosol products
from
GOME-2 observations

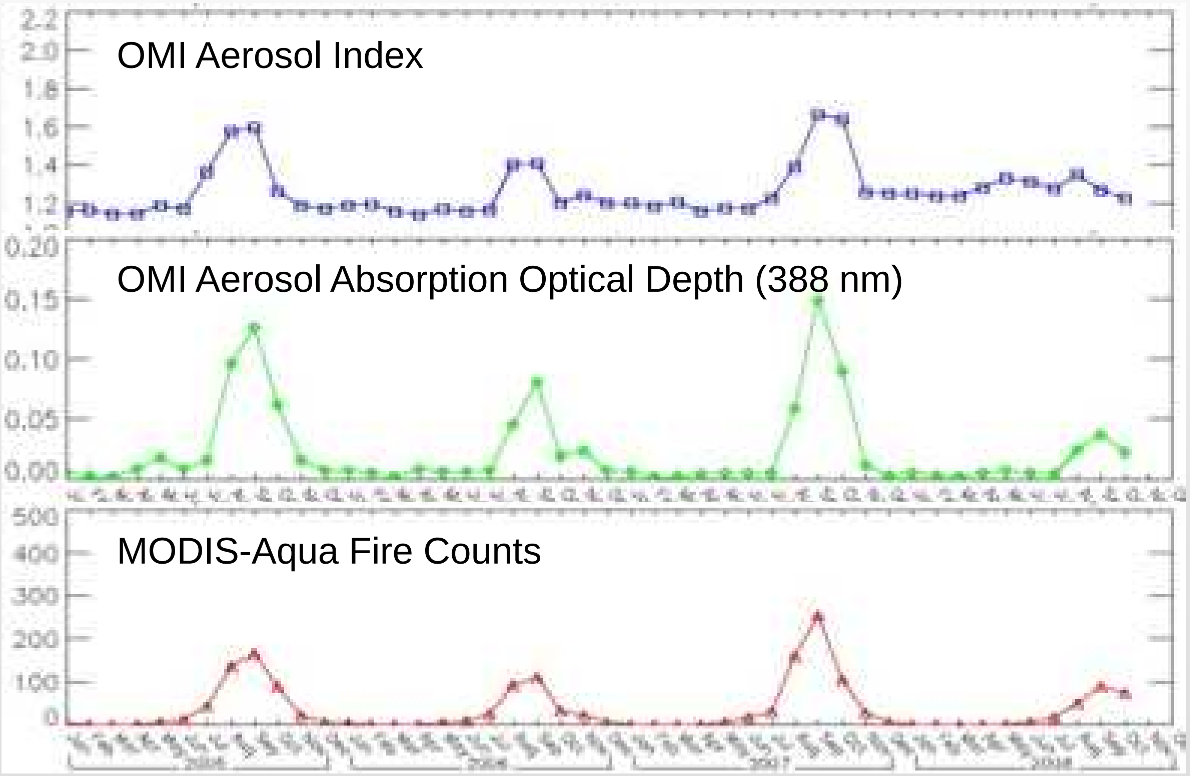
Aerosol Absorption Retrieval from the Ozone Monitoring Instrument (OMI)



September Average Aerosol Absorption Optical Depth (388 nm) for 2005-2008

The OMI aerosol algorithm makes use of the near UV sensitivity to aerosol absorption to quantify particle absorption

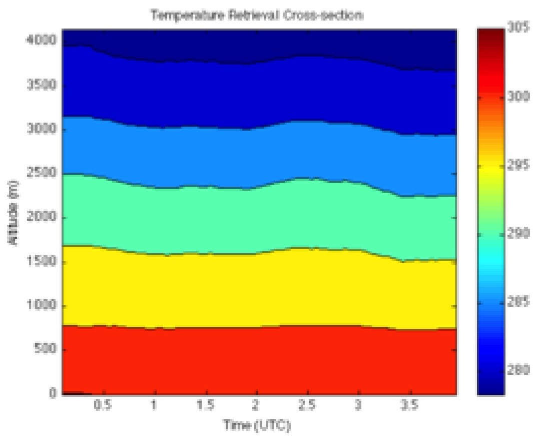
OMI observes large decrease of South American biomass burning in 2008



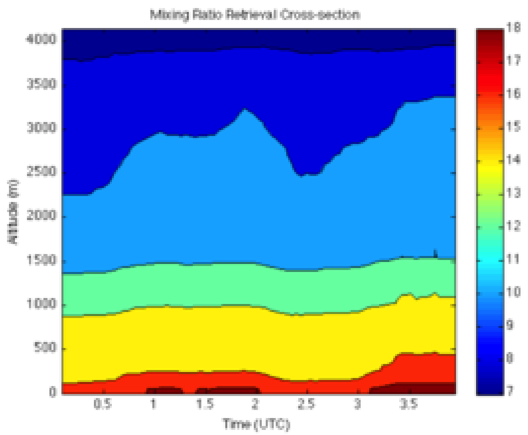
2005 2006 2007 2008

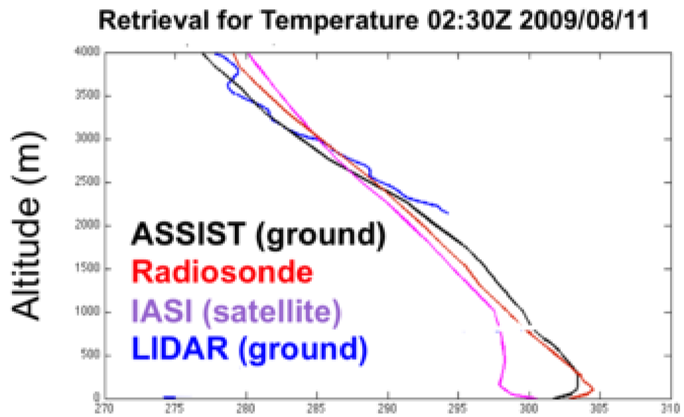
Planetary Boundary Layer (PBL) Studies

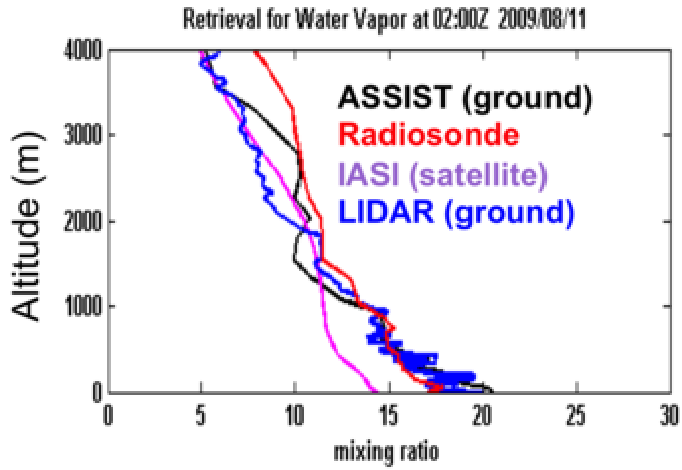
ASSIST vs IASI, Raob, and HU-LIDAR (August 11, 2009)



ASSIST (FTS)







A New DOE "ASSIST" Upward Looking Fourier Transform Spectrometer (FTS) is being Used at HU for Cloud and Atmospheric Sounding Studies.

