Evaluate and Enhance Suomi NPP Products for Air Quality and Public Health Applications

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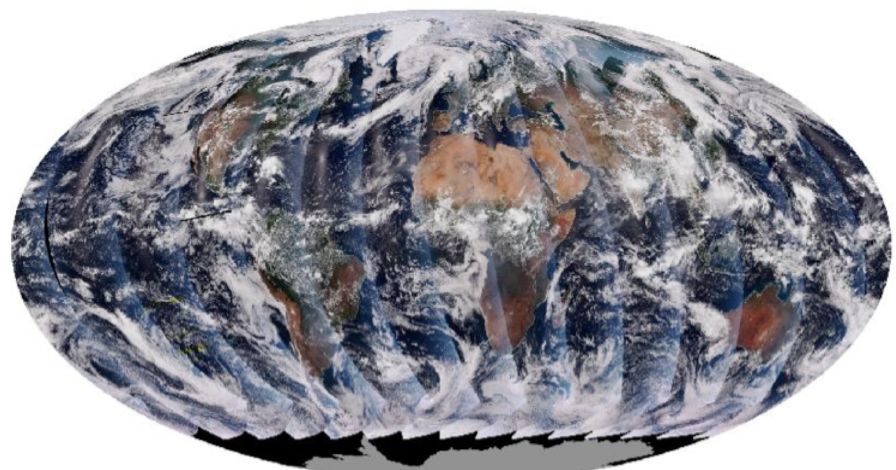
Chaoyang Li

Robert Holz



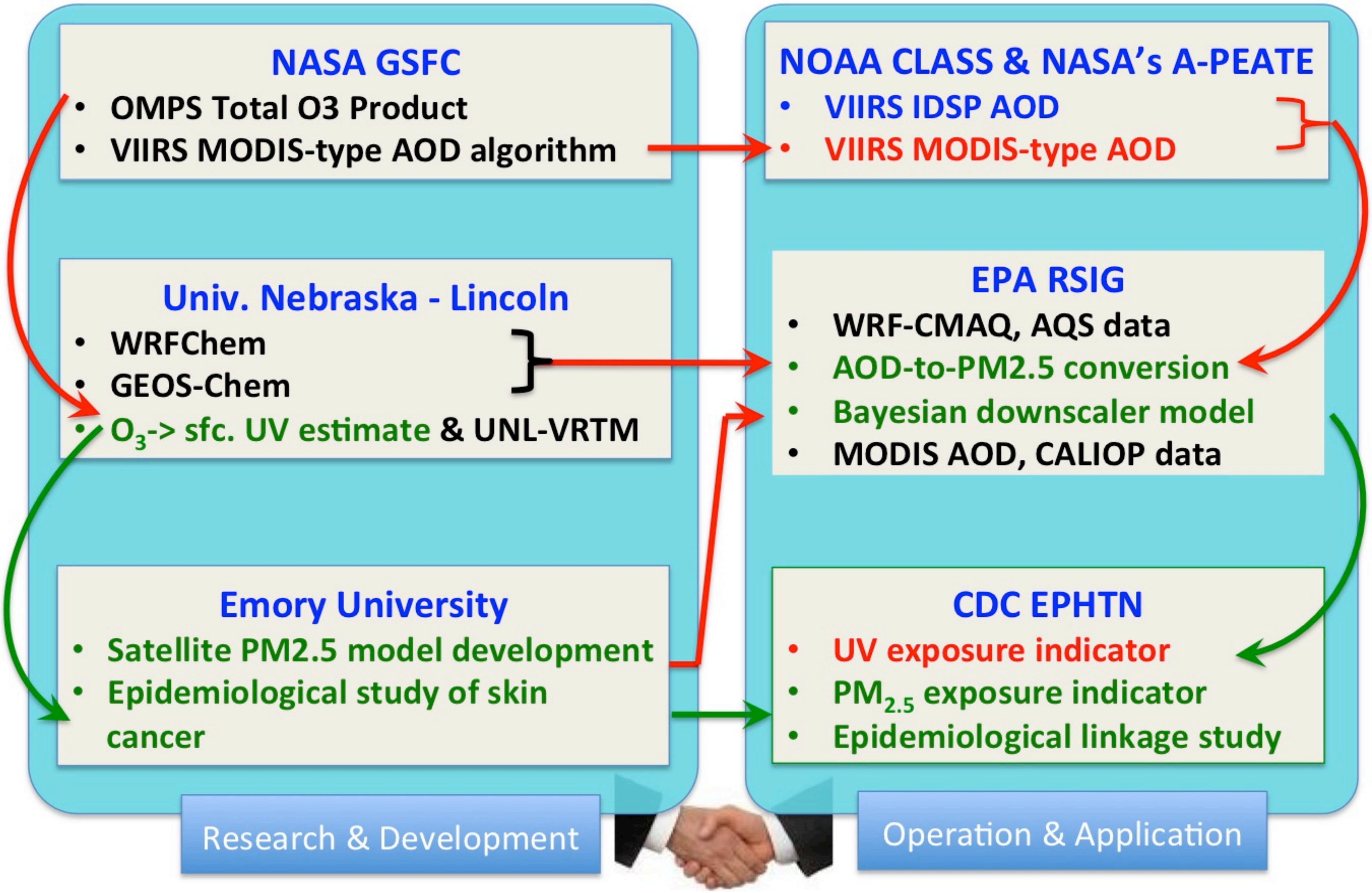
VIIRS,13:30 Local Time
14.1 revs/day

Objectives

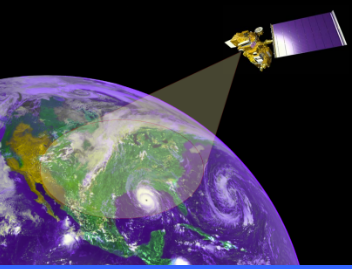
- **$PM_{2.5}$ applications**
  - Evaluate and improve the application of_the (MODIS-type if possible) VIIRS aerosol product for the operational monitoring of $PM_{2.5}$ air quality in EPA's Remote Sensing Information Gateway (RSIG)
  - Subsequently transfer RSIG's $PM_{2.5}$ estimates to the CDC's Environmental Public Health Tracking Network (EPHTN)
  - Evaluate and improve VIIRS-RSIG $PM_{2.5}$ estimates for enhanced spatial predictions in on-going EPA-CDC EPHTN efforts, currently using CMAQ model output and filter-based $PM_{2.5}$ observations from EPA-AQS.

- **Public heath (skin cancer research) applications**
  - Incorporate OMPS-based estimates of surface UVB irradiance and erythemal doses into the CDC's EPHTN, and apply them in both public heath advisory and skin cancer research.

