Use of Remote Sensing Data to Improve Air Quality Decision Support Systems Used to Protect Public Health

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3. National Aeronautics and Space Administration (NASA)
4. The Lake Michigan Air Directors Consortium (LADCO)
5. California Air Resources Board (CARB)
6. Texas Commission on Environmental Quality (TCEQ)
7. Georgia Environmental Protection Division (Georgia-EPD)
8. U.S. Environmental Protection Agency (USEPA)

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NSSTC

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

PROJECT INFORMATION

TOPIC: **Use of Remote Sensing Data to Improve Air Quality Decision Support Systems Used to Protect Public Health**

POP: 8/24/2018 - 8/23/2021 (ROSES17-A.39)
(Continuing Project – Second Year Report)

PI: Arastoo Pour Biazar (University of Alabama in Huntsville)
Co-Is: Dick McNider (UAH)

Partners: California Air Resources Board (CARB), USEPA, Texas Commission on Environmental Quality (TCEQ), Georgia Environmental Protection Division (GA-EPD), The Lake Michigan Air Directors Consortium (LADCO - representing states of Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin).

NASA Assets: NASA's GOES Product Generation System (skin T, surface insolation and albedo, cloud top T, cloud albedo); MODIS/VIIRS products (Skin Temperature, surface insolation and albedo)

Objective: To employ NASA assets and satellite products to improve the air quality management Decision Support Tools (DSTs) used in defining emission control strategies for attainment of air quality standards.

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Overall Objective: To Reduce the Uncertainties in Regulatory Air Quality Simulations Through the Use of NASA Science and Satellite Data Products

In SIP modeling it is imperative to reproduce the observed atmosphere. Model uncertainties translates into uncertainties in emission control strategy which has significant economic consequences.

Fundamental Approach in Air Quality Modeling Systems

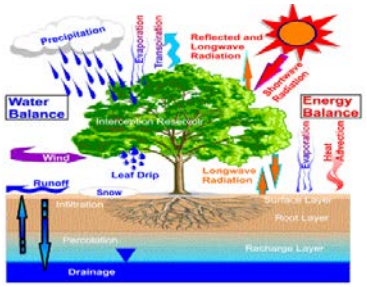
Physical Atmosphere

Models: e.g. WRF, Recreates the physical atmosphere (winds, temperature, precipitation, moisture, turbulence etc) during the design period

Clouds and microphysical processes

Atmospheric dynamics

Boundary layer development



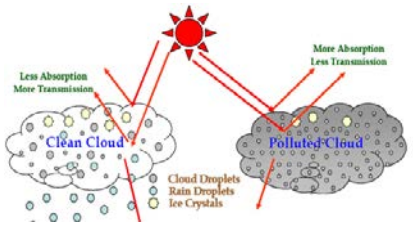
Fluxes of heat and moisture

LSM describing land-atmosphere interactions

Winds, temperature, BL height, Radiation, moisture, surface properties, surface fluxes, precipitation

