Diagnosing Near-Surface Model Errors with FV3-LAM Physics Schemes for Multi-Physics RRFS Ensemble

CIWRO Workshop on Forecast Applications Improvements

September 30, 2022, 12pm

Xiao-Ming Hu Center for Analysis and Prediction of Storms (CAPS) at University of Oklahoma (OU)

Co-Authors: Jun Park, Timothy Supinie, Nathan A. Snook, Ming Xue, Keith Brewster Jerald Brotzge, Jacob R. Carley



5 physics suites in FV3-LAM for Rapid Refresh Forecasting System (RRFS) ensemble

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Experiment names	Suite Characteristic	Microphysics	PBL	Surface Layer	LSM	S	М	T١	ר w נ	_	S
CNTL	RRFS-control-like	Thompson	MYNN (<u>Olson et</u> <u>al., 2019a;</u> <u>Olson et al.,</u> <u>2019b</u>)	MYNN (<u>Nakanishi</u> <u>& Niino,</u> 2009)	NOAH (Chen & Zhang, 2009)	18 25	19 26	13 1 20 2 27 2	7 8 14 1 21 2 28 2	3 9 5 1(2 2: 9 3() 10 5 17 3 24 0 31
LSM1	HRRR-like (Benjamin et al., 2016)	Thompson	MYNN	MYNN	RUC (Smirnova et al., 2016; Smirnova et al., 2000)	S 3	M 4	_	W 1	F F 1 7 8	5 2 3 9
LSM2	future GFS-like	Thompson	TKE- EDMF (<u>Han &</u> <u>Bretherton,</u> 2019)	GFS (<u>Zheng et</u> <u>al., 2012</u>)	NOAH-MP (<u>Niu et al., 2011</u>)	17	18 25	12 1 19 2 26 2	20 2 27 2	1 22 8 <mark>2</mark> 9	2 23 9 30
MP1	WoFS-like	NSSL	MYNN	MYNN	NOAH			•			
MP2	HWRF-like HAFS-like (Biswas et al., 2018)	Ferrier-Aligo	K-EDMF (<u>Han et al.,</u> 2016)	GFS (<u>Zheng et</u> al., 2012)	NOAH			l 1 th Sup			