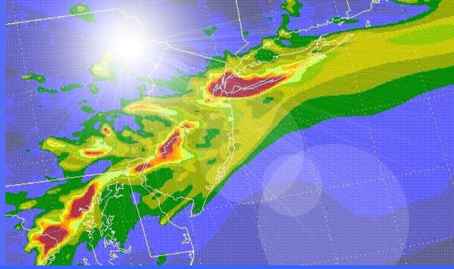
Work/Data Flow & Approaches



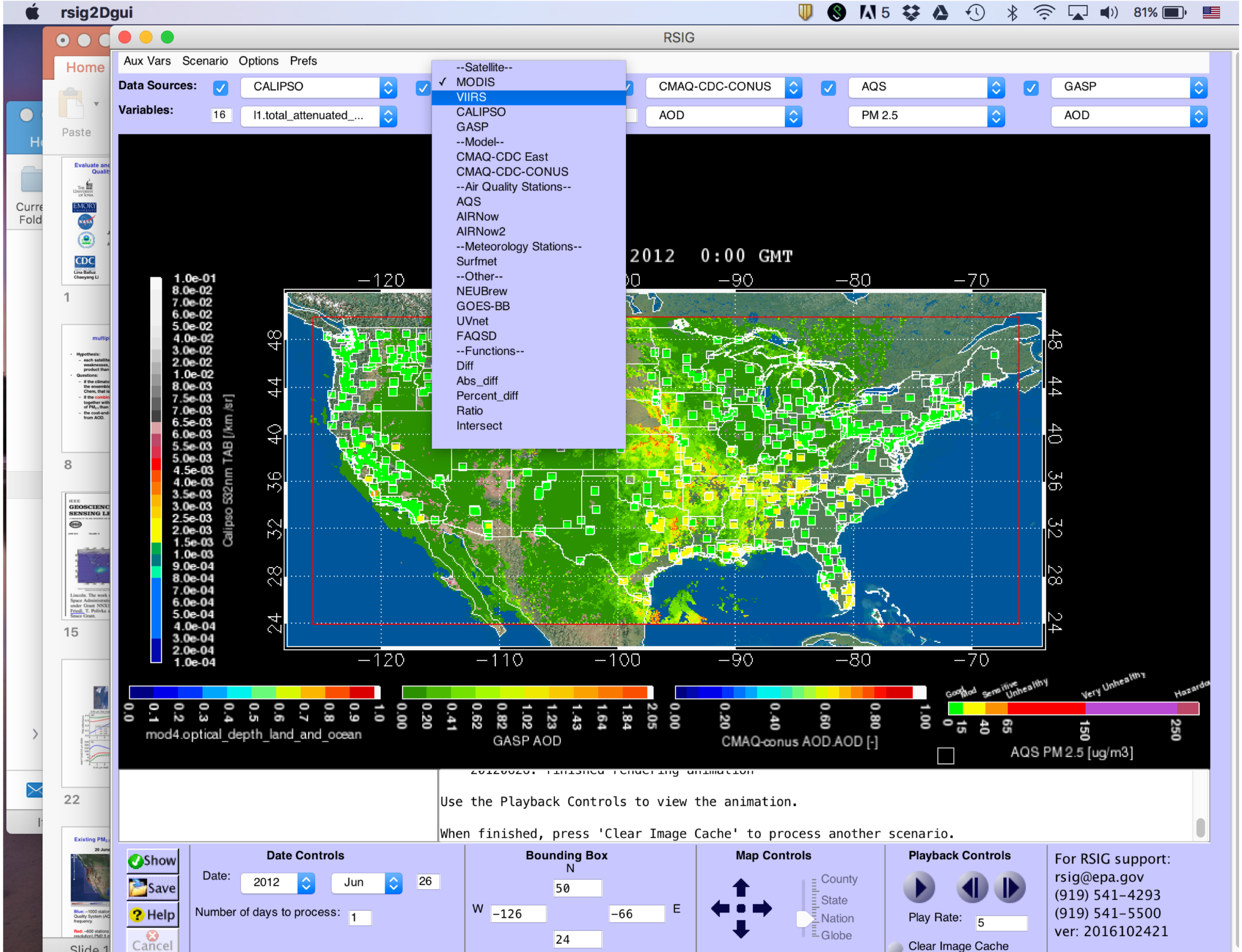
Black: datasets & model already in place; green: existing model capability and data flow that will be *improved*; red: the data and data flow will be created



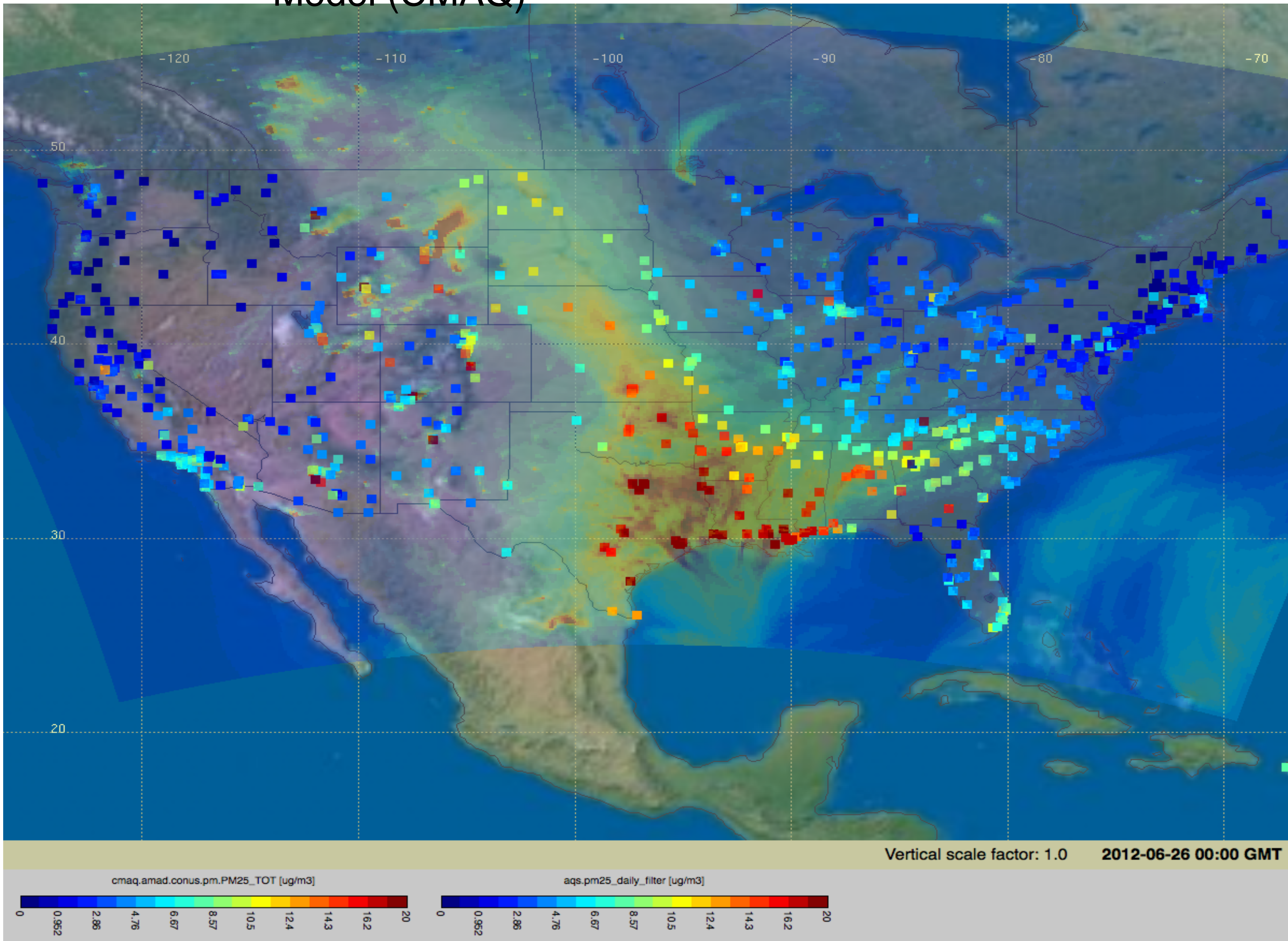
Key Features Designed into RSIG



- Accessible from computers outside the EPA network: (http://badger.epa.gov/rsig).
- Subsets files at the source, allowing users to access most current data version.
- Aggregates data files in time and space within visualization and save functions.
- Allows for on-the-fly re-gridding of satellite data onto standard CMAQ model grid or user specified grid parameters.
- Provides many useful "Save As" formats for the data and images, such as XDR binary, ASCII, HDF, MPEG, NetCDF, and KMZ.
- Interoperable with other OGC-compliant systems.