Chemical Atmosphere

Models: CMAQ, CAMx
Recreates the chemical atmosphere



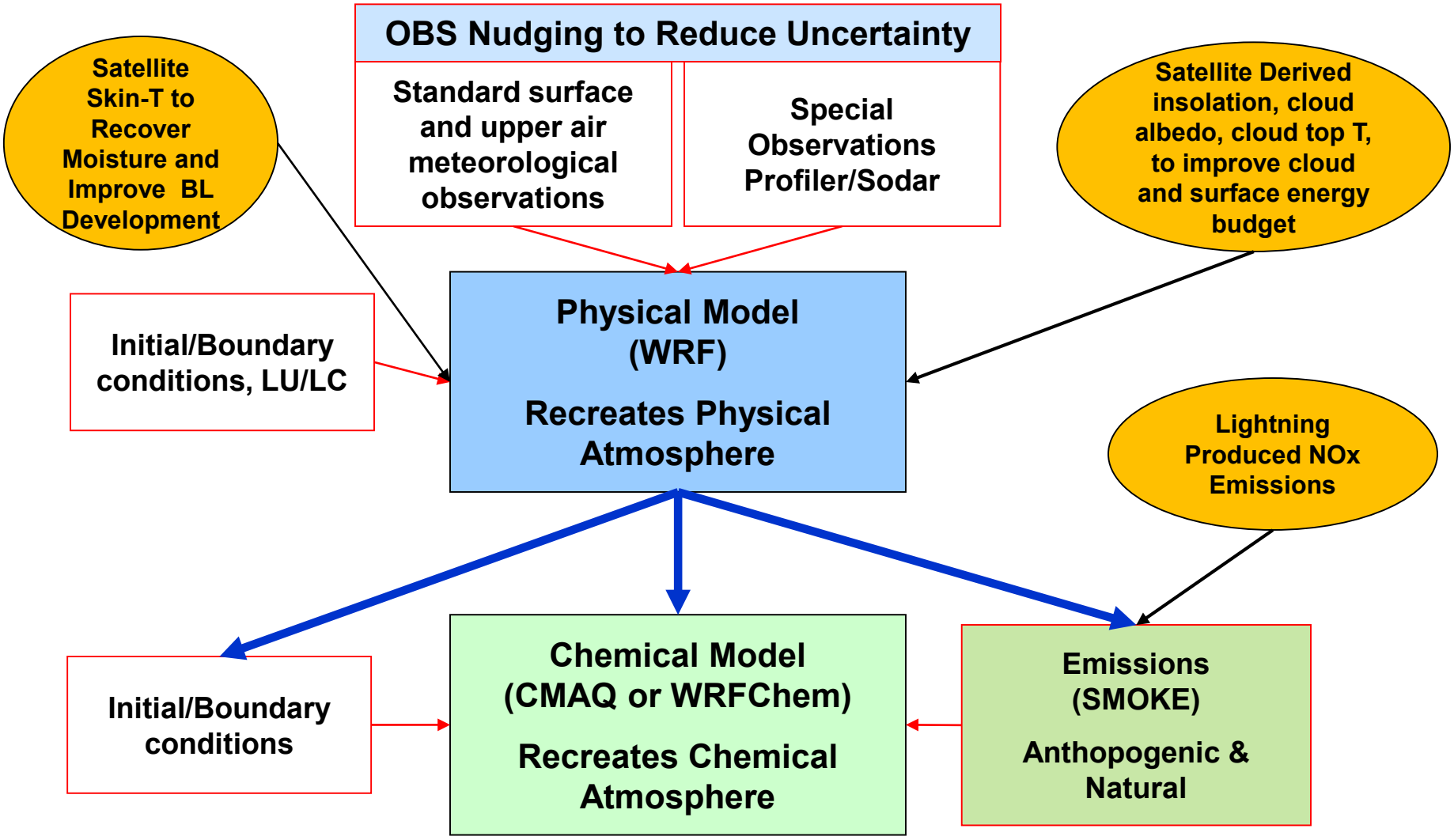
Heterogeneous chemistry, aerosol

Transport and transformation of pollutants

Photochemistry and oxidant formation

Natural and antropogenic emissions, Surface removal

Contribution of This Project in Reducing Simulation Uncertainties



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Specific Objectives

In This Project NASA Assets and Satellite Data Will Be Used to Improve the Quality and Accuracy of Retrospective Baseline Simulation in Which Proposed SIP Emission Reductions Are Tested

Upgrading Data Generation and Archiving System

- **Upgrading GOES Product Generation System (GPGS):** Collaborating with the NASA's the Short-term Prediction Research and Transition (SPoRT) Center, GPGS is being recoded to process GOES-16, 17, data.

Improving Physical Atmosphere

- **Improved Characterization of Surface Energy Budget:** Using satellite derived skin temperature to retrieve soil moisture and improve surface evapotranspiration performance in WRF.
- **Improving Boundary Layer Development in the Model:** By improving BL moisture and temperature structure.
- **Improving Model Cloud Field:** Assimilating satellite observed clouds in WRF.

Improving Emission Estimates in AQ Model

- **Utilization of Satellite Derived Lightning Generated NO (LNOx) Emissions:** This activity utilizes newly available lightning optical energy from the Geostationary Lightning Mapper (GLM) to produce lightning-generated NO emissions input for air quality models.

SCHEDULE / MILESTONES

Major Tasks	FY19	FY20	FY21
Retooling retrieval software for GOES-16 Advanced Baseline Imager (ABI)	New insolation retrieval code completed	Testing & evaluation	Reprocessing to fill the archive
GOES Skin-T retrieval (SPoRT)	Work has started, 2016 being priority	Testing & evaluation	Reprocessing to fill the archive
New Cloud Assimilation System	Software were revised and tested	Performing simulation for the summer of 2016	Test and evaluation with GOES16 products
LNOx Emission Estimates Using GLM obs.	Lightning NOx (LNOx) algorithm development	Testing & evaluation within AQ models	Realtime generation to be added to GPGS
Testing skin-T assimilation over regions of interest		2016 simulations using moisture adjustment (California)	Impact of moisture adjustment for eastern U.S.
Benchmarking (multiple activities)	Performing simulations for 2016, testing CAS	Performing simulations for 2016, testing LNOx emissions	Performing Benchmarking soil moisture adjustment
Transition (LADCO, TCEQ, G-EPD, …)		2016 SIP simulations	
Initial health and economic impact analysis		Using BenMAP	

Completed

Ongoing

Future

Stakeholder Involvement/Interaction

- Our monthly meetings with our partner organizations are continuing.
- Participants are: The Lake Michigan Air Directors Consortium (LADCO) representing states of Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin; California Air Resources Board (CARB), USEPA, Texas Commission on Environmental Quality (TCEQ), Georgia Environmental Protection Division (GA-EPD).
- Modeling results and lessons learned are shared and have been useful to the participants.
  - UAH will try to merge EPA's technique for use of lightning events to initiate convection in the model with UAH assimilation approach.
  - UAH investigated the impact of different model configurations (used by different agencies) on the improvements made by the assimilation.
- UAH provided data and relevant computer codes for model evaluation to LADCO.

