Evaluation of the CMAQv5.3 Modeling System

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CMAQv5.3 – Release and Major Updates

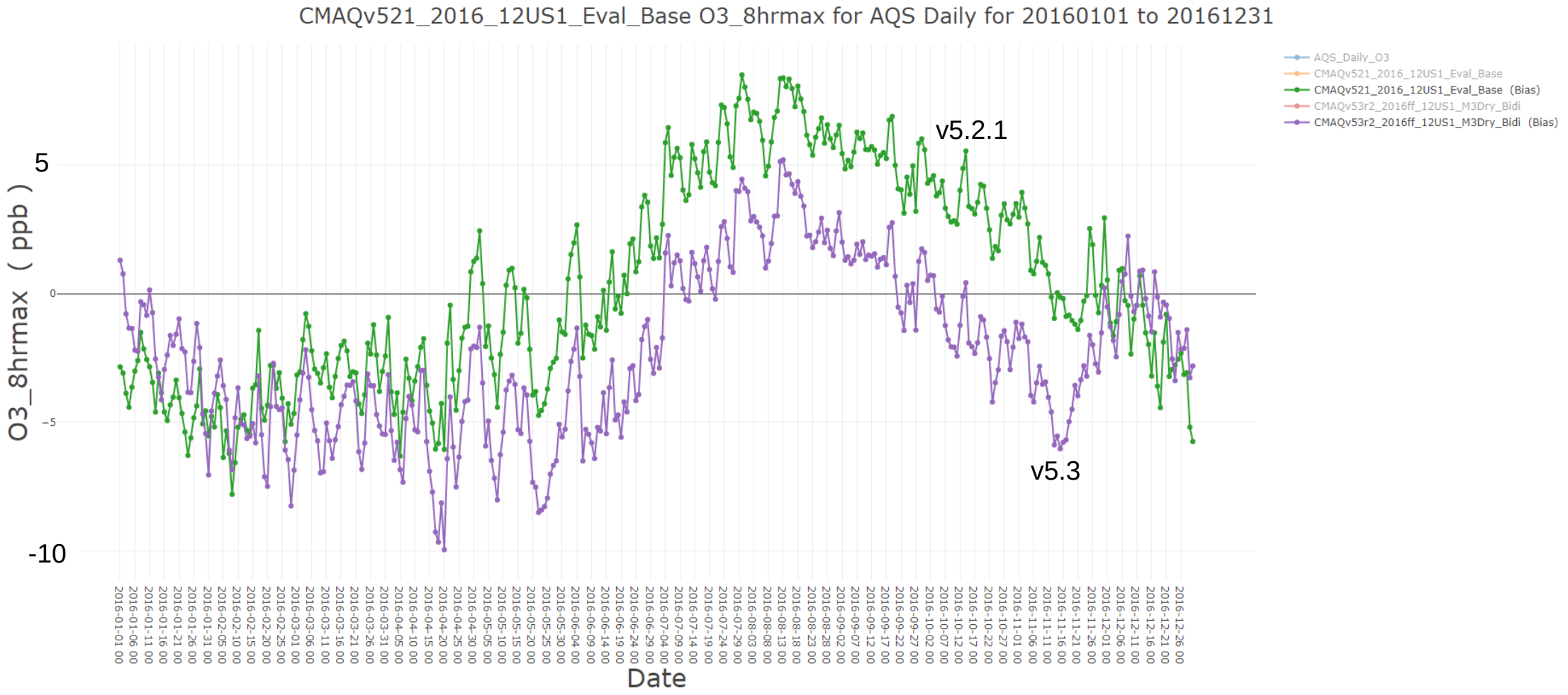
- **Release schedule**
  - Beta version released October 2018
  - Final version released August 2019: https://github.com/USEPA/CMAQ
  - Instrumented models – ISAM, Sulfur tracking (available w/ final release); DDM available sometime after release
- **New features**
  - **Aerosols**
    - New AERO7 module available
    - Increased monoterpene SOA (Pye et al. 2015 ES&T, Xu et al. 2018 ACP), uptake of water onto hydrophilic organic aerosol (Pye et al. 2017 ACP), and reorganization of anthropogenic SOA (M. Qin)
  - **Gas Chemistry**
    - Minor updates to CB6r3 (ClNO3 reaction added; first-order O_3 depletion)
    - Updated full halogen chemistry – included in optional detailed mechanism (Sarwar et al., Atmospheric Environment, 2019)
    - Added dimethyl sulfide (DMS) chemistry – optional detailed mechanism
  - **Deposition**
    - Updated M3Dry deposition scheme
    - New Surface Tiled Aerosol and Gaseous Exchange (STAGE) deposition scheme available
  - **Emissions**
    - New emission control file provides more direct control over emissions and emission scaling in CMAQ
  - **Source Apportionment**
    - The Integrated Source Apportionment Method (ISAM) has been updated to improve efficiency
    - Model runtime w/ v5.3 has been greatly improved when running with the ISAM option compared to v5.2.1
  - **Updated CMAQ documentation**
    - Completely new CMAQ User's Guide and science documentation
    - Updated CMAQ website (https://www.epa.gov/cmaq)
  - **Updated CMAQ tools**
    - ICON, BCON, Site compare, AMET, MCIP

CMAQ Inputs and Configuration

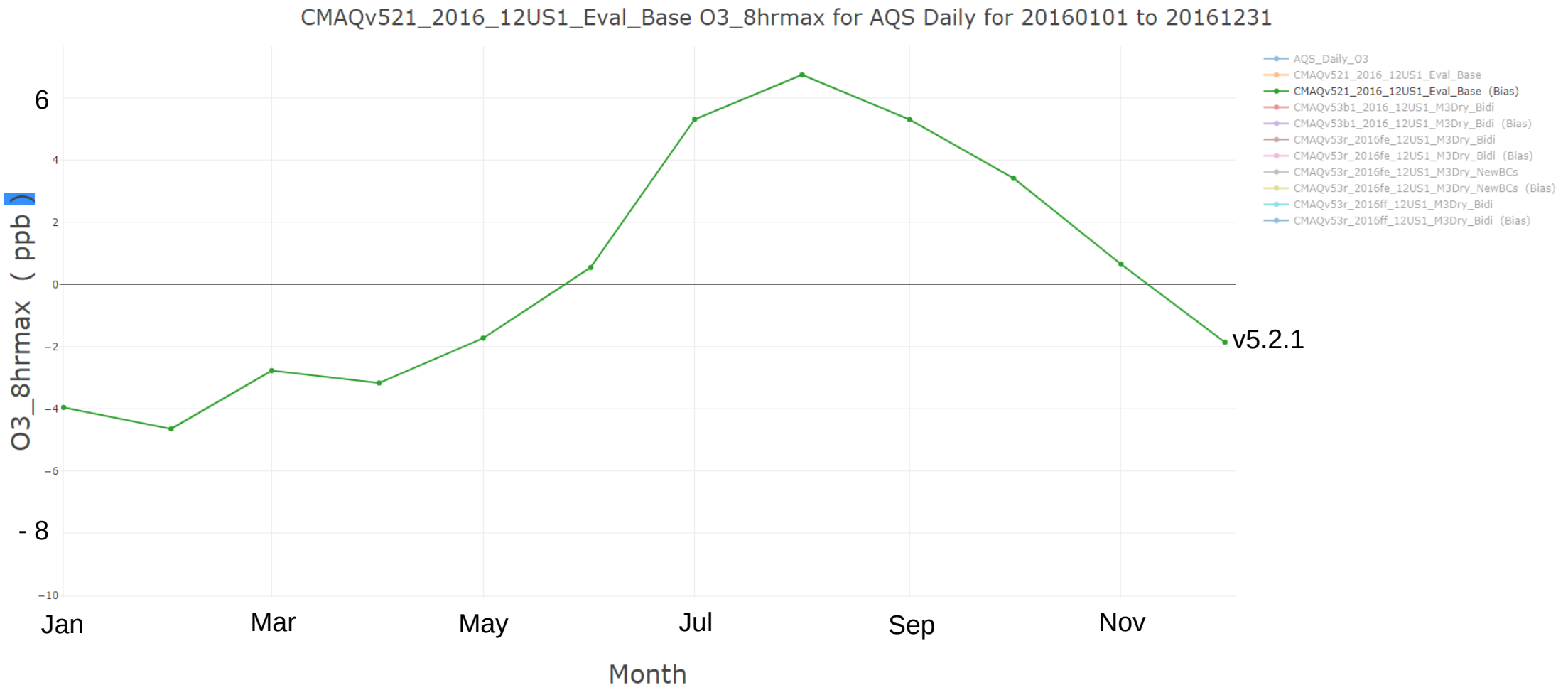
	CMAQv5.2.1	CMAQv5.3
Boundary Conditions	V5.2.1 Hemispheric CMAQ	V5.3β Hemispheric CMAQ
Chemical Mechanism	CB6r3	CB6r3
Aerosol Module	AERO6	AERO7
Deposition Scheme	M3Dry	M3Dry/STAGE
Bi-directional Ammonia	No	Yes
Wind-blown Dust	No	No
Lightning NOx	Yes	Yes

- **All simulations are 2016 CONUS 12-km annual simulation**
- **MCIP from the same 2016 WRF v3.8 simulation used in all simulations (WRF v4.1.1 simulations coming soon)**
- **2016 emissions based on NEI "fe" and "ff" beta versions (final 2016 NEI emissions coming soon)**

MDA8 O_3 Bias (Daily) – v5.2.1 vs v5.3 (M3Dry)



MDA8 O_3 Bias (Monthly) – v5.2.1 vs v5.3 (M3Dry)



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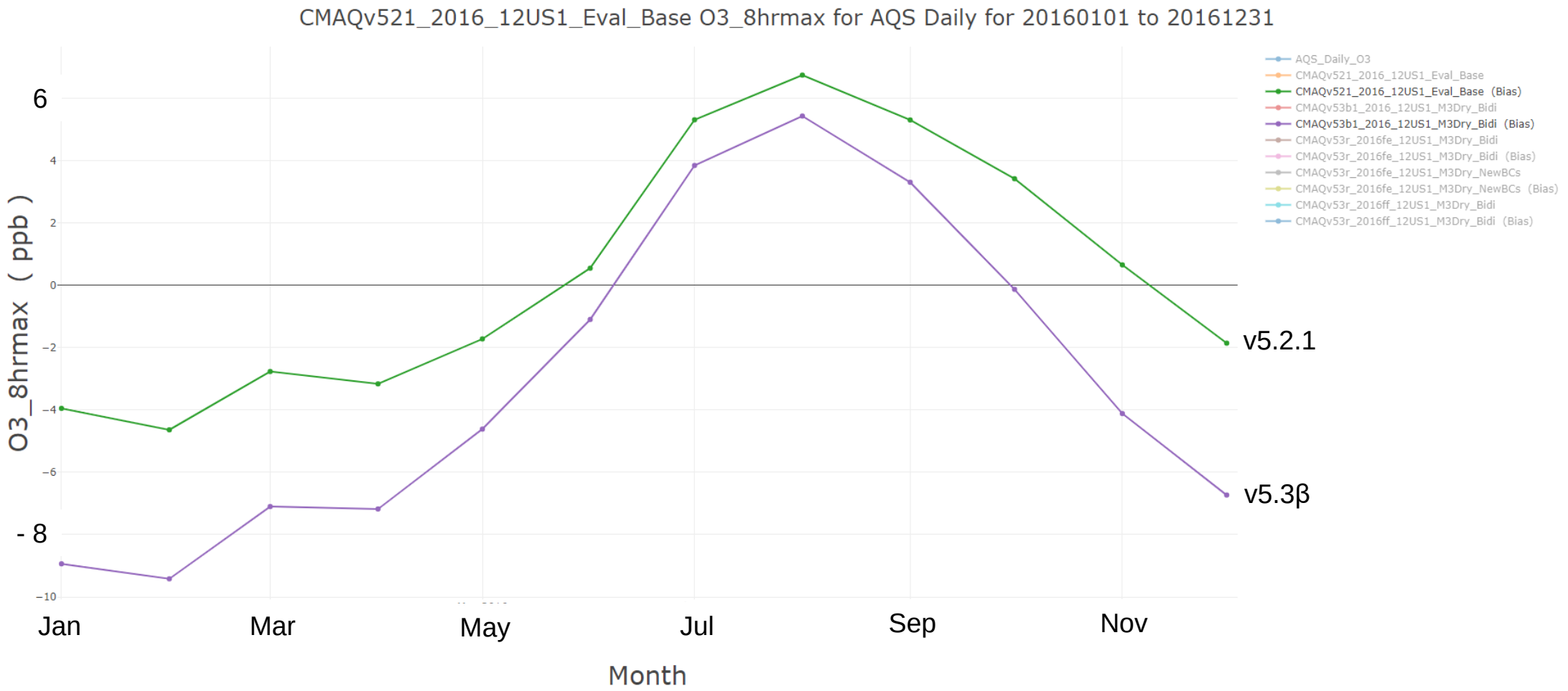