rsig2Dgui
RSIG
Aux Vars
Scenario
Options
Prefs
Data Sources:
CALIPSO
Variables:
16
l1.total_attenuated_...
--Satellite--
MODIS
VIIRS
CALIPSO
GASP
--Model--
CMAQ-CDC East
CMAQ-CDC-CONUS
--Air Quality Stations--
AQS
AIRNow
AIRNow2
--Meteorology Stations--
Surfmet
--Other--
NEUBrew
GOES-BB
UVnet
FAQSD
--Functions--
Diff
Abs_diff
Percent_diff
Ratio
Intersect
CMAQ-CDC-CONUS
AOD
AQS
PM 2.5
GASP
AOD
2012 0:00 GMT
Calipso 532nm TAB [/km /sr]
mod4.optical_depth_land_and_ocean
GASP AOD
CMAQ-conus AOD.AOD [-]
AQS PM 2.5 [ug/m3]
Use the Playback Controls to view the animation.
When finished, press 'Clear Image Cache' to process another scenario.
Show
Save
Help
Cancel
Date Controls
Date:
2012
Jun
26
Number of days to process:
1
Bounding Box
N
50
W
-126
-66
E
24
Map Controls
County
State
Nation
Globe
Playback Controls
Play Rate:
5
Clear Image Cache
For RSIG support:
rsig@epa.gov
(919) 541-4293
(919) 541-5500
ver: 2016102421

Model (CMAQ)



-120
-110
-100
-90
-80
-70
50
40
30
20
Vertical scale factor: 1.0
2012-06-26 00:00 GMT
cmaq.amad.conus.pm.PM25_TOT [ug/m3]
0 0.952 2.86 4.76 6.67 8.57 10.5 12.4 14.3 16.2 20
aqs.pm25_daily_filter [ug/m3]
0 0.952 2.86 4.76 6.67 8.57 10.5 12.4 14.3 16.2 20

An ensemble approach
multiple AOD products + multiple models
to derive PM from AOD

- **Hypothesis:**
  - **each satellite AOD product has its unique strengths and weaknesses, and a combination of them can yield a better AOD product than any individual product**
- **Questions:**
  - **if the climatology of $PM_{2.5}$-AOD ratio can be better represented by the ensemble mean of multi-models (instead of one model, GEOS-Chem, that is currently used);**
  - **if the combination of AOD from different sensors and algorithms together with $PM_{2.5}$-AOD ratio from (a) can yield the best estimate of $PM_{2.5}$ than from each individual source of AOD, and**
  - **the cost-and-benefits of using hindcast to estimate surface $PM_{2.5}$ from AOD.**

Model configurations

Model	Spatial resolution	Temporal resolution	MET	Chemistry BC	Anthropogenic emission	Fire emission	Biogenic emission	Chemical Mechanism (gas phase)	**Aerosol Module**
GEOS-Chem (v11-01)	0.5° x 0.667 °	Hourly	GEOS 5	GEOS-Chem v11-01 (2x2.5)	NEI 2011	FINN (daily)	MEGAN	HOx-NOx-VOC-O_3-BrOx	Sulfate-nitrate-ammonium, OC, EC, dust, sea salt
WRF-Chem (v3.6)	12 km	Hourly	WRFv 3.6	Model default	NEI 2011	FLAMBE	MEGAN (basics)	RADM2	MADE/SORGAM
CMAQ (V5.0.2)	12 km	Hourly	WRFV 3.4	GEOS-Chem v8-03-02 with GEOS 5	NEI 2011	BlueSky; Smart Fire Version 2	BEIS	CB05TUCL	AERO6

Aerosol module

GEOS-Chem: **sulfate-nitrate-ammonium, primary and secondary carbonaceous aerosols, mineral dust in four bins, sea salt in fine and coarse modes**

At 35% RH,
$PM_{2.5}$ = 1.33 (NH_4 + NIT + SO_4) + BCPI + BCPO + 2.1 (OCPO + 1.16 OCPI) + 1.16 SOA + DST1 + 0.38 DST2 + 1.86 SALA

WRF-Chem: **sulfate, nitrate, ammonium, BC, organic matters (OM), sea salt, mineral dust and water**

CMAQ: **sulfate, nitrate, ammonium, water, anthropogenic and biogenic organic carbon, element carbon and other unspecified material of anthropogenic origin**

Aerosol size distribution in the model

Modal approach: assume a log-normal distribution for each mode

- **Aitken mode : < 0.1 *μ*m**
- **Accumulation mode : 0.1 – 2.5 *μ*m**
- **Coarse mode : > 2.5 *μ*m**

