ARL
Air Resources Laboratory
Conducting research and development in the fields of air quality, atmospheric dispersion, climate, and boundary layer

NAQFC-β deployed to support measurement intensives – e.g., Firex-AQ

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19th CMAS Meeting, Oct 26-30 2020

Presentation Outline

I. NAQFC-β supports intensive measurement campaigns
- DISCOVER-AQ
- OWLETS
- Firex-AQ

II. Description of upcoming NAQFC-β
- Meteorology
- Emission
- Chemistry Transport modeling

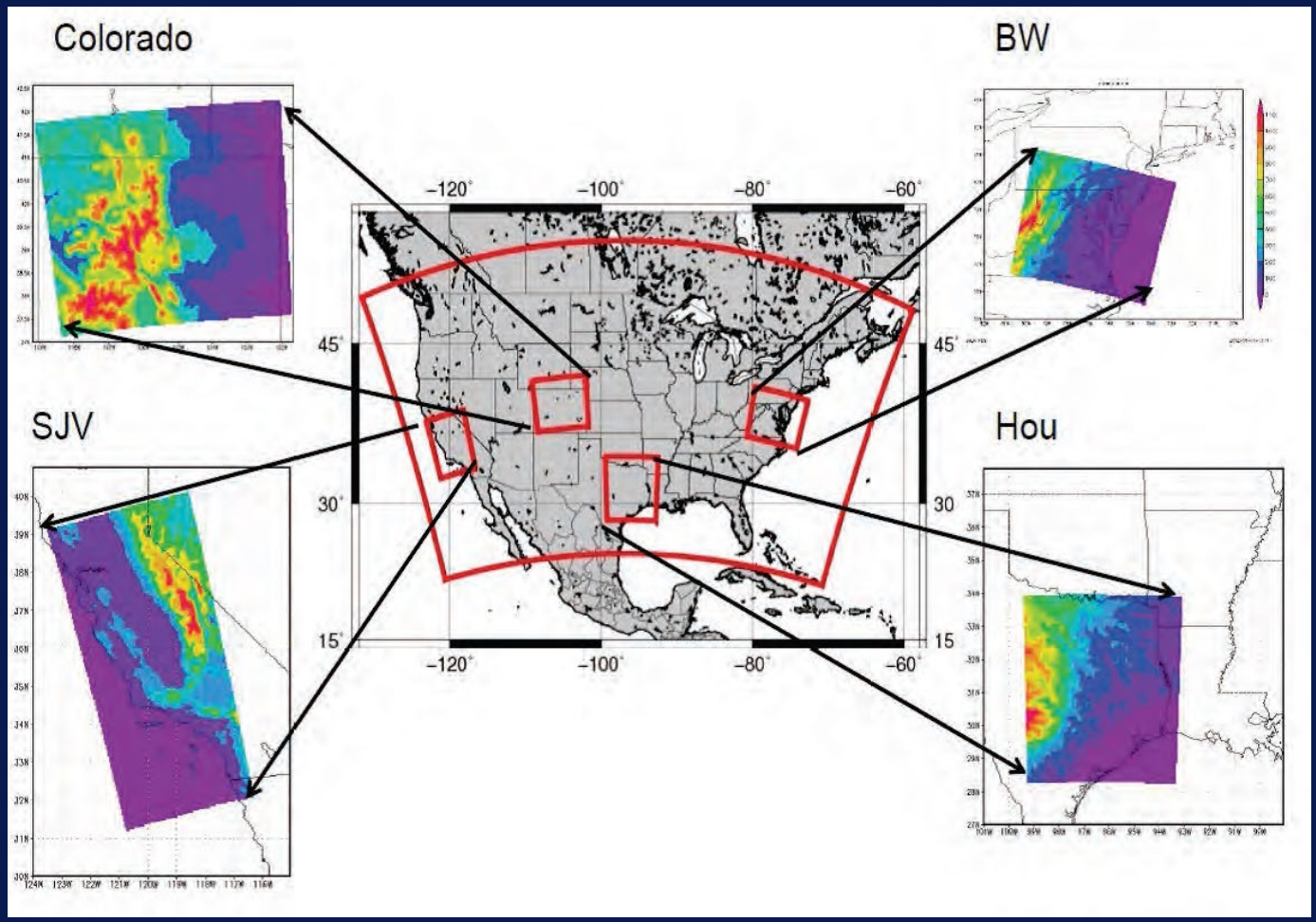
III. A preliminary evaluation of its performance during Firex-AQ
- Meteorology from NMMB to FV3-GFS-v15 change
- FV3-GFS-v15_CMAQ5.0.2 to FV3-GFS-v16_CMAQ5.3.1 (target sys) change

IV. Improve GBBEPX application by GEDI-assisted rapid refreshing LULC
- Derive fire duration to distinguish agricultural fires
- Explore possibility to rapid refresh LAI and biomass density