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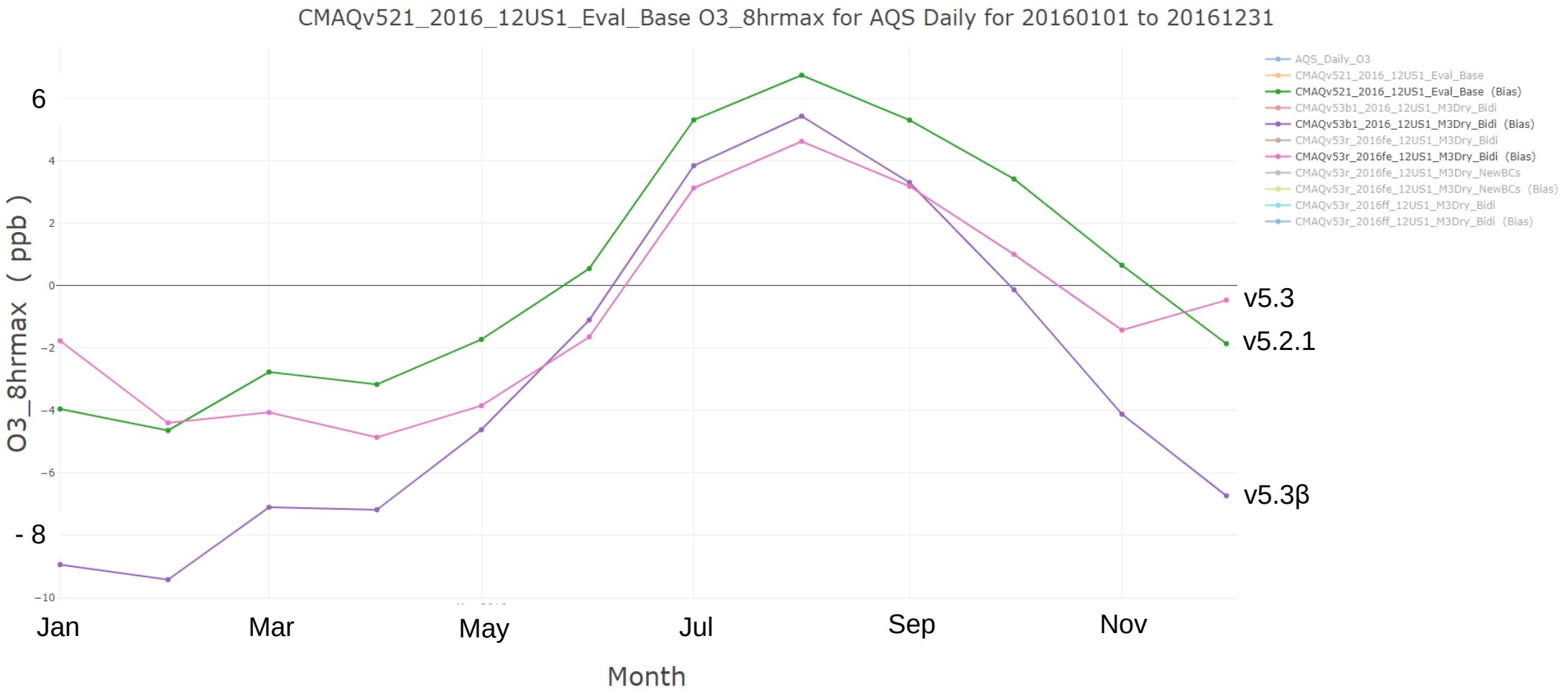

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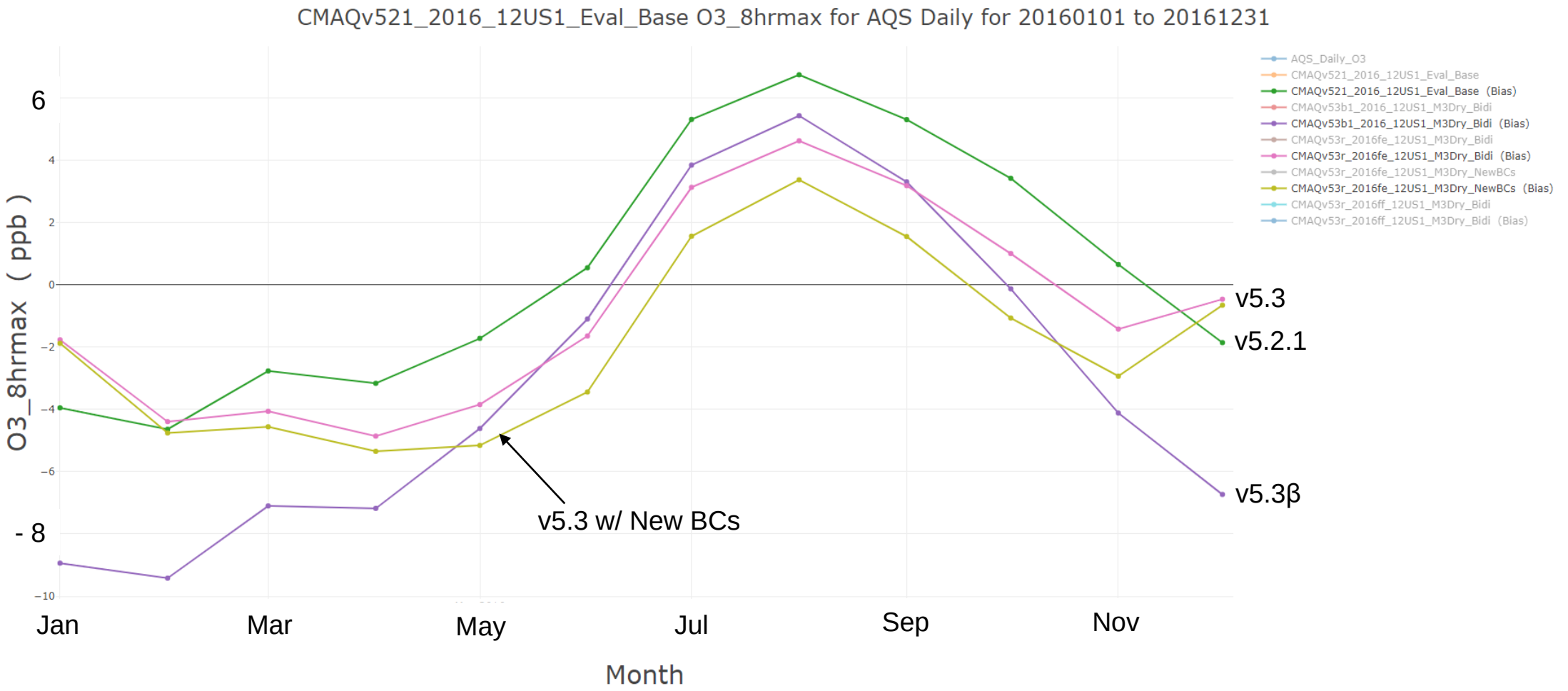

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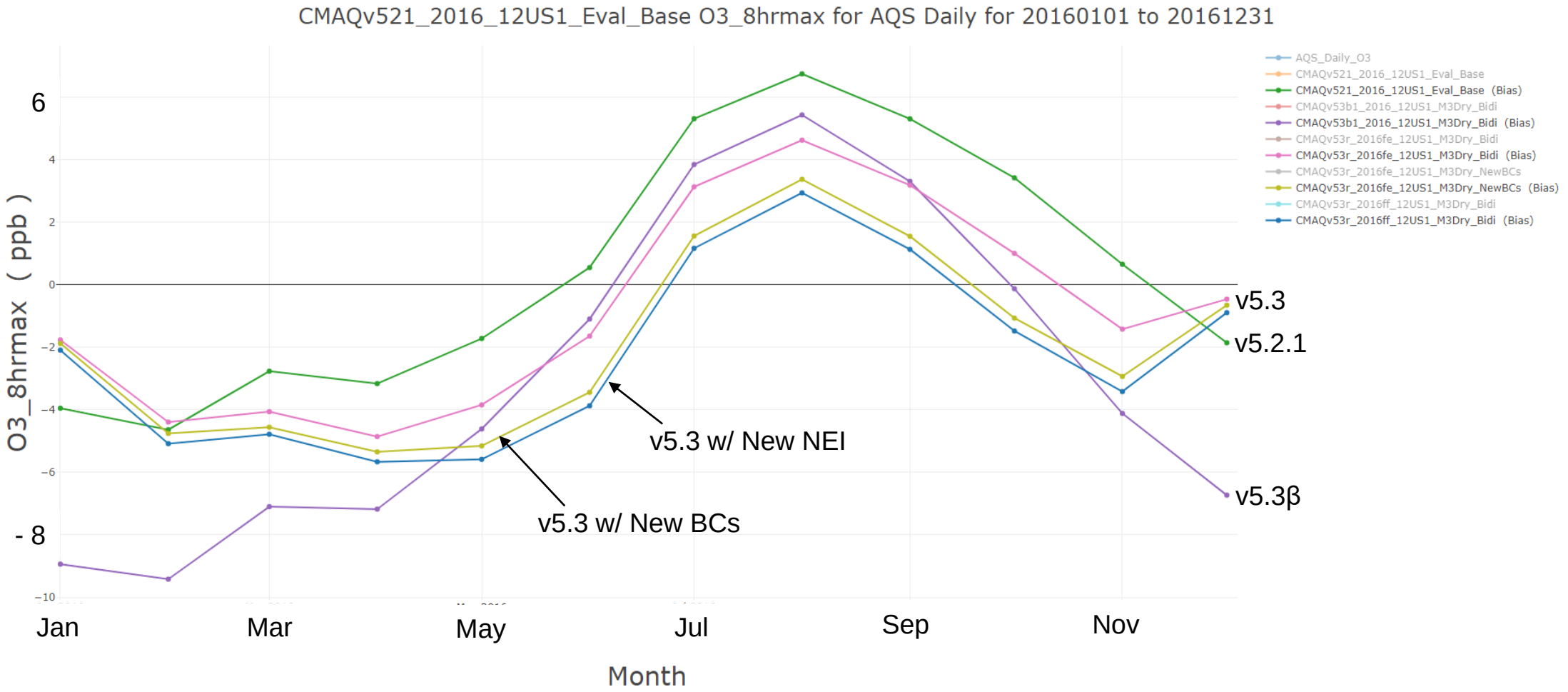
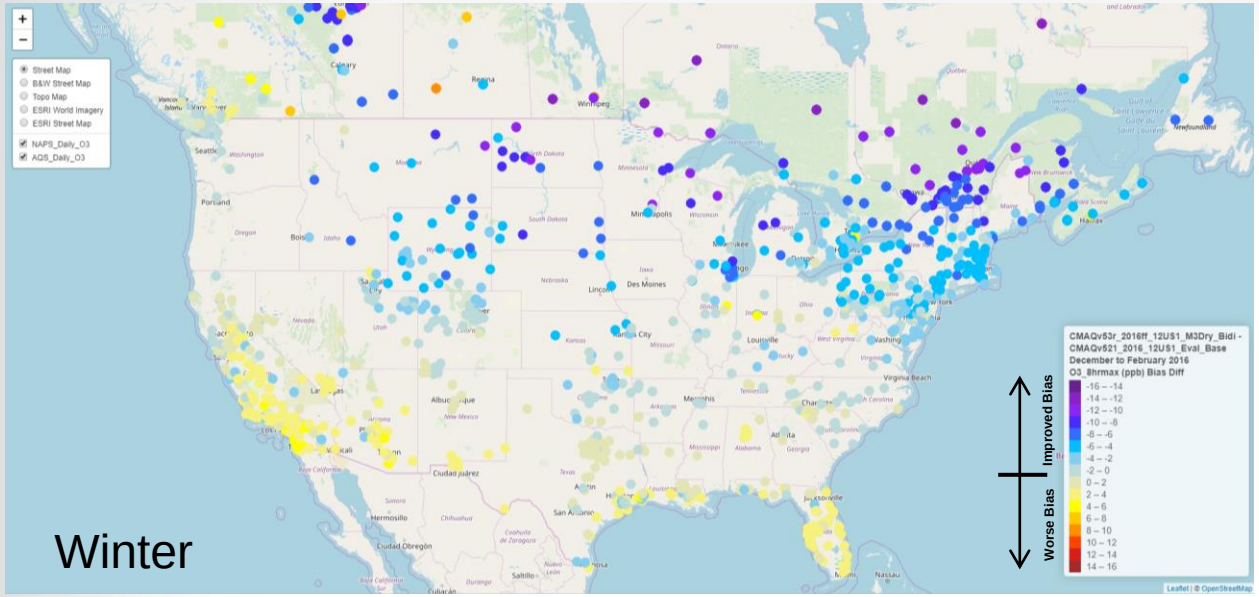
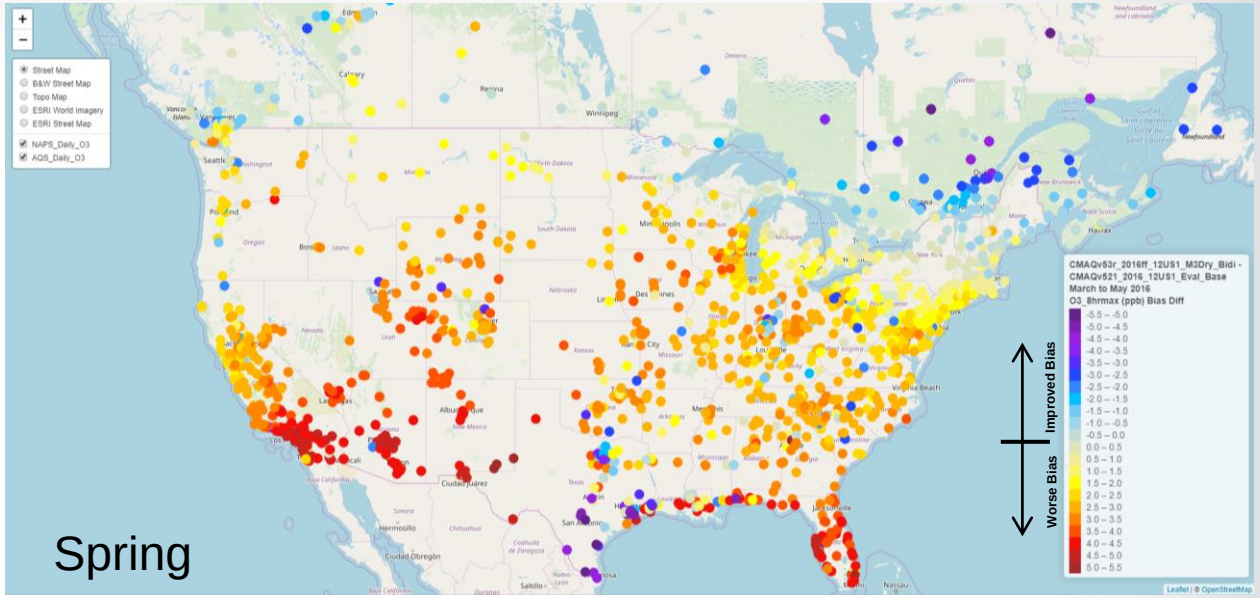
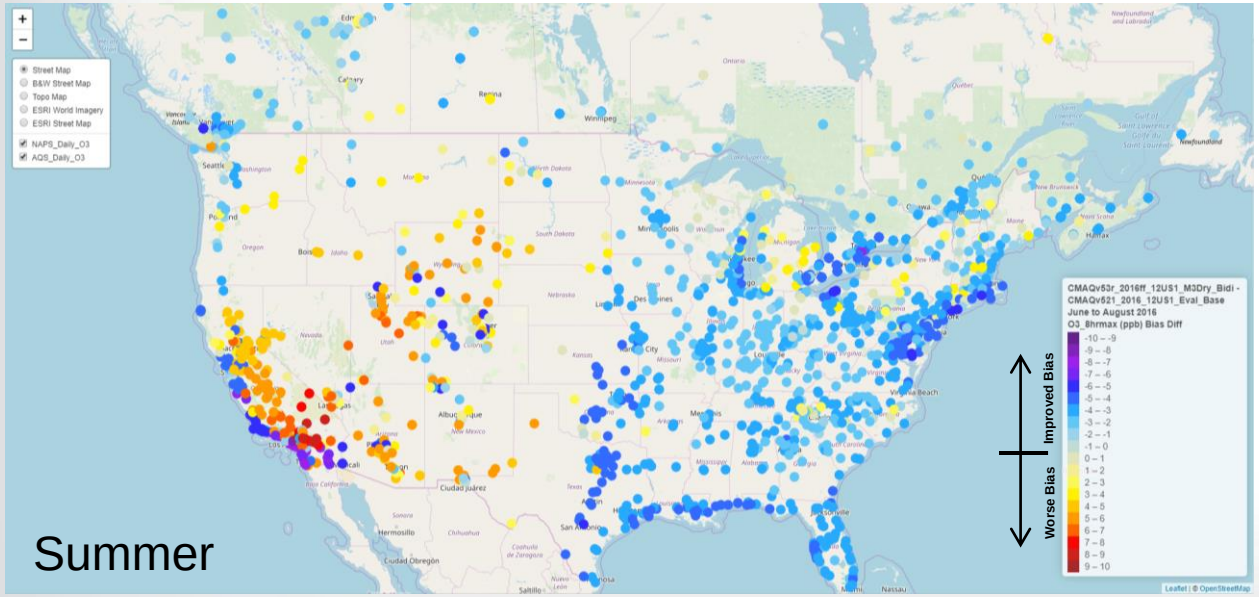
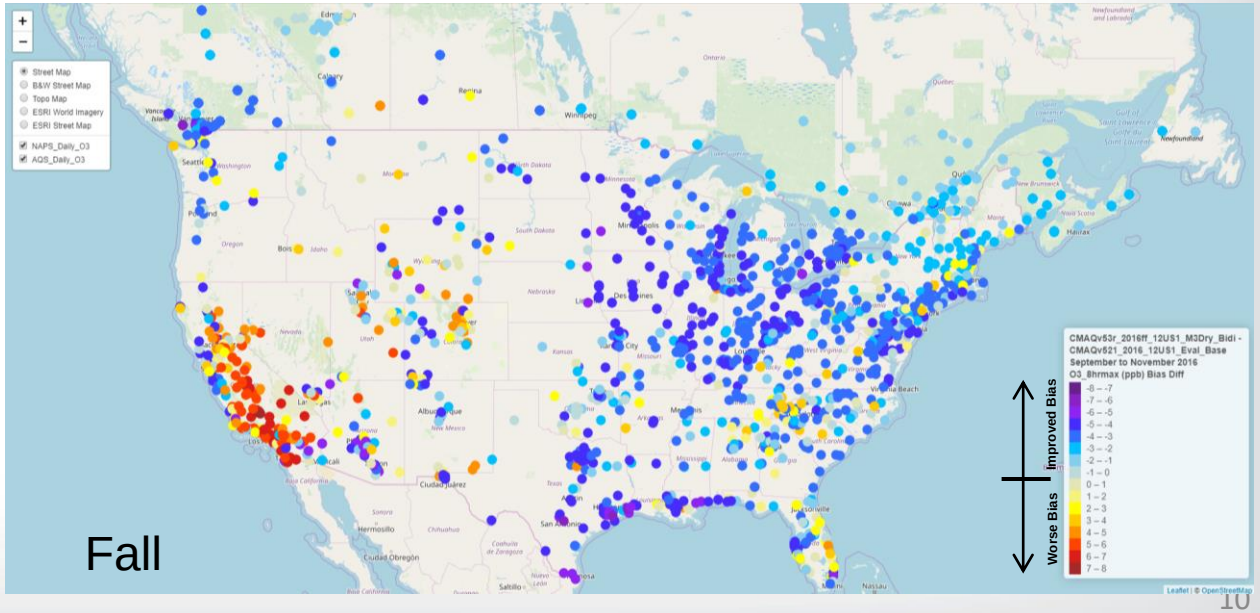