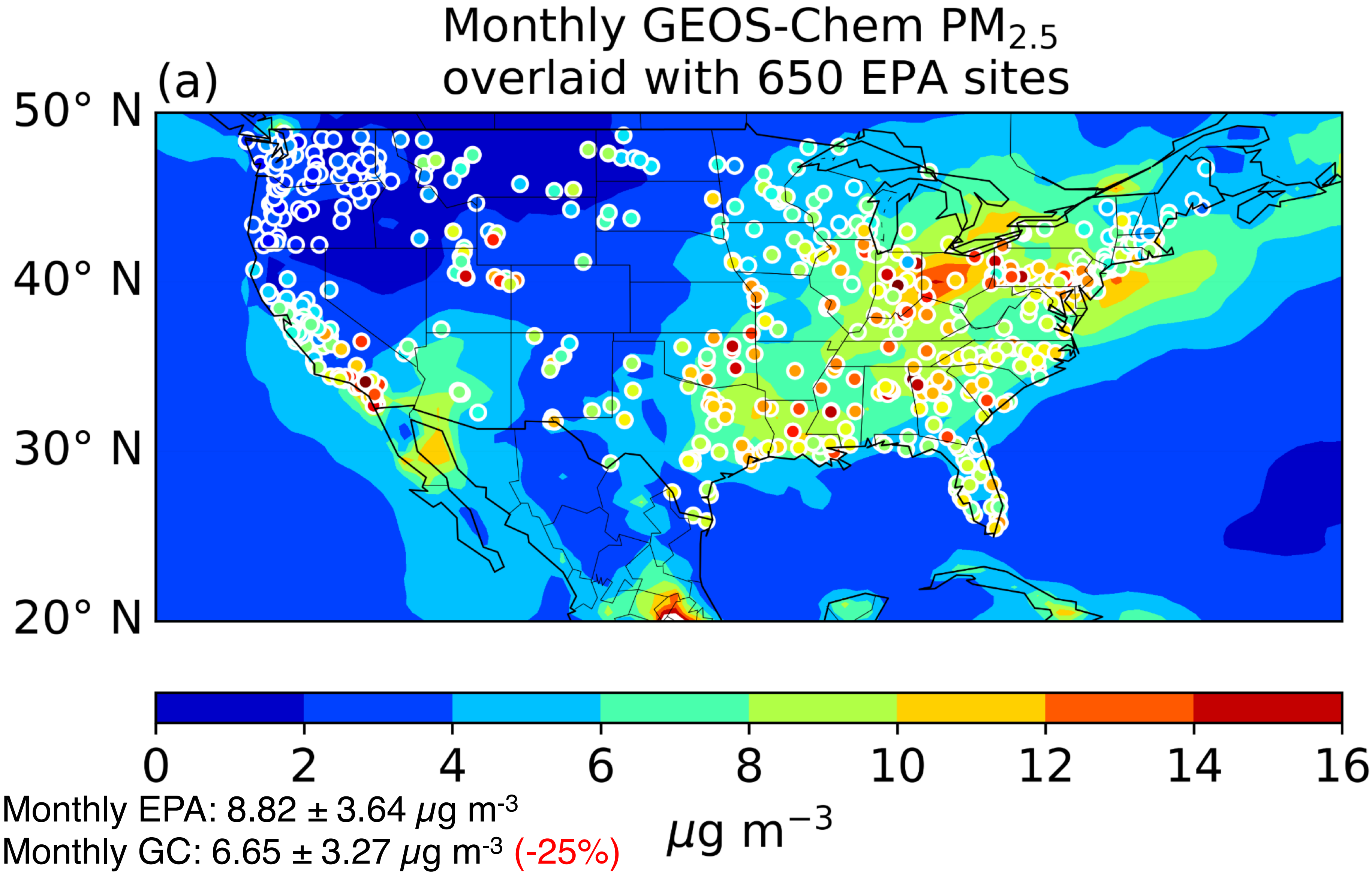
-WRF-Chem, CMAQ

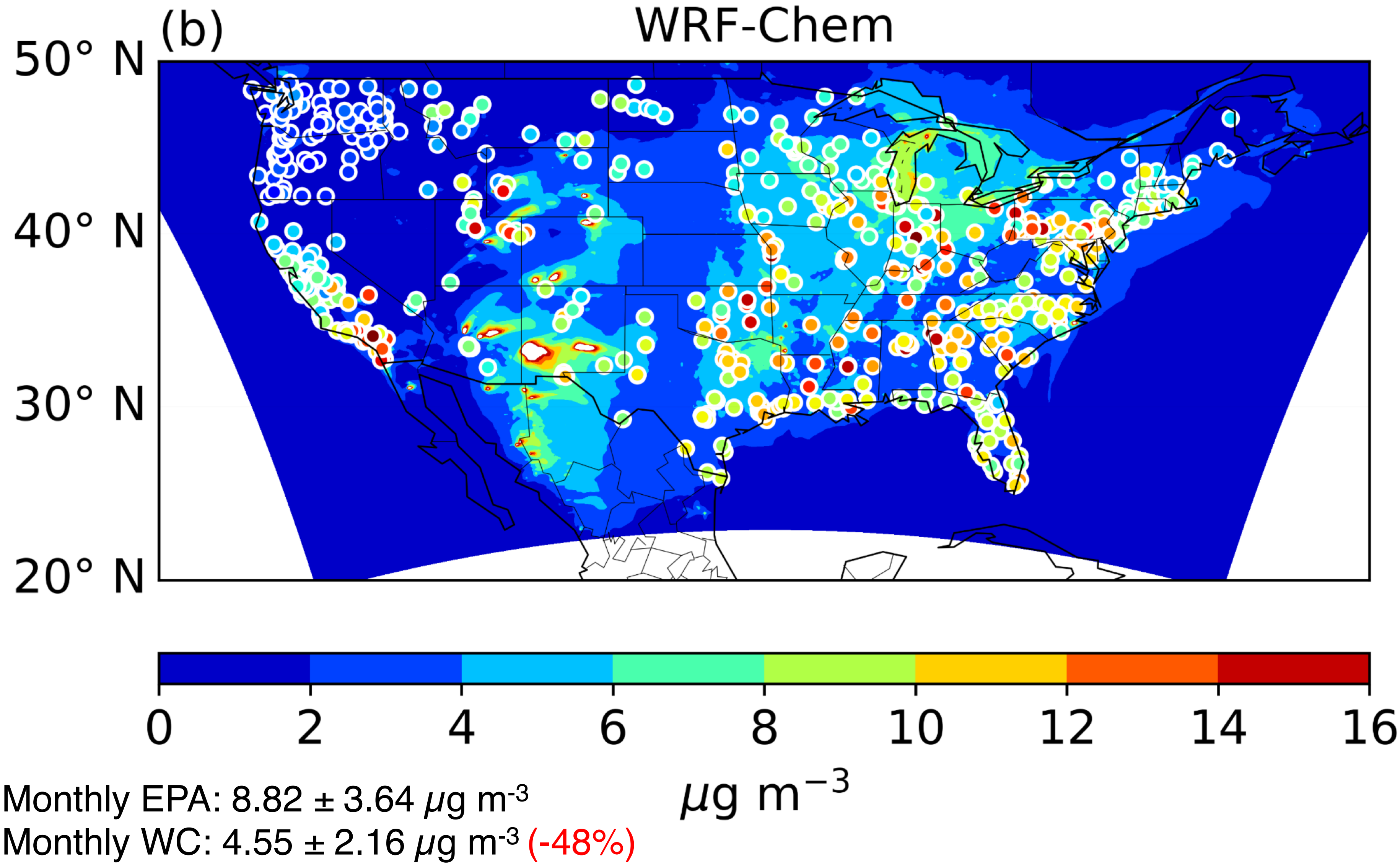
Sectional approach: use a discrete number of size bins

