Using VIIRS DNB and OMI NO2 retrievals for constraining NOx Emissions

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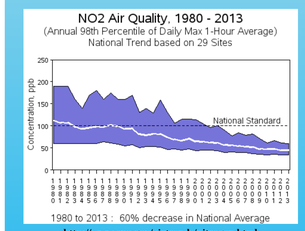
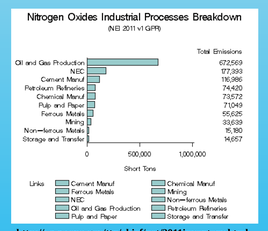
1) Motivation

This poster presents results from work being conducted as part of the NASA Air Quality Applied Science Team (AQAST) Oil and Natural Gas (ONG) Tiger Team investigating the use of the composite imagery from the Suomi NPP Visible Infrared Imaging Radiometer Suite (VIIRS) day night band (DNB) to spatially refine Aura Ozone Monitoring Instrument (OMI) NO2 retrievals. Methods for generating fine-scale (4x4km) OMI NO2 products are presented and compared to NO2 columns estimated from insitu airborne measurements obtained during the 2014 FRAPPE/DISCOVER-AQ field campaign.

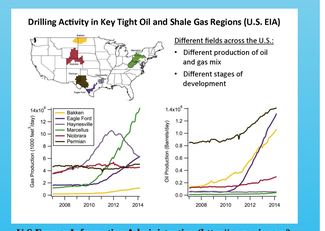
National Trends in Nitrogen Dioxide (NO2) Levels



http://www.epa.gov/airtrends/nitrogen.html



http://www.epa.gov/ttn/chief/net/2011inventory.html



U.S Energy Information Administration (http://www.eia.gov/)

Overall, surface and column NO2 amounts are declining over the US due to regulations from the Clean Air Act. This is due to reductions in the largest NO2 emissions from mobile sources (cars and trucks) and electric power generations (power plants). However, the third largest source of NO2 is industrial processes. Oil and Gas production are the largest source of NO2 emissions from industrial processes and are growing rapidly.

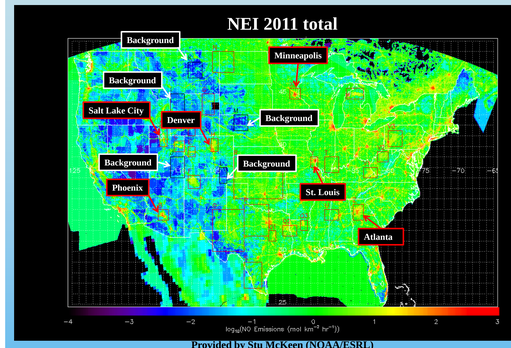
The National Emissions Inventory (NEI) is a comprehensive and detailed estimate of emissions of air pollutants from all air emissions sources. NEI is used to constrain Air Quality modeling in support of State Implementation Planning (SIP) required by the EPA.

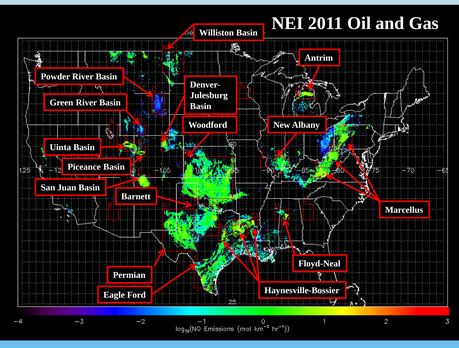
2) Monitoring Urban Emissions and Oil and Gas Production activities with the VIIRS DNB

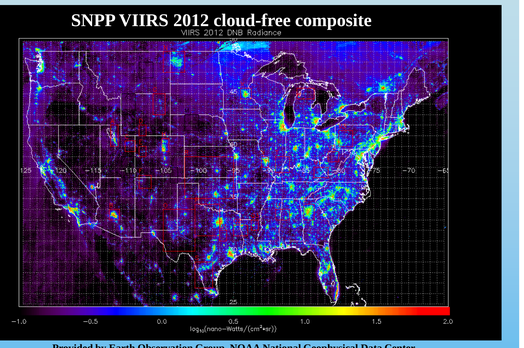
Approach

1) Evaluate the spatial correlation between NEI 2011 NOx (NO+NO2) emissions and VIIRS DNB on a regional scale