(The instrument was acquired by HU to perform joint ground-based and satellite FTS/LIDAR Cloud radiation studies)

Algorithm Development

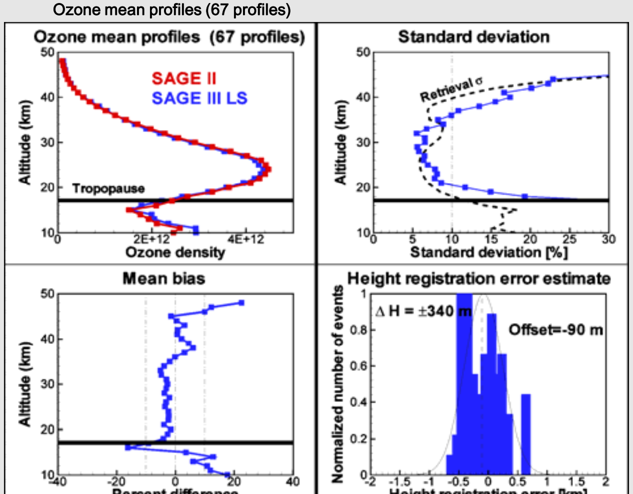
Stratospheric Ozone Retrieval from Limb Scattering Measurements

SAGE III

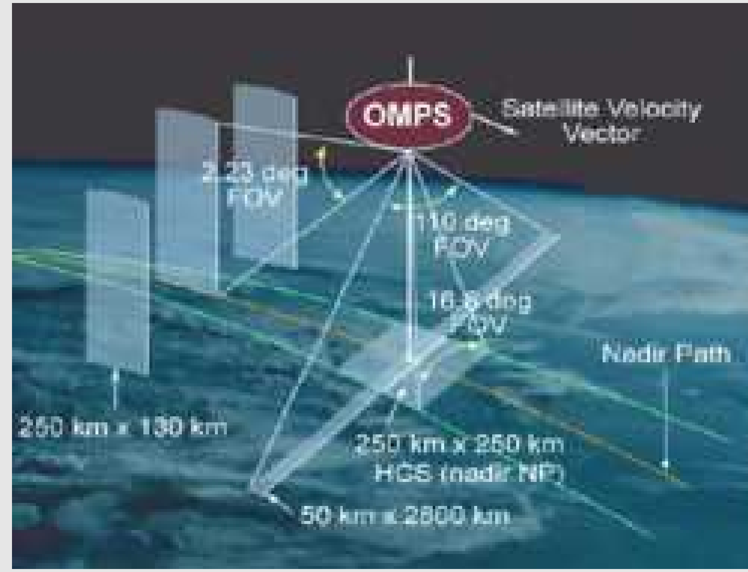
- Relative accuracy (with respect to SAGE II occultation) is 5-10% from tropopause to 45 km
- Relative precision is better than 10% from 20 to 40 km.
- Height registration RMS error is < 350 m.

Ozone mean profiles (67 profiles)

Ozone retrieval



OMPS Limb Profiler



Ozone Profile Requirements:

Accuracy: 10% (15-60 km)
20% (Tropopause -15 km)
Precision: 3% (15-50 km)
10% (Tropopause-15km,50-60km)
Long-term Stability: 2% over 7 years
Vertical resolution: 3 km
Reporting Period: 38 seconds

R. Loughman

Tropospheric Remote Sensing and Air Quality (TRAQ)

Tropospheric Remote Sensing and Air Quality Participants

CREST Researchers:

Sam Ahmed	CUNY
R. Blake	CUNY
Barry Gross	CUNY
Jorge Gonzalez	CUNY
F. Jans	CUNY
M. Jerg	CUNY
Julia Maantay	CUNY
Fred Moshary	CUNY
D. Padilla	CUNY
Jeff Steiner	CUNY
V. Vadutescu	CUNY
Y. Wu	CUNY
M. Patrick McCormick	HU
Jia Su	HU
Ruben Delgado	UMBC
Ray Hoff	UMBC
O. Mayol	UPRM
Hamed Parsiani	UPRM

NOAA Scientists:

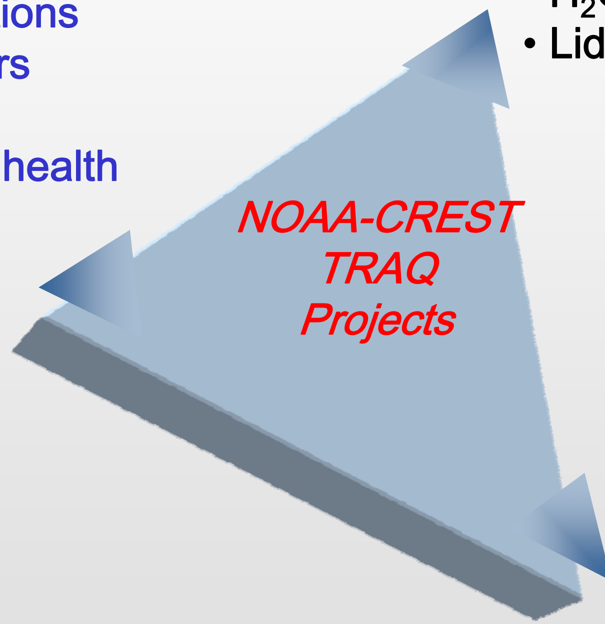
Ralph Ferraro	NESDIS
Shobha Kondragunta	NESDIS
Bruce Ramsay	NESDIS
Chuanyu Xu	NESDIS
Paul Menzel	CIMSS
Michael Hardesty	ESRL
John Ogren	ESRL
Patrick Sheridan	ESRL
Mark Cohen	NWS
Israel Matos	NWS
Jeff McQueen	NWS

NOAA|CREST

Tropospheric Remote Sensing and Air Quality

Ground-Based remote sensing and in-situ measurements:
- Applications to MODIS and GOES-R
- CREST lidar network
- H_2O & Temp. measurements from lidar
- Lidar-based PBL studies

Air Quality Modeling/Analysis:
- Satellite air quality applications
- Improving PM2.5 Estimators
- Nowcasting
- Modelling air pollution and health impacts



Satellite Validation and Algorithm Development :
- Applications to GOES and MISR
- Applications to CALIPSO
- Simulating and measuring atmospheric phenomena

TRAQ Contents

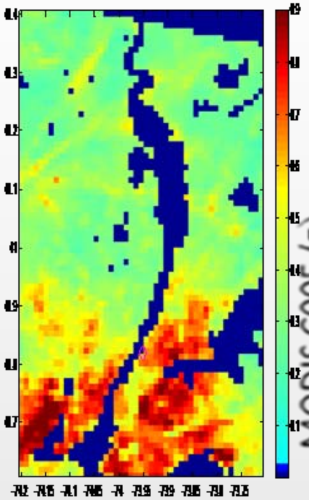
- Satellite Algorithms
  - Regional MODIS AOD improvement and Surface Modeling
  - GOES AOD (GASP) processing
- Ground Based Validation Networks
  - Multi-filter Shadowband Radiometer Network (Testbed activity)
  - Assessment of GASP using MFRSR network measurements.
  - Lidar observations of Plumes / Separation of Plumes from PBL
- Use of ground measurements for assessment of CMAQ models.
  - Optical Depth and Angstrom Coefficient validation
  - Vertical Structure
- Other Material
  - Simulating and Measuring Atmospheric Optical Phenomena
  - Creating Viable Smoke Signatures.
  - Modeling Air Pollution and Health Impacts