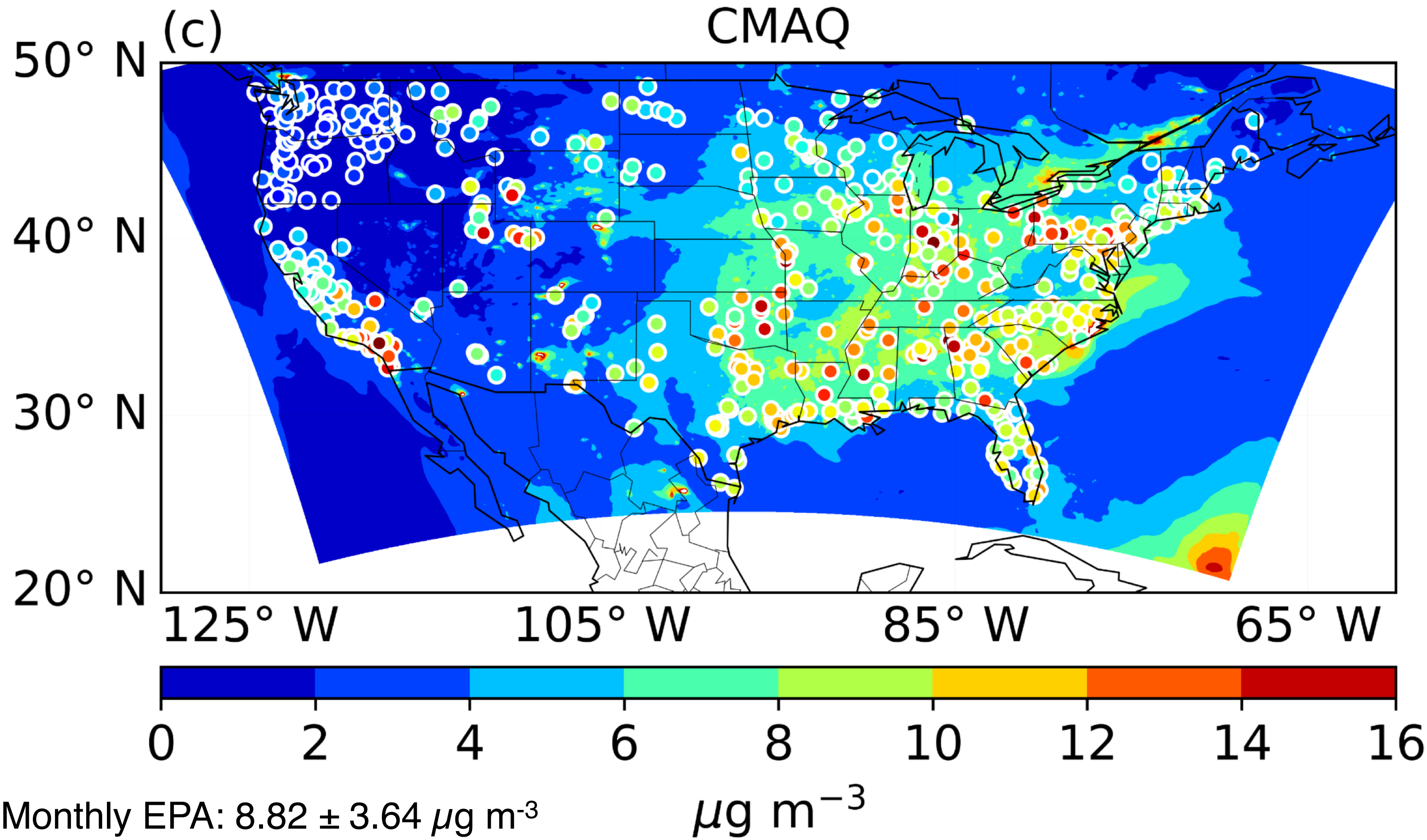
-GEOS-Chem dust: 0.1-1.0, 1.0-1.8, 1.8-3.0 and 3.0-6.0 *μ*m

↓ Calculating optical properties

0.1-0.18, 0.18-0.3, 0.3-0.6 and 0.6-1.0 *μ*m


Monthly GEOS-Chem PM2.5
overlaid with 650 EPA sites
(a)
50° N
40° N
30° N
20° N
0
2
4
6
8
10
12
14
16
μg m−3
Monthly EPA: 8.82 ± 3.64 μg m-3
Monthly GC: 6.65 ± 3.27 μg m-3 (-25%)

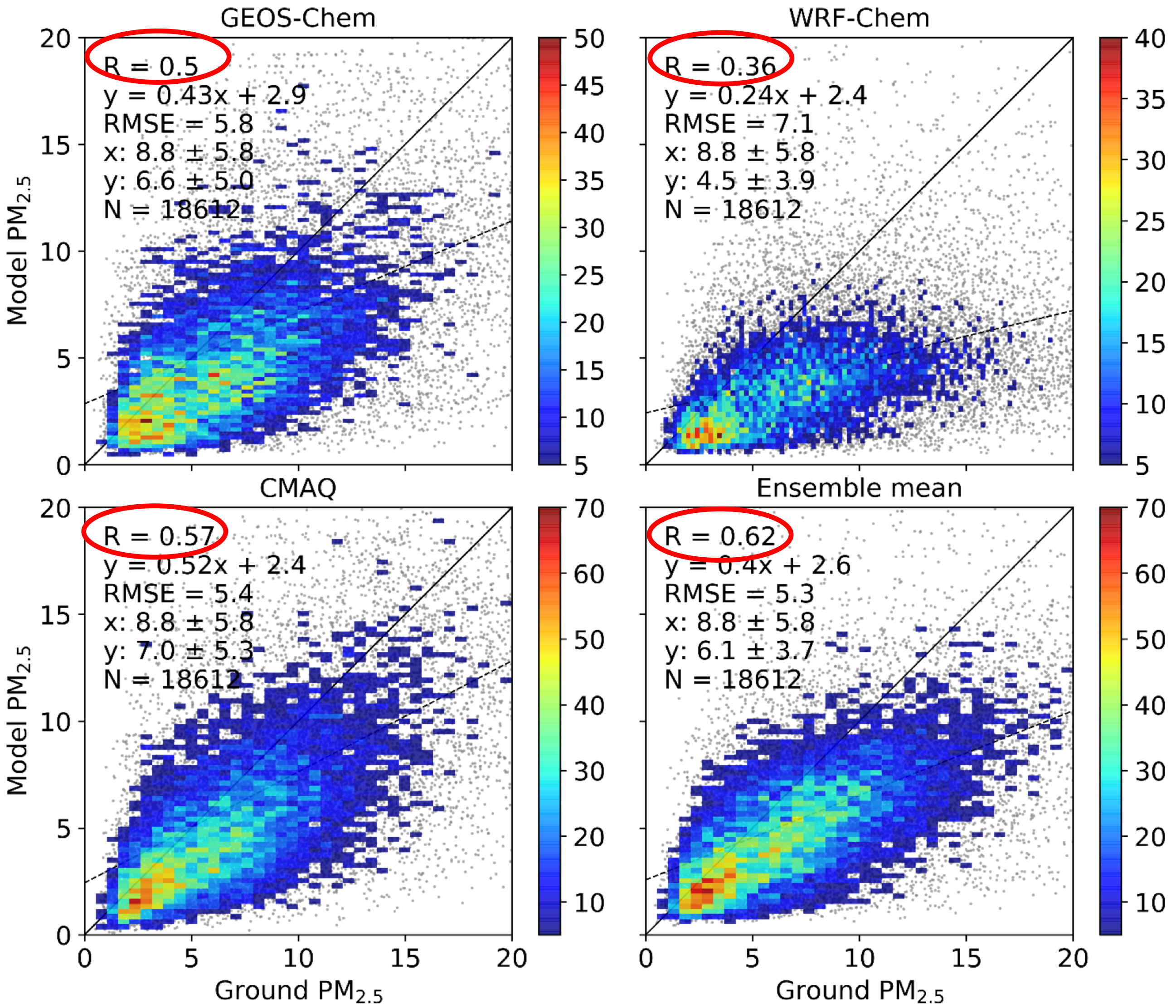

(b)
WRF-Chem
50° N
40° N
30° N
20° N
0
2
4
6
8
10
12
14
16
μg m⁻³
Monthly EPA: 8.82 ± 3.64 μg m-3
Monthly WC: 4.55 ± 2.16 μg m-3 (-48%)



Monthly EPA: 8.82 ± 3.64 μg m^{-3}

Monthly CMAQ: 7.04 ± 3.57 μg m^{-3}(-20%)