MDA8 O_3: CMAQv5.3 - v5.2.1 Seasonal Bias Difference

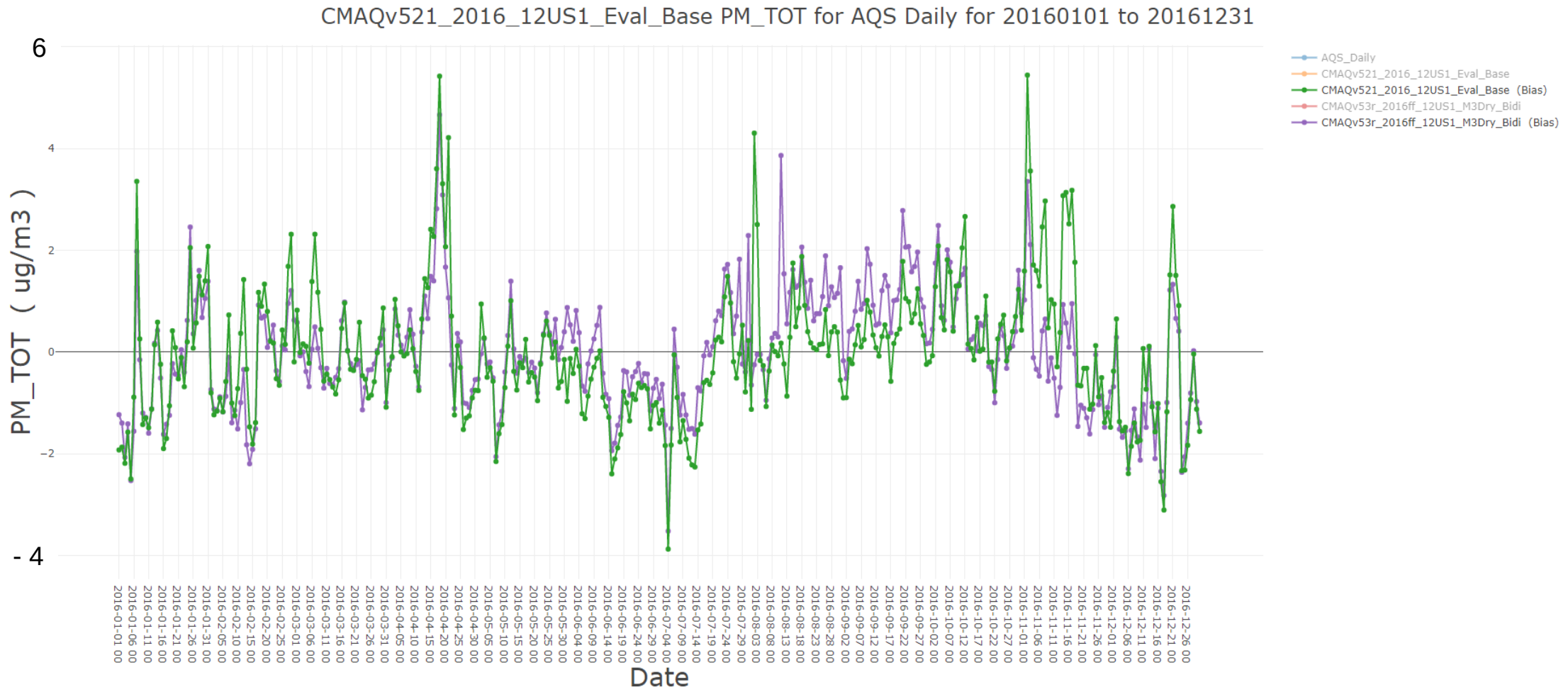








$PM_{2.5}$ Bias (Daily) – v5.2.1 vs v5.3 (M3Dry)



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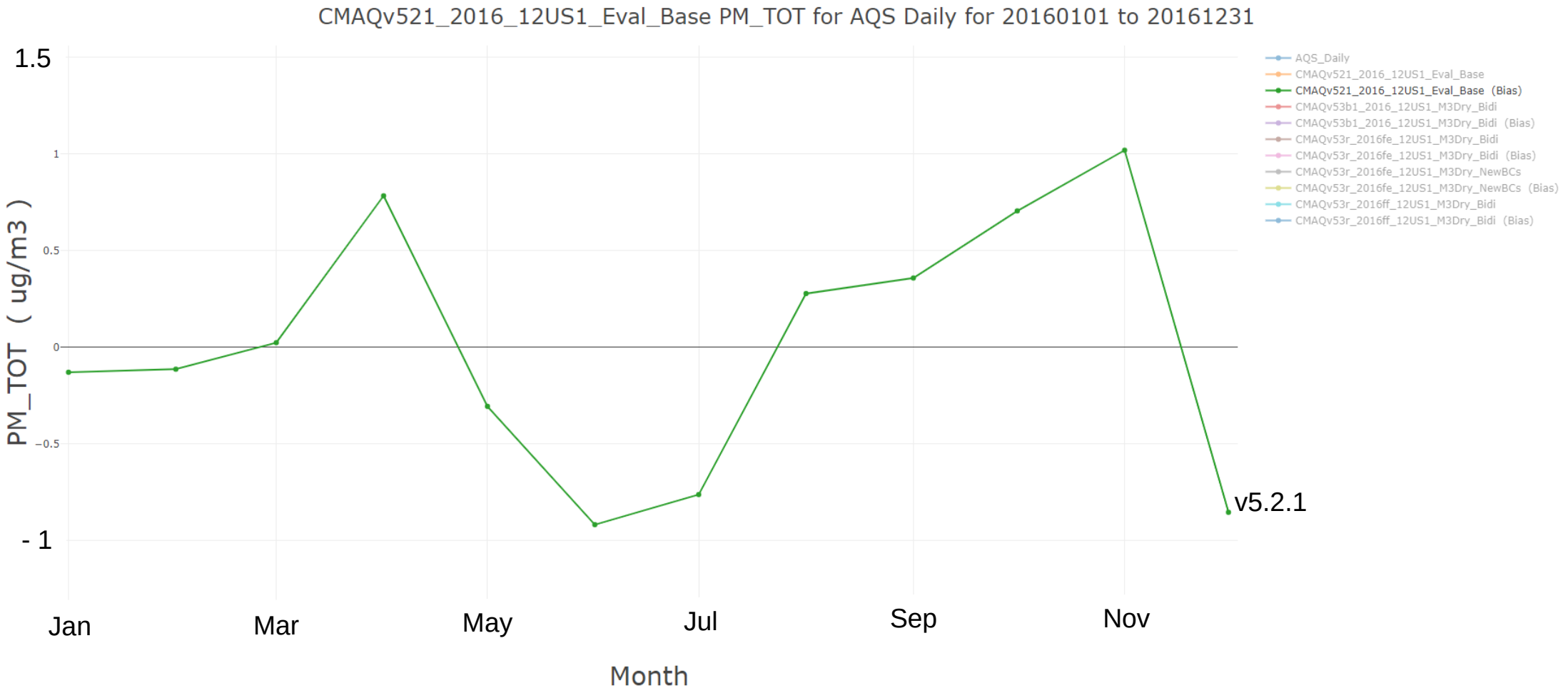

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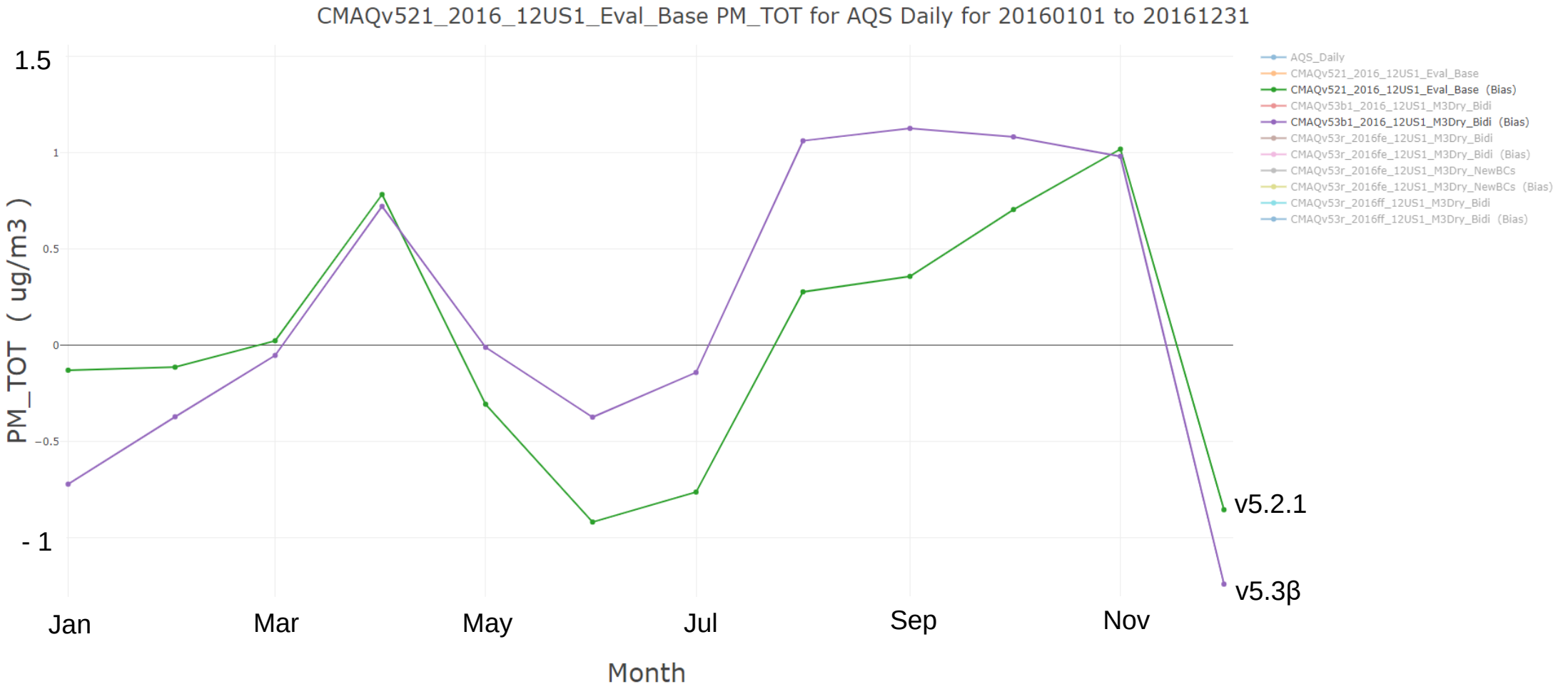