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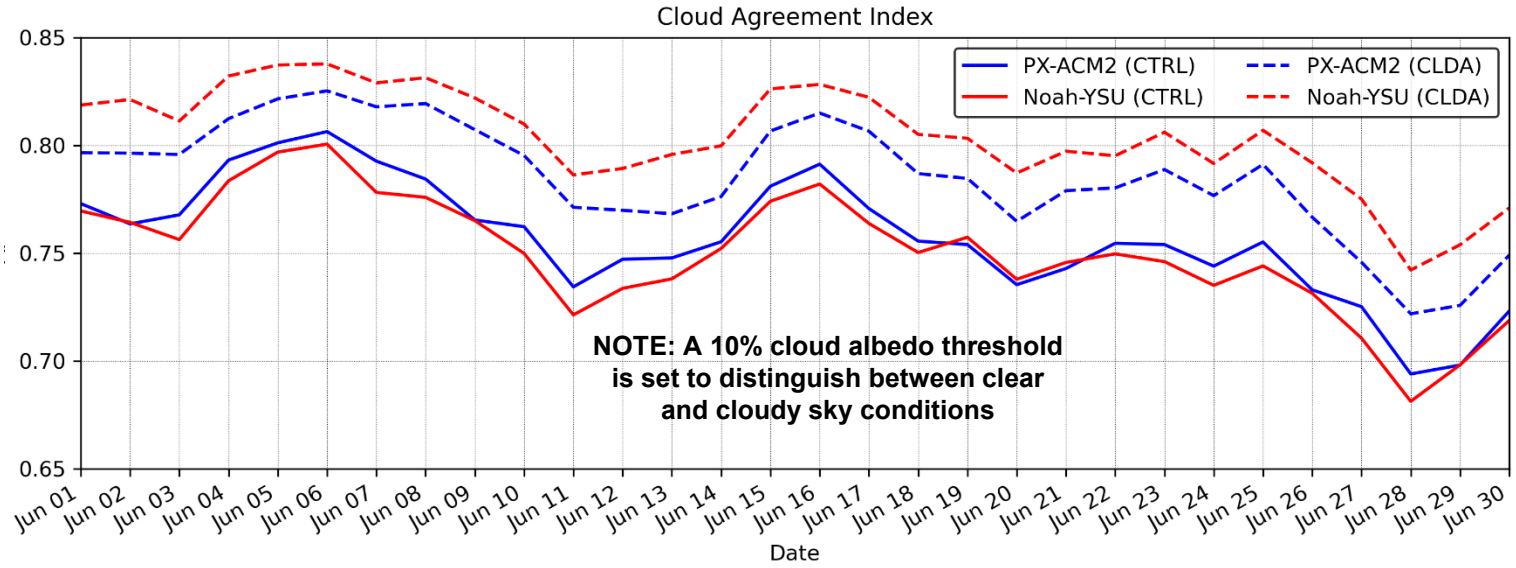
Improved Cloud Assimilation System (CAS)

- New improved Cloud Assimilation System (CAS) was tested in both 2013 and 2016 WRF simulations.