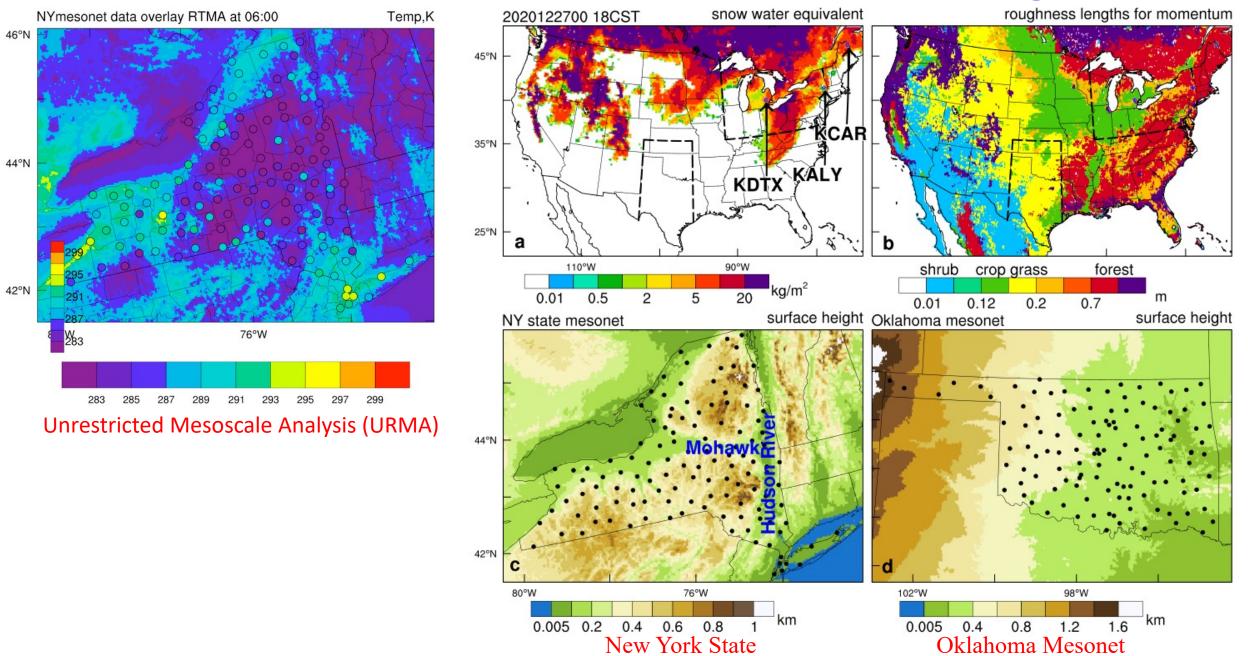
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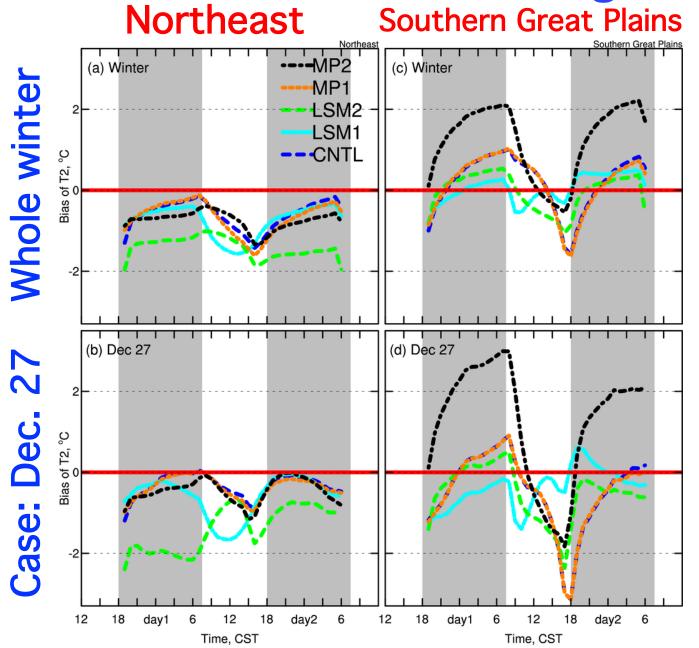
lydrometeorology Testbed (HMT) 1th Winter Weather Experiment (2020-21) Supinie et al. (2022, MWR)

relatively-well understood and operationally hardened, should thus be relatively easy to maintain in an operational setting.