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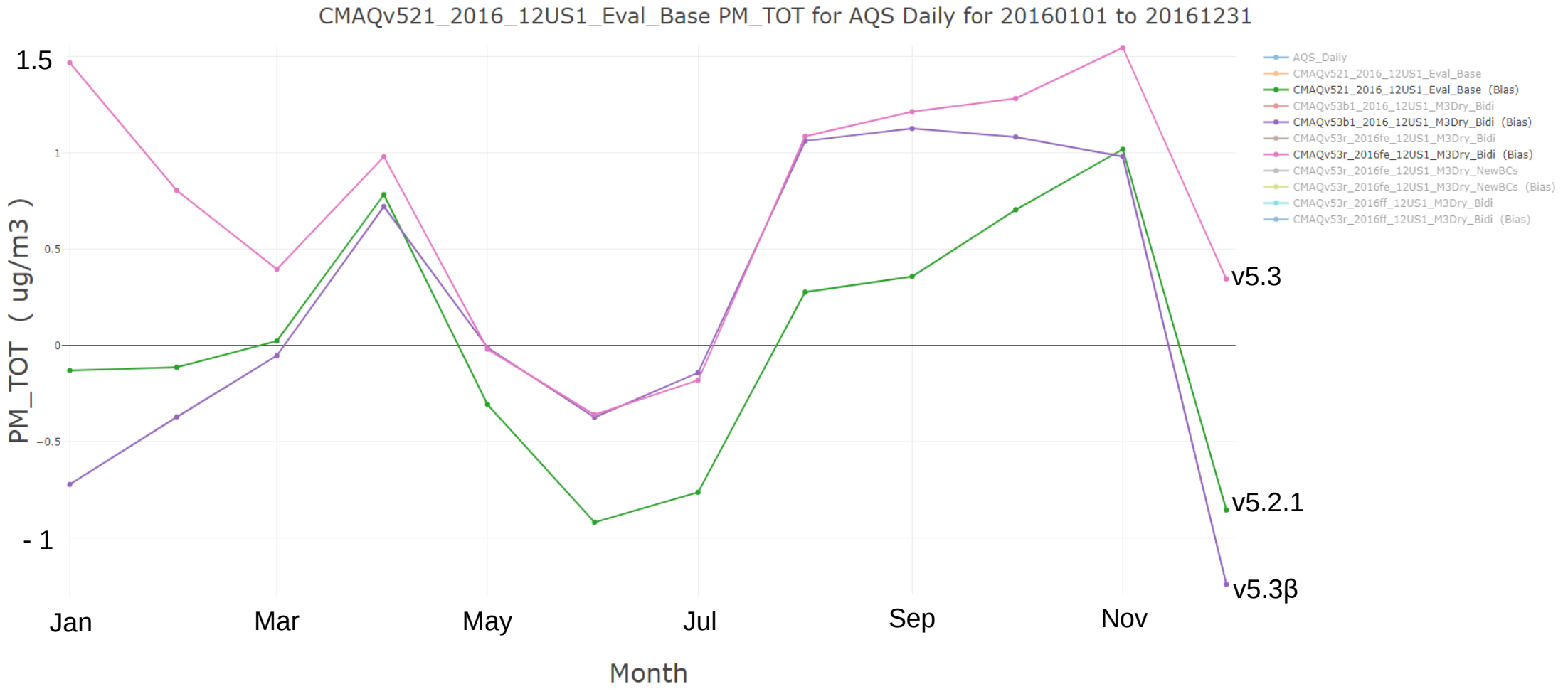

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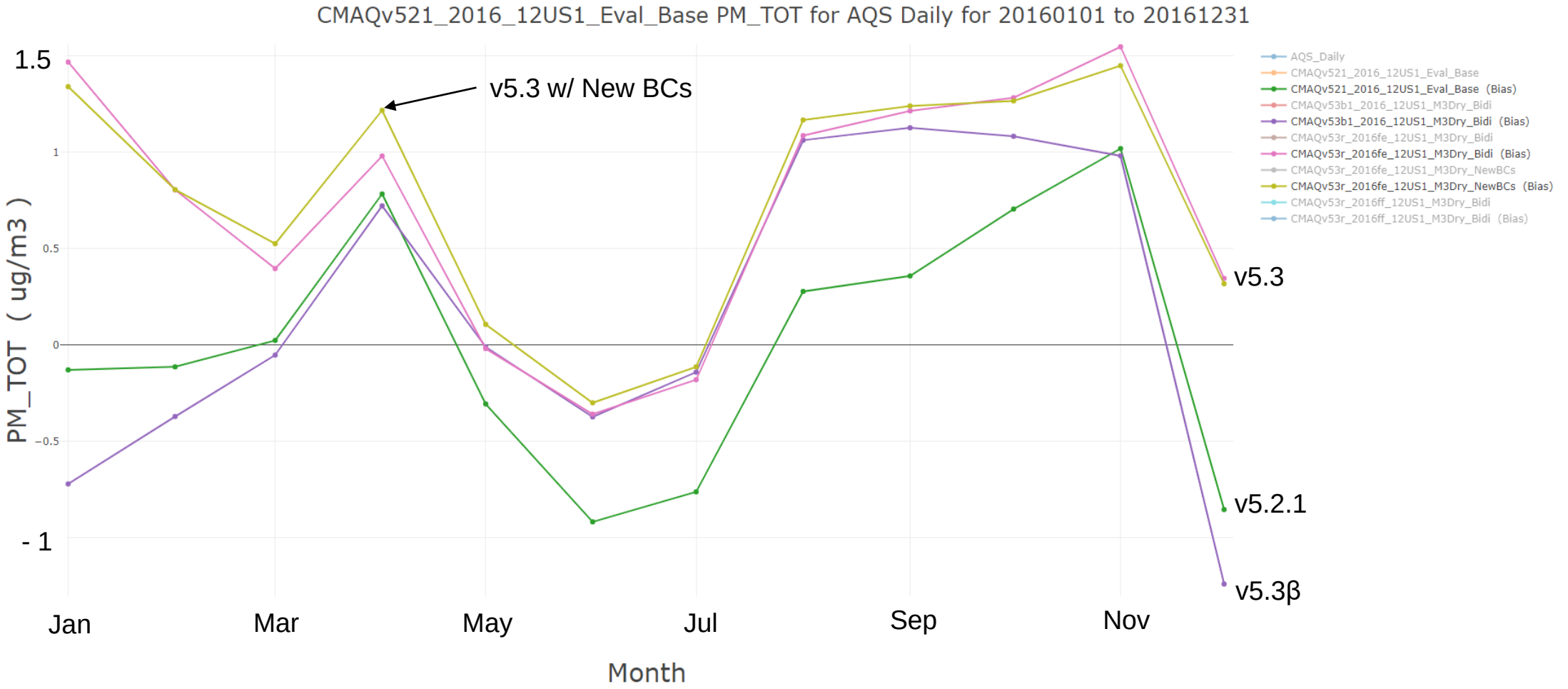