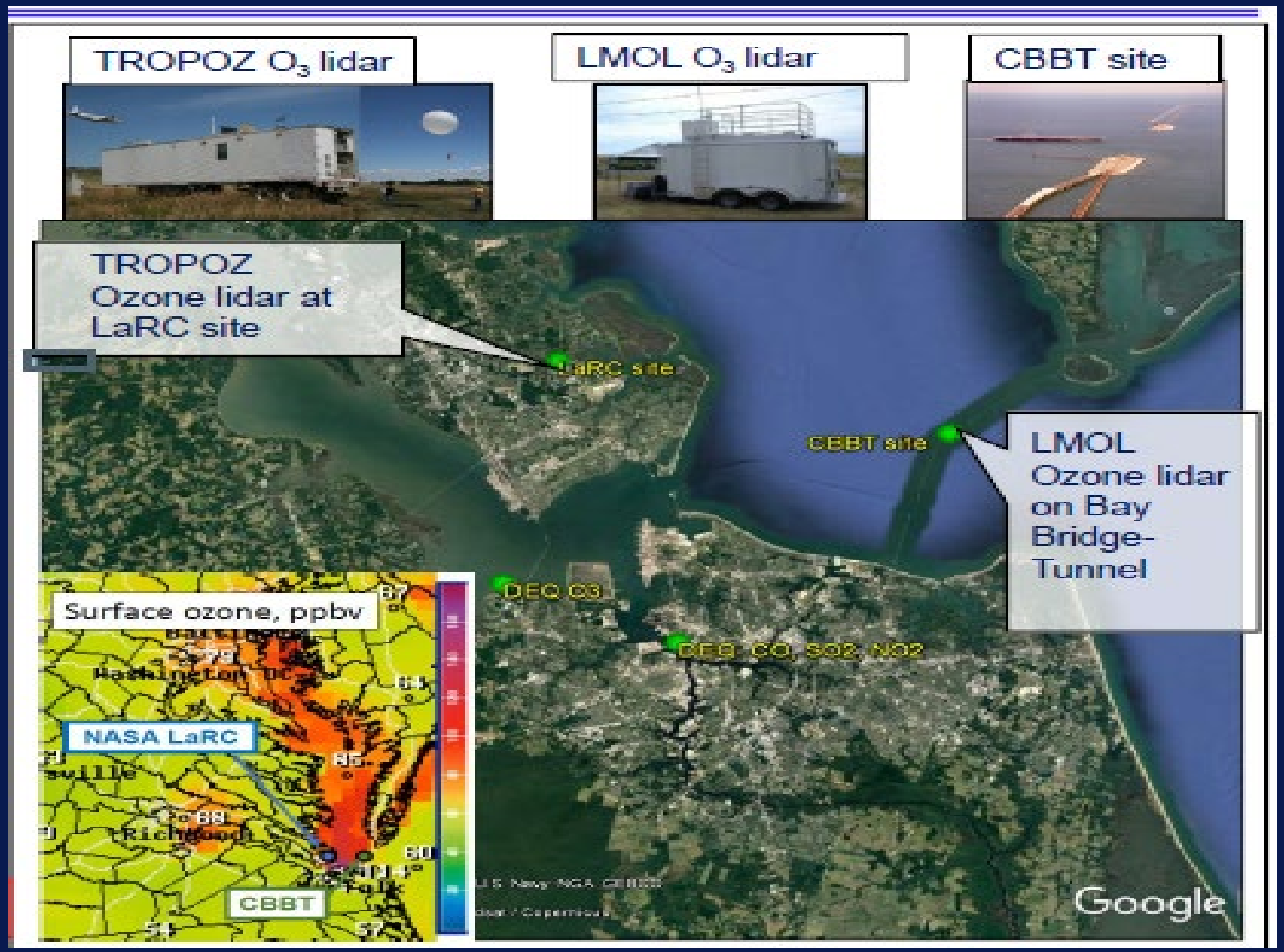
V. Summary

NAQFC supported DISCOVER-AQ

4 DISCOVER-AQ Campaigns
Pickering and Lee, EM 2014;

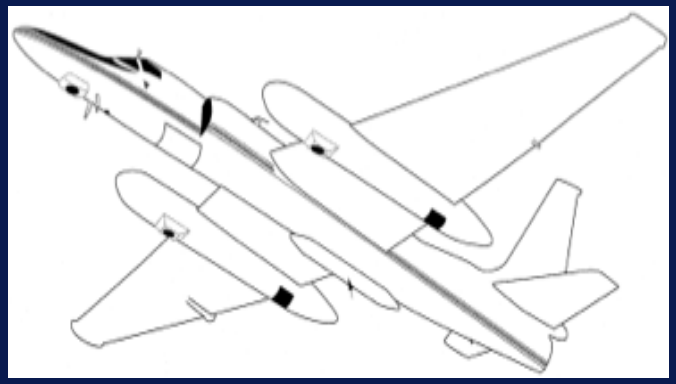


NAQFC supported OWLETS 2017 & 2018



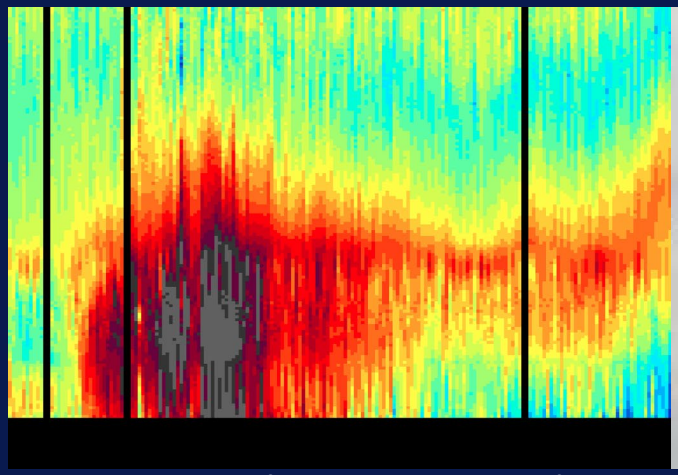
Courtesy:
T. Berkoff &
J. Sullivan

NAQFC supported Firex-AQ



NASA Lockheed ER-2