Observations for evaluation: URMA, Mesonet, Soundings

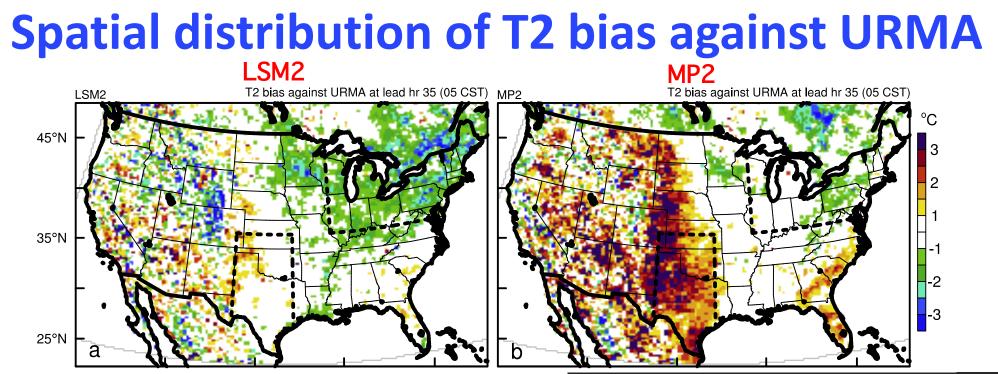


T2 bias against URMA



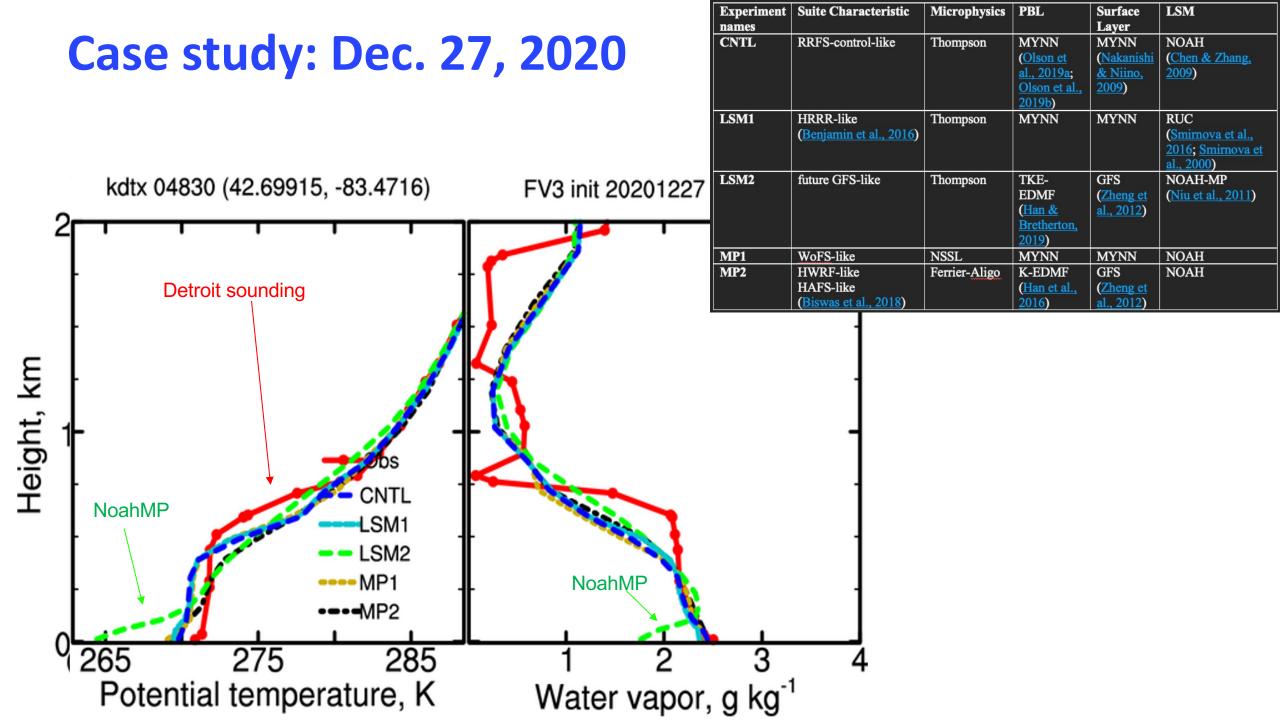
- Cold bias from LSM2 over Northeast
- Warm bias from MP2 over Southern Great Plains

Experiment names	Suite Characteristic	Microphysics	PBL	Surface Layer	LSM
CNTL	RRFS-control-like	Thompson	MYNN (<u>Olson et</u> <u>al., 2019a;</u> <u>Olson et al.,</u> 2019b)	MYNN (<u>Nakanishi</u> <u>& Niino,</u> 2009)	NOAH (<u>Chen & Zhang</u> , 2009)
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MP1	WoFS-like	NSSL	MYNN	MYNN	NOAH
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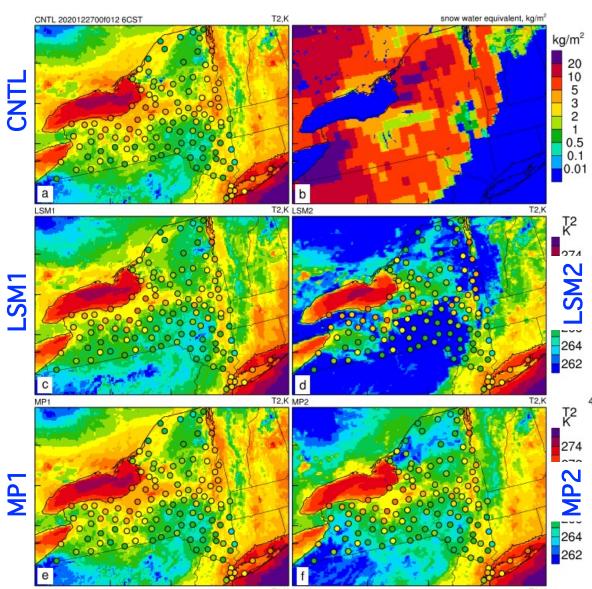