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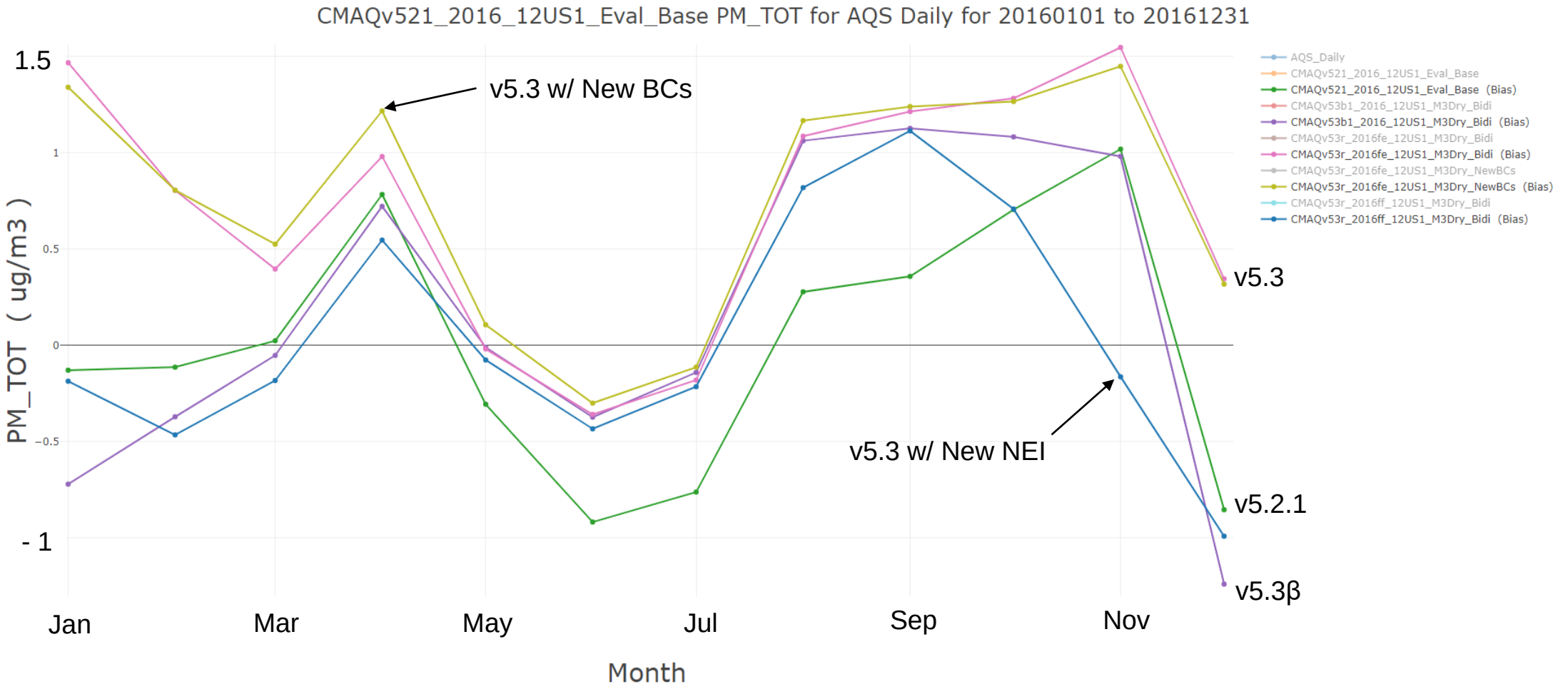
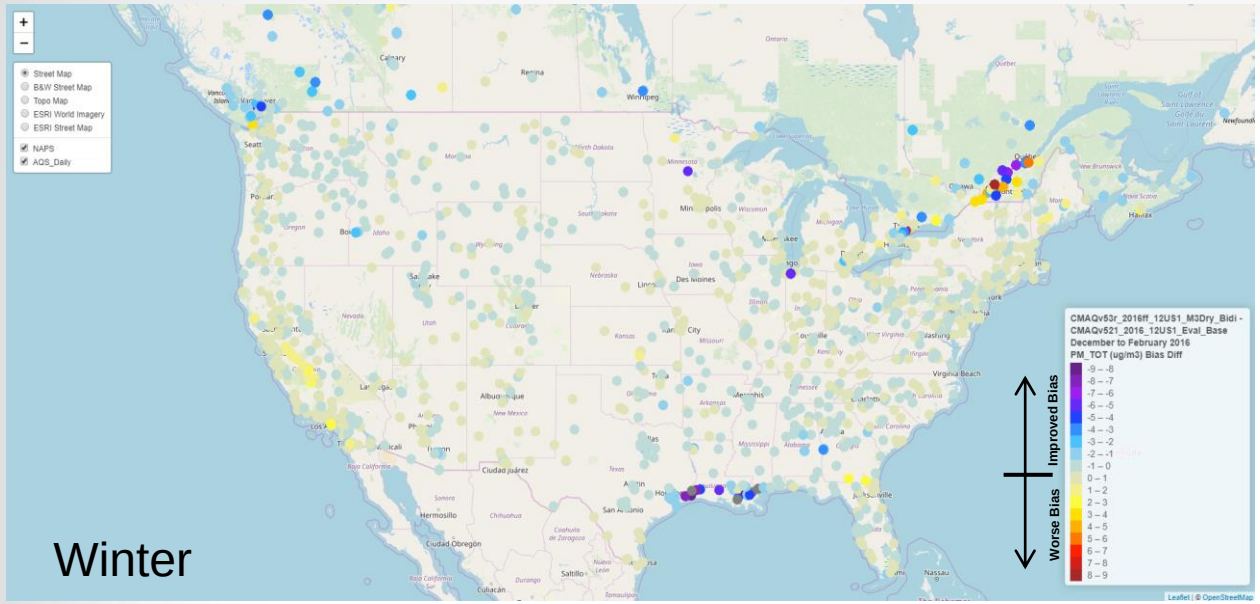
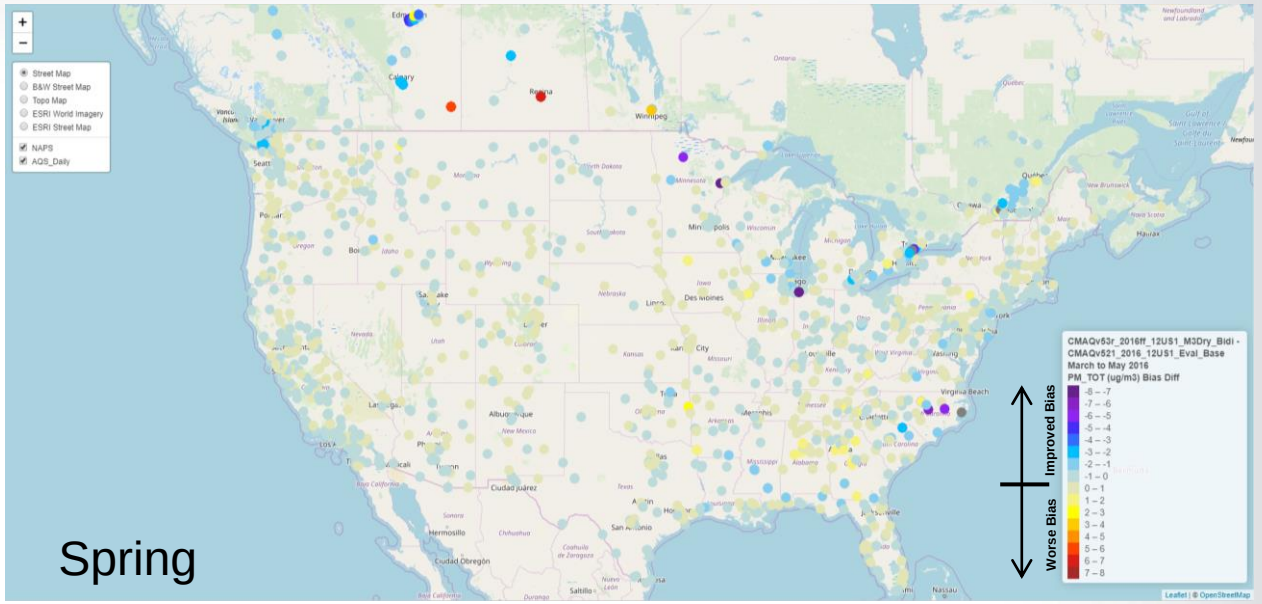
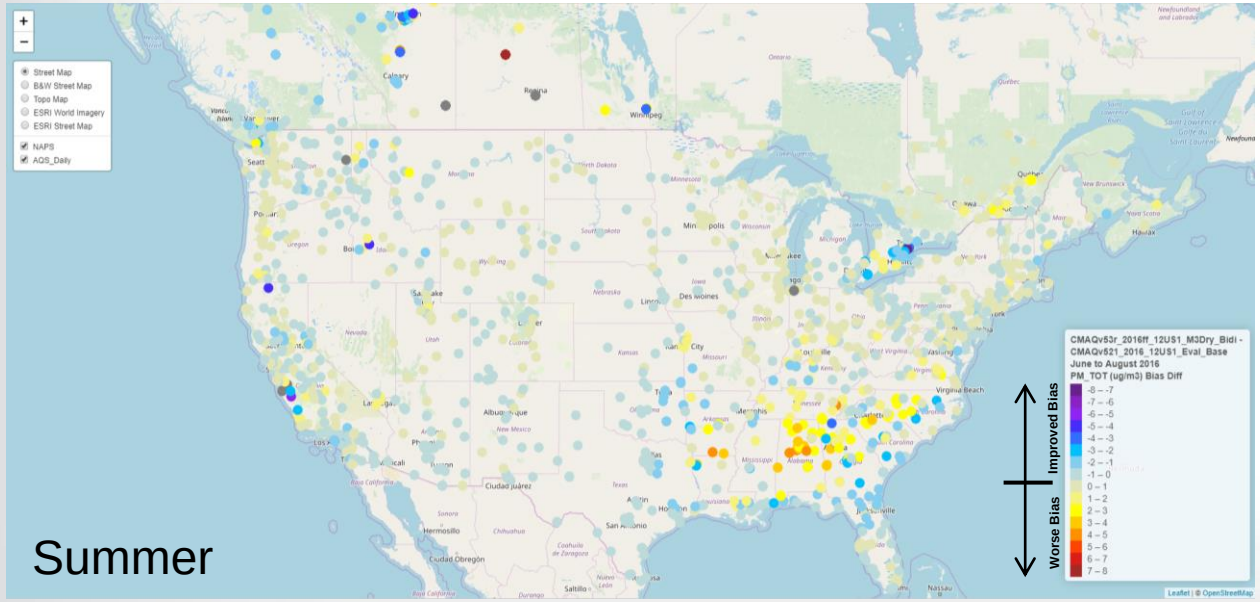
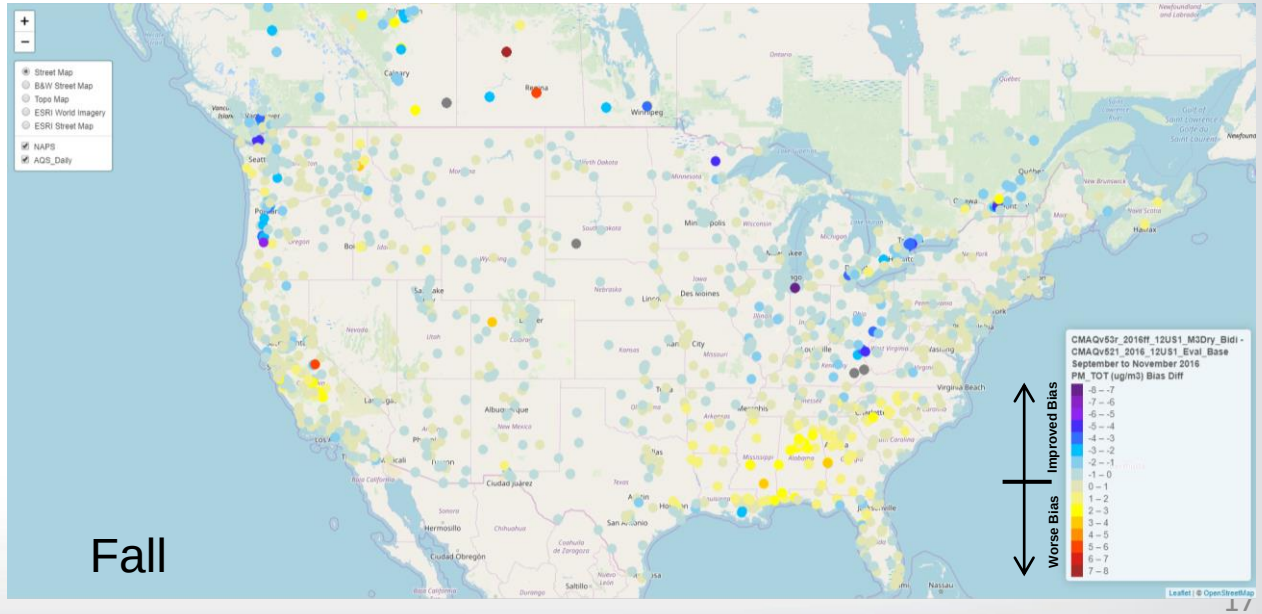


$PM_{2.5}$: CMAQv5.3 - v5.2.1 Seasonal Bias Difference



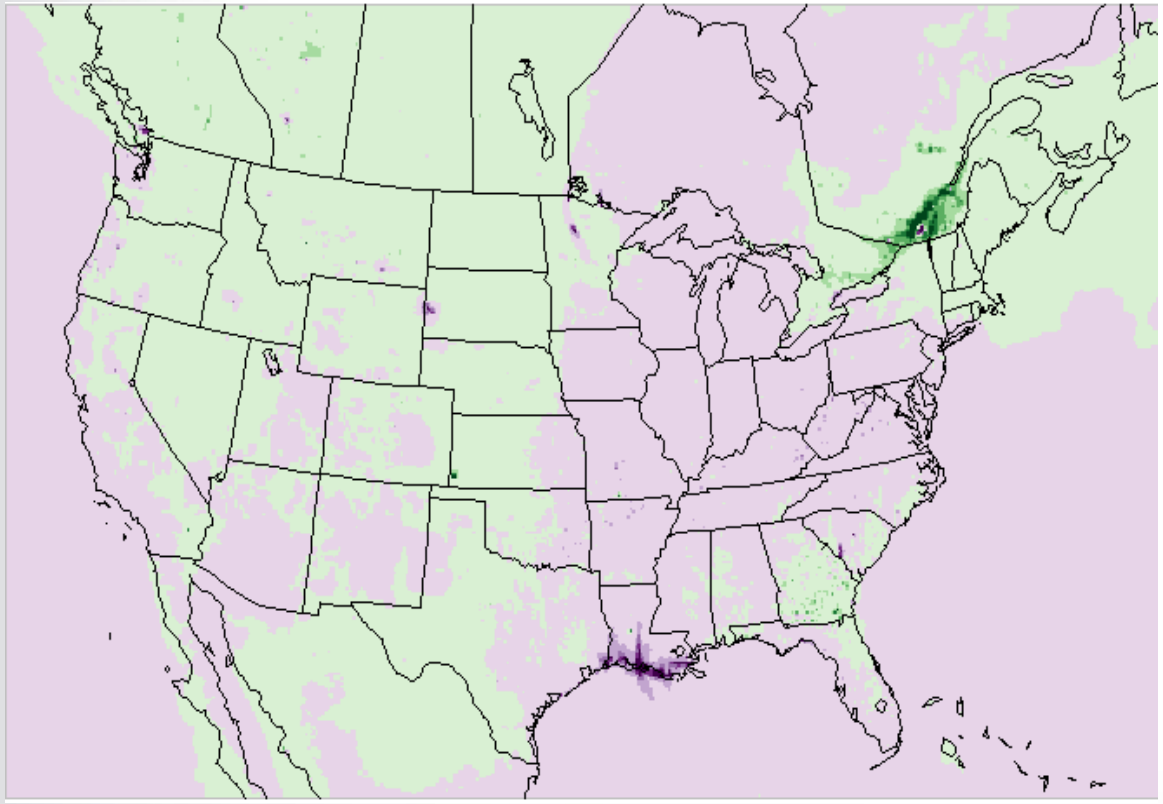




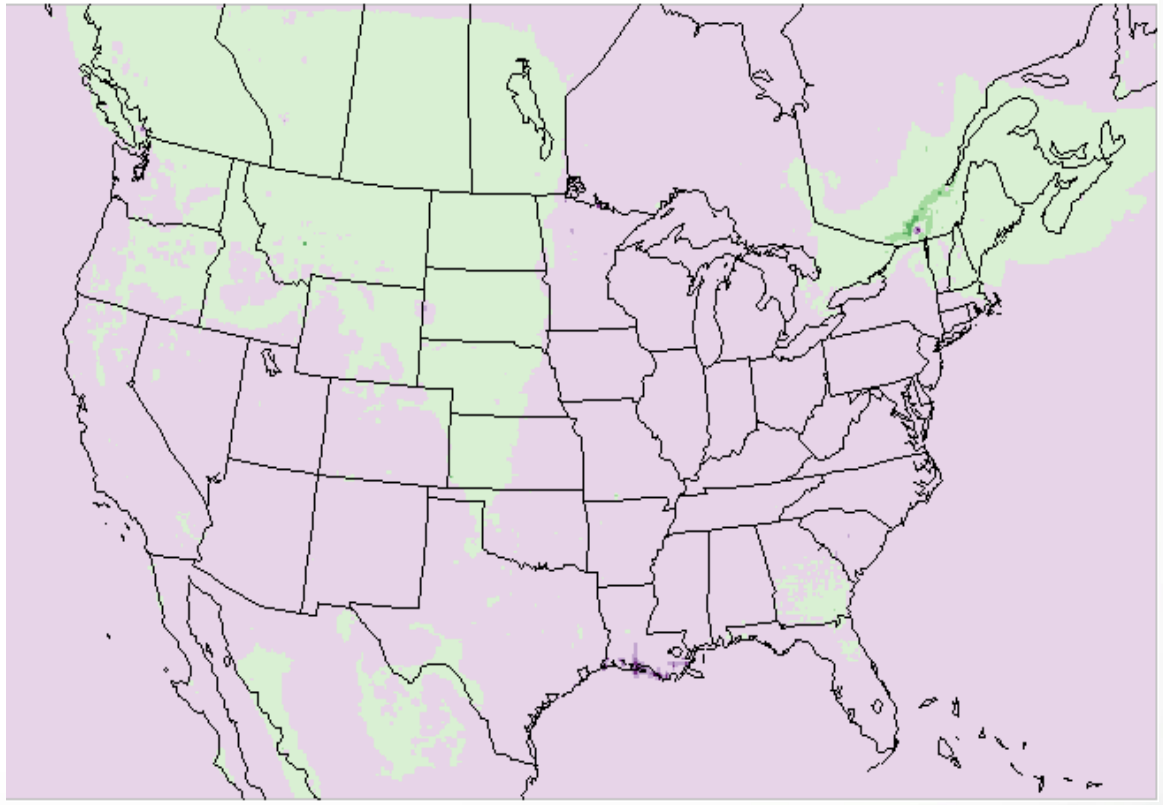


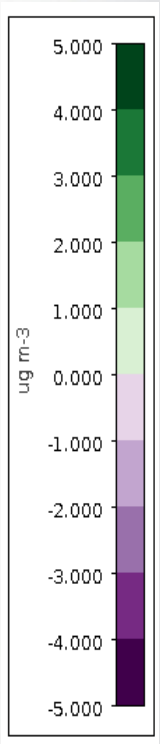
CMAQv5.3 - v5.2.1 (January)