Surface Modeling for IMPROVED & HI-RES AEROSOL OVER LAND PRODUCT

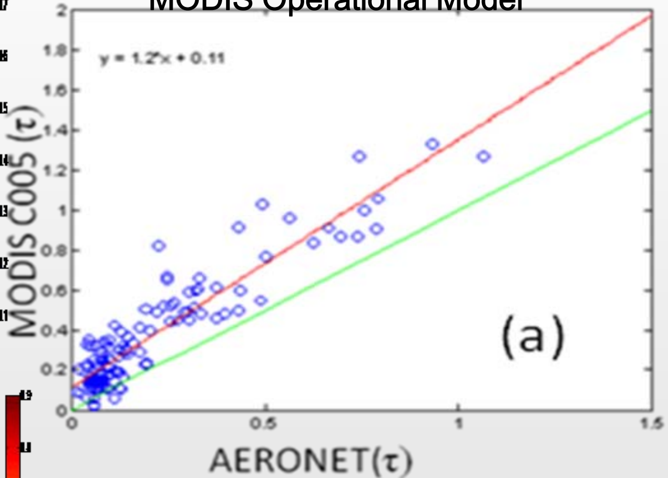
Using CCNY AERONET retrievals

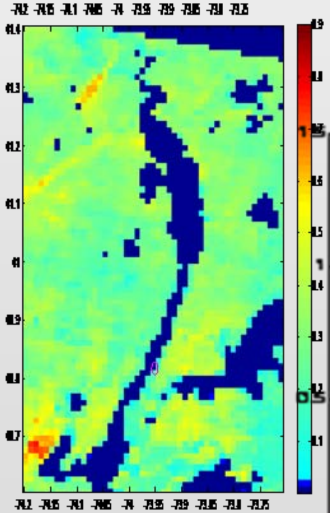
Applications to MODIS and GOES-R

1.5 Km resolution Local Scale Aerosol Optical Depth

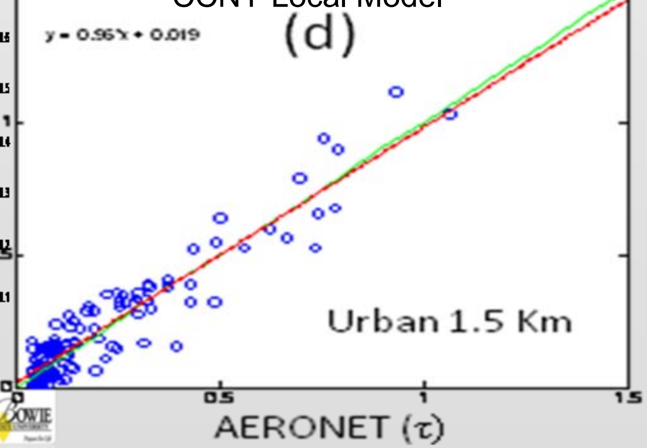


MODIS Operational Model

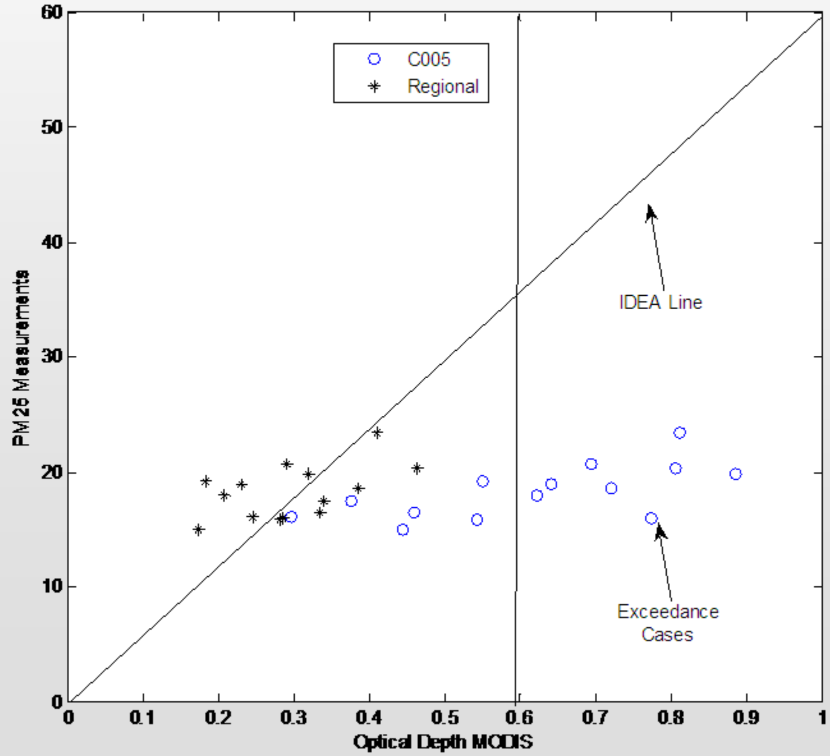




CCNY Local Model



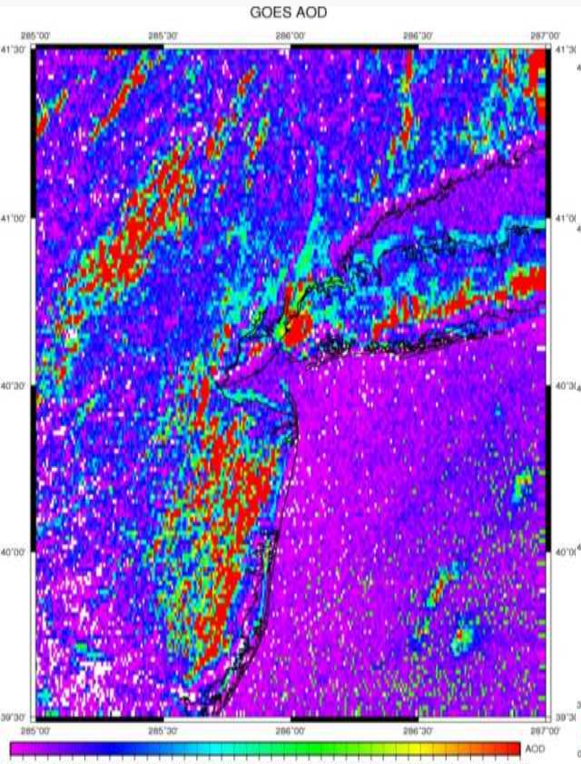
Regional retrieval of AOD vs Operational retrieval
Is more consistent with PM2.5 measurements using
IDEA PM2.5 estimator.



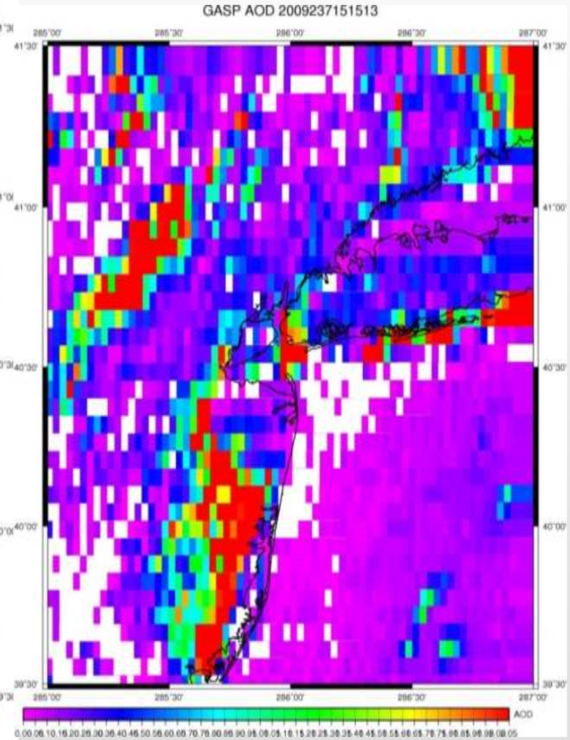
GOES Aerosol and Smoke Product (GASP) at CCNY

Planned Exploration of GASP Performance.

1) Make sure our Baseline results agree with operational product. (See below.)
2) Ingest Regional estimates of Minimum AOD (GASP used Min(AOD) = 0.02) and aerosol phase function. (Being done at present.)