Cloud Agreement Index June 2016

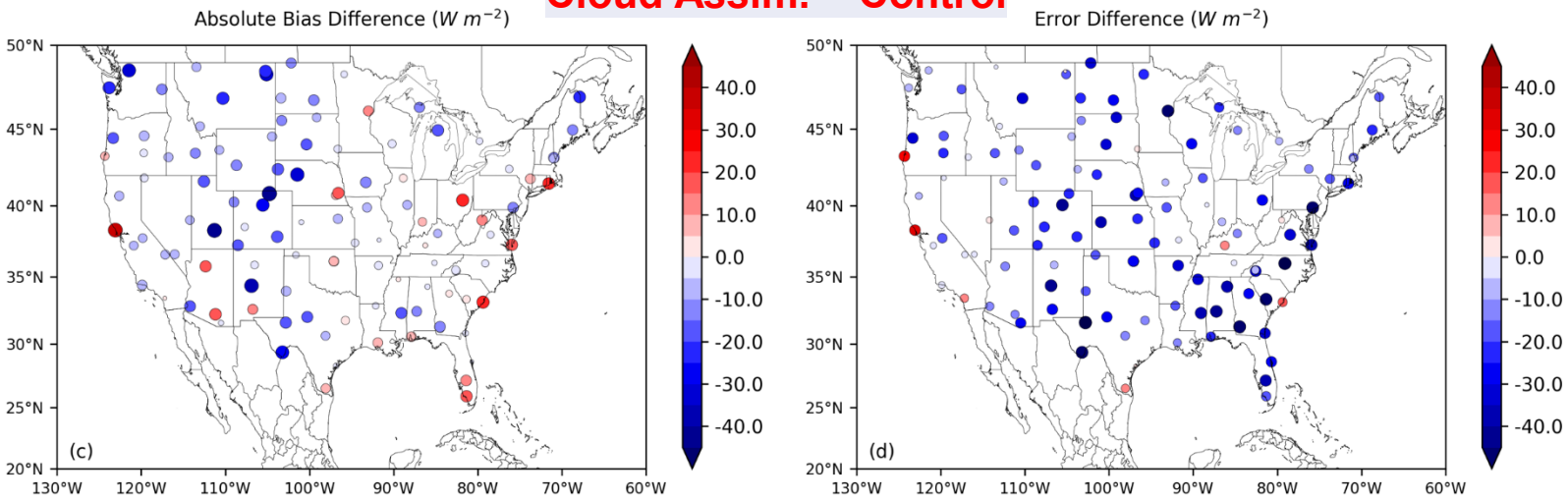
		CONTROL		CLOUD ASSIMILATION	
		Bias	RMSE	Bias	RMSE
PX-ACM2	All	63.76	163.91	58.46	150.76
	Clear	52.91	117.99	54.85	110.19
	Cloudy	81.43	218.59	64.66	199.63
NOAH-YSU	All	67.50	164.03	61.52	148.67
	Clear	52.80	114.61	58.26	110.17
	Cloudy	91.27	221.75	67.13	195.56

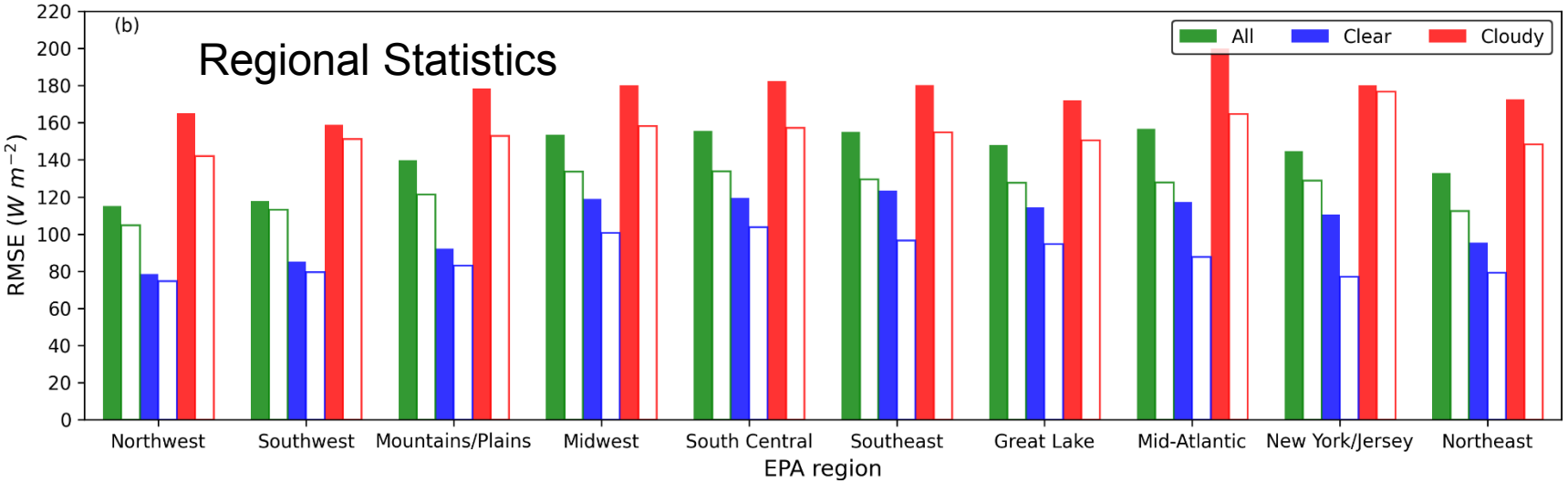
Surface insolation (W m^{-2}) compared to USCRN

Improvement in radiation BIAS and RMSE for August 2016

WRF insolation compared to USCRN surface observations (01 Aug 2016 – 31 Aug 2016)
Negative values indicate cloud assimilation improvements over control WRF simulation