Organic Carbon



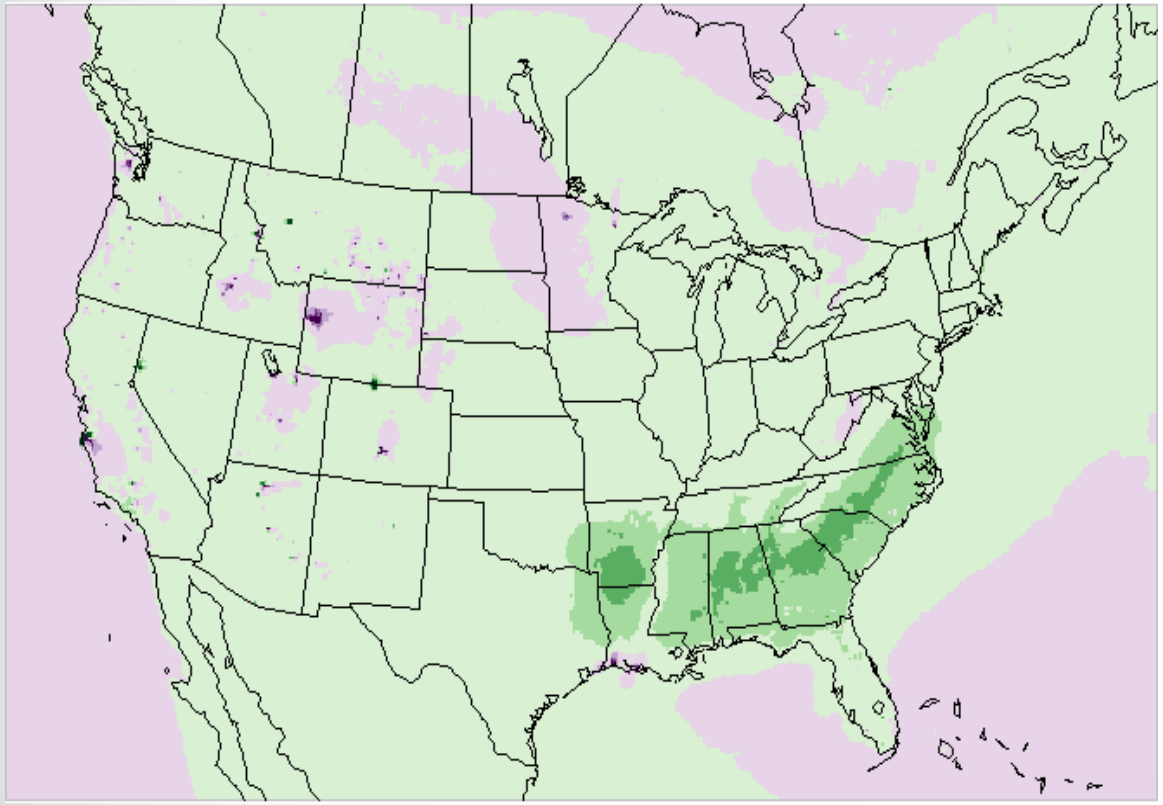
Non-Carbon Organic Matter





CMAQv5.3 - v5.2.1 (July)

Organic Carbon



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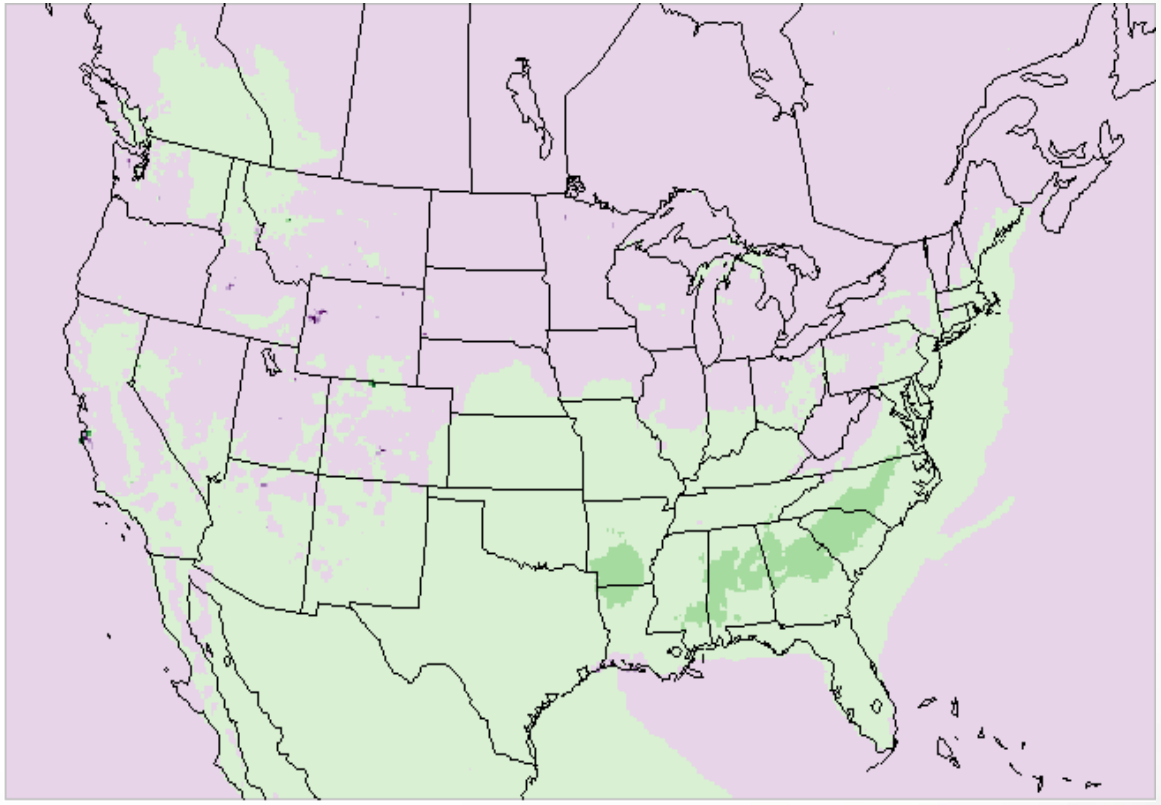
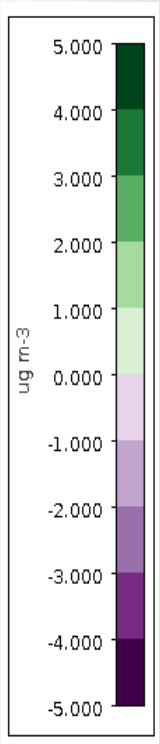
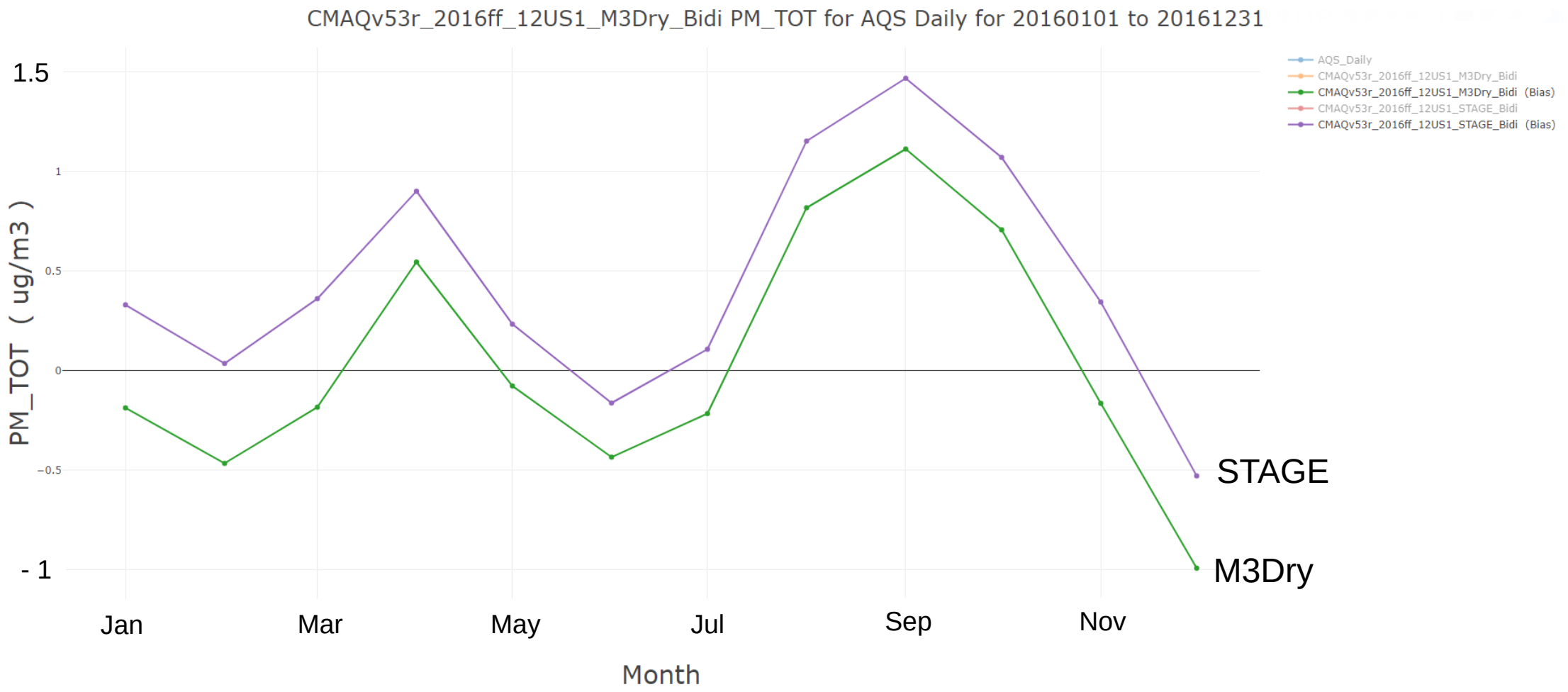
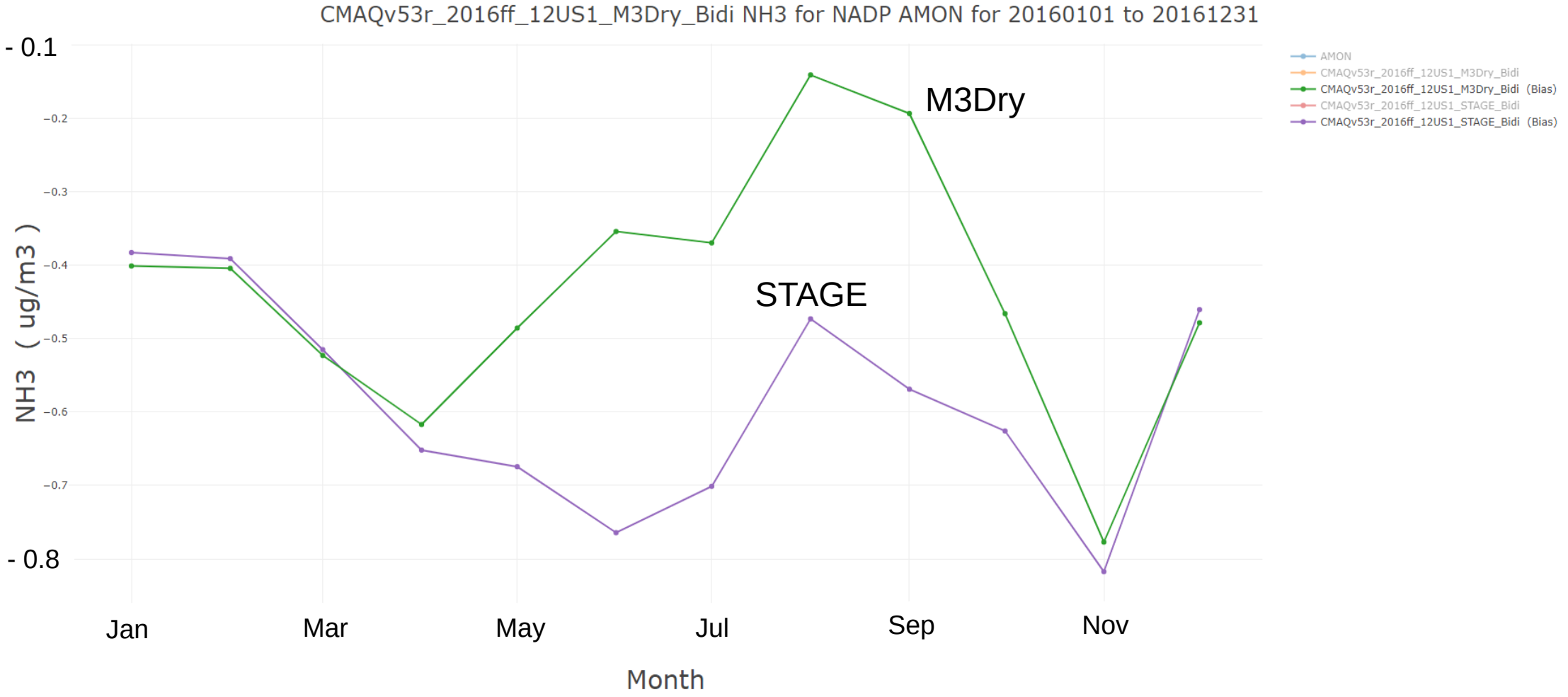