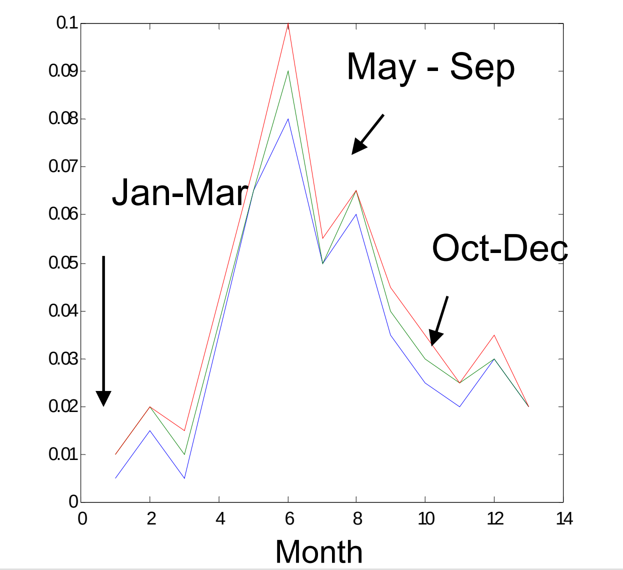


CCNY processing at 1km (no flags used)



GASP Product at 4km

Red 14 Day window
Green 21 Day window
Blue 28 Day window
Little statistical difference



Seasonal differences in “minimum” AOD needs to be accounted for

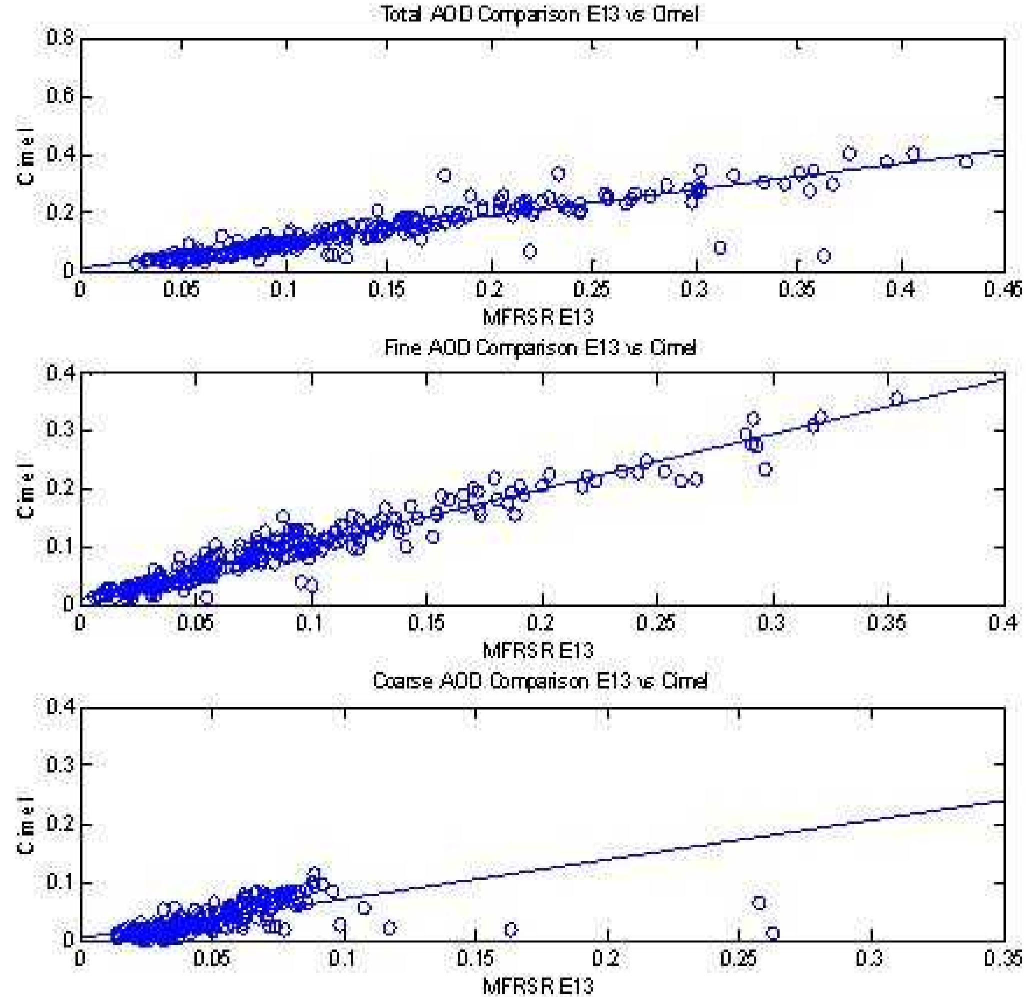
Multi-FilteR Rotating Shadowband Radiometer (MFRSR) Network Support Testbed Measurements

CCNY is deploying a network of ground-based radiometers which together with existing stations will enable hi-res AOD retrievals to be made for the delineated region.

This will improve hi-res surface model information (supplying needed AOD for surface training) to be used for testbed proxy data.

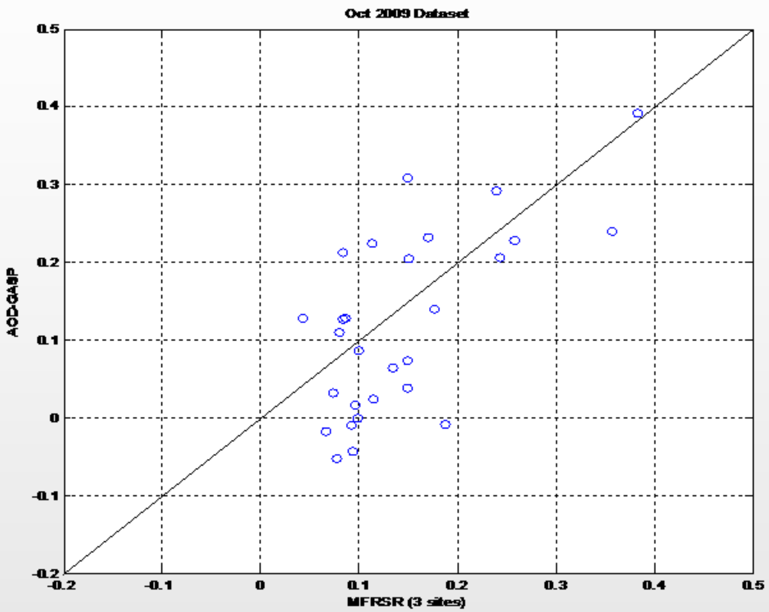
Application of combined diffuse-direct beams allows MFRSR measurements to measure fine mode AOD with high accuracy as compared to AERONET CIMEL.

Coarse-mode accuracy is less since highest wavelength of MFRSR is 865 nm.



Value of MFRSR Network

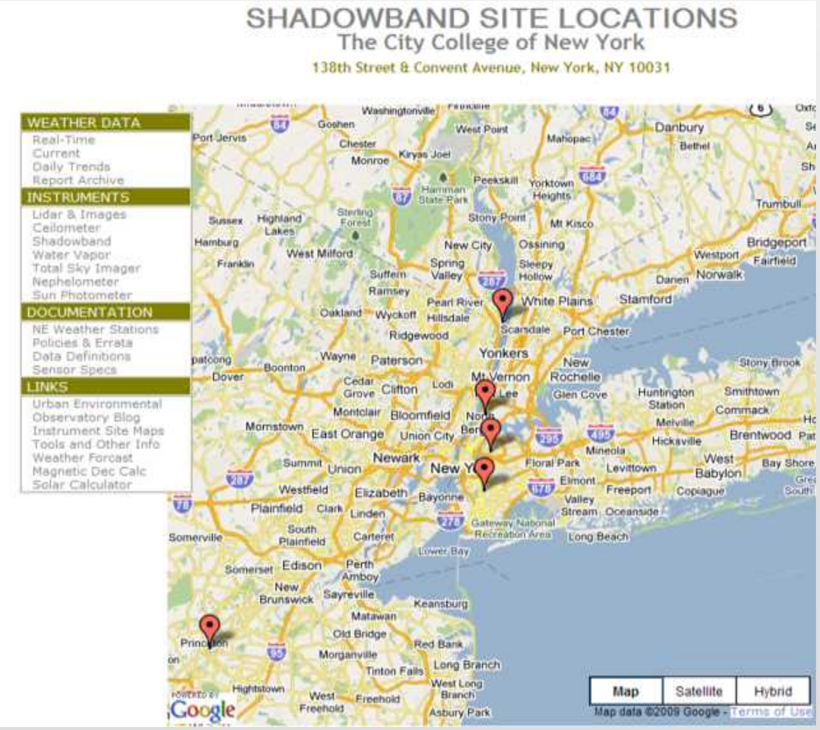
GOES-GASP product vs MFRSR AOD
(30 minute averages)



- New MFRSR algorithm provides accurate time series AOD measurements
- Multiple locations increase chances for overlap and validation of GOES GASP
- Comparison made over recent data set of Oct 1-15 2009.
- As expected , performance is degraded for low AOD where GASP often produces negative results.