Daily $PM_{2.5}$
at 650
ground sites



Method1: L-BFGS-B

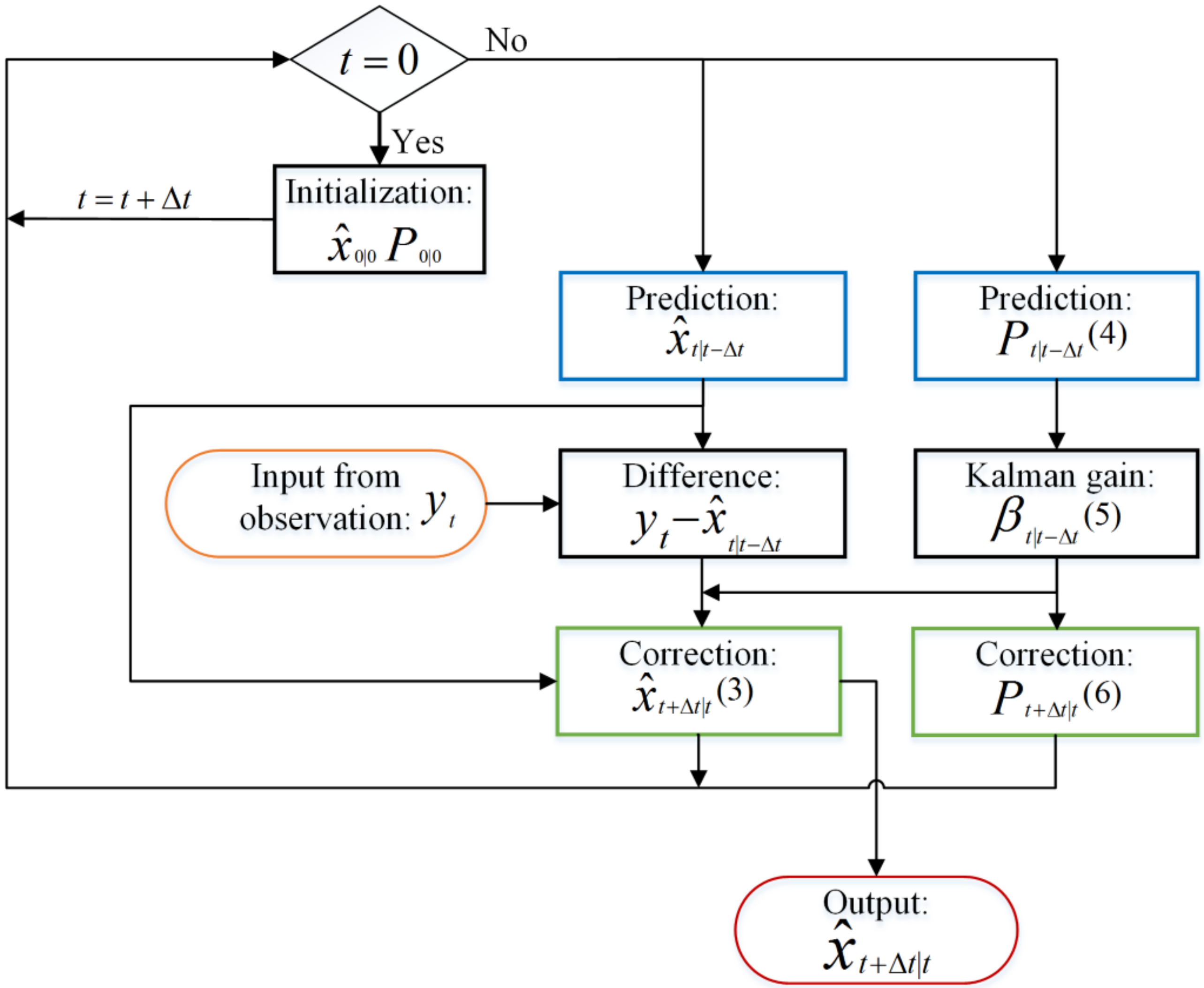
Cost-function =

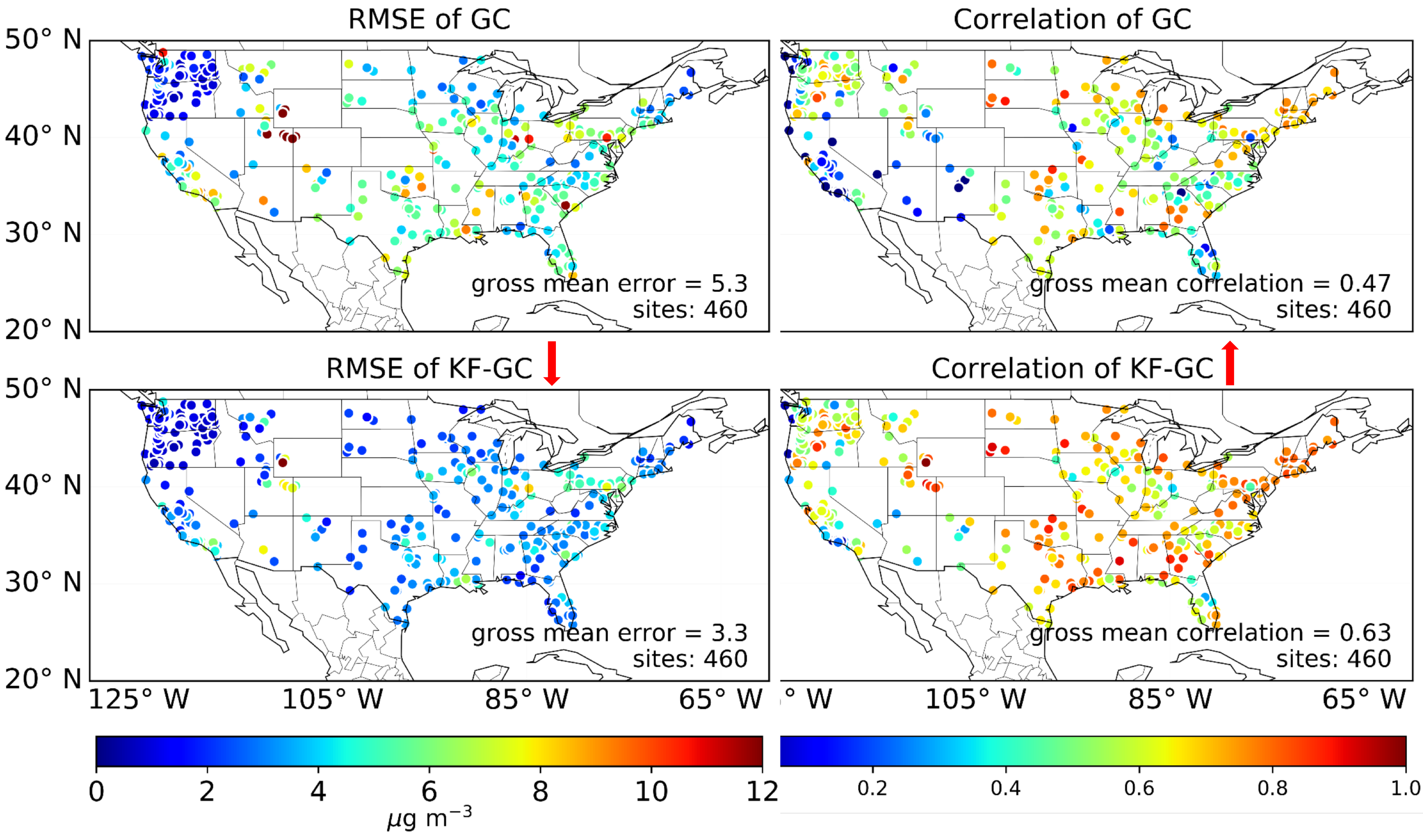
$$\sum_{i=1}^{d}(a * X_{gc,i} + b * X_{cmaq,i} + c * X_{wrf,i} - Y_{obs,i})^2$$

Where,

- d, the total number of days of data
- i , day
- a,b,c, the weighting factors to be optimized
- $X_{gc,i}$, $X_{cmaq,i}$, $X_{wrf,i}$, model PM2.5 concentration at day i
- $Y_{obs,i}$, EPA PM2.5 concentration at day I
- Initial a,b,c: 1./3., 1./3.,1./3.