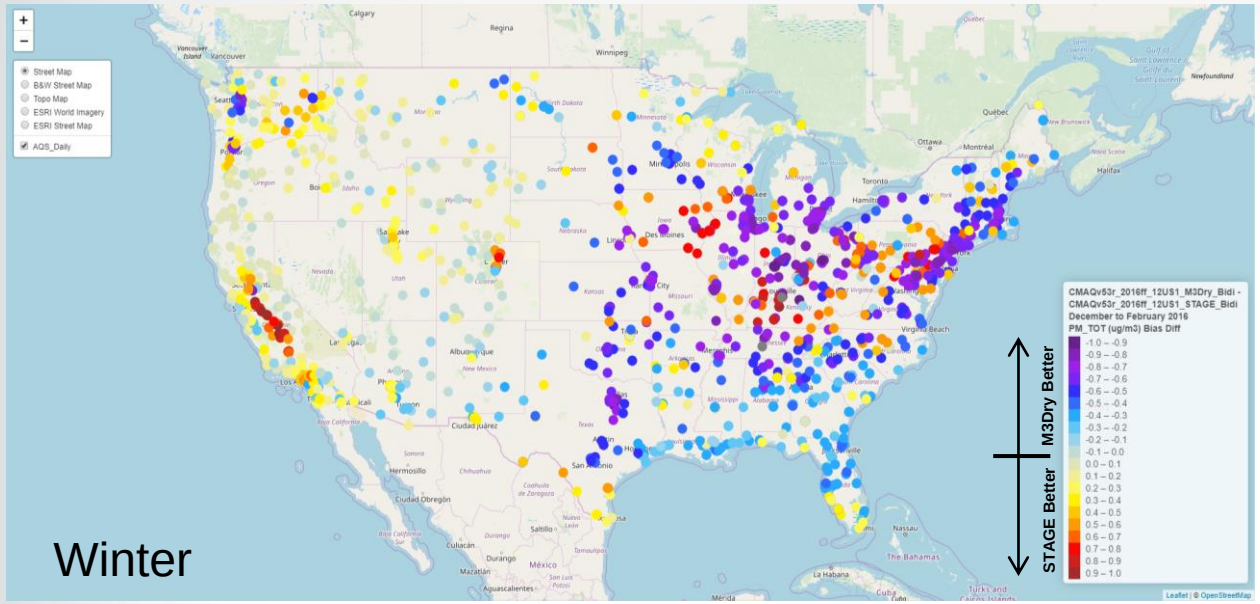
CMAQv5.3 $PM_{2.5}$ – STAGE vs. M3Dry

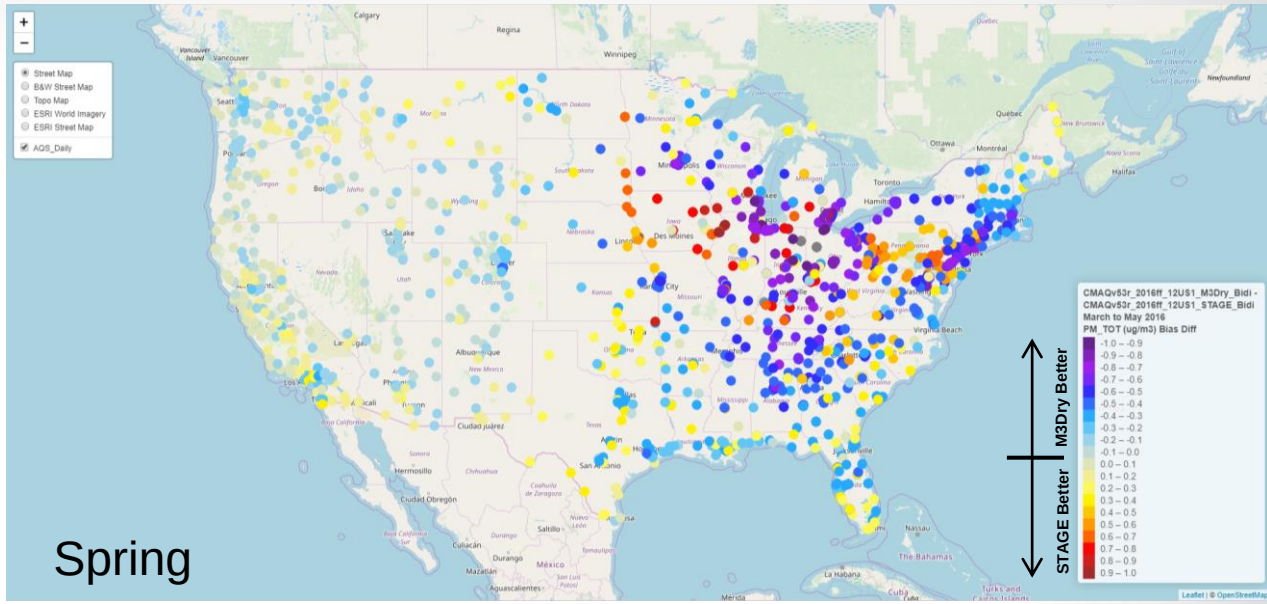


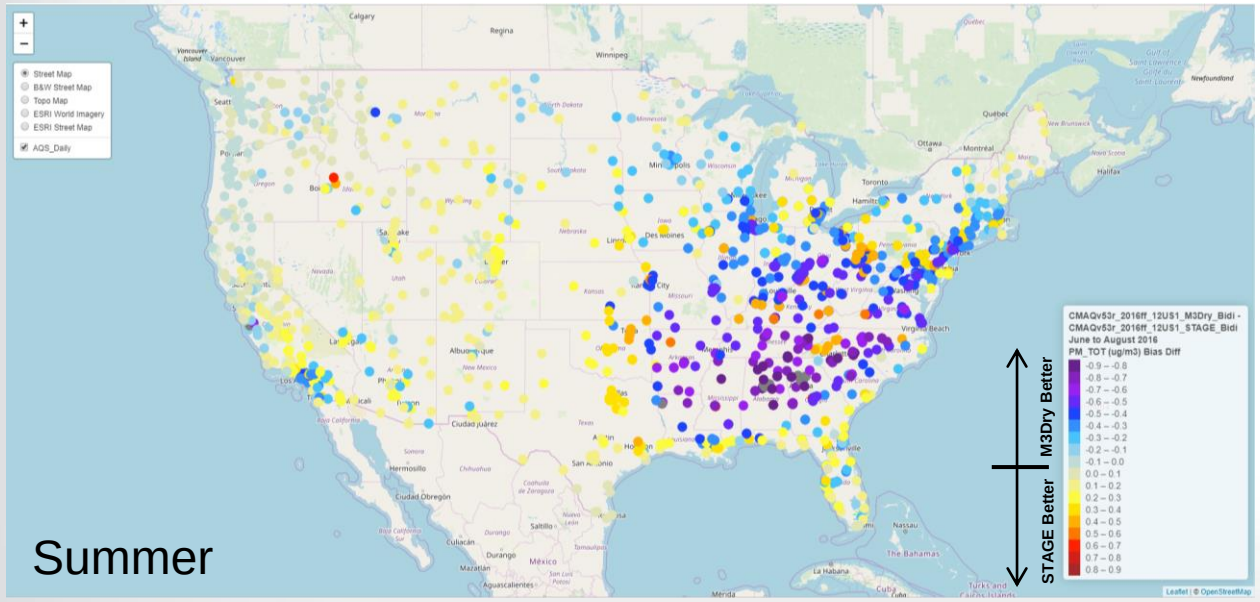
CMAQv5.3 NH_3 – STAGE vs. M3Dry

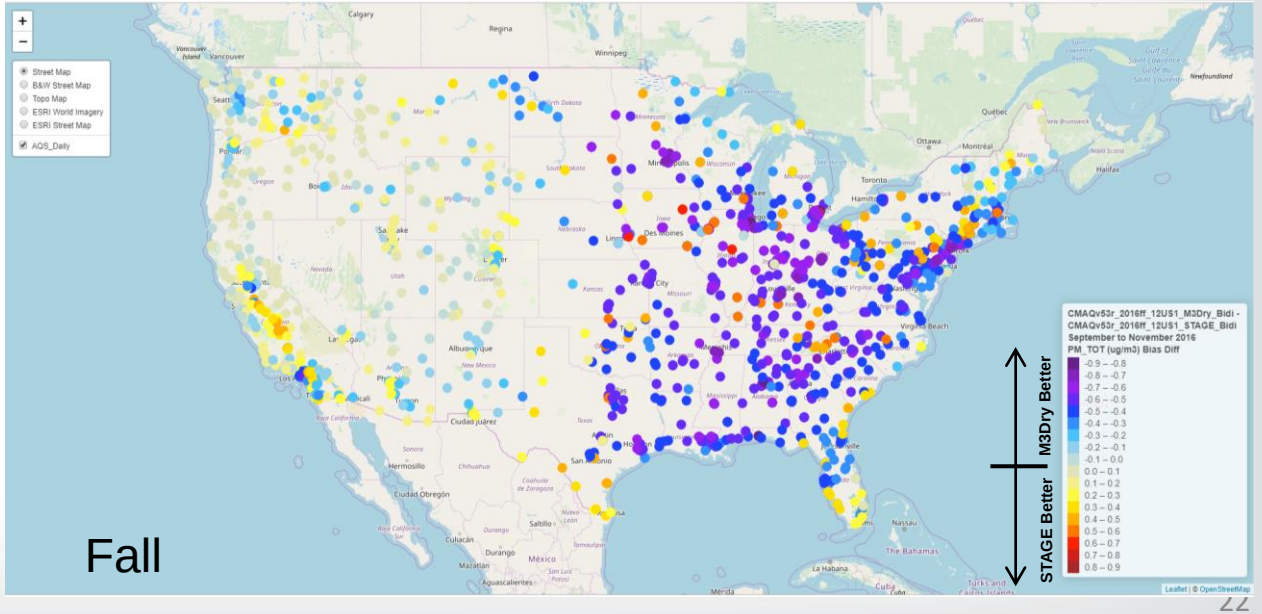


$PM_{2.5}$ – STAGE vs. M3Dry Seasonal Bias Difference

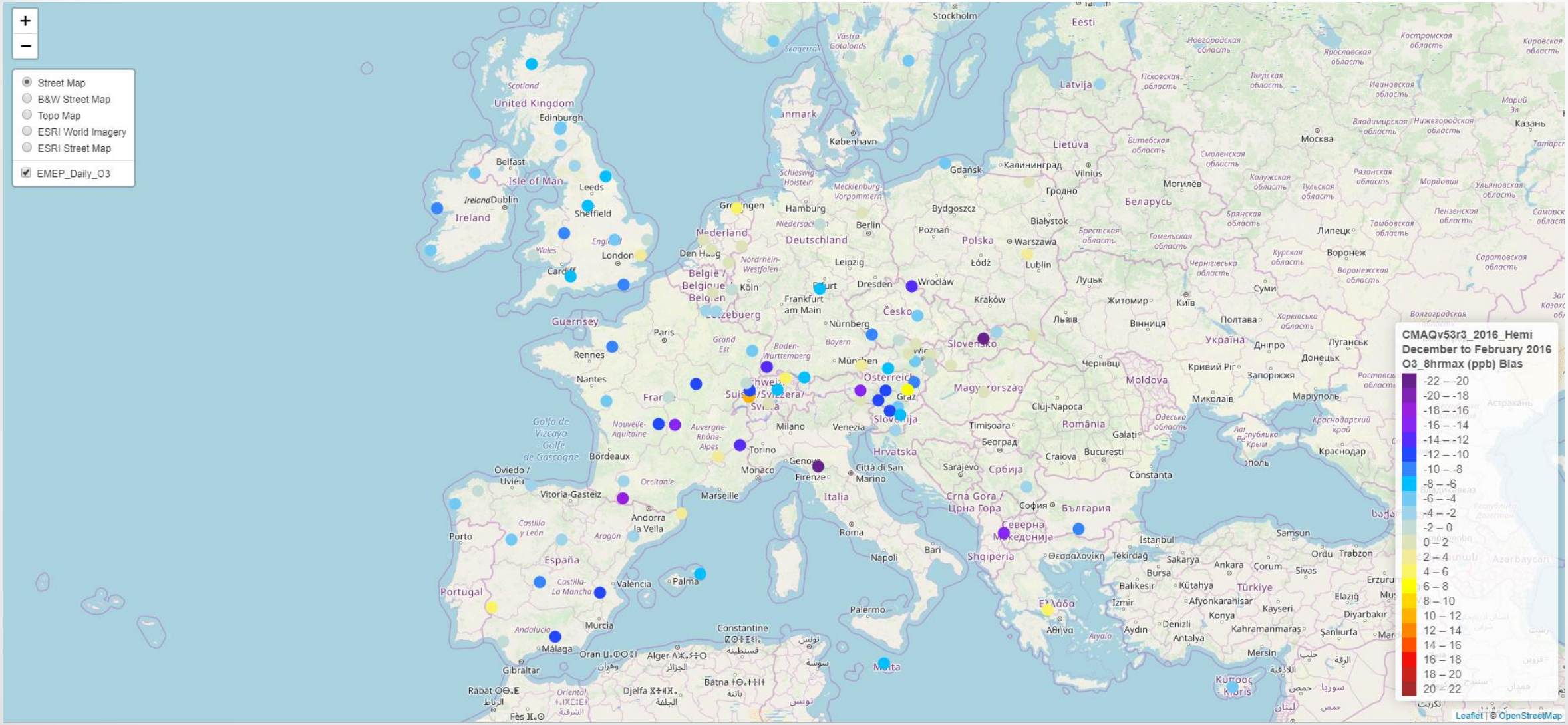




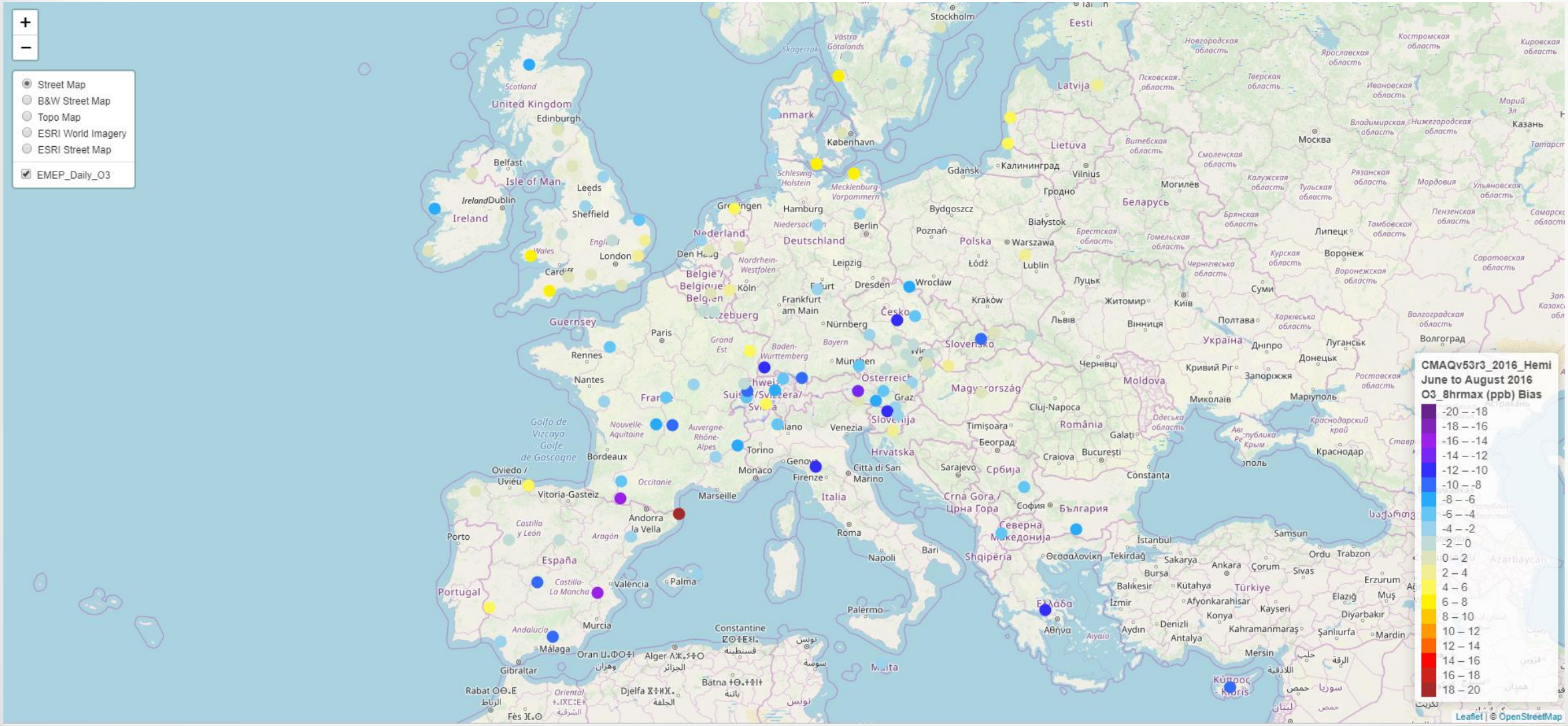




Hemispheric CMAQ – Winter MDA O_3



Hemispheric CMAQ – Summer MDA O_3



Summary

- **Ozone**
  - Generally lower O_3 with CMAQv5.3 vs v5.2.1
    - Improves summer/fall bias; increases winter/spring bias
    - due primarily to changes in the representation of dry deposition in v5.3
    - both M3Dry and STAGE reduce O_3
    - very large wintertime underestimation in beta v5.3 code reduced in final v5.3
    - springtime underestimation persists however
  - Summer overestimation reduced with CMAQv5.3
    - combination of deposition changes, updated BCs and minor chemistry updates
  - BCs created using v5.3β (M3Dry) hemispheric CMAQ simulation contribute to lower O_3 (vs BCs using v5.2.1)
    - largest in the winter and fall

- **Total $PM_{2.5}$**
  - Generally higher $PM_{2.5}$ in the summer w/ CMAQv5.3 vs. v5.2.1
    - primarily the result of increased SOA from monoterpene oxidation products
  - Similar $PM_{2.5}$ (to v5.2.1) outside of the summer with AERO7
  - M3Dry has a mixed effect on total $PM_{2.5}$