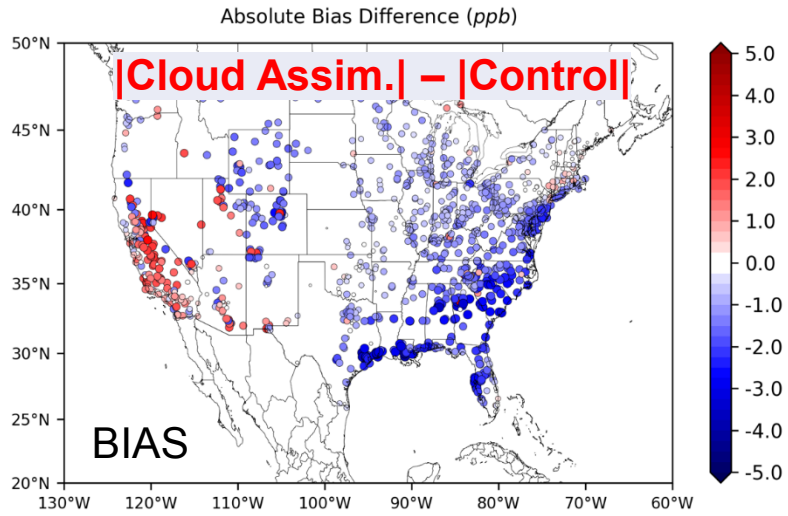
Cloud Assim. – Control

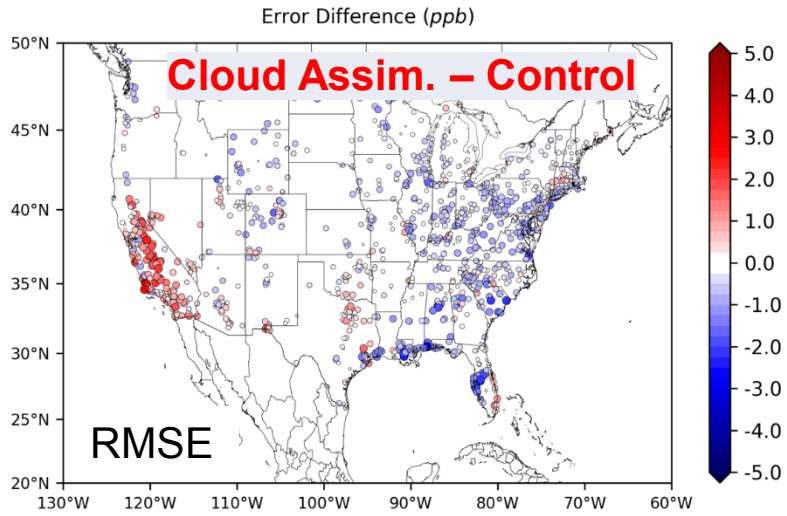




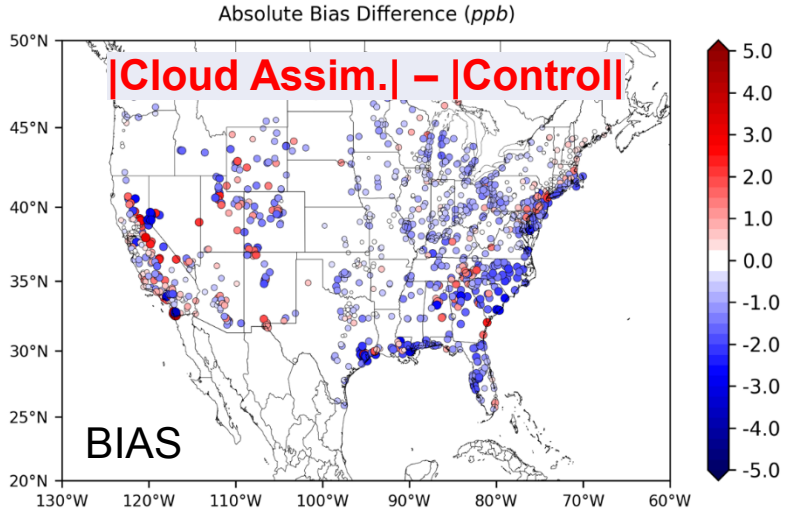
Improvement in ozone BIAS and RMSE (June-September 2016)