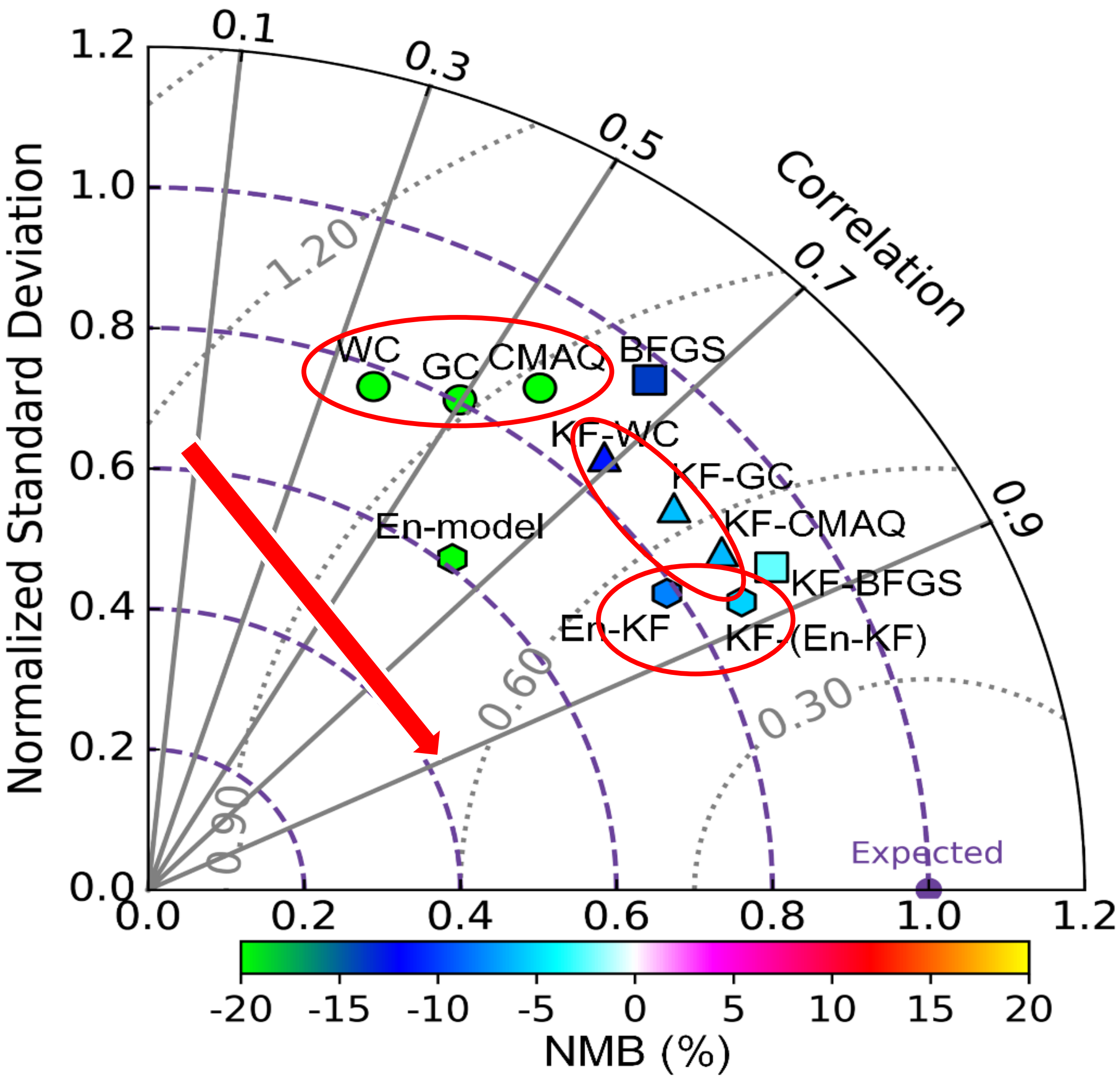
Method 2 : Kalman filter (KF) postprocessing predictor bias correction





RMSE of GC
Correlation of GC
gross mean error = 5.3
sites: 460
gross mean correlation = 0.47
sites: 460
RMSE of KF-GC
Correlation of KF-GC
gross mean error = 3.3
sites: 460
gross mean correlation = 0.63
sites: 460
50° N
40° N
30° N
20° N
125° W
105° W
85° W
65° W
0
2
4
6
8
10
12
μg m−3
0.2
0.4
0.6
0.8
1.0

Overall performance



Step II: Applying AOD for the forecast

$$PM_{2.5}(\text{estimated}) = PM_{2.5} \times \frac{AOD(sate)}{AOD(model)}$$

Summary

- **Milestones**
  - Data flow from UW-SIPS (Science Investigator Processing System) to EPA's RSIG is implemented, tested, and successful. **ARL4->ARL-7**
  - Evaluation of ensemble approach for surface PM2.5 estimates from VIIRS and other satellite projects is conducted for June 2012. This would provide insight on the selection and improvement of operation approach for remote sensing of surface $PM_{2.5}$. **ARL4->ARL7; manuscript in prep.**
- **Next steps**
  - Continue the evaluation of ensemble approach and make recommendations to RSIG
- **Budgets. No issues except**
  - It took sometime for EPA to receive funds from NASA; delay in spending because of change of institution
- **Risk and challenges**
  - **No risk. Things are as planned.**
  - **Challenges. No.**

IEEE

GEOSCIENCE AND REMOTE SENSING LETTERS

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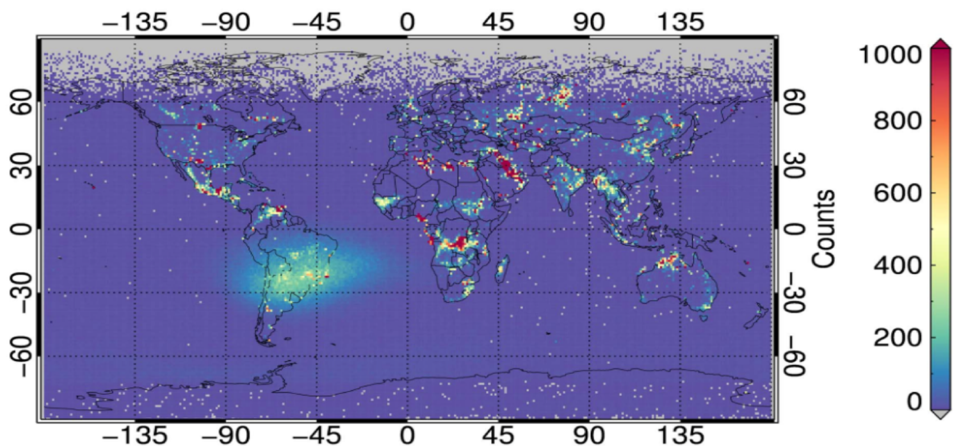
JUNE 2015 VOLUME 12 NUMBER 6 IGRSBY (ISSN 1545-598X)



Regions of frequent biomass burning and gas flaring highlighted by NOAAs Nightfire product during 18 March–14 July 2013. Interference from the South Atlantic Anomaly (SAA) is visible over a large portion of South America.