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- Warm bias from MP2 over Southern Great Plains

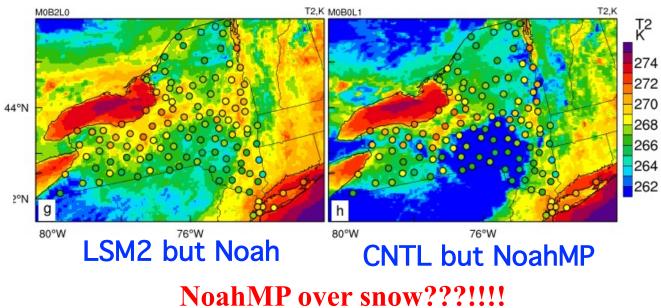
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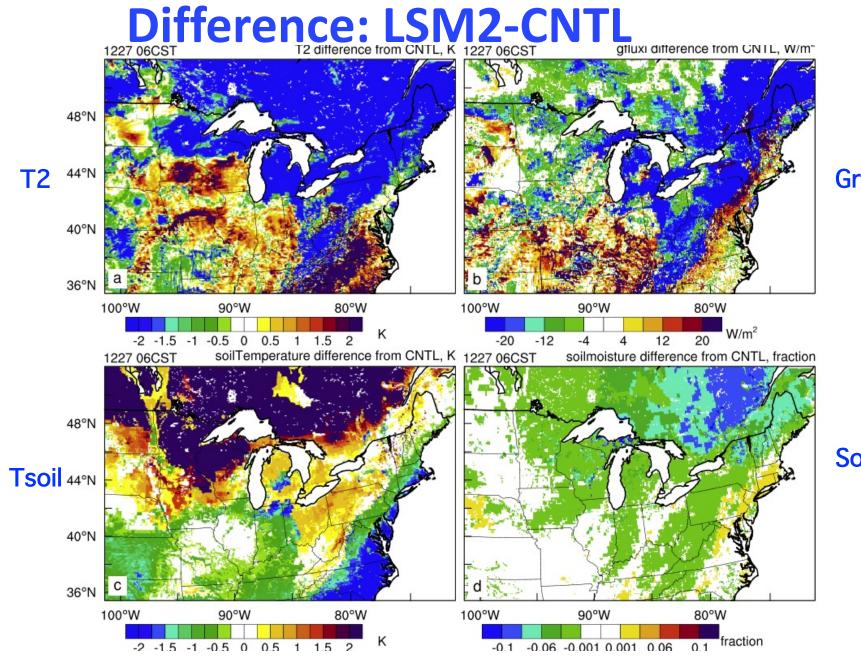
Diagnose cold bias from NoahMP



Experiment	Suite Characteristic	Microphysics	PBL	Surface	LSM
names				Layer	
CNTL	RRFS-control-like	Thompson	MYNN	MYNN	NOAH
			(Olson et	(Nakanishi	(Chen & Zhang,
			al., 2019a;	<u>& Niino,</u>	<u>2009</u>)
			Olson et al.,	<u>2009</u>)	
			<u>2019b</u>)		
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					2016; Smirnova et
					<u>al., 2000</u>)
LSM2	future GFS-like	Thompson	TKE-	GFS	NOAH-MP
			EDMF	(Zheng et	(Niu et al., 2011)
			<u>(Han &</u>	<u>al., 2012</u>)	
			Bretherton,		
			<u>2019</u>)		
MP1	WoFS-like	NSSL	MYNN	MYNN	NOAH
MP2	HWRF-like	Ferrier-Aligo	K-EDMF	GFS	NOAH
	HAFS-like		(Han et al.,	(Zheng et	
	(Rigwag et al. 2018)		2016	al 2012)	