NOAA Twin Otter



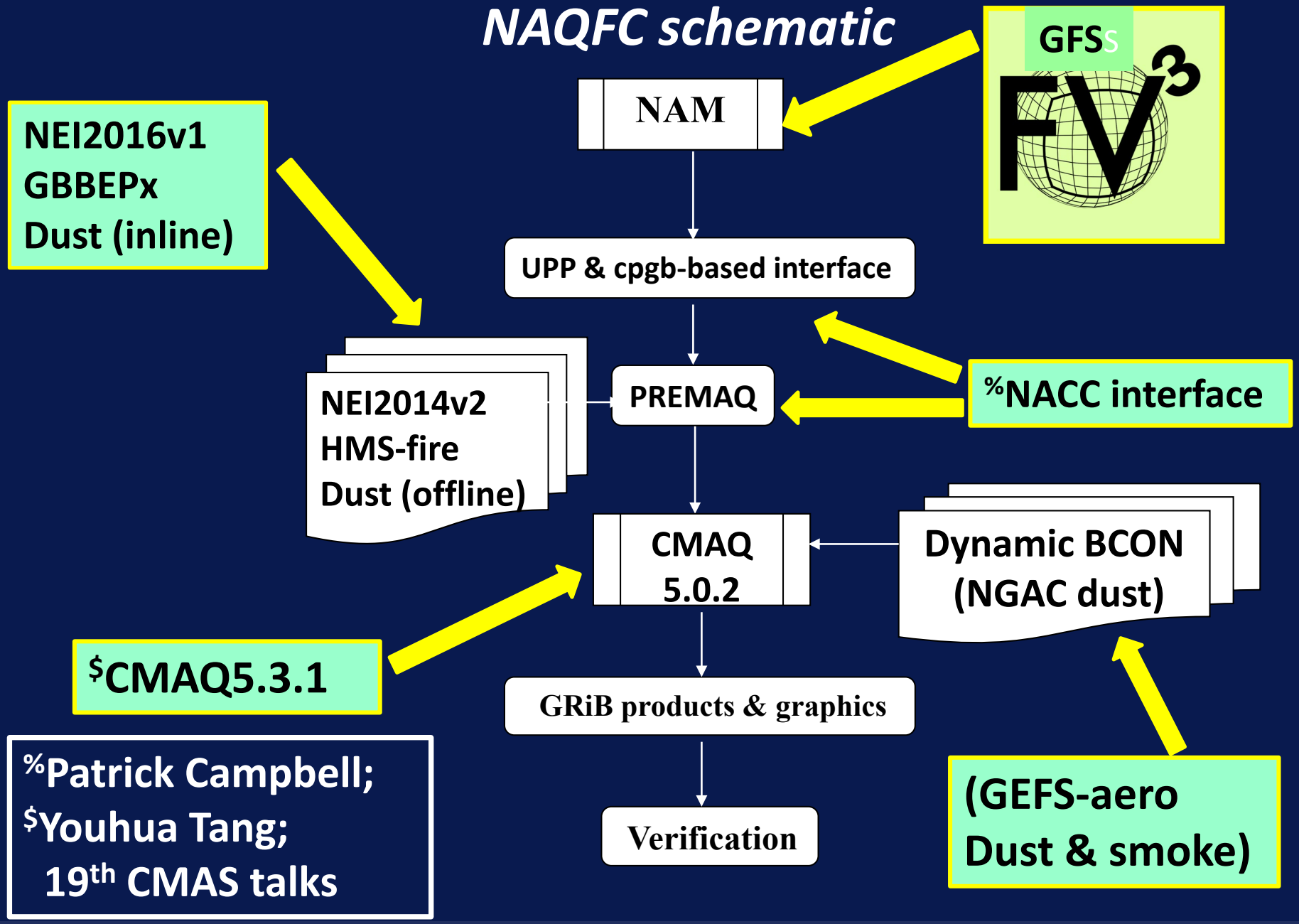
NASA Tropospheric Ozone Lidar network

NASA DC-8

Courtesy:
J. Crawford &
C. Warneke

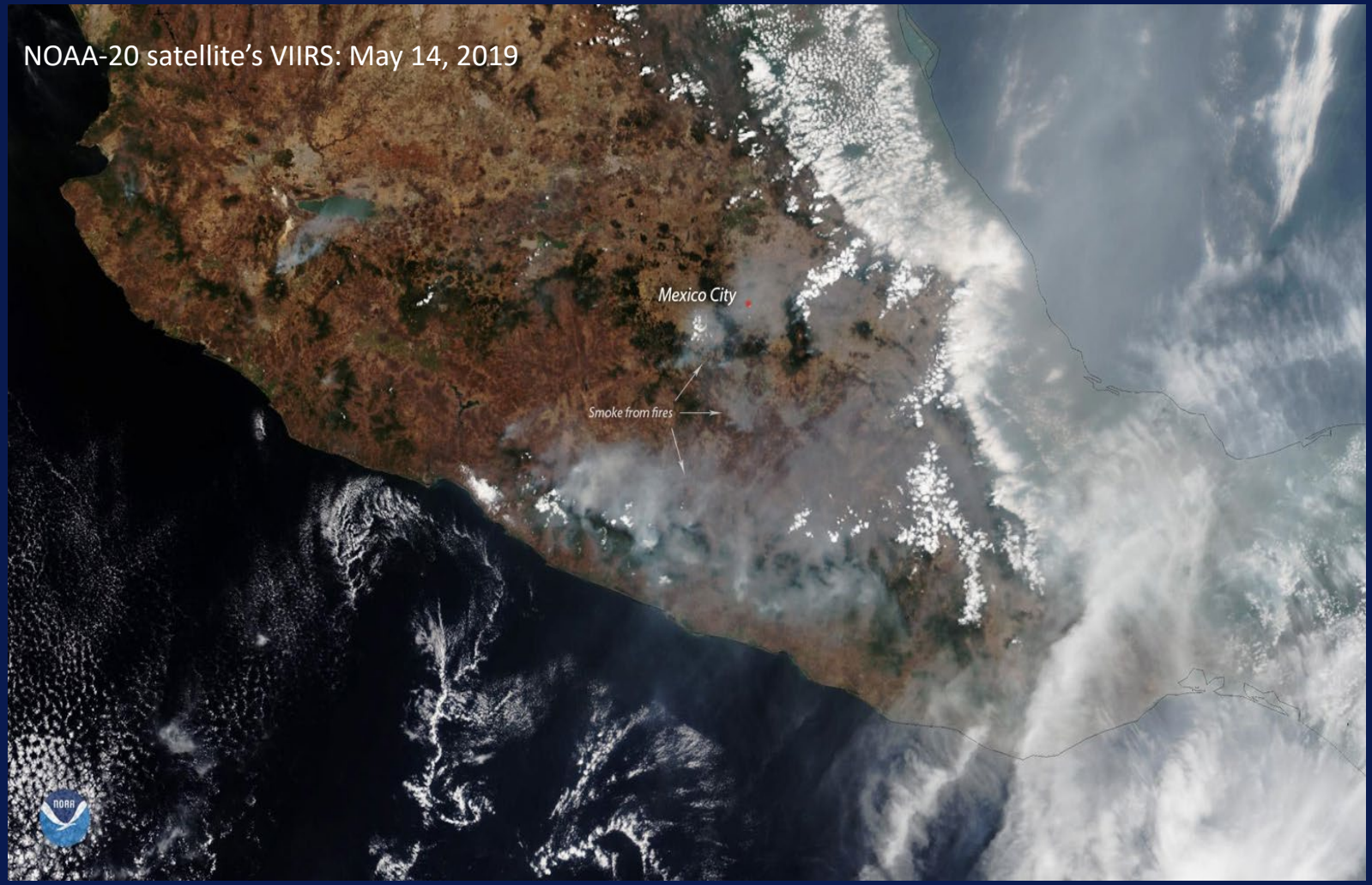
FIREX-AQ July 24 – September 5 2019 in western US

NAQFC schematic



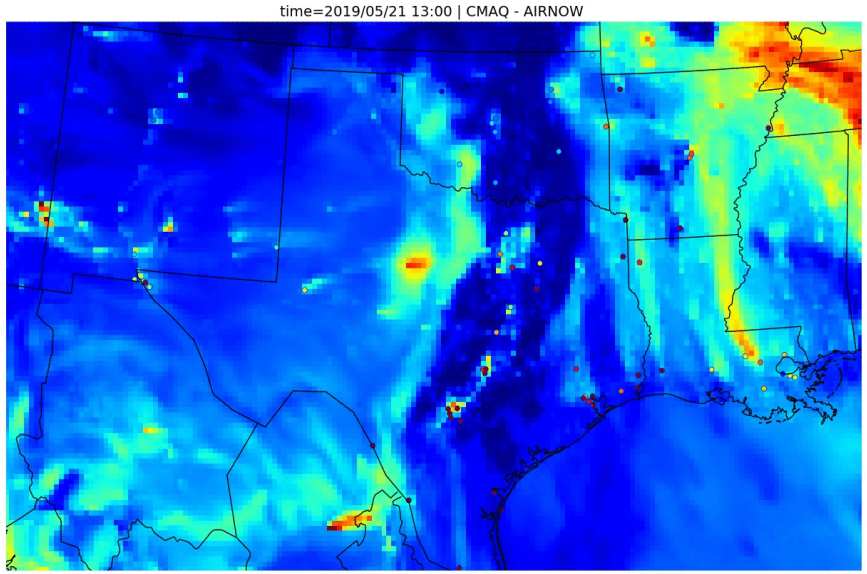
%Patrick Campbell;
$Youhua Tang;
19th CMAS talks