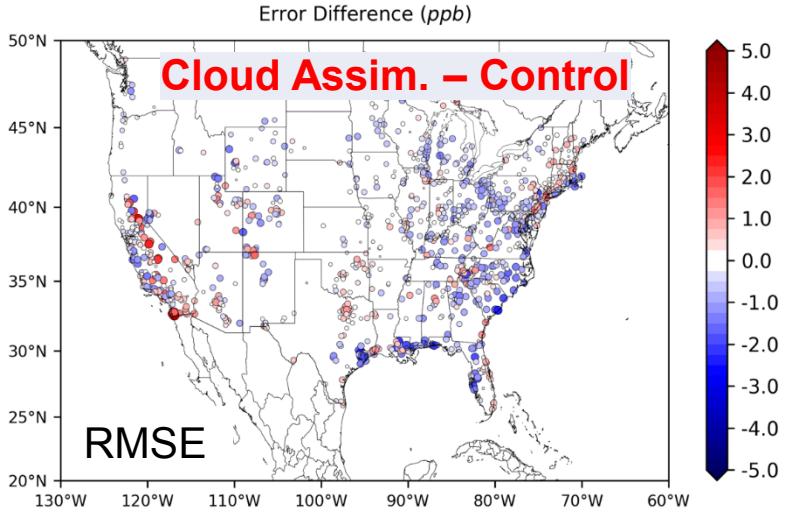
DAYTIME



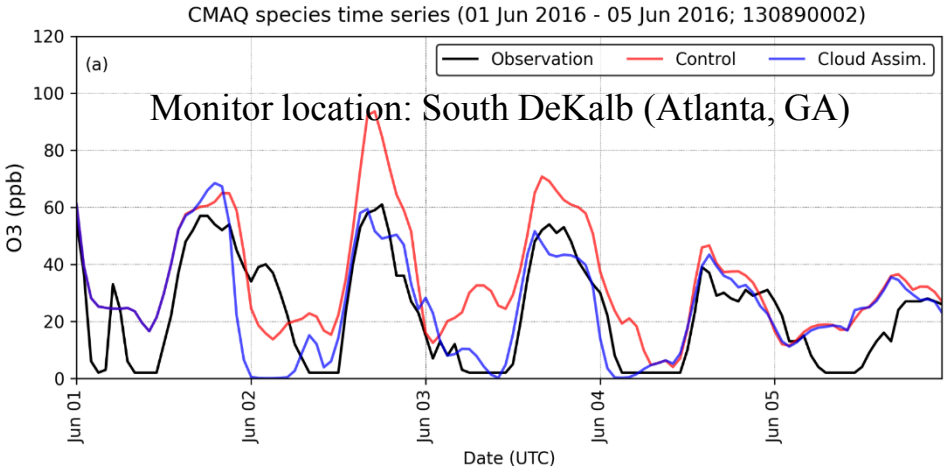


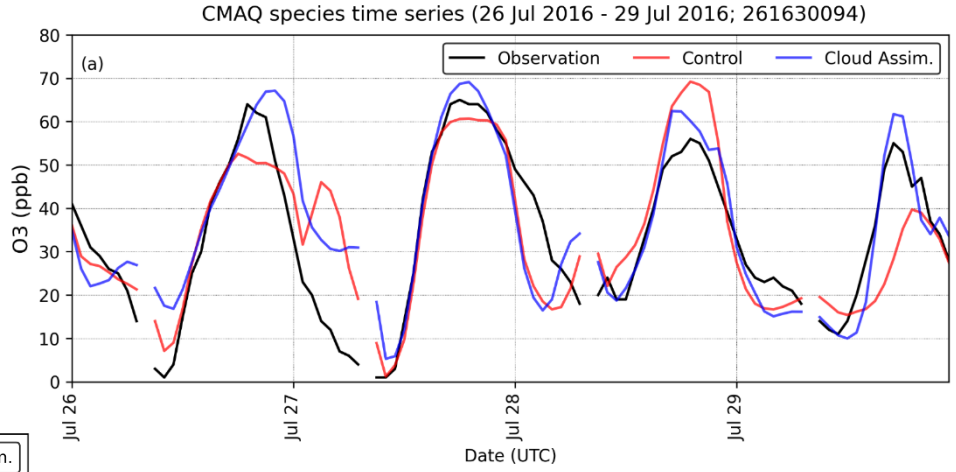
NIGHTTIME



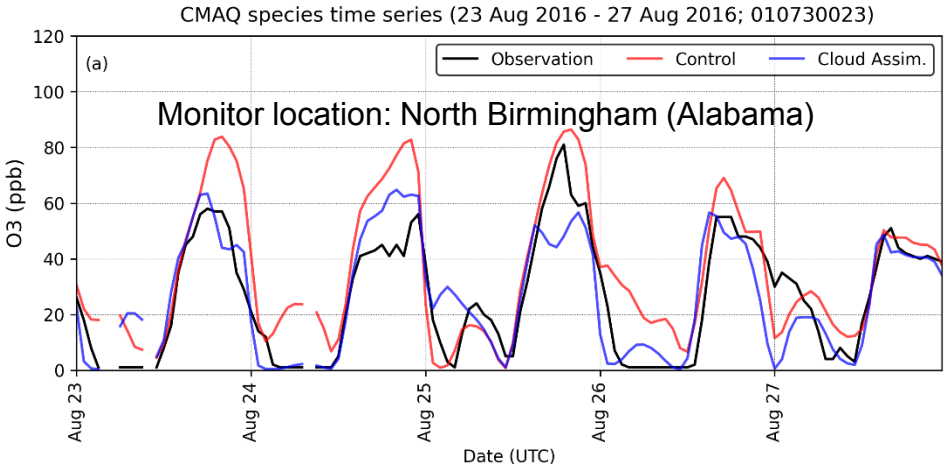


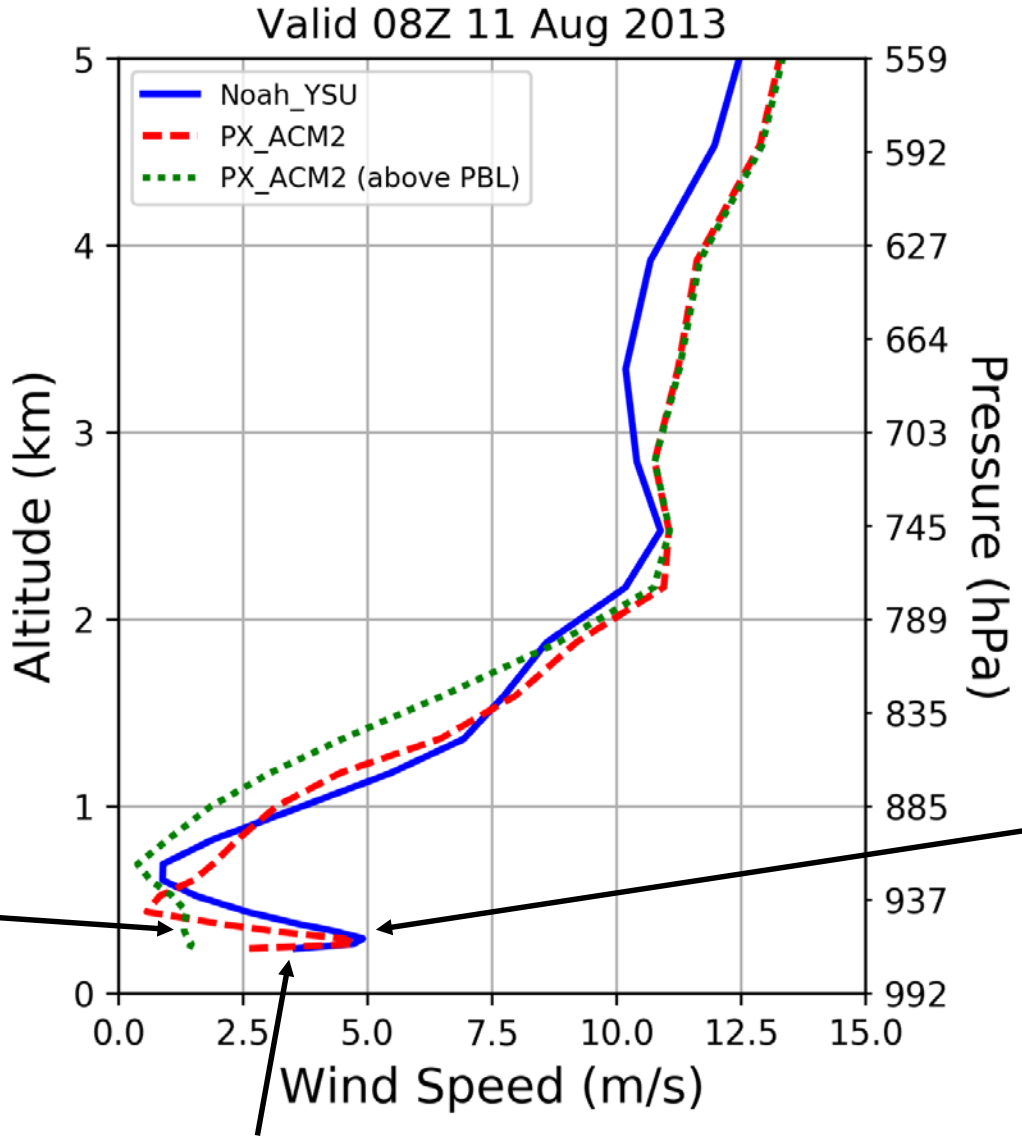
Improvements for specific sites/periods can be significant





Monitor location: Eliza Howell Downwind (Detroit, MI)





Using the traditional PBL height nudging cutoff can reduce the model's ability to develop the LLJ

When nudging is limited to above 1 km, both simulations capture the LLJ.