    - largest impact in the southeastern U.S. and the San Joaquin Valley in California
  - STAGE has consistently higher $PM_{2.5}$ than M3Dry throughout the year
  - M3Dry has smaller warm-season NH_3 bias vs. STAGE

Future Work

- CMAQv5.3 CONUS simulation with updated v5.3 BCs
  - evaluation of CMAQv5.3 hemispheric simulation using global datasets
- CMAQv5.3 CONUS simulation using WRFv4.1.1
  - testing impact of new hybrid coordinate in WRF
- Manuscript on CMAQv5.3 update and evaluation planned for 2020
  - overview of science updates and summary evaluation

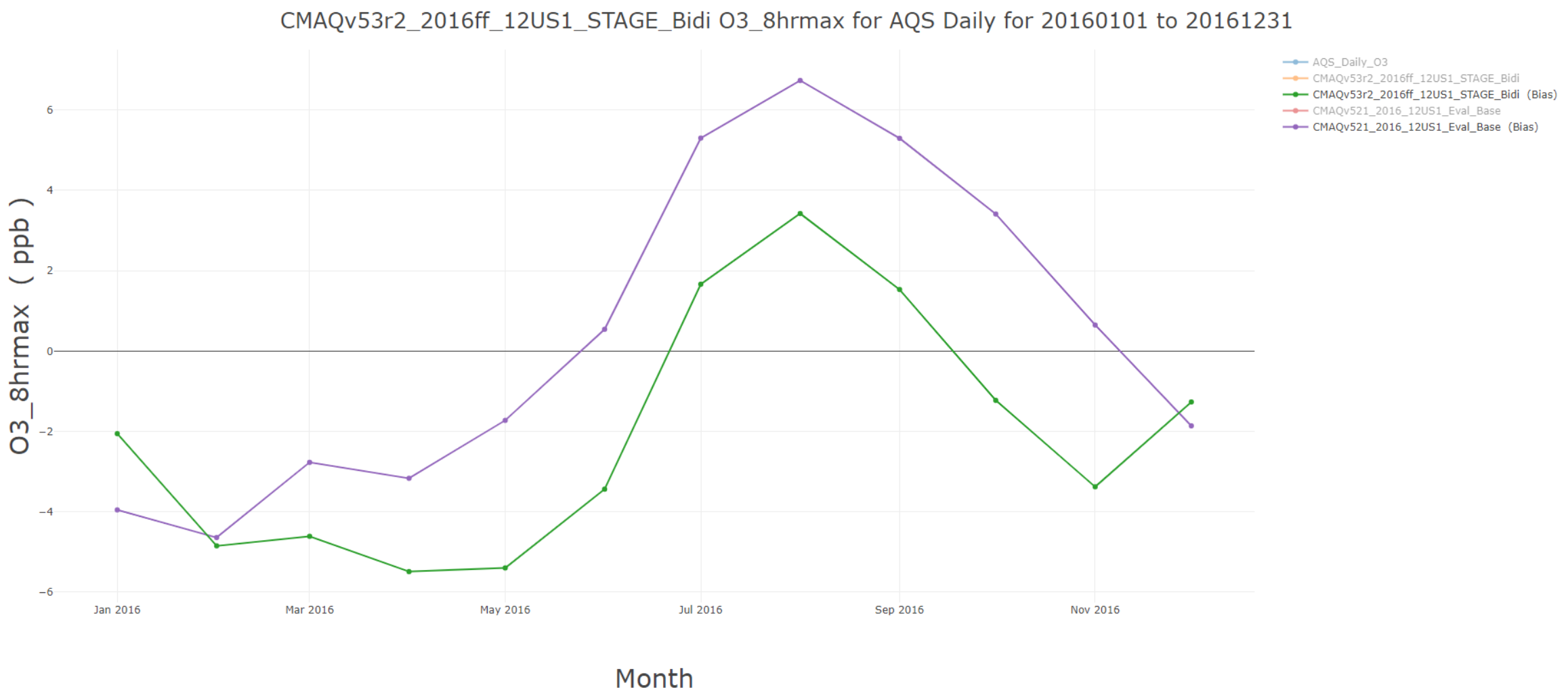
Acknowledgements and Disclaimer

- **CMAQ Development Team and Others**
  - Jesse Bash
  - Kathleen Fahey
  - Kristen Foley
  - Robert Gilliam
  - Christian Hogrefe
  - Bill Hutzell
  - Deborah Luecken
  - Rohit Mathur
  - Benjamin Murphy
  - Chris Nolte
  - Jon Pleim
  - George Pouliot
  - Havala Pye
  - Limei Ran
  - Shawn Roselle
  - Golam Sarwar
  - Donna Schwede
  - Fahim Sidi
  - Tanya Spero
  - David Wong

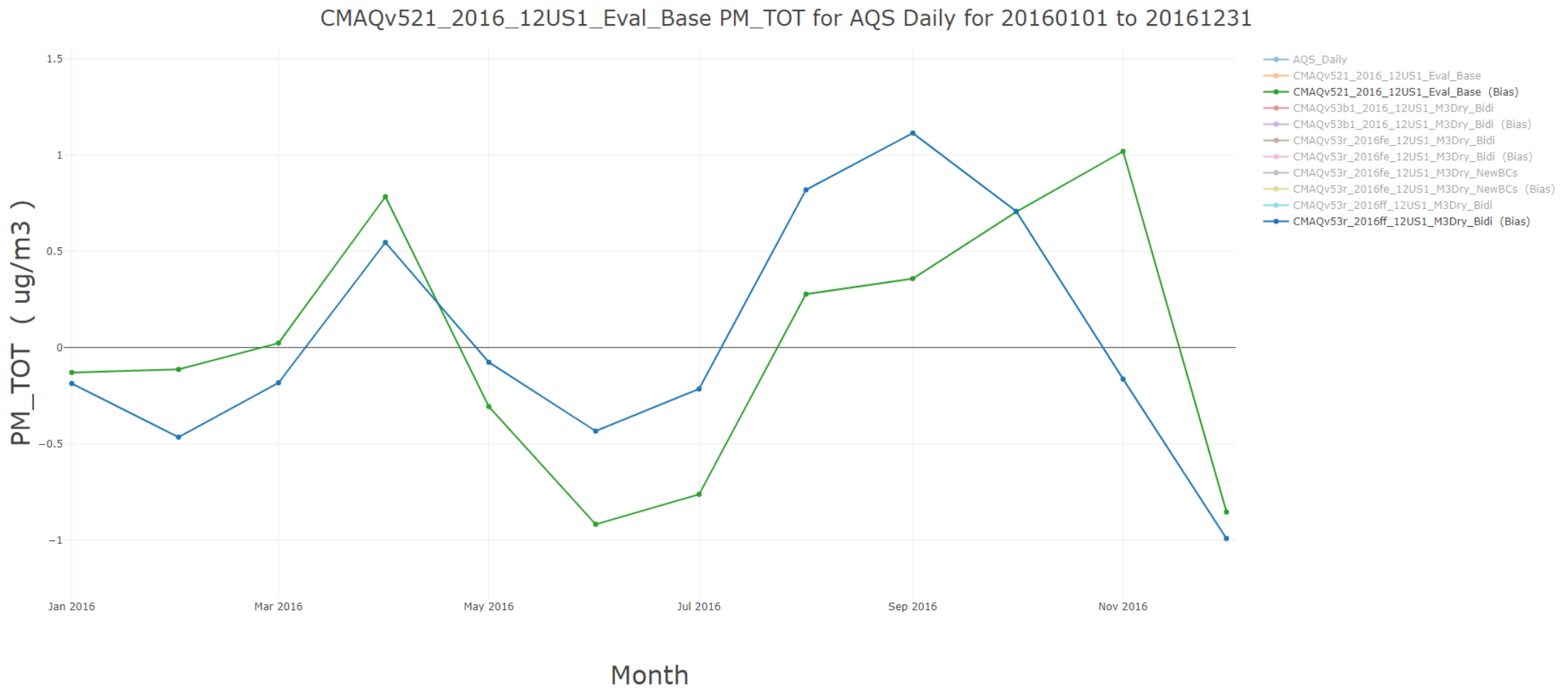
The views expressed in this presentation are those of the authors and do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency.

Extra Slides

MDA8 O_3 – CMAQv5.2.1 vs v5.3 (STAGE)

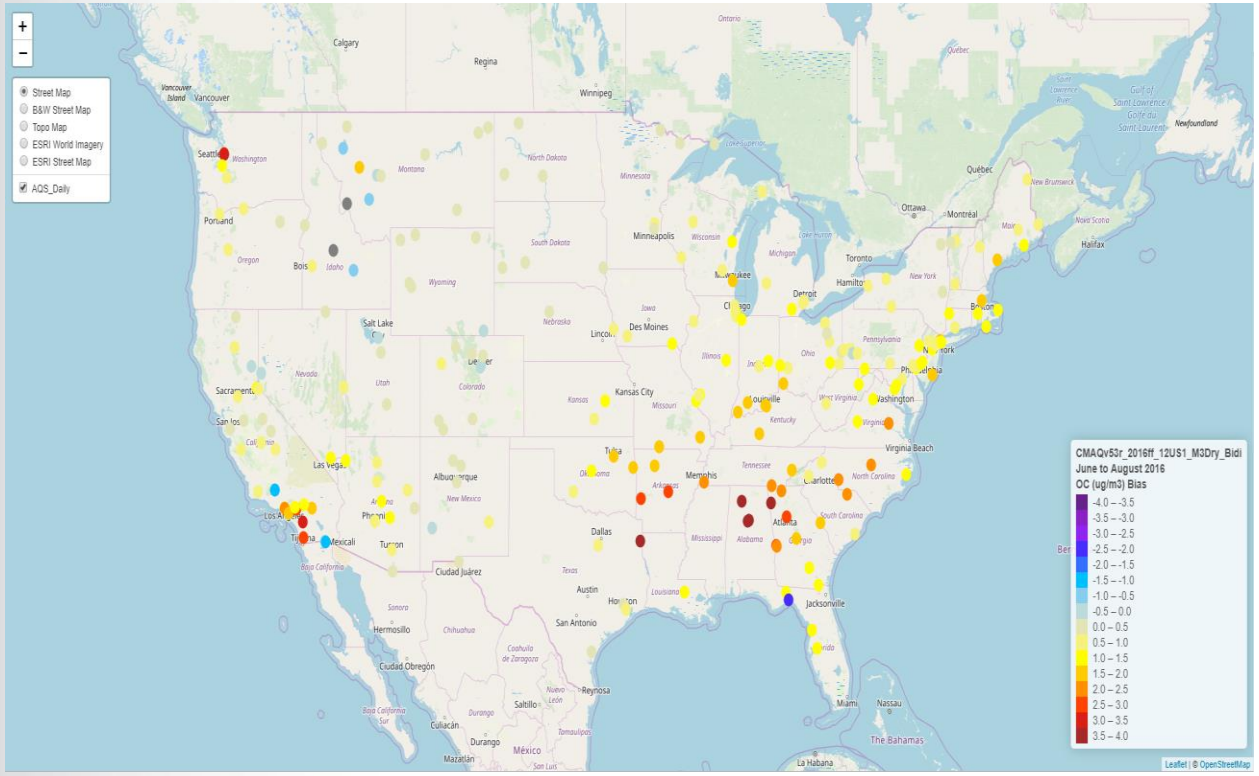


$PM_{2.5}$ – CMAQv5.2.1 vs v5.3



CMAQv5.2.1 vs v5.3 (Jun – Aug)

Organic Carbon



Non-Carbon Organic Matter