LBC accounts ex-domain emission: e.g. Wildfires burning around Mexico City May 21-23 2019

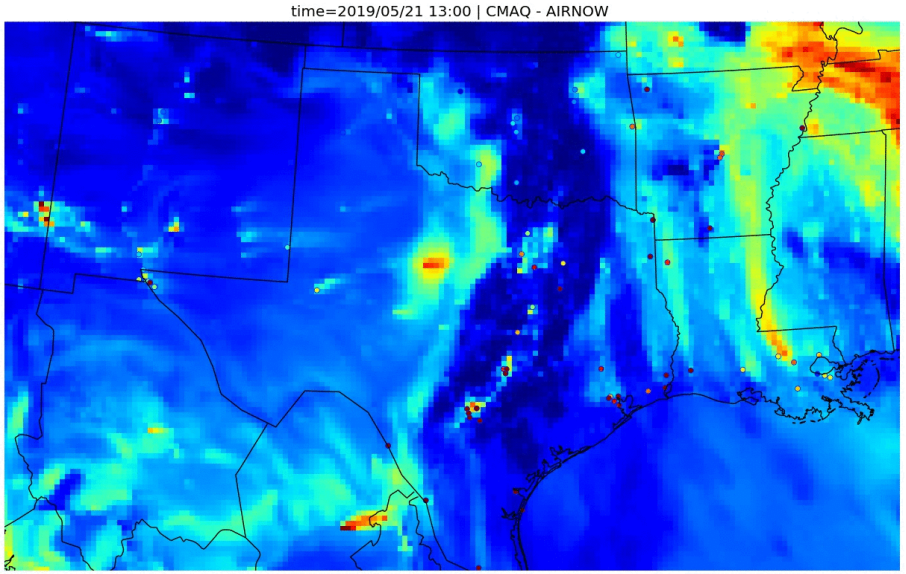


Evaluation with AIRNOW $PM_{2.5}$ - U.S. EPA Region 6

Static LBC



Dynamic LBC



Run	# Pairs	Observed (μg m^{-3})	MB (μg m^{-3})	NMB (%)	NME (%)	Corr.	IOA
Static LBC	155	14.25	-11.31	-79.35	80.03	0.31	0.39
Dynamic LBC	155	14.25	-10.57	-74.18	74.89	0.10	0.42

Smoke transport, Mexico Wildfires: Dynamic LBCs reduced the bias and error in R6, and increased the IOA. Yet decreased in correlation.

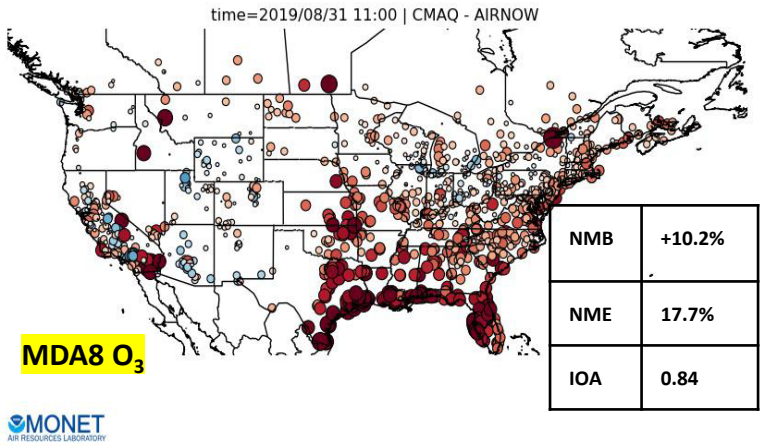
GFSv16-CMAQ5.3.1 vs GFSv15-CMAQ5.0.2 for August 01-31 2019

Run ID	Met driver	LAI and LU	CMAQ version /forecast/lev	Chemical Mech. Gas-Aer	LBCs	Anthro. Emission	Biog. Emission	Wildfire Emission	Dust Emission
NACC-CMAQ	FV3-GFSv16 12 Z cycle	MODIS climo monthly LAI and LU fraction	CMAQ 5.3.1/72 hr/35 lays	CB6r3-AE7	Static GEOS 2006 + GEFS-Aerosol smoke+dust	NEI platform 2016v1	BEISv3.6.1+ BELD3	GBBEPx OC, BC, CO, NH3, SO2 emission	n/a
Para13	FV3-GFSv15 12 Z cycle	LAI=4, USGS LU fraction	CMAQ 5.0.2/72 hr/35 lays	CB05tucl-AE6	Static GEOS 2006 + GEFS-Aerosol smoke+dust	NEI 2014v2 (PreMAQ)	BEISv3.1.4+ BELD3	GBBEPx OC/BC only	inline Fengsha

- *72 h forecast driven by FV3 at C768*
- *NESDIS latency is aimed to be within 24 h*
- *NGAC v2 (dust) + VIIRS AOT Northern LBC*
- *Gas phase chemistry for wild-fire species is active*

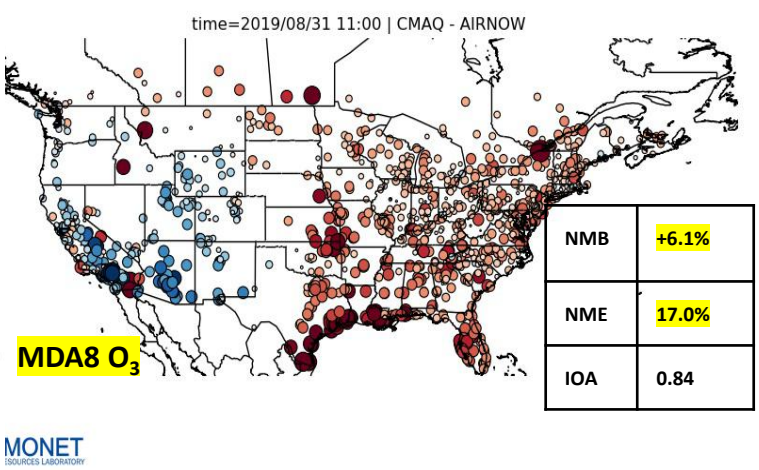
Spatial Evaluations of MDA8 O_3 and 24-hr $PM_{2.5}$