Circles: New York State Mesonet Measurements

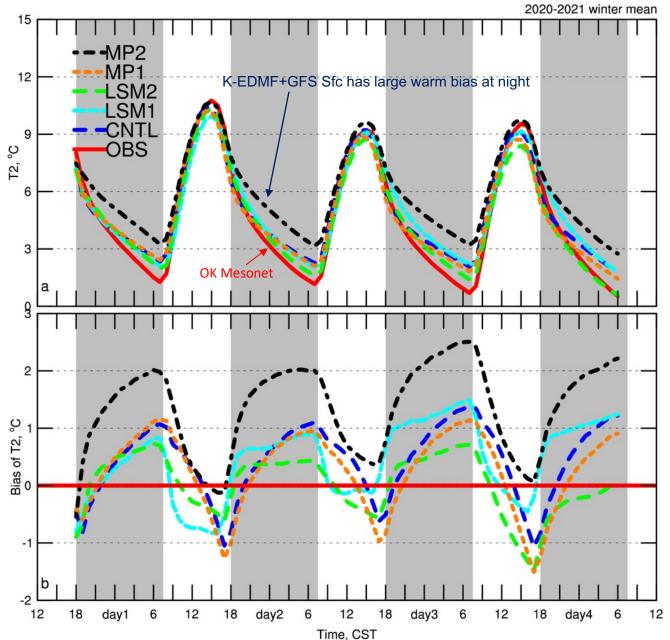


Ground flux

Soil moisture

NoahMP in LSM2: lower soil water =>lower conductivity=>lower upward ground flux=>too cold over snow