2) Use VIIRS DNB radiances to generate a spatially enhanced OMI NO2 column retrieval appropriate for constraining Air Quality model emissions through Data Assimilation

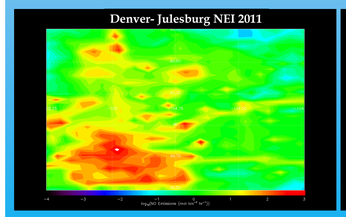


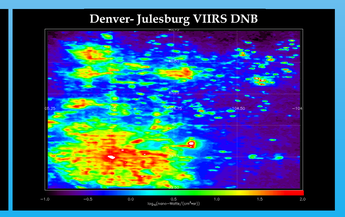


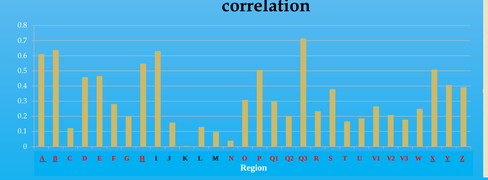


Provided by Stu McKeen (NOAA/ESRL)

Provided by Earth Observation Group, NOAA National Geophysical Data Center



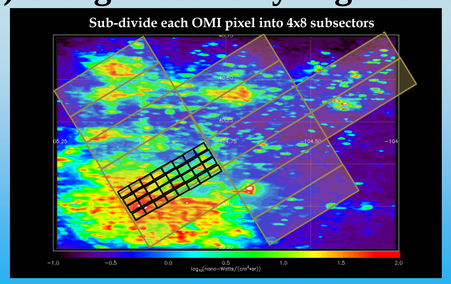




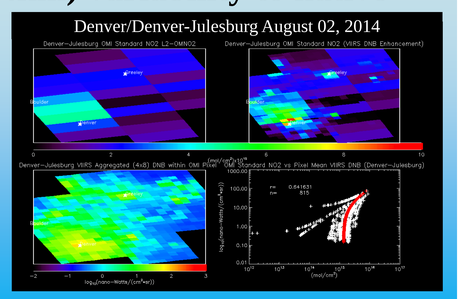
A= Salt Lake City
B=Phoenix
C=Uinta Basin
D=Green River Basin
E=Piceance Basin
F=San Juan Basin
G=Powder River Basin
H=Denver/Denver- Julesburg Basin
I=NW Background
J=SW Background
K=Northern Background
L=SW Background
M=Eastern Background
N=Williston Basin
O=Permian
P=Barnett
Q1=Haynesville-Bossie S
Q2=Haynesville-Bossie C
Q3=Haynesville-Bossie N
R=Woodford
S=Eagle Ford
T=New Albany
U=Floyd-Neal
V1=Marcellus S
V2=Marcellus C
V3=Marcellus N
W=Antrim
X=Minneapolis
Y=St. Louis
Z=Atlanta

VIIRS DNB shows reasonable (0.3-0.7) correlations with aggregated 2011 NEI NO emissions for urban areas (Salt Lake City, Phoenix, Denver/ Denver-Julesburg Basin, Minneapolis, St. Louis, Atlanta) and some O&G regions (Green River, Piceance, Permian, Barnett, Haynesville-Bossie North, Eagle Ford

3) Using VIIRS Day Night Band (DNB) radiances to add sub-pixel (~4x4km) variability to native (13x24km) OMI NO2 retrieval

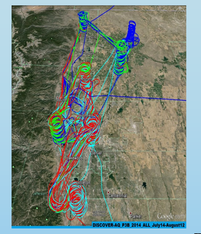


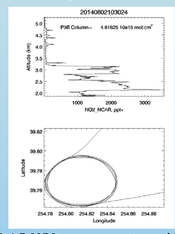
1) **Compute mean DNB radiance for each 4x8 subsectors**
2) **Compute linear regression between pixel mean DNB radiance and OMI NO2 for each swath**
3) **Use linear regression to redistribute OMI NO2 over sub-pixels**
4) **Adjust mean of sub-pixel NO2 to original pixel NO2**