Para13 GFSv15-PreMAQ-CMAQv5.0.2



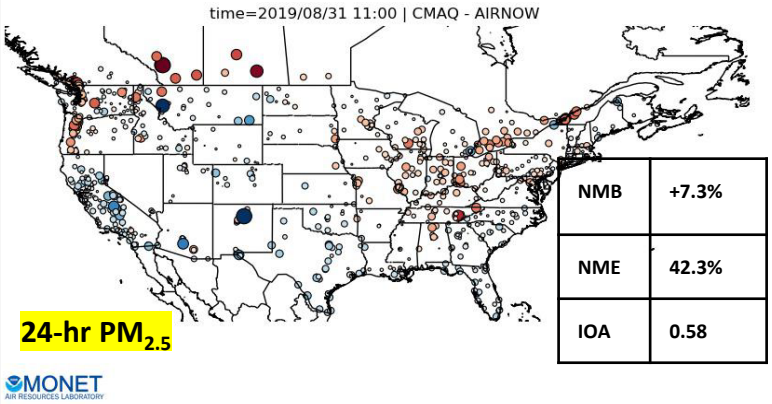
NMB	+10.2%
NME	17.7%
IOA	0.84

GFSv16-NACC-CMAQv5.3.1

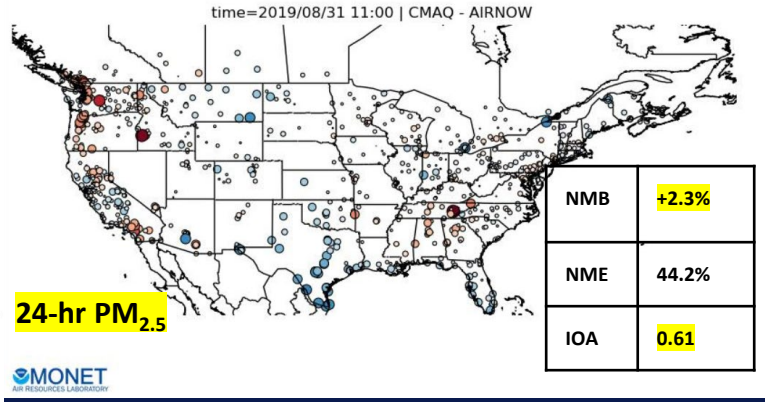


NMB	+6.1%
NME	17.0%
IOA	0.84

Overall Lower NMB and NME and same IOA.



NMB	+7.3%
NME	42.3%
IOA	0.58



NMB	+2.3%
NME	44.2%
IOA	0.61

Overall Lower NMB and higher IOA, but higher NME

Ozone Forecast performance statistics averaged over August 2019

CONUS-domain	Hourly Ozone forecast performance against Production					
	NMB		NME		IOA	
Forecast Day	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
Production	+17.9	+17.4	32.9	33.2	0.79	0.79
GFS-v15-cmaq5.0.2	**+18.3***	**+16.5**	**32.0**	**31.8**	**0.82**	**0.82**
GFS-16-cmaq5.3.1	**+5.7***	**+5.2**	**28.9**	**29.2**	**0.86**	**0.85**

***Color code definition: Green is better, red is degraded.**

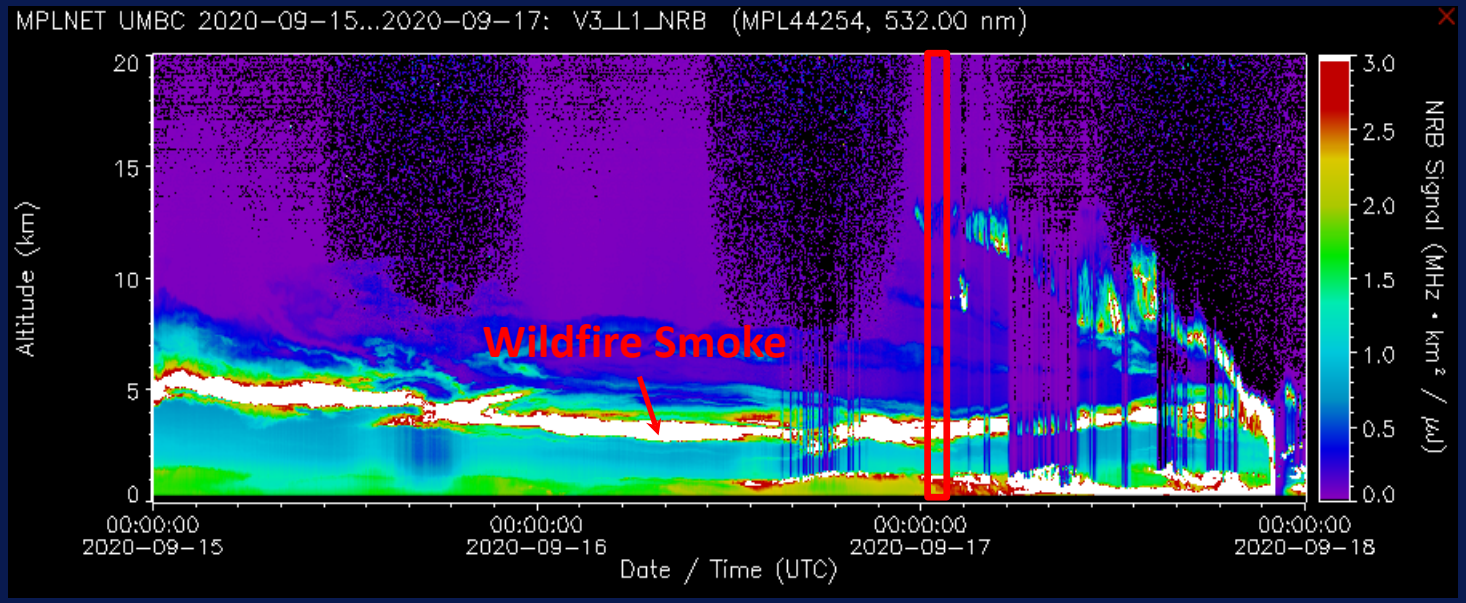
$PM_{2.5}$ Forecast performance statistics averaged over August 2019

CONUS	Hourly $PM_{2.5}$ forecast performance against Production					
	NMB		NME		IOA	
Forecast Day	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
Production	+23.1	+16.8	66.3	63.9	0.49	0.49
GFS-v15-cmaq5.0.2	**+6.1**	**-0.9**	**55.6**	**56.4**	**0.50**	**0.50**
GFS-16-cmaq5.3.1	**-0.8**	**+0.3**	**58.1**	**58.5**	**0.54**	**0.54**

***Color code definition: Green is better, red is degraded.**

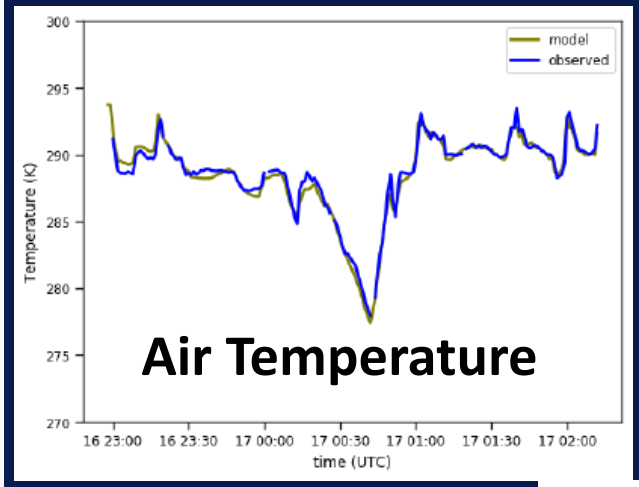
Stringent 3D evaluation of GFSv16-CMAQ5.3.1