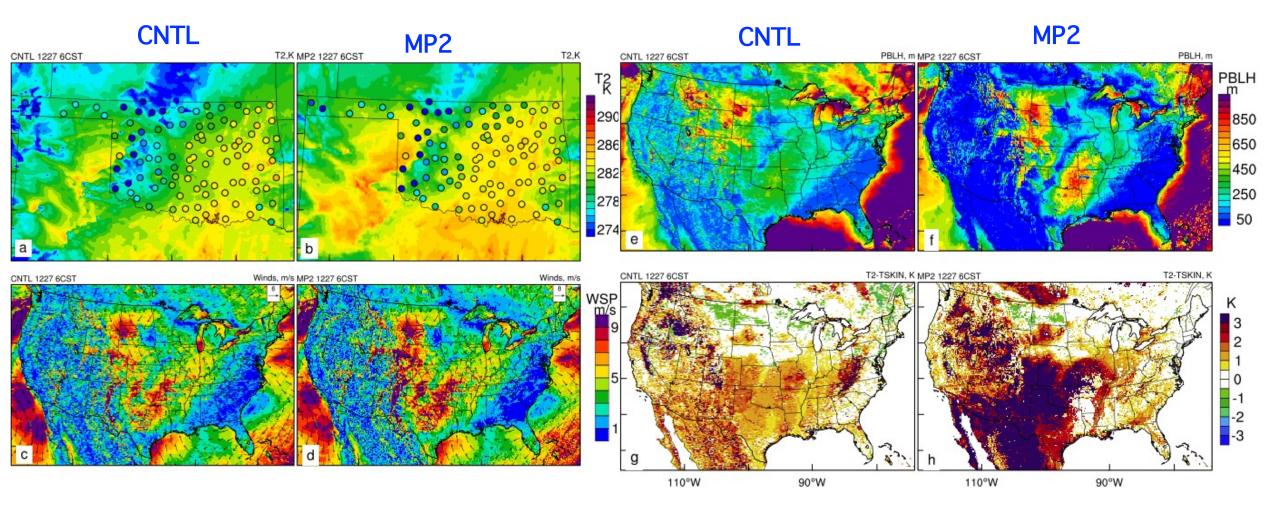
T2 evaluation against Oklahoma Mesonet



Experiment names	Suite Characteristic	Microphysics	PBL	Surface Layer	LSM
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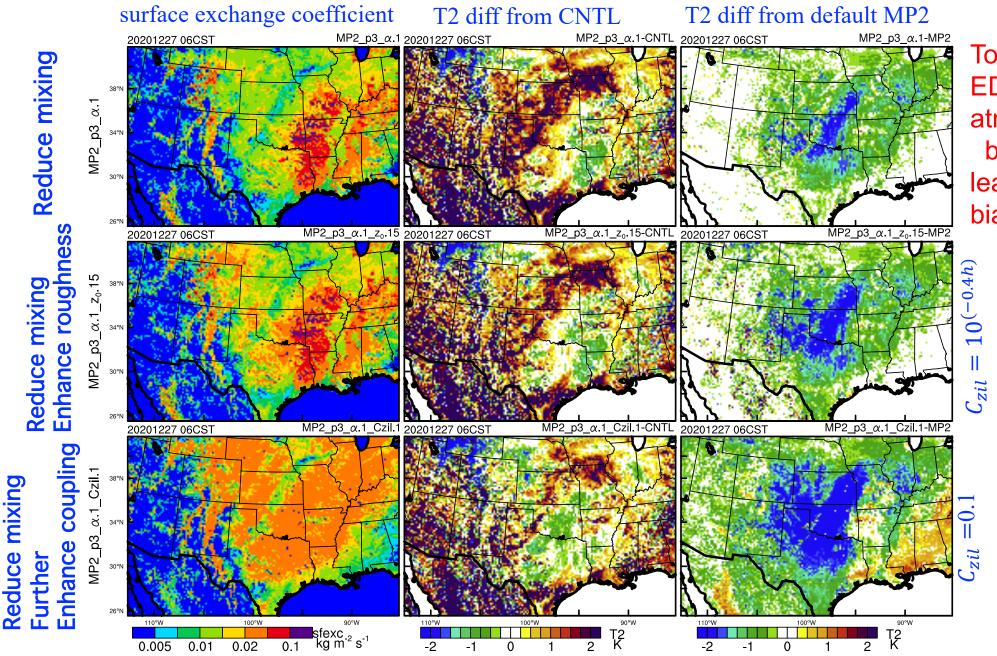
Nighttime warm bias over the southern Great Plains from MP2 with K-EDMF and GFS surface layer scheme

Case study: Dec. 27, 2020



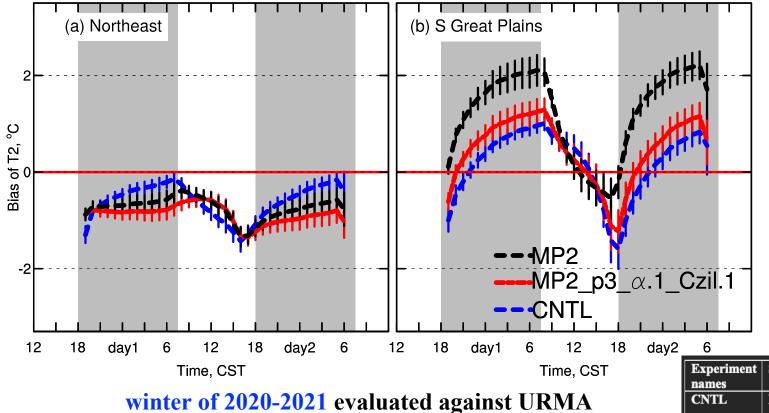
Too high PBL, and too strong near-surface temperature gradient from MP2 with K-EDMF and GFS surface layer scheme indicating model errors in vertical mixing and land-atmospheric coupling

MP2 sensitivity runs with different vertical mixing and land-atmospheric coupling



Too strong mixing by K-EDMF & too weak landatmospheric coupling by GFS surface layer lead to nighttime warm bias over grassland

MP2 sensitivity runs with different vertical mixing and land-atmospheric coupling



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Conclusions

- Noah-MP simulates lower soil water content, and thus lower thermal conductivity, leading to smaller upward ground flux during nighttime and consequently lower surface temperature over snow.
- Overestimated vertical mixing strength from the K-EDMF PBL scheme and insufficient land-atmospheric coupling from the GFS surface layer scheme over short vegetation lead to nighttime warm bias in the Southern Great Plains.

Hu, X.-M., J. Park, T. Supinie, N. A. Snook, M. Xue, K. Brewster, J. Brotzge, J. R. Carley (2022), **Diagnosing Near-Surface Model Errors with Candidate Physics Parameterization Schemes for Multi-Physics Rapid Refresh Forecasting System (RRFS) Ensemble during Winter over the Northeastern US and Southern Great Plains**, *Mon. Wea. Rev.*, doi:<u>10.1175/MWR-D-22-0085.1</u>