Thank you !

Journal-cover article: Polivka, T., E. Hyer, J. Wang , and D. Peterson, First global analysis of saturation artifacts in the VIIRS infrared channels and the effects of sample aggregation, *IEEE Geoscience and Remote Sensing Letters*, 1262-1266, 2015.

Lincoln. The work of J. Wang was supported by the National Aeronautics and Space Administration (NASA) S-NPP Program and Applied Science Program under Grant NNX11AJ03G managed by John A. Haynes and Lawrence A. Friedl. T. Polivka also acknowledges the support from the NASA Nebraska Space Grant.

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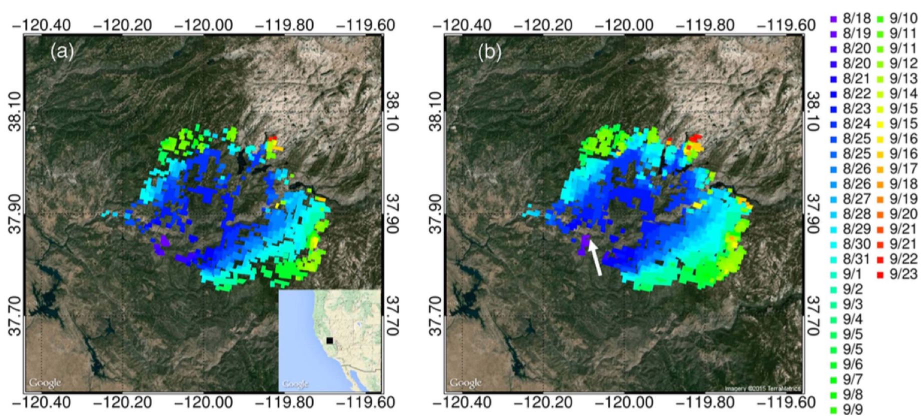

Progression of the 2013 Rim Fire from ignition to extinction, as revealed by the operational Active Fire Application Related Product (left) and the Firelight Detection Algorithm (right), both using the same input data from the VIIRS aboard the Suomi-NPP satellite.

Thank you !

Journal-cover article:

Polivka, T., **J. Wang**, L. Ellison, E. Hyer, and C. Ichoku, Improving Nocturnal Fire Detection with the VIIRS Day-Night Band, *IEEE Transactions on Geoscience & Remote Sensing*, 9, 5503-5519, 2016.

date of current version August 2, 2016. This work was supported in part by the NASA Suomi NPP Program and Applied Science Program managed by John A. Haynes and Lawrence A. Friedl and in part by the Interdisciplinary Studies (IDS) Program directed by J. Kaye and administered through the Radiation Sciences Program managed by Hal B. Maring. The work of T. Polivka was also supported by the NASA Nebraska Space Grant.

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journal homepage: www.elsevier.com/locate/atmosenv

Thank you !

Potential application of VIIRS Day/Night Band for monitoring nighttime surface $PM_{2.5}$ air quality from space

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[b] National Exposure Research Laboratory, U.S. Environmental Protection Agency, RTP, NC, USA

Acknowledgment

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Keywords:
Nighttime
PM2.5
VIIRS
Day/Night Band

light bulbs at the surface. We further show both quantitatively that the contrast of DNB images can indicate the change of air quality at the urban scale, and quantitatively that change of light intensity during the night (as characterized by VIIRS DNB) reflects the change of surface $PM_{2.5}$. Compared to four meteorological variables (u and v components of surface wind speed, surface pressure, and columnar water vapor amount) that can be obtained from surface measurements, the DNB light intensity is the only variable that shows either the largest or second largest correlation with surface $PM_{2.5}$ measured at 5 different sites. A simple multivariate regression model with consideration of the change of DNB light intensity can yield improved estimate of surface $PM_{2.5}$ as compared to the model with consideration of meteorological variables only. Cross validation of this DNB-based regression model shows that the estimated surface $PM_{2.5}$ concentration has nearly no bias and a linear correlation coefficient (R) of 0.67 with respect to the corresponding hourly observed surface $PM_{2.5}$ concentration. Furthermore, ground-based observations support that surface $PM_{2.5}$ concentration at the VIIRS night overpass (~1:00 am local) time is representative of daily-mean $PM_{2.5}$ air quality ($R = 0.82$ and mean bias of -0.1 μg m^{-3}). While the potential appears promising, mapping surface $PM_{2.5}$ from space with visible light at night still face various challenges and the strategies to address some of these challenges are elaborated for future studies.

AGU PUBLICATIONS

Geophysical Research Letters

RESEARCH LETTER

10.1002/2016GL070204

Thank you !

A new approach for monthly updates of anthropogenic sulfur dioxide emissions from space: Application to China and implications for air quality forecasts

Yi Wang[1,2], Jun Wang[1,2], Xiaoguang Xu[1,2], Daven K. Henze[3], Yuxuan Wang[4,5], and Zhen Qu[3]

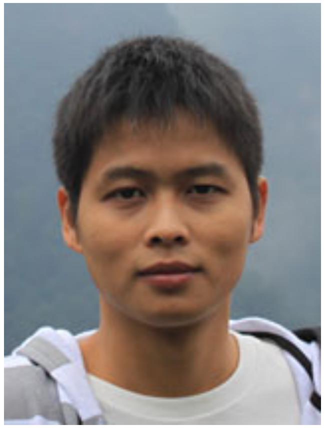
Key Points:

- OMI and adjoint modeling can constrain monthly anthropogenic SO_2 emissions
- Twenty percent emission reduction during the Beijing Olympic Games are made evident
- Posterior emissions improve monthly forecasts of surface and column SO_2

Acknowledgments

This work is supported by NASA Atmospheric Chemistry Modeling and Analysis Program (NNX13AK86G) managed by Richard S. Eckman, NASA Radiation Sciences Program managed by Hal B. Maring, NASA Aura Science managed by Kenneth Jucks, and NASA Applied Science program managed by John Haynes. Data shown in the paper can be obtained from the corresponding author through e-mail (jwangjun@gmail.com).

aska–Lincoln, Lincoln, Nebraska, USA, [2]Now at Center of
ıical and Biochemical Engineering, University of Iowa,
versity of Colorado Boulder, Boulder, Colorado, USA,
Houston, Houston, Texas, USA, [5]Ministry of Education
Science, Institute for Global Change Studies, Tsinghua



remote sensing

Thank you !

Article

MODIS Retrieval of Aerosol Optical Depth over Turbid Coastal Water

Yi Wang [1,2,3], Jun Wang [1,2,3,*], Robert C. Levy [4], Xiaoguang Xu [1,2] and Jeffrey S. Reid [5]

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Remote Sens. **2017**, *9*, 595;
doi:10.3390/rs9060595

Users' Feedback

- I noticed that, unlike MODIS files, these files contain no CoreMetadata.0 record with swath lon-lat bounds that could be read and compared to a user-specified bounds to quickly checked and skip files without having to read their lon-lat coordinate arrays. But that is minor…

- The main problem is that the Latitude and Longitude variables are still 16-bit integers, which after multiplying by 0.01, which allows for an error of over 1km! I don't think that is good enough for reasonable georeferencing.

- Is there still a plan to eventually have VIIRS file format match MODIS Collection 6 file format?

- Answer: "NASA VIIRS data will be in netcdf4 format instead of modis hdf4 format."

- Steady progress is now being made.