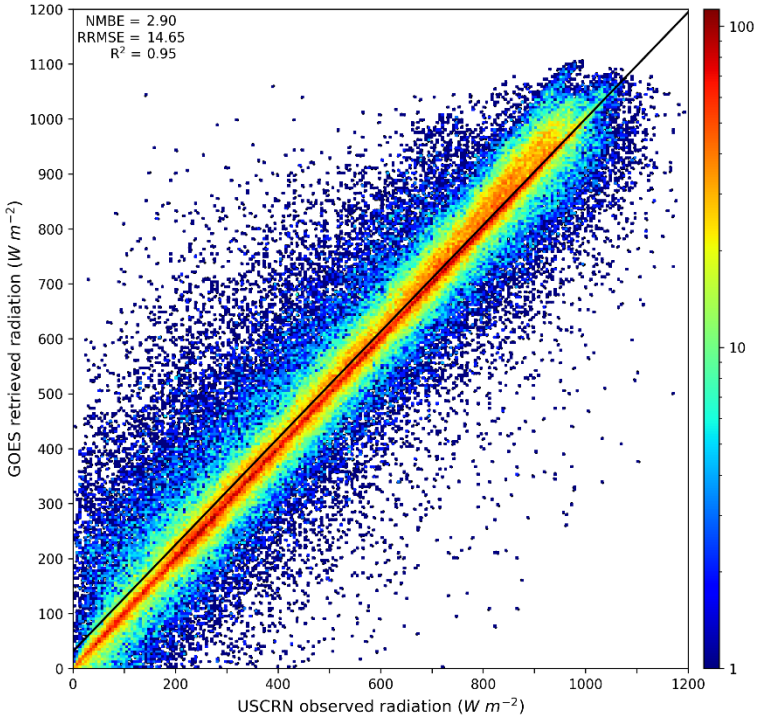
Even with similar LLJ maximum wind speeds, the Noah-YSU simulation has a consistently higher surface wind speed.

GOES-16 Insolation Retrieval

	Satellite	Start	End
	GOES-13	1-Jun-16	30-Sep-16
	MBE	RMSE	R2
All	15.12	76.35	0.95
Clear	18.13	61.71	0.89
Cloudy	11.29	91.36	0.96
	GOES-16	6-Jun-19	7-Jul-19
	MBE	RMSE	R2
All	-3.12	92.16	0.84
Clear	-9.92	69.60	0.69
Cloudy	2.87	108.33	0.85

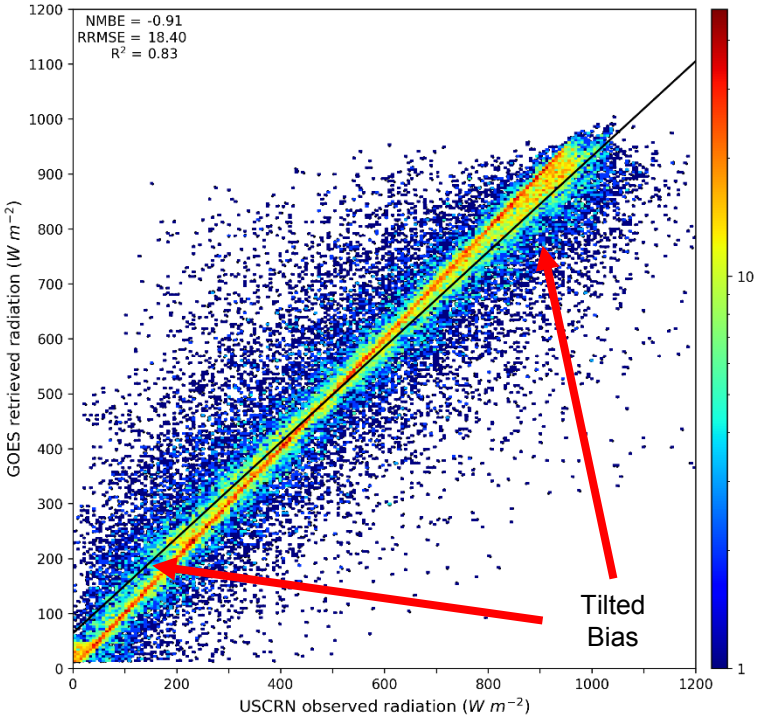
Retrieval quality is a concern

GOES-13 vs USCRN (June-September 2016)



Color bar:
# of points in each bin
Bin size:
5 W m^{-2} X 5 W m^{-2}

GOES-16 vs USCRN (June 2019)



RISKS & ISSUES

- The major challenges are due to the restricted working conditions under COVID-19 pandemic. Our partners are also experiencing slow-down due to this pandemic. We have tried our best to improve our communications and maintain regular virtual meetings. However, the progress continues at a slower pace.
- The quality of insolation retrievals is posing a serious challenge to successful conclusion of this project. NOAA operational product has the same issue, under-prediction at low zenith angle and over-prediction at higher zenith, and does not have the spatial resolution that is required for air quality simulations.
  - The issue seems to be the GOES-16 narrow band that is shifted toward red.
  - We are working on using COD instead.
- Our partner organizations are preparing for budget cuts due to the uncertain fiscal priorities and shortfalls due to COVID-19.

Thank You

ACRONYMS

ALEXI	THE ATMOSPHERE-LAND EXCHANGE INVERSE MODEL
CMAQ	EPA's Community Multiscale Air Quality (CMAQ) Model
CMAS	Community Modeling and Analysis System
EPA	Environmental Protection Agency
LNOx	Lightning Generated Nitrogen Oxides
MEGAN	Model of Emissions of Gases and Aerosols from Nature
NAAQS	National Ambient Air Quality Standard
NASA	National Aeronautics and Space Administration
SIP	State Implementation Plan
TCEQ	Texas Commission on Environmental Quality