Future Directions

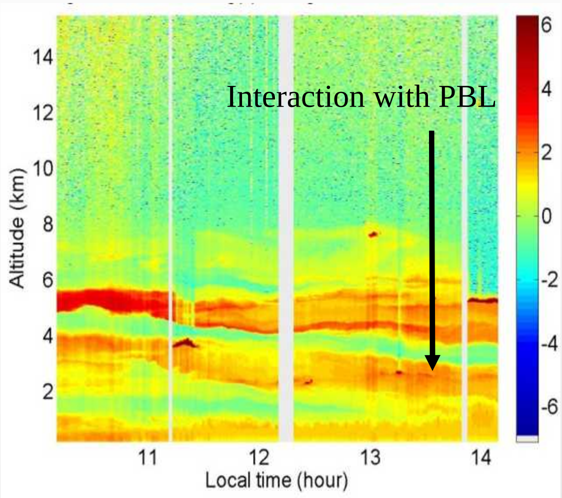
-GOES-R will require validation of aerosol fine and coarse mode AOD's provided by MFRSR
-Further refinements include column water vapor as well as Single Scatter Albedo (possibly)
-In addition, working on web tool to compare / MFRSR outputs over GASP / MODIS retrievals.

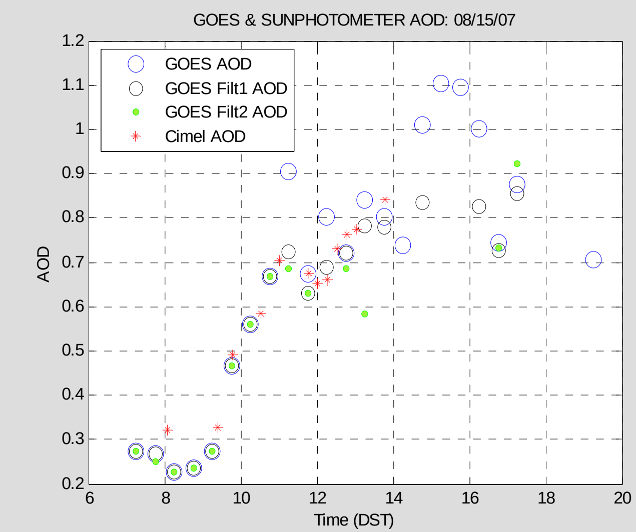


Lidar observations of Aerosol Plume Observation of Mixing with PBL

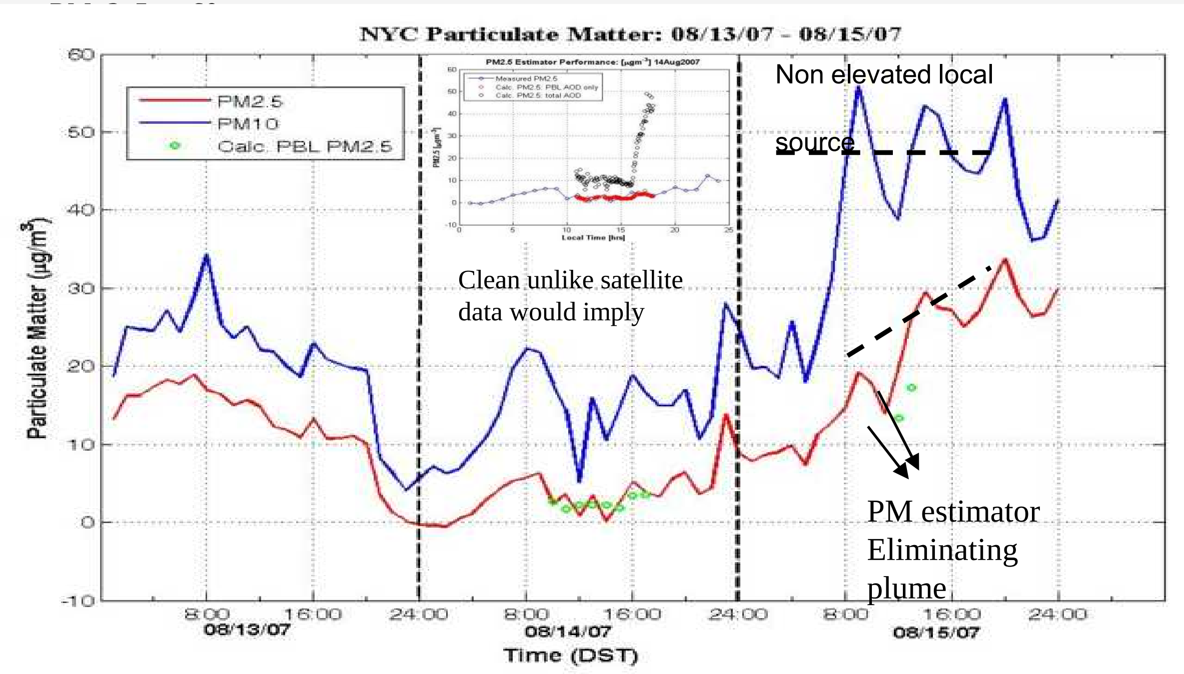
Implications for Satellite Air Quality applications

Aug.15, 2007 (Plume/PBL Interaction)

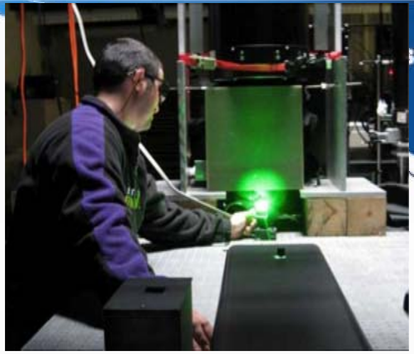




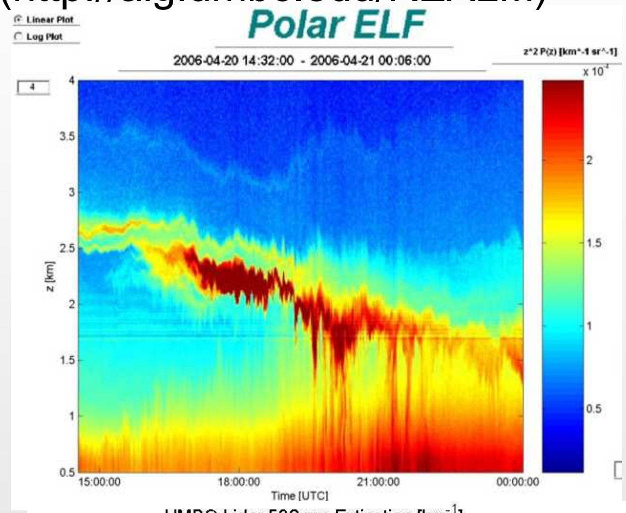
- 3 Day smoke plume case Aug 13-15 2007
- GOES, AERONET and CCNY Lidar all show consistent column AOD
- Lidar filtering of aloft layer necessary to convert column AOD into PBL AOD and subsequently to Proxy PM2.5
- Elevated surface PM2.5 seen when aloft plume mixed down into PBL