Micro-Pulse Lidar (MPL) observations at UMBC valid between 00Z Sep 15 – 00Z Sep 18 2020

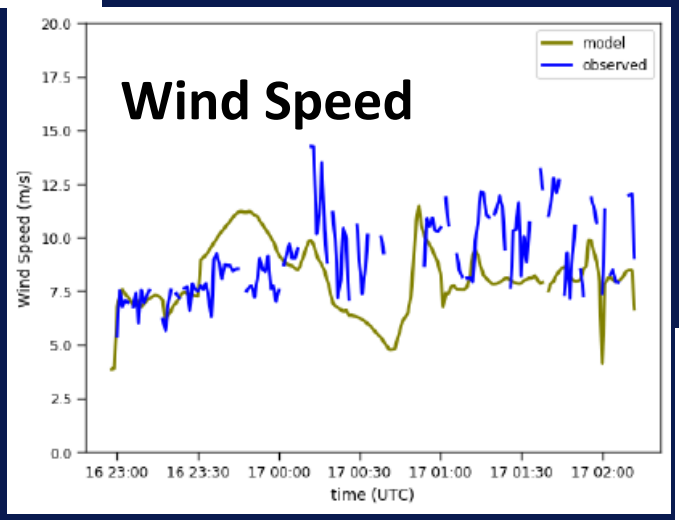


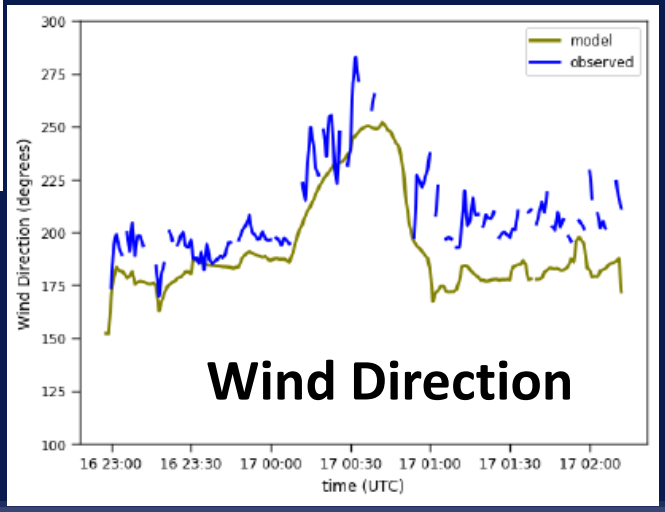
Courtesy: Ruben Delgado (https://mplnet.gsfc.nasa.gov/data?v=V3&s=UMBC&t=20200918)

- The red rectangle shows the time window of the aircraft spirals.
- An aerosol layer between 2.5 and 4 km is consistent with the aircraft observations.

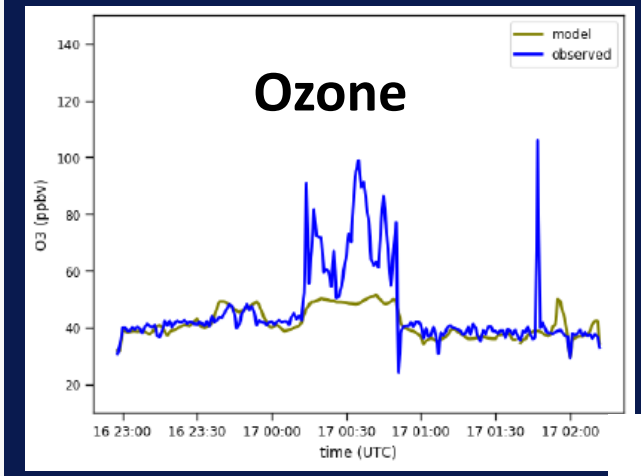


Meteorological properties along flight transect: 23:00UTC Sep 16 - 02:00UTC Sep 17 2020





Courtesy: Xinrong Ren and Russ Dickerson UMD



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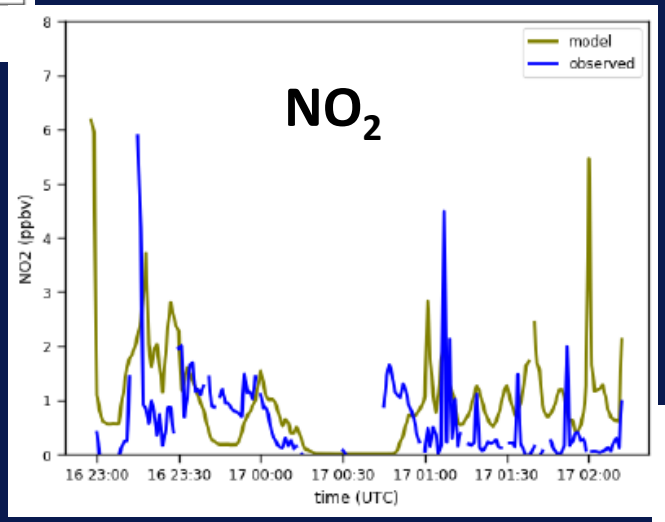
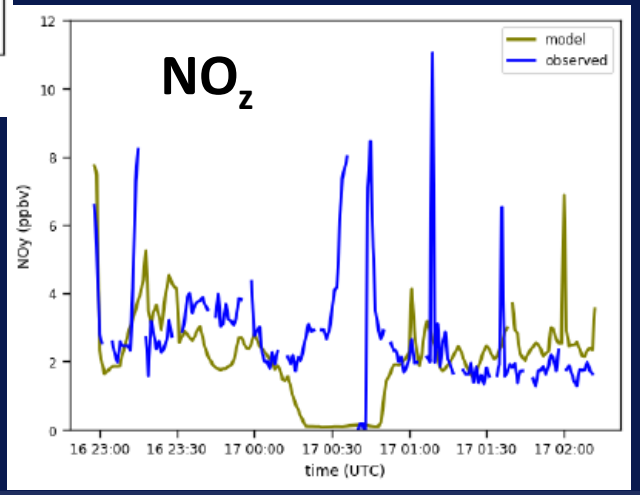