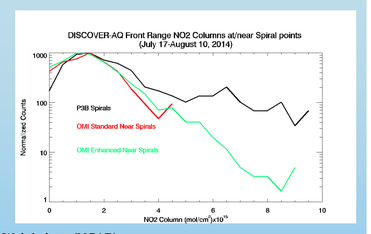


4) Validation During 2014 FRAPPE/DISCOVER-AQ

During the summer of 2014 NASA, NSF, NOAA, and Colorado Department of Public Health and Environment conducted an airborne field mission over the Front Range of Colorado. The NASA contribution to the effort is called DISCOVER-AQ, which stands for Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality. Integration of airborne insitu NO2 profiles collected during DISCOVER-AQ over the depth of the profile provide column NO2 measurements for validating the OMI Standard, and OMI Enhanced NO2 retrievals.

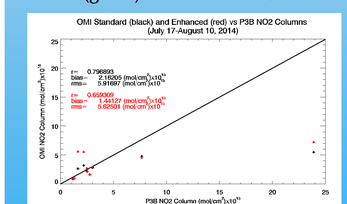


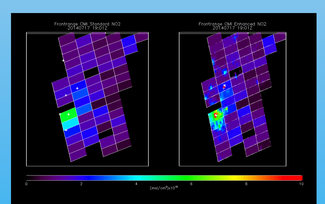




DISCOVER-AQ NO2 measurements provided by Andy Weinheimer (NCAR)

220 NO2 profiles were obtained over the Front Range during July and August, 2014. The full set of DISCOVER-AQ flights and an example airborne profile and the computed for NO2 column for August 2, 2014 is shown above. Histograms of the airborne NO2 columns (black) show a long tail towards higher values from profiles over the Denver metropolitan area which is better captured by the OMI Enhanced retrieval (green) than the OMI Standard retrieval (red)



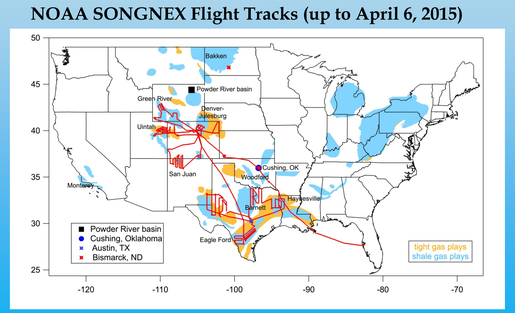


Out of 220 profiles there were only 10 coincidences which were near the center of the OMI Standard pixel and within +/- 3 hours which had cloud radiance fractions of less than 0.3. The OMI Enhanced retrieval shows somewhat lower correlations with the insitu NO2 columns (0.66 vs 0.80), but has lower biases (1.44 vs 2.16 x10^{15} mol/cm^2) and similar RMS errors (5.6 vs 5.9 x10^{15} mol/cm^2). The large RMS errors arise due to the very high NO2 column (23.9 x10^{15} mol/cm^2) obtained from the airborne profile over the Denver Metropolitan area on July 17. The OMI Enhanced retrieval shows significantly higher NO2 columns then the Standard retrieval just to the west of this spiral.

5) Future Plans

The NOAA/ESRL SONGNEX 2015 Shale Oil and Natural Gas Nexus field campaign is currently underway. The primary goal of NOAA's field study is to quantify the emissions of trace gases and fine particles from several different tight oil and shale gas basins in the western U.S., and to study the chemical transformation of these emissions. SONGNEX has already sampled a number of the oil and gas basins in the Western US. We intend to use NO2 profiles obtained during SONGNEX to continue our validation of the Enhanced OMI NO2 retrieval. Once validation is complete, we intend to conduct assimilation experiments using the OMI Enhanced NO2 retrieval within the regional WRF-CHEM/GSI air quality assimilation/forecast system.

NOAA SONGNEX Flight Tracks (up to April 6, 2015)



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