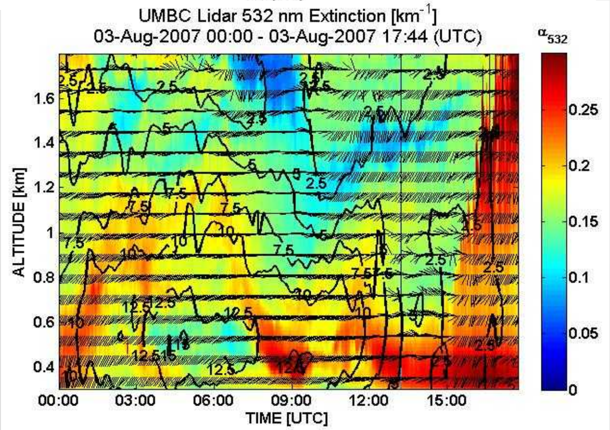


UMBC focuses on the CREST Lidar Network supporting GOES-R Air Quality Proving Ground



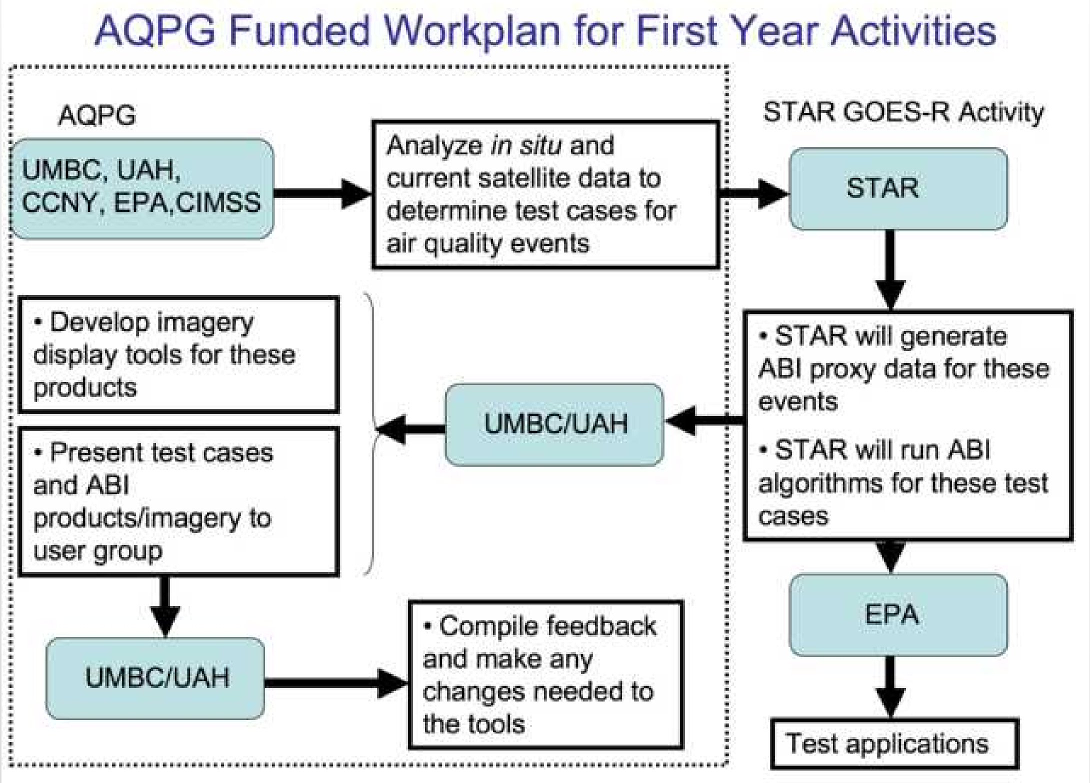
CREST Lidar Network measures transport to Maryland in conjunction with CREST partners (http://alg.umbc.edu/REALM)





Delgado et al. (2010) Nocturnal jets bring pollution to Maryland

For 2009-2015 (GOES-R launch), we will work with NESDIS to develop an intelligent data delivery system for GOES-R AQ data and build a user community at the state, local and EPA level

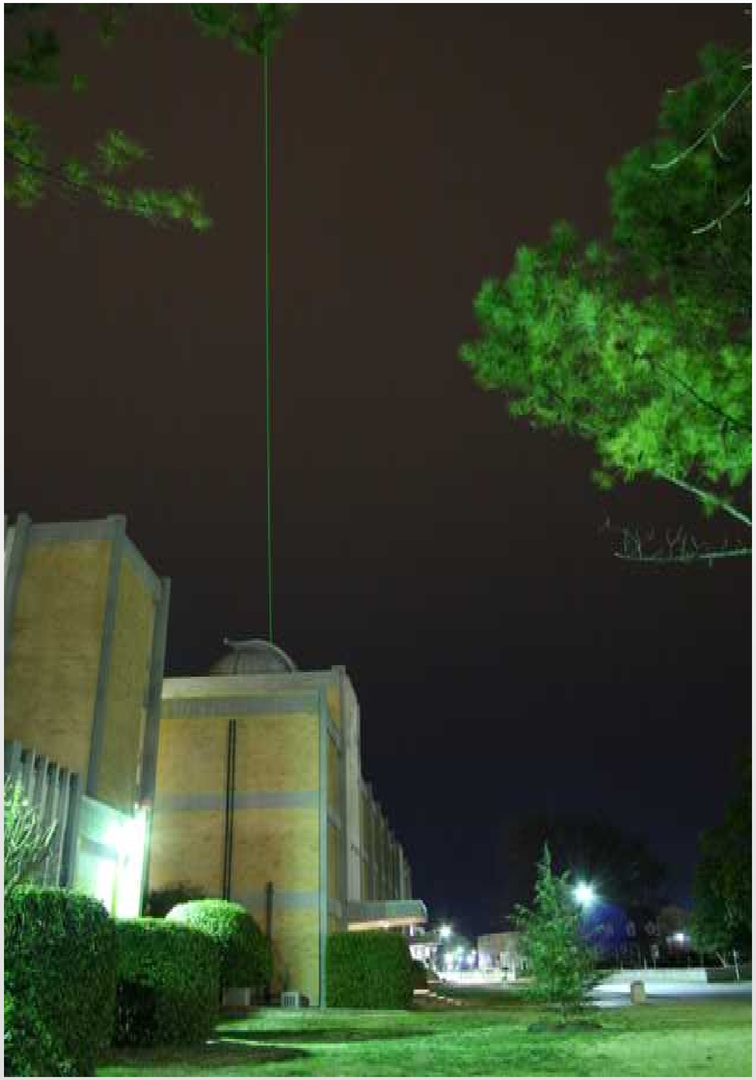


CREST LIDAR NETWORK (CLN)

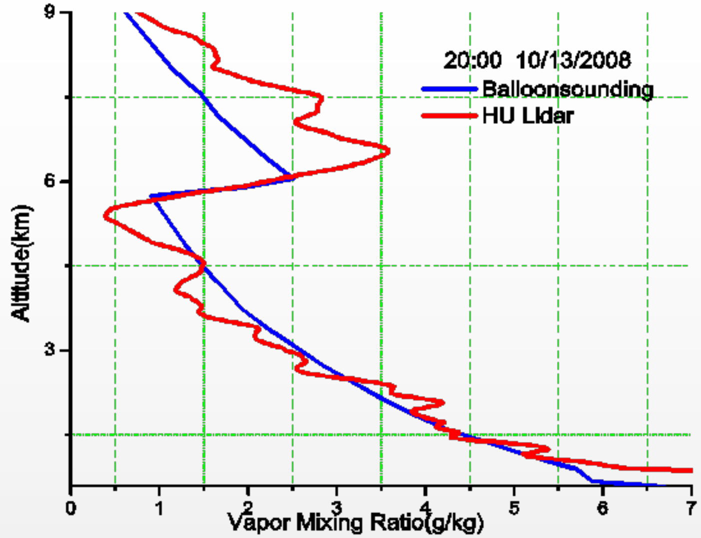
Station	Latitude deg N	Longitude deg E	Altitude m	Operational Status	System
CCNY New York	40.8214	-73.948	98 m	2004	BL, RL
CCNY Princeton	40.3441	-74.6459	34 m	2007-intermittent	BL
UMBC, Baltimore	39.25545	-76.7093	81 m	2001	BL, RL
HU, Hampton, VA	37.020270	-76.336709	20 m	2008	BL, RL
UPRM, Mayaguez, PR	18.30144	-67.20033	11 m	2008	BL