Courtesy: Xinrong Ren and Russ Dickerson UMD

Wildfire emissions : Assimilating 3D canopy data benefits

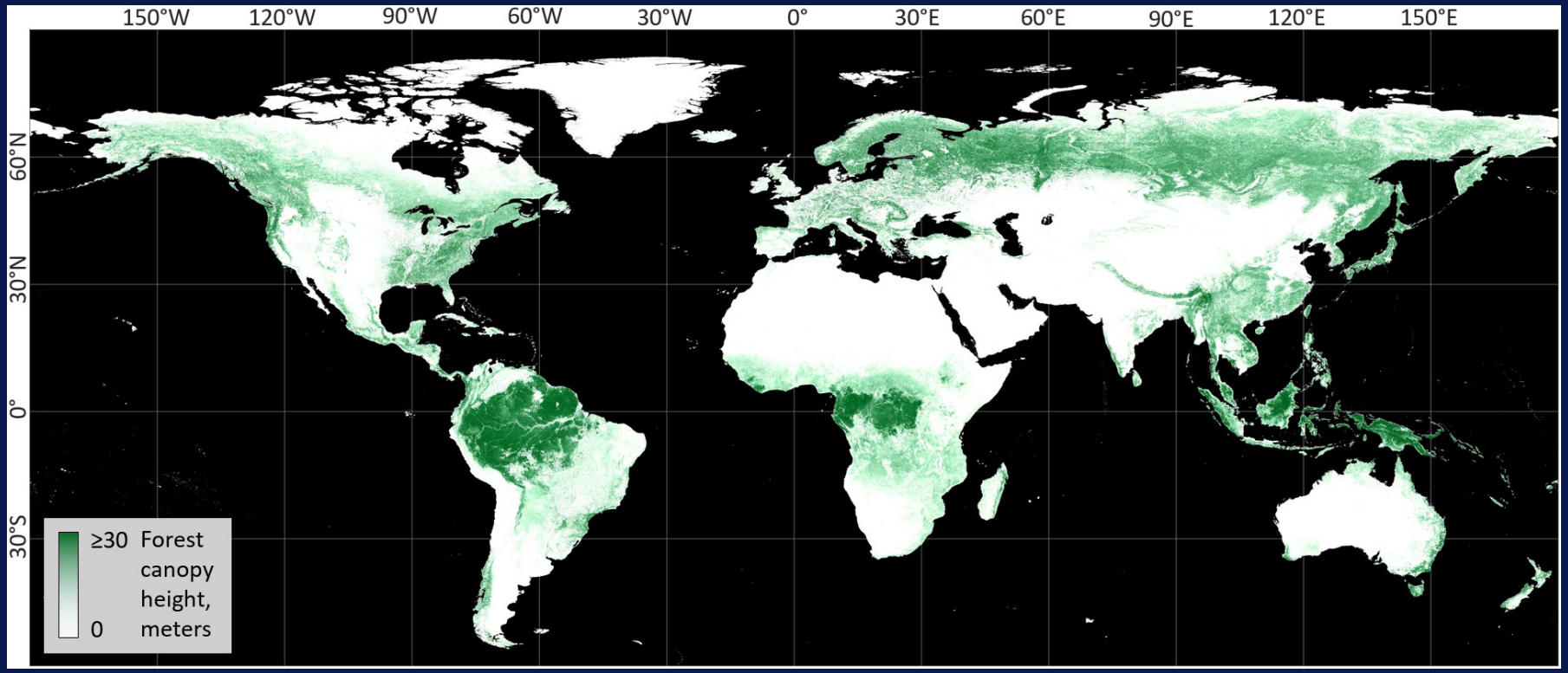
I. Canopy information to constrain fire duration:
   a) Vegetation Density
   b) Vegetation Stress
   c) Hot-Dry-Windy Index (HDW) + Use *In-Canopy* Wind and Vapor Pressure Deficit

II. Rapid refresh GEDI assisted canopy height data supplied to NCO monthly:
   a) L2B Products: Canopy Cover Fraction (CCF), CCF profile, Leaf Area Index (LAI), LAI profile (LAI refresh can also be used for general AQF)
   b) L3 Products: Gridded Level 2 metrics
   c) L4B Product: Gridded Above Ground Biomass Density (AGBD)

III. Burn scar data
   a) Rapid refresh of GEDI?

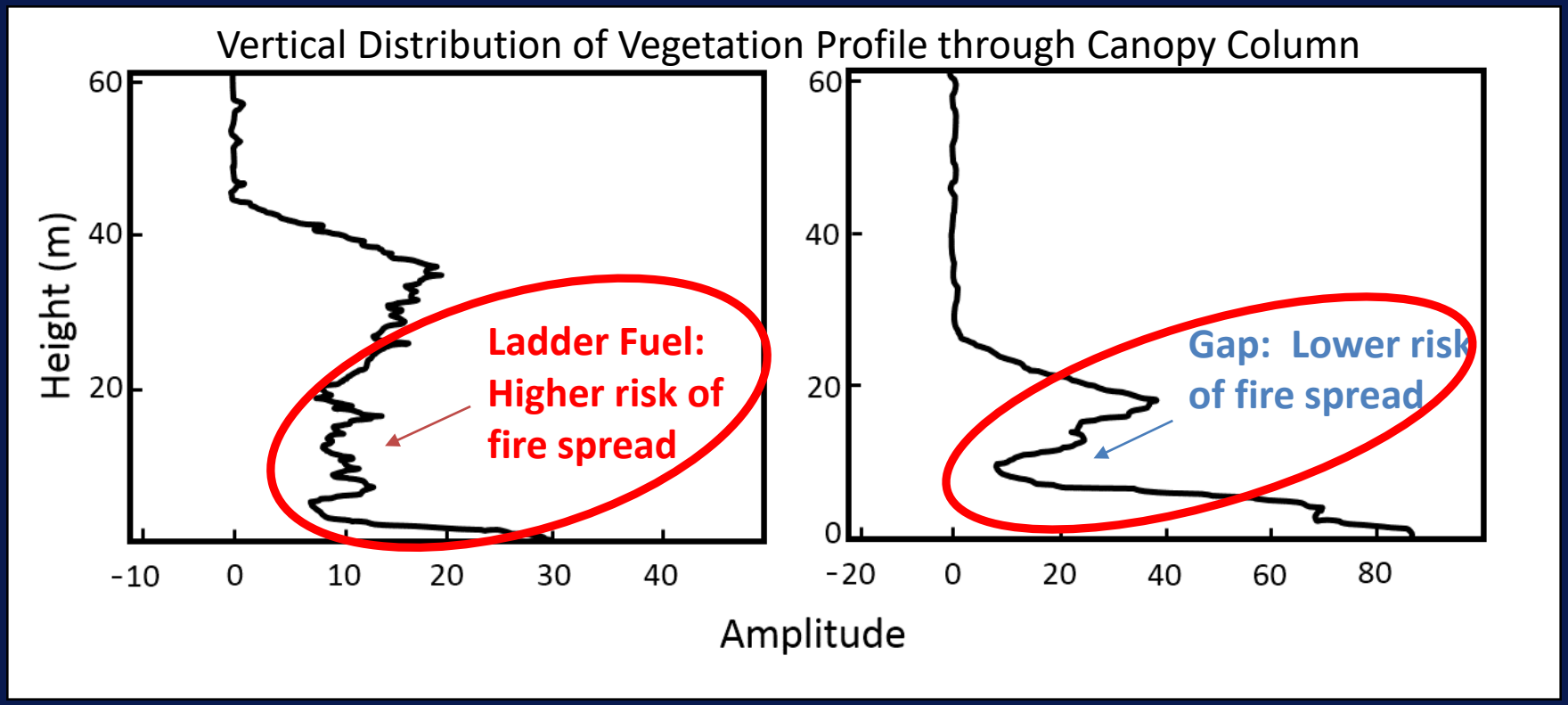
References:
https://gefi.umd.edu/data/products (GEDI)
https://www.hdwindex.org/abouthdw.html (HDW)