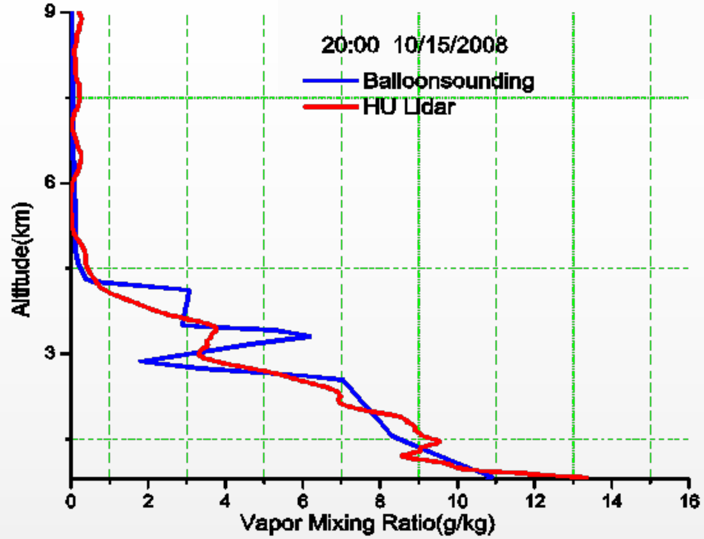
BL = Backscatter Lidar, RL = Raman Lidar

HU 48 inch Lidar

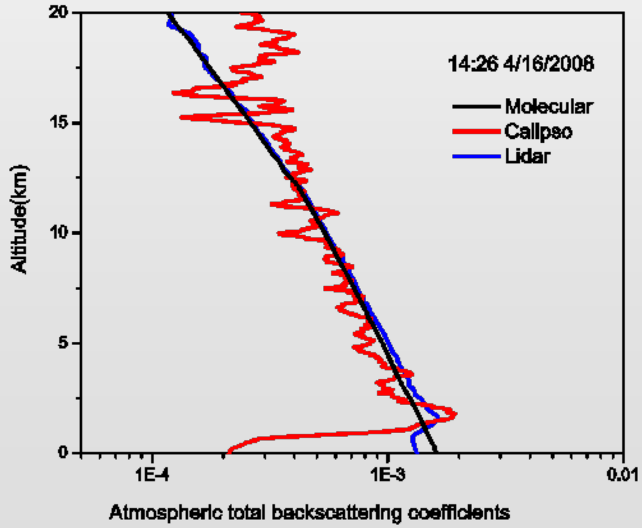


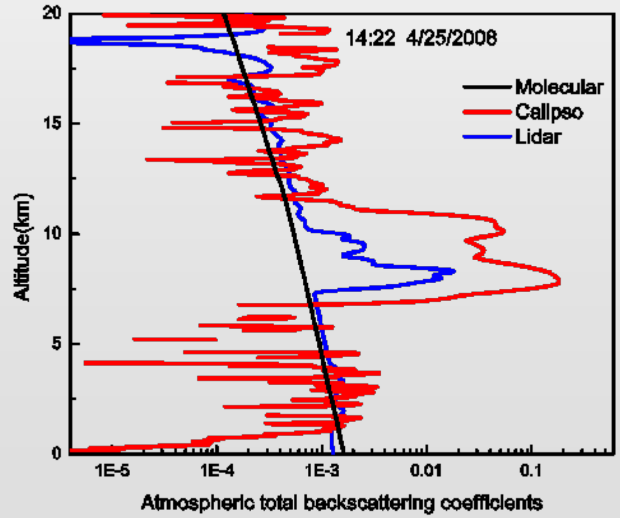
HU Lidar Water Vapor Comparisons with WFF Balloonsondes





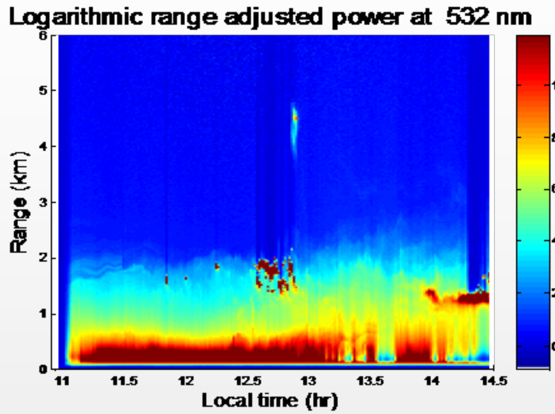
CALIPSO Comparisons with the HU Lidar

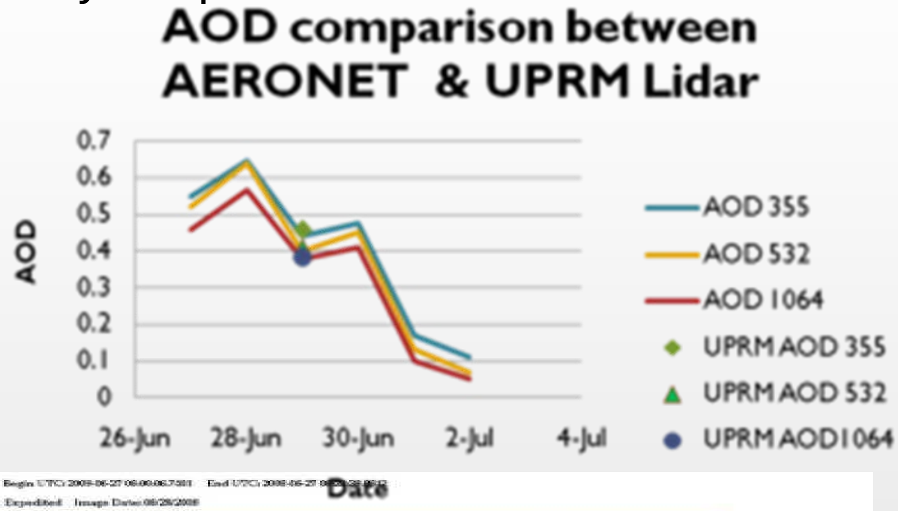


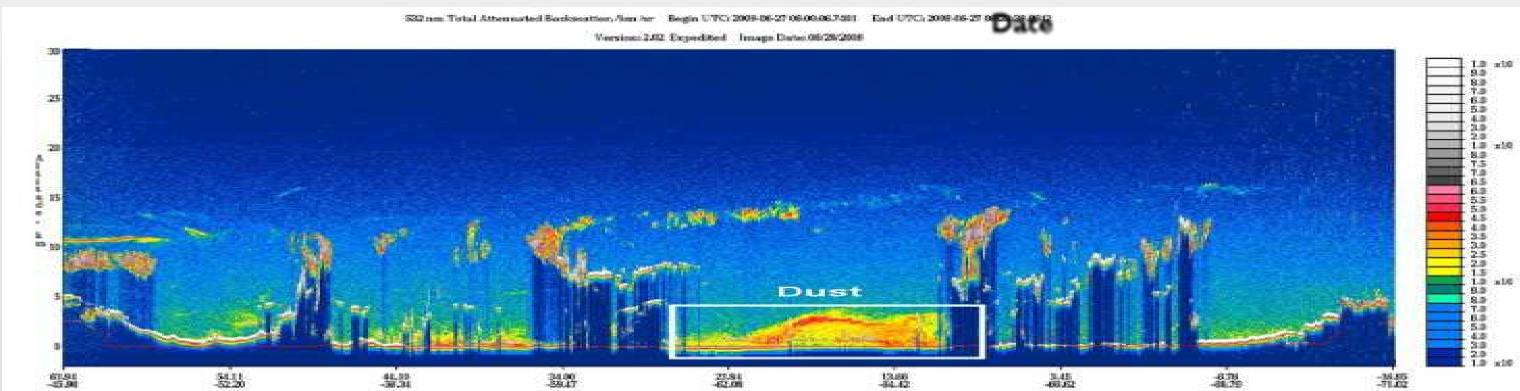


Data Processing Microphysics

June 29, 2009 Saharan Dust measured by UPRM-Lidar & observed by Calipso.





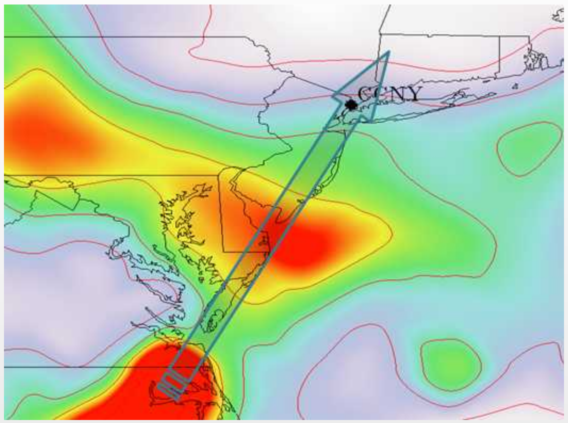


Pending installation of 387 & 407 nm receiving system at UPRM to permit WVMR using PR data

Lidar/ Radiometer Assessment of Air Quality Models such as CMAQ.

- In predicting Air Quality, Air Quality transport Models such as CMAQ (Community Multiscale Air Quality) are being used.
- Most assessments of performance are restricted to comparisons of ground level PM2.5 measurements.
- Most critical if transport is to be properly studied is to assess if the vertical distribution of aerosols is reasonable (such as PBL height)

Toxic Cloud Initiative: Identify Atmospheric Pollution Events - Decipher Contaminant Profiles – Construct Satellite-Based Monitoring Protocol

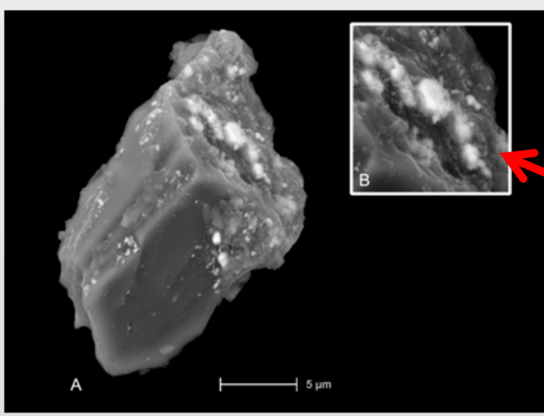


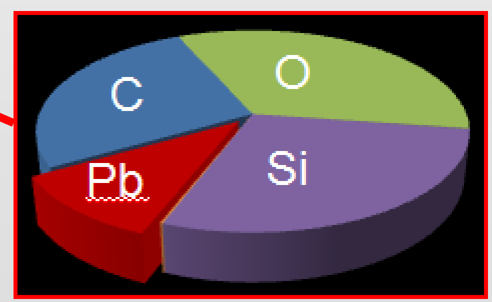
2004 Plume tracking northward toward NYC crossing Northern New Jersey

SEM/EDX Analyses showing accumulation of lead particulates

New Advances: A focusing/Scanning x-ray diffraction spectrometer for aerosol speciation

Future: Cooperative research on aerosol ground-truth, and cloud models

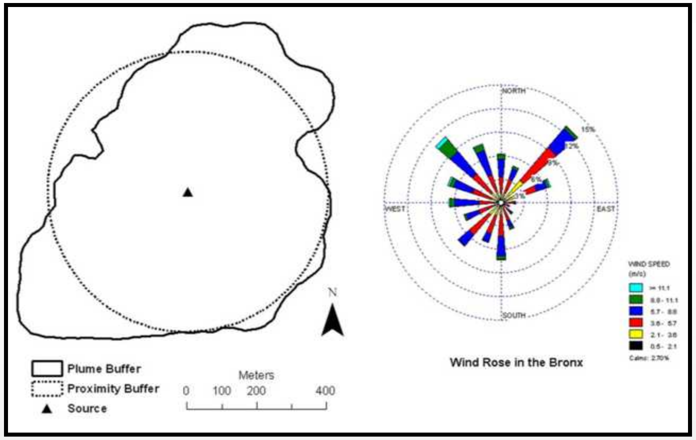




Modeling Air Pollution and Health Impacts – Lehman College, CUNY

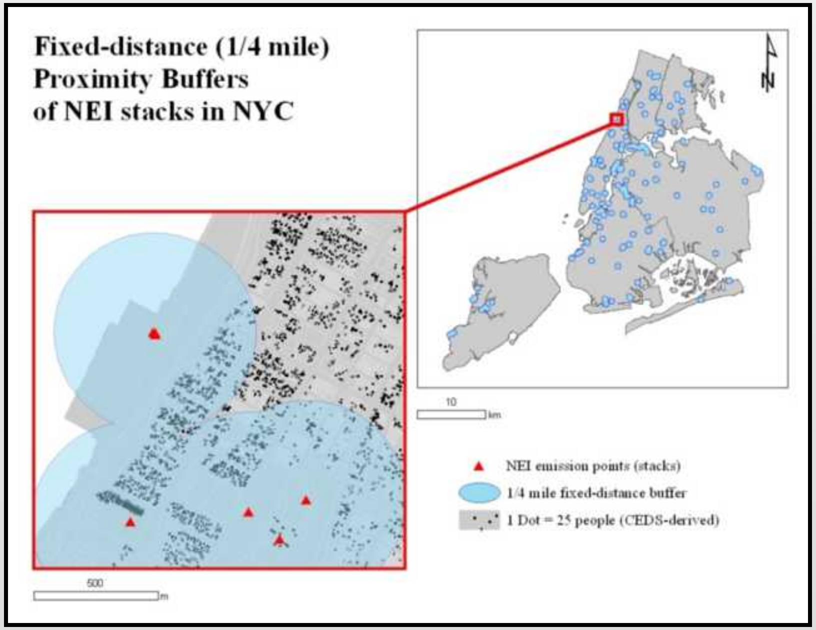
Highlights of research accomplishments, 2006-2009:

- Assessed asthma hospitalization risk for populations living in close proximity to sources of air pollution in the Bronx, NY (fixed distance proximity analysis using Filtered Areal Weighting - FAW).
- Evaluated available air dispersion models, conducted pilot study, and selected AERMOD.
- Modified AERMOD to account for air dispersion in a densely-settled urban environment.
- Created a loosely-coupled system combining a GIS with the air dispersion model.
- Generated plume buffers around stationary point sources, and compared to fixed distance impact buffers.
- Confirmed the existence of Environmental Justice issues of pollution exposure in the Bronx using proximity analysis, FAW, and plume buffers.



Plume buffer based on air dispersion model versus fixed-distance proximity buffer (above, left) and wind rose (above, right) from earlier study.

Left: Lehman College/CUNY NOAA-CREST Team in the GISc Lab, from left to right: Brian Morgan, Rosa Perez, Juliana Maantay, Andrew Maroko, Kristen Grady. **Top:** Geographic Information Science Lab, Lehman College, Environmental, Geographic, and Geological Sciences Dept.



Planned OMI work (2010)

1- Algorithm Upgrades (short term ~3-6 months)

- Improved Optical Model for biomass burning aerosols that accounts for the presence of organic carbon.

- Aerosol layer height determination using a CALIOP-based climatology

- Better absorbing aerosol type identification (smoke/dust) with the combined use of AIRS CO column amount and OMI Aerosol Index .

2- Algorithm Upgrades (mid-term ~9-12 months)

- Extension of retrieval capability to aerosol-cloud mixtures: aerosols in partially cloudy pixels and aerosols above clouds.

3- Other plans

- Application of OMI retrieval algorithm to GOME-2 observations in collaboration with Larry Flynn (NOAA)