Rapid-refresh canopy height by Global Ecosystem Dynamics Investigation (GEDI) to indicate crops & agricultural-fires



Courtesy: UMD Global Land Analysis & Discovery based on Landsat 30 m spatial resolution

Rapid-refresh canopy profile by GEDI to indicate fire spread/duration



THE WAVEFORM ON THE LEFT SUGGESTS THE PRESENCE OF VEGETATION FROM THE GROUND SURFACE INTO THE UPPER CANOPY, POSSIBLY AN INDICATOR OF LADDER FUEL. THE WAVEFORM ON THE RIGHT INDICATES A GAP BETWEEN SURFACE AND CANOPY FUELS, AND HENCE A POTENTIALLY LOWER RISK OF FIRE SPREADING FROM THE SURFACE INTO THE CANOPY. CREDIT: https://gedi.umd.edu/applications/forest-management-and-carbon-cycling/

Summary

I. NAQFC-β learns a lot from intensive measurement campaigns
- DISCOVER-AQ
- OWLETS
- Firex-AQ

II. Upcoming NAQFC in Spring 2022
- Meteorology
- Emission
- Chemistry Transport modeling

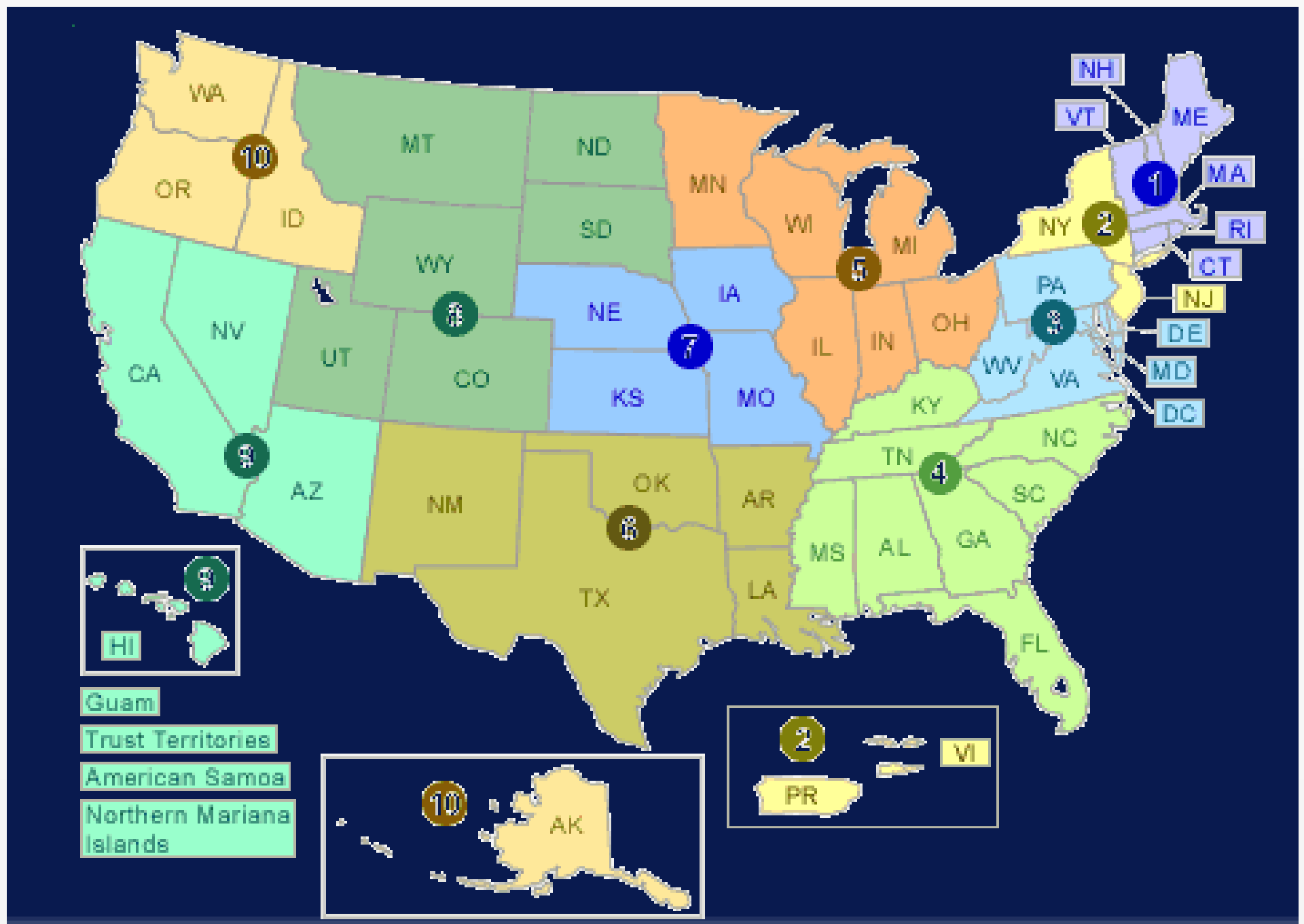
III. A preliminary evaluation of its performance during Firex-AQ:
- O3 forecast improved across the board
- PM2.5 requires improvement: eps. SOA in Southeast

IV. Improve GBBEPX application by GEDI-assisted rapid refreshing LULC :
- Derive fire duration to distinguish agricultural fires
- Explore possibility to rapid refresh LAI and biomass density

Auxiliary slides

Emission NEI2014v2 in operations

operation	Source Description
MOVES2014 version 2	EPA inventory & temperature dependence wrt 2017
ag (NEI 2014)	Agricultural NH3
afdust (2014)	Anthropogenic fugitive dust
c1c2rail (2014)	Class I and I marine sources, railroad
c3marine (none)	Class III marine sources (ocean going ships)
nonroad (2014)	Nonroad (US)
nonpt (2014)	Other area sources
othar (2014)	Mexican and Canadian area sources
np_oilgas (2014)	Non-point oil and gas sources
rwc (2014)	Residential wood combustion
Rail (2014)	Dominantly from diesel engines
ptnonipm (2014)	Non-ipm point sources
pt_oilgas (2014)	Oil and gas point sources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